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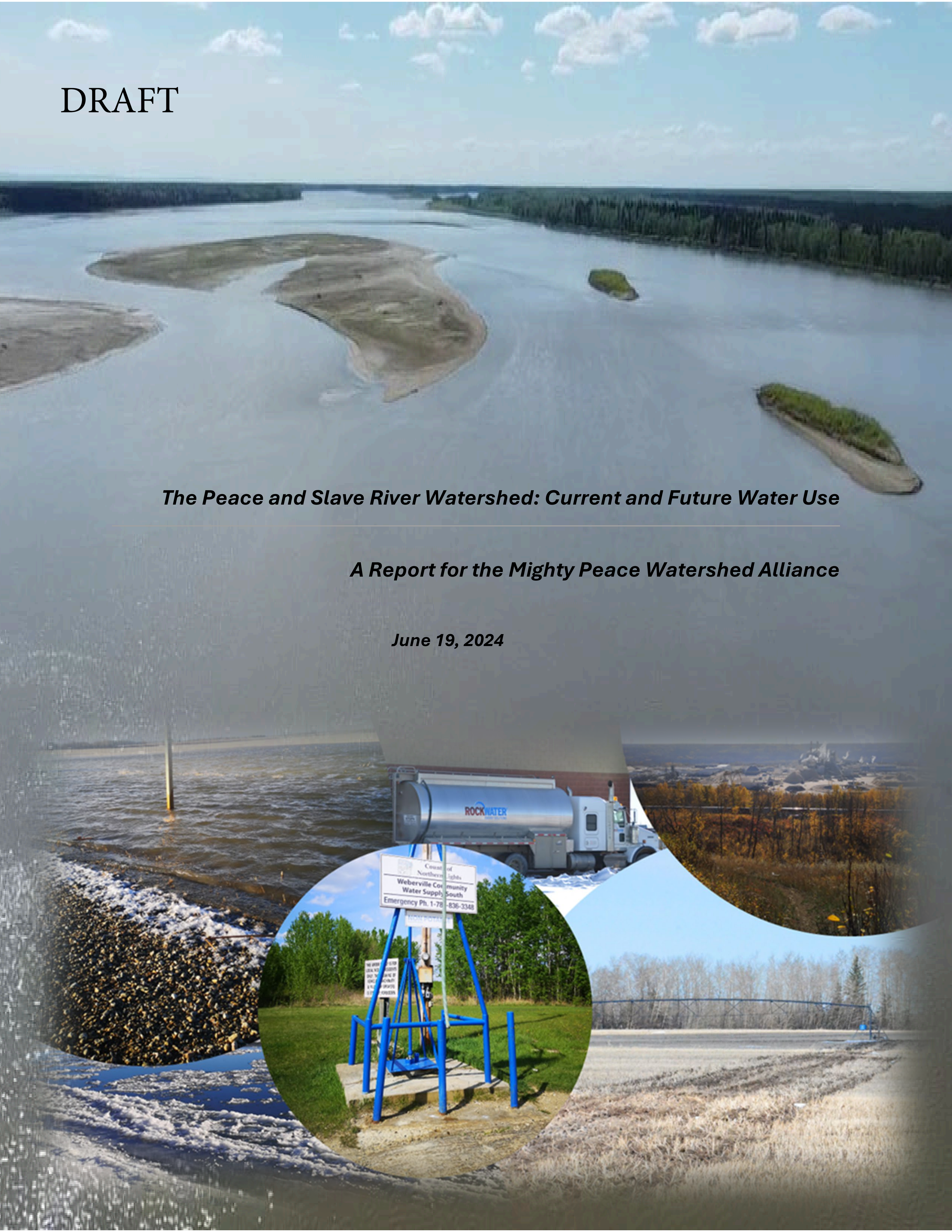
The Peace and Slave River Watershed: Current and Future Water Use

A Report for the Mighty Peace Watershed Alliance

June 19, 2024



Funding and Disclaimer

The report was prepared as information for the Mighty Peace Watershed Alliance (MPWA). However, the views and opinions expressed in this report are not necessarily those of the MPWA.

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Pattison Resource Consulting Ltd. Recognizes that the Peace and Slave River Watershed is located in Treaty 8 Territory, the traditional homeland of many Indigenous and Metis people. PRC also acknowledges the support the MPWA technical committee: Jim Webb, Ashley Rowney, Chris Thiessen, Dave Walty, Jill Henry and Richard Keillor; Adam Norris and Rhonda Clarke-Gauthier from the MPWA; Naba Adhikari, Janet Yan and Long Fu from Alberta Environment and Protected Areas (AEPA); and Daniel Moore from the Alberta Forest Products Association (AFPA). Pictures are credited to the MPWA.

About Pattison Resource Consulting Ltd.

Pattison Resource Consulting Ltd. is a natural resource consulting company specializing in the economic and social dimensions of environmental conservation. For more information, please see www.pattisonresourceconsulting.com.

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EXECUTIVE SUMMARY

Responsible water management is a key component of maintaining healthy ecosystems and ensuring the resilience of human communities—and related industries—that rely on them. The Mighty Peace Watershed Alliance (MPWA) is the watershed planning advisory council (WPAC) expressly dedicated to the conservation and understanding of ecological resilience of the Peace River. The Peace River watershed's large water network is comprised of six sub-basins: the Smoky/Wapiti River, Upper Peace River, Central Peace River, Lower Peace River, Wabasca River and the Slave River. Covering 28% of Alberta and over 1,900 kilometers in length, these rivers are the lifeblood of the region, providing a basis for traditional Indigenous ways of life and settler communities and the expanding agricultural, residential, oil and gas and forestry sectors that provide the economic engine for the northern portion of Alberta.

This report was commissioned by the MPWA to determine the state of current water use in the Peace River and Slave watersheds of Alberta and explore future scenarios of water use under changing conditions at the basin and sub-basin scales. Overall results indicate secure water quantity and quality in the mainstems of the Peace and Slave Rivers under changing future water use demands. However, it is important to note that much of the watershed accesses its water from small tributaries where there are limited flows and/or water quality issues. Although water use analysis at these local community levels is note detailed in this report, the assessment approach followed in this report allows for that extension.

Framed as an update to the 2012 Water Use Report, it will also serve to inform the upcoming State of the Watershed reporting of the MPWA. Methodologically, this report uses current historical and current water allocation and use data by sector—municipal, commercial, agriculture, forestry and industrial—from the Government of Alberta to develop projects of future water demands in the watershed, framed within the context of environmental and human dimensions. Guided by the technical advisory panel of the MPWA, five sectors are explored generally and at the sub-basin level—agriculture, municipal, commercial, forestry and oil and gas. Future issues impacting the watershed are also explored, including climate change, hydroelectric power (Site C), virtual and bulk water export, nuclear power and peat harvesting. Water demand scenarios are developed based upon low, medium and high human population growth and economic expansion.

With respect to future issues and the estimated impact on water use, results suggest:

Issue	Summary	Estimated Impact
Climate Change	More extreme weather conditions, demands for wildfire fighting and preparedness, increasing irrigation opportunities for agriculture, and social and economic outcomes will occur across the watershed, but have greater impact in the tributaries above the mainstream flow. More extreme periods of intense drought and intense rainfall are expected to lead to periods of water shortage (drought) and water quality issues (drought or flooding), especially in contributing areas above the main flow of the Peace and Slave Rivers.	High
Transboundary	Transboundary agreements between Alberta and B.C. and Alberta and Saskatchewan are slow, with Alberta completing its previous transboundary agreement with NWT in 2016	Low
Hydraulic Fracturing	Hydraulic fracturing will persist in the Peace Basin and will continue to be regulated by the AER	High
Hydroelectricity and Site C	Site C in 2025 will have a minimal impact on flow beyond the current impact of WAC Bennett Dam	Low

Lithium Mining	Lithium mining will begin soon in the river basin and the industry is expected to expand slowly	Moderate
Bulk and Virtual Water Export	No major virtual or bulk water export from due to long distances from markets	Low
Nuclear Energy	SMRs are proposed for northern Alberta, but no indication at this point this will occur	Low
Peat Extraction	Limited peat harvest in Alberta and not expected to increase significantly in the coming decade	Low

General results indicate that even under high projections of human population growth and industrial expansion, the impact on water quantity in the region on a watershed and sub-basin level will be minimal. On smaller and local scales however, constraints and challenges of water shortage and decreased quality are expected to increase, and some of the region's communities will continue to encounter difficulties surrounding water use and resilience. Such community level analysis is possible using the framework descried in this report but is not provided here. For the watershed and its sub-basins under high growth rates projected to 2050, water consumptive demands will use 1% of the flow of the Peace River. Groundwater as well will not be significantly impacted. More specifically and by sub-basin, results indicate:

Sub-Basin	Sector	Current Use and Projected Future Trends
Wapiti/ Smoky	Municipal / Commercial	23,980.52 dam^3 is currently allocated for *Municipal* purposes, while only 11,398.88 dam^3 is consumed from both surface and ground water sources. 1,643.353 dam^3 is currently allocated for *Commercial* purposes; 1,509.749 dam^3 is consumed.

	Based upon population growth trends, it is projected that water use (dam^3) will increase at a minimal rate. Municipal sector water consumption is estimated at 11,625 (2030), 12,004 (2040) and 12,383 (2050); Commercial water consumption is 1,540 (2030), 1,590 (2040) and 1,640 (2050).
Forestry	Second highest sector allocation in the sub-basin, but only consumes 4,464.34 dam^3 or 10.92% of their allocation. Water consumption is not expected to increase in the coming years.
Agriculture	Currently 1,709 farms with land in crops, with 1,710,893 acres in crops making up 44.09% of cropland in the Peace River watershed. In addition to this there were an estimated 143,680 cattle, 109, 118 swine, 688, 280 poultry, 36,714 turkeys, 3,473 horses and ponies, and 5,974 bison Estimates of irrigation and livestock water use show that in the Smoky / Wapiti River sub-basin both agricultural practices are likely consuming more than their total allocation. Irrigation in the sub-basin is consuming 12.83% or 213.89 dam^3 more than their allocation while livestock are consuming 68.67% or 1,231.46 dam^3 more. However, these figures represent water use for irrigation and livestock in the entire sub-basin, and because traditional users consume water for these same purposes it is likely that this over consumption can be attributed to traditional use. Future projections indicate that by 2030 water use for irrigation will increase by 327.31 dam^3, and water use for livestock will only increase by 108.89 dam^3. A similar but greater change is estimated for 2050, where irrigation water

		needs are projected to increase by 1,418.35 dam^3, and livestock water use by only 471.87 dam^3. While the exact water use of these sectors will vary from these projections, the likelihood they capture a trend in the growing water needs of both irrigation and livestock is high.
	Industrial	Oil and gas dominate the industrial sector of the sub-basin, but both mining and power generation are also present to a lesser extent. Current water use estimates indicate that the industrial sector is the highest water user in the sub-basin by a very large margin, consuming 68,072.05 dam^3, or 99.64% of their allocation. Representing the largest share of this water use is oil and gas water use which is allocated for 52,726.32 dam^3, and consuming 52,488.64 dam^3 Future projections indicate that Industrial sector water use is expected to increase considerably. These estimates show that in 2050 oil and gas water use will be 62.79% higher than in 2024. Allocations are also expected to increase following this projection curve given the current high utilization of water allocations in the sub-basin. Water consumption of the oil and gas sector in 2040 is estimated to reach 72,770.55 dam^3. Water use for mining is also expected to increase, and in 2040 is projected to be 4,488.81 dam^3. Increases in this sub-sector represent an expansion of mining operations in the sub-basin.
Upper Peace	Municipal / Commercial	4,375.01 dam^3 is allocated for municipal purposes, while only 1,553.68 dam^3, or 35.51% is consumed from both surface and ground water sources. Commercial allocations

		amount to 880.385 dam^3, and 91.85% or 808.633 dam^3 is consumed. Arising from population growth trends projections of future water use (dam^3) will be small. Municipal sector water consumption is estimated at 1,585 (2030), 1,636 (2040) and 1,688 (2050); Commercial water consumption is 825 (2030), 852 (2040) and 878 (2050).
	Forestry	Current forestry operations in this sub-basin are non-water intensive, and water use and allocations amount to 0 dam3. If water intensive forestry operations were to move into this sub-basin water use and allocation would increase. However, the likelihood of this would occur is unknown, and what volumes of water these operations would consume is dependent on many factors and therefore cannot be estimated.
	Agriculture	There are currently 1,110 farms with land in crops, with 1,099,710 acres in crops making up 28.34% of cropland in the peace basin for this year. In addition to cropped agriculture there were an estimated 88,581 cattle, 3,632 swine, and 2,620 horses and ponies, and small inventories of other livestock inventories. Livestock and irrigation water use in the Upper Peace sub-basin consumed 2,834.37 dam^3 in total, making cropped and livestock agriculture the largest water user in the Upper Peace sub-basin. Estimates of irrigation and livestock water use show that in the Upper Peace River sub- basin Livestock agricultural practices are likely consuming more than its total allocation by 696.37 dam^3, or 74.97%. Irrigation in the

		Upper Peace sub-basin is consuming 87.07% of its allocation, for a total of 1,209.11 dam^3 in water consumption. As noted earlier from allocation over-use, the figures for livestock water use may be made up in part by traditional agricultural water use, as water under this designation is consumed for the same purposes. Projections of future water use indicate that water used for irrigation will reach 2,121 dam^3 by 2050 while livestock water use stays relatively stable seeing only an increase of 253.541 dam^3 by the same year. Projections capture the growth of agriculture in this sub-basin over the last 10 years.
	Industrial	Oil and gas activity is the only industrial water user in the sub-basin whose current water allocation amounts to 1,525 dam^3, and current use to 1,509 dam^3 accounting to 98.95% of this sectors allocation. The results of this projection indicate that industrial sector water use is expected to increase marginally for each projection horizon. These estimates show that in 2050 oil and gas water use will be 62.79% higher than currently, reaching 2,457 dam^3. Given the high allocation utilization of the industrial sector in this sub-basin currently, it is likely that this upward trend in water use will persist. These projections indicate that despite its small share of current water allocations in the sub-basin, future water use for the industrial sector is expected to rise.
Central Peace	Municipal / Commercial	Currently 9513.61 dam^3 is allocated for municipal purposes, but only 3180.46 dam^3 is consumed from both surface and ground water sources. In this sub-basin the commercial

		sector uses a small amount of water, amounting to 155.87 dam^3. Water consumption in this sub-basin is quite small compared to the volume of water allocations currently held. Future water use (dam^3) estimates based on historical population growth show very small changes in municipal and commercial water consumption. Municipal sector water consumption is estimated at 3,244 (2030), 3,349 (2040) and 3,455 (2050); Commercial water consumption is 159 (2030), 164 (2040) and 169 (2050).
	Forestry	forestry in the Upper Peace sub-basin is currently allocated to use 70,355.47 dam^3 but are only consuming 37,031.46 dam^3 or 52.65% of their allocation. The Central Peace River sub-basin has the highest forestry water allocation and consumption in the entire Peace River watershed. However water consumption for forestry is not expected to increase in the near future.
	Agriculture	According to the most recent agricultural census the Central sub-basin had 369 farms with land in crops, with 447,211 acres in crops making up 11.53% of cropland in the Peace basin. Livestock inventories are primarily made up of cattle in this region with an inventory of 26,985 but also contained 498 horses and ponies. Estimates of irrigation and livestock water use show that in the Central Peace sub-basin both agricultural practices are consuming less than their total allocation. Irrigation is consuming an estimated 491.70 dam^3, or 39.22% of its allocation. And livestock agriculture is consuming 486.84 dam^3, or 76.58% of its total allocation. In total irrigation and livestock water use is 978.84 dam^3, or

		slight above half the total allocation of these two activities. Livestock and irrigation water use in the Central Peace sub-basin consumed 978.84 dam^3 in total, making agriculture the smallest water user in the sub-basin. Future water use (dam^3) estimates based on historical trends show differing in agricultural water consumption. Irrigation water consumption is estimated at 577 (2030), 720 (2040) and 862 (2050); Livestock water consumption is 504 (2030), 534 (2040) and 563 (2050).
	Industrial	Oil and gas is the primary industrial activity in this sub-basin, but some mining is also present. Oil and gas activity is allocated for 4,667 dam^3 but consuming 3,715 dam^3. While mining activity accounts for 1,233 dam^3 and consuming 99.98% of its allocation volume. Future use for oil and gas activity is estimated to reach 6,047 dam^3 by 2050, or 62.80% higher than it is now. Mining water will also increase but to only 2,008 dam^3 on the same horizon. The total volume of allocations for industrial use in the Central Peace sub-basin will presumably follow this upward trend, allowing water diversion on this scale to proceed.
Lower Peace	Municipal / Commercial	Total commercial and municipal water use amounts to 461.38 dam^3, or a small 27.71% of the total volume allocated. Commercial sector water allocation utilization is very high at 99.34%, but this allocation is small at 152.77 dam^3. Municipal water use equals a volume of 309.62 dam^3, only accounting for 20.47% of its water allocation.

		Increase in future water use (dam^3) are projected to be small. Municipal water use is estimated to be 316 (2030), 326 (2040), and 336 (2050); and commercial sector water use 156 (2030), 160 (2040, 165 (2050).
	Forestry	Foresty operations in the Lower Peace sub-basin are considered non water intensive, current use amounts to 342 dam^3, and the total volume allocated is 438 dam^3. Water use is not expected to increase unless water intensive operations move into the sub-basin.
	Agriculture	There are an estimated 753 farms with land in crops, with a total area of 491,411 acres, representing 12.66% of crop land in the Peace River watershed. The livestock sector of the Lower Peace sub-basin is small with a cattle inventory of 21,613, 779 horses and ponies, and 1,460 elk. Estimates of irrigation and livestock water use show that in the Lower Peace River sub-basin irrigation is consuming only a small portion of its water allocation, while livestock agriculture water use far exceeds the current allocation. The water use of livestock in this sub-basin represents the single largest overuse of water when compared to a sector or sub-sectors allocation. Despite overuse the actual amount of water consumed is still quite small and stands as the second lowest livestock water use for a sub-basin in the entire Peace River watershed. Water use for irrigation in this basin amounts to 540.30 dam^3 (more than livestock's estimated 408.23 dam^3 consumption). Together livestock and irrigation consumed 948.53 dam^3 of water in the Lower Peace River

		sub-basin, ranking third in this water use category for all sub-basins. Irrigation in the Lower Peace River sub-basin will likely see the most increase based on the projection; this is expected as cropped agriculture in the region expands. By 2040 Irrigation will be consuming an estimated 790.99 dam^3, while livestock consume 447.42 dam^3. These estimates also indicate that by 2050 livestock water use will not reach the current water use of irrigation in the sub-basin. These estimates capture the trends agriculture experiences in the sub-basin, as the presence of agriculture increases in the Lower Peace so too will water allocations and water use for this purpose. And given current water use allocations for livestock are far exceeded by estimated consumption, this discrepancy between use and allocation is also likely to persist.
	Industrial	The Lower Peace sub-basin has very little industrial activity. This sub-basin lies outside of the Peace River oil sands, and associated sedimentary basins where oil and gas activity, or mining could occur. Because of this miniscule sector there are currently no water allocations for the industrial sector in the region. Water use may increase in the region if industry were to move in, however this seems unlikely to occur.
Wabasca	Municipal / Commercial	Current water use estimates indicate the 1,111.31 dam^3 is consumed for municipal purposes, and 260.77 dam^3 for commercial in the Wabasca River sub-basin, most of this water is from surface water sources. Water consumption for

	the municipal and commercial sectors combined makes up only 51.74% of the total volume allocated. Increase in future water use (dam^3) are projected to be small. Municipal water use is estimated to be 1,133 (2030), 1,170 (2040), and 1,207 (2050); and commercial sector water use 156 (2030), 160 (2040, 165 (2050).
Forestry	Inside the sub-basin boundaries of the Wabasca River there are no forestry operations licensed to divert water from either surface or ground water sources. Slave Lake pulp mill is located near the boundary of the Wabasca sub-basin, but no water from the Wabasca River is licensed for withdrawal to be used at this pulp mill. Because of this water use and allocations for forestry in the Wabasca River amount to 0 dam^3. As always there is potential for forestry to move into this region, and depending on the type of operation could increase forestry water use from zero.
Agriculture	The total area of land in crops for the Wabasca sub-basin is 131,050 acres, accounting for 3.38% of crop land in the Peace basin, with 122 farms reporting cropped acres in 2021. And a reported 9,479 cattle, and 302 goats and sheep in the sub-basin. Estimates of irrigation and livestock water use show that in the Wabasca sub-basin both irrigation and livestock are likely consuming more than their total allocation. Irrigation in the Wabasca is consuming 144.087 dam^3 or 105.17% more than the allocation, and livestock are consuming 168.81 dam^3, or 468.92% of the current allocation. However, livestock are only consuming 168.90 dam^3, representing the smallest livestock water use in the

		entire Peace River watershed. A similar phenomenon is occurring with irrigation water use in the Wabasca River, whereby estimate current consumption is greater than the current irrigation allocation. Again, looking to the 144.09 dam^3 consumptions shows that this water use is still very small comparatively. Small growths in the agricultural sector of this sub-basin are likely, and with these increases in water use also. Irrigation water use (dam^3) is estimated to be 169 (2030), 211 (2040), and 235 (2050); and livestock 175 (2030), 185 (2040), and 195 (2050).
	Industrial	Oil and gas is the primary industrial activity in the sub-basin, accounting for water consumption in this sector. Combined surface and ground water consumption amounts to 2,381 dam^3, with an allocation of 2,382 dam^3. Future water use (dam^3) is projected to increase to 2,727 (2030), 3,302 (2040), and 3,877 (2050). Estimates for 2050 indicate that industrial water use will be 62.79% higher than currently.
Slave	Municipal / Commercial	The Regional Municipality of Wood Buffalo is the only other allocation holder in the Slave River sub-basin, with a total of 313.11 dam^3 allocated across four (4) licenses. Consumption, return flows, and losses are not reported by these licenses, so it is assumed they are using their full allocation. The purpose of these allocations is recreation—specifically snow/ice making. The source of the water is the Des Rocher River. Future water use in this region is not expected to increase, unless industry is allowed to move in,

		or the regional municipality of Wood Buffalo decides they need a fifth water license for snow/ice making.
	Forestry	There are no forestry water allocations in the Slave River basin.
	Agriculture	There is no agricultural activity in the Slave River basin.
	Industrial	There is no industrial sector water use in the Slave River basin.

Discretion must be exercised in interpreting these results, as it simply to fall for the "myth of hyperabundance" of this resource. The Peace River watershed is richly endowed with freshwater, but human activity in the region is increasing and impacting all aspects of the watershed. Furthermore, two factors not specifically addressed in this report control the availability of water for withdrawal: local specific geographic location and seasonality. For although the Peace and Slave River mainstems have a lot of water in them, most people and communities access water not from the mainstem but from smaller tributaries, which are more prone to water shortages as low flow periods have restrictions around withdrawals. Although the granularity needed to address these factors is beyond the scope of this report, the framework provided can be employed to determine critical actual water availability.

In addition, future analysis specifically focussed on integrating Indigenous traditional ecological knowledge (TEK) with the Western scientific quantification of the resource across the Peace River watershed highly recommended. Such "two-braided" approaches to conservation will assist in future conservation efforts. Water is a precious resource that is necessary for all life, and the careful stewardship of it for future generations of all species is essential.

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ACRONYMS

AAFC	Agriculture and Agri-Food Canada
ABMI	Alberta Biodiversity Monitoring Institute
AEPA AEP AE	Alberta Environment and Protected Areas Alberta Environment and Parks Alberta Environment
AER	Alberta Energy Regulator
AFETUW	Alberta Flow Estimation Tool for Ungauged Watersheds
AFP	Alberta Forestry and Parks
AFPA	Alberta Forest Products Association
AWA	Alberta Wilderness Association
AWP AWPS	Alberta Water Portal Alberta Water Portal Society
B.C.	British Columbia
CCS	Census Consolidated Subdivisions
CEC	Commission for Environmental Cooperation's
CFO	Confined Feeding Operation
CSPMA	Canadian Sphagnum Peat Moss Association
CSS	Cyclic Steam Stimulation
CUMSA	Canada-U.S.-Mexico Agreement
ECCC	Environment and Climate Change Canada
E-Flows	Environmental Flows
ES	Ecosystem Services
FITFIR	First in Time First in Right
FMU	Forestry Management unit
GHG	Green House Gas Emissions
GOA	Government of Alberta
IPS	International Peatland Society
IUCN	International Union for Conservation of Nature and Natural Resources
lpd	Liters per Day
LUF	Land Use Framework
MDP	Municipal Development Plan
MOU	Memorandum of Understanding
MPWA	Mighty Peace Watershed Alliance
MRBB	Mackenzie River Basin Board
NAFTA	North American Free Trade Agreement
NRBS	Northern River Basins Study
NREI	Northern Rivers Ecosystem Initiative
PTPC	Premier Tech Producers and Consumers

SAGD	Steam-Assisted Gravity Drainage
SMR	Small Modular Reactor
SOAER	State of the Aquatic Ecosystem Report
TDL	Temporary Diversion Licenses
TEK	Traditional Ecological Knowledge
TSAG	Technical Services Advisory Group
UNESCO	United Nations Education Science and Cultural Organization
USDA	United States Department of Agriculture
WCS Canada	Wildlife Conservation Society Canada
WPAC	Watershed Planning and Advisory Council
WURS	Water Use Reporting System

DEFINITIONS

Consumptive Water Use	*any type of water use that reduces or eliminates the overall volume of water available for other uses. For example, watering your lawn is considered consumptive, because the water used is retained by the grass to promote growth, with a certain percentage evaporating into the air.*
Non-consumptive water use	*refers to water used in such a way that it is available for other uses. Many indoor water uses are considered non-consumptive, such as running your dishwasher or taking a shower, because this water flows back into treatment systems that eventually return the water to primary sources.*

1.0 INTRODUCTION

Water is essential to life on earth. Integral to the functioning of natural ecosystems as well as the human communities that reside and rely on them, strategically planning for water use over various time scales is necessary to ensure secure and safe access to this resource. Discussions of responsible use of freshwater resources for future generations is an increasingly important topic at multiple scales. Internationally, it is evident in recommendations arising from the United Nations Water Expert Group on Transboundary Water (UN-Water 2020); continentally, it is evident in the Commission for Environmental Cooperation's (CEC) Strategic Plan (CEC 2021); nationally, it is evident in the creation of the Canada Water Agency (Government of Canada 2024a); and in Alberta is evident in the *Water Act* and initiatives such as the Watershed Planning and Advisory Councils (WPACs) (WPAC 2024). Projected modeling of climate change and erratic weather events have further prioritized the conversation of freshwater conservation.

Alberta is not immune from such water-related concerns. Although in aggregate terms Alberta is water rich province, the freshwater resources are not evenly distributed (Government of Alberta 2024c). The southern portions of the province are relatively water scarce, and the northern regions are relatively water abundant. The 2023-2024 drought conditions that are persisting across the Canadian Prairies have significantly raised concerns about freshwater resource use and are currently fixed in the forum of public discussion (CBC 2024c; Globe and Mail 2024). Alberta initiated a negotiation process for water license allocations and developed a drought response plan as dry conditions persist in the southern watersheds and across the province generally—despite a cooler and wetter temperatures experienced across much of the province in May 2024 (Government of Alberta 2024b).

The abundance of water in the northern regions is inextricably linked with the human communities that reside there. The Indigenous communities of the Treaty 8 First Nations of Alberta have a long history of using these waterways as travel corridors and hunting grounds (Tracking Change 2024). European settlers have also benefited from these water-based travel corridors and more recently, to support the various resource-based industries that support and maintain communities. The peace between the Cree and the Dene-Zaa at Peace Point in 1781, and one of the Treaty 8 signings between the Canadian Government and the Treaty 8 First Nations of Alberta at the Dunvegan Bridge on the Peace River in 1899 is a signal of the symbolic representation of the relationship all human communities in the region have with water, and with the Peace River specifically. The concept of environmental flows captures these human social and cultural implications of rivers and (Acreman 2016; Alexander et al. 2021) is explored in the literature section of this report.

A common occurrence when considering freshwater conservation is the myth of hyperabundance— *there is a lot of it so why should we conserve?* As such, the WPACs of Alberta are strategically placed to respond to this risk and have conducted important advocacy and supported rigorous scientific understanding on freshwater conservation at the watershed level. The formation of the Mighty Peace Watershed Alliance (MPWA) in 2011 was instrumental in exploring resilient water use in northern Alberta (MPWA 2024). Through the various activities of the MPWA, they have explored water and land use in the region and have added richness and information to the conversation locally and provincially. For example, in 2012 MPWA commissioned a report by Watrecon Consulting titled *Current and Project Water Use in the Mighty Peace Watershed* (Watrecon Consulting 2012). Framed at a sub-watershed level, this report provided an excellent planning resource for the region that has informed MPWA discussions for the last decade.

Significant landscape level, climate and human demographic changes have occurred in the Peace River Watershed over the last thirteen years. Human populations have increased the demand for municipal water use, increased resource extraction from forestry, mining and oil and gas are constantly evolving on the landscape and changing climatic conditions have led to greater volatility of flow, and agricultural expansion continues across certain regions of the watershed. To ensure their actions are proactive and based upon the most recent information possible, in 2024 the MPWA commissioned this report as an update to the 2011 report that considers various water use scenarios, and their related economic implications, to understand water use in the watershed into the future. The scope of the analysis is directed towards licenced and consumptive use of water by sector, though it is framed by discussion of current and future issues for water management and consumption in the watershed.

This report is structured as follows. *Section 2* provides an overview of the watershed, including the environmental and human dimensions, current state of identified water using sectors, and current issues; *Section 3* provides a literature scan on water use reports in the region; *Section 4* provides a methodological framework for the analysis; *Sections 5-10* provide a sub-basin analysis; *Section 11* analyzes wetland drainage on a watershed scale; and *Section 12* draws conclusions, identifies limitations and suggested next steps. Each component contributes to the objective to provide a structured analysis of water use to inform decisions makers in this unique and significant watershed of Alberta.

2.0 CONTEXT

2.1 OVERVIEW OF WATERSHED

2.1.1 PHYSICAL GEOGRAPHY

Prior to European settlement in the watershed, the Indigenous Dene-Zaa people named the river *unchaga,* or “big river”. This Indigenous name accurately describes this river and the watershed that feeds it. Encompassing approximately 28% of the province of Alberta, and entirely situated with the Territory of the Treaty 8 First Nations of Alberta, the myriad of creeks, streams and rivers that ultimately feed into the Peace River provide the environmental, economic and cultural framework for the region. Etymologically, the name of the river is in reference to the place on the lower sections of the river where Cree and Dane-Zaa Indigenous groups made peace in 1781 (Canadian Encyclopedia 2024).

Rising in the Rocky Mountains of Northern British Columbia, the river was formed approximately 15,000 years ago from the melting of Glacial Lake Peace. Until recent history, the Peace River formally started at the confluence of the Finlay and Parsnip Rivers. In 1960 the Bennett Dam was constructed on these three rivers, creating Williston Lake (Canadian Encyclopedia 2024). The resulting Peace River now flows from the eastern arm of Lake Williston and is joined by multiple rivers along the way, such as the Halfway, Beatton and Pine Rivers. Flowing in a northeastern direction across the northern prairie parkland landscape, in some places the river valley reaches 11km wide. Near the town of Peace River, the Smoky River joins and the combined river turns abruptly north and travels several hundred kilometers before reaching the confluence of the Wabasca River near Fort Vermilion. It then flows northeast again, and passes Peace Point and through Wood Buffalo National Park, before joining the Slave River in northern Alberta. Even without the combined tributaries, the Peace River travels approximately 1,900 kilometers before joining the Slave

River, whose combined waters travel to Great Slave Lake in the Northwest Territories, and ultimately the Mackenzie River and the Arctic Ocean.

Due to the vast drainage area and diversity of the landscape, the Peace River watershed is divided into six sub-basins which comprise the larger network (Figure 1). These include the Upper Peace, the Central Peace, the Lower Peace, the Slave River, and the Smoky/Wapiti and Wabasca tributaries. Specific descriptions of each of these sub-basins are provided in the respective sections of this report.

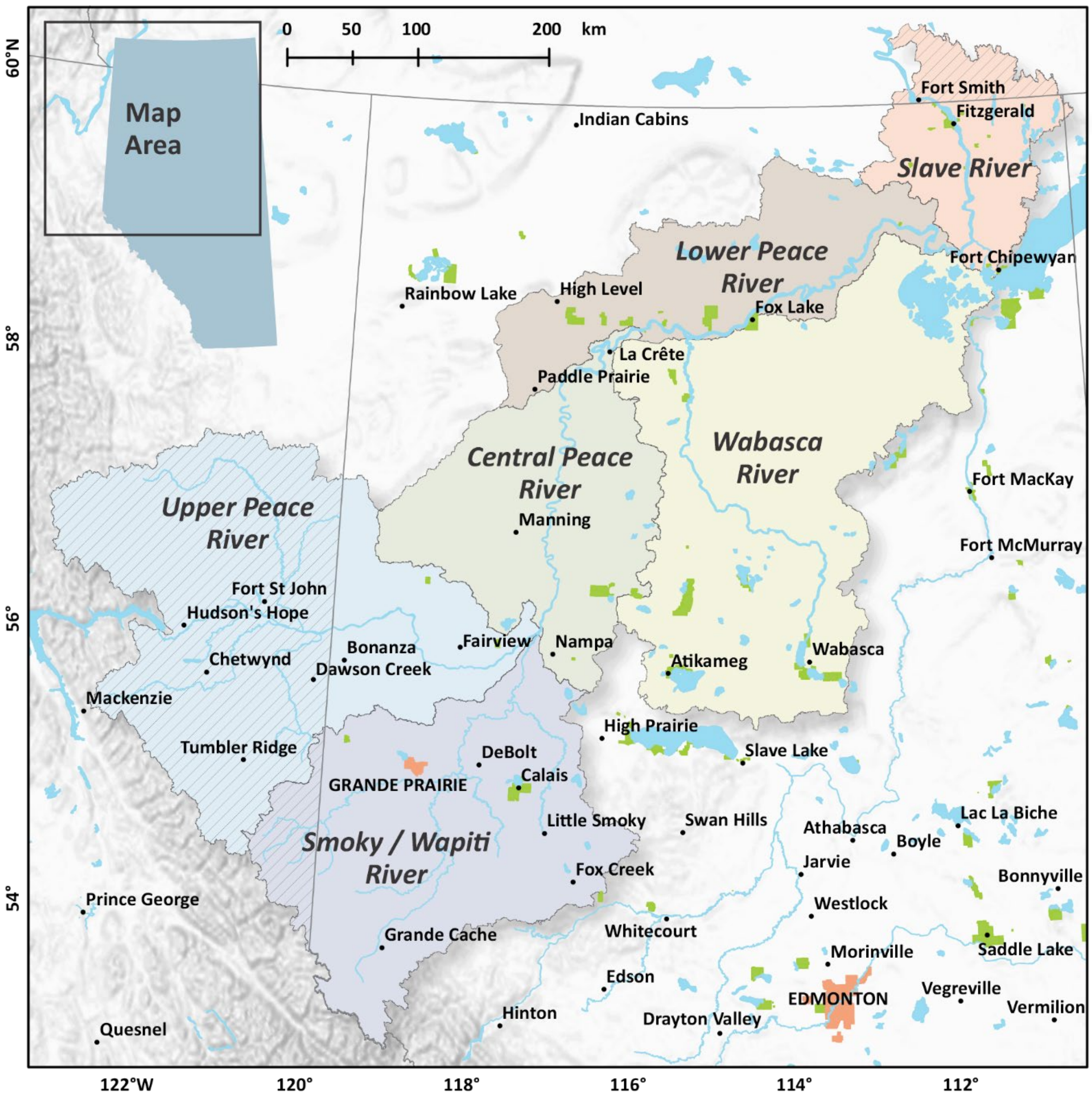


Figure 1. Map of the Peace River watershed and the six associated sub-basins.

2.1.2 HUMAN GEOGRAPHY

The Peace River Watershed in Alberta is situated with Treaty 8 Territory and the across the Metis Nation of Alberta Regions 4,5 and 6 (Figure 2). In terms of non-Indigenous boundaries, it is located within the municipal districts of Greenview No. 16, County of Grande Prairie No. 1, Smoky River No. 130, Spirit River No. 133, Peace No. 135, Saddle Hills County, Birch Hills County, Clear Hills County, Northern Sunrise County, Mackenzie County, Opportunity No. 17, Wood Buffalo Improvement District No. 24, and the Regional Municipality of Wood Buffalo (Alberta Municipal Affairs 2024).

Figure 2. First Nations reserves and Metis settlements in Alberta (Source: GOA 2021).

Canada Population Census data from 2006, 2011, 2016 and 2021 indicates the following population trends in the area (Figure 3) (Government of Canada 2021). Major population centers are few, with Grande Prairie, Peace River and High Level being the largest settlements. Population trends are positive, but at a smaller rate than the rest of Alberta and with very different ranges within the watershed. In some cases, there have even been negative populations trends.

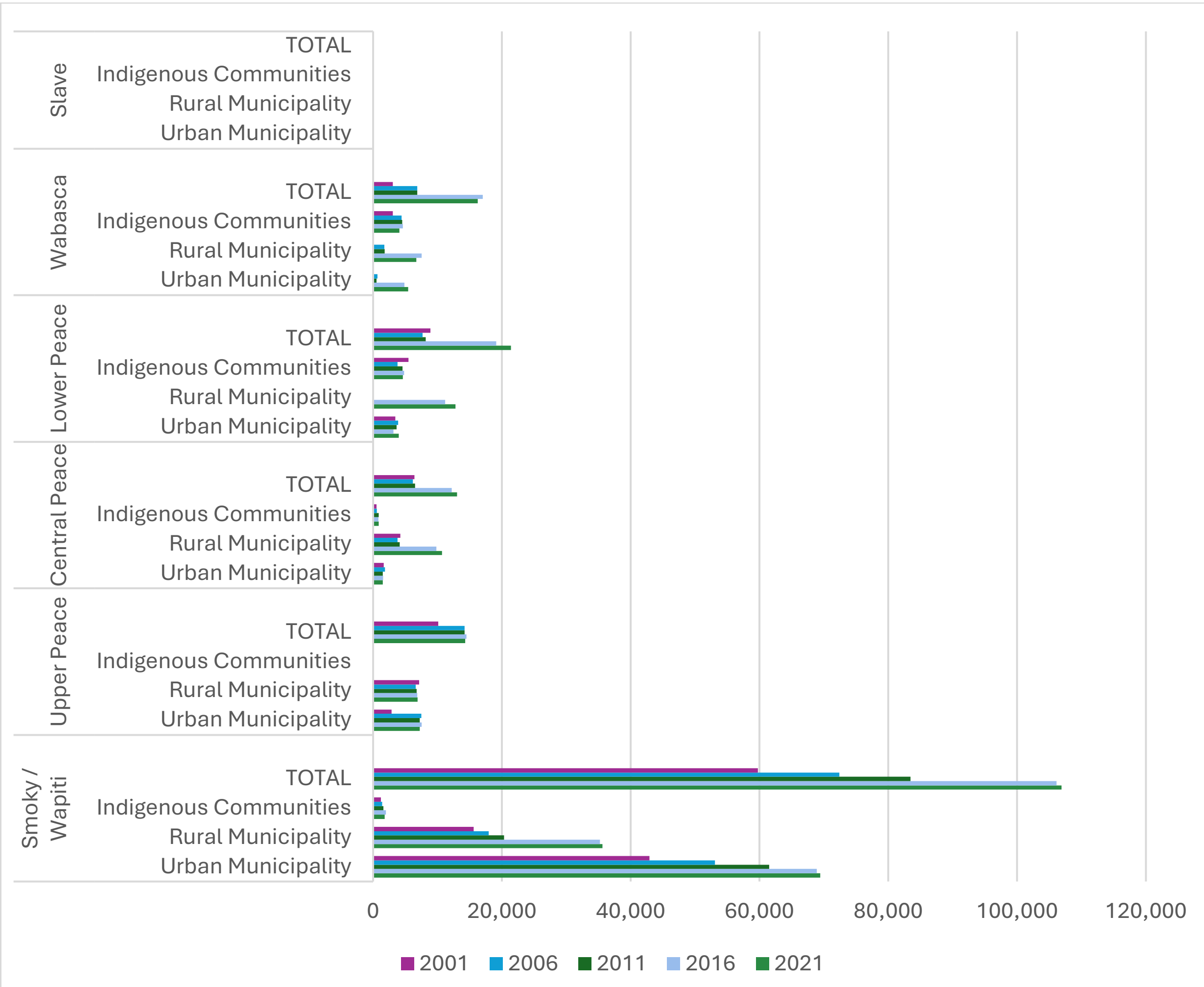


Figure 3. Population trends in the Peace River Watershed divided by sub-basin based upon Canada population Census 2001, 2006, 2011, 2016 and 2021. (Government of Canada 2021)

2.2 ENVIRONMENTAL FLOWS AND INDIGENOUS TREATY RIGHTS

Water management has evolved over time. Surface water management in the first of half of the 1900's was dominated by services provided to humans, such as flood control, water supply, hydropower generation and the other means that surface water can provide measurable economic benefit to human societies. In the 1970s a shift occurred to recognize biological and social systems, and in the 1990s this shifted again to the concept of environmental flows, which includes spiritual and cultural significance of rivers. In 2007 the Brisbane Declaration on Environmental Flows was endorsed, though despite the adoption of environmental flow policies, implementations remain limited (Acreman 2016; Poff and Zimmerman 2002).

The term environmental flows have become widely used to define the hydrological regime required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on them (Acreman 2016; Poff and Zimmerman 2002). The concept is particularly important when incorporating and prioritizing Indigenous water rights, globally and in Canada. Alexander et al. (2021) explores this in terms of bridging Indigenous and Western worldviews in water management in Canada. The authors assert *mutually respectful and reciprocal relationships between people and their environment is a central tenet of many Indigenous worldviews. This relational connection is particularly evident when it comes to freshwater ecosystems. However, there are numerous threats to these central relationships between Indigenous peoples and their environment. Using all available ways of knowing to conserve, prioritize, and restore relationships between Indigenous peoples and the environment they live in, and are a part of, is critical. Despite legislative requirements and policy commitments, developing and implementing inclusive approaches that bridge multiple ways of knowing remains a challenge* (Alexander et al. 2021). Changing this requires purposeful engagement with Indigenous people to achieve improved and holistic environmental flow outcomes (Mussehl et al. 2022), that can achieve long-term water sustainability .The concept of environmental flows as it pertains to Indigenous Treaty Rights is recognized by the government of Alberta and Canada (Government of Alberta 2024a; Reed et al. 2024).

The Peace River Basin has been home to many Indigenous people, including the Dena-Zaa, the Woodland Cree, the Sekani and the Metis (Parlee and Souza 2019) as well as the Rocky Mountain People, Aseniwuche Winewak Nation. Collectively part of the Treaty 8 First Nations of Alberta, these groups are concerned about climate change and water use. The Tracking Change Project explores many of the perspective and concerns of Indigenous people in this basin, as they face rapidly changing population and resource use pressures (Tracking Change 2024).

Canada has also been negligent in terms of Treaty Rights and access to water. Drought conditions in 2023-2024 highlight this condition, as several First Nation communities in the Peace River watershed face water concerns heading into the summer of 2024. For example, Tall Cree First Nation's drinking water comes from a stream that relies on snow run-off (CBC 2024b) and they are currently uncertain as to the reliability of the flow. They are not alone – although approximately 3,700 wells and 5,600 cisterns exist on reserves in Alberta, many do not have the access they need and are facing jurisdictional tension between provincial and federal government responsibility. The First Nations Technical Services Advisory Group (TSAG) of Alberta plays an integral role in water access for First Nation communities in Alberta. Future funding and engagement on water access for First Nations in the Peace River watershed will increase in importance in terms of investment and time.

A detailed exploration of the intersection of environmental flows and Indigenous Treaty Rights is beyond the scope of this report. However, as this is an important reconciliation issue, it is respectfully recommended that a dedicated analysis of this issue is undertaken; supported by and in close consultation with the Treaty 8 First Nations of Alberta and other Indigenous groups impacted culturally, spiritually and ecologically by the waters of this important basin.

2.3 WATER LICENSING AND ALLOCATION

The *Water Act* governs the use and diversion of surface and groundwater in the province of Alberta (see Government of Alberta 2024c). With the exception of First Nations and water storage projects, in order to use surface or groundwater, a licence is required for individuals or businesses. A license is *not* required for *statutory household use, traditional agriculture use (for original landowners, see Section 19 of the Water Act), firefighting, wells equipped with hand pumps, and alternate watering systems, which use surface water for grazing livestock and/or certain types of dugouts* (Alberta Water Portal 2023). Water licenses[1] are allocated under seven categories in the *Water Act* and are summarized in Table 1.

Table 1. Water licence allocations in Alberta (Source: Alberta Water Portal (2023))

Purpose	Description
Municipal	Urban use, camps, water use cooperatives, schools and institutions
Agricultural	Feedlots and stock watering
Irrigation	Crop agriculture
Registrations	Traditional agricultural users
Commercial	Aggregate washing, bottling, golf course, cooling, dust control
Industrial	Pulp mills, coal mines, gas and petrochemical plants, oilfield injection, power generation
Other	Water management, dewatering, lake level stabilization, recreation, fish farms, wildlife, wetlands, other purposes specified by a Director

Figure 4 presents a summary of the sectoral water allocations in the province of Alberta in 2010. Unfortunately, more recent mapping of the water allocations is currently not available (direct conversation with GOA, 2024).

[1] Water volume is measured by cubic decameters (dam^3), which equates to 1,000 m3 or 1 million litres of water.

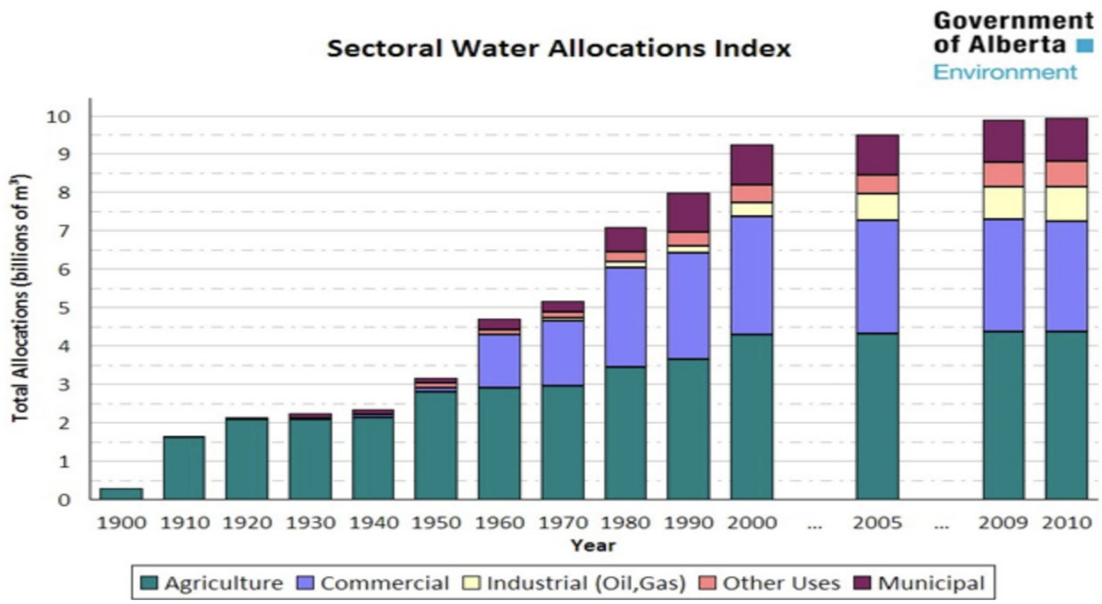


Figure 4. Sectoral water allocations in Alberta from 1900 to 2010 (more recent data is not available; Source: GOA 2010)

Note that water licence allocations do not represent actual water use. As such, some basins can be over-allocated but under-used. Provincially, surface water allocations in Alberta can be compared to their annual flow. In 2023, the Government of Alberta's drought management online site provides a report of the water allocation by basin. This graph confirms the statements of the vast water supply in the Peace River and Slave River basin, and the relatively small level of both consumptive and total allocations of water use (Figure 5).

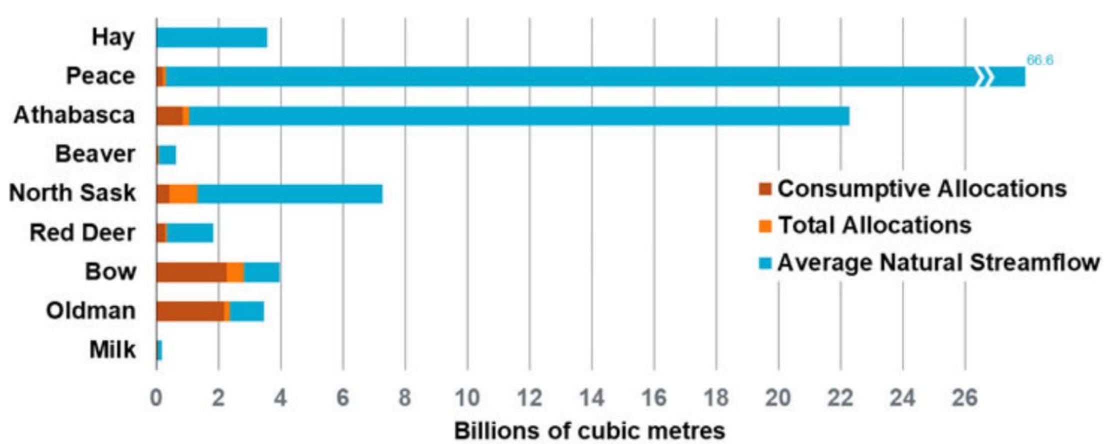


Figure 5. Surface water allocations by river basin compared to average natural streamflow volumes in 2023 (Source: GOA 2024a).

According to the Alberta Water Portal (AWP), *the existing water transfer system currently allows for the re-distribution (trading) of water licences between different water users, under certain conditions. The current system has several public policy protections: a public review of every water transfer, the consideration of hydrological and third-party impacts for each transfer, and the opportunity for the province to hold back 10 per cent of the allocation for environmental in-stream purposes* (Alberta Water Portal 2023).

Water scarcity concerns have led to moratoriums on new water licence applications in the past, such as the South Saskatchewan River watershed in 2006. Although the relatively water abundant Peace River watershed does not have such restrictions, drought conditions and future planning are essential to ensure this does not occur.

2.4 SECTOR ANALYSIS

The Peace River watershed is less populated than other portions of Alberta. However, this does not mean it is less impacted by human development. In 2012 (Watrecon Consulting 2012) reported information from Global Forest Watch Canada (2009), which asserted that *about 57% of the land in the Alberta portion of the Peace watershed has been disturbed as a result of some form of human activity, including agriculture, forestry, oil and gas development, mining, urbanization, or linear developments (roads, transmission lines). The undisturbed portions of the watershed are located in the mountainous areas in the upper portion of the Smoky/Wapiti sub-basin and in the lower portions of the watershed, particularly in the Lower Peace, Wabasca and Slave sub-basins. About 30% of the undisturbed land in the watershed is located in Wood Buffalo National Park, which accounts for 13% of watershed*. Global Forest Watch indicates that these trends of disturbance have continued over time, though updated directly comparable numbers are not available (Global Forest Watch 2024).

The analysis of water use in the Peace River watershed is conducted based upon the AEPA and AWP categories described in Table 1—municipal, commercial, agriculture (crop and livestock), industrial (oil and gas) and management. Forestry was separated from Industrial category for the purpose of this report.[2] This section provides a review of these sectors as a foundation for the analysis in Sections 5-10.

2.4.1 MUNICIPAL AND COMMERCIAL

The Peace River watershed is a place many people call home, with a population of almost 175,000 people across the watershed. A considerable portion of the population live in cities, towns, and small communities thus relying on municipal infrastructure. There are three large population centers in the peace: Grande Prairie, Peace River, and High Level. In addition to these centers there are many smaller communities like Bonanza, Fairview, and Atikameg. Most areas of the Peace River watershed have experienced population growth, growth that is expected to continue. Population changes for urban, rural, and Indigenous populations by sub-basin can be seen in Table 2. To prepare for these growths, municipal bodies have prepared and/or updated their municipal development plans (MDP). In most cases these plans are required by Alberta's *Municipal Government Act*. MDPs are long term planning frameworks that must address the following six areas: (1) Future land uses within the municipality, (2) the nature of and proposals for future development, (3) coordination of land use, future growth and infrastructure development with adjacent municipalities if no MDP for adjacent municipalities exists, (4) the provision of required transportation within the municipality and adjacent municipalities, (5) the provision of municipal facilities and services, and (6) other areas of importance to municipalities (City of Grande Prairie: MDP, 2024). MDPs work to optimize a municipality's existing land base and provide a planning framework for municipal sustainability (Town of Peace River: MDP, 2013).

The MDPs of Grande Prairie, Peace River and High level all outline specific goals and directions each municipality would like to achieve or work towards. The goals and directions are determined in by municipal governments in consultation with residents. While these

[2] Based upon guidance from the MPWA Technical Advisory Committee.

three municipalities are all expecting population growth, how they plan to manage their growth is slightly different.

Grande Prairie's MDP does not report exact figures on expected population growth, only stating that they expect their population to increase and the historical trend for high demand of single-family housing to continue. Data from the Statistics Canada 2021 Census of population ranks Grande Prairie as 9th in the province for population with a population growth of 1.5% between census periods. Grande Prairie's MDP plans to support and nurture this growth by employing "smart growth principles" (read more about smart growth from US EPA, 2013). Highlights of the city's application of these principles include diversified housing, mixed land use, and transportation choice. Managing this growth and implementing these principles takes the form of policies that prioritize development and use of existing infrastructure, development infill in residential and commercial areas, improve public transit and bicycle paths / lanes, and conservation of existing wetlands and natural features.

The MDPs of Peace River and High level are similar to that of Grande Prairie, but with some key differences. Both these towns have much smaller populations; Peace River with a population of 6,619 and High Level with a population of 3,922. The rate of population change is also distinct with Peace River experiencing -3.3% growth between 2016 and 2021, and High Level experiencing 24.2% growth. These population changes were unexpected for both municipalities based on the projections in their MDPs (Town of High Level: MDP, 2018; Town of Peace River: MDP, 2013). Despite differences in population and growth both MDPs identify the need to expand the town's land base to ensure there is space for residential, commercial, and industrial development. Both towns have plans to develop existing municipal land, but emphasis is placed on acquiring new land for future developments. Despite development constraints identified by both municipalities (such as the river valley in Peace River, and the brownstones, landfills, and the lagoon in High level) there is a need to expand to accommodate population growth in a way that support their local economies and citizen's needs.

MDPs for counties and rural areas also inform the current and future land uses of the Peace River Watershed. County and rural MDPs are similar to urban MDPs, but with different goals defined by their unique contexts. A top priority of the rural MDPs scanned was to maintain and support agricultural lands, and other lands with high economic potential (e.g., lands in forestry management units (FMUs)). Rural MDPs emphasize the importance of agriculture and the rural lifestyle but look to ensure that subdivision and housing does not encroach on prime agricultural land. Rural MDPs also emphasize the importance of hamlets and other small population centers, adopting policies that retain these unique rural areas. Additionally, rural MDP establish some policies that determine the locations of confined feeding operations (CFO) and their infrastructure, in accordance with relevant provincial legislation.

In general, the population of the Peace River watershed has trended upwards over the last 20 years. Growth projections present in the MDPs of the region indicate municipalities are expecting and preparing for this growth to continue. This comes with a commensurate increase in water demand for municipal use. However, of the MDPs reviewed, few make mention of water consumption. There are mentions of municipality's current infrastructure and its ability to support population growth up to specific point, but no mention is made of plans should water supplies or availability in the region decrease.

Table 2. Urban, rural, and Indigenous populations in the Peace River watershed and associated sub-basins as reported by the Statistics Canada population census of 2006 and 2021 (Source: Statistics Canada 2006; 2021).

Sub-Basin	Urban Population		Rural Populations		Indigenous Population		Total Population	
	2006	2021	2006	2021	2006	2021	2006	2021
Smoky-Wapiti	53,061	69,449	17,929	35,629	1,407	1,819	72,397	106,897
Upper Peace	7,486	7,262	6,604	6,924	102	111	14,192	14,297
Central Peace	1,853	1,493	3,772	10,678	556	846	6,181	13,017
Lower Peace	3,887	3,992	X*	12,804	3,803	4,601	7,690	21,397
Wabasca	678	5,450	1,747	6,697	4,436	4,099	6,861	16,246
Slave	0	0	0	0	0	0	0	0
TOTAL	66,965	87,646	26,836	62,900	15,944	23,647	107,336	171,854

**X indicates data was suppressed by Statistics Canada*

Despite municipal development plans leaving water and water consumption mostly unaddressed, efforts in the Peace River watershed to increase and secure municipal water supplies have occurred, with more efforts to come. The lack of these efforts in the municipal development plans indicate that they are somewhat impromptu, and that water resources are assumed, only requiring infrastructure to ensure supply. While municipalities in the region are guided by water supply masterplans, they are seemingly not integrated into the MDPs despite being driven by growth needs. There are a number of current and future projects in the Peace River basin that will increase water supplies for municipalities and their residents.

The G5 group of municipalities, made up of Saddle Hills County, Town of Spirit River, M.D. of Spirit River, the Village of Rycroft, and Birch Hills County announced the construction of a new water supply pipeline. Diverting water directly from the Peace River this new supply line is one of six parts in the plan to extend and upgrade the regions' municipal water pipeline network (MPE Engineering Ltd., 2022); construction of this project is currently underway (Government of Alberta, 2024a). In 2017 a 61 km water pipeline was built from the town of Peace River to Dixonville (Government of Alberta, 2019). And in 2030 the City of Grade Prairie's water provider Aquatera is expected to begin construction on a 4th water supply intake from the Wapiti River. Northern Sunrise County (2024), the village of Nampa, and Woodland Cree First Nation have partnered to build a new regional water system, replacing their current water treatment plants. This represents a trend in the region, where municipalities have extended the reach of their waterlines to service new communities, ungraded / added water pipelines, or diversified municipal water sources. Expansion, upgrades, and new water supply sourcing are likely to continue in the Peace Basin as municipalities look for reliable water sources for their growing populations.

Municipal projects like these are supported by the commercial sector. The commercial sector involves activities like construction, transportation, and retention. The entire Peace River basin population and municipalities of each sub-basin rely on these commercial services for their day-today activities, leisure, and work. Promoting economic development in this sector is important (City of Grande Prairie 2023), as it both attracts and supports residential populations. The municipal sector is closely tied to the commercial sector; a sector that provides the goods and services populations need, receiving business revenues in return for their support.

2.4.2 FORESTRY

While categorized and reported within the Industrial sector, the forest industry was separated from that category for the purpose of this report as it is an important and visible industry in the Peace River watershed. Reliant upon the abundant natural resources of Alberta's northern boreal forest, the forest sector covers a range of topographies, such as the Canadian shield, the Rocky Mountains and the foothills and parkland natural regions in the Peace River watershed (CPP Environmental 2015). Within the watershed's natural regions three subregions influence the vegetation, and subsequently what is harvested by the forestry industry. These are the Central mixed wood areas made up of aspen, white spruce; Jack pines are found in areas with coarser soil, and black spruce found around bogs and fens. Dry mixed wood areas contain balsam polar, aspen, and white spruce. Lastly, the Peace River Parkland areas consist of aspen, white spruce, and balsam poplar, with some riparian areas containing black spruce and willows (Alberta Wilderness Association 2023). The size and diversity of the Peace River watershed's forests coupled with waterway access is what drew forestry to the region, and ultimately what sustains it now.

The primary species harvested commercially in Alberta are white and black spruce, lodgepole pine, trembling aspen, and balsam poplar (AFPA, 2011). Each year about 1% of Alberta forests are harvested (AFPA, 2011), with government regulation in place to ensure harvest does not exceed forest growth. Areas for timber harvest, known also as timber stands, are delineated by forest management units (FMU) and designated as areas where timber is be harvested and managed for sustainable yield. Forestry companies make Forest management agreements (FMA) with the province, giving them the right to harvest, these agreements are seen in Figure 6. Timber can be harvested with a number of methods in FMUs, but clear-cutting is the most common in the Upper peace and Lower Peace; 98% of harvest in the lower and upper Peace regions was done by clearcutting in 2014/15 (Alberta Agriculture and Forestry 2017). Once timber is harvested it is de-limbed and transported to Alberta's sawmill, panel board mills, and pulp mills for processing (AFPA, 2011).

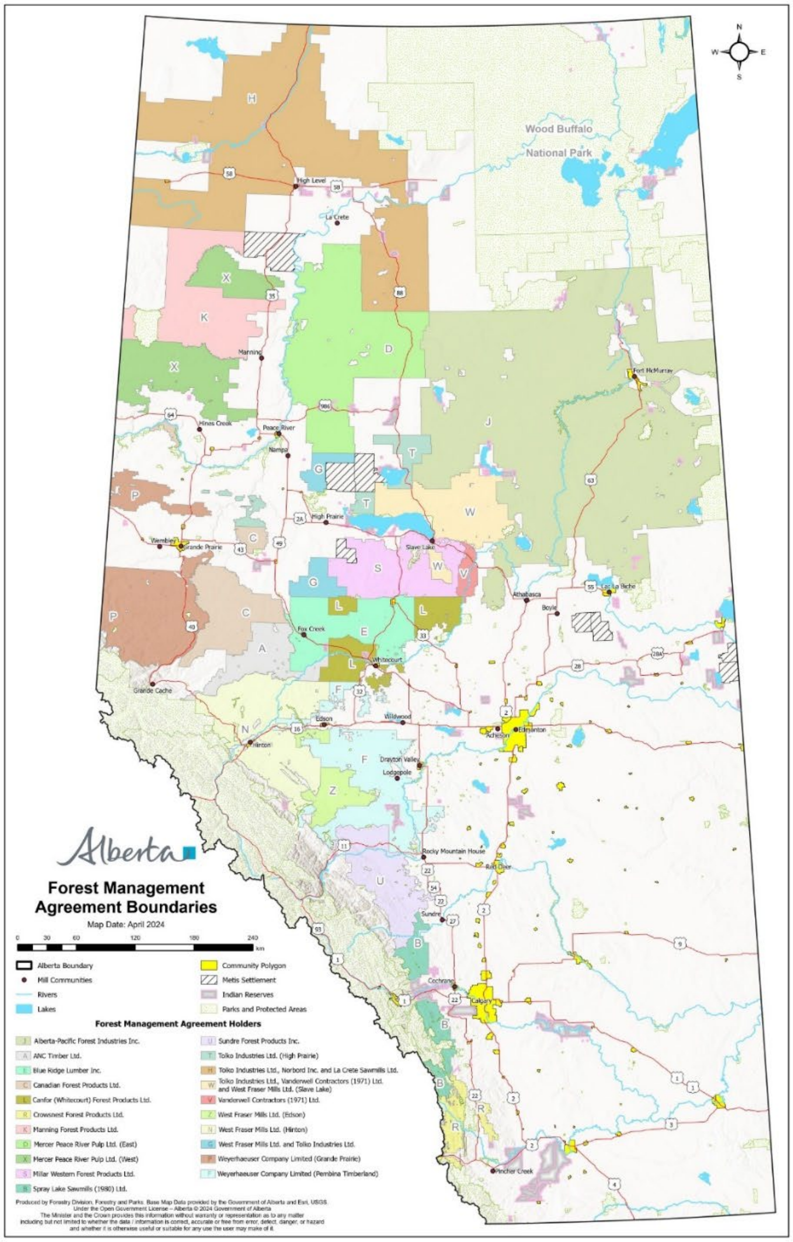


Figure 6. Forest management agreement boundaries (Source: GOA 2024).

One of the first forestry processing operations was a pulp mill built by Daishowa-Marubeni International (acquired by Mercer International Inc. in 2018), which is still in operation today. Since then, the industry has expanded with the Alberta Forest Products Association (AFPA) maintaining estimates on the number of forestry operations across the Peace Watershed. According to AFPA (2024) there are ten sawmills, two panel board operations, and two pulp and paper mills. The sub-basin these operations are located, the company that owns / operates them, the type of operation, and the closest population center can be seen in Table 3. The forestry sector in the Peace River region has remain relatively stable in the last decade, with no new operations commencing (AFPA, 2011; 2024); instead, changes have come in the form of acquisition and sale of some operations.

Table 3. Forestry processing operation data for the Peace River watershed (Source: AFPA 2024).

Sub-Basin	Company	Operation Type	Closest population center
Smoky-Wapiti	Canfor	Sawmill	Fox Creek
	Canfor	Sawmill	Grande Prairie
	Foothills Forest Products	Sawmill	Grande Cache
	Weyerhaeuser Company Limited	Sawmill	Grande Prairie
	West Fraser	Panel Board	Grande Prairie
	International Paper	Pulp Mill (Kraft)	Grande Prairie
Upper Peace	Zavisha Sawmills Ltd.	Sawmill	Hines Creek
Central Peace	Boucher Bros. Lumber Inc.	Sawmill	Nampa
	Manning Forest Products Inc.	Sawmill	Manning
	Mercer International	Pulp Mill (Kraft)	Peace River
Lower Peace	Tolko Industries	Sawmill	High Level
	West Fraser	Panel Board	High Level
Wabasca	La Crete Sawmills Ltd.	Sawmill	La Crete
Slave	-	-	-

Pulp mills are the major water users of the forestry industry. Pulp mills are regulated both federally and provincially and are required to monitor waterbodies that receive mill discharge (AFPA, 2011). Water use in the forestry industry has been declining since the 1980s (Natural Resources Canada 2009) with the forestry industry in the Peace River region investing in upgrades to their infrastructure to decrease their water consumption and ensure the water they discharge is safe for receiving water bodies (AFPA, 2011).

Management of the forestry sector in the watershed falls under the Alberta's Land Use Framework (LUF), a policy that governs the land use of the province. Two regions corresponding with the Peace River Watershed are identified in Alberta's LUF: the Upper Peace Region and the Lower Peace region.

2.4.3 AGRICULTURE

There is a long history of agriculture in the Peace River watershed. Land was opened for homesteading in 1910, and primarily European settlers arrived in the watershed on foot, by ox or horse, or on wagons or sleighs. When a railroad was built in 1916 the journey to the area became easier and settlers interested in homesteading flocked to the region and began farming. At the time local markets heavily influenced the type of farming practiced, with distance to markets playing a major role. Grain and livestock were the primary goods grown and sold during this time, with homesteaders with quality soil choosing grain, and those with lower quality soil choosing to retain pasture and produce livestock.

The agricultural history in the Peace River watershed has remained relatively consistent in 2024. Cattle (Table 4) and field crops still lead the regions agricultural production, making up over half of the region's farms (Statistics Canada 2022). But the sector profile has changed, and in addition to cattle horses, pigs, sheep, goats, elk, and bison also contribute to livestock production in the region. Poultry are also grown in the Peace, and like all other livestock are primarily raised in the Upper-Peace and Smoky/Wapiti watershed sub basins (Statistics Canada, 2022). Similarly, the crop sector of the Peace is diversified with canola and wheat being the two main commodities, and others like barley, oats and field peas also contributing to the sector profile (Statistics Canada, 2022).

Table 4. Cattle inventories for the Peace's sub-basin for 2011 and 2021 (Source: Agriculture Census 2011 and 2021).

Sub-Basin	Number Cattle farms		Cattle Inventory	
	2011	2021	2011	2021
Smoky-Wapiti	912	915	137,931	143,680
Upper Peace	529	550	67,404	88,581
Central Peace	187	178	23,127	26,985

Lower Peace	247	303	16,701	21,613
Wabasca	69	59	10,344	9,479
Slave	0	0	0	0
TOTAL	1,944	2,004	255,507	290,338

The farms and farmers in the Peace River watershed contribute greatly to the agricultural sector of Alberta. Revenues from Alberta farms accounted for over a quarter of Canada's agriculture revenue in 2020 (St Pierre and McComb 2023). The Peace River Watershed contains approximately 11.2% of Alberta's farms and generated ~1.3 billion in farm operating revenues in 2021 (Table 5), most farms (57%) in the region had operating revenues below $99,999 (Statistics Canada, 2022). Interestingly a small portion of farms in the region (6.3%) reported earning revenues from direct-to-consumer sales up over 4 percent from the previous census (Statistics Canada, 2017; 2022). This increase in direct-to-consumer sales for farms in the Peace River watershed follows a less intense, but similar trend to that of the rest of Canada following the COVID-19 pandemic (St. Pierre, 2023).

Table 5. Farm operating revenues of the Peace sub-basin's farms (Source: Statistics Canada 2022)

Sub-Basin	Number of Farms Reporting	Farm Operating Revenues (2021
Smoky-Wapiti	1,614	$663,390,695
Upper Peace	992	$345,574,176
Central Peace	866	$189,311,686
Lower Peace	470	$94,777,015
Wabasca	282	$60,638,676
Slave	0	$0
TOTAL	4,224	$1,353,692,247

The soil of the Peace region remains well suited to agriculture, has remained relatively unchanged since soil surveys were conducted from 1952 to 1983 (Alberta Agriculture and Forestry 2016). The region's soils are classified into the following groups: brunisols, dark grey / gray luvisols, dark grey chernozemics, and organics / organic cryosols (Agriculture and Agri-food Canada 2015). In the Peace agriculture is practiced almost exclusively in areas with dark grey chemozemics or dark gray / gray luvisols as these soils are highly productive

(Alberta Biodiversity Monitoring Institute n.d.). Dark grey chemozemics are known for occurring under regions with mixed trees, shrubs, and grasses on forest-grassland transition zones with cooler climates (Soil Classification Working Group 1998). Dark gray / gray luvisols are known for slight to moderate acidity, occurring under mixed forest vegetation in forest-grassland transition zones in a wide range of climate conditions. These soil types are found in the Smoky/Wapiti, Upper, Central, and Lower Peace River sub-basins (Agriculture and Agri-food Canada 2015; Alberta Biodiversity Monitoring Institute n.d.), aligning with the general areas where agriculture is practiced in the greater watershed. Agriculture is a dominant industry in the Smoky/Wapiti and Upper Peace sub-basins, defining the land-use and activity. Data from Canada's agricultural census shows the distribution of total number of farms reporting land in crops, cropped acreage, tame pasture, and improved pasture; values are approximate as census divisions do not align perfectly with watershed boundaries.

Table 6. Agriculture data on farm number, cropped and forage area (Source: Agriculture Census 2011 and 2021).

Sub-Basin	Number farms with land in crops		Cropped Acres		Tame Pasture		Native Pasture	
	2011	**2021**	**2011**	**2021**	**2011**	**2021**	**2011**	**2021**
Smoky-Wapiti	2,159	1,709	1,714,860	1,710,893	297,177	253,458	565,900	390,265
Upper Peace	1,260	1,110	1,041,719	1,099,710	192,099	150,307	315,655	264,334
Central Peace	489	396	436,365	447,221	79,355	70,693	109,392	69,788
Lower Peace	580	753	323,593	491,411	34,920	34,529	67,811	55,193
Wabasca	151	122	106,084	131,050	24,630	20,307	31,925	19,469
Slave	0	0	0	0	0	0	0	0
TOTAL	4,639	4,063	3,622,621	3,880,275	628,181	529,294	1,090,683	799,049

2.4.4 INDUSTRIAL

The industrial sector of the watershed and its associated sub-basins is dominated by the oil and gas industries. The Peace River oil sands contain deep deposits of bitumen and are the smallest of Alberta's major oil and gas resource formations (GOA 2013). Despite their small size they contain an estimated 24% of Alberta's total oil and gas resources (Sprague 2012). Oil and gas reservoirs are in part influenced by geography; cretaceous bedrock serves as the foundation of the Peace River region with layers above consisting of shales, siltstones, sandstones and thin bentonite and coal veins (Leslie and Fenten 2001). The Peace River oil sands are much deeper than Alberta's other oil sands, making them unsuitable for open-pit mining. Because bitumen is located at such depths "unconventional" recovery methods are used. These methods are done *in situ* (in place) (primarily through steam-assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS). To extract bitumen using SAGD, two horizontal wells are drilled parallel to each other, where one well lies near the top of the reservoir and the other near the bottom. Steam is injected into the well at the top of the reservoir melting the bitumen, which then flows into the lower well and is extracted using a pump (GOA 2013). For CSS directional wells are drilled into bitumen reservoirs, then steam is injected and left to "soak" in the revisor melting the bitumen. After enough time has elapsed wells are turned on and the bitumen is brought to the surface (GOA 2013). Natural gas is also found in the peace river oil sands (Saha and Quinn 2020) and is extracted using hydraulic fracturing.[3]

The Peace River sub watershed has a long history of unconventional oil and gas extraction. According to Alberta Culture and Tourism (n.d.) Shell began experimental oil and gas production in 1977 using steam injection producing 3,500 barrels of bitumen a day. That same Shell plant produced 1,000,000 barrels of bitumen in 1983, operating close to the approved production capacity. In the years following the Peace River Expansion project was approved and production capacity was increased to 10,500 barrels per day. This was only

[3] This process and its implications for the Peace River watershed are discussed in the "Current and Future Issues" section of this report.

the start of oil and gas extraction in the Peace with provincial regulators increasing the number of barrels unconventional production methods could produce.

Since then, the Peace Basin and associated sub-basin have experienced significant oil and gas activity, with it becoming a cornerstone of the region's economy. There are countless companies engaged in in situ bitumen extraction and even a greater number of businesses providing support to the sector in the Peace Basin. A history of inter-provincial workers (Ferguson 2011) makes it difficult to determine the exact number of people the peace oil sands employ. The City of Grande Prairie (2022) estimates that ~13,000 people living year-round in the region working directly in the local oil and gas sector. The Peace River oil sands are an important contributor to Alberta's GDP, helping the oil sands make up ~21% of Alberta's GDP (Statistics Canada 2022). It is likely oil and gas will continue to be a strong economic force in the peace region, with an estimated 1.6 trillion barrels of bitumen under the region (Peace Region Economic Development Alliance 2012; Sprague 2012). While only 18.6 billion barrels are currently recoverable, technological advancement in unconventional methods will likely see this number increase, and so too the Peace's contribution to Albertan oil and gas production.

However, oil and gas activity is not the only Industrial activity in the basin. A small portion of the sector is made up of mineral and metal mining and power generation. Mines, which primarily extract coal are found in the Smoky/Wapiti and Central Peace sub-basin. The coal mined is used primarily for power generation or may be exported and used to produce metallurgic coke (Alberta Geological Survey 2020). There is currently a single operating power plant in the Smoky/Wapiti sub-basin, located near Grande Cache that is capable of burning both coal and natural gas (Maxim Power Corp. 2024). In addition to this there are currently three more power projects listed on the Alberta major projects website. A geothermal plant in the municipality of Greenview, a natural gas plant near Fox Creek and solar plant near the town of Peace River. These three power projects are commencing in 2024, or to be completed by the end of 2024. The likelihood this represents a future trend of power generation in the Peace basin is uncertain. Despite being dominated by oil and gas the industrial sector of the peace is somewhat diverse, although this diversity is still very much revolving around fossil fuels.

2.5 CURRENT AND FUTURE ISSUES

A number of issues have been identified[4] that will impact water flow and use in the Peace River watershed and the associated sub-basins into the future. These include climate change, drought, flow variability and both positive and negative impacts to agriculture in the region. Additionally, Transboundary water agreements, and the Site C dam in British Columbia were also identified.

2.5.1 CLIMATE CHANGE

Extreme weather events are expected to increase due to climate change. This includes the drought scenario that Alberta is currently facing for 2024 (CBC, 2024). And it also includes increased forest fire activity (Tymstra et al., 2007; Whitman et al., 2022) which is particularly risky for biodiversity and infrastructure in the Peace River watershed. It comes at the cost of drying out of wetland and muskeg environments (Stirling et al., 2020), demand on surface water for firefighting activity, and the loss of terrestrial and aquatic biodiversity (Bond et al., 2008; Häder & Barnes, 2019). Models indicate that the world has surpassed the 1.5-degree boundary (McCulloch et al., 2024) and that this has, and will continue to lead to increased weather and climate volatility (NASA, 2021; Repetto & Easton, 2010). Climate change has affected the conditions and resources bases of sectors the Peace relies on like agriculture (Mapfumo et al., 2023; Masud et al., 2018) and forestry (Chhin et al., 2008).

While often unmentioned there are social outcomes of climate change. Communities' dependant on primary sectors like agriculture or forestry are uniquely sensitive to these changes (Lemmen et al., 2008) with many already feeling the effects (Davidson et al., 2003; Fletcher et al., 2021). Direct health outcomes like increases in heatwave-related deaths and

[4] Issues were identified in consultation with the MPWA technical advisory committee, AEPA officials and a scan of the literature.

expansion of infectious diseases may also be a new reality (Ford, 2009). Not to mention the effects on food-security and culture of Indigenous communities (Downing & Cuerrier, 2011).

There is also great potential for the economies of the watershed to be affected by climate change. Soil erosion serves as a major threat to agricultural areas, with drought and severe weather-stripping topsoil layers leaving agricultural fields unable to produce crops (Monasterolo, 2020). Biodiversity and species loss, especially of pollinators, can have similar outcomes (Pérez-Méndez et al., 2020). On a broader scale policy and regulation shocks in-response to climate change can slow down economies, decrease business' production, and turn investors away (Monasterolo, 2020). The economy of the Peace Basin is supported by a number of sectors, but climate change has the potential to impact them all producing undesirable outcomes for the region.

Although such climate scenarios are typically viewed with a negative lens, trade-offs will occur. Some models indicate an expansion of the prairie ecozone northwards due to the warmer conditions, and the expansion of viable agricultural land in Alberta (Schneider et al., 2009). And this may come as a benefit to cropped agriculture sector through increased yields and conversion of natural landscapes (Amir, Rawluk, and Wittenberg 2014) or to the livestock sector through increases in rangeland area (Thorpe, 2011). Any comment on this must be caveated on the uncertainty of such predictions, rather than asserting a coming golden age of agricultural expansion in the Peace Basins. It is likely that the costs of climate change and concurrent transformations in ecological, social and economic processes will far outweigh any associated benefits (Loxley, 2022; Sauchyn & Kulshershtha, 2008).

2.5.2 TRANSBOUNDARY AGREEMENTS

As a transboundary waterway, the Peace River also faces water demands from British Columbia and the Northwest Territories (Figure 7). The Mackenzie River Basin Transboundary Waters Master Agreement (GOA 1997) is a joint-governmental effort on the part of Alberta, British Columbia, the Northwest Territories, Yukon, and Saskatchewan that aims to establish shared cooperative management principles, an administrative body to apply these principles, the Mackenzie River Basin Board (MRBB), and a framework for Bilateral Water Management Agreements. This agreement came into effect on July 24th, 1997, outlining the following five principles.

Figure 7. The Mackenzie Basin (Source: Rosenberg International Forum on Water Policy 2013)

1. Managing water resources in a manner consistent with the maintenance of the ecological integrity of the aquatic ecosystem,
2. managing the use of the water resources in a sustainable manner for present and future generations,
3. the right of each to use or manage the use of the water resources within its jurisdiction provided such use does not unreasonably harm the ecological integrity of the aquatic ecosystem in any other jurisdiction,
4. providing for early and effective consultation, notification and sharing o information on development and activities that might affect the ecological integrity of the aquatic ecosystems in any other jurisdiction, and
5. resolving issues in a cooperative and harmonious manner.

For each boundary the Mackenzie River Basin crosses agreements must be negotiated between provinces. Pursuant to the Master Agreement Alberta is required to negotiate three Bilateral Water Management Agreements with the provinces of B.C. and Saskatchewan, and the Northwest Territories. Currently Alberta has only negotiated one bilateral agreement, ratifying its agreement with the Northwest Territories in 2015. So far only the territories have fulfilled their portion of the agreement outlined by the master plan. The Northwest Territories have established Bilateral Water Management Agreements with Yukon, B.C. and Alberta (Government of Northwest Territories, n.d.), and the Yukon with B.C. (Government of B.C., 2022). The Yukon-B.C. agreement was completed in 2016 and is the most recent.

Alberta has yet to complete two out of its three required Bilateral Water Management Agreements with negotiations with B.C. seemingly stalled and those with Saskatchewan nearly non-existent, or at the very least not made public. For the Peace Basin the Alberta-B.C. agreement is very important given the Alberta side of the region's water flow comes from the B.C side of the basin. Just after Alberta's 2015 agricultural disaster (Alberta Water Portal Society, 2024) it was expected that the Alberta-B.C. agreement would reach completion sometime in 2016 (CBC News, 2015; CTV News, 2015), with B.C.'s Environmental Minister at the time stating the agreement was in the works. Since then, no updates to the Agreement have been made by either province. The sate of the agreement is described by the Government of Alberta as "in development" (Government of Alberta, 2024) and by the B.C. government as "not yet completed" (Government of B.C., 2022). In 2021 the MRBB published a comprehensive study on the Basin titled *State of the Aquatic Ecosystem Report*. This study reported on the current water quantity, quality, habitat and species, and health and wellbeing of each watershed in the Mackenzie Basin. However, no mention of bilateral water agreements are made in the report. The Bilateral Water Management agreement between Alberta and B.C. required under the master agreement has seemingly stalled, with no indication of when negotiating may reopen, or if it will be completed. A similar situation exists for the Alberta-Saskatchewan agreement, with Alberta stating it is "in development" (Government of Alberta, 2024), and Saskatchewan's water management agency providing no update on negotiations (Water Security Agency, 2021).

2.5.3 HYDRAULIC FRACTURING

Hydraulic fracturing or "fracking," is an unconventional oil and gas extraction method that utilizes mixtures of sand, water, and chemical additives, also known as slickwater, to access and release natural gas that would otherwise remain trapped. As slickwater is injected deep into the earth using drilled wells it pressurizes, fracturing rock formations. These fractures release natural gas, which is pumped out from underground and harvested at the well's surface (Alberta Energy Regulator 2023). Hydraulic fracking is commonly combined with horizontal drilling (Zoback and Kohli 2019), which allows for a larger area under the earth to be fractured, and greater natural gas release and extraction (Gagnon et al. 2016). According to Chevron (n.d.), a global oil and gas company that holds a total water allocation volume of 3534.2 dam^3 for fracking in the Peace River Watershed, it can take three to ten days to frack on a drilled and prepared well. Once the fracking process is complete, a well may produce natural gas for many decades. Fracking has been used in Alberta since the 1950s; the Alberta Energy Regulator (AER) develops and enforces regulatory requirements for fracking, like all other oil and gas operations in the province (AER 2023). One such regulation requires that no liquid used in fracking, irrespective of whether it contains chemical additives, is allowed to enter natural water bodies. Additionally, the chemical additives used in slickwater must be reported, and are held on the open database fracfocus.ca hosted by the B.C. Energy Regulator (2024).

There are risks associated with fracking. Seismic activity in the peace river watershed (Earthquakes Canada 2024) has once again created concern around fracking in the region. In Fox Creek (the site of recent activity and public interest (Snowdon 2024)) the AER has installed a "traffic light" system that dictates how operations in the region must respond to seismic activity. Under this system seismic activity below 2.0 M_L (local magnitude) requires no action, activity equal to or greater than 2 M_L must be reported to the AER and a response plan initiated, and activity greater than or equal to 4 M_L must be reported to the AER and all company operations stopped. In the case of seismic activity above 4 M_L operations cannot resume until approval from the AER is granted (AER 2020). Despite the threat of fracking induced seismic activity, instances typically report small local magnitude and are rarely felt by people (Jackson et al. 2014).

Seismic activity is not the only environmental risk of hydraulic fracturing. Contamination of surface and ground water is still a possibility with regulation from the AER. The location of rock fractures created during fracking is decided and executed through a number of methods (Zoback and Kohli 2019), however unplanned fractures can still occur. While highly unlikely because of the depth, target, and cement barriers used in fracking, unplanned fractures could create access-ways between shallow groundwater sources with fracking wells, contaminating the water (Entrekin et al. 2011; Jackson et al. 2014). Alternatively, planned fractures may connect natural pathways, facilitating uncontrolled upward movement of contaminated water to the surface (Myers 2012).

Additionally, there are other concerns regarding fracking and water. The process of fracking, especially when used together with horizontal drilling, requires large volumes of water. In the Peace River Watershed 39,773.5 dam^3 of water is allocated for fracking. Water needs can vary greatly, but an estimated 8 - 80 dam^3 is required for extraction per well, with additional water needs for drilling the well and mining sand used in the slickwater (Jackson et al. 2014). While a relatively small allocation of water, it can no longer be allocated which may produce effects on other industries in the region (Hitaj et al. 2020). Despite this water need, hydraulic fracturing has one of the lowest water use intensities of most other fossil fuel extraction methods (Jackson et al. 2014).

As mentioned, the AER is responsible for regulating fracking In Alberta. The AER's current regulatory requirements for all fracking in Alberta are available from their website (AER 2023). These requirements are informed by a framework released in 2012 by the Energy Resources Conservation Board (their previous name). This framework outlines three goals: (1) Clearly identify and mitigate potential risks to public safety, the environment, and the resource, (2) ensure orderly development, and (3) avoid imposing unnecessary regulatory burden on industry. This manifests itself through a performance-based regulatory system where the challenges associated with unconventional extraction are solved by industry plans that meet regulatory directives. The AER (2023) states it conducts regular inspections and audits on fracking operations to ensure directives are met. Inspections involve a physical examination of well-pads and field operations, whereas an audit is review of a companies' paperwork, reports, and records (AER 2024). Companies may also submit voluntary disclosures of non-compliance. The AER expects self-identified non-compliance to be corrected, or operations terminated if needed. The AER has mechanisms in place to enforce directives and address non-compliance; these include notices, administrative sanctions, fees, and legal prosecution among other things (AER 2020). These and other regulations on fracking are in place to ensure that the people and environments in areas like the Peace River Watershed are protected, while ensuring oil and gas development persists.

In the Peace River watershed, there are two primary geological formations where fracking for natural gas occurs (Figure 8). The first is the Duvernay Shale Prospective Area located southeast of Grand Prairie, on the edge of the Smoky / Wapiti River sub-basin (AER 2014; Saha and Quinn 2020). This formation underlies Fox Creek, the site of recent seismic activity. The second formation is the Montney Tight Sandstone / Shale Prospective Area. This formation overlaps the Duvernay formation, while also underlying the City of Grand Prairie, extending northward past the Alberta border into B.C. The Montney formation reaches into the Central and Upper Peace River sub-basins and occupies most of the Smoky / Wapiti River sub-basin (AER 2014; Saha and Quinn 2020). Although these two formations underlie three sub-river basins in the Peace Watershed, no water allocations from fracking exist in the Central Peace sub-river basin. However, there is a small allocation of water for fracking in the Wabasca sub-river basin. Ultimately this means that three sub-basins of the Peace River Watershed have active fracking operations, the industry profile and water allocations vary greatly by sub-basin, these differences are discussed further in the report.

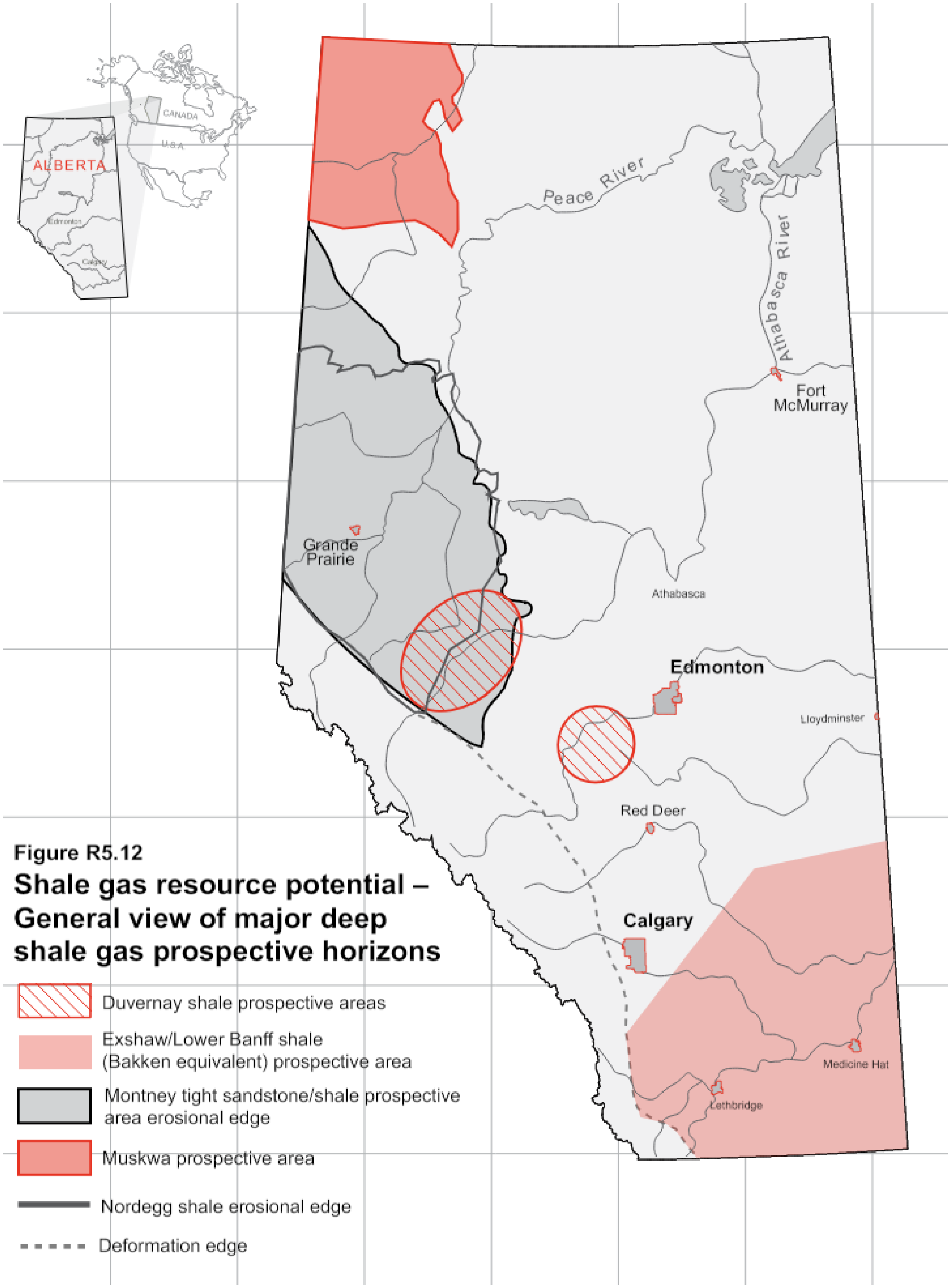
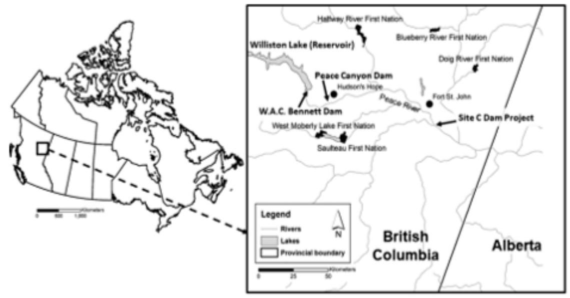


Figure 8. Alberta's potential shale gas resource areas (Source: AER 2014)

2.5.4 HYDROELECTRICITY

A current transboundary water issue between Alberta and British Columbia that has raised environmental concerns is the construction of the Site C Hydroelectric Dam in the Upper Peace River sub-basin in British Columbia. While acknowledging opposition from environmental and Indigenous organizations, approval was granted by the federal government in 2014. Construction began a year later and is expected to be completed by 2025. With an estimated cost of construction of $CAD 16 billion, Site C is the largest and one of the most expensive infrastructure projects in British Columbia history. When completed, Site C will be the third major dam[5][6] on the Peace River and is a major pillar of the British Columbia government's clean energy plan, as it is expected to produce *clean, reliable and affordable* power for 450,000 homes while generating about 5,100 gigawatt hours of energy each year (B.C. Hydro 2018).



Derived from Dubrule (2018), p. 4

Figure 9. Location of Site C dam in the Upper Peace River sub-basin in British Columbia.

Despite the energy benefits to society, Site C provides environmental uncertainty to many downstream water and land users. Holm et al. (2018) describes how the natural control of flow in the Peace River upstream of Alberta has historically been a concern from stakeholder groups. As such, there has been ongoing debate regarding Site C and its impending environmental impact on the surrounding ecosystem. For example, construction of the dam will result in the submersion of around 4,500 hectares of Class 1 farmland, including First Nations' territory and other wildlife habitat. Due to the poor consultation and lasting effects from past hydroelectric projects on the Peace River—from British Columbia to the Peace-

[5] The two other dams are the W.A.C Bennett Dam (1968) and the Peace Canyon Dam (1980).

[6] Consistent flows have made the Peace River basin attractive for hydroelectric power. In 2006 the Dunvegan hydroelectric project was proposed. However, in 2015 this project was cancelled by TransAlta due to significant stakeholder opposition, challenging economic returns and environmental concerns (AWA 2016).

Athabasca Delta (PAD)—many groups have contested the Site C project (Dusyk, 2011; Dubrule, 2018; Follett, 2019).

In particular, many Indigenous groups are in opposition to the construction of any dams on the Peace River due to the spiritual, cultural and environmental reasons. There is also an Indigenous prophecy that one day a major dam on the Peace River will fail (personal communication, 2024). This opposition permeates discussions and raises the importance of braiding TEK and Western Knowledge together, as expressed in concepts such as environmental flows and Indigenous Treaty Rights.

Recent published academic material relating to Site C remains brief and is focuses on the socioeconomic costs of the project at a macro level. While the WAC Bennett dam has been blamed for lowered water levels in the PAD and for altered critical wetland habitats, BC Hydro suggests the construction and operation of Site C will provide new and expanded recreation and tourism opportunities for residents of the Peace region moving forward (BC Hydro 2018). The projects' *Joint Review Panel* also confirms that Site C will lock in low electricity rates for many decades, while producing fewer greenhouse gas emissions per unit of energy than any source other than nuclear (BC Hydro 2018). Nevertheless, the current status of the Site C dam project is contentious, with varied agreement surrounding its economic viability, future environmental impact, and consideration to Indigenous rights.

2.5.5 LITHIUM MINING

Lithium (Li on the periodic table) is a soft, silvery-white alkali metal and is the least dense of all solid elements in its pure form (Royal Society of Chemistry, 2024). Lithium is primarily used in to produce lithium-ion batteries (Scrosati, 2011), but also has medical applications (Oruch et al., 2014). Demand for lithium has grown substantially in the last 20 years (Scrosati, 2011), and with the advent of electric vehicles or EVs that demand is expected rise considerably (Flexer et al., 2018; Kaunda, 2020). The Government of Canada (2023) identifies lithium as a critical mineral "essential for the sustainable economic success of Canada and its trading partners." Lithium is the 25th most abundant element in the earths crust (Taylor & McLennan, 1985) and found in two forms: hard rock and brines. The extraction methods for each of these forms are very different (Habashi, 1997), the following paragraph will focus on the methods of mining brines, as this is the form Alberta's lithium takes (Natural Resources Canada, 2022).

Figure 10. Alberta's lithium resources (Source: University of Alberta)

The extent of Alberta's lithium brine can be seen in Figure 10; much of the province' lithium is located under the Peace Basin. Flexer et al. (2018) outlines the most common method of lithium brine mining, the likely method that would be used in the Peace. First a well is drilled deep into the surface reaching the lithium brine, it is then pumped out from the ground using a well. The brine is then pumped into large, shallow, open-air pits where solar and wind evaporation passively remove water from the brine, increasing the concentration of lithium. The concentrated brine is then recovered and moved to another open-air pit to undergo the same process where contaminants are removed and other ions (e.g., sodium, potassium) may be harvested, this may be done several times. Once the brine is considered acceptable it is pumped to a recovery plant where it is processed, and non-target chemical species are removed; until the lithium reaches the desired purity. This entire process can take between twelve to twenty-four months. The mining and solar/wind evaporation of lithium brine is considered low impact when compared to mining and processing other metals (e.g., silver, lead) (Flexer et al., 2018).

Currently there is a small lithium mining sector in Alberta, with one pilot projected completed, and full-scale extraction and processing to start soon south of Edmonton. Lithium mining is regulated by the Alberta Energy regulator (AER) under the *Mineral Resource Development Act*, and by 2030 there will be an expected ~24 wells mining lithium brine in the province (AER, 2023). The first lithium brine extractions in the province will be in the peace region (Figure 11). NeoLithica Ltd. is slated to start lithium brine extraction in 2024 (AER, 2023; Government of Alberta, 2024), less than fifty kilometers north-east of Grande Prairie (NeoLithica, 2024). According to the Alberta major projects website the lithium mine is a pilot project and is considered in the "advanced stage" by Natural Resources Canada (2022).

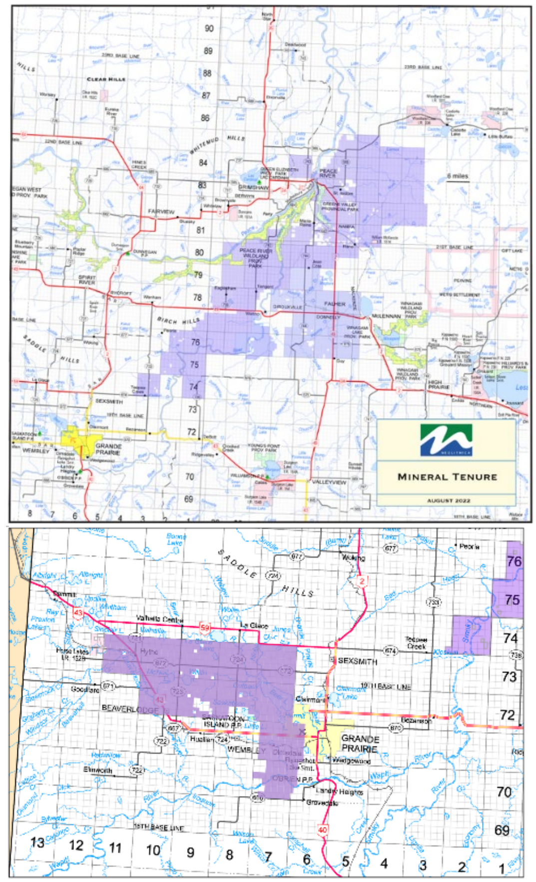


Figure 11. Lithium mining rights owned by NeoLithica (Source: NeoLithica 2024)

According to NeoLithica (2024) the first stage of the project was completed in early 2023, with NeoLithica finalizing a series of National Instrument (NI) reports. The second stage of the project, the pilot project, will involve drilling two wells to perform evaluations of the lithium reservoirs, determine their productivity, and the infrastructure needed for further mining. The brine that NeoLithica extracts from the pilot program will be fully refined into battery-grade lithium. After NeoLithica plans to commission a preliminary Economic Assessment to determine the feasibility of continuing lithium mining in their 609,853-hectare mining area. If they determine the project to be successful, they will make a final decision on lithium mining in the project pilot area. Additionally, NeoLithica has acquired lithium mining rights to 97,952 hectares of land immediately west of Grande Prairie. A geological study of this area is underway now, with expectations that lithium mining will be viable.

A second company poised to operate in a similar area is LithiumBank Resources Corp. A Vancouver based company that holds lithium mining rights across the prairies. In a recent presentation to shareholders, LithiumBank described the acquisition of Lithium brine permits for 732,870 hectares on two sites south-east of Grande Prairie. The first directly beside the town of Valley View and the other extending from Fox Creek down to Edson, then west to Hinton (Figures 12 and 13) (LithiumBank, 2024). LithiumBank believes Alberta is a "resource friendly jurisdiction" that is "quick to permit," indicating they will likely pursue lithium mining in the province.

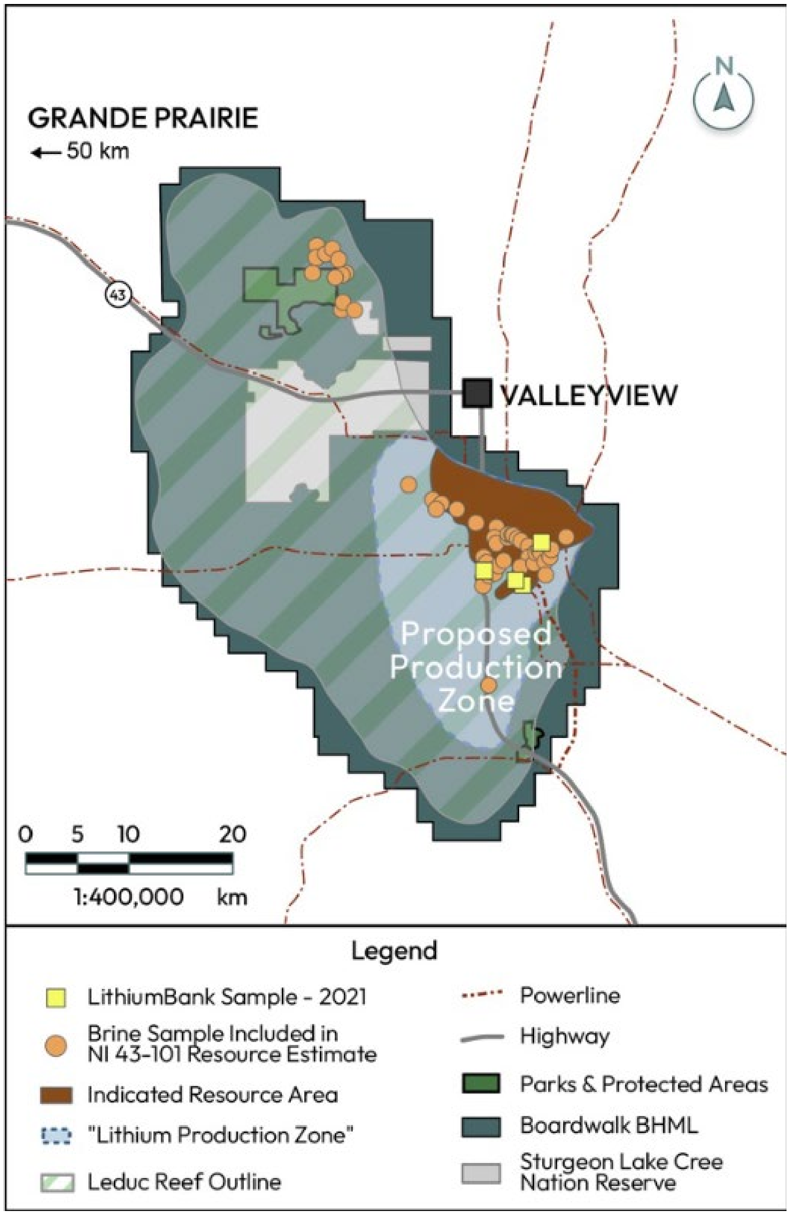


Figure 12. LithiumBank Mining rights south of Valleyview (2024)

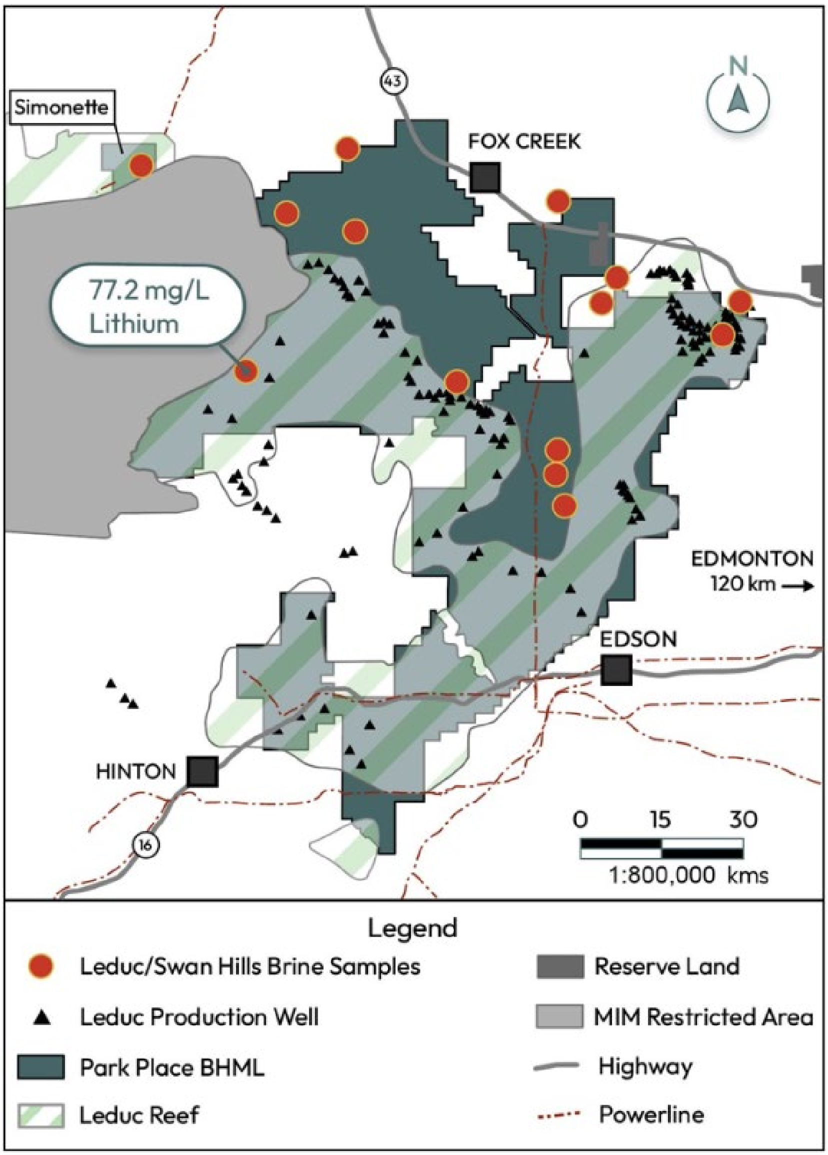


Figure 13. LithiumBank mining rights near Fox Creek (2024)

There is another area, partially within the Peace River watershed, containing lithium and other critical minerals known as the SBH Black Shale Project. Mining rights of this 850 km2 area was recently acquired by Critical Minerals Americas who are reviewing previous studies and NI reports (Mining Technology, 2023). The project is designated as being "on hold at the advanced stage" by Natural resources Canada (2022) indicating that mining of lithium or any other mineral will not occur in the near future. If mining of lithium or any other materials does occur, Critical Minerals Americas (2023) has stated it will be done using "open pit rip-mining" because the critical minerals are in their solid forms. The likelihood this project will continue is uncertain given its “on hold” status.

The impacts of lithium brine mining will be covered here because this type of mining will be underway soon in the Basin. Lithium brine mining has both positive and negative impacts on both the environment and socio-economic conditions (Chaves et al., 2021), however these effects may be understudied (Liu et al., 2019). Socio-economic effects are primarily beneficial, while the environmental effects are primarily negative (Chaves et al., 2021). Vera et al. (2023) provides a full overview of the environmental impacts of lithium mining from the process of drilling a well to refining the lithium.

Regarding water, the depletion of ground water stores and its associated effects are one of the biggest concerns (Chaves et al., 2021; Flexer et al., 2018; Kaunda, 2020). Lithium brine water is unsuitable for human consumption or agriculture given its high salinity, but nonetheless contributes to local hydraulic relationships (Liu et al., 2019). As mentioned, lithium brine is found in ground water stores, mining this lithium brine depletes these aquifers (Kaunda, 2020) potentially lowering natural water tables. And because this water is pumped into open air pits for evaporation, in most cases it is completely removed from its hydrological system. Wind / solar evaporation can require additional freshwater, ranging from 5 m3 to 50 m3 per ton of battery grade lithium (Flexer et al., 2018; Vera et al., 2023). Water contamination is also a potential outcome of lithium brine mining and can happen in two ways. The first and most obvious is by leakage of the open-air pits where the brine evaporates. These pits are typically PVC lined and could fail, releasing the brine and its contaminants in the environment (Wanger, 2011). Secondly, with the removal of water from groundwater aquifers, water may move through underground channels to occupy this space. This underground movement represents the potential for underground fresh water to be contaminated and the dilution of lithium brines, requiring more mining and evaporation (Flexer et al., 2018). Groundwater depletion and contamination has effects on vegetation (Maitre et al., 1999), agriculture (Tian et al., 2015) and many ecosystem goods and services (Brauman et al., 2007).

As indicated the environmental impacts of lithium brine mining are understudied (Liu et al., 2019), and the vast majority of research focused on south America where this industry has developed (Chaves et al., 2021). There are a great number of uncertainties surrounding lithium brine mining in the Peace. The viability and economic effects on the region are yet to be seen, and the environmental impacts of brine mining in regions like Alberta unclear. Some have suggested the environmental impacts of lithium mining in Alberta will be similar to that of the oil and gas industry (Smart Prosperity Institute & energyfutureslab, 2021; Tscherning & Chapman, 2021), and this is highly likely given the similarities in extraction methods.

2.5.6 BULK AND VIRTUAL WATER EXPORT

Bulk Water

The concept of exporting water in bulk has been largely criticized for the threat it poses to the sustainability of local water resources and the general environment (Pérez-Jvostov et al. 2020). Extracting water and transporting water in mass quantities can have significant environmental impacts, including habitat destruction, energy consumption and the emitting of GHGs. Nevertheless, bulk water exportation does withhold the potential to diminish major issues related to water inaccessibility. As such, the potential for the future implementation of bulk water export from the Peace River watershed is theoretically possible due to the vast reserves. However, even in times of water scarcity, such as those in 2024, discussions around cross-basin water transfers in Alberta have not included the idea of moving water from northern Alberta to southern Alberta, due to large distances and costs associated with such programs (CBC 2024a) and the Alberta policy that prevents such inter-basin water transfers.

Should the development of a Peace River-based water bulking system be proposed in the future, a comprehensive implementation process would be necessary, and this approach should take a *regional* rather than *global* perspective provided the risks to global water security and the environment (Dimitropoulos, 2020). In spite of this, the proposition to increase bulking exportation could be key to unlocking the many untapped northern markets within the water rich nation of Canada, home to 20% of the world's fresh water.

There is some evidence that Alberta's current legislative and policy prohibition on inter-basin water transfers, and by extension, bulk water exports, are based on an environmental rationale (i.e., Alberta *Water Act, rsa 2000, c. w-3 ss. 46-47,* and the *International Boundaries Treaty Act*, *sc 2009, c. i-17 s. 13)*. At the same time, however, there is no unambiguous statement to that effect (CWF, 2011, p. 2). Larson (2015) explores how bulk water exports could be an economic boon for Canada despite the rising concerns over global water security. For instance, in 2014 the Canadian government issued licenses to Canadian companies in British Columbia authorizing the export of nearly 55.5 million cubic metres of water annually by ocean tanker. The Canadian companies with these licenses would then award contracts to foreign companies to export water from Canada. A Canadian company called Snowcap received one such permit, and awarded a contract to a U.S. company, called Sun Belt, to export water from British Columbia to California. However, due to public opposition to these bulk water exports based on environmental concerns, the government of British Columbia issued a ban on exports and rescinded the licenses (Larson 2015).

Virtual Water

Water is an essential component to Canada's economy and the discussion surrounding global trade considers water and how it is used to produce goods and services. As such, requiring the measurement of water use in the exportation process is necessary to understand both its socioeconomic value and its environmental effect. The concept of *virtual water* asserts that when goods and services are exchanged, the water involved in making those goods are also exchanged. The now defunct North American Free Trade Agreement (NAFTA) previously identified the potential for international trade of water in North America, despite the lack of specification to engage in bulk water exportation (NAFTA 1994). The NAFTA treated water as a *good* and as an *object of investment*. However, an analysis report produced by the Canada West Foundation (CWF) examining this claim found the market-based instruments and measures that the province of Alberta was exploring at the time did not obligate the province of Alberta to begin bulk water exports under the NAFTA agreement (Coffin, Poulton, and Casey 2011).

The Canada-U.S.-Mexico Agreement (CUSMA) in 2020 seeks to liberalize trade between Canada, the USA and Mexico to abolish tariffs and other trade barriers (Government of Canada 2024b). The three nations have since agreed to a side letter on natural water resources affirming that CUSMA *does not create a right to the water resources of a party to the agreement*. It also does not create any obligation that allows for the exploitation of another party's natural water resources for commercial use, including its withdrawal, extraction or diversion for export in bulk (Government of Canada 2020). As a result, Canada's Water exports in January 2024 were C$1.97M and imports were C$6.9M, resulting in a negative trade balance of C$4.93M. Between January 2023 and January 2024, the exports of Canada's water decreased by C$-1.03M (-34.4%) from C$3M to C$1.97M while imports decreased by C$-5.1M (-42.5%) from C$12M to C$6.9M.[7] This represents one of the larger net negative balances for water in the nation's history.

Academics often argue whether CUSMA should take a regional rather than global approach to mitigate the general health risks of water security. Certainly, the advancement of provincial water security is necessary if water-rich regions such as Alberta find responsible and sustainable ways to export their water, but this will take years. Requirements for this depend on improving the empirical process for measuring virtual water use at the provincial level, however *recent research concerned with virtual water estimates in Alberta, specifically in the Peace River watershed, is limited*. In 2012, the Alberta Water Portal Society (AWPS) produced a *Virtual Water Flows Report*, which determined the average annual volume of virtual water exports in the province from 1999-2008 (Alberta Water Portal Society 2012). This was the first comprehensive virtual water assessment of Alberta's history.

[7] According to the OEC, Canada exported C$33.4M in water in 2022, making it the 19th largest exporter of water in the world and the 576th most exported product in Canada.

Table 7. Virtual water exports from Alberta (Source: Alberta Water Portal Society (2012)).

Virtual Water Exports of Alberta - AWPS (2012)					
Virtual Water			**Crop and Livestock Products**		
Average annual volume of virtual water exports	Average annual volume of virtual water imports	Average annual volume of virtual water exports	Average annual volume of virtual water exports	Average annual volume of virtual water imports	Average annual volume of net virtual water exports
12.10 Gm^3/year	**0.727 Gm^3/year**	**11.373 Gm^3/year**	**16.91 Gm^3/year**	**0.85 Gm^3/year**	**16.06 Gm^3/year**

Conclusions from the AWPS show the average net virtual water exports from Alberta were almost 2.5 times of the water footprint of Canada and domestic production of crop and livestock products were mainly used for food exports to other countries. Wheat, beef and canola were the three major products for net virtual water exports. Combined, they accounted for over 99% of the total net virtual water exported from Alberta and wheat accounted for almost half of the total net virtual water exported (Alberta Water Portal Society 2012). The average virtual water exports of crop and livestock products were 16.91 cubic gigameters per year (Gm^3/year) while the average virtual water imports of crop and livestock products were 0.85 Gm^3/year, which resulted in an average net virtual water exports of 16.06 Gm^3/year (Alberta Water Portal Society 2012). Note the virtual water imports were marginal compared to virtual water exports. Certainly, this an indicator of one of the ongoing effects in which NAFTA and CUSMA have had on the outcomes of water exportation in Canada and Alberta.

2.5.7 NUCLEAR POWER GENERATION

Nuclear power is the world's largest source of carbon-free energy, and to address climate change challenges, nuclear power is commonly discussed by policymakers as an approach to reducing greenhouse gas (GHG) emissions (NEI 2024; World Nuclear Association 2017). Nuclear power generating stations are facilities that harness nuclear reactions to produce electricity at mass scale. To date, there are four major nuclear power plants in Canada currently in operation. These include three active plants throughout Ontario; the *Bruce*

Nuclear Generating Station, *Pickering Nuclear Generating Station*, *Darlington Nuclear Generating Station*, and one in New Brunswick; the *Point Lepreau Generating Station* in Saint John.

According to the International Atomic Energy Agency, Small Modular Reactors (SMRs) are advanced nuclear reactors that have a power capacity of up to 300 MW(e) per unit, which is about one-third of the generating capacity of traditional nuclear power reactors (IAEA 2023). Globally, Russia's *Akademik Lomonosov*—the world's first floating nuclear power plant that began commercial operation in May 2020—is producing energy from two 35 MW(e) SMRs. Other countries with access to SMR technology include Argentina, China, Russia, South Korea and the USA. The notion of developing nuclear power in Alberta, specifically in the oilsands, has resurfaced several times over the decades. For instance, the 1950s *Project Cauldron* proposal to detonate a bomb underneath the province to assist in bitumen recovery was considered by the Government of Alberta (Jaremko 2020); the idea was aborted due to a multitude of safety issues. Some 70 years later however, there are no prescriptive regulations dictating the suitable attributes of a location for hosting a nuclear power reactor (Hatch 2023).

The prospect of building an SMR to provide electricity to Alberta's power grid took a notable step forward in January 2024 with a new partnership between Edmonton-based Capital Power and Ontario Power Generation. In particular, the oil sands (identified in Alberta's roadmap as one of three locations for SMRs) would see their emissions significantly reduced through the use of nuclear energy instead of natural gas to produce bitumen. Capital Power sees nuclear playing a critical role in providing baseload dispatchable generation in Alberta by 2035 (Calgary Herald 2024). While the main motivation for Alberta's interest in SMRs is to lower the province's greenhouse gas emissions there is significant debate regarding SMR implementation in the province (Calgary Herald 2024).

Natural Resources Canada released a SMR roadmap in 2018 and SMR plan in 2020 (CNA 2018; Natural Resources Canada 2020). The provinces of Ontario, Saskatchewan and New Brunswick signed memorandums of understanding (MOU) on SMRs in December 2019.

Alberta joined that MOU in August 2020. The original three provinces completed a feasibility study for SMRs (Hatch 2023), and in March 2022, now joined by Alberta, released a strategic plan for their deployment (McCarthy Tétrault 2023).

In Alberta, sites for hosting SMRs are expected to be evaluated using a graded approach, commensurate with risks posed by the facility's operating parameters. Alberta's oil sands are identified within the roadmap as one of three strategic locations for SMRs in Canada, however specification for a suitable location proximate to the Peace River watershed is unclear. The study does suggest dry cooling costs are much more sensitive to temperature. As a result, dry cooling is generally more suited to cold climates such as northern Alberta, reflecting the potential for future SMR implementation (McCarthy Tétrault 2023). However, to date there is no indication of immediate of SMR deployment in the Peace River watershed or any commensurate demands on water use.

2.5.8 PEAT EXTRACTION

Peat is the top layer of soil that contains partially decomposed organic material, mostly consisting of plant matter. It accumulates through natural water processes such as waterlogging, oxygen deficiency, high acidity, and nutrient deficiency (IPS, n.d.). These processes take tens of thousands of years to form peat (Charman, 2009). In Boreal and sub-Arctic regions like the Peace River Watershed, below freezing temperatures and slow decomposition rates create favourable conditions for peat accumulation. In these regions peat is primarily formed from the decomposition of bryophytes (IPS, n.d.), non-vascular plants, typically known as moss (Hedges, 2002). The USDA generally classifies it as soil that is made up of more than 20% organic matter, at a depth greater than 40cm (Kolka et al., 2016). This unique soil layer is found in and around peatlands, a wetland category that covers 3% of global land (IUCN, 2021), and ~21% of Alberta's landscape (Vitt, 2013). Peatlands and their many variations are also known as fens, mires, muskeg, bogs and peat swamps (WCS Canada, 2021). Peatlands play an incredible role in carbon sequestration, with an ability to sequester 16 times more carbon that agricultural soils, and 5 times more carbon than lake sediment and Alberta's forests (Vitt, 2013). Additionally, Albertan peatlands can safeguard against climate change, provide wildlife habitat (Stralberg et al., 2020), and support river networks (Webster et al., 2015); they can also act as important indigenous cultural areas and support food security (Joosten & Clarke, 2002; Townsend et al., 2020).

Peatlands and the services they provide are intrinsically valuable, but there are also use values of the peat itself. Peat extraction or harvesting, is the process of removing the top layer of peat soil from peatlands. Charman (2009) outlines the two primary ways peat is extracted from peatlands. The fist is a small-scale method, which involves hand cutting the peat into blocks and removing it from the ground. The second, more common method of extraction involves stripping away surface vegetation, draining the peatland and allowing it to dry, then using a large machine equipped with a mill for extraction. Peat is removed by the milling machine until only a thin layer is left. There are many different uses for extracted peat, for full coverage see Joosten & Clarke (2002). In Canada peat is primarily used as a horticulture additive to improve soil and growth medium conditions. Peat is used to prepare seedlings for greenhouse and cultivated crops, vegetables, fruits and herbs, or as a buffer for soil pH (CSPMA, 2022).

Despite having extensive peatlands in the upper two-thirds of the province, the peat industry in Alberta is relatively small. While the state of current production and exact area of peatlands are unknown, in 1996 3,000 hectares of peatlands were harvested in Alberta (Wilson et al., 2001), representing roughly 0.006% of Alberta's peatlands (AEP, 2016). In 2001 Daigle & Gautreau-Daigle estimated 17,000 hectares of peatlands were drained for peat extraction in Canada's *entire* boreal zone. Regulations on peat extraction In Alberta are outlined in the 2016 policy *Allocation and Sustainable Management of Peat Resources on Public Land*. This policy determines where peat can be harvested to ensure sensitive lands, fish and wildlife, and at-risk species are protected. Peat exploration is also regulated, with exploration approvals and public land leases needed beforehand. All commercial peat extraction from the point of application to reclamation must adhere to three statutes, the *Environmental Protection and Enhancement Act*, the *Public Lands Act*, and the *Water Act*.

Many of the largest areas available for peat extraction applications are in the Peace River Watershed (AEP, 2016), making the potential for peat extraction very high. However, actual peat extraction is currently low in the watershed. The Canadian Sphagnum Peat Moss Association's (CSPMA), a country wide peat producer group, lists only three companies currently operating in Alberta: Aurora Peat Products, Premier Tech Producers and Consumers (PTPC), and Sun Gro Horticulture. The exact location of Aurora Peat Products' operations is unknown, stating only that they extract peat in northern Alberta. PTPC makes the locations of all their peat extraction operations publicly available, of these only one is located in the Peace River Watershed (PTPC, 2023). Both Sun Gro peat extraction operations are located far south of the Peace River Watershed boundary. Additionally, there are no pending peat extraction impact assessments in the Government of Canada registry (https://iaac-aeic.gc.ca), or any peat extraction proposals in the Alberta Major projects registry (https://majorprojects.alberta.ca). This suggests that no new peat extraction operations will take place in the watershed for the foreseeable future.

However, the current state of the peat extraction industry in the watershed does not necessarily mean current operational capacity will be maintained. Horticultural peat extraction operations can occur for about 20 years (Wilson et al., 2001), so current operations may be enough currently, but in time new operations may appear. Given the extensive peatlands in the watershed open for extraction (AEP, 2016) there will always be a possibility of industry expansion. Although operators are required to reclaim extracted peatlands; water losses, wetland losses and associated environmental impact of extraction may persist. Disturbances to peat lands can reduce their carbon sequestration abilities by a factor of 6.5 (Vitt, 2013) and the effects on the wetland itself can last for over one-thousand years (Webster et al., 2015). This means disturbed peatlands will not be able to execute their primary role of sequestering carbon as effectively (Vitt 2006), support wildlife habitat and river networks to the fullest extent possible (Webster et al. 2015; Stralberg et al. 2020), and may negatively affect the food security of indigenous communities and the cultural resources they rely on peatlands for (Joosten and Clarke 2002).

2.5.9 HIGHLIGHTS OF ISSUES

Issue	Summary	Estimated Impact
Climate Change	More extreme weather conditions, demands for wildfire fighting and preparedness, increasing irrigation opportunities for agriculture, and social and economic outcomes will occur in the relatively water abundant region,	Moderate
Transboundary	Transboundary agreements between Alberta and B.C. and Alberta and Saskatchewan are slow, with Alberta completing its previous transboundary agreement with NWT in 2016	Low
Hydraulic Fracturing	Hydraulic fracturing will persist in the Peace Basin and will continue to be regulated by the AER	High
Hydroelectricity and Site C	Site C in 2025 will have a minimal impact on flow beyond the current impact of WAC Bennett Dam	Low
Lithium Mining	Lithium mining will begin soon in the river basin and the industry is expected to expand slowly	Moderate
Bulk and Virtual Water Export	No major virtual or bulk water export from due to long distances from markets	Low
Nuclear Energy	SMRs are proposed for northern Alberta, but no indication at this point this will occur	Low
Peat Extraction	Limited peat harvest in Alberta and not expected to increase significantly in the coming decade	Low

3.0 LITERATURE SCAN ON WATER USE

Water use projections in Alberta generally, and the Peace River watershed specifically, are not new. Environment and Climate Change Canada (ECCC), the Government of Alberta (GOA) and various Water and Planning Advisory Councils (WPACs) have conducted assessments on current and projected water use by sector over time. These documents have important methodological contributions and general conclusions that are important to explore to guide the development and conclusions arising from this report. This section contains a general summary of applicable studies for the Peace River Watershed.

3.1 WATRECON (2012)

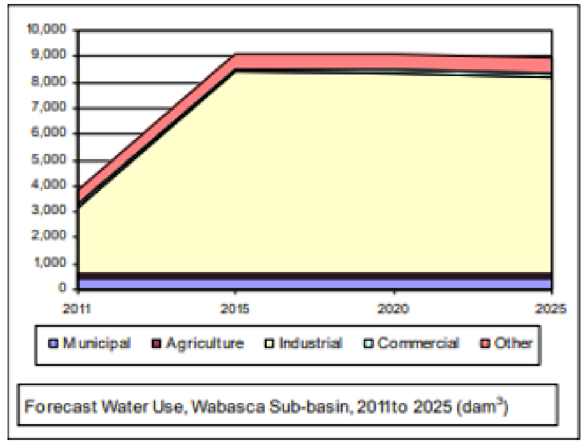
In 2012 MPWA commissioned Watrecon Consulting Ltd. to prepare a report on Current and Future Water Use and Issues in the Peace River watershed (Watrecon Consulting 2012). This document provides a comprehensive overview of water quantity, quality and water use in the Peace River watershed and the six sub-basins of Smoky-Wapiti River, Upper Peace, Central Peace and Lower Peace, Wabasca River, and Slave River. The current report follows the structure of Watrecon Consulting (2012) where possible to allow comparison over time.

Watrecon Consulting (2012) suggests there are no significant water management issues in the watershed, except perhaps at a *very local level*, and that *management regimes are evolving to address land and resource practices that could adversely affect water quality or quantity* (p. 99). This trend was showing times of changing, however, due to projected industrial growth, especially related to development of heavy oil and nuclear resources in Alberta's Peace River Oil Sands. Authors also suggest that hydroelectric development throughout the Peace River region will place more demands on the watershed.

As of 2011, water licenses and registrations issued to individuals and companies allowed for withdrawals of up to 148,728 cubic decameters (dam^3) of surface water of (Watrecon Consulting 2012). This number represented 89% of all water allocations in the watershed. Available information suggests that 29,397 dam^3 of surface water was actually used (Unger 2015). With regard to groundwater use, regulations allowed for withdrawals of up to 18,684 dam^3, representing 11% of water allocations in the watershed. Note that 8,402 dam^3 of groundwater was actually used in 2011 in the Peace watershed (Watrecon Consulting 2012). The following conclusion from Watrecon Consulting 2012 for the 2011-2025 duration include:

- *Water use in the Upper Peace sub-basin is expected to increase by 12%.*
- *Water use in the Smoky/Wapiti subbasin is expected to increase by 24%.*
- *Water use in the Central Peace subbasin is expected to increase by 51%.*
- *Water use in the Lower Peace sub-basin is expected to increase by 18%.*
- *Water use in the Wabasca sub-basin is expected to increase by 132%.*

Among the predictions made by the report, there are a number of items to consider. Industrial development in the Wabasca River sub-basin may be evaluated in an attempt to support key predictions made in the report. For instance, water use forecasts for the Wabasca sub-basin suggest that demand will increase by 132%. The increase stands as the highest single expected water use increase made in the entire report. Nearly all predicted change is due to a significant increase in the amount of water being used in oil and gas production, especially for in-situ processing of heavy oil using steam (Fekete 2013; Watrecon Consulting 2012). As such, forecasts for water use in the Wabasca sub-basin are heavily impacted by the industrial sector provided its overlapping geographic location with Alberta's Athabasca Oil Sands. Small changes in agricultural water use (a 3% increase) were also expected, including a 26% increase in commercial use, although total commercial use has remained quite small. The total change in water use was predicted to be 5,090 dam^3, and increased industrial demand was predicted to account for 98% of the increase.



Source: *Current Water Use Report* prepared by Watrecon Consulting (2012)

Figure 14. Forecasted water use in the Wabasca sub-basin from 2011-2025, arising from Watrecon (2012).

The *Current Use Report* makes evident that the extent to which the river can support additional demands without further compromising aquatic health is still *not known* (p. 100). For the main flow of the Peace River, the future challenges relate to the potential effects of future hydroelectric development and emerging hydrological trends influencing water use have been increasingly apparent. For instance, the Site C Hydroelectric project proposed by BC Hydro will have six generating units serviced on the Peace River by 2025. These projects have been in development since 2015. While river flows are unlikely to be further affected by this development, there remains uncertainty about how additional dams and structures will affect the ice regime, fish populations and migration, and populations of aquatic biota.

3.2 ALBERTA ENVIRONMENT (2007)

In 2007 the Government of Alberta Ministry of Environment (AE) published a technical report Current and Future Water Use in Alberta, which contains projected for each of the watersheds in the province. Section 12 of this report contains the results from the Peace/Slave River Basin, and as such has relevance to approaches in this report (Alberta Environment 2007). Basing their analysis upon the sectors identified in the water allocation and licensing data—municipal, agricultural, petroleum, industrial and "other". Results were also provided using a low, medium and high use scenarios to assist in future planning purpose. This study *predicted that water use in the basin would increase by 54% between 2010 and 2025. The forecast predicted that increased industrial demand for water (specifically water used for petroleum purposes) would account for 78% of the increase, compared to 12% for commercial use, 8% for agricultural uses, and 1% for each of municipal and other purposes* (Alberta Environment 2007). Tables 8 and 9 are provided from that report for reference to indicate the structing of results and sectors included.

Table 8. Summary of allocations and estimated water use in the Peace River and Slave River basins (Alberta Environment 2007).

Sector		Licensed Allocation and Use (dam^3)				Estimated Water Use (dam^3)		
		Allocation	Water Use	Return	Percent of Total Use	Use	Percent of Licensed Use	Percent of Total Use
Municipal		27,141	8,307	18,833	6%	1,457	18%	1%
Agricultural	Stockwatering	5,805	5,805	0	4%	3,730	64%	3%
	Irrigation	3,356	3,213	143	2%	3,213	100%	3%
Commercial		3,383	3,378	5	2%	3,378	100%	3%
Petroleum		20,586	19,631	955	13%	6,915	35%	6%
Industrial		90,690	20,795	69,895	14%	9,950	48%	8%
Other		92,436	89,833	2,603	60%	89,833	100%	76%
Total		**243,398**	**150,962**	**92,435**	**100%**	**118,476**	**78%**	**100%**

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Table 9. Forecast water use by sector under a high scenario of water use (Source: AE 2007)

Table 12-34 Forecast Water Use, By Sector, Peace/Slave Basin: High Scenario

Source	Sector	2005	2010	2015	2020	2025
Surface Water	Municipal	538	606	680	755	829
	Agricultural	5,846	6,313	6,823	7,380	7,990
	Commercial	3,006	3,720	4,514	5,367	6,277
	Petroleum	5,117	5,117	27,075	27,075	26,454
	Industrial	9,787	9,787	9,787	9,596	9,596
	Other	89,833	93,248	96,834	100,599	104,553
	Total	114,127	118,791	145,713	150,772	155,699
Groundwater	Municipal	919	1,035	1,162	1,290	1,417
	Agricultural	1,098	1,224	1,364	1,521	1,695
	Commercial	372	406	446	492	545
	Petroleum	1,798	1,798	10,427	10,427	10,183
	Industrial	163	163	163	163	163
	Other	0	0	0	0	0
	Total	4,350	4,626	13,562	13,893	14,003
Total	Municipal	1,457	1,641	1,842	2,045	2,246
	Agricultural	6,944	7,537	8,187	8,901	9,685
	Commercial	3,378	4,126	4,960	5,859	6,822
	Petroleum	6,915	6,915	37,502	37,502	36,637
	Industrial	9,950	9,950	9,950	9,759	9,759
	Other	89,833	93,248	96,834	100,599	104,553
	Total	118,477	123,417	159,275	164,665	169,702

3.3 MPWA WATER WORKING GROUP (2016)

In 2016, the MPWA Integrated Watershed Management Plan Steering Committee created a multi-sector *Water Quality, Availability and Consumptive Use Working Group* to investigate a number of water-related topics and provide recommendations to the Committee for consideration in their planning process. The Working Group met four times, sharing sector perspectives and information, before drafting the report. The Working Group concluded that *water quality* is generally good on the Peace River main stem, with its large volume and relatively few point and nonpoint source pollution inputs (Water Working Group 2016).

Some issues do arise on smaller tributaries and lakes; however, processes are in place to mitigate these issues to some degree in Alberta's *Water for Life Strategy* (Government of Alberta 2008). Similar to Watrecon Consulting (2012) the need for a more extensive and accessible monitoring, assessment and reporting system would benefit our understanding of water quality throughout the basin. This may be realized, at least in part, through the monitoring and assessment work of AEP[8] and its partners. For instance, the Working Group was provided an overview on water allocation in the Peace River Basin by AEP. This presentation included the number of licences (term and temporary), categories of water use (e.g. agricultural, commercial, industrial, municipal and water management and other use), the water use reporting system, and return flows. Such information is provided in Table 10.

Table 10. Water Quality, Availability and Consumptive Use in the Peace-Slave Watershed as reported by the MPWA Water Working Group (2016).

Industrial Activity	Surface Water (dam^3)	Groundwater (dam^3)	Total (dam^3)
Agricultural	7,720	2,378	10,098
Commercial	96,280	593	96,873
Industrial	9,924	9,568	19,492
Municipal	28,740	4,783	33,523
Water Management and Other Use	32,550	1,385	33,935
Total Allocations	175,213	18,708	193,921
Mean Peace River Flow / Yield (dam^3)	655,948,802,080 at Peace Point		

[8] The title of the Ministry when the report was authored.

As of December 2015, there were 1730 Temporary Diversion Licences (TDL) /Applications in the Peace-Slave watershed with 2896 points of diversion and 3864 points of use. Total volume allocated in these TDLs was 36,193 dam^3,[9] (Water Working Group 2016). Note the projections made in the following period tend to align with water use projections made by Watrecon Consulting (2012) despite existing limitations for determining water use. Limitations are provided below:

Water *availability* was not an issue for communities that draw source water from the Peace River main stem. However, due to their location throughout the watershed, many communities drew from smaller tributaries, lakes or from groundwater that did not provide optimal source quality or volume. Efforts to combat the safety issue were made; for example, *NEW Water Ltd*, can see communities, including First Nations reserves and Métis Settlements, and work together to find solutions to drinking water treatment and distribution challenges. Collaborations can also address a number of issues faced by communities throughout Alberta, including the cost of building and maintaining infrastructure for waterworks systems (treatment and distribution) and wastewater works systems (collection and treatment) as well as for recruiting, training, and retaining certified drinking water and wastewater staff. In addition, Alberta Environment and Parks, through its Watershed Resiliency and Restoration Program, undertook an assessment of flood, drought, and water quality risk for the province in 2015. Several areas in the Upper Peace and Smoky Wapiti sub-basins were rated as high risk (Water Working Group 2016). This program continues to provide grants to priority areas to mitigate risks and restore degraded watersheds.

In the report, the Working Group did look briefly at regional *consumptive water use*. The discussion about consumptive use is made more complex by the source (surface water or groundwater; saline or non-saline); timing of flows and withdrawals (particularly for small, seasonal tributaries and lakes), and the need for timely monitoring of the cumulative effects

[9] The regulator (Alberta Energy Regulator / Alberta Environment and Parks) has had an increasingly larger role to play in protecting smaller tributaries and lakes by requiring stream flow monitoring during withdrawals (so as not to exceed a certain volume of daily flow), by restricting withdrawal timing and rates, requiring screens on intakes, etc.

of multiple withdrawals at multiple diversion points on downstream aquatic health. Specifically, consumptive use of water in the basin is *hydraulic fracturing*, where fluids are injected at high pressure and volume to fracture rock and release hydrocarbons including oil, condensate, natural gas liquids, natural gas, etc. (Water Working Group 2016). The Working Group identified the *Grimshaw Gravel Aquifer* as an area requiring sound allocation management and protection from potential contamination. *Fox Creek* (located within the Smoky – Wapiti River) was another example of an area with concerns about the potential risk of contamination to local municipal groundwater supplies from surrounding land use activities (Water Working Group 2016) . Certainly, industrial developments over the past decade have inversely contributed in the area (i.e., the *SemCAMS Fox Creek Plant* and the *CNRL Fox Creek Oil Refinery*). Similarly, more recent research suggests the Smoky / Wapiti River to be a watershed having experienced an increase in activity from its oil, gas and mining industries provided the overlap with Alberta's Peace River Oil Sands. Conglomerate gas and mining companies operating in proximity to the sub-basin such as Canada Natural Resource Limited, Arch Resources Incorporated, Tourmaline Oil (formerly Jupiter Resources) and CST Canada Coal Limited have scaled operations since the WG assessment in 2015-2016. As such, the Working Group noted that many of its conclusions are similar to what other groups have indicated; to better manage water in this and other watersheds.

3.4 MACKENZIE RIVER BASIN BOARD (2021)

In 2022, the Mackenzie River Basin Board (MRBB) released their State of the Aquatic Ecosystem Report (SOAER 2021) which provides recent indicators of water quantity and quality in the Peace River sub-basin. Although the geographic scope of the report extends into mainland British Columbia, water use in the respective Peace River watershed is articulated. According to this report, water quantity in the Peace sub-basin has undergone moderate change. Observations by Indigenous communities and scientists suggest that ice is less thick, with earlier break-ups and later freeze-up dates in many waterbodies, particularly in the Lower Peace sub-basin. Less snow was reported in the Lower Peace (the northern and eastern regions of the sub-basin), while there is more snow accumulation in the Upper Peace (the western and southern regions) (SOAER 2021).

The MRBB make use of 2011 and 2013 estimates for *general water use*. The fifteen-year report gap would suggest further research is necessary in order to calculate projection estimates towards 2025. As per their website, 150 million m^3 of water was licensed for use in the Alberta portion of the Peace River watershed, which is 89% of the water allocations in the watershed. Surface water allocations equalled 0.3% of flows of Peace River at Peace Point. In 2013, 195 million m^3 was licensed for use. Sixty-six percent of the allocations are for commercial use, including pulp mills and thermal power projects, with 19% for municipal and with 7% for industry (oil and gas). Of the water allocations, only 38% (57 million m^3) is licensed for consumption with the remainder being returned to the Peace after use. Data shows that only 52% of licensed surface water was used in 2011. While total annual allocation represents a small portion of annual Peace River flows and a portion of water is returned, local impacts to smaller water courses are *less well understood* (SOAER 2021).

Since 2011, water levels in lakes, rivers, and creeks are more variable, although communities have generally observed lower levels than in the past. Late winter flows have increased in some small tributaries while freshet flows in Peace River have decreased. These changes are likely the result of a combination of flow regulation on the Peace River by the W.A.C. Bennett Dam and the effects of climate change (SOAER 2021). As such, changes in water quantity threaten to further disrupt the aquatic ecosystem health and the ability for Indigenous communities to practice a traditional way of life in the sub-basin. Historically, the relation between water quality/quantity and availability to treaty rights have been obscure. For instance, the 2016 Working Group report acknowledges that the Peace-Slave Watershed occurs in Treaty 8 lands. However, given the complexity and legality of the subject, the WG *did not explore the topic specifically nor did it make any recommendations* *on the topic* (Water Working Group 2016). Indigenous considerations and water protection are significant aspects of resource management in Alberta, particularly in industries like oil and gas, agriculture, and forestry. Alberta's most recent *water use* report produced in 2022 begins to incorporate indigenous consideration with water projection methodologies. However, the report does not assess contributing factors of indigenous knowledge, information, and data directly, despite identifying its theoretical importance.

Signs and Signals	Indigenous Knowledge Information and Data	Indigenous Knowledge Availability [1]	Science Information and Data	Science Data Availability[2]
Water Use	Not assigned a Sign or Signal	Not assessed.	Number of water licenses, purpose, volume allocated, and volume actually used vs. water flow / level; Water demand from various sectors, including dams, agriculture, oil and gas, etc., trends in water use over time	Water Licenses available but not retrieved for this report. Reports available.

Source: *MRBB State of the Aquatic Ecosystem Report (2022)*

Figure 15. State of the Aquatic Ecosystem Report (SOAER 2021) summary of assessment.

Overall, considering Indigenous people in water use is not only a matter of respect for cultural diversity and human rights but also a practical necessity for achieving sustainable and equitable water management practices. Future studies conducted in the Peace River watershed must work to better comprehend the Indigenous implication. For example, the recent approval of the Site C Hydroelectric development project has already had an impact. Members of Treaty 8 Tribal Association have limited their consumption of fish caught near Williston Reservoir in recent years due to warnings issued by BC Hydro for possible mercury contamination from nearby hydroelectric projects. A fish consumption advisory has been in place for the reservoir since the 1990s that recommends not to consume large amounts of fish from the reservoir. Community members have also expressed concern that fish in tributaries of the Peace River may have unsafe mercury levels (SOAER 2021).

3.5 WATERSMART SOLUTIONS (2024)

ECCC commissioned a report from WaterSMART Solutions to explore water use in the Peace and Athabasca watersheds (WaterSMART Solutions 2024). This report became available in April 2024, and while it includes the Athabasca River watershed and the oil sands activity in Fort MacMurray and surrounding area, it nevertheless provides a valuable reference for approaches to water use analysis and drawing conclusions. An excerpt from the Executive Summary of this report is copied below:

Overall, water use in the Athabasca, Peace, and Slave River Basins is generally a relatively small percentage (less than 1%) of mean annual streamflow. However, it was observed that water use can have a greater impact on streamflow when a large water user(s) is located on a smaller sub-watershed. It was also observed that water use has a greater impact on streamflow in dry years, as well as seasonally, specifically during lower streamflow periods that are typically observed from October to March on most rivers and tributaries in the Project Study Area. When looking at the entire Project Study Area on a per-sector basis, the oil and gas sector is the dominant water user, followed by water used for environmental water management, forestry, industry, and municipal sectors. The agriculture and other sectors are relatively small water users in the Project Study Area. Note that while the hydropower sector has very large water licence allocations, it was assumed for the purpose of this study that all of this water is non-consumptive (i.e., any water that is diverted is immediately returned to the watershed). (WaterSMART Solutions 2024)

3.6 NORTHERN RIVER BASINS / ECOSYSTEM INITIATIVE (1996; 2004)

Established in partnership between the governments of Canada, Alberta, and the Northwest Territories the Northern River Basins Study (NRBS) and Northern Rivers Ecosystem Initiative (NREI) aimed to address concerns surrounding industrial and resource development in the Peace, Athabasca, and Slave river basins. The NRBS (1996) was the first initiative whose goal was to “advance understanding of how development within the Peace, Athabasca, and Slave river basins had cumulative impacts on the mainstem and main tributary aquatic ecosystems” (NRBS, 1996a). Arising from the NRBS were twelve synthesis reports, these reports will be referred to as the final NRBS report is unavailable online. The NREI's (2004: 5) goal was to “address residents’ concerns about the health of the aquatic ecosystem of the basins.” Like the NRBS, the NREI (2004b) also prepared a synthesis report, providing a more detailed summary of the science and policy action taken.

The NRBS established the state of the Peace, Athabasca, and Slave rivers and provided recommended solutions to the problems the study identified. For the Peace basin notable findings included “radical” changes in hydrological regimes, water contamination especially in areas surrounding pulp mills, fish mercury levels, and water losses arising from the Bennett Dam. The synthesis reports provided recommendations that would potentially mitigate these problems, including increasing monitoring and reporting, simulation and future modelling, continued research, establishing guidelines, and engaging with the community on issues. Additionally, the NRBS engaged significantly with indigenous groups in the study area. It made recommendations for co-management agreements, developing a protocol to incorporate traditional knowledge into industrial decision making, and develop a traditional knowledge extension program to ensure “the perpetuation of traditional knowledge from Aboriginal elders to the youth, as well as to other sectors of society” (NRBS, 1996a: 95). Because the goal of the NRBS was to establish the baseline state of the Peace, Athabasca, and Slave rivers no further action was taken in this context.

Further action came with the NREI; the final report outlining every recommendation and action taken between 1998 and 2003 arising from the NRBS. The NREI identified the state of many of the largest industries in the peace, including agriculture, oil and gas, and forestry in addition to a breakdown of the basin’s water allocations at the time (Figure 16). In regard to protecting aquatic ecosystems from these potential threats the NREI synthesis report covers the *Mackenzie River Basin Transboundary Waters Master Agreement (*Government of Alberta 1997), Alberta’s *Water Act,* and a litany of regional policies that came into force during the study or were planned for shortly after. The NREI also identified newly established monitoring networks and additional research undertakings that modeled hydrology, assessed land cover classification, or studied migrant shorebirds, to name only a few.

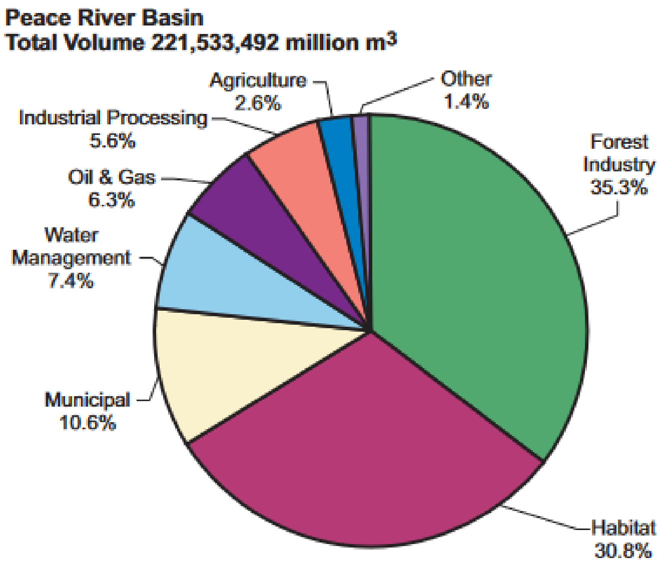


Figure 16. Water Allocations in the Peace River watershed in 2004 (Source: NREI 2004)

The NRBS and NREI are two parts of the same initiative. The NRBS established the baseline of the Peace, Athabasca, and Slave River basins, making recommendations for next steps in both the science and policy spheres. Then the NREI continued this effort, further studying the three basins and providing an overview of the policy implementations aimed at protecting these aquatic ecosystems. According to the NREI synthesis report pollution prevention, fish abnormalities, human health / drinking water, hydrology and climate, land planning and water use, and wildlife, among others, were major areas of progress in scientific research and policy arising from the NRBS and NREI. Unlike the NRBS, the NREI had less engagement with the people of the Peace, Athabasca, and Slave river basins representing a major limitation. Additionally, most of the recommendations surrounding the traditional knowledge documented and studied by the NRBS were not addressed.

3.7 WOOD BUFFALO ACTION PLAN | E-FLOWS (2026)

Wood Buffalo National Park, a world heritage site designated under UNESCO, is required by the *National Parks Act* to amend and re-table the park management plan every five years. A park's management plan must specify "the type and degree of resource protection and management needed to assure the ecological integrity of the park" and its cultural resources, and outline activities and services available to visitors (Parks Canada, 2008). Wood buffalo's most recent action plan was released in by Parks Canada in 2019), and contrary to what is required under the *National Parks Act,* "outlines a long-term program of work with identified actions which run until 2026" (Parks Canada Agency, 2023). However, reports from UNESCO (2020, 2022b, 2022a) identified many threats to the ecological integrity of the park, and in 2023 voted that Canada implement all recommendations to improve the park (CBC, 2023). If these recommendations are not implemented Wood Buffalo may be considered "in danger" by UNESCO, whose concerns for the park arose initially from a report by the Mikisew Cree First Nation (2016) identified threats both inside and outside the Park's boundaries (The Narwhal, 2023). Major issues identified first by the Mikisew Cree First Nation and then further by UNESCO are the disruption of seasonal flows because of dams on the peace river and the encroachment of the oil sands and associated tailing ponds in the park area.

UNESCO's world heritage committee also made requests that Wood Buffalo's Action Plan be updated by February 1st, 2024 (AWA, 2024). According to Parks Canada (2022, 2023) this update is set to revisit the structure of the Environmental Flows (E-Flows) framework with the Slave Basin. Through study of the basin and public consultation, E-Flows outline the timing and quality of freshwater flows and levels need to maintain the ecological integrity of ecosystems, and dependant human economies, livelihoods, and culture (Arthington et al., 2018). The E-Flows framework acts as a "road map" for making decisions about water in the Slave Basin, and consultations with those affected most have occurred (ECCC, 2019) but the E-Flows of the basin or the management framework has not been made public, or perhaps has not been completed. Additionally, as recommended by UNESCO their action plan is to address and design "water control structures" to better manage local water with the goal of restoring the flows in key areas of the basin.

Despite Parks Canada being required under the *National Parks Act* to update and re-table park action plans every five years, and UNESCO's request that a new action plan be finalized by early 2024, no new action plan has been made public. The most recent update on the progress of the action plan was made in 2023, with very little new information released. It is likely that parks Canada will maintain their own timeline and release the next Wood Buffalo Action plan in 2025/26, and with it their plans for water control structures, a study of the Slave's current E-Flows, the new E-Flows framework.

3.8 WAPITI RIVER: WATER MANAGEMENT PLAN (2020)

Completed in June of 2020, the Wapiti River Water Management Plan was developed to address concerns about the Wapiti River and the diversions of its waters during low winter flow periods (WRMP 2020). A steering committee was established, and recommendations were developed for the Smoky / Wapiti sub-basin to ensure future social and economic conditions could be sustained, without the loss of current or future aquatic resources. The river management plan makes recommendations along two lines of action; the first is in regard to the amount of water that should be allocated for human needs, and the second in regard to the amount of water required to protect the health of the Smoky / Wapiti's aquatic and supporting ecosystems. In doing so the management plan established water conservation guidelines that have been applied to all new surface water licenses since the policy came into effect and licenses subject to renewal. These conservation objectives are summarized as follows in the WRMP (2020) :

• *When natural flow in the Wapiti River below Big Mountain Creek is above 20 m^3/s: net water use up to 2 m^3/s is allowed in Wapiti River basin;*

• *When natural flow in the Wapiti River below Big Mountain Creek is between 10m^3/s and 20 m^3/s: net water use up to 1 m^3/s is allowed in Wapiti River basin; and*

• *When natural flow in the Wapiti River below Big Mountain Creek is less than 10m^3/s: net water use of 8% of natural flows are allowed in Wapiti River basin.*

Contingencies to ensure these conservation measures are adequate involve continued monitoring of the Wapiti's aquatic ecosystem, reviewing conservation objectives every ten years, and initiating a review of the plan if a large volume of new licenses is approved in the B.C. portion of the sub-basin. In preparing this plan public engagement was sought throughout the process, involving both Indigenous and non-Indigenous consultation and feedback.

In addition to public engagement a number of issues water issues in the Smoky/Wapiti sub-basin were considered to prepare the conservation objectives listed above. These issues included water-based recreation, geomorphology and riparian habitat, and climate change. In addition to these, and highly relevant to this report, future water supply and demand for a growing economy and population were also considered. Using water license information for 2014/15, projections of a "future water demand scenario" were made and are said to represent a "plausible upper limit on future water use" for the Smoky / Wapiti sub-basin. These water forecasts were made using input from industry stakeholders, and by combination of steering committee input and the previous water use report prepared by Watercon (2012). The Wapiti River Management Plan states that the steering committee believed it was reasonable that this upper limit of future water demand would be reached by 2040. Projected future water demand scenarios for licenses groups (similar to sectors in this report) arising from these forecasts for the 2014/15-2040 duration are stated in the WRMP (2020) as follows:

- *The Aquatera license group will increase its water diversions by 142%, and net use by 377%.*
- *The International Paper license will increase its water diversions by 0%, and net use by 0%.*
- *Lake stabilization and wetland licenses will increase water diversion by 0%, and net use by 0%.*
- *New licenses will increase water diversions by 190%, and net use by 190%.*
- *Temporary diversion licenses (TDLs) held by the oil and gas sector will increase water diversions by 788%, and net use by 788%.*

- *Total water diversions of the Smoky / Wapiti will increase by 68%, and net use by 303%.*

The reasons for water diversion and net use increases (or lack thereof) differ significantly between license groups. Future water use of the Aquatera license group is based on the maximum allocation held between two different water licenses, one of which was recently approved at the time of this management plan in preparations for a growing population in the sub-basin. The lack of increase in the International Paper's water diversion and net use is attributed to declining water use of the pulp mill from over the last ten years at the time of the report. Lake stabilization and wetland licenses experience no increases in diversion or net use, as these projects aim to "restore or compensate" wetland losses. Increases in water use for new licenses were based on a 16% projected increase over 15 years, using current estimate water use figures arising from Watercon (2012). Increased in oil and gas TDLs were based on the highest reported TDL water use in the Little Smoky River Basin at the time, with expectations that all current TDLS in the Wapiti River basin would reach this threshold by 2040.

The major conclusions drawn by the Wapiti River Water Management Plan from these future water demand scenarios indicate that there will be no water shortages for current (2014/15 and before) licenses or registrations in the sub-basin. Short term, small volume water shortages may occur in less than 5% of winters (less than once every twenty years) for new licenses holders. Similar shortages seemed likely for the oil and gas sector during late winter and early spring in less than 5% of years. In short, the conservation objectives implemented by this initiative will have minimal if any effects on the water diversion of the Smoky / Wapiti sub-basin, despite an expected water consumption increase of 68% by the year 2040 for the sub-basin.

3.9 HIGHLIGHTS

Available information suggests that, to date, our understanding of ecosystem health in Alberta comes from a few studies undertaken to assess the effects of specific projects. In the absence of accessible information about the current health of these aquatic ecosystems, more information will be needed to fully understand the effects of potential future development and to implement strategies and measures to protect, maintain and potentially enhance the health of these tributary rivers. Further, there has been no systematic attempt to document the functionality or health of aquatic ecosystems throughout the watershed. Provided that users are still not reporting actual withdrawals of surface or ground water, a number of limitations exist for projecting accurate water use estimations despite recent efforts made by the Alberta Energy Regulator to expedite the water reporting process.

These limitations include, but are not limited to:

- **Indigenous Considerations**: Obscure/ambiguous relationships between water quality/quantity projections and availability to treaty rights. Indigenous considerations and water protection are integral to sustainable resource management in Alberta, and ongoing efforts are needed to address the complex interplay of environmental, social, and economic factors.
- **Unlawful Action**: Failure to report actual withdrawals of surface or ground water among individuals and organizations.
- **Data Availability and Quality**: Accurate projections rely on robust data on current water usage, population trends, economic activities, climate patterns, and infrastructure. However, data may be incomplete, outdated, or of varying quality, particularly in regions with limited monitoring infrastructure or inconsistent reporting mechanisms.
- **Uncertain Future Conditions**: Projections typically rely on assumptions about future conditions, including population growth, economic development, technological

advancements, and climate change. However, predicting these factors with certainty is challenging, leading to uncertainties in water demand forecasts. For instance, Alberta, like any region, is susceptible to various natural hazards, including wildfires, floods, storms, and droughts. Alberta has experienced significant natural disasters in the past, and the province continues to implement measures to mitigate the impacts of such events and enhance resilience.

- **Methodological and Reporting Inconsistencies**: Projections of future water use rely on many different factors and can be done in many ways. While there are some consistencies across these methods, largely they are executed and reported differently, and at times the process and rationales behind them are inadequately explained. These circumstances make it difficult to compare results of future water use projections between what reports do exist.

4.0 METHODOLOGY

Due to the physical extent and diverse socioeconomic conditions of the Peace River watershed, the six sub-basins will be assessed individually[10]. However, a common process will be conducted for each that will allow for comparability and also aggregation for common messaging. The methodology will follow the process described in Table 11 and the specific methodology will be described in the rest of this section.

Table 11. Methodology and process followed in the current and projected water use by sector for each sub-basin.

Process	Description
I. Physical and Human Geography	Physical extent of the sub-basin, including water flow rates; demographics and population trends, economic and social issues, external factors beyond the sub-basin
II. Current Water Use by Sector	Current and project water use for municipal and commercial, agriculture, forestry and industrial sectors
III. Scenarios of Future Water Use	Consider changing economic conditions under 25%, 50%, 75%, 100% and 200% increases in demand

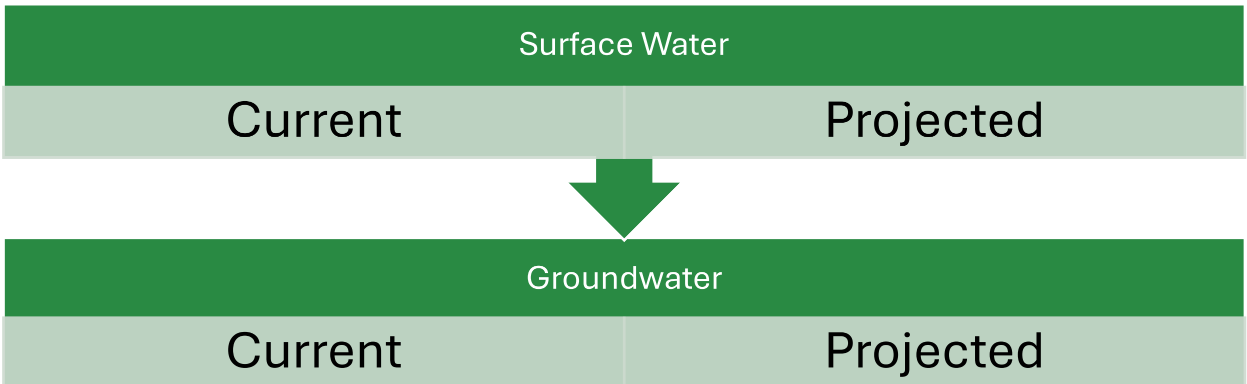
4.1 PHYSICAL AND HUMAN DIMENSIONS

Environmental conditions for the quantity and quality of surface water, wetlands and groundwater in each of the sub-basins will first be described to provide context. Hydrology and flow rates over time will be captured from GOA flow tool calculator, capturing the information from the respective flow monitoring meters. Trends will follow from 2024 and be projected to 2050.

Human dimensions include the various social and economic considerations of a particular location. In this context, this information informs water use and demand over time. First,

[10] Following the structure of Watrecon (2012).

population trends over time (2000-2024) will be provided from current Canada Census data and extrapolated to 2050. This will include both Indigenous and non-Indigenous populations. Second, any current social issues facing the communities in the sub-basin will be explored. This would include external influencing factors and local political matters. This section will be reported within the municipal sector area to prevent redundancy.



4.2 SECTOR-BASED CURRENT AND FUTURE WATER USE PROJECTIONS

This section will explore a sector-based water use and future projections approach at a sub-basin level. Sectors include i) municipal and commercial, ii) agriculture (crop and livestock); iii) forestry and iv) Industrial.

4.2.1 MUNICIPAL AND COMMERCIAL

As indicated, the municipal and commercial sectors are closely tied. The commercial sector provides services and support to the municipal, thus the commercial sector is dependent on the municipal sector for revenues. Because of this close relationship the used for estimating current and future water use are identical, and current and future uses of water for both these sectors will be included together in the same sections.

Additionally, a third category will be reported known as "management." Allocations for the purposes of management are for mostly flood control and wetlands, these support municipalities and make up only a small percent of water use in the entire basin. Allocations for management are likely to increase arising from uncertainty surrounding climate change and weather, but actual water use under this category is likely to remain to remain very small. Current allocations and use of the management sector will be reported for each relevant sub-basin, but future projections will not be made due to such low utilization.

4.2.1.1 CURRENT ESTIMATE

Municipal water use data for the Peace River watershed is available from the Alberta Flow Estimation Tool for Ungauged Watersheds (AFETUW) database. This database holds the most recent available data[11] on Alberta's water use. Municipal water use is considered water used for urban, suburban, rural, and institutional purposes. A fair proportion (71.26%) of the total municipal allocation for the Peace basin are reported by municipal licensees to Alberta Environment and Protected Areas (AEPA). Because such a fair proportion of water use is reported the municipal data from the flow tool is considered reliable, and representative of current water use for this sector. For those who do not report consumption, return flows, or losses to AEPA, the AFETUW database assumes the entire water allocation is consumed. This assumption is made throughout the Basin projections for this sector. While this assumption is likely to over-estimate water use for the municipal sector, to what extent is unknown.

Commercial water use data for the Peace Basin are also available from the AFETUW database. Commercial water use includes services and retail, recreation, gardening and sod, manufacturing, construction and transportation, and water sourcing. A low proportion (31.39%) of total commercial allocation for the peace basin are reported to AEPA. Because this is the sole database for commercial water use it is considered representative of current commercial water use in the basin. As with all sectors and water licenses, if consumption, return flows, or losses are not reported, the AFETUW database assumes the entire water allocation for a licensee is consumed. Again, this assumption is made throughout the basin

[11] Updated numbers downloaded May 7, 2024.

projections for this sector, and the extent to which using this data will result in an over-estimate of current water use is unknown.

4.2.1.2 SECTOR PROJECTION

Municipal water withdrawals have been decreasing over time, primarily due to more water efficient appliances (EPCOR Water Services Inc. 2021), however populations in the region are expected to grow. This creates circumstances where water use is simultaneously decreasing and increasing. The current municipal water consumption of each sub-basin will be multiplied by the yearly percent change in population for the Peace Basin between the last two Canadian Census periods (2016 - 2021). Additionally, the yearly percent change will be multiplied by the relevant number of years for each projection horizon. This projection estimate assumes that water use for the municipal sector is directly tied to population changes, and that the water efficiency of appliances will not increase further.

As with current water use, sector projections for the commercial sector will follow an identical method as the municipal sector. This is based on the logic that as populations increase, they will demand commercial services, resulting in the commercial sector increasing supply and subsequently increasing water use. The current municipal water consumption of each sub-basin will be multiplied by the yearly percent change in population for the Peace Basin between the last two Canadian Census periods (2016 - 2021). The yearly percent change will be multiplied by the relevant number of years for each projection horizon. As with the municipal projection this projection assumes that the water consumption of the commercial sector is directly proportional to population changes in each sub-basin, and that the water efficiency of the commercial sector will not increase.

4.2.2 AGRICULTURE

Agriculture is a driver of water use across the province. For each basin, this is divided by irrigated crop production, livestock production, and traditional use. As not all sub-basins have a major agricultural presence, this analysis will vary significantly between sub-basins. Water licenses are granted for irrigated crop production, livestock production and traditional use, but most licensees do not report their water consumption, loses, or return flows. Also, under the *Water Act*, licenses are not required to divert water from dugout, or alternative livestock watering systems (e.g., nose pumps). The variability in agricultural presence throughout out the sub-basins and lack of reporting requires that alternative methods for estimating current water use must be employed where possible. Alternative methods rely heavily on data from Canada's agricultural census; this data is organized by census agricultural divisions and does not align perfectly with sub-basin boundaries. To account for this agricultural census regions were assigned to each sub-basin based overlapping boundaries. The assignment of the agricultural census divisions or census consolidated subdivisions (CCS) is an approximation, and the results can be seen in Table 12. In cases where a sub-basin constitutes only half of a CCS exactly 50% of the associate data will be used for analysis.

Table 12. Peace River sub-basins and their assigned agricultural census divisions.

Sub-basin	Census Division or Census Consolidated Subdivision
Smoky / Wapiti	Census Division 18, CCS487019006, CCS487019041, CSS487019049
Upper Peace	CSS487017062, CSS487019054, CSS487019059, CSS487019066, CSS487019071,
Central Peace	CSS487017026 **(½),** CCS487017076
Lower Peace	CSS487017095
Wabasca	CSS487017026 **(½),** CSS487017033 **(½)**
Slave	CCS486016051

Data is available from AFETUW and will used where applicable, or in situations where alternative methods for estimation are deemed unreliable. The methodology for estimating the current use and for projecting future use for irrigation, livestock, and traditional use is outlined below.

4.2.2.1 IRRIGATION

Irrigation is that act of applying water to soil from sources such as rivers, lakes, or aquifers to meet the water needs of cropping crops (Bjorneberg and Sojka 2013). The type of irrigation system used depends on soil type, water location or climate conditions. Irrigation is less prevalent in the Peace basin compared to other parts of the province, but supports some agriculture, nonetheless. Many irrigators holding water licenses do not report their return flows, losses, or water consumption. Because of this the AFETUW database assumes they are using their full allocation. However, irrigation can vary significantly from year to year and is dependent on factors like snowpack, seasonal precipitation, and soil moisture. The variability of irrigation, and the lack of data available means that other methods must be used to determine its water use. Because it is impossible to know where the source of irrigation water is when calculating irrigation water use, current and future projections will be the total estimated use from both surface and ground water sources.

4.2.2.1.1 CURRENT ESTIMATE

To assess the water consumption of irrigation data accurately data from the Government of Alberta, the Canada agricultural census, and Environment and Climate Change Canada (ECCC) will be used. There are two parts to estimating current and future water use of irrigation in the Peace sub-basins; the first is to determine how many acres are irrigated, the second to determine irrigation needs per acres.

To determine how many acres are irrigated in the region, reports on the state of irrigation in the province will be used, provided yearly by the Alberta government and data from the most recent agricultural census. The Alberta irrigation reports mostly focus on the irrigation in the south, but total acres irrigated is reported for the Peace basin. The total acres irrigated for 2022 in the Peace Basin was 4,468 (GOA 2023). The most recent agricultural census provides information on total acres cropped, this area can be used to determine the proportion of cropped agriculture per basin. The proportion that each sub-basin contributes to the total area of cropped agriculture will be multiplied by the total acres irrigated for the peace, returning the number of acres of irrigated cropped agriculture for the relevant sub-basin. This method assumes that the proportion of cropped agriculture in each basin is equivalent to the area under irrigation. This method varies from the previous report (Watercon 2012) where water licenses for irrigation were assumed to be using their entire allocation because of non-reporting.

To determine the total irrigation needs per acre, information published by GOA on crop water use requirements for Alberta (McKenzie and Woods 2011) will be used, these water requirements are for any given area (Brouwer and Heibloem 1986). Canola was the crop with the most area planted for the Peace region according to the 2021 agricultural census, as such the water requirements for this crop will be used. Water requirements for canola range from 400-480 mm, the average of these values will be taken and used in the analysis (440 mm). This water requirement does not differentiate between precipitation or irrigation. To account for this, the average monthly precipitation for the growing season of canola (May - mid September for canola, 5.5 months) of the Grade Prairie area for the past 8 years will be subtracted from crop water requirements, this weather data is provided by ECCC (2024).

Taken together irrigation estimates will be calculated using the following equation for each basin:

$$I_w = (\% * A_i) * (N_i - R_A)$$

Where I_w is the estimated water use of irrigation for a sub-basin, % is the proportion of cropped acres in the relevant sub-basin, A_i is the total number of acres irrigated in the Peace Basin, N_i is average irrigation needs of canola, and R_A is the average seasonal rainfall for the Grande Prairie area since 2016. This method for determining the current water use of irrigation is approximate, assuming that the most common crop in the Peace basin is the only crop receiving irrigation, and no crops with higher and lower irrigation needs than that of canola are being irrigated. This method also assumes all acres are being irrigated, to achieve water needs not filled by average rainfall. Given these assumptions the probability that the estimate will over-estimate actual use is low. Using canola's irrigation needs will capture the differences in irrigation from crops with lower water requirements and crops with higher water requirements, thereby acting as an average of irrigation water use in the region.

4.2.2.1.2 FUTURE PROJECTION

Climate change is affecting precipitation patterns, which in turn affects the number of acres farmers must irrigate. While no model can perfectly predict the complexity of this situation, one that uses changes in irrigation acres will best project future changes, ideally capturing decisions to increase acres under irrigation resulting from a changing climate. Using historical trends in acres irrigated for the Peace from the yearly GOA irrigation reports, the following equation can be used for each basin:

$$FI_w = I_w * (1 + (Y * AY_{ci}))$$

Where FI_w is estimated future water usage or irrigation, I_w is the estimated water use of irrigation for a sub-basin, Y is the number of years in the projection horizon, and AY_{ci} is average year-over-year change in irrigation acres, using a base year of 2016.

4.2.2.2 LIVESTOCK

Livestock are animals raised or kept for use or the goods they produce. Most livestock in the Peace basin are raised to produce food, but others like horses are raised for pleasure. Many livestock operations do not report their return flows, losses, or water consumption. Because of this the AFETUW database assumes they are using their full allocation. However, stock watering can vary significantly from year to year and is dependent on factors like surface runoff, livestock inventories, and weather conditions. Because little water use is reported, and livestock water use is dependent on many factors the water use of this sub-sector must be estimated through other means. It is difficult to know where livestock operations source their water, so future and current estimates will be from both surface and groundwater sources.

4.2.2.2.1 CURRENT USE

To determine the water consumption of livestock more accurately in the Sub-basins of the peace, data from Canada's agricultural census on livestock inventories (Statistics Canada

2024), and livestock water requirements published by the GOA (2009) will be used. This follows the methodology of the previous report (Watercon 2012) and Alberta Environment (AE) (2007) water use report on the North Saskatchewan River Basin, where estimates are based on livestock populations and their total water consumption from all sources.

Cattle are expected to be the primary water consumers, their current consumption can be calculated using the following equation.

$$C_w = [C_r * 37.85 * 340] + [C_r * (37.85_{lpd} * 2) * 25]$$

Where C_w is total water cattle consume, and C_r is the number of cattle in the region. This estimate of current cattle water use makes the following assumptions:

1. all cattle in the region are feeders with a weight of ~570 Kg and require 37.85 liters per day (lpd) of water on days below 25℃, and twice as much on days above 25℃ (Government of Alberta 2009)
2. the average number of days above 25℃ for Grande Prairie (25 days/year) (Kienzle 2019a) is representative of the Peace River Watershed.

Cattle are not the only livestock in the region however. Therefore, the water use needs for other livestock (swine, poultry, sheep and goats etc.) will be calculated and included as well to give the most accurate estimate of livestock water use. A separate simplified equation will be used to estimate water-use for other types of livestock. For each livestock type water use will be calculated as a product of the following.

1. the number of livestock in the sub-basin
2. Livestock water requirement per day
3. 365

There are many livestock types in the watershed, but for simplicities sake it is assumed each livestock type are uniform, i.e., all swine are 50lbs feeders, all poultry are broilers, etc. and their water requirements are representative of the entire livestock type inventory for the basin, and its sub-basins.

Based on this the following equation will be used to determine the water use of livestock for each sub-basin.

$$T_{wl} = C_w + S_w + P_w + G_w + \ldots$$

Where T_{wl} is total livestock water use in the region, C_w is total water cattle consume, and S_w is the total water swine consume, P_w is the total water poultry consume G_w is the total water sheep/goats consume, etc.

4.2.2.2.2 FUTURE PROJECTION

The primary driver for livestock water consumption is livestock inventories, the more livestock the more water they consume. Because cattle are the primary water consumers, changes in cattle populations will be used to model future water livestock water use. Cattle inventories will be projected using archived agricultural census data. Average year-over-year change in cattle populations for the province of Alberta will be used to project future livestock water use. Projections of other livestock growth could be included, but their share of water consumption is considered negligible relative to cattle; this means the current water-use of all livestock will be projected using only the change in stocking rate for cattle. For each sub-basin the projected future water use of livestock is represented using the following equation

$$F_{wl} = T_{wl} * (1 + (Y * \Delta SR))$$

Where F_{wl} is the future total livestock water use in the region, T_{wl} is total current livestock water use in the region, Y is the number of years in the projection horizon, and ΔSR is equal to the average year-over-year stocking rate of cattle for the province of Alberta, using a base year of 2016.

4.2.2.3 TRADITONAL USE

In addition to water allocations for livestock and irrigation a third category exists in the sector know as traditional use. Traditional use is defined as water use for raising animals or crops (GOA 2002). Traditional use does not require a water license but instead users hold a water "registration." Registrations were implemented as the Water Act came into force and allows agricultural users to continue their water use with priority dating back to when water was first used. Registrations were only issued before 2002, and any agricultural users wishing to divert water above the agricultural exemption limit after this time must apply for a water license.

Other methods for estimate traditional water use would be preferable, but there is no way to know exactly what water is being used for under these registrations. Because of this, current estimates of traditional water use will rely on data from the AFETUW. There is also no need to project future traditional water usage because water registrations are no longer awarded, so use under this category cannot increase. It should be mentioned that because traditional water use can be for both livestock and crop farming, it may account for over-use in the livestock or irrigation current use figures, the extent of this phenomenon cannot be determined, however.

The category of traditional use will also include water licenses for aquaculture and sod and greenhouse farming. These two agricultural waters uses make up a very small portion of water use in relevant sub-basins, having a near negligible effect on current water use numbers. Future water use for aquaculture and sod and greenhouse farming is also difficult to project because of their small sector stake. Because of their negligible impacts and lack of projection aqua culture and sod and greenhouse farming were included under traditional use for each sub-basin.

4.2.3 FORESTRY

Although forestry is considered an industrial water user, for the purpose of this report it has been separated for analysis. This was done because forestry is a highly visible water user in the Basin, and a considerable economic driver. The forestry industry in the Peace River watershed is highly regulated by the Alberta Ministry of Forestry and Parks (AFP). Because of this almost all water licenses for forestry require that forestry operations report their return flows, losses, and consumption. This data is stored in the AFETUW database like all other sectors. An extremely high proportion (99.37%) of the total water allocation for the Peace basin report their water use, indicating the current use data for this sector is highly reliable, and will be used.

Water use in the forestry industry has declined since the 1980s (Natural Resources Canada 2009; Alberta Water Council 2017) through technological innovation. The large amount of progress made in the industry already presents a challenge for decreasing water use further (AFPA 2015). Therefore, it is assumed the forest sector at its present operating capacity will maintain its current water use, with the potential for marginal decreases in consumption. In short, there is not projection scenario for the forestry sector.

4.2.4 INDUSTRIAL

As mentioned previously the industrial sector of the Peace basin is dominated by oil and gas activity. Metal and mineral mining and power generation are also present in the basin, but to a far lesser extent. Current water use figures for the industrial sector are from the AFETUW database. Although a low proportion of the total allocation reports a full breakdown of consumption, losses, and return flows, it is high enough to be considered satisfactory. In addition to projecting the future water use of the industrial sector, a method for projecting the future water use of hydraulic fracturing was also developed.

4.2.4.1 OIL AND GAS

Historical data for the oil and gas sector's water use is not available through AFETUW, as such future projections for water use must be made based on metrics for which data is available. Bitumen production is closely tied to the water use of the oil & gas sector, as many extraction and processing methods rely on water. Using data made available from the AER (2023) on historic in situ bitumen production for the peace river oil sands future estimates for oil and gas water use can be made. Calculating the year-over year change in bitumen production since 2018, then multiplying this value by current oil & gas sector water use, and the number of years in the projection horizon will return estimates for future water use. Although this projection will be made with the best available data it is focused on in situ projects, an upstream oil and gas method, and therefore my not truly represent the oil and gas sector's future water use.

4.2.4.1.1 HYDRAULIC FRACTURING

Hydraulic fracturing is included in current and future projections for the oil and gas sector. However, in response to the concerns surrounding the water use of fracking a separate, more specific method was developed to project the water use of only this unconventional oil and gas method. The AER does not track water use for fracking in only the Peace Basin, but fracking water use trends are tracked for the Woodbend Group by the AER (2024). The Woodbend Group is a sedimentary basin that underlies a large area of Alberta, and much of the Peace Basin (Alberta Geological Survey 2020). The Woodbend Group includes the Duvernay formation, the area in the peace Basin where fracking is most prominent. Using the total water use trend of the Woodbend group, the average year-over-year change in water use was calculated and used to estimate the future water use of fracking in each relevant sub-basin, using a base year of 2015.

4.2.4.2 MINERALS AND METAL MINING

For the Peace basin little information exists on the water use of mineral and metal mines. Water use reporting for this sub-sector is miniscule and a lack of historical data exists on the water needs of this sub-sector. Most mining operations in the Peace Basin are extracting coal, which is considered a fossil fuel like oil and gas (Shafiee and Topal 2009). In place of more accurate information on the water use of mineral and metal mines, the same methodology used to project future oil and gas water use will be used to project the future water use of the Peace's mineral and metal mines.

4.2.4.3 POWER GENERATION

Because currently there is only one operating power plant in the Peace basin holding a water allocation, projections of water use in this sub-sector are highly unreliable. Thus, no method to project water use was developed for power generation. This however does not mean water use for power generation will not increase, as there are three new power plants planned in the Basin. But it is impossible to know what quantity of water these plants may use until their owners / operators apply for water licenses.

4.3 WATER DEMAND ANALYSIS

A scenario-based analysis based upon water licensing and consumption demand by sector will conclude each sub-basin analysis to project water consumptive demand to 2030, 2040 and 2050 under changing conditions. The framework is presented in Table 13 below.

Table 13. Water demand scenarios.

Water Licence and Consumption Demand	**Sector**
200% Increase (HIGH)	Municipal, Commercial, Agriculture, Forestry, Industrial and Management
100% Increase	Municipal, Commercial, Agriculture, Forestry, Industrial and Management
75% Increase (MEDIUM)	Municipal, Commercial, Agriculture, Forestry, Industrial and Management
50% Increase	Municipal, Commercial, Agriculture, Forestry, Industrial and Management
25% Increase (LOW)	Municipal, Commercial, Agriculture, Forestry, Industrial and Management
Current (Base)	Municipal, Commercial, Agriculture, Forestry and Industrial and Management

Accompanying these results will be a spreadsheet allowing MPWA to change variables based upon discussions about current and future issues. The power of this tool to conduct sensitivity analyses under changing conditions should provide added benefit for forecasting and predicting water demand changes over time. Figure 17 represents the cyclical and interdependent nature of water demand between the sectors and the various levels of demand provided in the water demand scenarios.

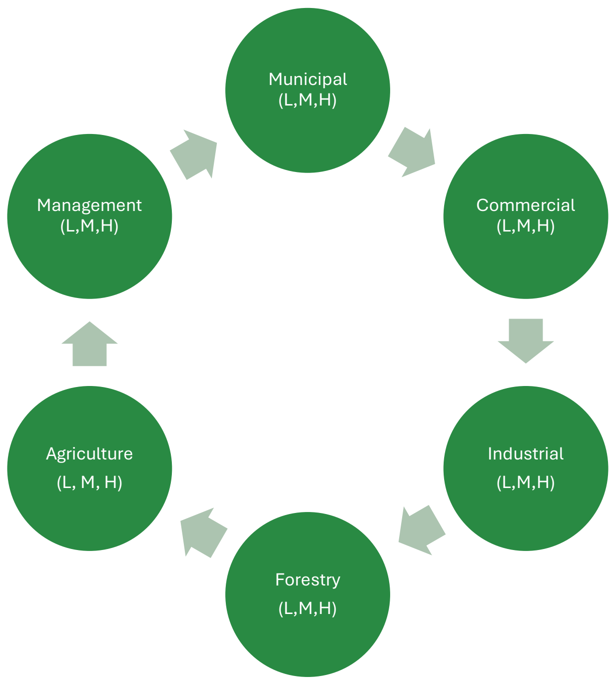


Figure 17. Interactions for water consumption by sector.

5.0 SMOKY / WAPITI RIVER SUB-BASIN

The Smoky and Wapiti sub-basin aligns with the Water Survey of Canada sub-basins 07G (Water Survey of Canada 2024) and consists of lands draining into either the Smoky or Wapiti Rivers above the confluence of the Peace River. Of the six sub-basins of the Peace River watershed, this is the most populated, primary due to the city of Grande Prairie and the communities surrounding the city. Municipal districts include Greenview No. 16, County of Grande Prairie No. 1, and Smoky River No. 130 (Alberta Municipal Affairs 2024). In the southern portion of the sub-basin this includes the mountain community of Grande Cache and the activities along Highway 40; the eastern communities of Fox Creek, Little Smoky, Valleyview, Calais, and Debolt; the western communities of Beaverlodge, Hythe, La Glace, Sexsmith; and the communities around Grande Prairie, including Clairmont, Dimsdale, Flyingshot Lake and Grovedale. Indigenous communities in the sub-basin include Horse Lakes First Nation and Sturgeon Lake First Nation. This section will explore the environmental dimensions, human dimensions, sector analysis and economic models of water use in this sub-basin.

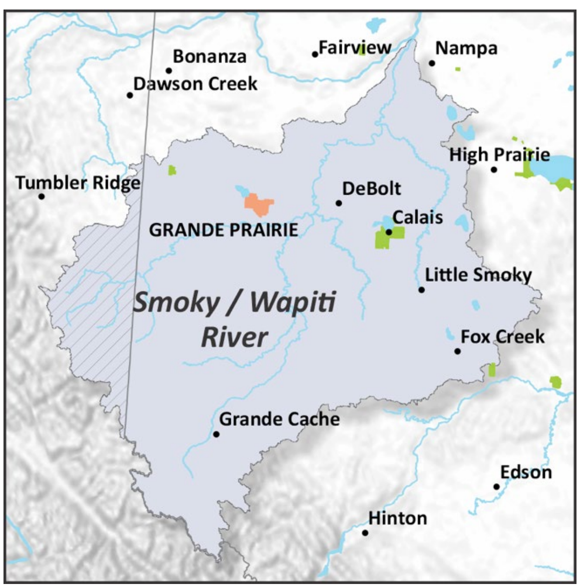


Figure 18. Smoky River and Wapiti River sub-basin of the Peace River watershed.

5.1 PHYSICAL GEOGRAPHY

The southernmost sub-basin in the watershed, the Smoky / Wapiti sub-basin, is the second largest sub-basin with an area of roughly 46,600 km^2, characterized by many different land uses that rely on a diverse physical geography. Many of Alberta's natural regions are represented in the Smoky / Wapiti sub-basin: boreal forest and foothills make up the largest portion, with Rocky Mountain and parkland contributing also (Alberta Parks 2015). Arising from this diversity are many animal and plant species that call the Smoky / Wapiti sub-basin home, they include but are not limited to North American Beavers, Ospreys, Aspen trees, low-bush cranberry, and brittle prickly cactus. The waters that support this biodiversity and human activity start in the rock mountain natural region and feed the Smoky River. In addition to the flow of these headwater the Smoky is also fed by smaller tributaries like the Sheep and Lignite creek, the Sulphur, south Kawa, Muskeg, Muddywater, and Cutbank Rivers. The eastern flows of the Smoky and its tributary network connect with the flows of the Wapiti River just east of Grande Prairie, where it is also met with the Simonette River. During its journey the waters of the Wapiti River is fed by tributaries as well like the Iroquois and Pipestone creeks, the Narraway, Bear, and Redwillow rivers. Then with increasingly larger volumes of water and greater force the Smoky River flows northward, gaining more water from the Puskwaskau and Bad Heart rivers. This force culminates with the Mighty Peace River east of Grimshaw, and just south of the town of Peace River with its flows entering a new river-sub-basin. In addition to these rivers, there are many lakes in the Smoky / Wapiti sub-basin, with large lakes situated primarily in areas of lower elevation. These lakes include Saskatoon Lake near Grande Prairie, Kimiwan, Bear, La Glace, Sturgeon, Snipe, and Losegun Lake by Fox Creek. The average flow range is provided in Figure 19 at Peace River, Alberta.

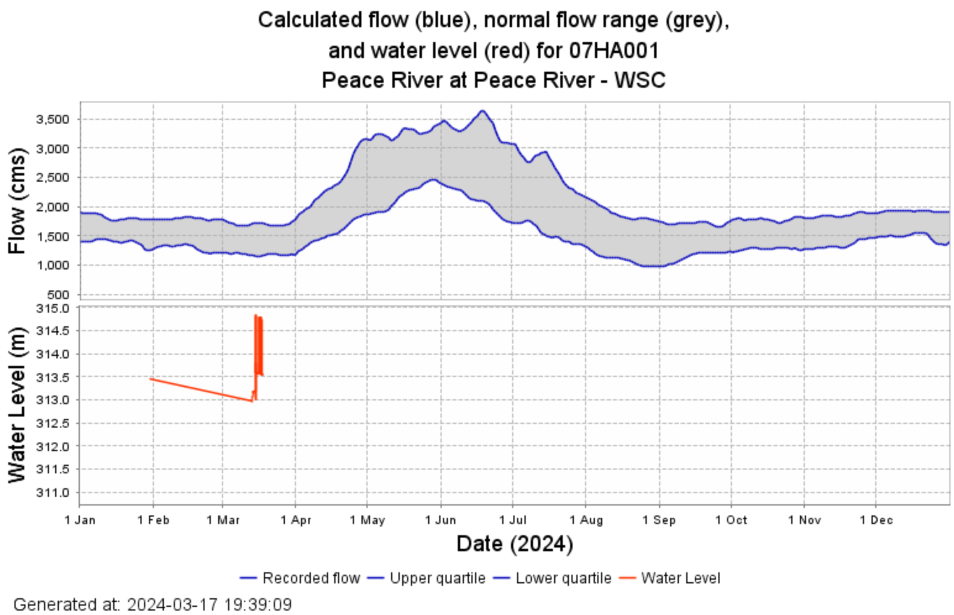


Figure 19. Calculated and normal flow range for the at the Smoky confluence with the Peace River at Peace River, retrieved March 17, 2024 from AEPA.

5.2 SECTOR BASED PROJECTIONS

5.2.1 MUNICIPAL AND COMMERCIAL

The Smoky / Wapiti sub-basin has an urban population of 69,449, a rural population of 35,629, and accounts for 62.20% of the total population in the entire Peace basin. The primary commercial center of the Smoky / Wapiti sub-basin is the City of Grande Prairie, but commercial activities can be found throughout the sub-basin in areas such as Grande Cache and Beaverlodge.

Table 14. Human population trends in the Smoky / Wapiti River sub-basin of the Peace River watershed (Source: Statistics Canada).

	2001	2006	2011	2016	2021
Urban Municipality	42,921	53,061	61,500	68,917	69,449
Rural Municipality	15,638	17,929	20,347	35, 227	36,629
Indigenous	1,210	1,407	1,588	1,969	1,816

Total	59,769	72,397	83,435	106,113	106,897

Current Water Use

As outlined in the methods, current water use estimates for the municipal and supporting commercial and management sectors were derived from the Alberta Flow Estimation Tool for Ungauged Watersheds (AFETUW). In Table 15 the current consumption, total allocation, and percentage of allocation consumed from surface and ground water sources is shown.

Table 15. Water consumption, allocated volume, and percentage used for the municipal, commercial and management sectors of the Smoky / Wapiti River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent Consumed
Municipal	**11,398.88**	**23,980.52**	**47.54%**
Surface Water	9,503.88	25041.11	37.95%
Ground Water	1,895	4,339.41	43.68%
Commercial	**1509.75**	**1643.35**	**91.87%**
Surface Water	1111.23	1235.91	89.91%
Ground Water	398.52	407.45	97.81%
Total	***12908.63***	***25623.87***	***50.38%***
Management	**207.89**	**11378.77**	**1.83%**
Surface Water	203.70	11374.58	1.79%
Ground Water	4.19	4.19	100.00%

Current water use data from the AFETUW database shows that in the Smoky / Wapiti sub-basin 23,980.52 dam^3 is allocated for municipal purposes, while only 11,398.88 dam^3 is consumed from both surface and ground water sources. For the commercial sector 1,643.35 dam^3 is currently allocated, but only 1,509.75 dam^3 is consumed. The management sector of the Smoky / Wapiti represents the smallest water use consuming 207.89 dam^3, or only 1.83% of their allocation. Overall water consumption in this sub-basin is almost exactly half the volume of water allocated for municipal and commercial uses. This data also shows that the Smoky / Wapiti River sub-basin has the highest combined water use of the commercial and municipal sectors in the entire Peace River watershed.

Projected Future Water Use

Using the projection methods for the municipal and commercial sectors, which are based on average year over year population growth in the Peace River watershed, future water use was projected on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. The results of this projection for the Smoky / Wapiti sub-basin can be seen in Table 16, these estimates represent water use from both surface and groundwater sources.

Table 16. Future water use projection in the Smoky / Wapiti for water use consumption in the municipal and commercial sectors in dam^3.

Sector	2024	2030	2040	2050
Municipal	11,398.88	11,625.93	12,004.34	12,382.76
Commercial	1,509.75	1,539.82	1,589.94	1,640.06

The projection of the Smoky / Wapiti sub-basin's future municipal and commercial water use indicates that water use will increase, but the increases in water needs arising from population growth will be quite small. For instance, this projection indicates that in 2050 12,382.76 dam^3 will be consumed by the municipal sector, representing an increase in 983.88 dam^3. As this sub-basin currently has the highest population in the Peace basin its commercial and municipal sectors will experience the greatest increases in water consumption. It is also likely that this projection overestimates future water use as the prevalence of water efficient appliances in the home and workplace increases. Given that current municipal and commercial allocations in this sub-basin consume 50.38% of their allocation currently, it is expected the proportion of water use will remain the same for each planning horizon, and allocations for municipal and commercial use will be double actual use.

5.2.2 FORESTRY

Major forestry operations in the Smoky / Wapiti sub-basin include the International Paper pulp mill, West Fraser Panel Board plant, and the Weyerhaeuser Sawmill. This sub-basin has some of the most forestry activity in the entire Peace basin. Current water use and allocation data for the forestry sector was derived from the AFETUW database and can be seen in Table 17. This data showed that forestry in the Smoky / Wapiti sub-basin is currently allocated to use 40,899.99 dam^3, the second highest sector allocation in the sub-basin, but are only consuming 4,464.34 dam^3 or 10.92% of their allocation. Most of the forestry sector's water use in this sub-basin is from surface water sources, specifically the Wapiti and Muskeg Rivers. Additionally, this sub-basin has the second highest forestry water allocation in the Peace River watershed, approximately 30,000 dam^3 below forestry water allocations in the Central Peace sub-basin.

Table 17. Current forestry sector water use, allocation volume and percent used for the Smoky / Wapiti Sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent consumed
Forestry	**4,464.34**	**40,899.99**	**10.92%**
Surface Water	4,262.34	40,697.99	10.47%
Ground Water	202.01	202.01	100%

5.2.3 AGRICULTURE

Current Water Use

During the last agricultural census, the Smoky / Wapiti sub-basin had 1,709 farms with land in crops, with 1,710,893 acres in crops making up 44.09% of cropland in the Peace River watershed. In addition to this there were an estimated 143,680 cattle, 109, 118 swine, 688, 280 poultry, 36,714 turkeys, 3,473 horses and ponies, and 5,974 bison among other animals. Overall, the Smoky / Wapiti sub-basin has a very strong agricultural presence and is a primary agricultural region in the Peace basin.

Because only a very small portion of agricultural users report their water use to the relevant authority, as outlined earlier alternative methods for estimate the current use of both irrigation and livestock water use were employed. Table 18 provides the current estimates in the Smoky / Wapiti River sub-basin, the estimated current water consumption for both irrigation and livestock can be seen, in addition to the current traditional and other water use as reported by the AEFTUW.

Table 18. Current agriculture sector water consumption, allocation volume, and percent used for the Smoky / Wapiti River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent used
Irrigation	**1,881.10**	**1,667.14**	**112.83%**
Surface Water	-	1,648.51	-
Ground Water	-	18.63	-
Livestock	**3,024.79**	**1,793.31**	**168.67%**
Surface Water	-	1,102.94	-
Ground Water	-	690.37	-
Total	**4,905.89**	**3,460.45**	**141.77%**
Traditional use & Other*	**2,515.48**	**2,520.83**	**99.79%**
Surface Water	1,299.00	1,303.92	**99.62%**

Ground Water	1,216.48	1,216.92	**99.96%**

**Other includes gardens and greenhouses, and aquaculture.*

Estimates of irrigation and livestock water use show that in the Smoky / Wapiti River sub-basin both agricultural practices are likely consuming more than their total allocation. Irrigation in the sub-basin is consuming 12.83% or 213.89 dam^3 more than their allocation while livestock are consuming 68.67% or 1,231.46 dam^3 more. However, these figures represent water use for irrigation and livestock in the entire sub-basin, and because traditional users consume water for these same purposes it is likely that this over consumption can be attributed to traditional use. Because traditional agricultural users are exempt from water licenses if they divert less than 6.25 dam^3 a year many irrigators or livestock farmers do not hold allocations, thus consumption is above the allocated use. The extent to which traditional use accounts for livestock and irrigation overconsumption is unknown. Livestock and irrigation water use in the Smoky / Wapiti sub-basin consumed 4,905.89 dam^3 in total, making these two activities the third largest water users in the sub-basin. Traditional and other water use in this basin is the highest in the entire watershed, currently holding 2,520.83 dam^3 in water diversion priority.

Projected Future Water Use

Using the estimated current water consumption of irrigation and livestock projections of future water use were made on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. These projections were based on historical changes in irrigation acres, and cattle stocking rates. A reminder that traditional and other agricultural water use is not projected, because water registrations are no longer awarded, and there is a high degree of unreliability in projecting other agricultural water use. The results of these projects for the Smoky / Wapiti River sub-basin are provided in Table 19 for both surface and groundwater sources.

Table 19. Projected future water use for agriculture in the Smoky / Wapiti River sub-basin in dam^3.

Sector	2024	2030	2040	2050
Irrigation	1,881.09	2,208.41	2,753.93	3,299.45
Livestock	3,024.79	3,133.68	3,315.17	3,496.66

Although approximate the results indicate that by 2030 water use for irrigation will increase by 327.31 dam^3, and water use for livestock will only increase by 108.89 dam^3. A similar but greater change is estimated for 2050, where irrigation water needs are projected to increase by 1,418.35 dam^3, and livestock water use by only 471.87 dam^3. While the exact water use of these sectors will vary from these projections, the likelihood they capture a trend in the growing water needs of both irrigation and livestock is high. With water use for agriculture expected to increase in the Smoky / Wapiti sub-basin, so too will water allocations for this sector.

5.2.4 INDUSTRIAL

Current Water Use

The Smoky / Wapiti River sub-basin has an extensive industrial sector, and major areas of industrial activity include Grande Prairie, Fox Creek, and Grande Cache. Oil and gas dominate the industrial sector of the sub-basin, but both mining and power generation are also present to a lesser extent. Major industrial companies operating the Smoky / Wapiti River sub-basin include STH Resources Limited, Pembina Pipeline Corp., and Cenovus Energy Inc. Current water use estimates for the industrial sector of this sub-basin are derived from the AFETUW database, in addition to current sector allocations. The current industrial sector surface and groundwater use of the Smoky / Wapiti River sub-basin is in Table 20 and is stratified by oil and gas, mining, and power generation activity.

Table 20. Current Industrial sector water use, allocation volume, and percent used for the Smoky / Wapiti sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent used
Oil & Gas*	**52,488.64**	**52,726.32**	**99.55%**
Surface Water	39,899.16	40,136.84	99.41%
Ground Water	12,589.48	12,589.48	100%
Mining	**3,237.73**	**3,248.41**	**99.67%**
Surface Water	2,920.87	2,920.87	100%
Ground Water	316.86	327.54	96.74%
Power	**12,345.68**	**12,345.68**	**100%**
Surface water	12,345.68	12,345.68	100%
Total	***68,072.04***	***68,320.41***	***99.64%***

**Includes hydraulic fracturing*

Current water use figures indicate that the industrial sector in the Smoky / Wapiti sub-basin is the highest water user in the sub-basin by a very large margin, consuming 68,072.05 dam^3, or 99.64% of their allocation. Representing the largest share of this water use is oil and gas water use which is allocated for 52,726.32 dam^3 and consuming 52,488.64 dam^3. Industrial sector water consumption in the Smoky / Wapiti sub-basin represents 88.51% of total industrial water consumption for the entire Peace River watershed. Surface water makes up the largest proportion of water use for the industrial sector in the smoky / Wapiti sub-basin.

Projected Future Water Use

Using data on the historical bitumen production of the Peace River oil sand, future water use for oil and gas and mining activity in the Smoky / Wapiti River sub-basin was projected on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. These projections are based on current water use as reported by the AFETUW database and can be seen below in Table 21, for both surface and groundwater sources.

Table 21. Projected future Industrial sector water use for the Smoky / Wapiti sub-basin in dam^3.

Sector	2024	2030	2040	2050
Oil & Gas	52,488.64	60,094.36	72,770.55	85,446.75
Mining	3,237.73	3,706.89	4,488.81	5,270.74

The results of this projection indicate that industrial sector water use is expected to increase considerably for each projection horizon. These estimates show that in 2050 oil and gas water use will be 62.79% higher than currently. Allocations for industrial sector use in the Smoky / Wapiti sub-basin are expected to increase following this projection curve also given the current high utilization of water allocations in the sub-basin. This sub-basin has the most oil and gas activity in the Peace River watershed, and because of this the projected future water use in this sector is very high. Given the pace at which the industrial sector operates the potential that water consumption of the oil and gas sector in 2040 will reach 72,770.55 dam^3 is probable. Water use for mining is also expected to increase, and in 2040 is projected to be 4,488.81 dam^3. Increases in this sub-sector represent an expansion of mining operations in the sub-basin.

As these projections are only estimates, true water uses for the industrial sector of the Smoky / Wapiti River sub-basin will likely differ. But given the current state of the sector water use will likely follow this upward trend. It should be noted however that although oil and gas operations are highly prevalent in the Smoky / Wapiti River sub-basin, economic diversification in the region may lead to a decrease in fossil fuel industrial activity, thereby decreasing future water use; but the extent and timing of this phenomenon is uncertain.

5.2.4.1 HYDRAULIC FRACTURING

Current Water Use

Current figures for fracking are included in water use for the oil and gas sector in Table 22 above, here water use for only hydraulic fracturing has been extracted from those figures for a separate analysis. Current fracking water use for the Smoky / Wapiti sub-basin is provided in Table 22 and derived from the AFETUW database.

Table 22. Current Industrial sector water use for hydraulic fracturing, allocation volume, and percent used for the Smoky / Wapiti River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent Consumed
Hydraulic Fracturing	**39,093.04**	**39,098.02**	**99.99%**
Surface Water	30,457.71	30,462.68	99.98%
Ground Water	8,635.33	8,635.33	100%

Current water use estimates indicate the Smoky / Wapiti sub-basin has the highest water allocations for hydraulic fracturing in the Peace basin, accounting for 98.29% of fracking allocations. Fracking water use in this sub-basin makes up 74.48 % of total oil and gas water use in the sub-basin. Currently 39,098.02 dam^3 is allocated from fracking in this basin, with the majority coming from surface water sources. Additionally, utilization of water allocations for fracking amount to 99.99%, meaning virtually all the water allocated for fracking in this basin is being used.

Projected Future Water Use

Using data on historical fracking water use for the sedimentary basin that underlies the Peace region future water use projections were made on 6-year (2030), 16-year (2040), and 26-year (2050) horizons for the Smoky / Wapiti sub-basin. The results of these projection are found in Table 23.

Table 23. Projected future Industrial sector water for the Smoky / Wapiti River sub-basin in dam^3.

Sector	Current consumption (2024)	2030	2040	2050
Fracking	39,093.04	44,991.29	54,821.72	64,652.15

The projection estimates that by 2030 water use for fracking will amount to 44,991.297 dam^3, and in 2040 54,821.72 dam^3. Out of the total oil and gas water use, fracking requires the largest portion, which is expected to remain relatively the same through the future, with fracking amounting to 75.33% of oil and gas water use in 2040. While actual future water use will vary it is highly likely that given current trends in the Smoky / Wapiti River sub-basin and advancements in fracking technology that increase extraction yields, water use for fracking will follow this upward trend.

5.3 WATER DEMAND SCENARIOS

Water use in the Smoky-Wapiti River sub-basin is dominated by agriculture, municipal and industrial demand. Figures 20 and 21 present this information by comparing the current (2024) licenced and consumed water in the sub-basin by the sectors licenced by the AEPA – agriculture, municipal, commercial, forestry, industrial and management. Data consistently indicates that consumption is lower than the licenced use, though agriculture and industrial consumption meets the licenced volume. Underutilized licenced water use can allow a “complacency of abundance”, and therefore it is useful to project changing demand scenarios to anticipate and plan for changes into the future. The five increased demand scenarios allow a range of differences from 2030, 2040 and 2050 to be considered.

Results from the surface water demand analysis indicate that it would require nearly a 100% increase in total water consumed across sectors to meet the 2024 licenced volume (Figure 20). This gap is positive in terms of conservation of water in the sub-basin and is unexpected to change in the short term (2030) even with increased municipal demand (population growth), moderate agriculture expansion and industrial demand. Forecasting further into the future is more challenging but is unlikely to change projecting out to 2040 or 2050 based upon previous trends. However, the 200% increase scenario does highlight the volume that it would take overcome current licence demands.

Groundwater licencing and consumptive data is also provided in Figure 21. Results trend in the same direction as freshwater demand and indicate that there remains a comfortable gap between consumed water use and licenced water use in the sub-basin. However, in the Smoky Wapiti basin, current issues such increased demand for agricultural water use arising from climate change scenarios and industrial fracking activity poses risk to groundwater resources, and therefore should be carefully reviewed into the future—particularly as agriculture and industrial water consumption match licenced use.

Figures 20 and 21 represent aggregate increases in demand. In reality, the changing demands with be sector specific and may vary significantly. As such, the dataset and accompanying model have been provided to MPWA to conduct a sensitivity analysis—to change variables based upon expected trends and revise based upon sector increases (or decreases) in demand.[12]

[12] The various permutations are many and therefore are not presented in this report; this information can be provided upon request by PRC staff.

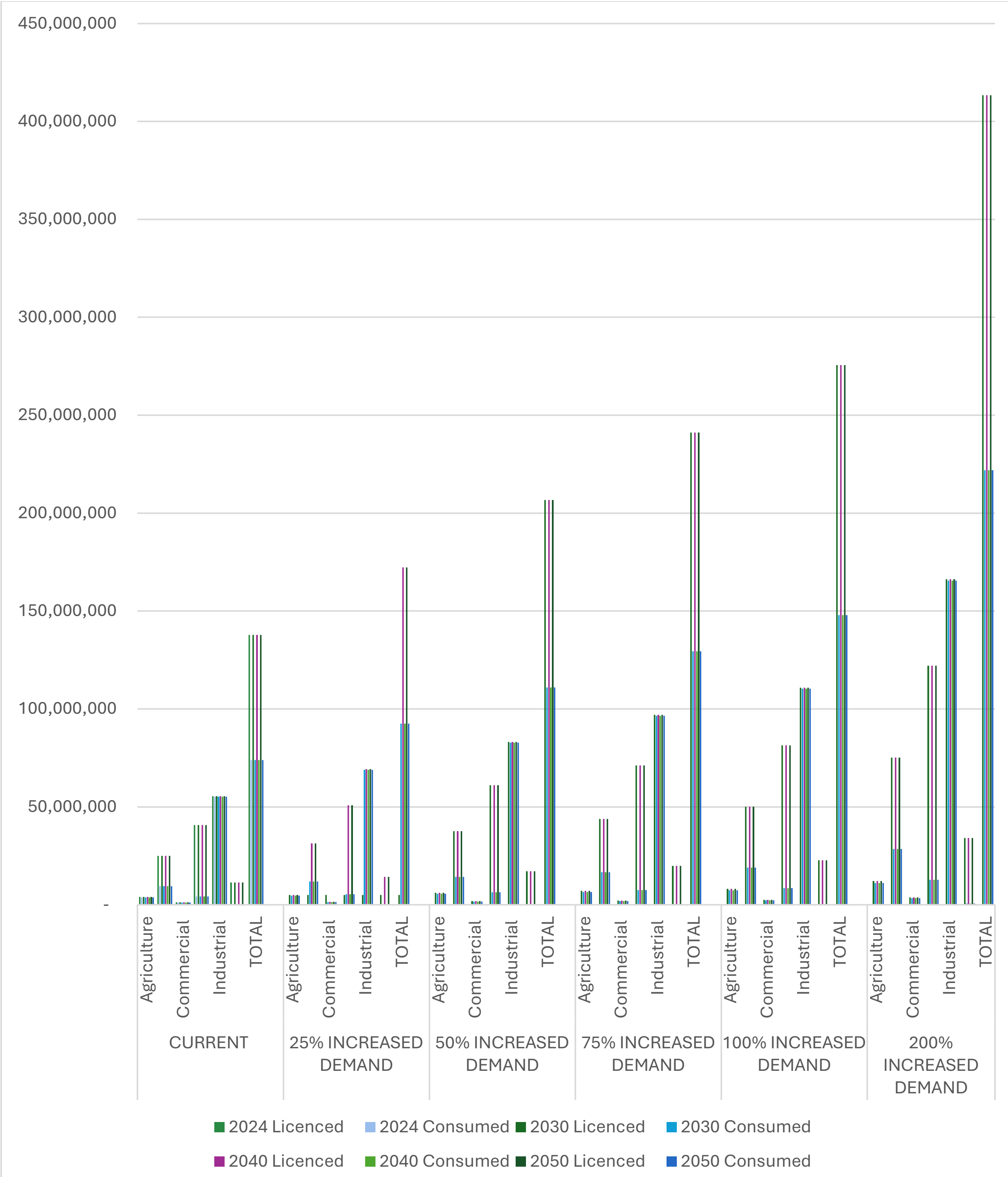


Figure 20. Surface water volume licenced and consumed by sector in the Smoky / Wapiti River sub-basin of the Peace River watershed under changing demand scenarios over time.

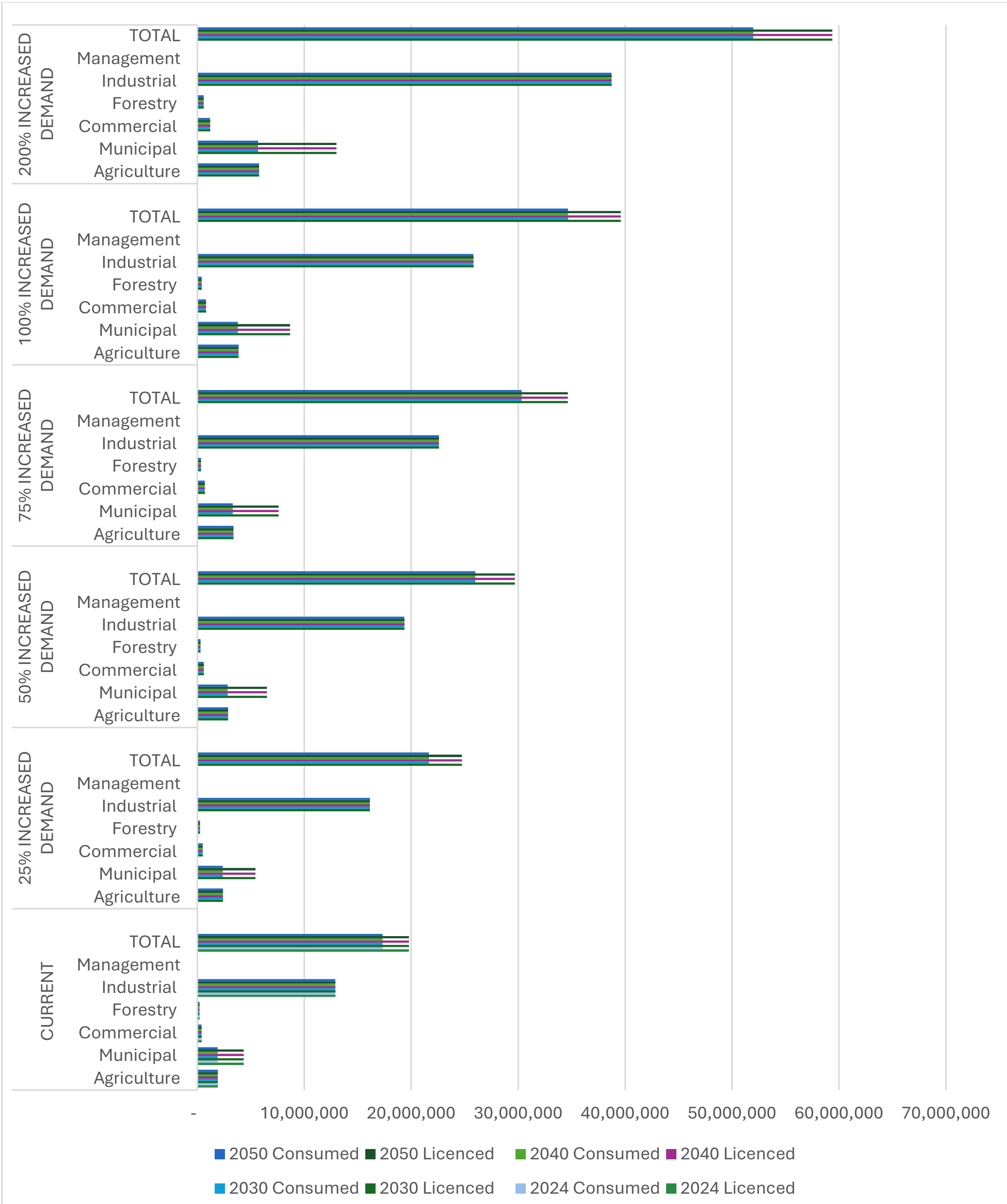


Figure 21. Groundwater volume licenced and consumed by sector in the Smoky / Wapiti River sub-basin of the Peace River watershed under changing demand scenarios over time.

5.4 HIGHLIGHTS

High Water Allocation and Use: Among the sub-basins the Smoky / Wapiti is the most highly allocated, and has the highest water use in the region. For the entire basin water allocations amount to 152,204.3 dam^3 and water use to 93,073.9 dam^3, meaning 61.15% of the total allocation is consumed. This large volume of water that is both allocated and used is due in part to two main factors. The industrial sector of the Smoky / Wapiti accounts for the highest water allocation and use in the sub-basin, and at a watershed level the second highest sector allocation. The large share the industrial sector makes up is expected given the extent of oil and gas activity in the Smoky / Wapiti. Secondly, Municipal and Commercial water allocation and use are highest in this sub-basin; again, this was expected given this is the most densely populated sub-basin in the watershed.

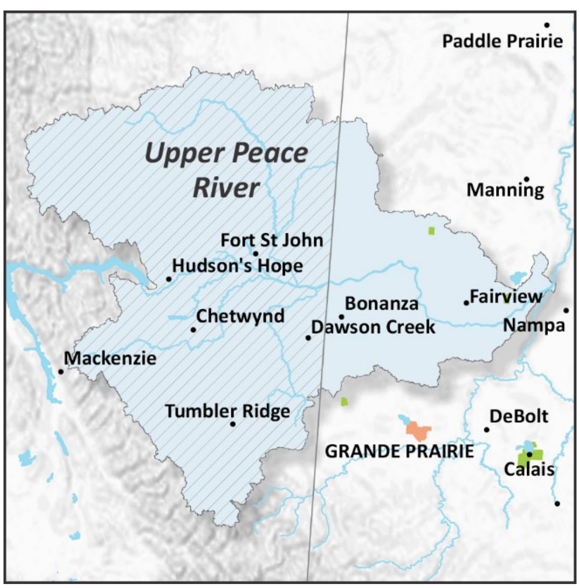
Agricultural Water Use: Agricultural water use for both irrigation and livestock watering combined amounted to 4,905.9 dam^3, or 41.77% more than what is currently allocated. Despite this however agricultural has the smallest sectoral water use in the Smoky / Wapiti sub-basin. While this does not represent an issue currently, if water restrictions were to be placed on this sub-basin, agricultural water users that do not hold licenses and therefore no priority to water may experience negative effects.

Future Oil and Gas Water Use: The future water use of oil and gas activity in the industrial sector is projected to increase greatly on all projection horizons, with water use for fracking consistently making-up a large share of this use. By 2050 it is projected that oil and gas water use will amount to 85,446.8 dam^3, with fracking making up 75.66% of this use. Based on this projection oil and gas water use in the Smoky / Wapiti sub-basin will be the single largest water use and water allocation holder in the Peace watershed. Renewable energy, exhaustion of oil and gas resources, or government regulation may however curb some growth of the sector and subsequently water use by this time.

Water Demand Scenarios: The range of increased surface and groundwater demand scenarios indicates the range of increased water consumption for the Smoky / Wapiti River sub-basin and indicate that total surface water consumption would have to increase to nearly 100% across all sectors to meet the 2024 licenced allowance. The accompanying model will allow MPWA to test various hypothesis of demand increases.

6.0 UPPER PEACE RIVER SUB-BASIN

The Upper Peace River sub-basin consists of the land that surround Williston Lake that drain into the Peace River directly above the town of Peace River in Alberta and align with the Water Survey of Canada sub-basin 07FD (Water Survey of Canada 2024). As a portion of the sub-basin is outside of Alberta, MPWA's responsibilities only fall to the portion inside the province. These lands are part of Treaty 8 and cover the territory of the Dane-zaa and Sekani (Tsay Key Dene) First Nations. On the British Columbia side of the sub-basin, settlements include Fort St. John, Hudson's Hope, Chetwynd, Tumbler Ridge and Dawson Creek. The Alberta portion of the sub-basin is more sparsely populated, municipal districts include Peace No. 135, Saddle Hills County and the southern portion of Clear Hills County (Alberta Municipal Affairs 2024). Settlements such as Bay Tree, Gordondale, Blueberry Mountain, Spirit River, Hines Creek, Rycroft, Fairview, Brownvale and Grimshaw. One of the historic Treaty 8 signings in 1899 was held in this sub-basin at Dunvegan Bridge, on the shore of the Peace River. This section will explore the environmental dimensions, human dimensions, sector analysis and economic models of water use in the Alberta portion of this sub-basin[13].



[13] Note that this report does not review the British Columbia portion of the watershed, which is outside the jurisdiction of the MPWA.

Figure 22. Upper Peace River sub-basin of the Peace River watershed in both Alberta and British Columbia.

6.1 PHYSICAL GEOGRAPHY

As the smallest sub-river basins in the Alberta portion of the Peace River watershed, the Upper Peace River sub-basin covers an area of around 17, 550 km^2 which includes three of Alberta's natural regions: boreal forest, foothills, and parkland (Alberta Parks 2015). Despite its size the region supports forestry with its large lodgepole pine and spruce forest stands. Diverse climate, topography, and land cover support this sub-basin's great diversity; species such as the red necked phalarope, wood frogs, walleye, and snowshoe hare. The waters of the Upper Peace basin are essential to all this life and human activity in the sub-basin. The Peace River flows eastward past Fort St. John, above the Alces river and across the B.C border and into Alberta. From here it is fed by many tributaries like the Montagneuse, Hamelin, Ksituan, and Saddle Rivers. It flows under the Dunvegan Bridge, past Elk Island campsites and Grimshaw just before converging with the Smoky River and entering the Central Peace River sub-basin. In addition to these watercourses there are a small number of lakes in the Upper Peace, of note are George and Gerry lakes. Figures 23 and 24 show the flow range for this portion of the river above the Alces River and at Peace River, Alberta.

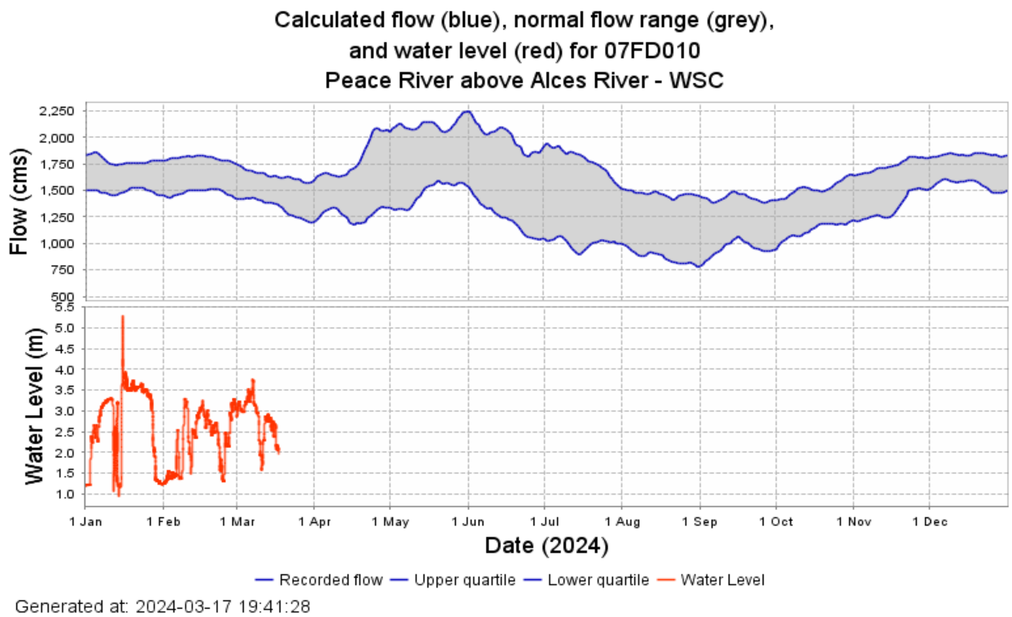


Figure 23. Calculated and normal flow range for Upper Peace River basin above Alces River, retrieved March 17, 2024 from AEPA.

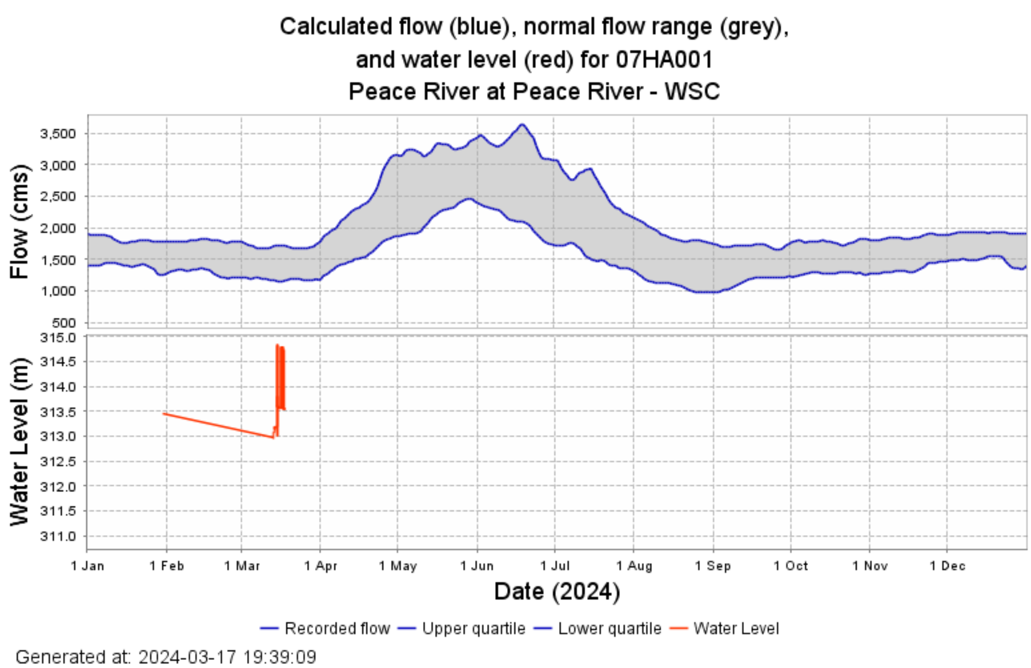


Figure 24. Calculated and normal flow range for Upper Peace River basin at Peace River Alberta, retrieved March 17, 2024 from AEPA.

6.2 SECTOR BASED PROJECTIONS

6.2.1 MUNICIPAL AND COMMERCIAL

Current Water Use

The Upper Peace River sub-basin has an urban population of 7,262, a rural population of 6,924, and accounts for 8.32% of the total population in the Peace River watershed. The primary commercial center of the sub-basin is the town of Peace River, but commercial activities can be found throughout the sub-basin.

Table 24. Human population trends in Upper Peace River sub-basin of the Peace River watershed (Source: Statistics Canada).

	2001	2006	2011	2016	2021
Urban Municipality	2,872	7,486	7,253	7,514	7,262
Rural Municipality	7,144	6,604	6,762	6,847	6,924
Indigenous	121	102	164	150	111
Total	10,137	14,192	14,179	14,511	14,297

Current water use estimates for the municipal and supporting commercial and management sectors were derived from the Alberta Flow Estimation Tool for Ungauged Watersheds (AFETUW). In Table 25 the current consumption, total allocation, and percentage of allocation consumed from surface and ground water sources is shown.

Table 25. Water consumption, allocated volume, and percentage used for the municipal, commercial and management sectors of the Upper Peace River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent Consumed
Municipal	**1,553.68**	**4,375.00**	**35.51%**
Surface Water	900.22	3,627.79	24.81%

Ground Water	653.46	747.21	87.45%
Commercial	**808.63**	**880.39**	**91.85%**
Surface Water	701.30	765.38	91.63%
Ground Water	107.33	115.01	93.32%
Total	***2,362.31***	***5,255.39***	**44.95%**
Management	**681.96**	**3,403.14**	**20.04%**
Surface Water	681.96	3,403.14	20.04%
Ground Water	0	0	-

Current water use data from the AFETUW database shows that in the Upper Peace sub-basin 4,375.01 dam^3 is allocated for municipal purposes, while only 1,553.68 dam^3, or 35.51% is consumed from both surface and ground water sources. Commercial allocations amount to 880.39 dam^3, and 91.85% or 808.63 dam^3 is consumed. Allocations for management are more than the commercial sector at 3,403.14 dam^3, but only 681.96 dam^3 is consumed. Municipal and supporting sector water consumption in this basin is just below half the volume of current water allocations. Current use data also shows that the percentage municipal and commercial sectors are consuming of their allocation is similar to the most populated sub-basin; the Smoky / Wapiti.

Projected Future Water Use

Using the projection methods for the municipal and commercial sectors, which are based on average year over year population growth in the Peace River watershed, future water use was projected on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. The results of this projection for the Upper Peace River sub-basin can be seen in Table 26, these estimates represent water use from both surface and groundwater sources.

Table 26. Future water use projection in the Upper Peace River sub-basin for the municipal and commercial sectors in dam^3.

Sector	2024	2030	2040	2050
Municipal	1,553.68	1,584.63	1,636.20	1,687.78
Commercial	808.63	824.74	851.58	878.43

The projection of the Upper Peace River sub-basin's future municipal and commercial water use indicates that water use will increase as the Peace basin's population increases. This increase will be small however, with consumption in 2040 being less than 100 dam^3 more than current use. A similar trend is evident for the commercial sector, which by 2050 will experience a projected ~78 dam^3 increase in water use. As with the municipal and commercial sectors of other sub-basins, the total allocation for these sectors is higher than actual use, a persistent theme for the entire watershed.

6.2.2 FORESTRY

The only major forestry operation in the Upper Peace River sub-basin is the Zavisha Sawmill near Hines Creek. This forestry operation, or other minor operations that may be operating in the sub-basin do not hold any water allocations. Sawmills typically do not use high volumes of water, explaining why forestry sector water use and allocation in the Upper Peace River sub-basin amount to 0 dam^3. It should be mentioned that if a water-intensive forestry operation were to move into the basin water allocations for forestry would then exist in the Upper Peace River sub-basin. However, the likelihood of this would occur is unknown, and what volumes of water these operations would consume is dependent on many factors and therefore cannot be estimated.

6.2.3 AGRICULTURE

The last Canadian agricultural census reported the Upper Peace River sub-basin had 1,110 farms with land in crops, with 1,099,710 acres in crops making up 28.34% of cropland in the peace basin for this year. In addition to cropped agriculture there were an estimated 88,581 cattle, 3,632 swine, and 2,620 horses and ponies, and small inventories of other livestock inventories. Overall, the Upper Peace River sub-basin has a relatively robust agricultural presence and is a primary agricultural region in the Peace River watershed.

Current Water Use

Because only a very small portion of agricultural users report their water use to the relevant authority, as outlined earlier alternative methods for estimate the current use of both irrigation and livestock water use were employed. The estimated current water consumption for both irrigation and livestock is provided in Table 27, in addition to the current traditional and other water use as reported by the AEFTUW.

Table 27. Current agriculture sector water consumption, allocation volume, and percent used for the Upper Peace River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent used
Irrigation	**1,209.11**	**1,388.75**	**87.07%**
Surface Water	-	1,388.74	-
Ground Water	-	0	-
Livestock	**1,625.26**	**928.89**	**174.97%**
Surface Water	-	860.06	-
Ground Water	-	68.83	-
Total	**2,834.37**	**2,317.64**	**122.30%**
Traditional use and Other*	**1,138.51**	**1,150.84**	**98.93%**

Surface Water	977.79	990.12	98.75%
Ground Water	160.72	160.72	100.00%

**Other includes gardens and greenhouses, and aquaculture.*

Estimates of irrigation and livestock water use show that in the Upper Peace River sub-basin livestock agricultural practices are likely consuming more than its total allocation by 696.37 dam^3, or 74.97%. Irrigation in the Upper Peace sub-basin is consuming 87.07% of its allocation, for a total of 1,209.11 dam^3 in water consumption. However as arising earlier from allocation over-use, the figures for livestock water use may be made up in part by traditional agricultural water use. Under the *Water Act* traditional users are allowed to consume 6.25 dam^3 yearly while only holding a registration, this may account for over-consumption in the livestock sub-sector. However, the extent to which traditional use explains this result is uncertain.

Livestock and irrigation water use in the Upper Peace sub-basin consumed 2,834.37 dam^3 in total, making cropped and livestock agriculture the largest water user in the Upper Peace sub-basin. Traditional and other water use in this basin is also comparatively high to the other sub-basins, amounting to 1,138.51 dam^3.

Projected Future Water Use

Using the estimated current water consumption of irrigation and livestock projections of future water use were made on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. These projections were based on historical changes in irrigation acres, and cattle stocking rates. A reminder that traditional and other agricultural water use is not projected, because water registrations are no longer awarded, and there is a high degree of unreliability in projecting other agricultural water use. The results of these projects for the Upper Peace River sub-basin are provided in Table 28 for both surface and groundwater sources.

Table 28. Projected future agriculture water use for the Upper Peace River sub-basin in dam3.

Sector	2024	2030	2040	2050
Irrigation	1,209.11	1,419.50	1,770.14	2,120.78
Livestock	1,625.26	1,683.77	1,781.29	1,878.80

The projection indicates that both water use for irrigation and livestock will both increase, with irrigation seeing the largest growth. This projection forecast indicates that water used for irrigation will nearly double by 2050, while livestock water use stays relatively stable seeing only an increase of 253.54 dam^3 by the same year. The Upper Peace sub-basin has seen considerable growth in its agricultural sector over the last two census periods, and with this growth comes continued increases in water use for the sector. Registrations and the ability to divert water under traditional use creates a high chance for future allocations and actual water use to be dissimilar, as it is currently.

6.2.4 INDUSTRIAL

Current Water Use

The Upper Peace sub-basin has a small industrial sector, major areas of industrial activity include the Hines Creek area and Grimshaw. Oil and gas almost completely dominates the industrial sector of the sub-basin, mining is present, but these operations do not hold any water allocations in the sub-basin. Canadian Natural Resources Ltd. Is one of the few major industrial companies operating in the Upper Peace River sub-basin. Current water use estimates for the industrial sector of the Upper Peace River sub-basin were derived from the AFETUW database, in addition to current sector allocations. The current industrial sector surface and groundwater use is provided in Table 29.

Table 29. Current Industrial sector water use, allocation volume, and percent used for the Upper Peace River sub-basin in dam3.

Sector	Consumption	Total Allocation	Percent used

Oil & Gas*	**1,509.29**	**1,525.32**	**98.95%**
Surface Water	1,160.94	1,176.97	98.64%
Ground Water	3,48.35	348.35	100%
Total	***1,509.29***	***1,525.32***	***98.95%***

**Includes hydraulic fracturing*

Current water use figures indicate that the industrial sector in the Upper Peace sub-basin is the third highest water user in the sub-basin, consuming 1509.29 dam^3, or 98.95% of their allocation. This water use is represented entirely by oil and gas activity. Surface water makes up the largest proportion of this use, accounting for 1,160. 94 dam^3 or 76.92% of total water consumption.

Projected Future Water Use

Using data on the historical bitumen production of the Peace River oil sands, future water use for oil and gas activity in the Upper Peace sub-basin was projected on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. These projections are based on current water use as reported by the AFETUW database and are provided in Table 30, for combined surface and groundwater sources.

Table 30. Projected future Industrial sector water use for the Upper Peace River sub-basin in dam^3.

Sector	Current consumption (2024)	2030	2040	2050
Oil & Gas	1,509.29	1,727.99	2,092.49	2,456.99

The results of this projection indicate that industrial sector water use is expected to increase marginally for each projection horizon. These estimates show that in 2040 oil and gas water use will be 38.64% higher than currently. Given the high allocation utilization of the industrial sector in this sub-basin currently, it is likely that this upward trend in water use will persists. These projections indicate that despite its small share of current water allocations in the sub-basin, future water use for the industrial sector is expected to rise.

The true future water increases in the sub-basin may be lower than projected if current fossil fuel resources are partially or fully exhausted over time or become more difficult to extract.

6.2.4.1 HYDRAULIC FRACTURING

Current Water Use

Current fracking water use for the Upper Peace sub-basin is shown in Table 31 and was separated for analysis from the oil and gas sector AFETUW data. Current water use estimates show the Upper Peace sub-basin has only a small amount of water allocated for hydraulic fracturing, amounting to 630.43 dam^3, or 41.77% of the total oil and gas water use in the Upper Peace. Most water used for fracking in the Sub-basin is obtained from surface water sources, and nearly the total allocation of water from these sources is used.

Table 31. Current Industrial hydraulic fracturing sector water use, allocation volume, and percent used for the Upper Peace sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent used
Fracking	**630.43**	**632.43**	**99.68%**
Surface Water	430.83	432.83	99.54%
Ground Water	199.60	199.60	100%
Total	***630.43***	***632.43***	***99.68%***

Projected Future Water Use

Using data on historical fracking water use for the Woodbend Group sedimentary basin that underlies the Peace River region future water use projections were made on 6-year (2030), 16-year (2040), and 26-year (2050) horizons for the Upper Peace River sub-basin. The results of these projection are found in Table 32.

Table 32. Projected future Industrial hydraulic fracturing sector water use for the Upper Peace sub-basin in dam^3.

Sector	Current consumption (2024)	2030	2040	2050
Fracking	630.43	725.54	884.07	1,042.60

The results show that by 2030 water use for fracking will amount to 725.54 dam^3, and in 2040 884.07 dam^3. Fracking will continue to make up a similar proportion of total oil and gas water use throughout all projection horizons. Given the Upper Peace River sub-basin lies on the edge of the sedimentary basin suitable for fracking, there are chances for fracking activity in the basin to increase. But as with all other oil and gas activity resources may become exhausted, or new technology will be developed making extraction more viable, ultimately creating high variability in future fracking water use.

6.3 WATER DEMAND SCENARIOS

Water use in the Upper Peace River sub-basin is dominated by agricultural demand. Figures 25 and 26 presents sectoral water use information by comparing the current (2024) licenced and consumed water in the sub-basin by the sectors licenced by the AEPA—agriculture, municipal, commercial, forestry, industrial and management. Data consistently indicates that consumption is lower than the licenced use, though agriculture and industrial consumption meets the licenced volume. Underutilized licenced water use can allow a "complacency of abundance", and therefore it is useful to project changing demand scenarios to anticipate and plan for changes into the future. The five increased demand scenarios allow a range of differences from 2030, 2040 and 2050 to be considered.

Results from the surface water demand analysis indicate that it would require nearly a 150% increase in total water consumed across sectors to meet the 2024 licenced volume (Figure 25). This gap is positive in terms of conservation of water in the sub-basin and is unexpected to change in the short term (2030) even with moderate agriculture expansion and industrial demand. Forecasting further into the future is more challenging but is unlikely to change projecting out to 2040 or 2050 based upon previous trends. However, the 200% increase scenario does highlight the volume that it would take overcome current licence demands.

Groundwater licencing and consumptive data is also provided in Figure 26. Results trend in the same direction as freshwater demand and indicate that there remains a comfortable gap between consumed water use and licenced water use in the sub-basin. However, in the Upper Peace River sub-basin, current issues such increased demand for agricultural water use arising from climate change scenarios and industrial fracking activity poses risk to groundwater resources, and therefore should be carefully reviewed into the future—particularly as agriculture and industrial water consumption match licenced use.

Figures 25 and 26 represent aggregate increases in demand. In reality, the changing demands will be sector specific and may vary significantly. As such, the dataset and accompanying model have been provided to MPWA to conduct a sensitivity analysis—to change variables based upon expected trends and revise based upon sector increases (or decreases) in demand.[14]

[14] The various permutations are many and therefore are not presented in this report; this information can be provided upon request by PRC staff.

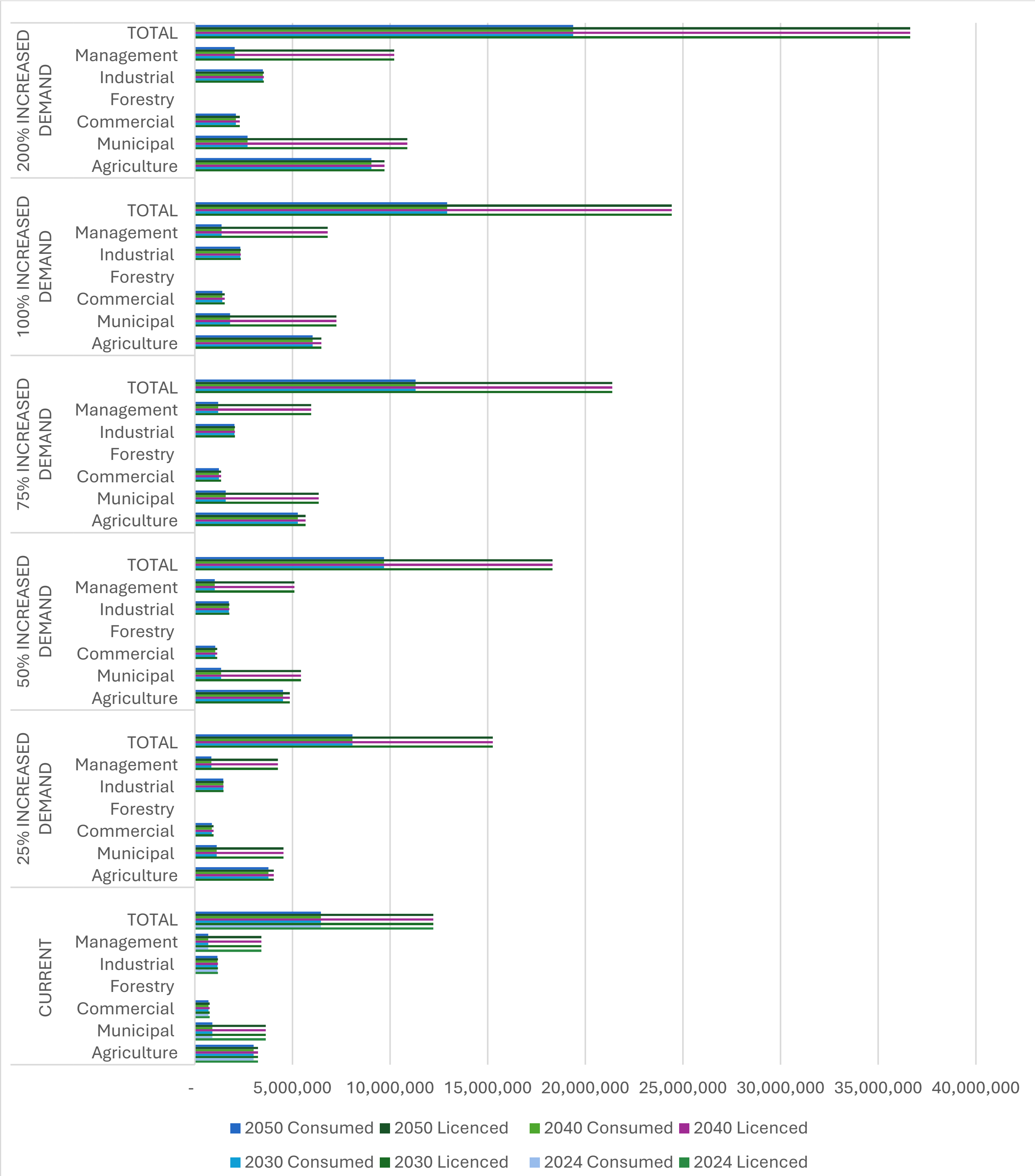


Figure 25. Surface water volume licenced and consumed by sector in the Upper Peace River sub-basin of the Peace River watershed under changing demand scenarios over time.

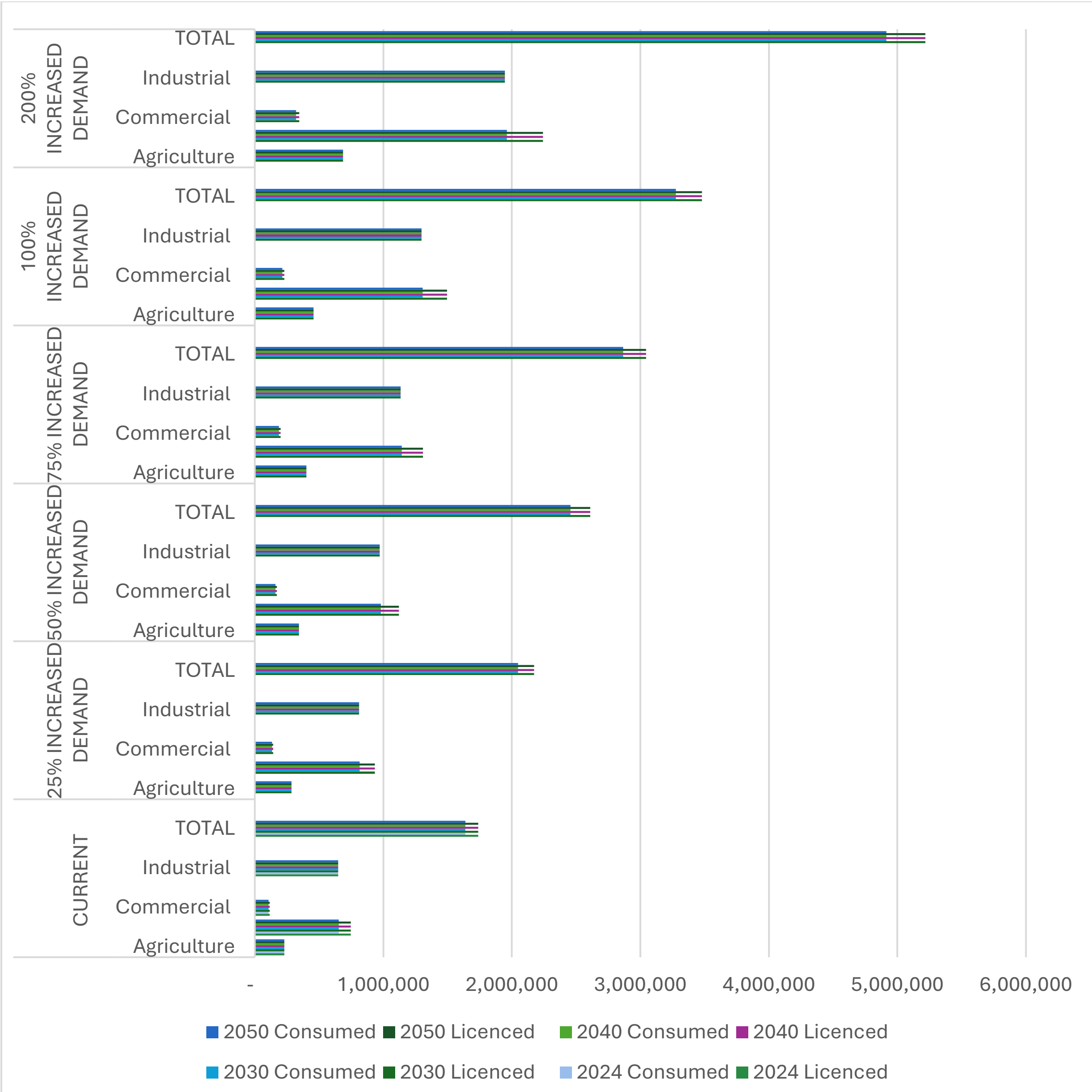


Figure 26. Groundwater volume licenced and consumed by sector in the Upper Peace River sub-basin of the Peace River watershed under changing demand scenarios over time.

6.4 HIGHLIGHTS

Current Agricultural Water Use: Water use for the agricultural sector of the Upper Peace sub-basin is estimated to exceed the current volume allocated by 22.3%. This is due to estimated livestock use exceeding the volume it is currently allocated by 696.4 dam^3. While this does not represent an issue now, this overuse may become a challenge if water restrictions were ever placed on the Upper Peace River sub-basin, as some agricultural water use would be restricted to ensure those who hold priority enact their right to water under the *Water Act*.

Small Usage Volume: The water use in the Upper Peace River sub-basin is quite small. The municipal, commercial, forestry, agricultural, and industrial sectors water use do not exceed 2,500 dam^3 in any single sector. This is likely due in part to the very small size of the Alberta portion of the Upper Peace sub-basin.

Surface water Use: Most water use in this sub-basin comes from surface water sources, with water use from ground water sources amounting to only a small portion of total water use in the sub-basin.

Water Demand Scenarios: The range of increased surface and groundwater demand scenarios indicates the range of increased water consumption for the Upper Peace River sub-basin and indicate that total surface water consumption would have to increase to nearly 200% across all sectors to meet the 2024 licenced allowance. The accompanying model will allow MPWA to test various hypothesis of demand increases.

7.0 CENTRAL PEACE RIVER SUB-BASIN

The Central Peace sub-basin aligns with the Water Survey of Canada sub-basin 07H (Water Survey of Canada 2024) and consists of lands that drain into the Peace River downstream from the confluence of the Peace and Smoky River and upstream of Fort Vermilion (Figure 27). From the town of Peace River, the river swings northwards for approximately 400km. Municipal districts include the County of Northern Lights, the western portion of Northern Sunrise County, and a small portion of the Mackenzie County (Alberta Municipal Affairs 2024). Settlements primarily follow Highway 35 and include Peace River, Manning, Notikewin, Hotchkiss, Keg River, the Paddle Prairie Metis Settlement and La Crete. This section will explore the environmental dimensions, human dimensions, sector analysis and economic models of water use in this sub-basin.

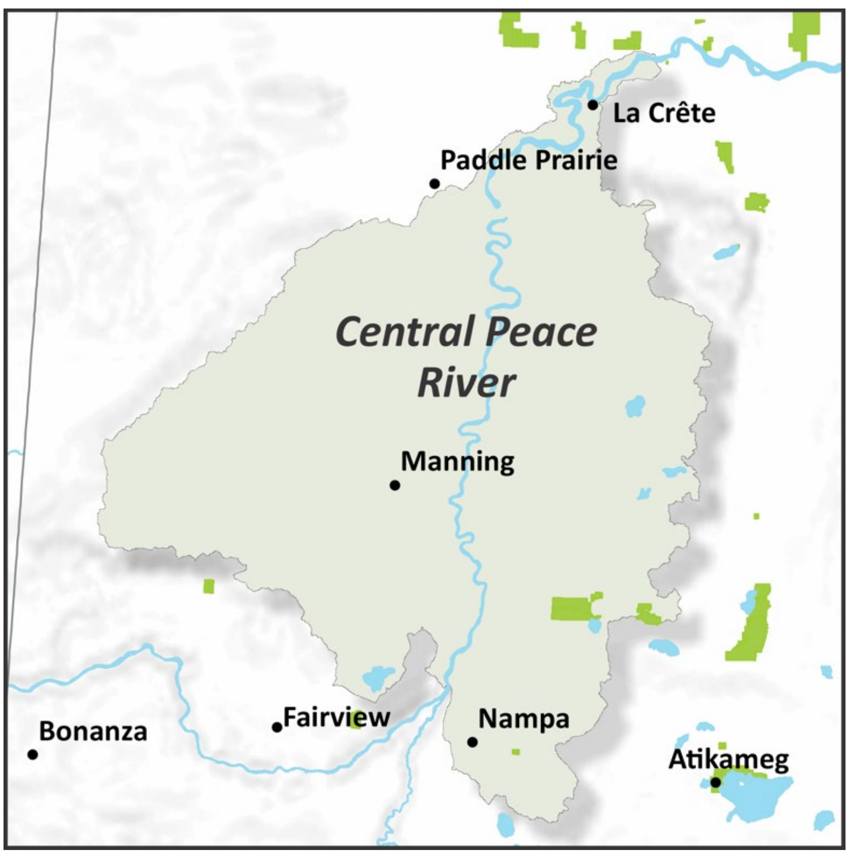


Figure 27. Central Peace River sub-basin of the Peace River watershed.

7.1 PHYSICAL GEOGRAPHY

With an area of 35,000 km^2 the Central Peace River sub-basin consists of largely boreal forest with areas of northern foothills to the west (Alberta Parks 2015). Dominated by aspen forests, moose, least flycatchers, Swainson's thrush, and arctic grayling are some of the many species that can be found in the Central Peace sub-basin. The water of the Central Peace is a vital force in supporting the region's forests, biodiversity and human activities. After the confluence with the Smoky River, the Peace River flows under the aptly named Peace River Bridge and coils northward. Passing east of Manning and Paddle Prairie, the peace increases its volume and force picking up water from tributaries like the Cadotte, Wolverine, and Keg Rivers before passing by La Crete and entering a new sub-basin at Fort Vermillion. There are also some larger lakes in the Central Peace with notable ones including Cadotte and Bison lakes, and Cardinal Lake near Grimshaw. Normal flow ranges at the start of the sub-basin (Peace River) and the terminus of the sub-basin (Fort Vermilion) are provided in Figures 28 and 29.

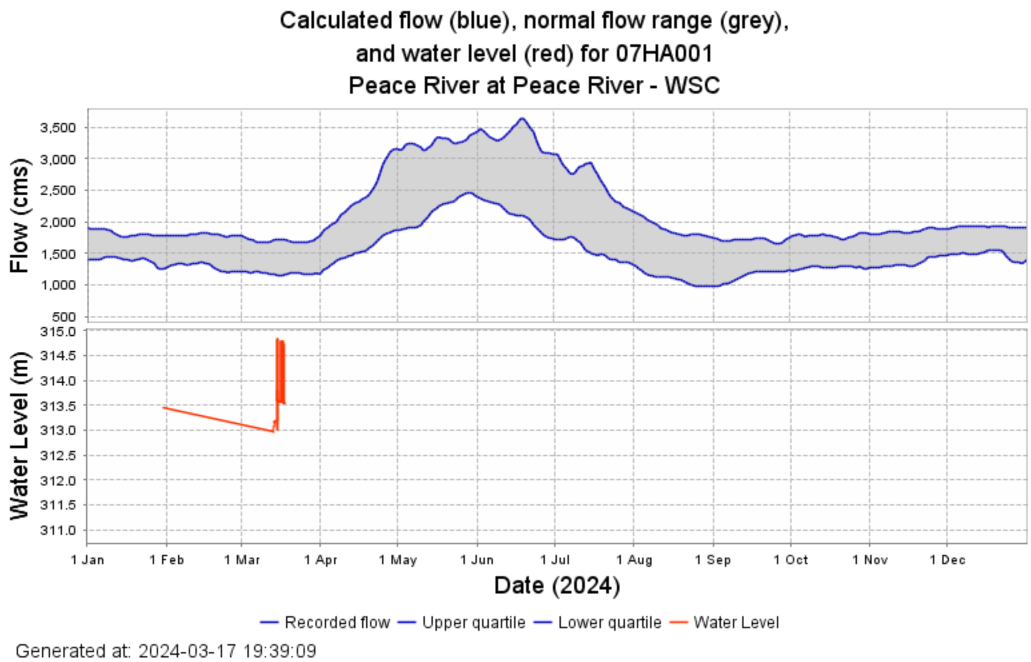


Figure 28. Calculated and normal flow range for Central Peace River basin at Peace River Alberta, retrieved March 17, 2024 from AEPA.

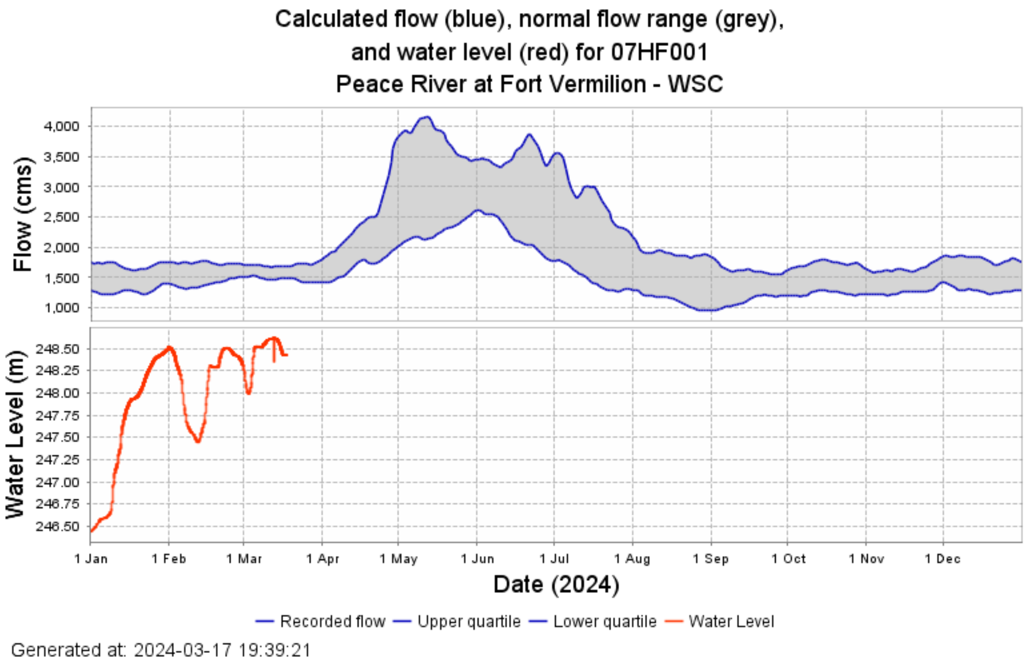


Figure 29. Calculated and normal flow range for Central Peace River basin at Fort Vermilion, Alberta, retrieved March 17, 2024 from AEPA.

7.2 SECTOR BASED PROJECTIONS

7.2.1 MUNICIPAL AND COMMERCIAL

Current Water Use

Central Peace sub-basin has a rural population of 10,678, a small urban population of 1,493, and an indigenous population 846, making up 7.57% of the Peace basin's entire population. The primary commercial center of the Central peace sub-basin is the town of Manning.

Table 33. Human population trends in the Central Peace River sub-basin of the Peace River watershed (Source: Statistics Canada).

	2001	2006	2011	2016	2021
Urban Municipality	1,665	1,853	1,526	1,547	1,493
Rural Municipality	4,217	3,772	4,117	9,809	10,678

Indigenous	514	556	849	843	846
Total	6,396	6,181	6,492	12,199	13,017

Current water use estimates for the municipal and supporting commercial and management sectors were derived from the Alberta Flow Estimation Tool for Ungauged Watersheds (AFETUW). In Table 34 the current consumption, total allocation, and percentage of allocation consumed from surface and ground water sources is shown.

Table 34. Current water consumption, allocated volume, and percentage used for the municipal, commercial and management sectors of the Central Peace River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent Consumed
Municipal	**3,180.46**	**9,513.61**	**33.43%**
Surface Water	2,792.24	8,585.98	32.52%
Ground Water	388.21	927.63	41.85%
Commercial	**155.89**	**195.81**	**79.62%**
Surface Water	131.23	171.14	94.21%
Ground Water	24.67	24.67	100%
Total	***3,336.35***	***9,709.41***	***34.36%***
Management	**149.42**	**2,332.29**	**6.41%**
Surface Water	149.42	2,332.29	6.41%
Ground Water	0	0	-

Water use data from the AFETUW indicates that currently 9,513.61 dam^3 is allocated for municipal purposes, but only 3,180.46 dam^3 is consumed from both surface and ground water sources. In this sub-basin the commercial sector uses a small amount of water, amounting to 155.87 dam^3. Similarly, the management sector uses 149.42 dam^3, or 6.41% of its 2,332.29 dam^3 surface water allocation. Overall water consumption in this sub-basin is quite small compared to the volume of water allocations currently held. This data also shows that the Central Peace River sub-basin has the third highest water uses for both commercial and municipal sectors in the entire Peace basin.

Projected Future Water Use

Future water use projections for the municipal and commercial sectors of the Central Peace River sub-basin are based on average year-over-year population growth in the Peace River watershed. Future water use was projected on 6-year (2030), 16-year (2040), and 26-year (2050) horizons using this method. The results of this projection for the Central Peace River sub-basin can be seen in Table 35, representing future water use from both surface and ground water sources.

Table 35. Future water use projection in the Upper Peace River sub-basin for the municipal and commercial sectors in dam^3.

Sector	2024	2030	2040	2050
Municipal	3,180.46	3,243.81	3,349.39	3,454.98
Commercial	155.90	159.00	164.18	169.35

Expected water use increases in the Central peace basin arising from population growth will be small. By 2050 it is forecasted that municipal water use will increase by 274.52 dam^3 or 8.63%, and commercial water use by only 13.46 dam^3. The Central Peace's population is primarily urban residents, with only a small urban population relying on municipal infrastructure for their water. Small increases in future municipal and commercial water consumption are expected given the population distribution. In fact, all estimated future municipal and commercial water use is below the current allocation volume for both sectors. So, while there will be increases in water use, it is probable they will be very small.

7.2.2 FORESTRY

Major forestry operations in the Central Peace sub-basin include Boucher Bros. Lumber sawmill, Manning Forest Products sawmill, La Crete Sawmill, and Mercer International Kraft Pulp mill. The Upper Peace sub-basin has considerable forestry activity, compared to other sub-basins. Current water use and allocation data for the forestry sector was derived from the AFETUW database, and can be seen in Table 36. This data showed that forestry in the Upper Peace sub-basin is currently allocated to use 70,355.47 dam^3 but are only consuming 37,031.46 dam^3 or 52.65% of their allocation. All the forestry sector's water use in this sub-basin is from surface water sources, especially the Peace River. The great majority of this use is attributed to the Mercer International pulp mill. The Central Peace River sub-basin has the highest forestry water allocation and consumption in the entire Peace River watershed.

Table 36. Current forestry sector water use, allocation volume and percent used for the Central Peace River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent consumed
Forestry	**37,031.46**	**70,355.47**	**52.65%**
Surface Water	37,031.46	70,355.47	52.65%
Ground Water	0	0	-

7.2.3 AGRICULTURE

Current Water Use

According to the most recent agricultural census the Central sub-basin had 369 farms with land in crops, with 447,211 acres in crops making up 11.53% of cropland in the Peace basin. Livestock inventories are primarily made up of cattle in this region with an inventory of 26,985 but also contained 498 horses and ponies. This sub-basin has a small agricultural contribution to the overall sector in the Peace watershed. In Table 37 below for the Central Peace River sub-basin, the estimated current water consumption for both irrigation and livestock can be seen, in addition to the current traditional and other water use as reported by the AEFTUW.

Table 37. Current agriculture sector water consumption, allocation volume, and percent used for the Central Peace River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent used
Irrigation	**491.70**	**1,253.69**	**39.22%**
Surface Water	**-**	1,247.63	-
Ground Water	**-**	6.06	-
Livestock	**486.84**	**632.69**	**76.58%**
Surface Water	-	520.28	-
Ground Water	-	112.41	-
Total	***978.54***	***1,886.38***	***51.87%***
Traditional use and Other*	**591.73**	**1,028.10**	**57.56%**
Surface Water	475.09	911.47	**52.12%**
Ground Water	116.63	116.63	**100.00%**

*Other includes gardens and greenhouses, and aquaculture.

Estimates of irrigation and livestock water use show that in the Central Peace sub-basin both agricultural practices are consuming less than their total allocation. Irrigation is consuming an estimated 491.70 dam^3, or 39.22% of its allocation. And livestock agriculture is consuming 486.84 dam^3, or 76.58% of its total allocation. In total irrigation and livestock water use is 978.84 dam^3, or slight above half the total allocation of these two activities.

Livestock and irrigation water use in the Central Peace sub-basin consumed 978.84 dam^3 in total, making agriculture the smallest water user in the sub-basin. Traditional and other agricultural water use amounted to 591.37 dam^3, representing just over half the total volume of registrations and allocations.

Projected Future Water Use

Using the estimated current water consumption of irrigation and livestock, projections of future water use were made on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. These projections were based on historical changes in irrigation acres, and cattle stocking rates. The results of these projections for the Central Peace River sub-basin can be seen below in Table 38 and are for both surface and groundwater sources.

Table 38. Projected future agriculture water use for the Central Peace River sub-basin in dam^3.

Sector	Current consumption (2024)	2030	2040	2050
Irrigation	491.70	577.26	719.85	862.44
Livestock	486.84	504.37	533.58	562.79

Water use for both irrigation and livestock are expected to increase in the sub-basin, but to varying degrees. The results indicate that by 2030 irrigation will be using 85.57 dam^3 more than currently, while livestock will see increase of only 17.53 dam^3 in the same period. Actual future water use is likely to deviate from these projections, but this captures the small upward trend the in agricultural water use the sub-basin will experience.

7.2.4 INDUSTRIAL

The Central Peace sub-basin has a sizeable industrial sector, with major operations being conducted by Canadian Natural Resources. In addition to oil and gas, there is also a small mining sector present in the sub-basin. Estimates on the current water use of these industrial activities in the Central Peace Sub-basin were derived from the AFETUW database, in addition to current sector allocations. Current water use figures can be seen in Table 39.

Table 39. Current Industrial sector water use, allocation volume, and percent used for the Central Peace River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent used
Oil & Gas	**3,714.79**	**4,666.64**	**79.60%**
Surface Water	3,478.89	4,430.30	78.52%
Ground Water	235.90	236.34	99.81%
Mining	**1,233.20**	**1,233.50**	**99.98%**
Surface Water	1,233.20	1,233.50	99.98%
Ground Water	0	0	-
Total	***4,947.99***	***5,900.14***	***83.86%***

The industrial sector is the second highest water user in the Central Peace sub-basin. Water consumption is primarily due to oil and gas activity representing 3,714.79 dam^3 in water use. While mining activity accounts for 1,233.20 dam^3, or 24.92% of industrial water use in this sub-basin. Total water use for the industrial sector is 4,947.99 dam^3, with most water being diverted from surface sources.

Projected Future Water Use

Future water use for all industrial activity in the Central Peace River sub-basin was projected based on historical bitumen production of the Peace River oil sands. Using current consumption, future water use was forecasted on three projection horizons. The results of this effort are provided in Table 40. Future estimates do not differentiate between surface water and ground water sources.

Table 40. Projected future Industrial sector water use for the Central Peace River sub-basin in dam^3.

Sector	Current consumption (2024)	2030	2040	2050
Oil & Gas	3,714.79	4,253.07	5,150.20	6,047.34
Mining	1,233.20	1,411.89	1,709.72	2,007.54

For both mining and oil and gas activity water use is expected to increase. Future use for oil and gas activity is estimated to reach 4,253.07 dam^3 by 2030, with mining water use increasing also by a smaller quantity. Additionally, by 2050 water use for oil and gas activity will be 62.80% higher than it is now. The total volume of allocations for industrial use in the Central Peace sub-basin will presumably follow this upward trend, allowing water diversion on this scale to proceed. Increased water use for mining activity represents an expansion of the sub-sector in the Central Peace. As this sub-basin falls in the upper to mid-range for industrial activity in the entire Peace basin it is likely these estimates are representative of future trends, as oil and gas and mining look to expand their operations.

7.3 WATER DEMAND SCENARIOS

Water use in the Central Peace sub-basin is dominated by forestry demand. Figures 30 and 31 present sectoral water use information by comparing the current (2024) licenced and consumed water in the sub-basin by the sectors licenced by the AEPA—agriculture, municipal, commercial, forestry, industrial and management. Data consistently indicates that consumption is lower than the licenced use, though agriculture and industrial consumption meets the licenced volume. Underutilized licenced water use can allow a “complacency of abundance”, and therefore it is useful to project changing demand scenarios to anticipate and plan for changes into the future. The five increased demand scenarios allow a range of differences from 2030, 2040 and 2050 to be considered.

Results from the surface water demand analysis indicate that it would require nearly a 110% increase in total water consumed across sectors to meet the 2024 licenced volume (Figure 30). This gap is positive in terms of conservation of water in the sub-basin and is unexpected to change in the short term (2030) even with moderate agriculture expansion and industrial demand. Forecasting further into the future is more challenging but is unlikely to change projecting out to 2040 or 2050 based upon previous trends. However, the 200% increase scenario does highlight the volume that it would take overcome current licence demands.

Groundwater licencing and consumptive data is also provided in Figure 31. Results trend in the same direction as freshwater demand and indicate that there remains a comfortable gap between consumed water use and licenced water use in the sub-basin. However, in the Central Peace River sub-basin, municipal and industrial uses are the dominant groundwater consumers. Current issues such increased demand for municipal sources and industrial hydraulic fracturing activities poses risk to groundwater resources, and therefore should be carefully reviewed into the future— particularly as industrial water consumption matches licenced use.

Figures 30 and 31 represent aggregate increases in demand. In reality, the changing demands with be sector specific and may vary significantly. As such, the dataset and accompanying model have been provided to MPWA to conduct a sensitivity analysis—to change variables based upon expected trends and revise based upon sector increases (or decreases) in demand.[15]

[15] The various permutations are many and therefore are not presented in this report; this information can be provided upon request by PRC staff.

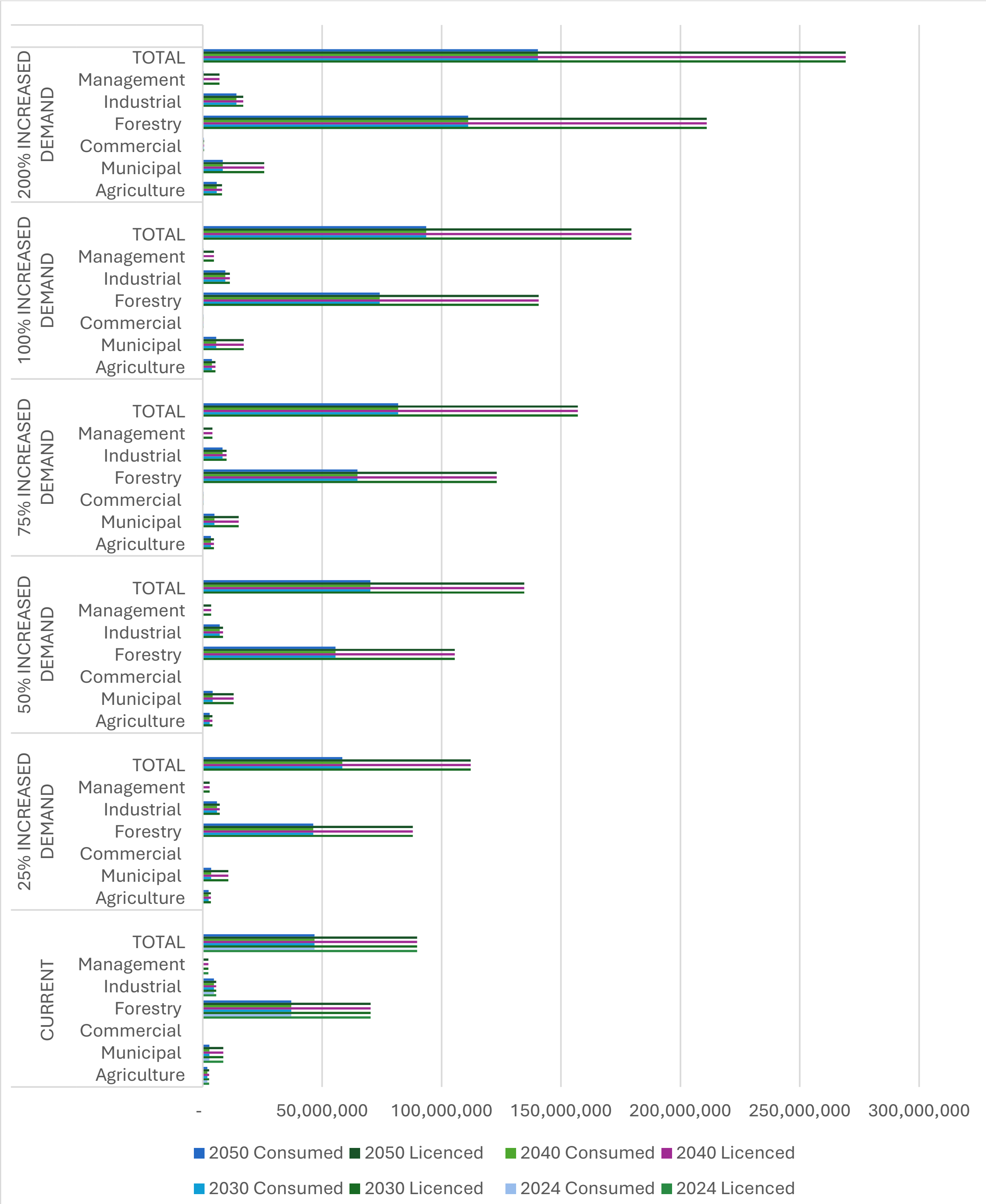


Figure 30. Surface water volume licenced and consumed by sector in the Central Peace River sub-basin of the Peace River watershed under changing demand scenarios over time.

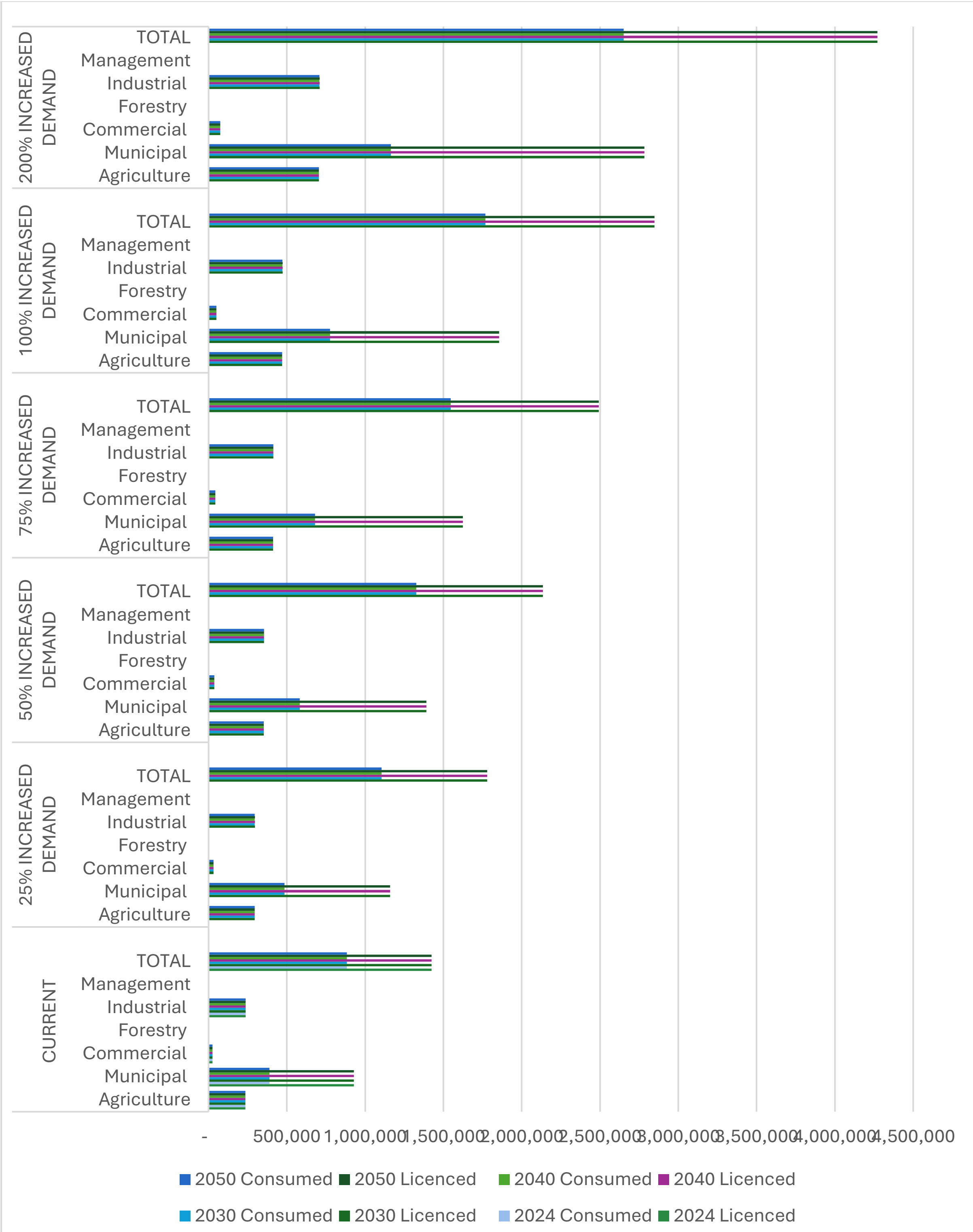


Figure 31. Groundwater volume licenced and consumed by sector in the Central Peace River sub-basin of the Peace River watershed under changing demand scenarios over time.

7.4 HIGHLIGHTS

Forestry Sector Water Use: Water allocations for forestry in the Central Peace sub-basin amount to a total volume of 70,355.5 dam^3 all of which comes from surface water sources (The Peace River). Only about half (52.65%) of this allocation, or 37,031.5 dam^3 of this allocation is consumed, however. The greatest volume of water allocation and use is attributed to the Mercer International pulp mill, with smaller forestry operations contributing a nearly negligible amount. The Peace has the highest forestry water allocation and consumption in the Peace watershed.

Industrial Water Use: Industrial water use in this basin stands out, as the volume of water allocated and subsequent use are high in comparison to other sectors, except for forestry. Oil and gas activity primarily contributes to this, but mining is present and consuming water in the sub-basin as well; 95.23% of this use is from surface water sources.

Municipal and Commercial Water Use: The Central Peace sub-basin has the second highest municipal and commercial water use in the entire Peace watershed, following the Smoky / Wapiti. Current use amounts to 3,336.4 dam^3, however this represents consumption of only 34.36% of the 9,709.4 dam^3 allocation. However, municipal and commercial water use stands as only the third largest water use in this sub-basin.

Future industrial Use: Although current small industrial water use is expected to rise in this sub-basin. Despite this area being on the edge of known oil and gas reserves there is opportunity for oil and gas activity to increase or intensify, with this associated water allocations and use will rise.

Water Demand Scenarios: The range of increased surface and groundwater demand scenarios indicates the range of increased water consumption for the Central Peace River sub-basin and indicate that total surface water consumption would have to increase to nearly 200% across all sectors to meet the 2024 licenced allowance. The accompanying model will allow MPWA to test various hypothesis of demand increases.

8.0 LOWER PEACE RIVER SUB-BASIN

The Lower Peace River sub-basin aligns with the Water Survey of Canada sub-basins 07JF, 07KA, 07KB and 07KC (Water Survey of Canada 2024) and consists of lands that drain into the Peace River downstream of Fort Vermilion and upstream of the confluence with the Slave River. The Peace River swings east again at this point, including the municipal district of Mackenzie County and the central portion of Improvement District No. 24 (Wood Buffalo) (Alberta Municipal Affairs 2024). Settlements include High Level and Indigenous communities situated along Highway 58, such as John D'Or Prairie First Nation and Fox Lake First Nation. The gravel road terminates at Garden Creek at the western edge of Wood Buffalo National Park. Within Wood Buffalo National Park, the historic Peace Point is located upstream of the confluence with the Slave River, where peace was made between the Cree and the Dene-Zaa Indigenous peoples in 1781—and the namesake of the Peace River. This section will explore the environmental dimensions, human dimensions, sector analysis and economic models of water use in this sub-basin.

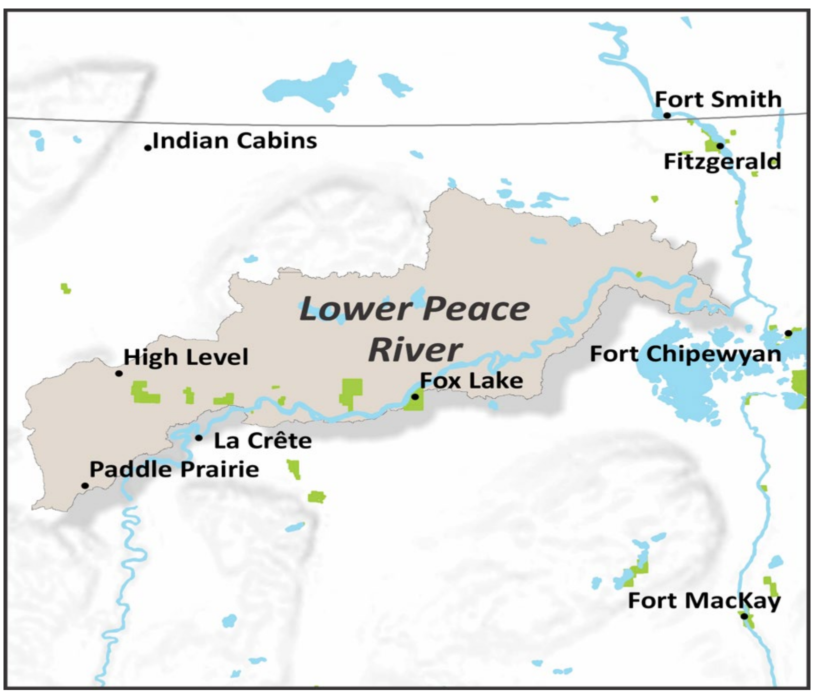


Figure 32. Lower Peace River sub-basin of the Peace River watershed

8.1 PHYSICAL GEOGRAPHY

The Lower Peace River sub-basin covers an area of about 29,000 km^2 as the third smallest sub-basin in the Peace watershed. This sub-basin is the only sub-basin made up of entirely one natural region, the Canadian boreal forest. The central and dry mixed wood natural sub-regions of the Lower Peace are home to aspen and white spruce forests, North American Beavers, Canada buffaloberry, and stairstep moss. The Might Peace River continues to flow passing first by Fort Vermillion, receiving water from many tributaries, then moving eastward by Fox Lake. Some notably tributaries in this sub-basin include the Caribou, Wabasca, Pakwanutik, Jackfish and Claire rivers. With this added water the Peace begins moving slightly more northward, reaching its end at Peace point in Wood Buffalo National Park where it enters the Peace Athabasca Delta (PAD). Figures 33 and 34 present the annual normal flow range for the Peace River at the start of the sub-basin (Fort Vermilion) and the terminus (Peace Point).

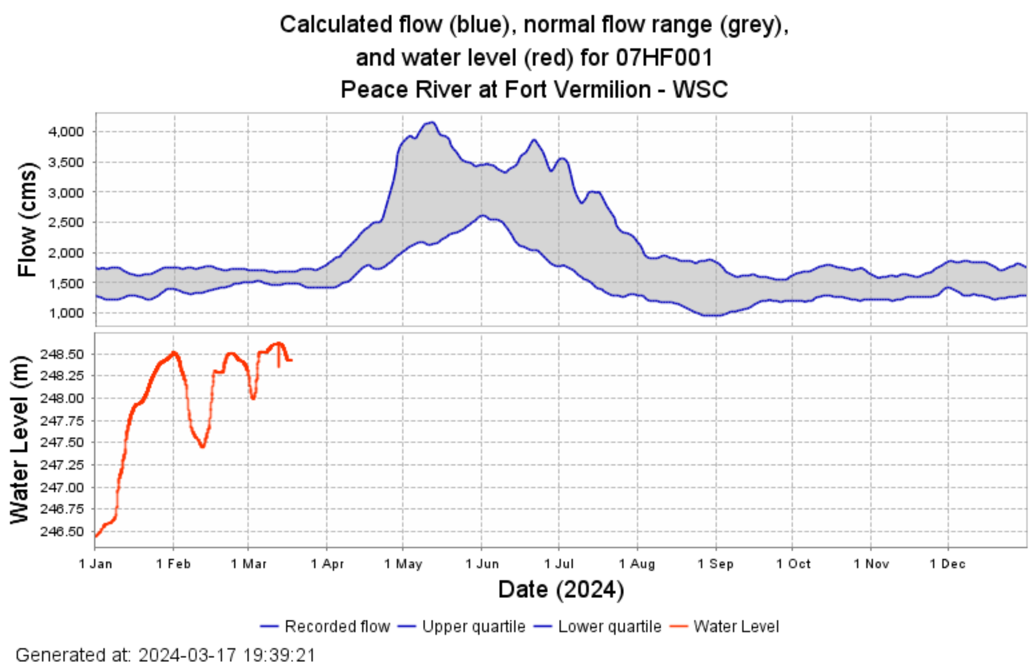


Figure 33. Calculated and normal flow range for Lower Peace River basin at Fort Vermilion, Alberta, retrieved March 17, 2024 from AEPA.

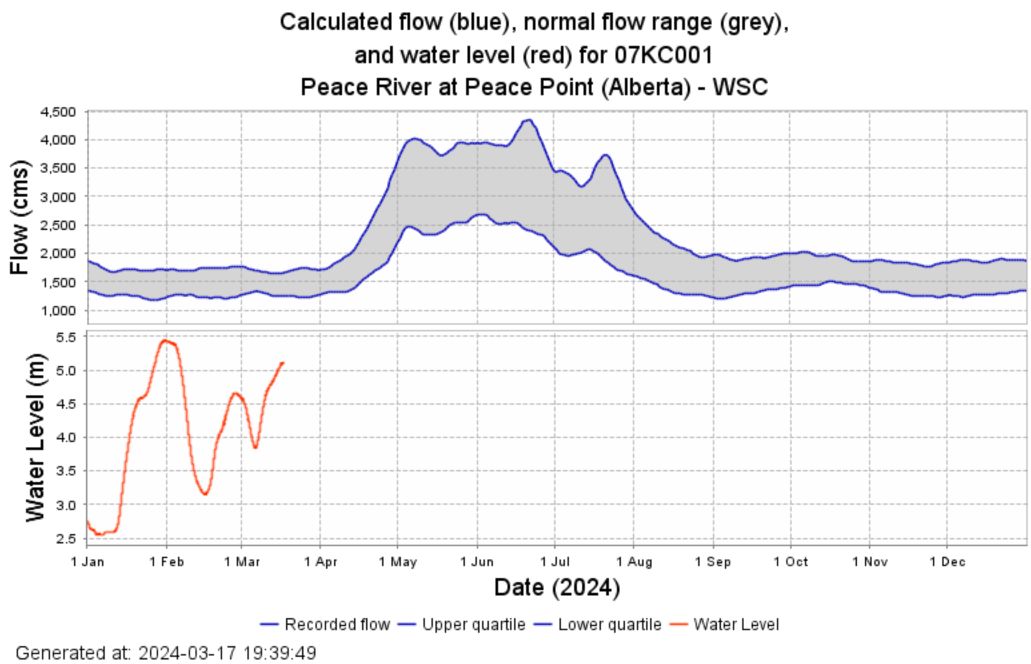


Figure 34. Calculated and normal flow range for Lower Peace River basin at Peace Point, Alberta, retrieved March 17, 2024 from AEPA.

8.2 SECTOR BASED PROJECTIONS

8.2.1 MUNICIPAL AND COMMERCIAL

Current Water Use

The Lower Peace sub-basin has a rural population of 12,804, Indigenous and urban populations of around 4,000 each, representing 12.45% of the Peace's population (Table 41). The main commercial center of the basin is the town of High Level, with few others because of the predominantly rural population.

Table 41. Human population trends in the Lower Peace River sub-basin of the Peace River watershed (Source: Statistics Canada).

	2001	2006	2011	2016	2021
Urban Municipality	3,444	3,887	3,641	3,159	3,992
Rural Municipality	-	-	-	11,171	12,804
Indigenous	5,471	3,803	4,550	4,805	4,601

Total	-	-	-	19,135	21,397

Using data derived from the AFETUW database current water use estimates for the municipal and supporting commercial and management sectors were derived from the Alberta flow tool. Total consumption, total allocation, and percentage of allocation consumed from surface and ground water sources is shown in Table 42 below.

Table 42. Current water consumption, allocated volume, and percentage used for the municipal, commercial and management sectors of the Lower Peace River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent Consumed
Municipal	**309.62**	**1,512.42**	**20.47%**
Surface Water	309.62	1,512.42	20.47
Ground Water	0	0	-
Commercial	**151.76**	**152.77**	**99.34%**
Surface Water	151.76	152.77	99.34
Ground Water	0	0	-
Total	***461.38***	***1,665.19***	***27.71%***
Management	**0.01**	**0.01**	**100%**
Surface Water	0.01	0.01	100%
Ground Water	0	0	-

For the Lower Peace River sub-basin total commercial and municipal water use amounts to 461.38 dam^3, or a small 27.71% of the total volume allocated. Commercial sector water allocation utilization is very high at 99.34%, but this allocation is small at 152.77 dam^3. Municipal water use equals a volume of 309.62 dam^3, only accounting for 20.47% of its water allocation. Water use and allocation for the management sector of the Lower Peace sub-basin are nearly insignificant amounting to 0.01 dam^3, or 10 m^3. Overall water consumption in this sub-basin is quite small compared to the volume of water allocations currently held. This data also shows that the Lower Peace sub-basin has the smallest combined municipal and commercial water consumption in the entire Peace River watershed.

Projected Future Water Use

Using the average year over year change of the Peace basin's population current water use was projected on 6-year (2030), 16-year (2040), and 26-year (2050) horizons to return future use estimates. Table 43 shows the results of these projections for the Lower Peace sub-basin.

Table 43. Future water use projection in the Lower Peace River sub-basin for the municipal and commercial sectors in dam^3.

Sector	Current Consumption (2024)	2030	2040	2050
Municipal	309.62	315.79	326.06	336.34
Commercial	151.76	154.79	159.82	164.86

The Lower Peace sub-basin's future municipal and commercial water use will increase with population growth, but only by a small margin. In the furthest projection horizon (2050) municipal and commercial use will only increase by 26.72 dam^3 and 13.90 dam^3 respectively. This sub-basin's population is currently quite small and not expected to drastically increase, hence why future increases in water use are expected to be small.

8.2.2 FORESTRY

There are two major forestry operations in the Lower Peace sub-basin. The first is the Tolko Industries sawmill and the second is the West Fraser Panel Board plant; both operations are located around the town of High Level. Current water use and allocation data for the forestry sector of this sub-basin was derived from the AFETUW database and can be seen in Table 44. As there are no pulp mills in this sub-basin, the water allocation and use of forestry is comparatively very small. Most of the forestry water use (88.09%) comes from surface water sources in the Lower Peace sub-basin.

Table 44. Current forestry sector water use, allocation volume and percent used for the Lower Peace River sub-basin in dam^3

Sector	Consumption	Total Allocation	Percent consumed
Forestry	**341.55**	**437.61**	**78.05%**
Surface Water	300.88	300.88	100%
Ground Water	40.67	136.73	29.73%

8.2.3 AGRICULTURE

Current Water Use

Canada's 2021 agricultural census reported 753 farms with land in crops, with a total area of 491,411 acres, representing 12.66% of crop land in the Peace River watershed. The livestock sector of the Lower Peace sub-basin is small with a cattle inventory of 21,613, and 779 horses and ponies. Interestingly, the lower peace basin is the only sub-basin in the Peace watershed where elk farming is reported by statistics Canada, with an inventory of 1,460 elk. Agriculture in this sub-basin mostly found around the La Crete area but is expanding (personal communication, 2024). Table 45 shows the current estimated water use of the irrigation and livestock sectors, as wells as total allocations in the region, and percent of the total allocation consumed for these agricultural activities and traditional and other agricultural uses.

Table 45. Current agriculture sector water consumption, allocation volume, and percent used for the Lower Peace River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent used
Irrigation	**540.30**	**3,773.23**	**14.32%**
Surface Water	-	3,773.23	-
Ground Water	-	0	-
Livestock	**408.23**	**20.16**	**2,025.16%**
Surface Water	-	12.61	-
Ground Water	-	7.55	-
Total	***948.53***	***3,793.39***	***25.00%***
Traditional Use & Other*	**97.76**	**102.76**	**95.13%**
Surface Water	97.73	102.73	95.13%
Ground Water	0.03	0.03	100.00%

**Other includes aquaculture, gardens and greenhouses.*

Estimates of irrigation and livestock water use show that in the Lower Peace River sub-basin irrigation is consuming only a small portion of its water allocation, while livestock agriculture water use far exceeds the current allocation. The water use of livestock in this sub-basin represents the single largest overuse of water when compared to a sector or sub-sectors allocation. Despite the shocking 2,025.16% use of livestock water allocation in the Lower Peace sub-basin, the actual amount of water used is still quite small and stands as the second lowest livestock water use for a sub-basin in the entire Peace. In fact, water use for irrigation in this basin amounts to 540.30 dam^3, more than livestock's 408.23 dam^3 consumption. Why there is a such a discrepancy between estimated current use and allocation volume is unknown. In total livestock an irrigation consumed 948.53 dam^3 of water in the Lower Peace River sub-basin, ranking third between this use category for all the sub-basins. In addition to this, traditional and other agricultural water amounted to 97.76 dam^3, or 95.13% of the total registration / water allocation.

Projected Future Water Use

As outlined in the methods future water use projections were made using historical changes in irrigation acres for the Peace and historical cattle stocking rates for the province of Alberta. Future water use forecasts were made on three projection horizons of 6-years (2030), 16-years (2040), and 26-years (2050). For both surface and ground water sources the estimated future water use of livestock and irrigation in the Lower Peace River sub-basin is seen in Table 46.

Table 46. Projected future agriculture water use for the Lower Peace River sub-basin in dam3.

Sector	Current consumption (2024)	2030	2040	2050
Irrigation	540.30	634.31	790.99	947.68
Livestock	408.23	422.93	447.42	471.92

Irrigation in the Lower Peace River sub-basin will likely see the most increase based on the projection; this is expected as cropped agriculture in the region expands. By 2040 Irrigation will be consuming an estimated 790.99 dam^3, while livestock consume 447.42 dam^3. These estimates also indicate that by 2050 livestock water use will not reach the current water use of irrigation in the sub-basin. These estimates capture the trends agriculture experiences in the sub-basin, as the presence of agriculture increases in the Lower Peace so too will water allocations and water use for this purpose. And given current water use allocations for livestock are far exceeded by estimated consumption, this discrepancy between use and allocation is also likely to persist.

8.2.4 INDUSTRIAL

The Lower Peace sub-basin has very little industrial activity. This sub-basin lies outside of the Peace River oil sands, and associated sedimentary basins where oil and gas activity, or mining could occur. Because of this miniscule sector there are currently no water allocations for the industrial sector in the region. Water use may increase in the region if industry were to move in, however this seems unlikely to occur.

8.3 WATER DEMAND SCENARIOS

Water use in the Lower Peace sub-basin is dominated by agricultural and forestry demand. Figures 35 and 36 present sectoral water use information by comparing the current (2024) licenced and consumed water in the sub-basin by the sectors licenced by the AEPA—agriculture, municipal, commercial, forestry, industrial and management. Data indicates that consumption is lower than the licenced use is surface water use, with the exception of agriculture sector demand, thought in groundwater consumption matches licencing. Such close alignment of consumption and licencing emphasizes the importance of exploring changing demand scenarios to anticipate and plan for changes into the future. The five increased demand scenarios allow a range of differences from 2030, 2040 and 2050 to be considered.

Results from the surface water demand analysis indicate that it would require nearly a 75% increase in total water consumed across sectors to meet the 2024 licenced volume (Figure 35). This gap is positive in terms of conservation of water in the sub-basin and is unexpected to change in the short term (2030) even with moderate agriculture expansion and industrial demand. Forecasting further into the future is more challenging but is unlikely to change projecting out to 2040 or 2050 based upon previous trends. However, the extreme 200% increase scenario does highlight the volume that it would take overcome current licence demands.

Groundwater licencing and consumptive data is also provided in Figure 36. Results differ freshwater demand as water consumption and licencing are closely aligned. water use and licenced water use in the sub-basin. In the Lower Peace River sub-basin, agriculture and forestry are the dominant groundwater consumers. Current issues such agricultural expansion into the boreal and forestry-based activity poses risk to groundwater resources, and therefore should be carefully reviewed into the future.

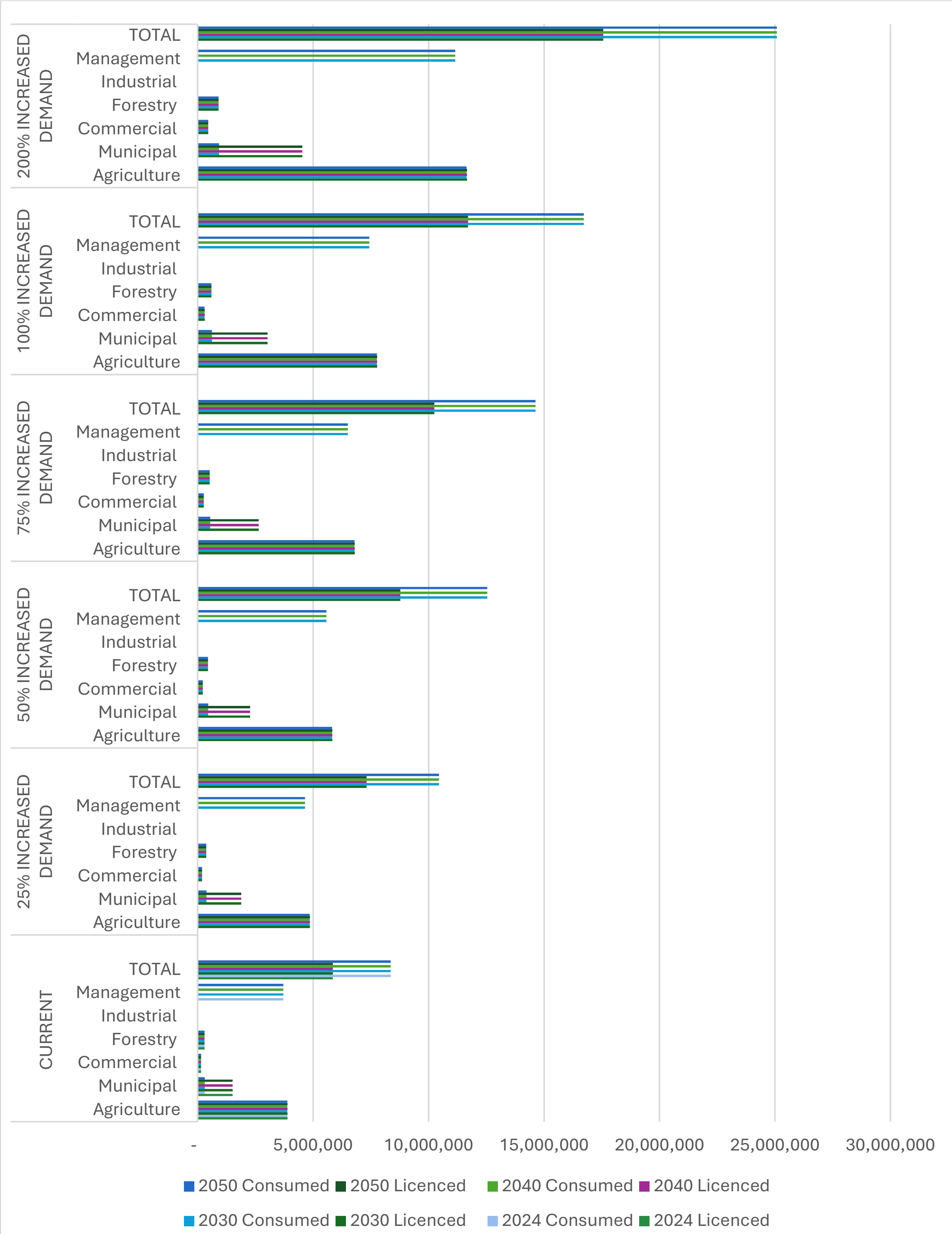


Figure 35. Surface water volume licenced and consumed by sector in the Lower Peace River sub-basin of the Peace River watershed under changing demand scenarios over time.

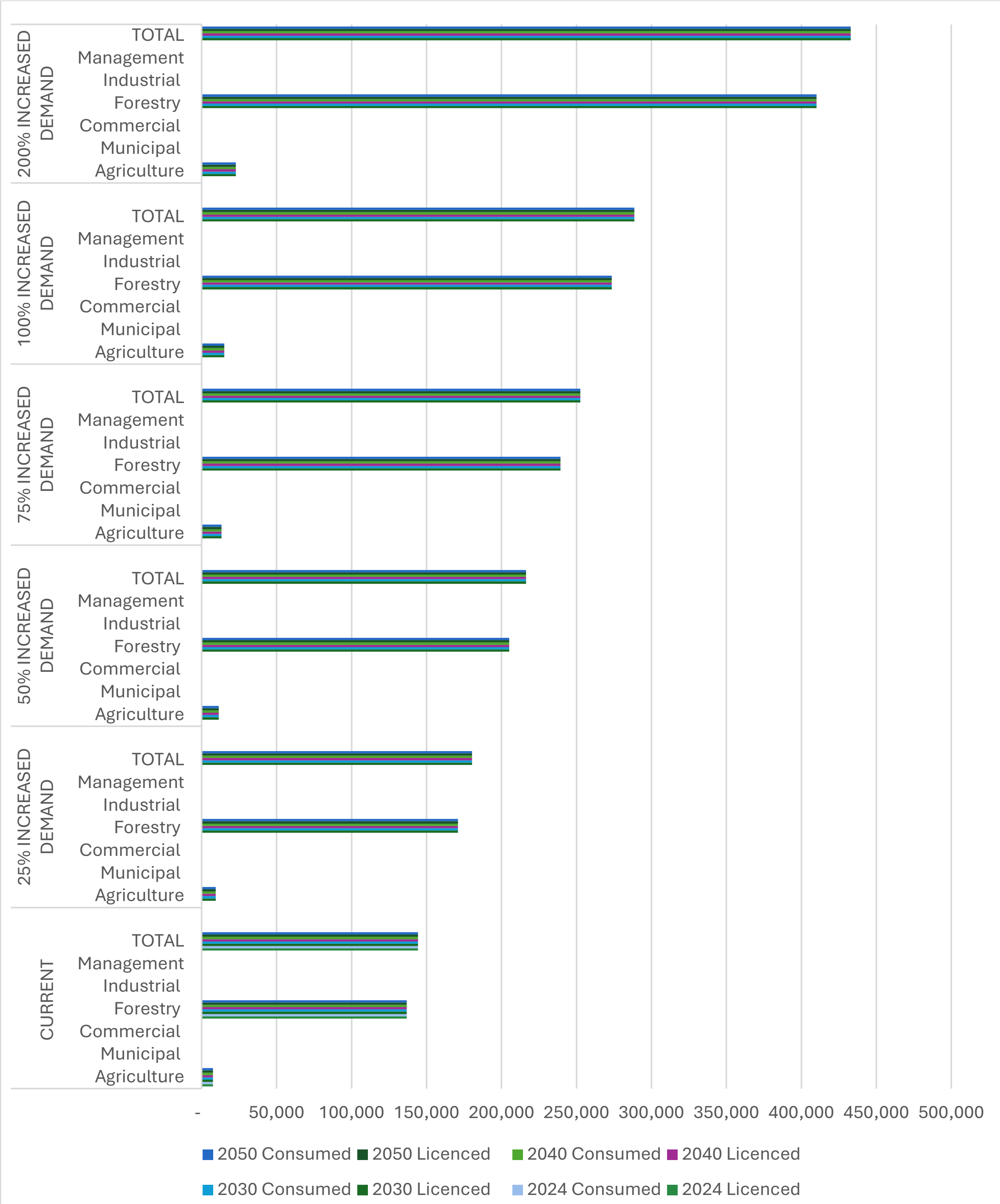


Figure 36. Groundwater volume licenced and consumed by sector in the Lower Peace River sub-basin of the Peace River watershed under changing demand scenarios over time.

8.4 HIGHLIGHTS

Livestock Water Use: Standing out among these results is the use of livestock in the Lower Peace sub-basin. Estimates derived from livestock inventories and average livestock water needs indicate that livestock are consuming 408.2 dam^3, or 2,025.16% greater amount than allocated for this use. There is a glaringly small allocation for livestock water use in this sub-basin, amounting to a volume of only 20.2 dam^3; the reason for this discrepancy between estimated use and total allocation is unknown. Despite this large overuse in comparison to total allocation, livestock water use is quite small. At only 408.2 dam^3, livestock are consuming less than irrigation in the sub-basin and combined municipal and commercial use also.

Overall Low Water Use: Water use and allocations in the Lower Peace sub-basin are small, with no single sectors consumption exceeding 1,000 dam^3. Given the sub-basins small size, small and mostly rural population, and lack of industrial sector this is expected. For instance, municipal and commercial water consumption amounts to a total of 461.4 dam^3, or 27.71% of the total allocation, this trend of small water consumption in relation to allocated volume is the broad trend for this sub-basin.

Future Agricultural Water Use: Agricultural water use for irrigation in the Lower Peace region will see the greatest increases with water use projected to reach 947.7 dam^3 by 2050. Given the expansion of cropped agriculture in the sub-basin and the effects climate change may have on the region this increase in water use for irrigation seems likely.

Water Demand Scenarios: The range of increased surface and groundwater demand scenarios indicates the range of increased water consumption for the Lower Peace River sub-basin and indicate that total surface water consumption would have to increase to nearly 75% across all sectors to meet the 2024 licenced allowance. The accompanying model will allow MPWA to test various hypothesis of demand increases.

9.0 WABASCA RIVER SUB-BASIN

The Wabasca sub-basin aligns with the Water Survey of Canada sub-basins 07JA, 07JB, 07JC, 07JD, 07JE, 07KD, 07KE and 07KF (Water Survey of Canada 2024) and consists of lands that drain into the Wabasca and Mikkwa rivers before they enter the Peace River, as well as lands that drain into Lake Claire and then into the Peace River either directly or through the Chenal des Quatre Fourches (Figure 37). Municipal districts include portions of Northern Sunrise County, Opportunity No. 17, southern portion of Mackenzie County, western sections Wood Buffalo and Improvement District No. 24 (Wood Buffalo) (Alberta Municipal Affairs 2024). The population of this sub-basin is relatively sparse and primarily are situated along Highway 88 ("Red Earth Road") that travels forth from Lesser Slave Lake to Fort Vermilion. Indigenous communities comprise the majority of the population, including Loon Lake First Nation, Wabasca-Desmarais First Nation, Atikameg First Nation and the Gift Lake Metis Settlement. This section will explore the environmental dimensions, human dimensions, sector analysis and economic models of water use in this sub-basin.

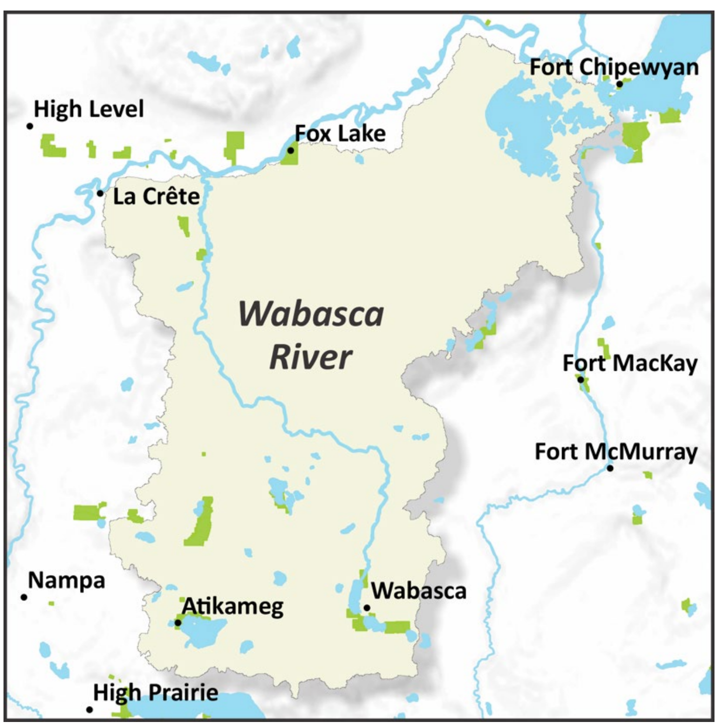


Figure 37. Wabasca River sub-basin of the Peace River watershed.

9.1 PHYSICAL GEOGRAPHY

Covering an expanse of nearly 70,000 km^2 the Wabasca sub-basins land is defined by the natural regions it overlies. Made up of primarily boreal forest, there is a very small portion of foothills at the southernmost end of the sub-basin (Alberta Parks 2015). Given its large size a wide range of both plant and animal species can be found in this sub-basin, they include but are not limited to green alder, lodgepole-jack pine hybrids, white-tailed and mule deer, and wild sarsaparilla. The primary water course of the Wabasca sub-basin is the Wabasca river, which starts at the Wabasca lakes travels northward receiving water from tributaries like the Willow, Muskwa, Woodenhouse, Panny, and Loon rivers. It passes under the highway 88 Wabasca River bridge and finishes its flows in the Peace River east of Fort Vermillion and west of Fox Lake. Figure 38 indicates the annual normal flow of the Wabasca River at Highway 88.

The Wabasca river sub-basin additionally contains Lake Claire which is part of the Peace Athabasca Delta (PAD). The PAD is the convergence of the Peace, Birch, and Athabasca rivers located on the eastern portion of the Athabasca lake (Parks Canada 2023). Designated as a Ramsar Wetland of International Importance the PAD is protected under the extent of Wood Buffalo National Park (Neary et al. 2021). The PAD serves many important functions including acting as habitat for many of Alberta's waterfowl species, bison, and semi-aquatic mammals (Beltaos 2023). Ice jams are integral to the ecosystem services that the PAD supplies, with arising floods, flow reversals, and backwater effects filling surrounding wetlands and landscapes seasonally with water (Peters et al. 2006; Parks Canada 2023).

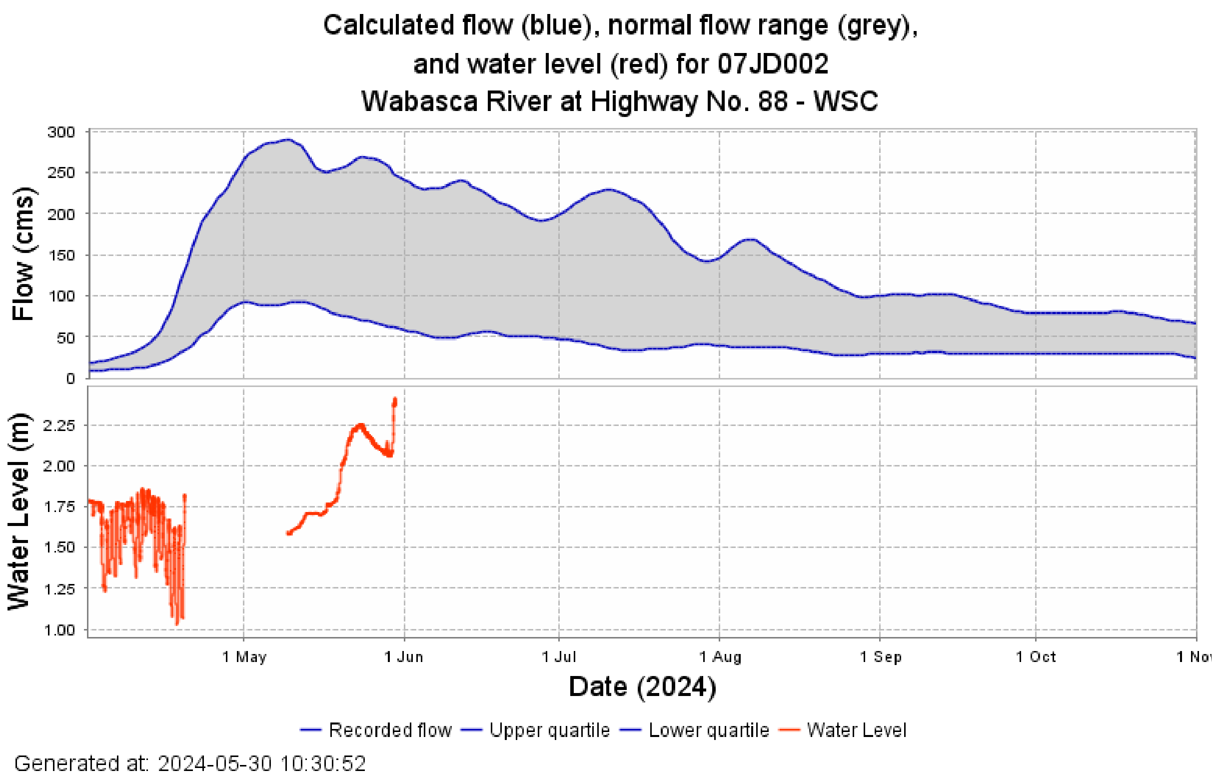


Figure 38. Calculated and normal flow range for Wabasca River basin at the Wabasca River at Highway No. 88, retrieved May 31, 2024 from AEPA.

9.2 SECTOR BASED PROJECTIONS

9.2.1 MUNICIPAL AND COMMERCIAL

Current Water Use

The Wabasca River sub-basin has an Indigenous population of 4,099, a rural population of 6,697, and an urban population of 5,450 accounting for 9.45% of the Peace River watershed's total population (Table 47). Because of the small population commercial centers only exist in very few places.

Table 47. Human population trends in the Wabasca River sub-basin of the Peace River watershed (Source: Statistics Canada).

	2001	2006	2011	2016	2021
Urban Municipality	-	-	-	4,876	5,450

Rural Municipality	-	-	-	7,546	6,697
Indigenous	3,076	4,436	4,530	4,617	4,099
Total	-	-	-	17,039	16,246

Current water use estimates for the municipal and supporting commercial and management sectors were derived from the AFETUW database. In Table 48 the current consumption, total allocation, and percentage of allocation consumed from surface and ground water sources is provided.

Table 48. Current water consumption, allocated volume, and percentage used for the municipal, commercial and management sectors of the Wabasca River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent Consumed
Municipal	**1,111.31**	**2,371.59**	**46.86%**
Surface Water	750.86	1480.61	50.71%
Ground Water	360.45	890.98	40.46%
Commercial	**260.77**	**280.10**	**93.10%**
Surface Water	213.99	227.99	93.86%
Ground Water	46.78	52.106	89.77%
Total	***1,372.08***	***2,651.69***	***51.74%***
Management	**0**	**11,187.27**	**0.00%**
Surface Water	0	11,182.27	0.00%
Ground Water	0	0	**-**

Current water use estimates indicate the 1,111.31 dam^3 is consumed for municipal purposes, and 260.77 dam^3 for commercial in the Wabasca River sub-basin, most of this water is from surface water sources. There is a large volume of water allocated for management use, but currently none is consumed. Water consumption for the municipal and commercial sectors combined makes up only 51.74% of the total volume allocated.

Projected Future Water Use

Future estimates of commercial and municipal water use in the Wabasca sub-basin were calculated following the protocol outlined in the methods of this report. Water use forecasts were made on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. Estimates for future water consumption from surface and ground water sources for both the municipal and commercial sectors are in Table 49.

Table 49. Future water use projection in the Wabasca River sub-basin for the municipal and commercial sectors in dam^3.

Sector	Current consumption (2024)	2030	2040	2050
Municipal	1,111.31	1,133.44	1,170.34	1,207.23
Commercial	260.77	265.97	274.62	283.28

Municipal and commercial water use in the Wabasca River sub-basin will increase as the region's population increase. For both these sectors future increases will be small, for instance in 2040 municipal consumption is projected to increase by 59.03 dam^3, and commercial consumption by 13.85 dam^3. As this sub-basin current has small commercial and municipal sectors increases in water use will be relatively small. Given the municipal and commercial sectors in the Wabasca sub-basin consume 51.74% of their total allocation currently, it is likely that allocations for these purposes will continue to be sufficient in this sub-basin.

9.2.2 FORESTRY

Inside the sub-basin boundaries of the Wabasca River there are no forestry operations licensed to divert water from either surface or ground water sources. Slave Lake pulp mill is located near the boundary of the Wabasca sub-basin, but no water from the Wabasca River is licensed for withdrawal to be used at this pulp mill. Because of this water use and allocations for forestry in the Wabasca River amount to 0 dam^3. As always there is potential for forestry to move into this region, and depending on the type of operation could increase forestry water use from zero.

9.2.3 AGRICULTURE

Current Water Use

The agricultural sector of the Wabasca River sub-basin is relatively small but does contain both livestock and cropped agriculture. The most recent Canadian agricultural census reports there are 9,479 cattle, and 302 goats and sheep in the sub-basin. The total area of land in crops for the Wabasca sub-basin is 131,050 acres, accounting for 3.38% of crop land in the Peace basin, with 122 farms reporting cropped acres in 2021. Current estimates for water use of the irrigation, livestock, and traditional and other agricultural activities in the Wabasca sub-basin are provided in Table 50.

Table 50. Current agriculture sector water consumption, allocation volume, and percent used for the Wabasca River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent consumed
Irrigation	**144.09**	**137.00**	**105.17**
Surface Water	-	137.00	-
Ground Water	-	0	-
Livestock	**168.81**	**36.00**	**468.92%**
Surface Water	-	36.00	-

Ground Water	-	0	-
Total	***312.90***	***173.00***	***180.87%***
Traditional use and Other*	**89.71**	**91.71**	**97.81**
Surface Water	82.04	84.04	97.62%
Ground Water	7.67	7.67	100.00%

**Other includes aquaculture, gardens and greenhouses.*

Estimates of irrigation and livestock water use show that in the Wabasca sub-basin both irrigation and livestock are likely consuming more than their total allocation. Irrigation in the Wabasca is consuming 144.087 dam^3 or 105.17% more than the allocation, and livestock are consuming 168.81 dam^3, or 468.92% of the current allocation. Excluding traditional and other water use, the agricultural sector in the Wabasca sub-basin is using 312.90 dam^3. Although to a lesser extent, like the Lower Peace River sub-basin the estimated overuse of livestock in the Wabasca sub-basin sems contradictory. Again, there seems to be a discrepancy between water allocations and estimated actual use. As mentioned however livestock are only consuming 168.90 dam^3, representing the smallest livestock water use in the entire Peace River watershed. A similar phenomenon is occurring with irrigation water use in the Wabasca River, whereby estimate current consumption is greater than the current irrigation allocation. Again, looking to the 144.09 dam^3 consumptions shows that this water use is still very small comparatively. For traditional and other agricultural purposes water use is also small, representing 89.71 dam^3 in consumption.

Projected Future Water Use

Using the estimated current water consumption of irrigation and livestock, projections of future water use were made on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. These projections are based on historical changes in irrigation acres, and cattle stocking rates. The results of these projections for the Wabasca sub-basin are for both surface and ground water sources are provided in Table 51.

Table 51. Projected future agriculture water use for the Wabasca River sub-basin in dam^3.

Sector	Current consumption (2024)	2030	2040	2050
Irrigation	144.09	169.16	210.94	252.73
Livestock	168.81	174.89	185.02	195.15

As with other sub-basins the results of the projection show that irrigation and livestock water use will increase. Water for irrigation stands to increase the most, reaching an estimated 252.73 dam^3 by 2050, a 75.40% increase from current use. A similar scenario is expected for livestock water use will is projected to reach 195.15 dam^3 in 2050, but with only an increase of 15.60% from current use. Small growths in the Wabasca River sub-basin's agriculture sector are likely and these future water use projections capture this trend.

9.2.4 INDUSTRIAL

Current Water Use

Industrial activity inside the Wabasca sub-basin boundaries is medium sized, with major companies such as Imperial Oil Resourced and CENOVUS inside the boundary. Areas where these companies operate, among others includes the Fort McKay and Cristina Lake area. There are no mining or power generation operations with water allocations to divert from inside the Wabasca sub-basin. Hence oil and gas activities dominate the industrial sector of this sub-basin, and its water consumption. Current water use estimates for the industrial sector of the Wabasca sub-basin was derived from the AFETUW database, in addition to current sector allocations and can be seen in Table 52. Current water use figures indicate that the industrial sector of the Wabasca sub-basin is the second largest water user in the sub-basin, after municipal and commercial use. Oil and gas activity consumes an estimated 2,381.45 dam^3, or 99.94% of its allocation. Industrial water use in this sub-basin falls into the mid-range when compared to the other sub-basins. Unlike other sub-basins however, most industrial water is from ground water sources.

Table 52. Current Industrial sector water use, allocation volume, and percent used for the Wabasca River sub-basin in dam3.

Sector	Consumption	Total Allocation	Percent used
Oil & Gas	**2,381.45**	**2,382.90**	**99.94%**
Surface Water	548.51	549.96	99.74%
Ground Water	1,832.95	1,832.95	100%
Total	***2,381.45***	***2,382.90***	***99.94%***

Projected Future Water Use

Using data on the historical bitumen production of the Peace River oil sand, future water use for oil and gas activity in the Wabasca sub-basin was projected on 6-year (2030), 16-year (2040), and 26-year (2050) horizons. These projections are based on current water use as reported by the AFETUW database and can be seen below in Table 53 for both surface and ground water sources.

Table 53. Projected future Industrial sector water use in the Wabasca River sub-basin in dam^3.

Sector	2024	2030	2040	2050
Oil & Gas	2,381.45	2,726.53	3,301.66	3,876.79

The results of this projection indicate that industrial sector water use is expected to increase considerably for each projection horizon. These estimates show that in 2050 oil and gas water use will be 62.79% higher than currently. Allocations for industrial sector use in the Wabasca sub-basin are expected to increase following this projection curve also, given the very high utilization of current water allocations in the sub-basin. Although current oil and gas activity in the boundaries of the Wabasca sub-basin are small, given the pace at which the industrial sector operates water consumption of 2,726.53 in 2030 is a feasible assessment. It should be mentioned that while oil and gas operations in the Wabasca are currently small with potential to increase, the potential to decrease also exists. Economic diversification may lead to a decrease in fossil fuel activity, thereby decreasing future water use; however the possibility, extent, and timing of this phenomenon is uncertain.

9.2.4.1 HYDRAULIC FRACTURING

Current Water Use

Current figures for fracking are included in water use for the oil and gas sector in Table 53 above, here water use for only fracking has been extracted from those figures for a separate analysis. Current fracking water use for the Wabasca sub-basin is in Table 54 and are derived from the AFETUW database.

Table 54. Current hydraulic fracturing water use in the Wabasca River sub-basin in dam^3.

Sector	Consumption	Total Allocation	Percent used
Fracking	**50.00**	**50.00**	**100%**
Surface Water	0	0	-
Ground Water	50.00	50.00	100%

Current water use estimates indicate the Wabasca River sub-basin has the smallest water allocations for fracking in the Peace River watershed, account for only 0.13% of fracking allocations. Current fracking in this sub-basin makes up 2.10% of total oil and gas water allocations in the sub-basin. Currently 50 dam^3 is allocated from fracking in this basin, all coming from ground water sources. All water allocated for fracking in the Wabasca sub-basin is used.

Projected Future Water Use

Given the very small quantity of water used for fracking in the Wabasca sub-basin future projections were not made. Because current water use for fracking is so currently small, extrapolating the water use trends of the Woodbend Group was considered a misrepresentation of estimate future fracking water use. This is not to say that water use for fracking will not increase in the Wabasca sub-basin, but the trend any future water increases would follow is unknown. Future fracking water use in the Wabasca will depend on a number of factors including technological advancement, energy regulator approval, and exploration of trapped oil and gas resources.

9.3 WATER DEMAND SCENARIOS

Water use in the Wabasca River sub-basin is dominated by municipal and industrial (oil and gas) demand. Figures 39 and 40 present sectoral water use information by comparing the current (2024) licenced and consumed water in the sub-basin by the sectors licenced by the AEPA—agriculture, municipal, commercial, forestry, industrial and management. More than any other sub-basin, data consistently indicates that consumption is lower than the licenced use, though industrial consumption meets the licenced volume. Underutilized licenced water use can allow a “complacency of abundance”, and therefore it is useful to project changing demand scenarios to anticipate and plan for changes into the future. The five increased demand scenarios allow a range of differences from 2030, 2040 and 2050 to be considered.

Results from the surface water demand analysis indicate that it would require nearly a 400% increase in total water consumed across sectors to meet the 2024 licenced volume (Figure 39). This gap is positive in terms of conservation of water in the sub-basin and is unexpected to change in the short term (2030) even with moderate industrial expansion demand. Forecasting further into the future is more challenging but is unlikely to change projecting out to 2040 or 2050 based upon previous trends.

Groundwater licencing and consumptive data is also provided in Figure 40, with notably lower total water use reported. Results differ from freshwater demand as consumption and licenced industrial water use—the dominant user in the sub-basin—are closely aligned. Current issues such increased demand for municipal sources and industrial fracking activity poses risk to groundwater resources, and therefore should be carefully reviewed into the future— particularly as industrial water consumption matches licenced use.

Figures 39 and 40 represent aggregate increases in demand. In reality, the changing demands with be sector specific and may vary significantly. As such, the dataset and accompanying model have been provided to MPWA to conduct a sensitivity analysis—to change variables based upon expected trends and revise based upon sector increases (or decreases) in demand.[16]

[16] The various permutations are many and therefore are not presented in this report; this information can be provided upon request by PRC staff.

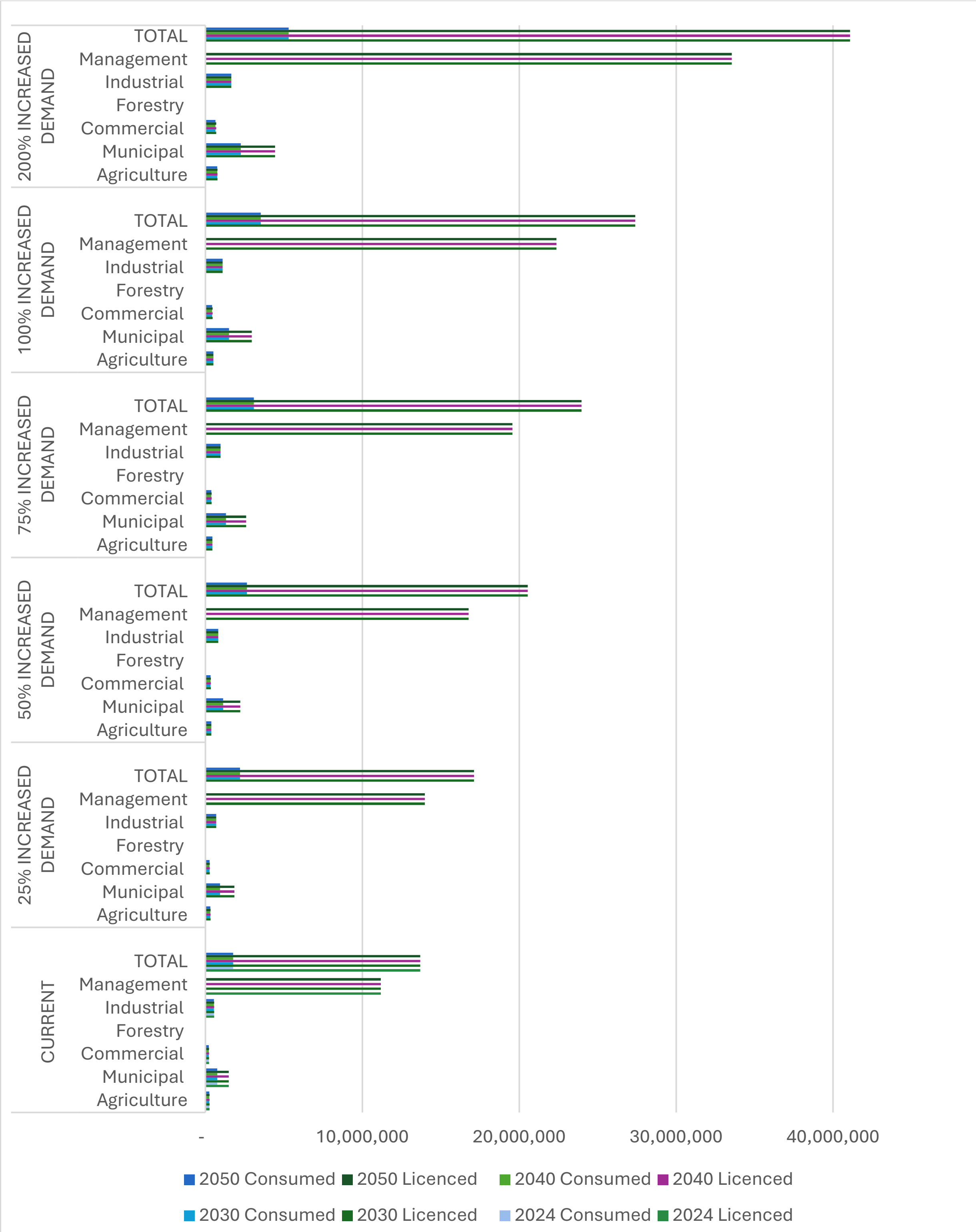


Figure 39. Surface water volume licenced and consumed by sector in the Wabasca River sub-basin of the Peace River watershed under changing demand scenarios over time.

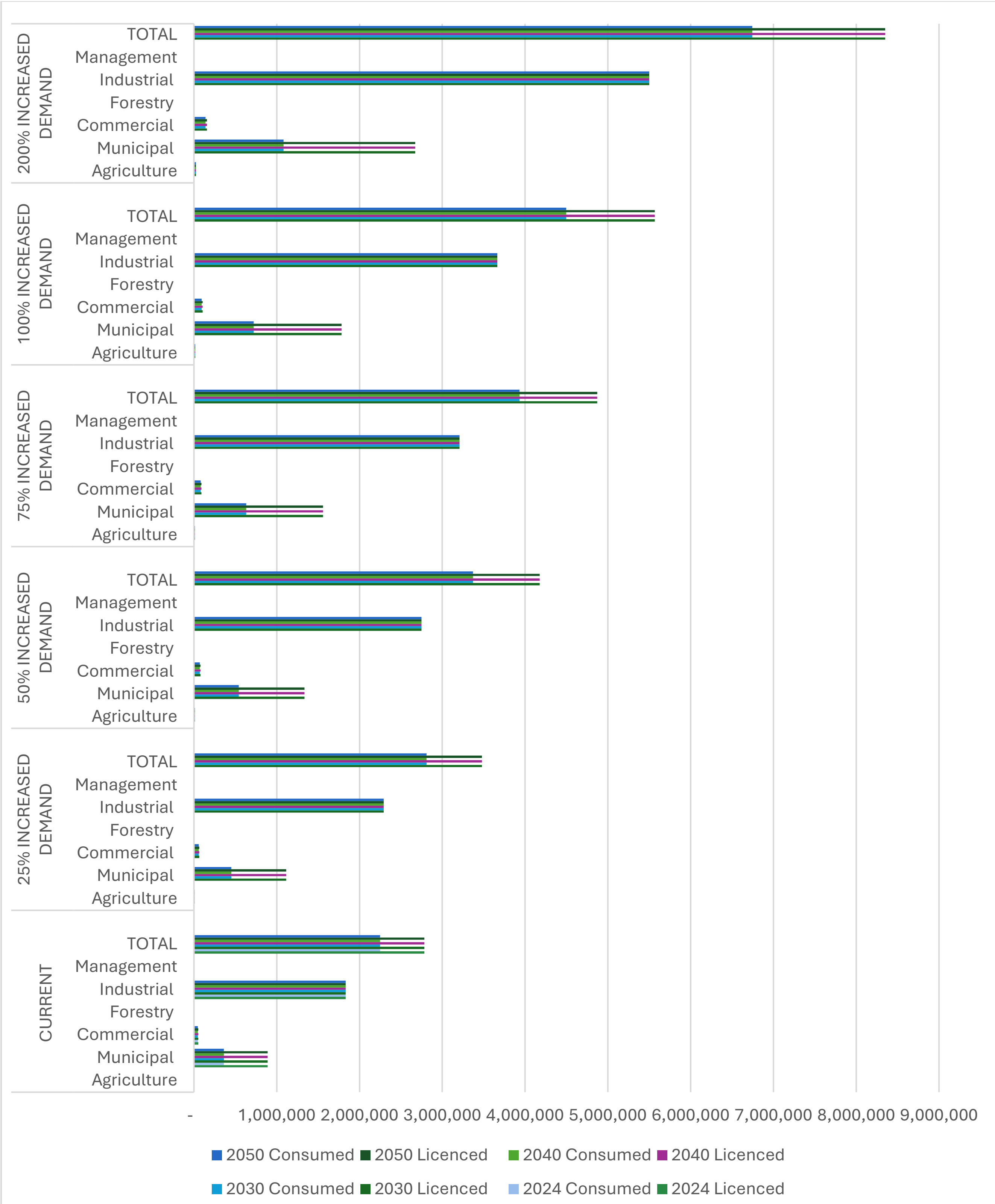


Figure 40.Groundwater volume licenced and consumed by sector in the Wabasca River sub-basin of the Peace River watershed under changing demand scenarios over time.

9.4 HIGHLIGHTS

Proportionally High Municipal and Commercial Water Use: Given the Wabasca sub-basin's small population it was expected that current municipal and commercial water use would be small, however based on current estimates this is not the case. Combined municipal and commercial water use amount to 1,372.1 dam^3, while this is still a relatively small volume of water it is high compared to sub-basins with similar populations. Primarily made up of municipal water use this high value represents an outlier for municipal and commercial water use in the watershed.

Agricultural Over-consumption: Current estimates for both irrigation and livestock water use in the Wabasca sub-basin exceed the current allocated water volume in both instances by 105.17% and 468.92% respectively. Irrigation is estimated to over-consume by a small 7.1 dam^3, while livestock is estimated at 132.8 dam^3. The difference in consumption and allocation for livestock represents a sizeable discrepancy, however the reason for this is unknown. Despite this over-consumption however these amounts are small and currently do not represent an issue for the sub-basin. But if water restrictions were place on Wabasca agricultural water users would have to reduce their water use to ensure the water rights of other license holders could be guaranteed.

Current Industrial Sector Water Use: Although small the current industrial sector water use of 2,381.5 dam^3 in the Wabasca sub-basin stands as the third highest industrial sector water use in the Peace watershed. Oil and gas activity constitute the entirety of this water use. In contrast with almost all other water use in the entire Peace watershed, the majority of industrial sector water use in the Wabasca sub-basin is from ground water sources, an oddity in a region with such abundant surface water resources.

Water Demand Scenarios: The range of increased surface and groundwater demand scenarios indicates the range of increased water consumption for the Wabasca River sub-basin and indicate that total surface water consumption would have to increase to nearly

400% across all sectors to meet the 2024 licenced allowance. The accompanying model will allow MPWA to test various hypothesis of demand increases.

10.0 SLAVE RIVER SUB-BASIN

The Slave River sub-basin aligns with the Water Survey of Canada sub-basin 07N (Water Survey of Canada 2024) and consists of land that drains into the Slave River downstream from the Slave River confluence with the Peace River to the Alberta-Northwest Territories border (Figure 41). Human settlement in this region is limited and is covered by the northern portion of the Regional Municipality of Wood Buffalo and the eastern section of Improvement District No. 24 (Wood Buffalo) (Alberta Municipal Affairs 2024). Despite the existence of the historic settlement of Smith's Landing (Fitzgerald), year-round communities currently do not exist in the Alberta portion of this sub-basin[17]. Multiple First Nation reserves are evident but currently no population for these communities is recorded in Statistics Canada's 2021 Population Census. This section will explore the environmental dimensions, sector analysis and changing demand of water use in this sub-basin.

Figure 41. Slave River sub-basin of the Peace River watershed

[17] Note that the community of Fort Chipewyan is not included in this sub-basin.

10.1 PHYSICAL GEOGRAPHY

With an area just over 13,000 km^2 the Slave River basin is located entirely within a protected area known as Wood Buffalo National Park. The land of the Slave Basin is split between Canadian Shield and Boreal forest. The Canadian shield makes this a highly unique area of Alberta and is home to sandhill cranes, peregrine falcons, northern river otters, caribou, and American dune grass (Alberta Parks 2015). The Slave River begins at the Peace Athabasca Delta flowing northward receiving water from small tributaries such as the Hornday, Bocquene, and Dog Rivers before finally entering the Northwest territories past the Indigenous reserve Fitzgerald. Figure 42 shows the annual normal flow range of the Slave River at Fitzgerald, Alberta.

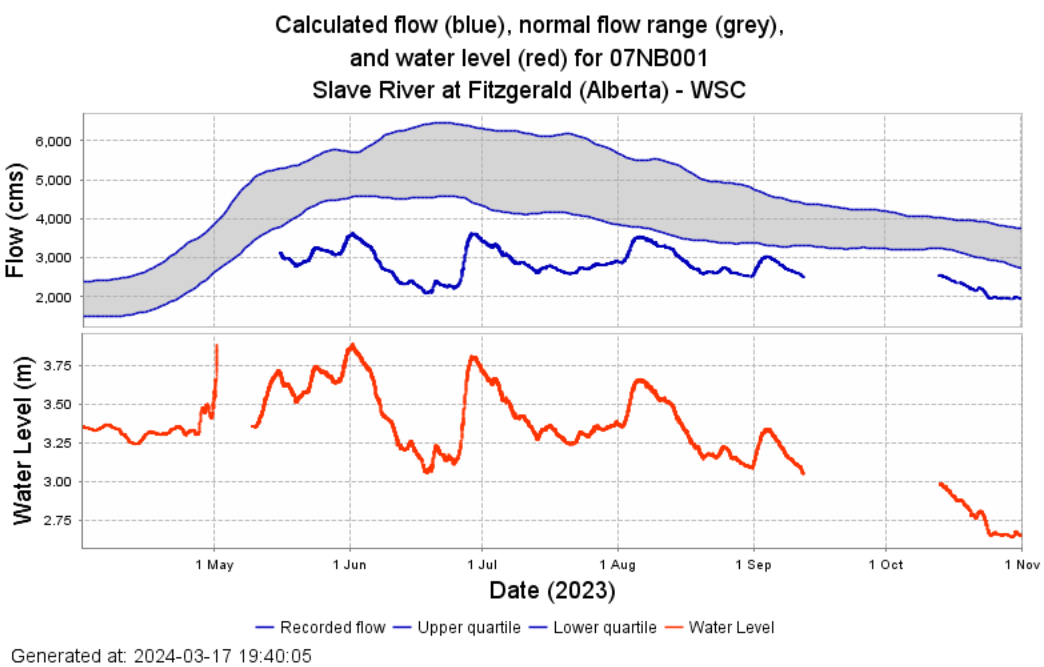


Figure 42. Calculated and normal flow range of the Slave River basin at Fitzgerald, Alberta, retrieved March 17, 2024 from AEPA.

10.2 SECTOR BASED PROJECTIONS

10.2.1 MUNICIPAL AND COMMERCIAL

Water Management & Recreation water uses are the only allocations in this watershed; these allocations are for surface water only; no ground water allocations exist (AEFTUW). Alberta Environment and parks is allocated 0 m^3 for flood control & drainage, the town of Fort Smith is allocated 0 m^3 for flood control & drainage from the Alberta portion of the basin also. Population estimates are provided in Table 55.

Table 55. Human population trends in the Slave River sub-basin of the Peace River watershed (Source: Statistics Canada).

	2001	2006	2011	2016	2021
Urban Municipality	0	0	0	0	0
Rural Municipality	0	0	0	8	0
Indigenous	0	15	30	43	0
Total	0	15	40	51	0

The regional municipality of Wood Buffalo is the only other allocation holder in the Slave River sub-basin, with a total of 313.11 dam^3 allocated across four (4) licenses. Consumption, return flows, and losses are not reported by these licenses, so it is assumed they are using their full allocation. The purpose of these allocations is recreation—specifically snow/ice making. The source of the water is the Des Rocher River

Future water use in this region is not expected to increase, unless industry is allowed to move in, or the regional municipality of Wood Buffalo decides they need a fifth water license for snow/ice making.

Table 56. Current water consumption, allocated volume, and percentage used for the municipal, commercial and management sectors of the Slave River sub-basin in dam3.

Sector	Consumption	Total Allocation	Percent Consumed
Municipal	**0**	**0**	**-**
Surface Water	0	0	-
Ground Water	0	0	-
Commercial	**313.11**	**313.11**	**100.00%**
Surface Water	313.11	313.11	100.00%
Ground Water	0	0	-
Total	**313.11**	**313.11**	**100.00%**
Management	**0**	**0**	**-**
Surface Water	0	0	-
Ground Water	0	0	-

10.2.2 FORESTRY

There is no forestry water use in this region (AEFTUW).

10.2.3 AGRICULTURE

There is no agricultural sector in this sub-basin (Statistics Canada).

10.2.5 INDUSTRIAL

There is no energy sector water use in this region (AEFTUW).

10.3 WATER DEMAND ANALYSIS

Water use in the Slave River basin currently only has commercial demand. Figure 43 presents sectoral freshwater use information by comparing the current (2024) licenced and consumed water in the sub-basin by the sectors licenced by the AEPA—agriculture, municipal, commercial, forestry, industrial and management. Notably, there is very limited freshwater use and no ground water licensing for this sub-basin. The five increased demand scenarios allow a range of differences from 2030, 2040 and 2050 to be considered.

Results from the surface water demand analysis indicate all surface water use arises from commercial activity and that consumption matches licencing (Figure 43). Volume is small, however, and it is not expected that there will be major changes to the sub-basin into the future. However, the increased demand scenarios are available should new industrial activity occur in the basin into the future.

In reality, the changing demands with be sector specific and may vary significantly. As such, the dataset and accompanying model have been provided to MPWA to conduct a sensitivity analysis—to change variables based upon expected trends and revise based upon sector increases (or decreases) in demand.[18]

[18] The various permutations are many and therefore are not presented in this report; this information can be provided upon request by PRC staff.

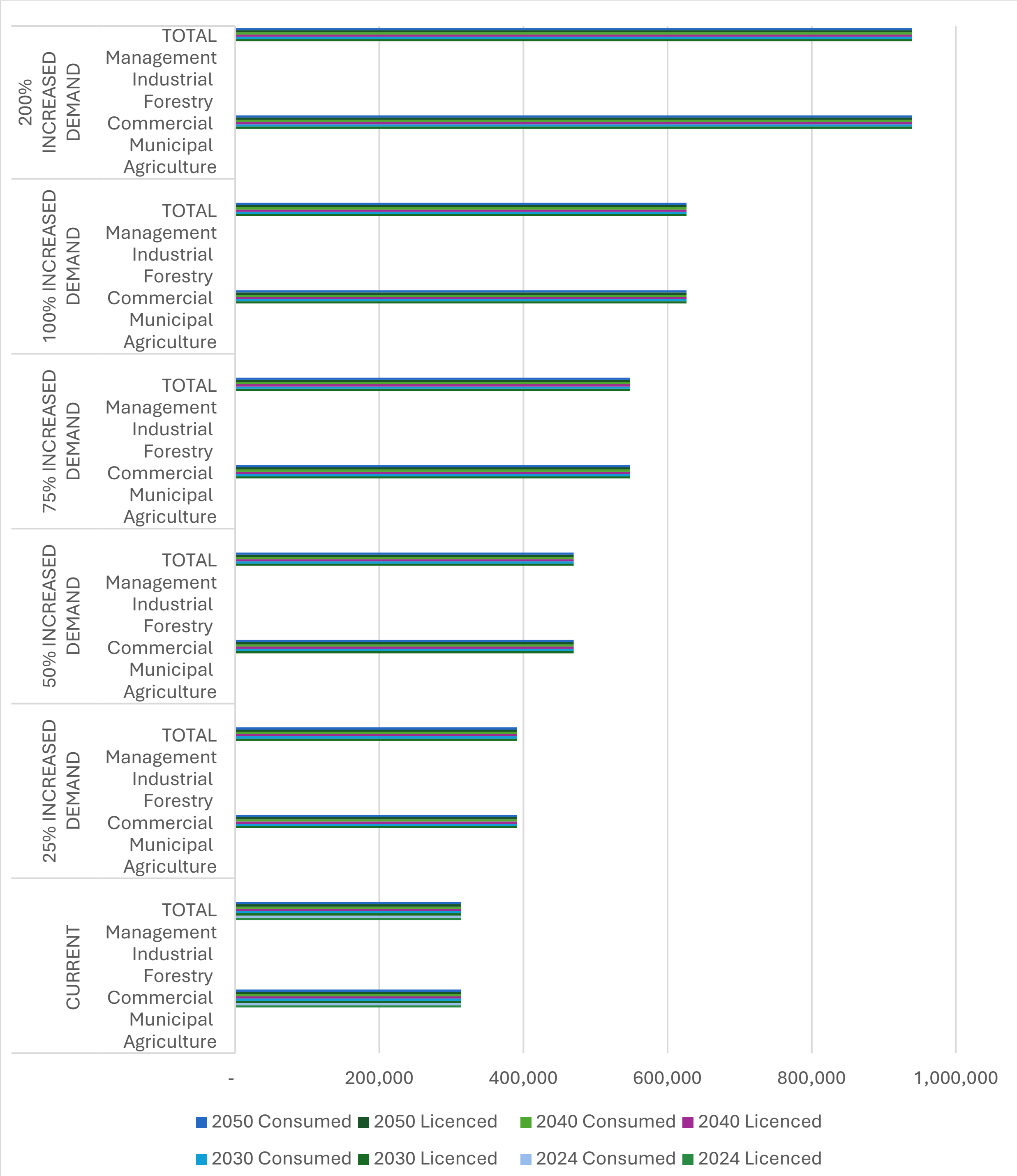


Figure 43. Surface water volume licenced and consumed by sector in the Slave River sub-basin of the Peace River watershed under changing demand scenarios over time.

10.4 HIGHLIGHTS

Protected Area Status: The protected area status of Wood Buffalo Nation Park and World Heritage Site arising from its protection of Wood Bison populations and habitat (Parks Canada 2019), among other conservation efforts has essentially barred development in the region. This has meant that water consumption remains were low, although there are pressures from development, these are unlikely to impact the Slave River basin, as losing this area to human activity would represent a major embarrassment for the province and Canada on the global stage. Additionally, the small and seasonal populations result in very little water consumption for municipal purposes so much so that water licenses for these purposes have not been sought in the Slave River basin.

Water Demand Scenarios: The range of increased surface and groundwater demand scenarios indicates total surface water consumption would have to increase to nearly 200% across all sectors to meet the 2024 licenced allowance. The accompanying model will allow MPWA to test various hypothesis of demand increases.

11.0 WETLANDS AND AGRICULTURE

Wetlands are an important water source external to the Peace River and associated tributaries. Despite protection under the *Water Act*, these ecosystems are at high risk of drainage due to cropped agriculture. As such, a Section 11 is dedicated to the analysis of return on investment for agricultural-based wetland drainage in the entire watershed.

Wetland drainage scenarios based on percent retention of historical wetland areas and agricultural land use capability are provided in Associated Engineering (2022). These scenarios are described in Table 57. Scenarios range from 100% of historical area retained (0% drained) downwards by 10% until a “floor” where it is not physically feasible for further wetlands to be drained[19].

The model is based upon a risk-neutral crop producer considering the financial opportunities of draining wetlands in a certain period (*T*)[20]. *P* represents the annual profit for the landowner. To normalize the equation, it is assumed the surface area of land is one acre and that the decision to rent is irreversible for a 10-year period. Uncertainty around prices and yields meant that the agricultural returns per acre fluctuate and are simply captured using low and high ranges.

$$\frac{d\pi t}{\pi t} = \alpha dt + \sigma dzt \qquad (1)$$

If the landowner converts the land at the generic time *t*, the expected net present value of future income is equal to:

$$NPV(Scenario) = E\{\int_0^T (p - \pi_t)e^{-rt}dt : \pi_0 = \pi\}$$

$$= \int_0^T (p - \pi e^{\alpha t})e^{-rt}dt \qquad (2)$$

[19] The theoretical concept of a wetland “floor” has been employed the by the Saskatchewan Research Council in their analysis of wetland conversion in that province.
[20] This model is adapted from (Gazheli and Di Corato, 2013).

$$= p\,\frac{1 - e^{-rT}}{r} - \pi\frac{1 - e^{-(r-\alpha)T}}{r - \sigma}$$

Where *r* is a riskless interest rate, π_t is profit at time *t,* and *p* is the NPV.

$$\pi \leq \pi^{NPV} = \frac{p(\frac{\left(1-e^{-rT}\right)}{r}}{\frac{(1-e^{-(r-\alpha)T})}{(r-\sigma)}} \tag{3}$$

Land use changes and management practices have a dynamic dimension to them, meaning that implementation and effects of the changes occur over several years (i.e., drainage of a wetland). As a result, a multi-year time horizon is used in the simulation models. A common time horizon is 30 years, as this value is seen as sufficiently long to capture any effects of the changes (Jeffrey et al. 2012). All present values and return on investment calculations were calculated using a 1-, 10-, and 30-year time horizon, and the discount rate was 8%.[21]

To capture the economic costs and benefits of drainage, this equation can be rewritten with covariate names included:

$$NPV_{Scenario} = \frac{\Sigma_{t=1}^{T}[\left((Yield * Price) - (Input\ Costs + Opportunity\ Costs)\right) - Drainage]}{(1+r)^t}$$

Another useful comparison using the outputs of the same base equation is a drainage return on investment, where the net present benefit is divided by the net present costs. A ratio >1 indicates the producer is receiving more than their input; <1 implies that they are losing money.

$$ROI_{Drainage} = \frac{\frac{\sum_{t=1}^{T}[Y+P]}{(1+r)^t}}{\frac{\sum_{t=1}^{T}[VC+FC_{Scenario}+Drainage]}{(1+r)^t}} \tag{5}$$

[21] Note that the discount rate used in the private analysis is 8%, while the public analysis is 3%. This difference reflects the literature on discount rates for private and public goods, which have different values in the short and long term.

This analysis reflects the private economic benefits of wetland drainage for agricultural crop production, and commensurately the costs borne by landowners who are required to implement mitigation measures as a condition of drainage approvals. The results are presented graphically for a representative 5,000-acre grain farm by the drainage scenarios in terms of i) economic benefits of drainage, ii) the drainage return on investment, and iii) the per acre benefit over a 30-year period.

All results are based upon a 3-year crop rotation under the following permutations of input costs, commodity prices, and crop yield. These eight combinations provide the broad array of risks that crop producers face each year. The presented results in the body of the report are based upon a Grey wooded soil type.

Table 57. Description of various combinations of price, yield and input costs presented in the analysis.

Code	Components of Code
LLL	Low Variable Costs, Low Prices, Low Yields
LLH	Low Variable Costs, Low Prices, High Yields
LHL	Low Variable Costs, High Prices, Low Yields
LHH	Low Variable Costs, High Prices, High Yields
HLL	High Variable Costs, Low Prices, Low Yields
HLH	High Variable Costs, Low Prices, High Yields
HHL	High Variable Costs, High Prices, Low Yields
HHH	High Variable Costs, High Prices, High Yields
AVE	Averages of variables from 2002 to 2023

Drainage scenarios were all calculated over 10- and 30-year periods. As drainage costs are assumed to occur in the first year, this impacts the first year of profitability and it is not included in the following Figures. To graphically illustrate the results over time, the average of all variables over time was chosen and presented in the terms of DROI, NPV, and profit per wetland acre in Figures 44, 45 and 46 below. All information is based upon an 8% discount rate being employed over the respective time periods.

In Figure 44, the DROI indicates that low drainage (high retention) scenarios showed higher returns on investment, primarily because of increasing drainage costs. Wetland drainage is profitable at a decreasing rate until approximately 80% drainage (20% retained), at which profitability drops below 1, where the drainage costs are greater than benefits. Over longer periods of time, these drainage costs are distributed and start to “pay for themselves”, therefore making it economically viable for higher levels of drainage over longer periods of time.

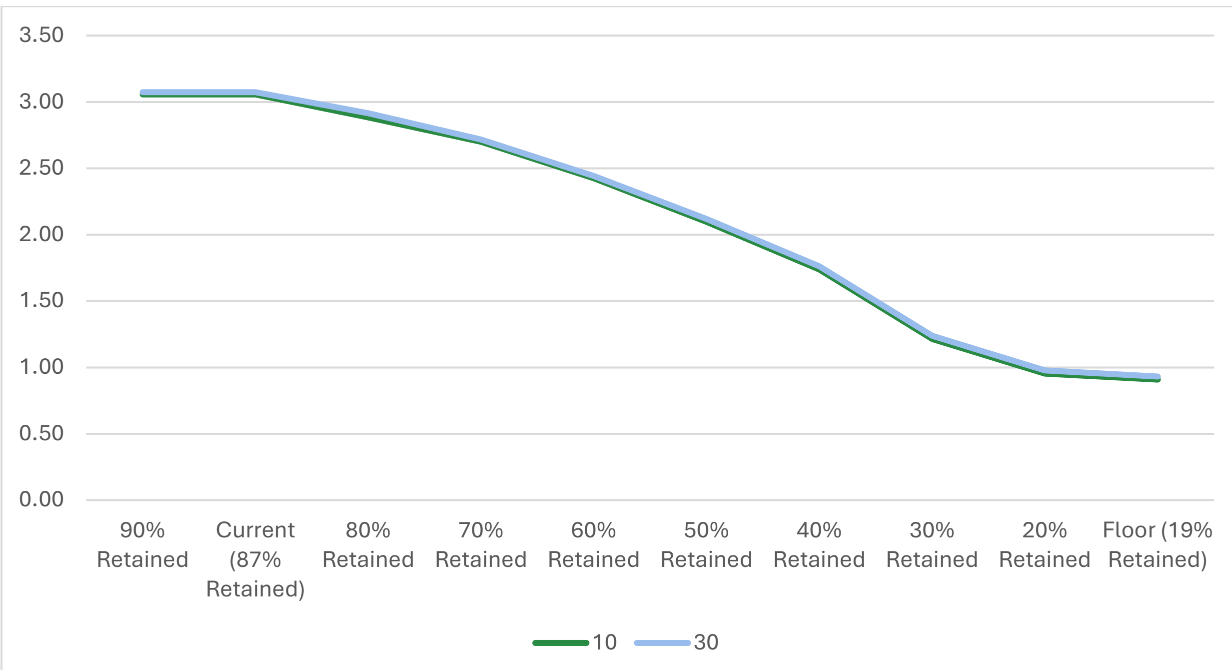


Figure 44. The DROI for wetland retention and loss in the Peace River watershed in Alberta on 5,000-acre farm with 10% wetland cover.

Figure 45 presents the same information in terms of NPV (economic gains). As in Figure 44, low levels of drainage yield financial gains, which peak at the 50% drained scenario. After this point there are diminishing financial returns to drainage, which become negative at 80%

drainage. Financially, the 50% drainage scenario would provide an additional $2.9 million income for a representative 5,000-acre farm over 30 years.

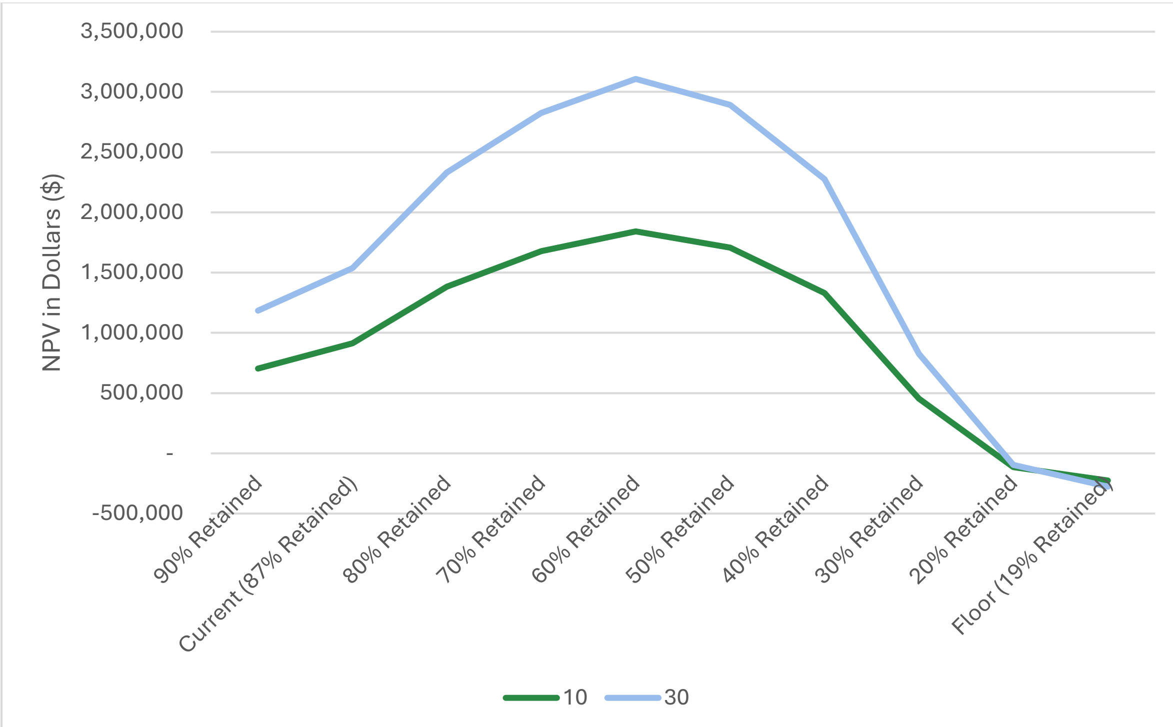


Figure 45. NPV of economic benefits for a 5,000-acre farm with 10% wetland cover under wetland drainage scenarios for average input, average price, and average yields over 10- and 30-year time periods in the Peace River watershed in Alberta.

Figure 45 indicates that under the "best case scenario" of low input prices, high yields, and high prices (LHH), all levels of drainage are financially viable over 30 years. Conversely, under the "worst case scenario" of high input costs, low prices, and low yields (HLL) producers would be experiencing large financial losses.

The most realistic situation over time is the average conditions presented earlier, but Figure 46 is also useful in showing the perceived incentives for drainage that occur when cropped agricultural conditions are positive, such as in 2022. Under "2022 conditions" (high input costs, high prices and high yields) drainage is economically viable at all levels. However, yield is the primary driver of income in these situations, and should this decrease, it only remains profitable up to 50% drainage. Models where input costs are high, and profits and yields are low result in financial loss in nearly all higher-level scenarios of drainage.

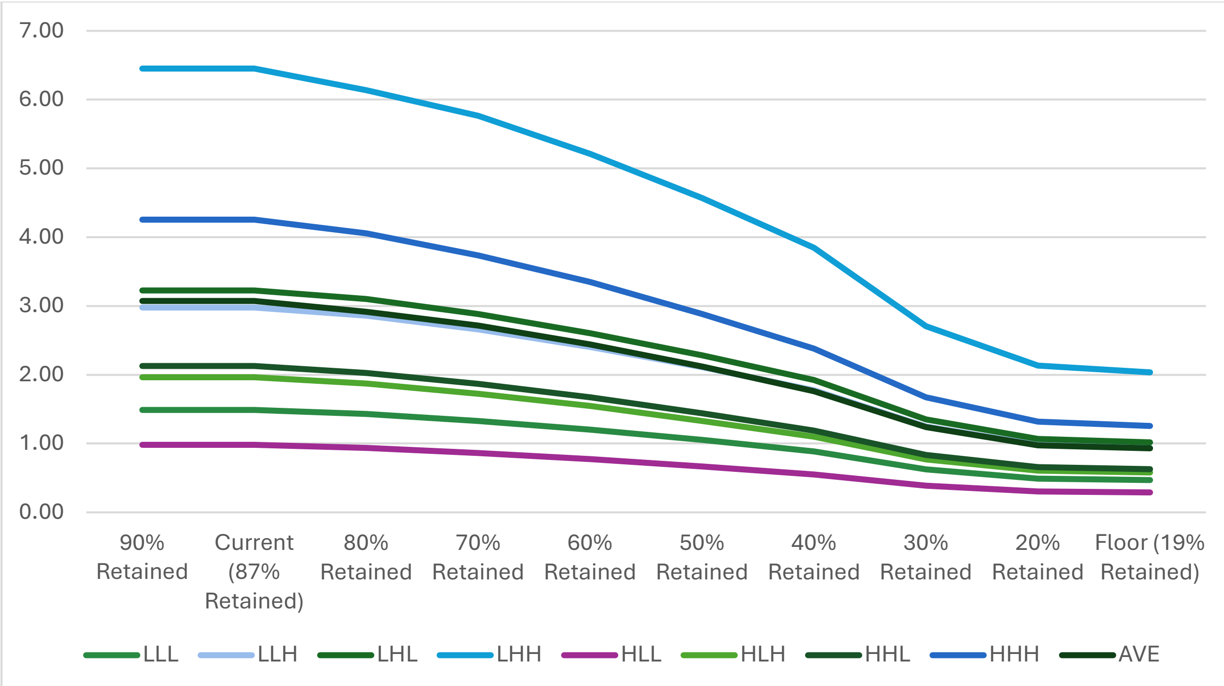


Figure 46. DROI under different drainage scenarios for a 5,000-acre farm with 10% wetland cover with different variable costs, commodity prices and yields for a 3-year rotation of crop over a 30-year time in the black/grey wooded soil zones of the Peace River watershed.

12.0 CONCLUSION

Responsible water management is a key component of maintaining healthy ecosystems and ensuring the resilience of human communities—and related industries—that rely on them. The Mighty Peace Watershed Alliance (MPWA) is the watershed planning advisory council (WPAC) expressly dedicated to the conservation and understanding of ecological resilience of the Peace River. The Peace River watershed's large water network is comprised of six sub-basins: the Smoky/Wapiti River, Upper Peace River, Central Peace River, Lower Peace River, Wabasca River and the Slave River. Covering 28% of Alberta and over 1,900 kilometers in length, these rivers are the lifeblood of the region, providing a basis for traditional Indigenous ways of life and settler communities and the expanding agricultural, residential, oil and gas and forestry sectors that provide the economic engine for the northern portion of Alberta.

This report was commissioned by the MPWA to determine the state of current water use in the Peace River and Slave watersheds of Alberta and explore future scenarios of water use under changing conditions at the basin and sub-basin scales. Overall results indicate secure water quantity and quality in the mainstems of the Peace and Slave Rivers under changing future water use demands. However, it is important to note that much of the watershed accesses its water from small tributaries where there are limited flows and/or water quality issues. Although water use analysis at these local community levels is not detailed in this report, the assessment approach followed in this report allows for that extension.

Framed as an update to the 2012 Water Use Report, it will also serve to inform the upcoming State of the Watershed reporting of the MPWA. Methodologically, this report uses current historical and current water allocation and use data by sector—municipal, commercial, agriculture, and industrial—from the Government of Alberta to develop projects of future water demands in the watershed, framed within the context of environmental and human dimensions. Guided by the technical advisory panel of the MPWA, five sectors are explored generally and at the sub-basin level—agriculture, municipal, commercial, forestry and oil and gas. Future issues impacting the watershed are also explored, including climate change, hydroelectric power (Site C), virtual and bulk water export, nuclear power and peat harvesting. Water demand scenarios are developed based upon low, medium and high human population growth and economic expansion.

Discretion must be exercised in interpreting these results, as it simply to fall for the “myth of hyperabundance” of this resource. The Peace River watershed is richly endowed with freshwater, but human activity in the region is increasing and impacting all aspects of the watershed. Furthermore, two factors not specifically addressed in this report control the availability of water for withdrawal: local specific geographic location and seasonality. For although the Peace and Slave River mainstems have a lot of water in them, most people and communities access water not from the mainstem but from smaller tributaries, which are more prone to water shortages as low flow periods have restrictions around withdrawals. Although the granularity needed to address these factors is beyond the scope of this report, the framework provided can be employed to determine critical actual water availability.

In addition, future analysis specifically focussed on integrating Indigenous traditional ecological knowledge (TEK) with the Western scientific quantification of the resource across the Peace River watershed highly recommended. Such “two-braided” approaches to conservation will assist in future conservation efforts. Water is a precious resource that is necessary for all life, and the careful stewardship of it for future generations of all species is essential.

LITERATURE CITED

AEP. (2016). *Allocation and Sustainable Management of Peat Resources on Public Land*. Government of Alberta. https://open.alberta.ca/dataset/a3866d2b-d28c-40fb-ac84-eec270e936d0/resource/0b5dc1ec-3572-4e3c-97ae-578771369b4f/download/PeatAllocationPublicLand-Dec16-2016.pdf

Alberta Energy Regulator (AER). (2014). *ST98-2014 Alberta's Energy Reserves 2013 and Supply/Demand Outlook 2014-2023* (p. 289). Government of Alberta. https://static.aer.ca/prd/documents/sts/ST98/ST98-2014.pdf

AER. (2020, July 2). *Compliance and Enforcement Tools*. Alberta Energy Regulator. https://www.aer.ca/regulating-development/compliance/compliance-and-enforcement-tools

AER. (2023c, June 26). *Crude Bitumen—In Situ Production*. Alberta Energy Regulator. https://www.aer.ca/providing-information/data-and-reports/statistical-reports/st98/crude-bitumen/production/in-situ

AER. (2020, July 3). *Fox Creek*. Alberta Energy Regulator. https://www.aer.ca/providing-information/by-topic/seismic-activity/fox-creek

AER. (2023, June 26). *Emerging Resources—Lithium*. Alberta Energy Regulator. https://www.aer.ca/providing-information/data-and-reports/statistical-reports/st98/emerging-resources/lithium

AER. (2023b, February 21). *Hydraulic Fracturing*. Alberta Energy Regulator. https://www.aer.ca/providing-information/by-topic/hydraulic-fracturing

AER. (2023a). *Thermal In Situ (TIS) Water Publication*. Alberta Energy Regulator. https://www.aer.ca/providing-information/data-and-reports/activity-and-data/thermal-in-situ-tis-water-publication

AER. (2024a, March 18). *Compliance Assurance Program*. Alberta Energy Regulator. https://www.aer.ca/regulating-development/compliance/compliance-assurance-program

AER. (2024b, March 28). *Water Use Performance: Hydraulic Fracturing*. Alberta Energy Regulator. https://www.aer.ca/protecting-what-matters/holding-industry-accountable/industry-performance/water-use-performance/hydraulic-fracturing-water-use

Alberta Forest Products Association. (2011). *Alberta's Forest Sector Water CEP Plan: A Journey towards Sustainable Water Management*. Alberta Forest Products Association. https://www.awchome.ca/_projectdocs/?file=b6efcc1d17b2128b

AFPA. (2024). *Association Members*. AFPA. https://albertaforestproducts.ca/about/association-members/

Agriculture and Agri-food Canada. (2015). *Soil Group Map of Alberta* [Map]. Government of Alberta. https://www1.agric.gov.ab.ca/soils/soils.nsf/SoilGroupMapOfAlberta.pdf

Alberta Agriculture and Forestry. (2016). *Soil Survey Reports by Map*. Soil Survey Index. https://www.agric.gov.ab.ca/soil/survey-reports/

Alberta Agriculture and Forestry. (2017). *Sustainable Forest Management: 2015 Facts & Statistics*. Government of Alberta. https://open.alberta.ca/dataset/72d4f8aa-a493-4773-a5d0-bdaf370f6cfc/resource/f328d473-d711-4c11-ae61-d7315865b384/download/2015-area-harvested.pdf

Alberta Biodiversity Monitoring Institute. (n.d.). *ABMI Soil Layers*. ABMI - ABMI Soil Layers. http://abmi.ca/home/data-analytics/da-top/da-product-overview/Other-Geospatial-Land-Surface-Data/ABMI-Soil-Layers.html

Alberta Culture and Tourism. (n.d.). Peace River. In *Oil Sands: Alberta's Energy Resources Heritage*. Government of Alberta. http://www.history.alberta.ca/energyheritage/sands/underground-developments/in-situ-development/peace-river.aspx

Alberta Geological Survey. 2020. Chapter 12 - Devonian Woodbend-Winterburn Strata. In: Atlas of the Western Canada Sedimentary Basin. Edmonton, AB: AER. [accessed 2024 May 13]. https://ags.aer.ca/atlas-the-western-canada-sedimentary-basin/chapter-12-devonian-woodbend-winterburn-strata.

Alberta Parks. 2015. Natural Regions & Subregions of Alberta: A Framework for Alberta's Parks. Edmonton, AB: Government of Alberta. [accessed 2024 May 23]. https://albertaparks.ca/media/6256258/natural-regions-subregions-of-alberta-a-framework-for-albertas-parks-booklet.pdf.

Alberta Water Council. (2017). *Looking Back: Evaluating Sector Improvements in Water Conservation, Efficiency and Productivity*. https://www.awchome.ca/_projectdocs/?file=d86483b3094da16b

Alberta WaterPortal Society. (2024). Drought in 21st Century Alberta. *Alberta WaterPortal*. https://albertawater.com/history-of-drought-in-alberta/drought-in-21st-century-alberta/

Alberta Wilderness Association (AWA). (2024, February 26). News Release: No Update to Action Plan for Wood Buffalo National Park Despite Recommendations – Environmental Groups Disappointed. *Alberta Wilderness Association*. https://albertawilderness.ca/news-release-no-update-to-action-plan-for-wood-buffalo-national-park-despite-recommendations-environmental-groups-disappointed/

AWA. (2023). Peace River. *Alberta Wilderness Association*. https://albertawilderness.ca/issues/wildwater/peace-river/

AMEC. (2007). Methodology. In *Current and Future Water Use in the North Saskatchewan River Basin*. https://www.nswa.ab.ca/wp-content/uploads/2007/09/Chapter_2_Methodology.pdf

Aquatera. (2024). *Capital Projects*. https://www.aquatera.ca/transparency-growth/capital-projects

Arthington, A. H., Bhaduri, A., Bunn, S. E., Jackson, S. E., Tharme, R. E., Tickner, D., Young, B., Acreman, M., Baker, N., Capon, S., Horne, A. C., Kendy, E., McClain, M. E., Poff, N. L., Richter, B. D., & Ward, S. (2018). The Brisbane Declaration and Global Action Agenda on Environmental Flows (2018). *Frontiers in Environmental Science*, *6*. https://doi.org/10.3389/fenvs.2018.00045

Basso, B., Martinez-Feria, R. A., Rill, L., & Ritchie, J. T. (2021). Contrasting long-term temperature trends reveal minor changes in projected potential evapotranspiration in the US Midwest. *Nature Communications*, *12*(1), 1476. https://doi.org/10.1038/s41467-021-21763-7

B.C. Energy Regulator. (2024). *Home | FracFocus Chemical Disclosure Registry*. http://fracfocus.ca/en

BC Hydro. 2018a. Site C Clean Energy Project: Regional and Community Benefits. [accessed 2024 Mar 27]. https://www.sitecproject.com/sites/default/files/info-sheet-regional-and-community-benefits-april-2018.pdf.

BC Hydro. 2018b. Site C Clean Energy Project: Economic Benefits. [accessed 2024 Mar 27]. https://www.sitecproject.com/sites/default/files/info-sheet-economic-benefits-march-2018_0.pdf.

BC Hydro. 2018c. Site C Clean Energy Project: Green House Gas Emissions. [accessed 2024 Mar 27]. https://www.sitecproject.com/sites/default/files/info-sheet-greenhouse-gas-emissions-feb-2018_0.pdf.

Beltaos S. 2023. The Drying Peace–Athabasca Delta, Canada: Review and Synthesis of Cryo-Hydrologic Controls and Projections to Future Climatic Conditions. Sustainability. 15(3):2103. doi:10.3390/su15032103.

Bond, N. R., Lake, P. S., & Arthington, A. H. (2008). The impacts of drought on freshwater ecosystems: An Australian perspective. *Hydrobiologia*, *600*(1), 3–16. https://doi.org/10.1007/s10750-008-9326-z

Bratt, D. and McClenaghan, T. (2022). 'Should Alberta Have Nuclear Energy?', *Alberta Views*, 25(8), pp. 38–41.

Brauman, K. A., Daily, G. C., Duarte, T. K., & Mooney, H. A. (2007). The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. *Annual Review of Environment and Resources*, *32*(1), 67–98. https://doi.org/10.1146/annurev.energy.32.031306.102758

Brouwer, C., & Heibloem, M. (1986). Chapter 2: Crop Water Needs. In *Irrigation Water Management Training Manual no. 3: Irrigation Water Needs*. Food and Agriculture Organization. https://www.fao.org/3/s2022e/s2022e02.htm

CBC. (2023, September 14). A call to action: UNESCO reaffirms environmental threats to Wood Buffalo National Park. *CBC News*. https://www.cbc.ca/news/canada/edmonton/unesco-wood-buffalo-national-park-canada-1.6966446

CBC. (2024, May 2). Alberta outlines the drought conditions that would lead to state of emergency. *CBC News*. https://www.cbc.ca/news/canada/calgary/alberta-rebecca-schulz-drought-emergency-tricia-stadnyk-1.7190588

CBC News. (2015, October 15). N.W.T., B.C. sign historic deal to jointly manage Mackenzie River Basin. *CBC News*. https://www.cbc.ca/news/canada/north/mackenzie-watershed-deal-1.3273311

Charman, D. J. (2009). Peat and Peatlands. In G. E. Likens (Ed.), *Encyclopedia of Inland Waters* (pp. 541–548). Academic Press. https://doi.org/10.1016/B978-012370626-3.00061-2

Chaves, C., Pereira, E., Ferreira, P., & Guerner Dias, A. (2021). Concerns about lithium extraction: A review and application for Portugal. *The Extractive Industries and Society*, *8*(3), 100928. https://doi.org/10.1016/j.exis.2021.100928

Chevron. (n.d.). *Hydraulic Fracturing*. Chevron.Com. https://canada.chevron.com/environment/hydraulic-fracturing

Chhin, S., Hogg, E. H. (Ted), Lieffers, V. J., & Huang, S. (2008). Potential effects of climate change on the growth of lodgepole pine across diameter size classes and ecological regions. *Forest Ecology and Management*, *256*(10), 1692–1703. https://doi.org/10.1016/j.foreco.2008.02.046

City of Grande Prairie. (2022, January 10). *Energy & Clean Technology*. City of Grande Prairie. https://cityofgp.com/economic-development/key-sectors/energy-clean-technology

City of Grande Prairie: Municipal Development Plan, Bylaw C-1462 (2024). https://cityofgp.com/sites/default/files/2024-01/bc%201462%20MDP%20for%20Web%20with%20Maps_0.pdf

CPP Environmental. (2015). *State of The Watershed* (p. 80). Mighty Peace Watershed Alliance. http://mightypeacesow.org/pdf/MPWA-SoW_Full.pdf

Critical Minerals Americas. (2023). *The SBH Critical Minerals Property*. Critical Minerals Americas. https://criticalmineralsamericas.com/the-sbh-property

CSPMA. (2022). Peat. *APTHQ*. https://peatmoss.com/peat/

CTV News. (2015). *B.C., N.W.T sign deal to jointly manage Mackenzie River watershed*. https://www.ctvnews.ca/canada/b-c-n-w-t-sign-deal-to-jointly-manage-mackenzie-river-watershed-1.2611731

Daigle, J.-Y., & Gautreau-Daigle, H. (2001). *Canadian peat harvesting and the environment* (Second edition). North American Wetlands Conservation Council Committee.

Davidson, D. J., Williamson, T., & Parkins, J. R. (2003). Understanding climate change risk and vulnerability in northern forest-based communities. *Canadian Journal of Forest Research*, *33*(11), 2252–2261. https://doi.org/10.1139/x03-138

Downing, A., & Cuerrier, A. (2011). *A synthesis of the impacts of climate change on the First Nations and Inuit of Canada*. *10*(1).

Dubrule, T., Patriquin, D.L.D. and Hood, G.A. (2018). 'A Question of Inclusion : BC Hydro's Site C Dam Indigenous Consultation Process', Journal of Environmental Assessment Policy and Management, 20(2), pp. 1–19.

Dusyk, N. (2011). Downstream effects of a hybrid forum: The case of the Site C Hydroelectric Dam in British Columbia, Canada. Annals of the Association of American Geographers, 101(4), 873–881.

Earthquakes Canada. (2024). *Earthquake Details (2024-03-22)*. https://www.earthquakescanada.nrcan.gc.ca/recent/2024/20240322.2226/index-en.php

ECCC, A. H. (2019). *Development of an Environmental Flows Framework for the Peace-Athabasca Delta*. Government of Canada.

Energy Resources Conservation Board. (2012). *A Discussion Paper: Regulating Unconventional Oil and Gas in Alberta* (p. 36). Government of Alberta. https://static.aer.ca/prd/documents/projects/URF/URF_DiscussionPaper_20121217.pdf

Entrekin, S., Evans-White, M., Johnson, B., & Hagenbuch, E. (2011). Rapid expansion of natural gas development poses a threat to surface waters. *Frontiers in Ecology and the Environment*, *9*(9), 503–511. https://doi.org/10.1890/110053

Environmental Protection and Enhancement Act, RSA 2000 § c E-12. Retrieved April 4, 2024, from https://canlii.ca/t/55zj8

EPCOR Water Services Inc. (2021). *Edmonton's Changing Water Use: Water Use Trends and Design Guidelines*. City of Edmonton. https://www.epcor.com/products-services/new-connections/Documents/2021-Water-Use-Discussion-Paper.pdf

Ferguson, N. (2011). From Coal Pits to Tar Sands: Labour Migration Between an Atlantic Canadian Region and the Athabasca Oil Sands. *Just Labour*. https://doi.org/10.25071/1705-1436.35

Fletcher, A. J., Hurlbert, M., Hage, S., & Sauchyn, D. (2021). Agricultural Producers' Views of Climate Change in the Canadian Prairies: Implications for Adaptation and Environmental Practices. *Society & Natural Resources*, *34*(3), 331–351. https://doi.org/10.1080/08941920.2020.1823541

Flexer, V., Baspineiro, C. F., & Galli, C. I. (2018). Lithium recovery from brines: A vital raw material for green energies with a potential environmental impact in its mining and processing. *Science of The Total Environment*, *639*, 1188–1204. https://doi.org/10.1016/j.scitotenv.2018.05.223

Follett, A. (ed.) (2019). 'A life of dignity, joy and good relation': Water, Knowledge, and Environmental Justice in Rita Wong's undercurrent', *Canadian Literature*, pp. 47–63.

Ford, L. B. (2009). Climate Change and Health in Canada. *McGill Journal of Medicine : MJM*, *12*(1), 78–84.

Gagnon, G. A., Krkosek, W., Anderson, L., McBean, E., Mohseni, M., Bazri, M., & Mauro, I. (2016). Impacts of hydraulic fracturing on water quality: A review of literature, regulatory frameworks and an analysis of information gaps. *Environmental Reviews*, *24*(2), 122–131. https://doi.org/10.1139/er-2015-0043

Government of Alberta (GOA). (2013). *Alberta Oil Sands Industry: Quarterly Update* (p. 16). Government of Alberta. https://open.alberta.ca/dataset/b70a79b3-387f-475a-be38-6fe4cd5bb007/resource/9b4b10be-b4ba-46cd-885a-372173898055/download/2614198-2013-winter-aosid-quarterlyupdate.pdf

GOA. (2009). *Farm Water Supply Requirements*. Government of Alberta. https://open.alberta.ca/dataset/3bbc6503-184e-4cff-9446-0d7bda2247f6/resource/4bf71133-4152-442d-bfad-c120e09866d9/download/2009-716c01.pdf

GOA. (2019). *South Regional Waterline (Dixonville)*. https://www.majorprojects.alberta.ca/details/South-Regional-Waterline-Dixonville/3481

GOA. (2023). *Alberta irrigation information—Open Government*. https://open.alberta.ca/dataset/3295832

GOA. (2024a). *Central Peace Regional Water Project (Phase 1 and 2)*. https://majorprojects.alberta.ca/details/Central-Peace-Regional-Water-Project-Phase-1-and-2/4204

GOA. (2024b). *Peace River Arch Lithium Project*. https://majorprojects.alberta.ca/details/Peace-River-Arch-Lithium-Project/9516

GOA. (2024c, April 29). *Mackenzie River Basin | Alberta.ca*. https://www.alberta.ca/mackenzie-river-basin

Government of British Columbia. (2022). *Water Management Agreements—Province of British Columbia*. Province of British Columbia. https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-planning-strategies/water-management-agreements

Government of Canada. (2023). *Critical minerals: An opportunity for Canada* [Campaigns]. https://www.canada.ca/en/campaign/critical-minerals-in-canada/critical-minerals-an-opportunity-for-canada.html

Government of Northwest Territories. (n.d.). *Transboundary water agreements* [Information]. Government of the Northwest Territories. https://www.gov.nt.ca/ecc/en/services/water-management-and-monitoring/transboundary-water-agreements

Habashi, F. (Ed.). (1997). *Handbook of extractive metallurgy*. Wiley-VCH.

Häder, D.-P., & Barnes, P. W. (2019). Comparing the impacts of climate change on the responses and linkages between terrestrial and aquatic ecosystems. *Science of The Total Environment*, *682*, 239–246. https://doi.org/10.1016/j.scitotenv.2019.05.024

Hedges, S. B. (2002). The origin and evolution of model organisms. *Nature Reviews Genetics*, *3*(11), 838–849. https://doi.org/10.1038/nrg929

Hitaj, C., Boslett, A. J., & Weber, J. G. (2020). Fracking, farming, and water. *Energy Policy*, *146*, 111799. https://doi.org/10.1016/j.enpol.2020.111799

Holm, W. (ed.) (2018). *Damming the peace: the hidden costs of the Site C Dam*. James Lorimer & Company Ltd., Publishers.

IPS. (n.d.). *What is peat?* International Peatland Society. https://peatlands.org/peat/peat/

IUNC. (2021, December). *Peatlands and climate change* [Resource]. https://www.iucn.org/resources/issues-brief/peatlands-and-climate-change

Jackson, R. B., Vengosh, A., Carey, J. W., Davies, R. J., Darrah, T. H., O'Sullivan, F., & Pétron, G. (2014). The Environmental Costs and Benefits of Fracking. *Annual Review of Environment and Resources*, *39*(1), 327–362. https://doi.org/10.1146/annurev-environ-031113-144051

Joosten, H., & Clarke, D. (2002). *Wise use of mires and peatlands: Background and principles including a framework for decision-making*. International Peat Society ; International Mire Conservation Group.

Kaunda, R. B. (2020). Potential environmental impacts of lithium mining. *Journal of Energy & Natural Resources Law*, *38*(3), 237–244. https://doi.org/10.1080/02646811.2020.1754596

Kienzle, S. (2019a). *Summer Days (25° C or higher) Average for 1991-2017* [Map]. University of Lethbridge. https://www.albertaclimaterecords.com/imgs/maps/summerdays/Summer_Days_Mean9117.jpg

Kienzle, S. (2019b). *Summer Days (25°C or higher) Average for 2041-2070* [Map]. University of Lethbridge. https://www.albertaclimaterecords.com/imgs/maps/summerdays/Summer_Days_Mean4170_hrm3.jpg

Kolka, R., Bridgham, S. D., & Ping, C.-L. (2016). Soils of peatlands: Histosols and gelisols. *Wetland Soils*.

Lemmen, D. S., Warren, F. J., Lacroix, J., & Bush, E. (2008). *From impacts to adaptation: Canada in a changing climate 2007*. Government of Canada. https://doi.org/10.4095/226455

Leslie, L. E., & Fenten, M. M. (2001). *Quaternary Stratigraphy and Surficial Geology Peace River Final Report* (Alberta Geograhpical Survey Speacil Report SPE10; Canada – Alberta MDA Project M93-04-035). Alberta Energy and Utiilities Board. Alberta Geological Survey Branch. https://static.ags.aer.ca/files/document/SPE/SPE_010.pdf

LithiumBank. (2024, May). *Developing a Large Portfolio of Deep Brine Lithium Projects in North America*. https://assets-global.website-files.com/659bb4279842c79d410c6dca/66312b67584fa37b57a3b4f5_LBNK-Presentation-30.04.2024%20-%20Compressed.pdf

Liu, W., Agusdinata, D. B., & Myint, S. W. (2019). Spatiotemporal patterns of lithium mining and environmental degradation in the Atacama Salt Flat, Chile. *International Journal of Applied Earth Observation and Geoinformation*, *80*, 145–156. https://doi.org/10.1016/j.jag.2019.04.016

Loxley, M. (2022). *A Snapshot of the Changing Prairie Climate*. Climate West. https://climatewest.ca/wp-content/uploads/2023/06/Snapshot-Changing_Prairie-Climate-2022.pdf

Maitre, D. C. L., Scott, D. F., & Colvin, C. (1999). A review of information on interactions between vegetation and groundwater. *Water South Africa*, *25*(2), 137–152.

Mapfumo, E., Chanasyk, D. S., Puurveen, D., Elton, S., & Acharya, S. (2023). Historic climate change trends and impacts on crop yields in key agricultural areas of the prairie provinces in Canada: A literature review. *Canadian Journal of Plant Science*, *103*(3), 243–258. https://doi.org/10.1139/cjps-2022-0215

Masud, M., Ferdous, J., & Faramarzi, M. (2018). Projected Changes in Hydrological Variables in the Agricultural Region of Alberta, Canada. *Water*, *10*(12), 1810. https://doi.org/10.3390/w10121810

McCulloch, M. T., Winter, A., Sherman, C. E., & Trotter, J. A. (2024). 300 years of sclerosponge thermometry shows global warming has exceeded 1.5 °C. *Nature Climate Change*, *14*(2), 171–177. https://doi.org/10.1038/s41558-023-01919-7

McKenzie, R. H., & Woods, S. A. (2011). *Crop Water Use and Requirements*. Government of Alberta. https://open.alberta.ca/dataset/9a017865-5692-464d-92ac-93b5d50558db/resource/c0d20e0c-9f14-4f6d-8144-b8a6bc3452ba/download/5485851-2011-agri-facts-crop-water-use-requirements-revised-100-561-1-2011-11.pdf

Mikisew Cree First Nation. (2016). *Water is Everything – nipî tapîtam: An indigenous understanding of the Outstanding Universal Value of Wood Buffalo National Park*. https://static1.squarespace.com/static/551ae203e4b037522df64b1c/t/592ee6ead2b857da9368881c/1496246025759/Firelight+MCFN+UNESCO+2016+dft+18.pdf

Mineral Resource Development Act, SA 2021 § c M-16.8. Retrieved May 12, 2024 from https://canlii.ca/t/55xvr

Mining Technology. (2023, January 11). Critical Minerals acquires Canadian rare earth elements property. *Mining Technology*. https://www.mining-technology.com/news/critical-minerals-acquires-rare-earth/

Monasterolo, I. (2020). Climate Change and the Financial System. *Annual Review of Resource Economic*, *12*, 299–320. https://doi.org/10.1146/annurev-resource-110119031134

MPE Engineering Ltd. (2022). *Central Peace Regional Water Supply System*. https://www.saddlehills.ab.ca/media/py3pzrqv/central-peace-powerpoint-2.pdf

MRBB. (2021). *Mackenzie River Basin Board: State of the Aquatic Ecosystem Report*. https://soaer.ca/

Municipal Government Act, RSA 2000 § c M-26. Retrieved May 6, 2024, from https://canlii.ca/t/567fm

Myers, T. (2012). Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers. *Groundwater*, *50*(6), 872–882. https://doi.org/10.1111/j.1745-6584.2012.00933.x

NASA. (2021). *Extreme Makeover: Human Activities Are Making Some Extreme Events More Frequent or Intense—NASA Science*. https://science.nasa.gov/earth/climate-change/extreme-makeover-human-activities-are-making-some-extreme-events-more-frequent-or-intense/

Natural Resources Canada. (2009). *Water Use by the Natural Resource Sectors—Facts*. Government of Canada. https://natural-resources.canada.ca/sites/www.nrcan.gc.ca/files/www/pdf/com/resoress/publications/wateau/wateau-eng.pdf

Natural Resources Canada, N. R. (2022, January 18). *Lithium facts*. Natural Resources Canada. https://natural-resources.canada.ca/our-natural-resources/minerals-mining/mining-data-statistics-and-analysis/minerals-metals-facts/lithium-facts/24009

National Parks Act, S. C. 2000, c. 32. Retrieved May 16, 2024, from https://canlii.ca/t/55pgq

Neary LK, Remmer CR, Krist J, Wolfe BB, Hall RI. 2021. A new lake classification scheme for the Peace-Athabasca Delta (Canada) characterizes hydrological processes that cause lake-level variation. Journal of Hydrology: Regional Studies. 38:100948. doi:10.1016/j.ejrh.2021.100948.

NeoLithica. (2024). *Our Projects*. NeoLithica Ltd. https://www.neolithi.ca/our-projects

Nistor, M., Mîndrescu, M., Petrea, D., Nicula, A., Rai, P. K., Benzaghta, M. A., Dezsi, Ş., Hognogi, G., & Porumb-Ghiurco, C. G. (2019). Climate change impact on crop evapotranspiration in Turkey during the 21st Century. *Meteorological Applications*, *26*(3), 442–453. https://doi.org/10.1002/met.1774

Northern Sunrise County. (2024). *Resident Services*. Northern Sunrise County. https://northernsunrise.net/departments/resident-services/

NRBS. (1996a). *Cumulative impacts within the northern river basins* (11; Northern River Basins Study Synthesis Report). Government of Canada, Government of Alberta, Government of Northwest Territories. publications.gc.ca/pub?id=9.883476&sl=0

NRBS. (1996b). *Northern River Basins Study: Report to the Ministers*. Alberta Environment.

NREI (Ed.). (2004a). *Northern Rivers ecosystem initiative 1998-2003: Final report*. Northern Rivers Ecosystem Initiative.

NREI. (2004b). *Synthesis Report*. Government of Canada, Government of Alberta, Government of Northwest Territories. https://open.alberta.ca/dataset/fdd3a211-1d0c-49bd-bcf5-1c2adedf666c/resource/0779a528-cec7-466b-85af-98b9ce53f8d6/download/northern-rivers-ecosystem-initiative-synthesis-report-2004.pdf

Oruch, R., Elderbi, M. A., Khattab, H. A., Pryme, I. F., & Lund, A. (2014). Lithium: A review of pharmacology, clinical uses, and toxicity. *European Journal of Pharmacology*, *740*, 464–473. https://doi.org/10.1016/j.ejphar.2014.06.042

Parks Canada. (2008). 2.0 Management Planning. In *Parks Canada Guiding Principles and Operational Policies*. Government of Canada. https://parks.canada.ca/agence-agency/bib-lib/politiques-policies/gestion-management/princip/sec2/part2a/part2a4

Parks Canada. (2019). *Wood Buffalo Nation Park World Heritage Site: Action Plan*. Government of Canada. https://mightypeacewatershedalliance.org/wp-content/uploads/2023/03/WoodBuffalo-WHS-Action-Plan_LOWres_FINAL.pdf

Parks Canada. (2022). *Wood Buffalo National Park Action Plan*. *1*(1). Avalible from: https://parks.canada.ca/pn-np/nt/woodbuffalo/info/action/bulletin

Parks Canada. 2023 Feb 2. Hydrology Wood Buffalo National Park. [accessed 2024 May 30]. https://parks.canada.ca/pn-np/nt/woodbuffalo/nature/delta/hydro.

Parks Canada. (2023). *Wood Buffalo National Park Project Update*. *2*(3). Avalible from: https://parks.canada.ca/pn-np/nt/woodbuffalo/info/action/bulletin

Parks Canada. (2023, November 14). *Wood Buffalo National Park World Heritage Site Action Plan*. https://parks.canada.ca/pn-np/nt/woodbuffalo/info/action

Peters DL, Prowse TD, Pietroniro A, Leconte R. 2006. Flood hydrology of the Peace-Athabasca Delta, northern Canada. Hydrological Processes. 20(19):4073–4096. doi:10.1002/hyp.6420.

Pérez-Méndez, N., Andersson, G. K. S., Requier, F., Hipólito, J., Aizen, M. A., Morales, C. L., García, N., Gennari, G. P., & Garibaldi, L. A. (2020). The economic cost of losing native pollinator species for orchard production. *Journal of Applied Ecology*, *57*(3), 599–608. https://doi.org/10.1111/1365-2664.13561

PTPC. (2023). *About us | PRO-MIX*. https://www.pthorticulture.com/en/about-us/

Public Lands Act, RSA 2000 § c P-40. Retrieved April 4, 2024, from https://canlii.ca/t/55xcb

Repetto, R., & Easton, R. (2010). Climate Change and Damage from Extreme Weather Events. *Environment: Science and Policy for Sustainable Development*, *52*(2), 22–33. https://doi.org/10.1080/00139151003618183

Rosenberg International Forum on Water Policy. 2013. Rosenberg International Forum: The Mackenzie River Basin. The Gordon Foundation. [accessed 2024 May 3]. https://gordonfoundation.ca/wp-content/uploads/2017/03/2013_Rosenberg_FINAL_WEB.pdf.

Royal Society of Chemistry. (2024). *Lithium—Element information, properties and uses | Periodic Table*. https://www.rsc.org/periodic-table/element/3/lithium

Saha, G. C., & Quinn, M. (2020). Integrated Surface Water and Groundwater Analysis under the Effects of Climate Change, Hydraulic Fracturing and its Associated Activities: A Case Study from Northwestern Alberta, Canada. *Hydrology*, *7*(4), 70. https://doi.org/10.3390/hydrology7040070

Sauchyn, D., & Kulshershtha, S. (2008). Chapter 7: Prairies. In D. S. Lemmen, F. J. Warren, J. Lacroix, & E. Bush (Eds.), *From Impacts to Adaptation: Canada in a Changing Climate 2007* (pp. 275–328). Government of Canada. https://natural-resources.canada.ca/sites/nrcan/files/earthsciences/pdf/assess/2007/pdf/ch7_e.pdf

Scarpare, F. V., Rajagopalan, K., Liu, M., Nelson, R. L., & Stöckle, C. O. (2022). Evapotranspiration of Irrigated Crops under Warming and Elevated Atmospheric CO2: What Is the Direction of Change? *Atmosphere*, *13*(2), 163. https://doi.org/10.3390/atmos13020163

Schneider, R. R., Hamann, A., Farr, D., Wang, X., & Boutin, S. (2009). Potential effects of climate change on ecosystem distribution in Alberta. *Canadian Journal of Forest Research*, *39*(5), 1001–1010. https://doi.org/10.1139/X09-033

Scrosati, B. (2011). History of lithium batteries. *Journal of Solid State Electrochemistry*, *15*(7–8), 1623–1630. https://doi.org/10.1007/s10008-011-1386-8

Smart Prosperiy Institute, & energyfutureslab. (2021). *Renewal and Reinvention of Alberta's Hydrocarbon Cluster: Learning from the Past*. https://energyfutureslab.com/wp-content/uploads/2022/04/renewal-and-reinvention-of-alberta-.pdf

Snowdon, W. (2024, March 26). Fracking site shut down after earthquake shakes Fox Creek, Alta. *CBC News*. https://www.cbc.ca/news/canada/edmonton/earthquake-shakes-fox-creek-shuts-down-northern-alberta-fracking-site-1.7156034

Soil Classification Working Group. (1998). *The Canadian System of Soil Classification* (3rd ed.).

St Pierre, M. (2023). *Canada's farms are adjusting the ways they sell their products to consumers* (p. 10). Statistics Canada.

St Pierre, M., & McComb, M. (2023). *Alberta has the highest farm operating revenues in Canada*. Statistics Canada. https://publications.gc.ca/collections/collection_2022/statcan/96-325-x/CS96-325-2021-9-eng.pdf

Statistics Canada. (2022). 2021 Census of Agriculture. https://www.statcan.gc.ca/en/ca2016

Statistics Canada. (2017). 2016 Census of Agriculture. https://www.statcan.gc.ca/en/ca2016

Statistics Canada. (2012). 2011 Census of Agriculture. https://www.statcan.gc.ca/en/ca2011/index

Statistics Canada (2022). 2021 Census of Population. https://www12.statcan.gc.ca/census-recensement/index-eng.cfm

Statistics Canada (2017). 2016 Census of Population. https://www12.statcan.gc.ca/census-recensement/2016/index-eng.cfm

Statistics Canada (2012). 2011 Census of Population. https://www12.statcan.gc.ca/english/census01/home/Index.cfm

Statistics Canada (2007). 2006 Census of Population. https://www12.statcan.gc.ca/english/census01/home/Index.cfm

Statistics Canada (2002). 2001 Census of Population. https://www12.statcan.gc.ca/english/census01/home/Index.cfm

Statistics Canada. (2022). *Alberta Sector Profile: Mining, Quarrying, and Oil and Gas - Job Bank*. http://www.jobbank.gc.ca/contentjmr.xhtml

Stirling, E., Fitzpatrick, R. W., & Mosley, L. M. (2020). Drought effects on wet soils in inland wetlands and peatlands. *Earth-Science Reviews*, *210*, 103387. https://doi.org/10.1016/j.earscirev.2020.103387

Stralberg, D., Arseneault, D., Baltzer, J. L., Barber, Q. E., Bayne, E. M., Boulanger, Y., Brown, C. D., Cooke, H. A., Devito, K., Edwards, J., Estevo, C. A., Flynn, N., Frelich, L. E., Hogg, E. H., Johnston, M., Logan, T., Matsuoka, S. M., Moore, P., Morelli, T. L., ... Whitman, E. (2020). Climate-change refugia in boreal North America: What, where, and for how long? *Frontiers in Ecology and the Environment*, *18*(5), 261–270. https://doi.org/10.1002/fee.2188

Tan, Q., Liu, Y., Pan, T., Song, X., & Li, X. (2022). Changes and determining factors of crop evapotranspiration derived from satellite-based dual crop coefficients in North China Plain. *The Crop Journal*, *10*(5), 1496–1506. https://doi.org/10.1016/j.cj.2022.07.013

Taylor, S. R., & McLennan, S. M. (1985). *The continental crust: Its composition and evolution: an examination of the geochem. record preserved in sedimentary rocks*. Blackwell.

The Narwhal. (2023). ‘This has to stop’: Oilsands, hydro dams continue to threaten Canada’s largest national park. *The Narwhal*. https://thenarwhal.ca/wood-buffalo-national-park-unesco-warning/

Thorpe, J. (2011). *Vulnerability of Prairie Grasslands to Climate Change* (12855-2E11; Saskatewan Research Council Publication). Prairies Regional Adaptation Collaborative. https://www.parc.ca/rac/fileManagement/upload/12855-2E11%20Vulnerability%20of%20Grasslands%20to%20climate%20change.pdf

Tian, Y., Zheng, Y., Wu, B., Wu, X., Liu, J., & Zheng, C. (2015). Modeling surface water-groundwater interaction in arid and semi-arid regions with intensive agriculture. *Environmental Modelling & Software*, *63*, 170–184. https://doi.org/10.1016/j.envsoft.2014.10.011

Town of High Level: Municipal Development Plan, Bylaw No. 987-18 (2018). https://highlevel.ca/DocumentCenter/View/80/987-18-Municipal-Development-Plan-Bylaw-PDF

Town of Peace River: Municipal Development Plan, Bylaw No. 1874 (2013). https://peaceriver.ca/wp-content/uploads/2015/08/ConsolidatedBylaw1874PeaceRiverMDPsmuptoAug122013.compressed.pdf

Townsend, J., Moola, F., & Craig, M.-K. (2020). Indigenous Peoples are critical to the success of nature-based solutions to climate change. *FACETS*, *5*(1), 551–556. https://doi.org/10.1139/facets-2019-0058

Tscherning, R., & Chapman, B. (2021). Navigating the emerging lithium rush: Lithium extraction from brines for clean-tech battery storage technologies. *Journal of Energy & Natural Resources Law*, *39*(1), 13–42. https://doi.org/10.1080/02646811.2020.1841399

Tymstra, C., Flannigan, M. D., Armitage, O. B., & Logan, K. (2007). Impact of climate change on area burned in Alberta’s boreal forest. *International Journal of Wildland Fire*, *16*(2), 153. https://doi.org/10.1071/WF06084

UNESCO. (2020). *Report on the State of Conservation of Wood Buffalo National Park World Heritage Site (Canada)*. https://cabinradio.ca/wp-content/uploads/2020/12/WBNP-SOC-report-20201201-Final.pdf

UNESCO. (2022a). *Report on the Joint World Heritage Center/IUNC Reactive Monitoring Mission to the World Heritage Property Wood Buffalo Nation Park (Canada)*.

UNESCO. (2022b). *Report on the State of Conservation of Wood Buffalo National Park World Heritage Site (Canada)*.

US EPA, O. (2013, April 8). *Examples of Smart Growth Communities and Projects* [Collections and Lists]. https://www.epa.gov/smartgrowth/examples-smart-growth-communities-and-projects

University of Alberta. 2024. Lithium | Earth and Atmoshperic Sciences. [accessed 2024 May 8]. https://www.ualberta.ca/earth-sciences/facilities/collections-and-museums/minerals-of-alberta/lithium.html.

Varcoe, C. (2024). ‘Prospects for nuclear power have just brightened in Alberta’: *The Calgary Herald*. Accessed March 25, 2024.

Vera, M. L., Torres, W. R., Galli, C. I., Chagnes, A., & Flexer, V. (2023). Environmental impact of direct lithium extraction from brines. *Nature Reviews Earth & Environment*, *4*(3), 149–165. https://doi.org/10.1038/s43017-022-00387-5

Vitt, D. H. (2013). Peatlands. In *Encyclopedia of Ecology* (pp. 557–566). Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.00741-7

Wanger, T. C. (2011). The Lithium future-resources, recycling, and the environment: The Lithium future. *Conservation Letters*, *4*(3), 202–206. https://doi.org/10.1111/j.1755-263X.2011.00166.x

Water Act, RSA 2000 § c W-3. Retrieved April 4, 2024, from https://canlii.ca/t/565n7

Water Security Agency. (2021, February 16). *Interjurisdictional Water Management*. https://www.wsask.ca/about/governance/interjurisdictional-water-management/

Watercon Consulting, Ellehoj Redmond Consulting, Aquality Environmental Consulting Ltd., & McNaughton, D. (2012). *The Peace Watershed: Current and Future Water Use and Issues, 2011*. https://mightypeacewatershedalliance.org/wp-content/uploads/2023/03/Current-and-Future-Water-Use-and-Issues-Report.pdf

WCS Canada. (2021, November 15). *Northern Peatlands in Canada*. ArcGIS StoryMaps. https://storymaps.arcgis.com/stories/19d24f59487b46f6a011dba140eddbe7

Webster, K. L., Beall, F. D., Creed, I. F., & Kreutzweiser, D. P. (2015). Impacts and prognosis of natural resource development on water and wetlands in Canada's boreal zone. *Environmental Reviews*, *23*(1), 78–131. https://doi.org/10.1139/er-2014-0063

Whitman, E., Parks, S. A., Holsinger, L. M., & Parisien, M.-A. (2022). Climate-induced fire regime amplification in Alberta, Canada. *Environmental Research Letters*, *17*(5), 055003. https://doi.org/10.1088/1748-9326/ac60d6

Wilson, S., Griffiths, M., & Anielski, M. (2001). *The Alberta GPI Accounts: Wetlands and Peatlands* (23; Genuine Progress Indicators (GPI) System of Sustainable Well-Being Accounts, p. 34). Pembia Institute. https://www.pembina.org/reports/23_wetlands_and_peatlands.pdf

Zoback, M. D., & Kohli, A. H. (2019). Horizontal Drilling and Multi-Stage Hydraulic Fracturing. In *Unconventional Reservoir Geomechanics: Shale Gas, Tight Oil, and Induced Seismicity* (1st ed., pp. 233–262). Cambridge University Press. https://doi.org/10.1017/9781316091869