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Alberta Oil Sand Pollution Impacts on Local Indigenous Communities and Cooperation with Indigenous Peoples

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Executive Summary

The Alberta oil sands, located primarily in the northeastern part of the province, are one of the largest deposits of crude oil in the world. These oil sands are an important driver of Canada's economic growth (approximately $1 trillion) and provide a significant number of jobs (approximately 205,000). However, the environmental, social and cultural impacts of oil sands development are far-reaching, particularly for Indigenous communities living in and around the Athabasca region. This report explores the multifaceted impacts of Alberta's oil sands development on Indigenous communities, particularly on the Fort McKay First Nation and Métis groups in the Athabasca region. The report provides an in-depth analysis of environmental, cultural and socio-economic impacts through a comprehensive review of existing studies, both government and industry reports, and Indigenous knowledge.

The Alberta oil sands are mined by two main methods: open pit mining and in-situ mining. The environmental impacts of these extraction methods are extensive and multifaceted. Greenhouse gas emissions, including carbon dioxide and methane, are a major contributor to global climate change. In the Athabasca region, these emissions come mainly from the fuel used to generate steam for in situ mining and from the heavy machinery required for open-pit mining. In addition to greenhouse gases, other air pollutants such as sulfur dioxide (SO2), nitrogen oxides (NOx), and volatile organic compounds (VOCs) are released during the extraction and processing of bitumen. These pollutants reduce air quality, contribute to acid rain, and pose a threat to human and wildlife health.

Water pollution is another major environmental problem. Tailings ponds cover large areas of the oil sands region and contain a mixture of water, sand, clay and residual bitumen, as well as a variety of toxic chemicals used in the mining process. The ponds are near the Athabasca River, an important water resource for Fort McKay's First Nation communities. Evidence shows that the tailings ponds may leak, resulting in contaminants such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), and naphthenic acids entering the river and groundwater system. These contaminants pose a serious risk to aquatic ecosystems and may bioaccumulate in fish and other wildlife, which are essential food sources for the Fort McKay community.

The Fort McKay First Nations community has lived in the Athabasca region for generations and relies on the land for traditional activities such as hunting, fishing, trapping, and gathering. Environmental degradation caused by oil sands development has profoundly impacted these communities. Traditional activities are becoming increasingly difficult to sustain as pollution and habitat destruction disrupt local ecosystems. Contaminated water and soil have raised concerns about the safety of traditional food sources such as fish, game, and berries, which are central to the dietary and cultural practices of the people of Fort McKay. The shift from reliance on traditional foods to store-bought alternatives has not only affected the community's physical health. However, it has also eroded cultural practices associated with food preparation and consumption. The loss of traditional lands and resources has also resulted in the diminished transmission of cultural knowledge and practices to younger generations, threatening the long-term survival of Fort McKay's cultural heritage.

While the oil sands industry provides some economic benefits to the Fort McKay community, such as employment opportunities and revenue-sharing agreements, these benefits come at a high cost. The economic opportunities provided by the industry are unevenly distributed, and communities face challenges such as increased living costs and the disruption of traditional social structures. The influx of non-Indigenous workers and the shift to a cash economy has further exacerbated tensions in the community's social fabric.

The report also highlights the significant disconnect between government and industry stakeholder narratives and the actual experiences of Fort McKay's First Nations communities. Government and industry reports typically emphasize the economic benefits of oil sands development and the regulatory measures taken to mitigate environmental impacts. These reports often downplay or ignore the cumulative and long-term impacts of pollution on the environment and the health of Indigenous communities. In contrast, Indigenous communities and independent researchers point to serious and ongoing environmental degradation that they believe is often underestimated or ignored in official assessments. We urgently need to engage more meaningfully with Indigenous knowledge systems that provide a holistic understanding of the environment deeply rooted in the cultural and spiritual connections between people and the land. Indigenous perspectives emphasize the interconnectedness of ecosystems and the importance of maintaining balance and harmony with nature. However, these perspectives are often marginalized in decision-making processes, leading to land use and resource management conflicts.

The report concludes with several key recommendations to promote more equitable and sustainable management practices. These recommendations include recognizing and protecting the right to self-determination of Fort McKay's indigenous communities and ensuring they have a meaningful voice in decisions affecting their lands and resources. The report also advocates for integrating Indigenous knowledge into environmental management and reclamation, recognizing its value in sustaining ecosystems and cultural heritage. Strengthening regulatory frameworks is also essential to better address the cumulative and long-term impacts of oil sands development on indigenous lands, with a focus on reducing pollution and restoring damaged ecosystems. At the same time, the development of co-management agreements to ensure that Indigenous communities are equal partners in resource management was emphasized. Such agreements should prioritize sustainable development, balancing economic interests with cultural and environmental protection. The report calls for a change in the way the oil sands are developed, prioritizing the well-being of indigenous peoples and the protection of their lands and cultures.

By adopting these recommendations, the Fort McKay First Nations community and the broader Athabasca oil sands region can hope for a more just and sustainable future. The report urges all stakeholders to work together to ensure that the benefits of oil sands development do not come at the expense of the environment, cultural heritage or the rights and well-being of First Nations.

1. Introduction

1.1 Oil Sands Description

1.1.1 Mineralogy and Properties

Oil sands, an unconventional naturally occurring petroleum deposit, are a complex mixture of sand, clay, water, and bitumen (Moussa et al., 2021). Unlike conventional petroleum resources, oil sands must be heated or diluted in order to flow or be pumped because they contain bitumen, a very dense and viscous crude oil (Oil Sands Environmental Impacts / | Canada Commons, 2024). As shown in Figure 1, oil sands typically consist of approximately 55 - 80 weight percentages of sand and clay, 2-15 weight percentages of brackish water, and 4-18 weight percentages of bitumen (Mirjavad Geramian et al., 2018). The minerals of oil sands are mainly quartz, kaolinite, illite, and montmorillonite (Marek Osacky et al., 2013). Due to the presence of bitumen, oil sands are dark brown to black in color, and their texture can be either loose, unconsolidated sand, or viscous depending on the content of bitumen and moisture level (Mirjavad Geramian et al., 2018). The composition of Alberta's oil sands has been characterized by four main categories: estuarine sands (ES), estuarine claystone (EC), marine sands (MS), and marine claystone (MC), which represent different minerals and bitumen contents, respectively. Different oil sands compositions can have different impacts on the extraction efficiency and extraction quality of aqueous and non-aqueous bitumen, as well as subsequent waste recycling management.

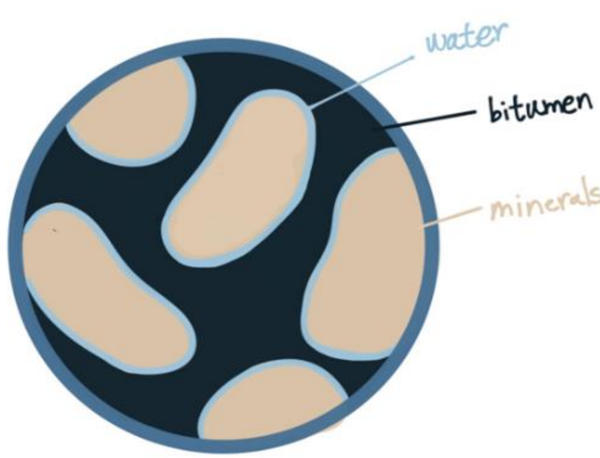

Figure 1. Shows the Simple schematic of the localized oil sands, created by Corrine Yu, 2024.

Bitumen is an ultra-heavy petroleum that is immobilized in the reservoir state, and its hydrocarbon content is usually categorized into saturated hydrocarbons, aromatic hydrocarbons, resins, and asphaltenes, collectively referred to as SARA fractions (Ahmadi, 2023). Bitumen in Alberta's oil sands mines, however, has lost its saturated hydrocarbons and aromatics and, therefore, consists mainly of heavy hydrocarbons such as asphaltenes and resins (Yang et al., 2011). The high asphaltene content gives bitumen a dense and viscous consistency. As a result, bitumen in oil sands is almost solid at room temperature (Yang et al., 2011). This chemical complexity makes bitumen difficult to process and refine into lighter, more useful products such as gasoline and diesel. However, through a wide range of upgrading processes, including coking, hydrocracking, and catalytic reforming, bitumen can be converted to synthetic crude oil, which can then be further refined into a variety of petroleum products and easily transported by pipeline (Yang et al., 2011).

1.1.2 Range and Productivity

The Alberta oil sands has one of the largest crude oil reserves in the world (Alberta Energy Regulator, 2015). These huge natural oil deposits are located primarily in northeastern Alberta, Canada and cover an area of approximately 142,200 square kilometers (Alberta Energy Regulator, 2015). The oil sands are divided into three main regions: Athabasca, Cold Lake, and Peace River. As shown in Figure 2, the Athabasca region, located around Fort McMurray, is the largest and most developed of the three regions, covering approximately 93,000 square kilometers. Cold Lake is located in the southeastern part of Athabasca and covers about 18,000 square kilometers, while Peace River is located in the northwestern part of the region and covers about 29,000 square kilometers (Alberta Energy Regulator, 2024).

Oil sands production throughout Alberta is not to be underestimated, with the entire region reaching 542000 cubic meters per day in 2023 and projected to reach a total of 628000 cubic meters per day in 2033, according to the Alberta Energy Regulator (2024). The most notable of these is the production from the Athabasca oil sands region, which is located in northern Alberta, Canada, and contains one of the largest bitumen reserves in the world (Alberta Energy Regulator, 2015). The area contains all of Canada's current open pit mines and accounts for 89% of Canada's total crude bitumen production, estimated at approximately 2.7 million barrels per day (mb/d), with production set to continue to increase to reach 3.4 mb/d by 2030 (Government of Canada, 2022).

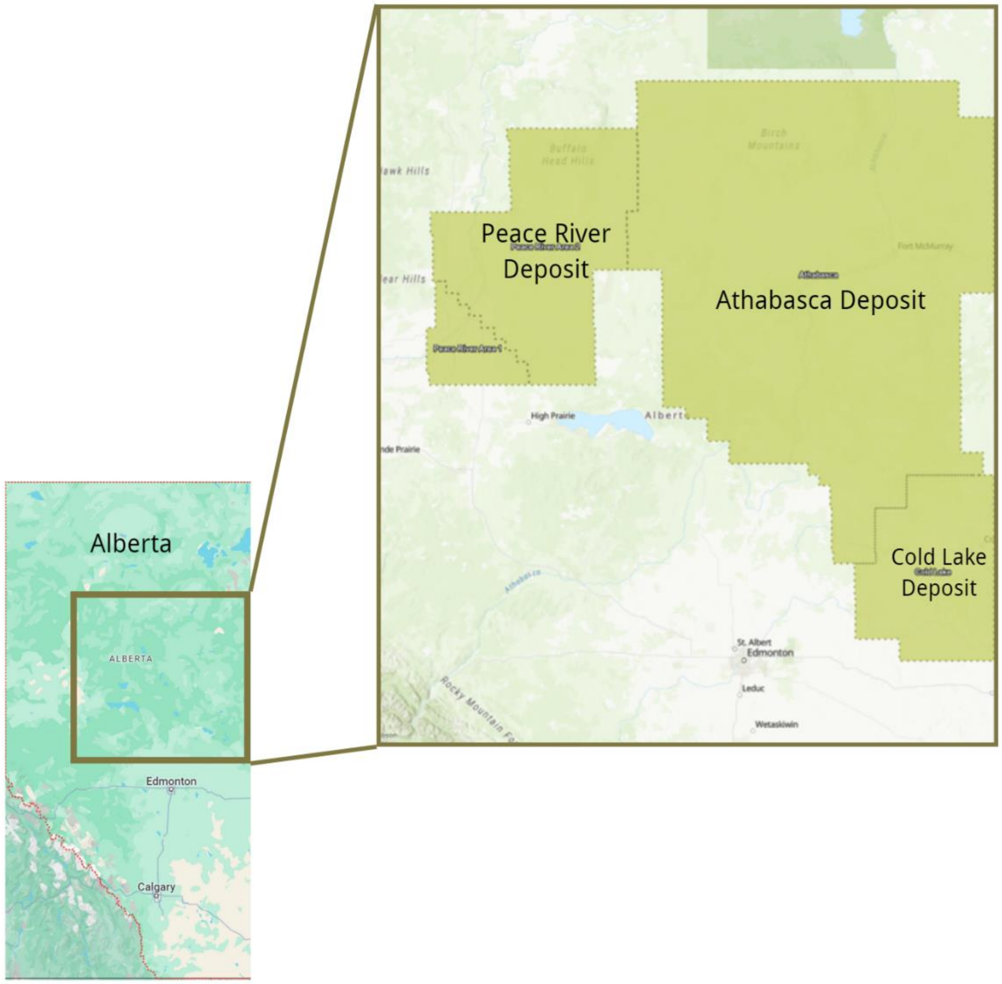

Figure 2. Shows the location of three main oil sands deposits in the Province of Alberta. Created by Corrine Yu 2024, using Google Maps and ArcGIS Pro.

1.1.3 Process of Extraction and Potential Impacts

Because the high viscosity and complex composition of oil sands make them difficult to transport, mining oil sands typically uses two different methods to extract the bitumen from the oil sands depending on the depth of the reservoir-surface mining and in-situ techniques. According to Oil Sands Facts and Stats (2017), 80% of the proven recoverable oil sands across the Alberta oil sands requires in-situ technology and 20% needs to be extracted through mining, although at today's level of extraction, the amount of bitumen extracted annually through the two extraction methods is nearly equal. Because of the differences in the two production methods, they have different environmental impacts (Oil Sands Environmental Impacts / | Canada Commons, 2024).

Surface Mining

Surface mining is used to extract oil sands within 75 meters of the surface (Oil Sands Facts and Stats, 2017). This technology is mature and relatively simple. The process begins with the removal of the overburden, which consists of soil, vegetation, and rock, followed by large shovels and trucks that excavate the oil sands and deliver the ore to an extraction facility (Oil Sands Environmental Impacts / | Canada Commons, 2024). Here, the bitumen is separated from the sand, clay and water and tailings are produced. Finally, the bitumen is upgraded into synthetic crude oil for sale and transportation.

Surface mining can have a number of environmental impacts:

First, surface mining leads to deforestation and the creation of large numbers of open pits. In the Athabasca oil sands region, which covers an area of approximately 900 square kilometers, the mining process has removed all vegetation and soil up to a depth of 75 meters (Santana-Martinez et al., 2024). This has led to habitat destruction and loss of biodiversity, affecting wildlife species in the area.

Secondly, wastes from the extraction process, including water, sand, clay and residual bitumen, are stored in tailings ponds (Oil Sands Environmental Impacts / | Canada Commons, 2024). These ponds cover large areas and pose a risk of soil and water contamination due to the presence of toxic substances, including heavy metals, which easily leak and seep through to the local water resources (Oil Sands Environmental Impacts / | Canada Commons, 2024). In 2023, the Canadian government reported a tailings spill that lasted nine months. Additional, open pit mining techniques require large amounts of water to separate the bitumen from the oil sands. This water, which often comes from local rivers and lakes, can deplete local freshwater resources and affect aquatic ecosystems (Oil Sands Environmental Impacts / | Canada Commons, 2024).

Finally, large-scale mining can lead to significant greenhouse gas emissions, as open-pit mining uses large amounts of fuel for the trucks that drive it, and the process of extracting bitumen, which is almost entirely fossil-fueled with today's technology, contributes to climate change. At the same time, the mining process is often characterized by odors, dust, and deterioration of air quality, which can be attributed to the increased concentration of nitrogen dioxide and total hydrocarbons produced during operations (Davidson & Spink, 2018). Meanwhile, unorganized emissions of volatile organic compounds from tailings ponds contribute significantly to air pollution.

In-situ Technologies

Most oil sands mines are buried deep underground, and when it comes to extracting oil sands at depths greater than 80 meters, the cost of removing the overburden is too great. So, in-situ techniques are often used to extract bitumen deep underground, with two main methods: steam-assisted gravity drainage (SAGD) and cyclic steam sparging (CSS) (Alberta Energy Regulator, 2024).

The SAGD technique uses two wells. One steam well heats the nearly solid oil sands minerals around the well to reduce their viscosity. The heated bitumen is fluid and is fed into the other well, from where it is pumped to the surface for further processing (Alberta Energy Regulator, 2024).

CSS, also known as "throughput", is a technology that uses only one well and injects steam into a single well for several weeks to heat the bitumen around the well. After the injection phase, the well is soaked, followed by a production phase where the heated bitumen is pumped to the surface (Alberta Energy Regulator, 2024). Typically, CSS recovers 20% of the original bitumen while the newer SAGD technology recovers 50% of the original bitumen.

In-situ technologies can also have environmental impacts:

First, both SAGD and CSS are energy intensive due to the large amount of natural gas used to generate steam. This leads to significant greenhouse gas emissions that contribute to global warming (Oil Sands Environmental Impacts / | Canada Commons, 2024).

Secondly, although in-situ mining technologies use less water than surface mining, they still require a large amount of steam generation, and in addition, for CSS technologies, there is a risk of groundwater contamination from the injection and production process (Oil Sands Environmental Impacts / | Canada Commons, 2024).

Then, although on-site techniques reduce much of the damage to the overburden compared to surface mining, they still involve land disturbance. This is because the construction of well pads, roads, and infrastructure can destroy habitat and damage local wildlife (Oil Sands Environmental Impacts / | Canada Commons, 2024).

Finally, the process of steam generation and bitumen extraction releases pollutants, including nitrogen oxides (NOx) and sulphur dioxide (SO_2), which can affect air quality and contribute to the formation of acid rain and smog (Oil Sands Environmental Impacts / | Canada Commons, 2024).

Both surface mining and in-situ mining techniques for extracting bitumen from Alberta's oil sands (SAGD and CSS) have significant environmental impacts. Surface mining is associated with large-scale landscape destruction, large amounts of water use, tailings ponds, and high greenhouse gas emissions. In contrast, in situ technologies such as SAGD and CSS, while occupying a smaller footprint, are still energy intensive, while consuming large amounts of water and posing risks to air quality and groundwater.

1.2 Fort McKay Indigenous Group Description

Indigenous peoples in Alberta's oil sands region have a long history and are dispersed throughout the region and have been impacted to varying degrees by the local oil sands industry. Among the most severely impacted are the Fort McKay First Nation and Métis community in the Athabasca oil sands region (FORT MCKAY AREA STRUCTURE PLAN," 2017). For the First Nations communities around Fort McKay, these impacts are not only environmental, but also socially and culturally relevant. Traditional ways of life are threatened and key activities such as hunting, fishing and gathering are becoming increasingly difficult in a changing environment (Natcher et al., 2020).

The community of Fort McKay is located in the Municipality of Wood Buffalo in the heart of the Athabasca oil sands region and is completely surrounded by oil sands mining (Buffalo et al., 2011). This First Nation community is 60 kilometers north of Fort McMurray and is bordered by two large rivers, the Athabasca and McKay Rivers. The community is home to two main Indigenous groups, the Fort McKay First Nation and the Métis community (FORT MCKAY AREA STRUCTURE PLAN," 2017). Although they share similar values and customs, they are actually governed by separate jurisdictions (FORT MCKAY AREA STRUCTURE PLAN," 2017). Figure 3 shows the land dividing line between these two Indigenous communities.

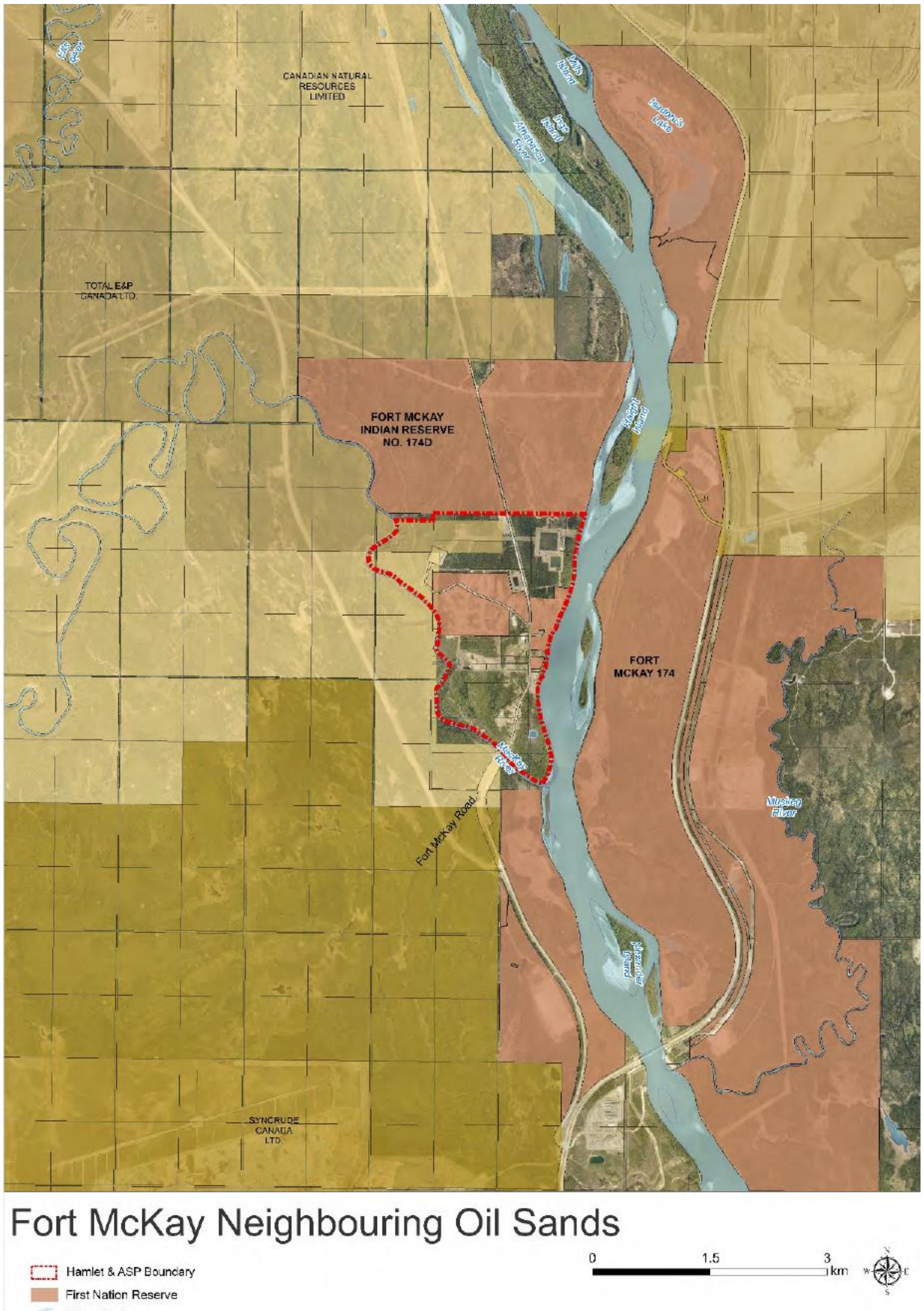

Figure 3. The area of the living area of Fort McKay First Nation and Métis Communities. The red dashed line represents the area that belongs to the Fort McKay Métis community, and the Flesh pink area represents the area belongs to Fort McKay First Nation community (FORT MCKAY AREA STRUCTURE PLAN,2017)

1.2.1 Fort McKay First Nation

The Fort McKay First Nation today consists of 900 Cree and Dene people who live primarily along the Athabasca River, with their primary landholding being Treaty 8 Territory, known as Fort McKay Reserve 174 (Christine et al., 2024). The Fort McKay First Nation has a long history of traditional activities on this land, such as fishing, hunting, and medicine gathering, among many other activities and ceremonies. However, with the development of the oil sands industry in the area, their way of life has been deeply impacted (Christine et al., 2024).

1.2.2 Fort McKay Métis

The Métis community of Fort McKay is located in the Athabasca oil sands region of northern Alberta, approximately 60 kilometers north of Fort McMurray along the Athabasca River (FORT MCKAY AREA STRUCTURE PLAN, 2017). The community resides primarily in Hamlet, a settlement close to the Fort McKay First Nation, where the Métis have traditionally engaged in traditional activities such as hunting, fishing, and trapping (FORT MCKAY AREA STRUCTURE PLAN, 2017). The community is centered around the village of Fort McKay and has approximately 400 members who live in and around the settlement (Alberta Métis Nation, 2021).

The Fort McKay Métis place a high value on their cultural heritage, which includes a blend of Indigenous and European traditions. However, with the development of the oil sands industry in the area, their way of life has been deeply impacted (Christine Anne Daly et al. 2024).

1.3 Fort McKay First Nation Community in the Athabasca Oil Sand Region

The environmental impacts of oil sands operations are widespread, including water pollution, air pollution, deforestation, and destruction of wildlife habitat (Westman & Joly, 2019). For First Nations groups around Fort McKay, these impacts are not just environmental but are deeply intertwined with social and cultural. Traditional ways of life are threatened, with key activities such as hunting, fishing, and gathering becoming increasingly difficult in a changing landscape (Natcher et al., 2020).

There are reports of frequent odors, dust, and degradation of air quality in the community, which may be due to increasing concentrations of nitrogen dioxide, total hydrocarbons, and other greenhouse gases produced during operations (Davidson & Spink, 2018). At the same time, the unorganized emissions of volatile organic compounds from the tailing ponds contribute significantly to the total emissions, leading to changes in air quality observed by those affected Indigenous communities (Moussa et al., 2021).

Edwards (2014) found higher than normal levels of heavy metals (arsenic and mercury) and polycyclic aromatic hydrocarbons (PAHs) in moose, ducks, and muskrats, all of which are a major source of protein for the Fort McKay First Nation. During monitoring, berry fields throughout the Athabasca oil sands region were contaminated to varying degrees. At the same time, aluminum, iron, vanadium, nickel, and copper concentrations were higher in berry fields near Fort McKay than elsewhere. These results may indicate that the village of Fort McKay is an input site for fugitive dust/tailings from oil sands processing, burning, haul roads, and general anthropogenic emission sources (Baker, 2018).

The Alberta government and some of its mandated scientific reports have concluded that the environmental impacts of oil sand operations have been minimal, stating that the pollution levels are within acceptable limits. The deforestation is being managed through reforestation programs, local communities (including the Fort McKay First Nation community), and some independent scientists have pointed out that their observations and results are very different from those of the government (Natcher et al., 2020). This discrepancy highlights a key issue: the environmental impacts of the oil sands industry and its far-reaching effects on the health, heritage, and livelihoods of Indigenous people living near these developments may be underestimated or downplayed. The voices of those directly affected by oil sand operations, particularly Fort McKay's Indigenous groups, are often marginalized in the broader discussion of energy development. These communities report significant environmental degradation, including water and air pollution, which they attribute to nearby oil sands activities (Parlee, 2015).

Although there have been many analyses and reports of environmental pollution from the oil sands industry, there is a lack of analysis and assessment of the extent to which the people of the Fort McKay First Nation have been affected by the following:

1. the extent to which the water quality of the Athabasca River adjacent to Fort McKay has been polluted

2. the extent of air pollution in Fort McKay

3. the extent of food pollution in the Fort McKay First Nation and

4. the extent to which the traditional culture, way of life, and heritage of the Fort McKay First Nation have been affected due to the above pollution.

This project offers a unique perspective by focusing on the impacts of oil sands pollution on the Fort McKay Indigenous Groups, particularly the Fort McKay First Nations community (Natcher et al., 2020). These communities have inhabited the region for thousands of years and have relied on the land for their culture, health, and livelihoods, which are now completely disrupted (Baker, 2020).

The review and synthesis of the four identified areas should aid Government officials and Fort McKay First Nation communities and stakeholders by providing informed information to minimize the negative impacts on the affected First Nation communities and to integrate indigenous knowledge systems and Western science in the management of the Fort McKay First Nation communities affected by the Athabasca oil sands industry.

2. Objectives

This study aims to review, assess, and communicate available information on the environmental impacts of Athabasca oil sands development and the potential impacts on Indigenous communities' lifestyles, heritage, and livelihoods in the Athabasca oil sands region. Specifically, this study aims to

- assess the environmental impacts of Athabasca oil sands operations. This includes thoroughly investigating the impacts of oil sands activities on water and air quality. The study focuses on the extent and type of contamination of local water bodies, including rivers and lakes, and the impact on groundwater. The air quality assessment will examine emissions from oil sands operations and their impact on local and regional air pollution. In addition, the study will examine the contamination of food sources (e.g., fish, wildlife, and plants) that are integral to the diets of Indigenous communities.
- Assessment of socio-economic and cultural impacts on Indigenous communities: This component explores how oil sands development has affected the traditional lifestyles, heritage, and knowledge systems of Indigenous people. The study considers changes in land use, disruption to traditional hunting, fishing, and gathering practices, and impacts on cultural sites and practices. It will also assess the broader socio-economic

consequences, including changes in employment, income and community well-being.

- Explore discrepancies between government and industry narratives and local observations: The study investigates discrepancies between official government and industry reports and the observations and experiences of local communities and independent researchers. This involves analyzing a variety of data sources and testimonies to identify inconsistencies and understand their reasons. The goal is to develop a more accurate and comprehensive understanding of the impacts of oil sands development.
- Identify best practices for co-management: The study aims to find effective co-management strategies between Indigenous communities and government authorities. This will include examining existing co-management frameworks and their successes and challenges. The study will assess proposed improvements to ensure that Indigenous communities participate meaningfully in decision-making processes, respect their rights and knowledge, and manage natural resources sustainably.

By achieving these specific objectives, the study aims to develop a comprehensive understanding of the multifaceted impacts of Athabasca oil sands development on the environment and Indigenous communities and to make recommendations for more equitable and sustainable management approaches.

3. Methods

3.1 Study Site Background

The study site encompasses Fort McKay Reserve 174, located in the Athabasca Oil Sands Region in Northern Alberta, Canada (Area Redevelopment and Area Structure Plans, 2017). The area is taking 3106.70 hectares. It focuses on areas surrounding Fort McKay First Nations (population 900) impacted by the Athabasca oil sands development. This region is chosen for its ecological significance, the intensity of oil sand operations, and the presence of Indigenous communities with longstanding ties to the land.

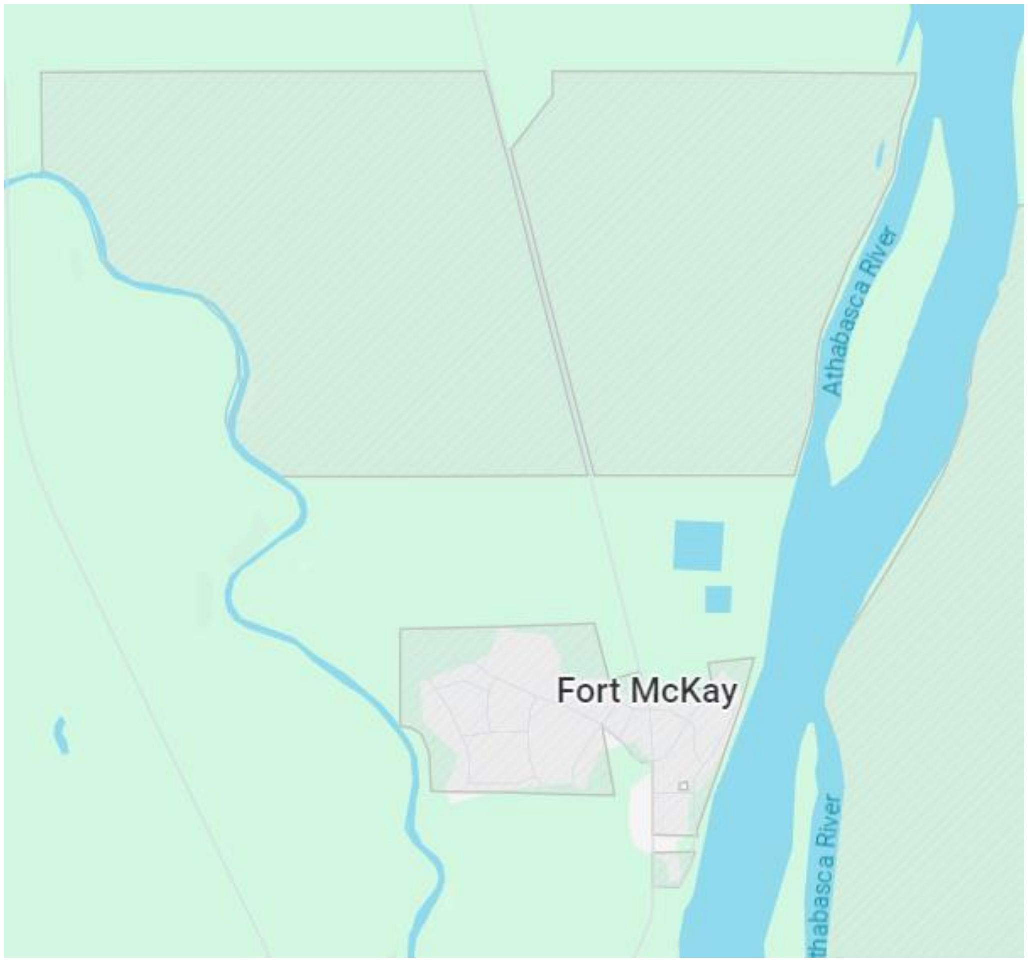

Figure 4. Map of the study site, shaded area is 174D under the jurisdiction of the Fort McKay First Nation (image courtesy of Google Maps)

3.2 Project methodology

The project focused on data analysis and assessment through a literature review.

1. Environmental impact assessment:

Literature Review: A comprehensive review of existing studies, reports, and data related to the environmental impacts of the Athabasca oil sands. Focused on identifying studies that collected water, soil, and air samples from the region to collect levels of pollutants associated with oil sands extraction, including heavy metals, polycyclic aromatic hydrocarbons (PAH), aerosols, and greenhouse gases. Use data from reliable sources such as academic publications, government reports, and studies conducted by environmental organizations, and analyze data collected to determine the presence and concentration of pollutants.

Impact Assessment: Based on existing literature and expert interviews, assess the environmental impacts of oil sands operations. This includes assessing water and air quality, soil contamination, and impacts on local ecosystems and human health.

2. Socio-economic and cultural impact assessment:

Data Collection: Through a literature review, understand the experiences and perceptions of Indigenous community members in the Athabasca region about the impacts of oil sands development. Collect qualitative data on changes in traditional lifestyles, cultural practices, and economic activities. Record stories, anecdotes, and observations that highlight community adaptation and resilience in the face of industrial development.

Impact Documentation: Document the socio-economic and cultural impacts of oil sands development. This will include changes in traditional practices, displacement of traditional lands, and shifts in economic activity. Analyze how these changes affect community well-being and cultural preservation.

3. Comparative Analysis:

Analyze differences in claims made by government and Indigenous communities: By reviewing and analyzing official reports and statements from government agencies and oil sands companies. Identify key claims made about the environmental and socio-economic impacts of oil sands development. Compare these claims with the observations and experiences of local communities and independent researchers. Highlight differences and explore the reasons behind different perspectives.

4. co-management strategies:

Review existing frameworks: Review existing co-management frameworks and agreements between Indigenous communities and government authorities. Identify successful practices and areas for improvement. Gather the experiences of key stakeholders, including Indigenous leaders, government officials and industry representatives, in co-management and their suggestions for strengthening cooperation.

Recommend best practices: Develop recommendations for best practices in co-management. Focus on ensuring meaningful participation of Indigenous communities in decision-making processes, respecting their rights and knowledge, and promoting sustainable management of natural resources.

4. Results & Discussion

4.1 Air

4.1.1 Greenhouse Gases Emissions

Anthropogenic carbon dioxide (CO2) and methane (CH4) are the most significant greenhouse gases contributing to global climate change (Erland et al., 2022). According to the ECCC Data Catalogue / Catalogue de Données D'ECCC (2024), in 2019, the measurement site at Fort McKay South showed an average value of CO2 at 424.870 ppm and CH4 at 2.047 ppm. In the study area, as the Athabasca oil sands region surrounds it, GHGs are generated from oil sands mining and related processes, such as the burning of fuel to sustain the steam that heats the oil sands and the large work trucks that transport the oil sands and bitumen (Gonzalez Moguel et al., 2022). At the same time, tailings in the region probably emit about 34% of the total methane gas emissions (Gonzalez Moguel et al., 2022). With the introduction of methane reduction targets set by the Alberta government, methane emissions have been reduced by about 45% between 2014 and 2022. It has had a significant effect on the reduction of greenhouse gas levels in the local air.

4.1.2 Air Pollutant Emissions

In addition to GHGs, operations in the Athabasca oil sands field produce many other airborne pollutants such as sulphur dioxide (SO2), nitrogen oxides (NOx), volatile organic compounds (VOCs), alkylated polycyclic aromatic hydrocarbons (APAH) and particulate matter (PM) (Spangelo et al., 2016). According to Oil Sands Environmental Impacts / | Canada Commons (2024), some of these releases can affect humans and animals, as well as create localized acid rain and other environmentally harmful impacts such as soil acidification. These contaminants can affect water bodies in a 90-kilometer radius around the facility (Hebert et al. 2013)

Sulpfur Dioxide and Nitrogen Oxides

Sulfur dioxide contributes to acid rain and is also toxic (Oil Sands Environmental Impacts / | Canada Commons, 2024). Nitrogen oxides contribute to the formation of ground-level ozone, as well as the formation of nitric acid which contributes to acid rain and is itself somewhat toxic (Oil Sands Environmental Impacts / | Canada Commons, 2024). Between 2010 and until 2014, total nitrogen oxide emissions within a thirty-kilometer circle centered on Fort McKay 174 have remained at approximately sixty-three thousand tons per year (Spangelo et al., 2016). According to the data obtained by Davidson and Spink (2018), in Fort McKay, the concentration of nitrogen oxides tends to increase in the middle and high percentiles and is positively correlated with local asphalt production with high correlation. At the same time, exceedances of the NOx standard have become more frequent, with 588 events occurring between 1998 and 2014, although there have been no events exceeding the Alberta Ambient Air Quality Objective (AAAQO) (> 159 ppb). Total sulfur dioxide emissions within a thirty-kilometer square circle centered on the study area ranged from 80,000 to 100,000 tons per year between 2010 and 2013 but decreased to 40,000 tons in 2014 (Spangelo et al., 2016). Concentrations of sulfur dioxide showed a non-linear and significant elevation from 1998 to 2014, but sulfur dioxide emissions from the oil sands industry in the study area showed a slight negative correlation with local sulfur dioxide concentrations (Davidson and Spink, 2018). Meanwhile, between 1998 and 2014, there were 1,843 exceedances of the sulfur dioxide standard, with 1,175 Class 2 (> 12 ppb), 462 Class 3 (> 24 ppb), and 205 Class 4 (> 36 ppb) events, exceeding the Alberta Ambient Air Quality Objective (AAAQO) (> 172 ppb) with one incident (Davidson and Spink, 2018).

Particulate Matter (PM 2.5 and PM10), except PAHs

Particulate matter (PM) are small solid or liquid particles in the air that are less than 2.5 micrometers in diameter (PM2.5) and between 2.5 and 10 micrometers in diameter (PM10) and can cause lung damage when inhaled. Trace elements contained in these particles can also be toxic (Environmental Impacts of the Oil Sands/Canadian Public Resources, 2024). PM in the Fort McKay region comes primarily from facility emissions from the oil sands industry, such as smokestacks from mills, exhaust from vehicles transporting oil sands, and dust from mining facilities (Brook et al., 2019). Of this, 70% of PM2.5 comes from oil sands dust, which is much larger than PM2.5 (8%) manufactured by the oil sands industry (Yang et al., 2024). According to data obtained by Davidson and Spink (2018), in Fort McKay, while there is no data to suggest that airborne PM2.5 and PM10 have increased significantly in recent years, there is a weak positive correlation (~0.3) between concentrations of these small particles and local bitumen production. Meanwhile, between 1998 and 2014, there were 92 exceedances of PM2.5 concentrations, especially in 2011, which may have been caused by a severe forest fire in the vicinity that year (Davidson and Spink, 2018). Based on the calculations, there is a trend of increasing PM2.5 concentration exceedance events from year to year. According to Brook et al. (2019), the total black carbon emissions from surface mining facilities are approximately 707 ± 117 tons/year. According to the most recent data reported by Yang et al. (2024), trace elements contained in PM2.5 and PM2.5-10 around the study area were highest for silicon, calcium, and aluminum, which accounted for 42%, 21%, and 14% of the total elemental emissions of PM2.5 and PM2.5-10, respectively. Yang et al. (2023) mentioned that the average concentrations of all the elements were higher in Fort McKay than in other parts of the Athabasca region. Yang et al. (2024) also mentioned the cancer risk of these PM2.5 and PM2.5-10 elements and of the potentially carcinogenic heavy elements (e.g., lead and cadmium), only chromium Cr had a maximum carcinogenicity value that was above the acceptable level, but below the tolerable risk level (~4.03 *10-6), and the non-carcinogenicity values for each element were below the acceptable level. The non-carcinogenic values for each element are below acceptable levels, which means that respiratory diseases such as asthma and rhinitis are less likely to occur (Yang et al. (2024). Mercury (Hg), the toxic element of greatest concern, is produced during oil sands extraction in the form of PM, and mercury deposition is seasonal, with emissions from wildfires being the main source of atmospheric mercury during the summer months, with average concentrations that can reach 2.5 nm per square meter per day. In winter, on the other hand, Hg deposition mainly originates from oil sands operations, and during the period 2012-2013, when Hg emissions were at their highest, there was an increase in Hg deposition of 146-500% in winter, compared to an increase of 13-56% in summer (Dastoor et al., 2021). It is clear that oil sands mercury releases are a significant source of mercury contamination around Fort McKay and that this mercury deposition is absorbed by vegetation and transported into the soil and may also enter the local water system with snowmelt (Dastoor et al., 2021).

Volatile Organic Compound (VOC)

Volatile organic compounds (VOCs) are a group of organic chemicals that readily turn into vapors or gases, usually containing carbon and hydrogen (Oil Sands Environmental Impacts / | Canada Commons, 2024). In the Fort McKay area, VOCs are emitted from a variety of sources associated with oil sands extraction, processing, and transportation, as well as from the release of hydrocarbon solvents from tailings ponds, which has received much attention in recent years (Yousif et al., 2023). These compounds are released during the extraction and purification of bitumen, as well as from storage tanks, tailings ponds and fossil fuel combustion. Elevated levels of VOCs can lead to a number of environmental and health problems (Moussa et al., 2021). Environmentally, VOCs contribute to the formation of ground-level ozone and particulate matter, both of which reduce air quality and pose a hazard to vegetation and wildlife (Oil Sands Environmental Impacts / | Canada Commons, 2024). In terms of health, exposure to high levels of VOCs has been linked to respiratory problems, headaches, dizziness, and in some cases long-term effects such as liver and kidney damage, as well as an increased risk of cancer (Spangelo et al., 2016).Yousif et al.,(2023) state that in the study area, the majority of detectable VOCs are from tailings ponds and fugitive plant sources (66% of total VOCs), Syncrude tailings ponds, due to their proximity to Fort McKay, they are the source of VOCs that most affect VOCs concentrations at the study site, with isoprene and n-pentane being the most dominant VOCs constituents, and they give off odors. However (Moussa et al., 2021) suggested that suncor tailings ponds are the most influential (57% of VOCs) to Fort McKay, where tailings ponds in the area produced 3322± 727 tons of VOCs in 2017.

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are organic compounds that contain multiple aromatic rings and are also common in the Fort McKay area as a result of oil sands activities (Oil Sands Environmental Impacts / | Canada Commons, 2024).PAHs are produced during incomplete combustion of organic matter, and in the context of the oil sands, they are released through the processes such as bitumen extraction, purification, and tailings pond discharge (Yang et al., 2024). These compounds are known for their persistence in the environment and their potential to accumulate in the food chain (Yang et al., 2024). Although (Oil Sands Environmental Impacts / | Canada Commons, 2024) states that these PAH emissions are not high, a more recent report from Brook et al., (2019) suggests that PAH emissions are underestimated and that modeled concentrations are much lower than those actually observed. (which may be due to the limitations of current technology), with concentrations of PAHs up to 23 times higher than those seen prior to oil sands extraction. Foremost among these is an important oil sands production contaminant called alkylated polycyclic aromatic hydrocarbons (APAHs), which have higher toxicity and environmental concentrations than PAHs and are more likely to accumulate in the environment (Yang et al., 2024). Suspended dust from mining is the primary source of PAH, followed by gas-phase PAH from tailings ponds, with the highest concentrations of PAH reaching approximately 140 ng per cubic meter in tailings ponds west of Fort McKay (Yang et al., 2024).

4.2 Water

4.2.1 Water Usage

Extracting and processing bitumen from oil sands requires large amounts of water. The main methods used to extract oil sands are surface mining techniques and on-site extraction (Oil Sands Environmental Impacts / | Canada Commons, 2024). Both of these techniques consume large amounts of water during implementation, especially surface mining and warming (Oil Sands Environmental Impacts / | Canada Commons, 2024). This water would come primarily from the Athabasca River, one of the largest freshwater resources in the region (Energy Regulator, 2024). The Athabasca River is not only a major water resource for the Athabasca oil sands, but also a source of domestic water for the people of Fort McKay in the study area. According to data collected by (Oil Sands Environmental Impacts / | Canada Commons, 2024), between 2005 and 2013, an average of 3.2 barrels of fresh water was consumed for every barrel of bitumen produced by surface mining, while on-site techniques required an average of 3.4 barrels of cold water (fresh + salt) to produce a barrel of bitumen. While Fort McKay First Nation Year in Review 2019 (2019) suggests that in recent years, 80-95% of the water used in surface mining has been recovered, and 85-95% of the water used in on-site technologies has been recovered, the total amount of water used in both bitumen extraction technologies has been increasing each year (Oil Sands Environmental Impacts / | Canada Commons, 2024). At the same time, Zaghloul et al. (2022) suggest that the total flow of the Athabasca River has been declining over the past 60 years (from 1971 to 2022). From 1991 to 2022, the river flow in Fort McMurray near Fort McKay decreased by 32% to about 3.059 cubic meters per year (Aryal et al., 2024). Reduced streamflow in the Athabasca River near the study area has resulted in a lowering of the Lake Athabasca water level line (Aryal et al., 2024). And while it is not clear that this will cause a decline in water levels in the Athabasca River watershed adjacent to Fort McKay, it cannot be ruled out that with the total flow in this reach decreasing from year to year, the water level will also slowly decline.

4.2.2 Water Contaminants

The Fort McKay region is located in the Athabasca oil sands region of Alberta, which faces significant challenges related to water pollution due to extensive industrial activity. Various processes for extracting and processing bitumen from the oil sands result in significant amounts of pollutants in local water bodies One of the main issues is the creation of tailings ponds, which are large containerized areas for by-products of bitumen extraction, where oil sands process-affected water (OSPW), wastes, and other materials from the extraction of the bitumen are stored in tailings ponds for later reuse (Oil Sands Environmental Impacts / | Canada Commons, 2024). These tailings contain water, sand, clay, residual bitumen, and a mixture of chemicals used in the mining process, such as hydrocarbon solvents used to extract bitumen (Oil Sands Environmental Impacts / | Canada Commons, 2024). These tailings are close to the Athabasca River, a water resource that the Fort McKay First Nation relies on, and these tailings ponds may leak, causing hazardous substances to flow into the river and contaminants from the oil sands industry (e.g., heavy metals such as mercury) may also enter the local water system through sedimentation (Dastoor et al., 2021). Frank et al. (2014) suggest that oil sands process-affected water (OSPW) is leaking from tailings ponds into groundwater and is flowing into rivers near tailings ponds, particularly the Athabasca River and its tributaries.

Heavy Metals

Heavy metal contaminants, including arsenic, cadmium, lead, and mercury, are released during the mining and purification processes, and some of these heavy metals leach into water bodies from tailings ponds, mining wastes, and industrial runoff (Yang et al., 2024). These elements are persistent in the environment and can accumulate in the tissues of aquatic organisms, leading to bioaccumulation and biomagnification in the food chain (Dastoor et al., 2021). Exceedances of heavy metals occur during the spring flood season and rarely during normal times. According to Brook et al. (2019), common metallic elements such as iron, aluminum, and copper are often exceeded, but this is common. Heavy metal arsenic, on the other hand, was found to exhibit higher concentrations than the CCME bed sediment quality guidance in the Athabasca

River near the oil sands and its tributaries. Loads of arsenic, selenium, and vanadium were found to be more than 200% higher in the downstream area of the Athabasca (and reaches close to the study area) than in the upstream reaches (Brook et al., 2019). Meanwhile, downstream concentrations of heavy metals associated with oil sands mining, such as molybdenum, nickel, rhenium, and vanadium, have increased annually, but concentrations of other heavy metals, such as silver and arsenic, have not increased with oil sands mining (Klemt et al., 2021). In the Athabasca River near Fort McKay, most metal concentrations were less than CCME thresholds, except for Cr, which that were greater than 4.8 times the Interim Sediment Quality Guidelines for the Protection of Aquatic Life (ISQG) minimum enrichment threshold (Klemt et al., 2021). Mercury, on the other hand, reaches its highest concentrations in the River during the flood season, ranging from 3-16 ng per liter (normally only less than 2 ng per liter), and poses a risk to Fort McKay's environment (Dastoor et al., 2021). In addition to the River, there are many marshes near the study area (Fort McKay) that are the most important source of water for the local population. In these marshes, silver, arsenic, bismuth, cadmium, copper, lead, antimony, thallium, and zinc concentrations are much lower than in other provinces in Canada, where heavy metal contamination has not been detected (Shotyk et al., 2016).

Polycyclic Aromatic Hydrocarbons (PAH):

PAHs have been found in air, water, and soil in the Fort McKay area as a result of emissions from industrial processes and tailings ponds (Yang et al., 2024). Based on samples taken from the Athabasca River, Vignet et al. (2019) found that most of the PAHs come from bitumen produced by the local oil sands industry. These PAHs enter the Athabasca River through several main pathways: 1. natural erosion of exposed oil sands mines 2. dust from the mining process 3. wastewater leaks originating from tailings ponds (either directly into the river or through contaminated groundwater) 4. volatilization of PAHs from tailings ponds (Evans et al., 2019). High concentrations of PAHs in water can be toxic to fish and other aquatic organisms, causing reproductive and developmental problems (Evans et al., 2019). For humans, exposure to PAHs has been linked to a variety of health problems, including respiratory problems and increased cancer risk (Baker, 2018). Although PAHs deposited in snow enter the Athabasca River as the snow melts as temperatures rise, total PAH concentrations in the river became significantly lower, from 23,815 to 273,140 ng per liter in the snow to 50 ng per liter in the water, likely due to dilution of contaminant exposures (Brook et al., 2019). According to Evans et al. (2019), at Fort McKay, PAH was generally greater on the east bank of the River than on the west bank, with an average concentration of 23,500 ± 19,700 ng/g on the east bank compared to 336 ± 44 ng/g on the west bank, while there was not much variation in PAH concentrations upstream and downstream, which may be due to the fast flow rate of the Athabasca River through the oil sands operation area (Evans et al., 2019).

Naphthenic Acids

Naphthenic acids, a group of naturally occurring constituents of oil sands that are concentrated in OSPW during the extraction of bitumen, are prevalent in tailings ponds resulting from oil sands operations, which contain concentrations of naphthenic acids in the range of 80 to 110 mg per liter (Kavanagh et al., 2009). These acids are highly toxic to aquatic organisms, leading to risks of long-term exposure to wildlife and humans, and their presence in water bodies can disrupt the reproductive systems of fish and other aquatic species, leading to declining fish populations and ecosystem imbalances (Gutgesell et al., 2022). The natural concentration of naphthenic acids in surface waters in the region is around 1-2 mg per liter and based on sampling by Kavanagh et al. (2009), the average naphthenic acid concentration in the Athabasca River is less than 0.6 mg per liter, so it can be concluded that the Athabasca River does not exceed the natural background concentration in the Fort McKay watershed and does not pose a significant threat. However, those groundwater samples near Fort McKay near the tailing ponds had naphthenic acid concentrations of 26 mg per liter, well above natural levels, and naphthenic acid leaking from the tailing ponds at the OSPW is seriously contaminate the groundwater and has the potential to enter the Athabasca River in the future.

4.3 Wildlife Contaminants & Biodiversity

The Athabasca oil sands region, particularly around Fort McKay, faces significant ecological challenges due to oil sands-related industrial activities. The extraction and processing of bitumen not only affects the local economy but also has far-reaching impacts on wildlife, biodiversity, and land use (Brook et al., 2019). The introduction of pollutants into the environment, habitat destruction, declining wildlife as well as fish populations, and changes in land use patterns have had complex and often detrimental impacts on the region's natural ecosystems (Behr et al., 2019).

4.3.1 Contaminants in Wildlife

Oil sands operations have resulted in the release of a variety of contaminants into the environment, which in turn affects local wildlife. Major contaminants include the heavy metal mercury, polycyclic aromatic hydrocarbons (PAH), and naphthenic acids (Brook et al., 2019). These substances are released through mining activities, tailings ponds, and atmospheric deposition, can accumulate in the environment, and are toxic to wildlife (Spangelo et al., 2016; Brook et al., 2019). They have been detected in the tissues of fish, birds, and mammals in the region and complete bioaccumulation and biomagnification in organisms, which can lead to reproductive failure, neurological damage, and death in affected species (Gutgesell et al., 2022).

According to Evans et al. (2019), PAH concentrations in *Trout* and *Bass* in the Athabasca River basin near the study area ranged from 85 ± 21 ng/g to 131 ± 14 ng/g, whereas the average PAH level in fish caught during the fall fishing season in the study area was 126 ng/g, with *Northern Pike (Esox lucius)* having the highest average PAH levels. The highest mean PAH levels were found in *Northern Pike (Esox lucius)* at 183 ng/g, and the lowest mean PAH levels were found in *River Cod (Lota Lota)* at 84 ng/g. Concentrations in these fish were not high enough to cause human health problems, either because PAH concentrations in the water were reduced due to a high water exchange rate or because some PAHs are challenging to absorb (Evans et al., 2019). No report has yet mentioned the effects of these PAH concentrations on the above fish caught in the study area. However, *Mucus Sculpin* in the more downstream areas of the Athabasca River became bioindicators and was found to have reduced juvenile survival and reduced gonadal development downstream (Brook et al., 2019). *Waterfowl*, the top predator in the study area, accumulate these contaminants in their bodies, and their eggs carry them. According to Hebert et al. (2013), eggs collected from Lake Athabasca in the upper part of the study area showed a trend of increasing mercury levels from year to year, with California gulls' eggs showing a 66% increase in mercury levels in 2012 compared to 1977, but not all bird species' eggs showed this trend of increasing mercury concentrations over time, and in the southern part of the country, mercury levels in the eggs were higher. in bird eggs in the South decreased by 57% in 2012 compared to 2008, which may be due to a reduction in mercury emissions from surrounding facilities. While there is no separate study of mercury levels in waterfowl at Fort McKay in the study area, Hebert et al. (2013) suggest that mercury levels in bird eggs would be higher near the Athabasca River than elsewhere.

4.3.2 Biodiversity

The Athabasca oil sands region is home to a wide variety of species, including boreal forest animals such as caribou, wolves, and bears, as well as numerous bird species. However, industrial activities have led to significant habitat loss and fragmentation, which is a major threat to biodiversity (Behr et al., 2019). The construction of roads, pipelines, and other infrastructure associated with oil sands development has fragmented the landscape, disrupting migration patterns and breeding sites (Behr et al., 2019). Drainage and alteration of wetlands for oil sands extraction can reduce the availability of these important habitats and further exacerbate pressure on local wildlife populations.

According to Oil Sands Environmental Impacts / | Canada Commons (2024), the retention of species diversity in the Athabasca region was 94% in 2012. In 2012, native birds were the most impacted species with biodiversity integrity of 80%, with eight species of birds losing their ancient forested habitat decreased in abundance, such as the *Black-Throated Green Warbler*, while 10 species increased in abundance due to adaptation to human activities. Large top predators such as the Gray Wolf were observed to maintain 91% integrity among mammals. However, almost all observed species integrity was lower than expected in the Athabasca oil sands region, with the worst species integrity at 87%. 183 vascular plant species had an average species integrity of 88%. The most negatively impacted plants were from young deciduous forests and old coniferous forests, with an integrity of only 56% to 78%. In contrast, *Red Fescue*, a native grass adapted to operations in the oil sands, has locally achieved three times the expected. Although berry plants were negatively impacted in the Athabasca area, species integrity reached 97 %.

4.3.3 Soil Disturbance

The expansion of oil sands operations has led to significant changes in land use patterns in the region. Large tracts of boreal forest have been cleared for mining and infrastructure development, resulting in a loss of forest cover (Santana-Martinez et al., 2024). This deforestation has resulted in habitat loss and broader ecological impacts, including increased greenhouse gas emissions and altered hydrologic cycles. Changes to the natural landscape have also impacted Indigenous communities, who rely on these lands for traditional activities such as hunting, fishing, and gathering. In the Athabasca oil sands region, mining has impacted 2.5% of the area. While 86% of the land was unaltered in 2010, only 67% of the land was more than 50 meters away from land with human activity (Oil Sands Environmental Impacts / | Canada Commons, 2024).

Reclamation is required by law, but restoring the land to its original condition is extremely challenging and often falls short of pre-development conditions. The reclamation process is slow and complex, involving soil reestablishment, replanting of native vegetation, and re-establishment of water bodies. Even with these efforts, the restored landscape may not fully support the original biodiversity or provide the same ecosystem services (Santana-Martinez et al., 2024). As of 2012, 5,042 hectares of the 85,000 hectares impacted had been fully reclaimed, but only 103 hectares had been officially certified as reclaimed, and more than 90% of the impacted land remains disturbed (Oil Sands Environmental Impacts / | Canada Commons, (2024)).

4.4 Impacts and Co-Management with Fort McKay First Nation

4.4.1 Impacts

The Fort McKay First Nation is located in the Athabasca oil sands region of northern Alberta, which has changed dramatically over the past few decades due to the rapid growth of the nearby oil sands industry. These changes have affected all aspects of their lives, including traditional lifestyles, diet, health, and socioeconomic conditions (Westman & Joly, 2019). While the oil sands industry has brought economic opportunities, it has also brought great challenges that have affected the cultural heritage of the community, such as language and knowledge as well as limitations on the rights associated with subsistence activities, a phenomenon also known as slow industrial genocide (Parlee, 2015; Huseman & Short, 2012).

Culture

The Fort McKay First Nation has a rich cultural heritage that is closely tied to the land. Traditional activities such as hunting, fishing, trapping and gathering have been an integral part of their lifestyle for generations (Baker & Westman, 2018). These activities are not only for subsistence but also have cultural and spiritual significance (Parlee, 2015). As a result, there is a strong relationship between the land and the Fort McKay First Nations. Under Treaties VIII and VI, the Fort McKay First Nations were granted rights to a range of activities on the land (Baker2010 & Westman, 2018). However, the expansion of the oil sands industry has led to extensive land destruction, air pollution, and water contamination, among other things, which violates the rights of the Fort McKay First Nations and related treaties (Behr et al., 2019). These environmental changes have drastically reduced the areas available to the Fort McKay First Nations for traditional activities, and it has been calculated that 307,762 hectares of land had been rendered unusable for traditional activities by the end of 2017 (Behr et al., 2019). Behr et al. (2019) mention that some transportation corridors are not available to the Fort McKay First Nations, such as the Aostra Road. There are also some waterways that are not usable due to declining water levels; they have also lost some of their fisheries in the Athabasca River, such as the area for fishing the *Jackfish and Pickerfish*. Medicinal plants and edible berry gathering have been destroyed, and log cabins and campsites of the Fort McKay First Nation people of historical significance have been destroyed. With the destruction of these areas where traditional activities can occur, the Fort McKay First Nations are concerned about depriving future generations of the opportunity to learn and practice their traditional culture (Behr et al., 2019).

Food and Health

Fort McKay First Nations have traditionally fed on local wildlife, fish, and plants. However, industrial activities have raised concerns about the safety of these traditional food sources (Behr et al., 2019). Although Evans et al. (2019) suggest that concentrations of PAHs in fish species caught within the Athabasca River study area do not cause health concerns. However, community members reported changes in the taste and quality of the fish, an increasing probability of deformed fish, and concerns about the long-term health effects of consuming contaminated food (Natcher et al., 2020). Despite the fact that, according to Shotyk et al. (2016), heavy metal levels in groundwater do not pose a threat to humans, and PAH and Alkylcyclic acid levels in the water are not exceeded except during the spring flooding season, Fort McKay First Nation have stated that they do not even trust that the tap water is safe, or that it is safe to drink water from the creeks, and have switched to drinking bottled water instead. Meanwhile, the Fort McKay First Nations feel that meat, berries, and medicinal plants can become unsafe due to contamination, Bake (2018) suggests that of the 150 food samples they took within the boundaries of the Fort McKay First Nations, they found that the mercury concentrations in meat mostly exceeded Health Canada's guidelines, while berries picked in the Athabasca River and the study area would have heavier metals than other places, and while not exceeding Health Canada guidelines, it was uncertain whether there would be any human health impacts. As a result, many in the community turn to store-bought foods, and lack of access to traditional foods can erode cultural practices associated with food preparation and consumption (Baker, J., 2018).

Environmental changes and industrial activities in the area have had a significant impact on the health of the Fort McKay First Nations. According to Spangelo et al. (2016), between 2010 and 2014, 56 complaints were received about environmental changes and pollution, including air pollution, water pollution, and noise pollution. According to Behr et al. (2019), the Fort McKay First Nation expressed their disbelief that the thresholds and guidelines of the AAAQOs protect their health and that they trust their elders and observations more. At the same time, there are no accurate findings to date that show a relationship between cancer and environmental pollution in the study area, with different results being obtained due to different research methods (Baker & Westman, 2018).

Social and Economic Impacts

While the oil sands industry has had a negative impact on the environment, it has brought opportunities to the Fort McKay First Nations to boost the local economy (Baker & Westman, 2018). On the one hand, the community benefits from employment opportunities, economic partnerships, and revenue-sharing agreements with oil sands companies that accumulate billions of dollars (Baker & Westman, 2018). These economic gains provide millions of dollars in funding for community infrastructure, education, and other social services (Baker & Westman, 2018). At the same time, large oil sands companies have provided employment opportunities for the Fort McKay First Nation, with an employment rate of 5% (Parlee, 2015). However, Parlee (2015) also suggests a “resource curse”, stating that with unemployment rates around the study area ranging from 11%-33% and with oil sands companies providing jobs that tend to be laborers rather than well-paid technicians, Fort McKay's economy is growing at a slow rate, especially with such a lucrative oil resource industry. Baker & Westman, (2018) also suggest that the cost of living in towns rises with the development of the oil sands industry and that the decline of Indigenous customary users and loss of language can lead to “slow industrial genocide” as young people flock to the oil sands industry.

4.4.2 Conflicts between Government Organizations and Indigenous Groups

Government agencies and oil sands companies emphasize the economic benefits of oil sands development more than the environmental impacts. Official reports often emphasize job creation and overall contribution to the country's energy and economy (Government of Canada, 2022). For example, governments often cite the oil sands industry's considerable economic output, including energy output and resource value, as well as indirect benefits to related industries (ALBERTA ENERGY OUTLOOK, 2024). In terms of environmental impacts, government and industry reports typically focus on the regulatory frameworks in place to mitigate negative impacts. These include monitoring programs, environmental assessments, and reclamation requirements to manage water use, reduce greenhouse and hazardous gas emissions, and restore disturbed landscapes (Oil Sands Environmental Impacts / | Canada Commons, 2024). The government and associated oil sands industry companies have also emphasized technological advances aimed at reducing the environmental footprint and have advocated for the use of these technologies to reduce environmental impacts where economically feasible, such as improved tailings management and water recycling technologies (Responsible Actions: A Plan for Alberta's Oil Sands, 2009). 2009). At the same time, the government is more interested in the "prosperity" that the oil sands industry can bring to the region in terms of economic development and population growth (Responsible Actions: A Plan for Alberta's Oil S ands, 2009).

In contrast, Indigenous communities and independent researchers tend to take a more critical view of the impacts of oil sands development. Indigenous communities, such as the Fort McKay First Nation, have emphasized the negative impacts on their traditional lands and way of life (Behr et al., 2019). They report significant changes in the environment, including contamination of water sources with pollutants such as heavy metals and polycyclic aromatic hydrocarbons (PAHs), affecting the safety and availability of traditional foods such as fish and game, and they place more faith in the conclusions of the community's Elders through experience in these areas, even when they have access to accurate data from government testing (Behr et al., 2019). At the same time, the Fort McKay First Nation community is also concerned about their own cultural heritage, with the loss of culture due to the large reduction of traditionally available land leading to fewer opportunities for them to perform traditional activities (Behr et al., 2019). The influx of non-Indigenous workers and the shift to a cash economy is believed to have undermined traditional social structures and cultural practices and has led to increased unemployment and higher local costs of living as well as deterioration in the style of living of the Fort McKay First Nation people (Baker & Westman, 2018).

Government and industry stakeholders typically prioritize economic growth and energy security, emphasizing job creation and economic benefits (Government of Canada, 2022). In contrast, First Nations communities prioritize environmental integrity and cultural preservation, focusing on the direct impacts of industrial activities on their land and way of life (Behr et al., 2019). Government and industry reports tend to focus on regulatory compliance and technological advances, often underestimating the cumulative and long-term impacts of oil sands development. On the other hand, Indigenous communities and independent researchers emphasize broader ecological and health impacts, including the disruption of traditional practices and cultural erosion (Behr et al., 2019).

There are often differences in how risks are perceived and communicated. Government and industry may emphasize the effectiveness of mitigation measures, but Indigenous communities and researchers may view them as insufficient, especially in light of ongoing environmental degradation and health concerns (Natcher et al., 2020). Lack of trust in government and industry-led assessments can also lead to differing perspectives (Parlee, 2015).

4.4.3 Cooperation and Recommendation

Indigenous knowledge systems deeply understand local ecosystems and cultural practices, and the Fort McKay First Nation people have emphasized the importance of protecting their lands and local ecology and have provided valuable insights into Western ecology (Wilcox et al., 2023). While the perspectives of the Fort McKay First Nations have been ignored in the past, as governments and oil sands companies become increasingly aware of the need to protect their environment and culture, they realize that effective co-management strategies in the region can enhance environmental stewardship, ensure resource sustainability, and respect the rights and knowledge of First Nations communities and their heritage (Parlee, 2015).

Differences Between Indigenous Knowledge Systems And Western Science

Indigenous knowledge systems are fundamentally different from Western science in their approach to understanding and interacting with the environment. Indigenous knowledge systems take a holistic view; they emphasize the relationships between plants, animals, humans, and the natural world, focusing on how these relationships contribute to the balance and health of ecosystems (Wilcox et al., 2023). This knowledge is based on centuries of observing and interacting with the environment, accumulated over generations, and transmitted through oral traditions, stories, and cultural practices (Miriti et al., 2022). In addition, Indigenous knowledge incorporates cultural and spiritual beliefs and customs and rituals closely associated with the land, emphasizing respect for, management of, and sustainable use of natural resources (Wilcox et al., 2023). Meanwhile, Western Science Passage aims to understand specific elements of the environment through controlled experiments and empirical data collection (Miriti et al., 2022). The scientific method, which is at the heart of Western science, consists of formulating hypotheses, experimenting, observing, and analyzing to conclude, aiming to eliminate bias and ensure rigorous testing of theories (Miriti et al., 2022).

Recommendations Based on Past Actions:

First, it is imperative to recognize, respect, and protect the right to self-determination of the Fort McKay First Nation people.

According to “Article 1 of the International Covenant on Civil and Political Rights (ICCPR) and the International Covenant on Economic, Social and Cultural Rights (ICESCR)”, the right to self-determination implies the right to have specific cultural beliefs, languages, lifestyles and to determine the direction of economic development, and The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) (Chima Onyeneke et al.). Declaration on the Rights of Indigenous Peoples (UNDRIP) grants the right of self-determination to Indigenous peoples globally. However, this right of implementation is not given to the local Indigenous people but to the colonial powers that own the Indigenous territories, such as the Canadian government (Chima Onyeneke et al.). However, with the development of the oil sands, Canada has become increasingly inconsistent with its original commitment to UNDRIP, as well as violating Indigenous peoples' right to free, prior, and informed consent (FPIC) (Birrell, 2022). Despite the signed agreements and cooperation, it is evident that the Fort McKay First Nations have expressed their discontent and protests on several occasions over the negative impacts of oil sands extraction on their lives, such as the encroachment of traditional lands, contamination of tailings ponds, and contamination of heavy metals in their food, which demonstrates Canada's failure to comply with FPIC and the right to self-determination of the Fort McKay First Nations in the extraction of oil sands (Brunet et al., 2020). Therefore, protecting the right to self-determination and FPIC of the Fort McKay First Nation is of utmost importance because it will allow them to reap the economic benefits of oil sands development while being able to say no to any oil sands project that may affect them in order to avoid the resource curse and industrial genocide (Birrell, 2022).

Kalyta (2022) proposes a four-step ladder for Indigenous governance, which are, non-participation (ignored or no participation), Tokenism (limited participation, superficial recognition of rights), Degrees of Power (some decision-making power, participation in governance and decision-making processes), and Indigenous Control (full control of their territory and governance). (full control of their territory and governance processes), with the hope of reaching the third and fourth ladders by adhering to the right of self-determination of the Fort McKay First Nation.

Based on the protection of self-determination and FPIC for the Fort McKay First Nation, we can further apply Indigenous knowledge to manage and control the impacts of oil sands mining. Indigenous knowledge protects and manages local lands and environments in a sustainable way by protecting and enhancing Indigenous peoples and local ecosystems. In some instances, resource selection function models from Western science are not as accurate as those based on Indigenous knowledge (Jessen et al., 2021). At the same time, it is possible to learn from the Red Sucker Lake First Nation (RSLFN) in Manitoba, Canada, which is also disturbed by mining, and which has proposed the creation of Indigenous Protected Areas (IPCAs) within their territory to protect their lands, waters, and cultures and to minimize the negative impacts from mining (Chima Onyeneke et al.). Although the PSLFN's proposal was rejected, it would have been viable in Fort McKay if the First Nation's right to self-determination had been protected and observed in Fort McKay.

Land reclamation is also urgent, and as mentioned above, 90% of the disturbed land has not been reclaimed, so a closure plan for the oil sands mines near Fort McKay is a good proposal (Oil Sands Environmental Impacts / | Canada Commons, (2024)). According to Christine Anne Daly et al. (2024b), most of the current mine closure plans in Fort McKay do not comply with UNDRIP and FPIC, and few plans have listened to and taken into account the views of the First Nations of Fort McKay, and have failed to reference and utilize Indigenous knowledge. Therefore, there is a need to add some protection of traditional flora and fauna and cultural landscapes to the reclamation process, with Indigenous knowledge as a core guide, as well as revising policies, such as the revision of provincial policy: Alberta's SED 003, which encompasses the establishment of mandatory Indigenous councils for each mine to ensure that Indigenous people's voices are heard and empowered to make key decisions at every step of oil sands extraction.

Unity of opinion within the Fort McKay First Nation was also crucial, as they were wealthier than other First Nations due to services such as transportation and waste disposal for oil companies, although they still failed to become a tar sands producer (Kelly, 2024). This has led to disagreement within the group, with half agreeing to oil sands extraction for economic support and the other half opposing it due to the destruction of the environment and traditional culture (McDonough, 2022). And according to Kelly (2024), Suncor Energy will sign a Memorandum of Understanding (MOU) with the Fort McKay First Nation, where the company wants to expand oil sands mining, and the Chief of the Fort McKay First Nation seeks more control over the land and resources in order to balance the continuation of the traditional culture with economic development. This may help harmonize opinion differences within the Fort McKay First Nations community.

5. Conclusions

The development of Alberta's oil sands has dramatically altered the environmental, cultural, and socio-economic landscape of the Fort McKay First Nation. The extraction and processing of bitumen have resulted in widespread pollution, including the release of greenhouse gases, air pollutants, and pollutants from local water bodies and particularly high concentrations of pollutants in tailings ponds, all of which have negatively impacted the traditional lands and customs of the Fort McKay community.

While the oil sands industry has brought economic benefits, including employment and revenue-sharing opportunities, these benefits have come at the expense of Indigenous communities' cultural and environmental integrity. The loss of traditional lands, the contamination of food and water sources, and the erosion of cultural practices have led to significant cultural and social disruption within communities.

The report presents a stark contrast between the narratives of government and industry stakeholders, which often emphasize the economic benefits of oil sands development and regulatory compliance, and the first-hand experiences of Indigenous communities, who face the direct consequences of environmental degradation and cultural loss. This disconnect highlights the need for more meaningful engagement with Indigenous knowledge systems and greater respect for Indigenous rights and self-determination.

Going forward, adopting more inclusive and sustainable management practices that prioritize the well-being of Indigenous communities and protect their lands and cultures is important. This includes recognizing and respecting the right to self-determination, integrating Indigenous knowledge into environmental management, and ensuring that Indigenous voices are heard and respected in decision-making processes. Only through these measures can we hope to achieve a more equitable and just future for the Fort McKay Indigenous community and the broader Athabasca oil sands region.

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