Harmonizing Water Resource Management with Indigenous Ways of Knowing: A Collaboration in the Saskatchewan River Delta

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ABSTRACT

Increases in the global population and accompanying demands for water and food production are having detrimental impacts on the sustainability of freshwater systems. These impacts include reduced water quality, abnormal flow fluctuations, and changes in sediment transport by water, among others. Another stressor on watersheds is climate change, as it is for all sensitive ecosystems. The Saskatchewan River Delta (SRD) is no exception. Populations in the SRD, such as the Indigenous communities in Cumberland House, have been adversely affected by upstream water withdrawals for irrigation, dam-induced alterations of the seasonal river flows for hydropower, and legacies of industrial pollution. Although research has demonstrated these and other problems, to date the perspective of the Cumberland House community has been inadequately considered in water resources modeling efforts and flow management. Consequently, the residents of the Delta have seen little in the way of adaptations and solutions.

In this project, I sought to inform water resources and environmental modeling processes and practitioners with the values, insights, and perspectives of how altered water resource management in the SRD have changed from the point of view of the people of Cumberland House, so that developing models representing the Delta may better reflect local contextual factors in their execution. To achieve this objective, I used on-land participant observations and semi-structured interviews as a decolonizing tool to co-gather and analyze community members' narratives on the issues in their environments. The results of this research identified and consolidated how the altered flows are affecting the Saskatchewan River Delta's ecosystem and resident human and animal populations in terms of seasonality, livelihood, spiritual and cultural practices, and aesthetics. This research was completed within a community-engaged scholarship (CES) framework, which brought attention to issues in SRD communities, enhanced voice and agency of SRD residents, and paved the way for future knowledge incorporation not only in the SRD but also in other parts of the world, where interdisciplinary approaches to environmental sciences could lead to more vibrant and sustainable ecosystems.

ACKNOWLEDGEMENTS

This study was conducted in Treaty 5 Territory and Homelands of Cree and Métis Peoples. I would like to start by thanking Cumberland House community members for their time, guidance, and hospitality. You have welcomed me into your lives and opened my horizon to your culture, wisdom, and the truth that lies in this land and its long-lived residents.

I would like to pay special gratitude towards my supervisor and mentor Dr. Graham Strickert. You enabled me and encouraged me to go beyond my comfort zone and I am incredibly fortunate to have worked with you. Thank you for the incredible work environment, motivation and support you provided for me during my study period and extended with pandemic!

It is difficult for an international student coming from a different background and geography to start and establish themselves in the field of social hydrology in the prairies, add a pandemic to it! Therefore, I would also like to sincerely thank my advisory committee and the IMPC team who each provided invaluable support, plentiful experience, and exemplary teamwork and professional ethics on my way. To Hayley Carlson and Laila Balkhi whom without the achievements in this study would not have been possible.

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DEDICATION

To Sima Kargar and Amir Mohammadiazar who presented me to the world in 1995 in Shiraz, Iran.

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LIST OF ABBREVIATIONS

SRD Saskatchewan River Delta

SRB Saskatchewan River Basin

CH Cumberland House

CES Community-engaged Scholarship

TK Traditional Knowledge

TEK Traditional Ecological Knowledge

PBK Place-based Knowledge

IMPC Integrated Modeling Program for Canada

GWF Global Water Future

GIWS Global Institute for Water Security

WSA Water Security Agency

TRC Truth and Reconciliation Commission of Canada

CS Citizen Science

WS Western Science

CHAPTER ONE

THROUGH THE APERTURE[1]: CUMBERLAND HOUSE AND WATER RESOURCE MANAGEMENT

1.1 Study Context: Problem Statement

Sustainability of watersheds is threatened with increasing population, accompanying demands on natural resources, and human developments. In particular, downstream watersheds face uncertain and altered flow regimes, decreased water quality, and soil productivity in addition to climate change. The Saskatchewan River Delta (SRD) is one example. Populations in the SRD, such as Indigenous communities, have been adversely affected by harmful implications of upstream water withdrawals for irrigation, dam-induced alterations of the seasonal river flows for hydropower, and legacies of industrial pollution. Although institutionalized research has demonstrated these and other problems, to date the perspective of the Cumberland House community has not been adequately considered in water resources modeling and management. This research aims to fill some of this gap. As part of a larger community-based participatory research program, it examines the human dimensions of water security in the Saskatchewan River Delta.

This research used community-engaged scholarship, an approach in which the researcher works with a community partner to co-generate and co-distribute knowledge that benefits the community and contributes to the discipline (Saltmarsh et al., 2009). In this research, members of Indigenous Nations living in Cumberland House co-created and co-disseminated knowledge, with the goal of identifying more values held for water flows in the Saskatchewan River Delta in terms of seasonality, livelihood, spiritual and cultural practices, and aesthetics. This kind of place-based knowledge (Haywood et al., 2016) can advance efforts to accurately represent the water flows from upstream to downstream to illustrate the conditions that lead to adverse impacts on the Delta and its communities.

[1] The opening through which light passes through the lens to enter the camera. Its size can be modified to control how much light reaches the sensor or negative film. I use this term because in this chapter I am giving the readers a first look at the community of Cumberland house, and the need for modifying the way researchers and community members reach each other.

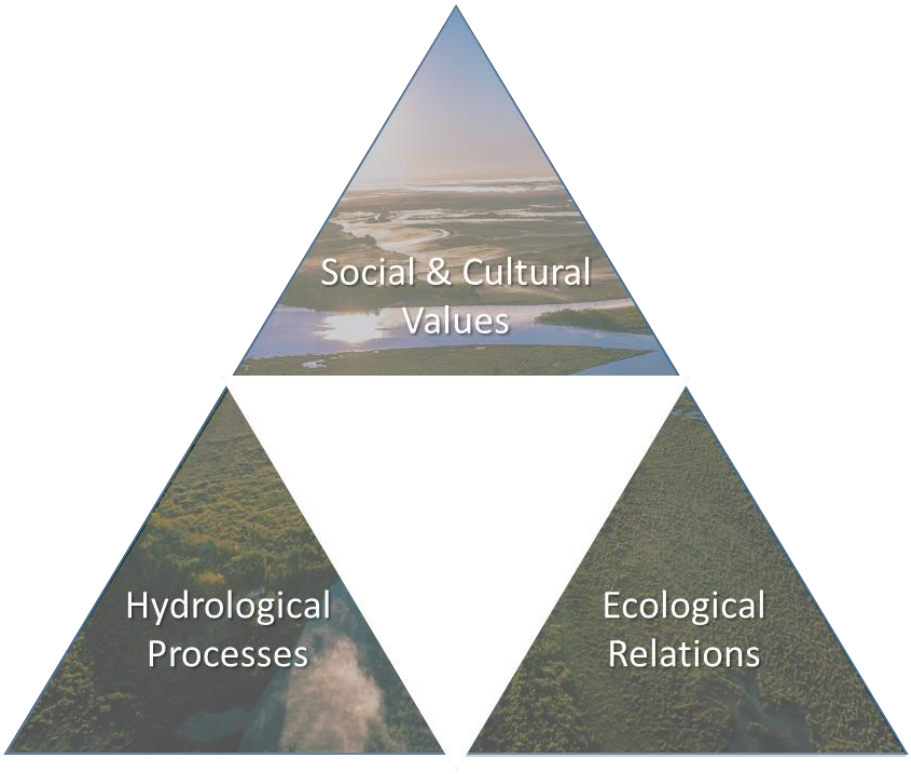


Figure 1.1 *Conceptual Display of three key components of the SRD ecosystem that is viewed through Traditional Indigenous Knowledge in this study to illuminate modeling efforts and decision-making processes for the region*

This project was funded by the Integrated Modeling Program for Canada (IMPC) operating out of the Global Institute for Water Security at the University of Saskatchewan. Together with downstream communities, the IMPC project strove to build advanced modeling capacity to represent complex environmental interactions under the four themes of A) Integrated Earth Systems Modelling, which undertakes basin streamflow modeling, B) Coupling Human-driven and Natural Systems, Environmental flows and nutrient modeling, C) Decision Making Under Uncertainty and Non-stationarity, and D) User Engagement and Knowledge Mobilization.

The community-engaged scholarship approach used in my study (within theme D of the IMPC project) is based on qualitative research techniques and respects the application of Traditional Knowledge and place-based observations to enhance user engagement and knowledge mobilization in water resource management (Kurtz, 2013; Robinson et al.,2016). My research was

open and transparent in considering community's concerns; I followed the lead of co-learners from Cumberland House in my participation in the research, as they preferred me to do.

1.2 Research Objectives

The purpose of this project was to inform water resources models and future management practices with the values, insights, and perspectives of how water resources in the SRD have changed from the point of view of people residing in Cumberland House, so they can verify and augment modeler's assumptions and draft work. To address this purpose, my objectives were as follow:

Objective 1: To determine preferences for flow conditions (e.g., timing, color, smell, the extent of flooding, fluctuations, and seasonality) among residents of Cumberland House;

Objective 2: To determine the impacts flow conditions have on animals and people in the Delta, according to the people who live there; and

Objective 3: To convey observations and knowledge of the people in the SRD, to western scientists so that emerging models and future management practices can reflect and respond to the Delta's needs.

1.3 Research Significance

Despite the long history of planning and land stewardship as a key cultural element among some Indigenous communities, the literature points to a lack of meaningful and regular collaboration with communities and respect for responsive water resource management and governance policies (Gober & Wheater, 2014; Hassanzadeh et al., 2014; Patrick et al., 2017; Saskatchewan River Delta Water Stewardship Plan, 2018). Communities in northern Saskatchewan, for example, until recently have not been consulted and have been ignored in dialogue about water governance and watershed planning (Strickert et al., 2018, Andrews et al. 2018).

To try to be more responsive to the needs of communities—particularly Indigenous communities—universities and researchers are developing longer-term partnerships with communities with the goal of mutual dialogue and learning. In recent years, a few scholars in environmental management studies have implemented community-based approaches such as community-engaged planning and community-based and archival research in the Saskatchewan River Delta (Delta Stewardship Committee 2018; Abu, 2017). Lemoine and Patrick (2014) provided in-depth insight into water governance challenges and opportunities in Northern Saskatchewan, emphasizing the problems 1) with public education, and 2) the lack of consultation with local Indigenous peoples on water governance. Lemoine and Patrick (2014) interviewed local people who expressed their concern about the practical effects of the leadership structure they were subjected to and demanded involvement in and authority over human-environmental interactions. Communities in the SRD have specifically called on the university to enhance partnerships because they want to engage in Delta stewardship activities that include research.

1.4 Area of Study

1.4.1 The Saskatchewan River Delta

North America's largest inland freshwater Delta, the Saskatchewan River Delta (SRD) (*Kitaskinaw* in Cree) near the Saskatchewan and Manitoba border, is home to Cree and Métis Peoples, connects treaties 5, 6, and 10, and occupies about 10,000 km^2 (Gober & Wheater, 2014; Strickert et al., 2016). The initial source water travels all the way from the Rocky Mountains in Alberta into the Saskatchewan River, which eventually supplies water to Cumberland Lake in Saskatchewan's upper Delta. From there, the water is drained by three channels from Cumberland Lake reaching the lower Delta near The Pas in Manitoba. Figure 1.2 shows the Saskatchewan River basin in the three provinces of Alberta, Saskatchewan, and Manitoba, with the SRD boundaries at the end of the basin. A renowned wildlife district, the SRD is home to a diverse range of species, from fish to birds and mammals, as well as to abundant plant life and nutrients that sustain the people and wildlife (Waldram, 1989; Abu, 2017). The Delta is

recognized for its waterfowl-supporting wetlands, which occupy about half of the Delta (Partners for the Saskatchewan River Basin, 2009). In operation for many years, the E.B. Campbell and Gardiner dams have impacted the river's natural flow patterns, causing vast alterations in the flow characteristics such as timing, volume, temperature, nutrient, and sediment loads (Smith et al. 2016), and to the riverine and land species habitats (Abu et al. 2019).

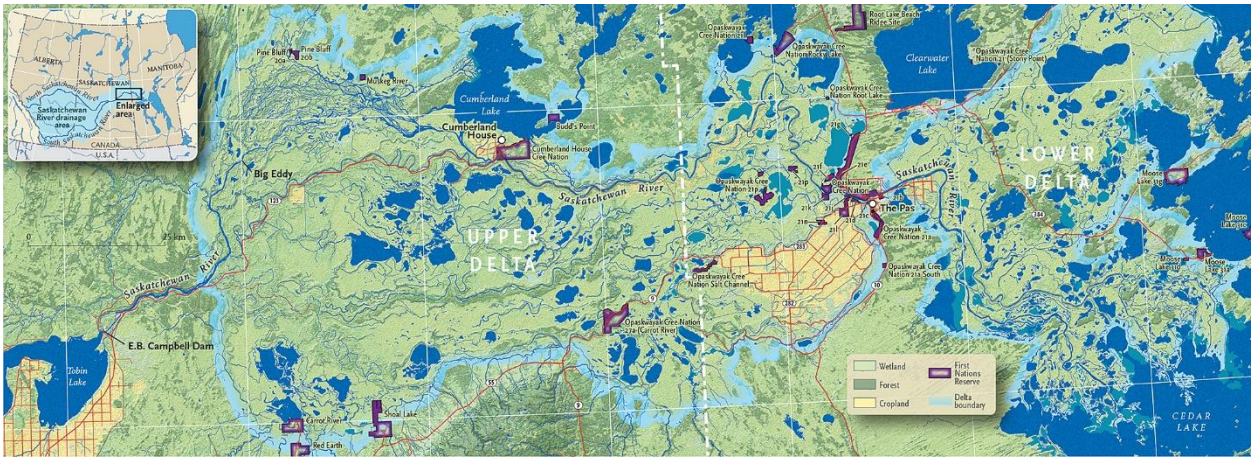


Figure 1.2 *"Map of the Saskatchewan River Delta"* *Chris Brackley/Canadian Geographic. Hydrologic, land cover, elevation and road data provided by Geobase® Retrieved May 14, 2019, from* *https://www.canadiangeographic.ca/article/hope-saskatchewan-river-delta*

1.4.2 Cumberland House

A remote community geographically located on an island in Northern Saskatchewan, Cumberland House (*Waskahikanihk* in Cree) is surrounded by the marshes of the SRD (Goulet, 2013). Embedded in Treaty 5 territory and 450 kilometers northeast of Saskatoon, it is the oldest settlement in western Canada (Goulet, 2013). Humans have been living in this vibrant area for 7000 years according to Goulet (2013), long before Europeans settled in 1774. This establishment was of particular importance in forming a fur-trade route (Abu, Reed, & Jardine, 2019). Cumberland House is now home to more than 2000 people of both Métis (The Northern Village of Cumberland House) and First Nation (Cumberland House Cree Nation) descent and a formal Métis government (Métis Local 42) (Andrews et al., 2018). In the Cumberland House community, there are two trappers' associations (N28 and N90), each with their own respective groups (fur block). There are also two schools (Charlebois Community School and Nisto Awasisak Memorial School) and an angler's cooperative group.

Indigenous ways of life have historically coexisted with natural ecosystems, socially, economically, and spiritually (Brunet et al., 2020). Today, there is less water in the Delta (Sagin et al. 2014). Less water corresponds with altered livelihoods, lowered ecosystem productivity, and changed long-time characteristics of the Delta (Waldram, 1989). According to local people in Cumberland House, the traditional trapping livelihood is threatened, as populations of muskrats, moose, deer, and fish have dropped remarkably (Abu et al. 2019). Along with ecosystem losses, there have been some progressive political and infrastructural changes in the past two decades. In 2004, a minimum flow of 75 cubic meters per second was established as a baseline flow from the E.B. Campbell Dam into the Delta. Sediments are, however, still being trapped by the upstream dams (Smith et al. 2016), leading to scouring of the riverbed and banks downstream of the dam and further reducing the ability of the river to reach the many off-channel wetlands (Smith et al. 2016).

Another concern for people in Cumberland House is the poor condition of the access road. The only bridge connecting Cumberland House to the mainland was built in 1996 (Goulet, 2013). About 137 kilometers long, Highway 123 to the Delta is a coarse gravel road that freezes up in winter, is difficult to navigate safely when rainy conditions persist and is inconvenient to travel with regular tires in summer. The closest town to Cumberland House is Nipawin, a two-hour drive southwest from Highway 123.

1.5 Literature Review

1.5.1 Overview of the Literature Review

This literature review offers insight into current understanding and management of the flows into the SRD and investigates to what extent place-based knowledge influences the decision making in the Saskatchewan River Delta. Revealing the existing knowledge about the SRD's ecosystem challenges, this literature review draws on the gap in the understanding of environmental flow requirements and sustainability in the Delta, and the role of Traditional Ecological Knowledge in water resources management. Both of these topics have emerged in dialogue with local people in the Delta but have been neglected in policies that affect the Delta

and its populations. I begin by providing an overview of the study site and the larger river basin in which the SRD is located, by discussing the challenges in managing the Delta's water resources, and by assessing the natural and human-induced impacts of changes in the region's water resources. Next, I draw on the roles and power dynamics in play between different existing knowledge providers and their influence on policy. Finally, I reflect on the gaps in knowledge and discuss the relative contributions of each of the knowledge sources in the current management of the Saskatchewan River and the SRD's socio-ecological system.

The Saskatchewan River basin is a transboundary system flowing through three of Canada's Prairie Provinces. Used and regulated by many sectors and with multiple management structures and reservoirs, the basin supplies about half of the water resources for the population of both Alberta and Saskatchewan (Burke, 2013). Authority in the SRB, as with other transboundary freshwater systems in Canada, is divided between provincial and federal governments, with multiple regional, municipal, and conservation agencies splitting the provisions and responsibilities (Swainson, 2009). While the Master Agreement of the Prairie Provinces Water Board governs the interprovincial flows in the SRB, in Saskatchewan, the Water Security Agency (WSA) is the governing authority that supplies water resources for agricultural, industrial, and drinking use; manages 72 dams, and regulates habitat conservation in the province in partnership with the Saskatchewan Ministry of Environment (Gober & Wheater, 2014). Much of the literature on policy in the basin addresses fragmentation in policy, overlapping governance, uncertainties, ambiguous definitions and priorities, and competition for water across and within regions of the basin (Sauchyn et al., 2016; Gober & Wheater, 2014). Different levels of authority and approaches across and within jurisdictions inevitably challenge the water regulations, security, and equilibrium in this cross-border and multisector water supply system where complex human interventions affect the basin (Brooks, 2015; Gober et al., 2015).

Recent studies have established that geographical, jurisdictional, or contextual levels across the SRB have multiple views and differing priorities that either comply or compete with one another (often there is competition between different users within jurisdictions) (Strickert et al., 2016; Carlson, 2016; Wheater, 2015). Depending on the location in the basin, political

views, and especially colonial and Indigenous standpoints, perceptions of water availability, allocation, risk management, sustainability, and justice differ. These differences cause ambiguity, fragmentation, and injustice in water governance, especially if few people have expertise in water management and empathy for others' views is limited (Bradford, et al., 2019; Gober et al., 2015).

Many mixed factors are driving water resource allocations in the Saskatchewan River basin, and specific utilities affect various sectors differently, leaving complex environmental footprints (Conallin, et al., 2018; Weber & Cutlac, 2014). For example, although irrigation has economic and employment benefits, it alters flow and water quality (Carlson, 2016). Similarly, dams provide energy and employment benefits to society yet modify natural flow patterns, negatively affecting downstream environments. Further stressors are climate change, population growth, increasing demand, and extreme flood and drought events (Nazemi et al., 2020). Finding a balance between the requirements for the competing utilities and needs in the basin is delicate and complex, requiring different stakeholders, rights holders, policy influencers, and regulators to work through the issues together (Scolobig & Lilliestam, 2016).

Water governance complexities are also magnified because understanding of environmental flows is limited (Pahl-Wostl et al., 2013). As defined by the Brisbane Declaration (2007), environmental flows refer to water flows with quality, quantity, timing, and other characteristics that meet the socio-ecological standards of freshwater ecosystems and that are required to sustain their well-being. The flow regime is the primary determinant of the riverbed and bank soils, vegetation patterns, and biodiversity composition of a river system (Swainson, 2009). Therefore, adhering to the requirements of the natural environmental flow while meeting the needs of multiple stakeholders is critical for multi-dimensional management of water in the 21st century (Wheater, 2015). However, the requirements for environmental flows are neither clearly mandated by policy nor identified in many important and ecologically disturbed regions of the SRB (Swainson, 2009). The lack of a synthesized knowledge base for both freshwater as a whole and for different river systems, as well as unclear ecological connections to the flows released from dams, poses challenges to downstream flows and wetland restoration (Renöfält et al., 2010).

1.5.2 The under-explored consequences of modified flows in the SRD

Located downstream of the interprovincial and multi-sectoral SRB, the Saskatchewan River Delta (SRD) is threatened by many cumulative environmental and social threats (Kornder et al., 2019). The river's natural flow has been diminished by the operations of three upstream hydroelectric facilities: the Gardiner Dam, Nipawin Dam, and E.B. Campbell Dam, which has the most significant daily impact because of its location immediately upstream of the Delta (30 km) (Delta Stewardship Committee, 2018). Becoming operational in the 1960s, the Gardiner and E.B. Campbell Dams have been reducing the amount of water, sediment, and nutrients heading downriver. The Gardiner Dam with a larger reservoir is responsible for most of the changes to the seasonal flow regime. The E.B. Campbell Dam, on the other hand, is responsible for daily fluctuations, leading to fish stranding and ultimately affecting the Delta's entire food chain and ecosystem (DFO et al., 2019; Mihalicz et al., 2019). For more than half a century, these heavily regulated and modified flows have changed the biotic and geomorphological compositions in the ecosystem and affected the relationship of Indigenous Peoples with the land and water in the SRD (Abu, 2017). Some of the challenges facing the Delta's ecosystem are reduced endemic land and aquatic species (Jardine et al., in press), modified vegetation patterns and overgrowth of invasive plants (Dirschl and Coupland, 1972), reduced connectivity of the wetlands (MacKinnon et al., 2015), and geomorphological and land-use change (Smith et al., 2016; Waldram, 1989).

Additionally, the health and productivity of the Delta have declined due to depletion of ice jams in the spring months and the growth of cane grass year-round (*Phragmites*) (Waldram, 1989). This dense grass has contributed to reductions in the size and depth of Cumberland Lake and surrounding wetlands (Abu 2017; Partners for the Saskatchewan River Basin, 2009). In spring and summer, the Delta and its populations face unnatural and disruptive flow variations, from minimum flow levels elevating rapidly to extreme high discharge events due to dam operations and reservoir capacity (DFO et al., 2019; Massie & Reed, 2013). In winter, the lake and channels freeze, noticeably reducing the number of fish such as walleye and sturgeon (Jardine et al., in press). Other water-dependent animals such as muskrats are negatively impacted by dam operations (Carlson, 2016).

In addition to the environmental costs, these seasonal alterations have had social and economic consequences for Indigenous Peoples who live and sustain themselves in the SRD (Abu, 2017). Water is central to Indigenous communities' well-being, as it is a source of food, income, and recreation. Cultural activities such as fishing, trapping, bartering, and traveling—all are made possible through water (Andrews, 2017). Depletion of water levels and quality results in depletion in nature-human relationships, financial stability, cultural connectivity and, overall well-being (Abu, 2017), and quick shifts in the flow regime and seasonal patterns also jeopardize people's capacity to adapt, exposing them to new dangers (Gober & Wheater, 2014). Knowledge has demonstrated that Indigenous values indicate both what Indigenous Peoples and the surrounding environment needs (Mantyka-Pringle et al., 2017). However, Indigenous People's profound vulnerability to flow circumstances, their local observations, and values are rarely reflected in water resource decision making (Jackson et al., 2014).

Despite the importance of local observations in establishing the needs for local environmental flow, the Delta communities have not been equipped to systematically collect these observations (Andrews et al., 2018; Rawlyk & Patrick, 2013). Until recently, upstream authorities in the SRB either failed to understand and accommodate environmental and Indigenous flow needs or did not have access to them (Baijius & Patrick, 2019). This disregard is not unique to the Saskatchewan River Basin and has been described in other literature on North American watersheds where Indigenous communities are compelled to adapt to new conditions imposed on them by upstream sectors (Wyllie de Echeverria & Thornton, 2019; Marshall et al., 2018; Simms et al., 2016).

In the absence of environmental flow understanding, water resource policy makers have directed their attention to water withdrawals for public and industrial supply and power generating solutions such as dam operations (Neachell, 2014), failing to support the socio-ecological needs of downstream ecosystems (Swainson, 2009). For example, the SRD has been subjected to hydropeaking at E.B. Campbell Dam, a process that stops the flow of water in the Saskatchewan River for hours at a time. Under their license from 1963 to 2004, dam operators were allowed to release 150 m^3/s of a water as a daily average but there was no continuous minimum flow (Andrews, 2017). As a result, zero flow events within a day were common and the

daily average flows were inadequate to sustain and protect the freshwater ecosystem. In the past decade, the minimum flow requirement has increased modestly from 75 m^3/s to 100 m^3/s, as a continuous minimum flow; therefore, understanding of the minimum flow threshold has evolved (DFO et al., 2019). Still, the ecosystem and socio-economic functions of the Delta are not protected from extreme flow variations caused by hydropeaking dam operations. The accuracy and efficiency of flow management, risk management, and emergency preparedness, habitat and land management all depend on the understanding of the modified flow behavior in different streams and wetlands within the SRD, which is a critical gap.

The risks the SRD environment is facing are neither ecologically nor socially acceptable, yet the vulnerability of Indigenous Peoples and animal populations to water fluctuations has been vastly neglected in dam operations. Inevitably, with population growth, human development footprints and over-allocation of water resources for irrigation and industry will impose even greater impacts on the SRD's already threatened ecosystem (Poff et al., 2010).

1.5.3 Obstacles to Water Management efforts for the SRD

Management of water resources calls for the integration of various quantitative and qualitative data from technical and traditional sources across different scales (Gober & Wheater, 2014). By quantifying data for policymakers and by generating support for collecting data with the help of communities, the scientific community can help advance the legitimacy of environmental flows and ecological response relationships. One contribution of western scientists to understanding the complexity in management of water resources is with computational and quantitative models of water flows in the Delta. Water resources and hydrological modelers who conceptualize water systems in different desired formats can catalyze effective decision making and water system management by exploring scenarios of interest. Poff et al. (2010, p. 18) point out that scientists play an important role in adaptive management of complex human-natural systems by mediating and optimizing the "the tradeoffs inherent between resource exploitation and resource conservation." Specifically, models that can predict and control future scenarios are of great interest for integrated modeling efforts (Neachell, 2014). The IMPC project strives to build effective water resources models by integrating different

knowledge sources.

There are, however, challenges to integrated modeling. Efforts to quantify and efficiently represent ecological feedback and impacts of flow alterations across large watersheds such as the SRB, and specifically for the Saskatchewan River Delta, are in their infancy (Wheater, 2015). First, because the flow from upstream deviates, there is limited reliable data on how the water levels are changing in different parts of the Delta (Sagin et al., 2015). Second, since the relationship among human beings, ecosystems, and water flow is not fully understood (Bradford et al., 2020), uncertainty abounds when it comes to making social and ecological connections to flow conditions and water resources. This uncertainty, coupled with the challenge of evaluating existing data on different temporal scales, make decision making a difficult task (Gober & Wheater, 2014). Third, what is known about human dimensions of water security is not effectively reflected in hydrological or water management models that are being developed (Bradford et al., 2020).

Even when scientists overcome these challenges, the models they produce may not influence decision makers because in top-down governance, power plays the biggest role. Ultimately, the decision makers may factor in only the facts that support their pre-existing perspectives on issues. For example, despite the WSA's 25-Year Saskatchewan Water Security Plan to deliver water equity to the province of Saskatchewan, Alberta's "first in time, first in right" (FITFIR) policy constrains water security in the Delta (based on the Master Agreement on Apportionment, 1969) (Strickert et al., 2016). This Alberta policy allows water irrigation use to reach its allocation limits, making it almost impossible to prioritize the environmental needs of the downstream communities (Shah, 2020). In the current management approach, despite advancements, stakeholder engagement is also low and only takes place at the later stages of decision making and implementation rather than through the processes of identifying problems and planning (Bradford et al., 2020).

Another challenge for the SRD is that because water resource management (Shah, 2020) and environmental models (Anderson et al., 2019) provide large scale analyses across the basin, they miss regionally important details and lack efficiency and clarity for end users and regional

planners. Neglecting regional details often means that these models work better for upstream stakeholders than marginalized downstream communities. Efforts have been made to improve the usefulness of models for end users by striving to provide a real time representation of flows in the South Saskatchewan River Basin (Bradford et al., 2020; Wang et al., 2008). Unlike large-scale management models that provide an overview of the entire river, more recent IMPC water simulation models such as MODSIM (developed originally in 1978) represent multiple dimensions of allocation and operations provide interactive decision support systems (DSS) and so are more useful for the users downstream (Shah, 2020; Labadie & Larson, 2007). Such interactive yet numerically efficient models can inform decision makers of the over allocated and stressed regions of the basin and enhance stakeholder awareness and engagement (Morway et al., 2016). In conveying research findings to broader audiences and building bridges across disciplines, boundary objects such as visual models, interactive maps, art-based communication, and performances have also proven to play an effective role (Steelman et al., 2019; Strickert & Bradford, 2015). As more flexible models with cross-scale interaction capacity are developed, interdisciplinary knowledge, mutual learning, and broader discussions between decision makers and knowledge holders are gaining momentum to fill the gaps in decision-making processes (Gober & Wheater, 2014).

In Canada, both communities impacted by and researchers working on water issues have recently criticized current approaches, demanding that more attention be paid to the weaknesses of top-down water governance that benefits authorities involved in decision making (Baijius & Patrick, 2019; Simms et al., 2016). In 2017, for example, Andrews argued that decision-making power is being constrained by upstream authorities in the Saskatchewan River Basin (e.g., by the WSA and SaskPower). Today, the consequences and shortcomings of top-down decision-making approach are known, but this approach has yet to benefit Indigenous communities (Acosta et al., 2017). In the recently updated report on the progress of the 25-year Saskatchewan Water Security Plan, for example, there is no mention of the SRD or Indigenous communities (*25 Year Saskatchewan Water Security Plan Report for 2019-20*).

That the localized non-market values and sustenance water needs of the SRD continue to be ignored confirms the impacts of colonization and a lack of capacity to engage community

partners and listen to their untold stories about water (Jackson et al., 2014). The SRD is not the only part of Canada where Indigenous communities are either excluded from or not informed about water governance decisions that affect them. The result is incomplete and short-term solutions that ignore a critical portion of the population (Hitomi & Loring, 2018). Indigenous Nations have a history of marginalization and limitations to participate in management conversations. In the stories of Indigenous Elders lie important and detailed knowledge about the land and water that will be lost if not listened to as fewer people continue to live alongside and sustain themselves by rivers (Wyllie de Echeverria & Thornton, 2019). This knowledge, known as Traditional Ecological Knowledge (TEK) is used as an umbrella term for the worldviews and experiences of Indigenous communities linked to their relationship with the land (Berkes et al., 1993). Traditional Ecological Knowledge and place-based observations of these knowledge keepers, although discounted by the approach quantitative modelers take in their practices, provide contextual understanding and insight into the species and biological mechanisms in the ecosystem, which are vital for the understanding of environmental needs (Di Baldassarre et al., 2019).

As more interdisciplinary and multi-evidence-based research is completed, Traditional Ecological Knowledge and the Indigenous Peoples' lifetime experiences are complementing and adding value to western understanding and practices (Wyllie de Echeverria & Thornton, 2019; Bradford et al., 2017). For example, Wyllie de Echeverria and Thornton (2019) demonstrated in their research that Indigenous terminology could add value to a general understanding of the land, whether it be fluctuations in flows or culturally important species on the Pacific Coast. In the SRD, Abu (2017) examined culturally important species using a two-eyed seeing framework that combined traditional and observational knowledge with western documents (Marshall & Bartlett, 2010). Traditional and place-based knowledge are often used interchangeably in the context of Indigenous communities addressing their environmental observations and concerns (Ray et al., 2012). Brunet et al. (2020) found that traditional place-based knowledge agreed with western science in fish population assessments in other affected communities. Knowledge pluralism is a term used by Andrews (2017) to address the intense need for diverse knowledge systems to be included in water resource decisions, highlighting the influence of Traditional

Knowledge in balancing the current power dynamics in the decision making in the SRD. Traditional Ecological Knowledge and increased public awareness can both advance solutions to problems with water resource management through negotiation of trade-offs and through driving adaptive decision making (Conallin et al., 2018; Pahl-Wostl et al., 2013).

As Lemoine and Patrick (2014) argue, if there is to be reconciliation with the people in the Delta, decision makers must admit to the uncertainties and complexities of the SRD's environmental flow needs and show respect for the affected communities through meaningful consultation and committing to joint action. In other words, a holistic and responsive water management in the basin would recognize and use local inputs, balance the needs of downstream ecosystems with those of upstream water users (Hassanzadeh et al., 2017), and discontinue reproducing inefficient flow management (Andrews, 2017). Traditional knowledge holders, through their connection with the land, hold a vital role in mediating the interests and outcomes of environmental decision-making (Dressel et al., 2020), and they should stand alongside their academic partners.

1.6 Predicted Research Contributions

The results of this research will reveal how traditional and place-based knowledge complements western understanding and scientific practices in water resource management as well as enhancing agency among people who live in the SRD. This project's goals would also contribute to some of the calls to action of the Truth and Reconciliation Commission of Canada (TRC) (National Centre for Truth and Reconciliation, 2015). The researcher's supervisory team has been working with the Delta Stewardship Committee of Cumberland House for over six years and together have completed many projects.

The university is advancing collaborations with members of the community through this project by sharing camera equipment with community members and asking them to guide the research team on gathering evidence of the adverse impacts of changing flow regimes on the Delta. The community has reached out for help for many years, and the research team believes that providing a tool to highlight concerns through a combination of narratives and photos can

boost modelers' representation of ecosystem functions and stakeholders' decision-making, as well provide a good example of involvement and participation for the community and the youth. Building these narratives of the community knowledge and making them accessible will ensure memories and experiences stay with the community even when the local people who relate them are no longer there.

CHAPTER TWO:

A COMPOSITE[2] OF COMMUNITY-ENGAGED METHODS

2.1 Overview of Methodology

A growing body of literature revealed the Delta's ecology and its vulnerability to upstream development, yet it became clear that the literature often does not address questions about the Delta community's stated flow needs or reflect the community's perspectives (Strickert & Bradford, 2015). Few papers call for support of traditional and place-based knowledge (Hitomi & Loring, 2018), and there is little reference to the power imbalance between the policymakers making decisions about water and the people of the Delta (Andrews, 2017). The failure to address this power imbalance speaks to a lack both of collaboration with communities and of respect for their intense need for better water resource management, fairness, and access to information for effective governance in the region.

Community-engaged scholarship has been put forward as an approach and a method that can boost and support the involvement of communities in research about matters that concern them (Castleden et al., 2012). In Canada, this type of scholarship has been discussed for more than a decade. Community-engaged scholarship exists on different research topics including teaching, research, and services that serve local communities (Calleson et al., 2005). I have chosen this kind of scholarship over other similar frameworks (i.e., participatory action research as per McIntyre, 2008) to work more rigorously together with the people from the Delta to gather knowledge about the flows in the Delta that affect their lives and livelihoods. The results of my research will be used by policymakers and scientists developing ecological conceptualizations and water resources models for the Saskatchewan River Basin. Thus, the outcomes of the research will be relevant to the community and can help support decision-making in all communities across the socio-ecological system.

[2] A composite is a picture created by combining multiple images into a single one. In this research, I used a composite of methods to gain a composite of perspectives on how to enhance conceptualizing the effects of upstream developments on the Delta with community perspectives.

2.1.1 Community-Engaged Scholarship in Principle

Building on the foundations of participatory research, Community-Engaged Scholarship (CES) occurs when academic scholars collaborate with members of a community to investigate local and public challenges facing communities (Robinson & Hawthorne, 2018; Sandmann et al., 2009). Both researchers and non-scholar participants benefit from sharing perspectives, voices, and ownership in the form of knowledge co-creation (Castleden et al., 2012). Community-Engaged Scholarship is based on the idea that true knowledge production is not exclusive to academia; that communities themselves produce useful knowledge; and that research should be based on a mutually respectful partnership (Bateman, 2018; Boyer, 1996; Hammel et al., 2015). In other words, both parties benefit from the partnership and approach the collaboration without a goal of personal gain.

Although some conventional research methodologies do engage participants, the idea of engagement is foundational to community-engaged scholarship. Boyer (1996) explains why this idea is so critical: “The scholarship of engagement means connecting the rich resources of the university to our most pressing social, civic and ethical problems, to our children, to our schools, to our teachers and to our cities” (p.11). As opposed to conventional forms of scholarship, which are known to create and advance knowledge in academic disciplines, “community-engaged scholarship can be transdisciplinary and often integrates some combination of multiple forms of scholarship” (Calleson et al., 2005, p. 16, as cited in Hammel et al., 2015, p. 3).

As Bateman (2018) points out, participatory research considers the learning opportunities, extensive contribution, and scholarship that local communities present to academia. Hammel and colleagues go further, introducing a “community-engaged scholarship of practice (SOP) model” that contributes to identifying, influencing, and even transforming society and policies through participation and practical action (Hammel et al., 2015, p. 1). Thus, participatory research has a strong practical component. Results from this kind of research do not remain in academia; rather, they are used by the community that helped to develop the results to forward a mission or goal. Because this kind of research is so intricately involved with community, care must be taken to be sensitive about cultures and knowledge held by

community, particularly in Indigenous ones. This point is emphasized within the CES methodology (Hammel et al., 2015).

2.1.2 How Community-Engaged Scholarship fits into Water Resource Management and Decision-making

CES has been introduced and practiced by academics for about two decades, and many academic scholars now welcome CES and the meaningful knowledge that it generates. This, again, “does not mean that such meaningful work did not exist before, rather that it has taken center stage” (Bateman, 2018, p. 1). In the following paragraphs, I will discuss the rationale for choosing Community-Engaged Scholarship as the framework for my study.

The notion of engagement itself has a long history and grows out of earlier research. Sandmann (2003), notes that several authors in the late 1990s argued that the "the traditional concept of service and outreach" should be expanded "to embrace engagement instead of one-way assistance or direction" (Sandmann, 2003, p. 4). Brukardt et al., (2004) concur, arguing that the idea of scholarship of engagement is not about service but rather about going beyond ordinary forms of doing research to "what happens when different forms of knowledge come together” (p.2). Such structural shifts in perspective and performance are needed in environmental sciences, particularly when human dimensions of environmental issues are incorporated.

Two critical parties in environmental and water resource management are 1) academia and 2) Indigenous communities; each brings different objectives and has different perspectives. Both can benefit extensively from mutual collaborations. Academic researchers and institutions can boost social change and governance by investing in community engagement principles, sharing power, and promoting capacity building for action (Armitage & Levac, 2015). Engagement, power-sharing, and developing capacity are all highly relevant in Indigenous communities. Indigenous ways of planning deliver a collective vision, highlight essential cultural values, and evenly distribute benefits to the plan-making process, which can provide key solutions to complex environmental problems (Patricket al., 2017; Rydin & Pennington, 2000). In

Saskatchewan, every Indigenous community has its own plan, varying from resource-specific plans such as watershed and land-use protocols to broader and more inclusive plans that investigate the wide-ranging needs of the community as a society. However, scholars have argued that planning should go beyond the community level and even the provincial level to offer effective national communication in the form of dialogue, consultation, and engagement (Dempsey, 2010) as the major prerequisite for environmental decision-making and "acknowledgment of Aboriginal Treaty Rights" (Lemoine & Patrick, 2014, p. 11).

Indigenous communities and academic researchers are not the only critical parties when it comes to environmental and water resource management. Other stakeholders from different sectors—e.g., agriculture and industry—have a substantial role in governance, and their interests often conflict with those of Indigenous communities (Quinn, 2013). There exists a pressing need for scholars to help communities convey their voices to stakeholders and for stakeholders to understand communities' needs (Bradford et al., 2019). Boundary organizations such as research institutes play a key role in this matter by promoting more effective communications between stakeholders and communities through mediating and addressing effective tools that can bring water security to cross-boundary settings, where multiple stakeholders and actors hold different perspectives and, therefore, different priorities in water resource management (Strickert et al., 2016). Today, academia welcomes community-based principles to drive user engagement. Likewise, the scholarship of engagement brings fairness to the decision-making process (Richards et al., 2004), fosters social learning, promotes public awareness, and assures that stakeholders are prompted to gain knowledge of communities and understand their needs (Blackstock et al., 2007). In this regard, many scholars have pointed out that CES is particularly appropriate for environmental and sustainability research.

It is now imperative that both researchers in academia and policy makers in management acknowledge marginalized communities as key players in fluid and complex settings such as water resource management (Robson et al., 2009). As recently expressed by Robinson and Hawthorne (2018, p. 7), the scholarship of engagement may play a large role in "solving some of society's intractable challenges" by "understanding and formally recognizing the fluid ways in which engaged scholarship cuts across the conventional pillars of academic research, teaching,

and service." Embracing this fluidity is essential in determining the considerable influence of the practical engagement of our non-scholar partners; otherwise, "we will not proceed to the next generation of knowledge co-production" (Stanton, 2008, p.2). After all, only by affirming such commitments can we guarantee long-term planning and sustainable management with local communities.

2.1.3 Community-Engaged Scholarship in Practice

The goal of CES is creation of a mutually beneficial partnership between two separate parties who work together towards achieving common objectives; therefore, it is best handled sensitively. Working with Indigenous communities calls for particularly high standards of respect, patience, and effort. Historically, Indigenous Peoples have been subject to colonialization and mistreatment; thus, as settler scientists and Canadians, we need to be particularly respectful because of our duty to reconciliation (Smith, 2013). If we extended the same care we do with engagement and relationships with all partners, it would benefit everyone and provide an exampleto enhance scientific engagement overall (Bradford et al., 2018).

When engaged in planning and research with Indigenous communities, researchers should be enthusiastic in contributing their time, developing relationships, listening, and honoring the stories they hear. As outsiders, researchers must break down the walls between themselves and the community, thus enabling the members of the community to feel they are mutual partners rather than merely subjects (Markides, 2019; Patrick et al., 2017;Sandmann, 2017). These actions are particularly important when doing research with communities that have been mistreated or neglected and therefore lack confidence in the presence of outsiders, especially academia (Armitage et al., 2015).

Experienced researchers have noted that those engaging with Indigenous communities need to have many qualities. First, they must respect Indigenous culture and ways of knowing (Brnhardt & Kawagley, 2005). For example, researchers must respect communities' knowledge about community planning. Planning is not a new phenomenon for Indigenous Peoples: they have always planned, both for the present and future use of their lands, used a variety of planning

approaches, and added value to the scientific world (Patrick et al., 2017). Second, researchers must also be patient and flexible when working with Indigenous communities (Patrick et al., 2017). For cultural reasons, it is common to experience meeting delays or cancellations, which may disturb scheduled timelines. Third, researchers need to be prepared for possible constraints and additional responsibilities; for example, they may need to redesign their methods as the project progresses (Armitage et al., 2015).

An important aspect of engaging the community is acknowledging the risks associated with the participants as well as the benefits. Emotional risks, experimental fatigue, and cultural inconvenience are among unexpected factors that require mindfulness and preparation of alternative plans from scholars (Scolobig et al., 2016)). These factors are even more delicate when researchers engage with vulnerable communities such as youth or Indigenous Peoples. All told, each scholar, myself included, conducting research within community-engaged scholarship principles will go through a unique journey of unknowns of the research unfold. Reflecting on the journey and addressing ongoing challenges is an essential and constant need for community engaged researchers.

During my research, I was aware that adhering to the community's needs would require me to be flexible and willing to take time to develop the research plan in a culturally sensitive way. I was aware that the actual data collection process for this research would come after weeks of staying in the community, earning people's trust, and engaging their progressive ideas in the project. This did indeed prove to be the case.

2.2 Research Design

The purpose of this study was to co-create qualitative data from the SRD communities that could inform modelers and decision makers of the water issues facing downstream communities in the SRB. This study followed Armitage's community-engaged scholarship framework to gather the SRD community's perception of the river's flow using on-land participant observations and face-to-face semi-structured interviews (Armitage et al., 2015). Active engagement of the residents of the delta and respectful gathering of their narratives of

long-lived experiences were indispensable to this study and IMPC's collaboration in the SRD. Therefore, it was important for me to make efforts to become established in the community and to gain the trust of its residents, whether they were participants in the study or not. I made multiple trips to the community with other researchers prior to the data collection period, becoming accustomed to the traditional lifestyle and values of many Cumberland House community members.

This study values community-based participatory protocols to respect and empower the community in the research process (Castleden et al., 2008). Therefore, a main goal of my research was to maintain a steady presence and ongoing contact with the community members and the research participants. Traditionally, northern Indigenous communities have been subject to "helicopter/parachute researchers" (Abu, 2017). That is, once the research was completed, the researchers left the community taking data with them, whose members felt forgotten and left without any capacity to change. However, in my case, active participant observation was established by researchers before me (see references in Abu, 2017). Thus, I sought to maintain the foundation they had established and to enhance it, so it became even more collaborative.

I entered the broader SRD community with the preconception that there would be different constituencies and different political forces. Other researchers had suggested I might encounter community members who disagreed with others on many issues. Through the interviews, however, I realized that when it came to water and land, people tended to leave their differences aside and unite. I wondered what accounted for this consistent perspective and learned that starting in the fall of 2019; the community members had made an effort to overcome differences and to move forward with a collaborative agenda to protect the Delta. They said that the University of Saskatchewan researchers working in the Delta had had a positive influence on them and that they were therefore abandoning their differences for the good of the Delta. The community members expressed their ongoing support for these researchers. As requested by the people I interviewed, I regarded the constituent communities in the Delta as one community of Cumberland House, all working to protect the Delta.

I had initially proposed using Photovoice (as per Wang & Burris, 1997) as my data collection method because it is a collaborative, arts-based approach to qualitative research studies that through a combination of narratives and photos provides opportunity for empowerment, enhances the voices of its members, and increases public awareness and engagement (Boydell & Gladstone, 2012; Fraser & al Sayah, 2011). Before implementing photovoice protocol, I needed to co-determine with key community members, the purpose of the project and to recognize that a community-engaged framework required me to follow the lead of the Cumberland House community. In other words, I would carry out the research in ways suggested by the community. After meeting the participants and learning about their research needs, I understood that photovoice was not a good fit for this community and project. Photovoice research process requires significant time commitment and is best suited to capture visual processes through individual participant lenses independently. My research is instead interested in detailed socio-ecological impacts of the past and present flow events, some of which were impossible to visually capture within the timeframe of my research. Additionally, the participants were interested in telling their narratives in person rather than capturing them in photos. They were also seeking a deeper and mutual connection with the researcher. Therefore, a better fit for the participants' preferences, my research objectives and timeframe was participant observation and photographs enriched with in-depth semi-structured interviews to access perspectives and lived experiences.

I sent out the study's approach and interview questions and other processes of data collection to the Behavioral Research Ethics Committee at the University of Saskatchewan for approval. The application was approved on August 20, 2019, with application ID#1446. I also had translators made available in case participants chose to communicate in their traditional language; however, all participants were comfortable with and proceeded with interviews in English.

2.2.1 On-land Participant Observations and Positionality

When I went to the community, I found that people had observed and experienced issues with the river's flow over decades of upstream human development. These observations and experiences of flow conditions in the SRD were key to this study, so I needed a way to collect them. To do this, I gave members of the Cumberland House Community cameras and prompted them to capture images of the river that reflected their observations and experiences. I asked them to take photographs of what they think is important about water flows and sediment in the SRD.

I stayed at a teacherage for one month and at a senior's complex for another month. My stays in both places provided opportunities for me to meet and interact with education providers, students, and Elders in the community. I deliberately chose these places rather than a bed and breakfast because I wanted to promote the feelings of companionship and humility with community members. The relationships I formed allowed me to achieve these goals within two months. Moreover, the Charlebois School was very generous to provide me with an office space where I could meet and sit with participants if they chose to meet there. Active participation and involvement with the Cumberland House population meant that I was able to obtain an in-depth understanding of the local dynamics, while fulfilling my scholarly objectivity. This experience also had personal benefits and implications for me as an international student. I learned about and identified with a lifestyle and culture that are rarely portrayed in Canadian history, the issues and challenges of people living in the northern remote communities, and their unappreciated views of life. In many ways, I could relate to the challenges and obstacles facing the residents of the Delta, from being dishonored and discriminated against to the lack of inclusive governance, infrastructure and management strategies that could benefit the community.

As an international female researcher with an engineering background, I was not only welcomed by the community but also respected and regarded as a person who listens, can be trusted, and who sincerely interacts with community members. During my time in the community, I was invited to the Remembrance Day ceremony, different school and public events, a wedding, and a funeral (both of which were my first experiences out of my own culture and in Canada). However, because of my age and gender, I was occasionally dismissed by several Elders.

I was privileged to be invited into some residents' homes and camps in and outside of the developed town. In addition to having me at their remote camps, some participants took me on their boat on a tour of the Delta and showed me important locations on the Saskatchewan River, Mossy River, Angling River, and Cumberland Lake. When possible, we took photos of the occurrences and locations that they spoke about in the interviews. These experiences provided me with first-hand observations of the flow conditions and their impacts. In addition to learning about the experiences and observations of expert Elders, I had my own experiences in the wilderness that helped me to understand the needs of animals and traditional land users, and the obstacles community members faced when it came to transportation, nutrition and sustenance. Guided by the community, I have built a strong relationship with, and appreciation of, the Indigenous way of life in the SRD, which were instrumental to the development of this research. The community members who participated in this study and I have united to share and inform academic partners of the current situation and the needs and demands in the Delta.

2.2.2 Semi-structured Interviews

In this research, I was interested in gaining an in-depth understanding of the impacts of the upstream hydropeaking facility; that is, the E.B. Campbell Dam, on the SRD. After spending two months in the community and acquiring the trust of community members, by late summer 2019, I was ready to co-create and gather qualitative data of these impacts by carrying out semi-structured interviews coupled with participant observation. I explicitly targeted Elders as the most valuable source of knowledge and recollections of the flow changes. In Cumberland House, an Elder is an experienced person who knows about the land and water rather than someone of a specified age.

I initially interviewed five people who identified as female and five people who identified as male participants to obtain a binary gendered perspective. Analyzing the narratives, I realized there was a gap in the data on winter and cold month conditions. I, therefore, made another trip to the community in November to conduct more research, even though transportation challenges at that time of year meant going to the river itself was impossible because of unstable

ice conditions. I interviewed four more participants bringing the total to nine males and five females, including Elders and a young participant who lives along the river year-round. All but one of the participants were Indigenous and made a living from land-based activities such as trapping, hunting, fishing, outfitting, guiding, and plant harvesting. Regardless of their age or ancestral background, every participant stated that they had grown up doing traditional activities in the Delta, where they were brought up to help their parents and learn how to sustain and protect themselves using natural resources.

I was interested in documenting Elders' knowledge and memories of the Delta before and after the E.B. Campbell Dam went into operation in the 1960s. I, therefore, focused on this knowledge in the semi-structured interviews. A semi-structured interview consists of a predetermined yet flexible set of questions to maximize the depth of the data (Castleden et al., 2012). This flexibility allowed participants to freely express and reflect on their priorities and on their own terms. Another reason that the semi-structured interview style was suitable was that I did not want to interrupt the participants and distract them from the flow of their memories as they were coming to them. The questions I had designed covered three categories of information I was interested in (flow preferences, flow impacts, and community engagement with research). *See Appendix A for the interview questions.*

After reviewing the consent form with participants and gaining consent, I opened the interviews by introducing myself and asking participants to share their experiences and memories of water, prompting them to open up about their childhood and upbringing. Their stories provided me with oral histories associated with places in the Delta that they had rarely been asked about by settlers. Because of the semi-structured nature of the interview, I then was free to ask follow-up questions to capture important details about the places and experiences the participants talked about. After we established that I understood their values, ties to the land, and their perceptions about water itself, I asked questions about the flow changes, species populations, their habitats, and needs for the water (i.e., seasonality of environmental flows). The third part of our conversation focused on the community's efforts toward problem solving as a whole and their vision for the future of the Delta.

Listening to participants sharing historical memories (especially in the pre-dam era) revealed how the changes in the flow conditions and ecological functions of the Delta have changed. It also broadened my views of traditional values and place-based knowledge. If participants were available, I asked for follow-up meetings so we could review evidence, discuss the photos they had taken with the cameras provided, and go through any documents they wanted me to pass on to university researchers and modelers (i.e., community contracts, dam agreements, and personal notes).

The participants were aware that they could tell me to switch the recording device off at any time though they did not, which showed their trust in me. Because I was an outsider, they taught me about their heritage, Indigenous ways of life and their experiences with discrimination. I concur with Abu's (2017) experience that the power of an interview comes from the interviewer being at one with, and equal to the people being interviewed, rather than imposing a situation on them. This method gives the data collection process a new soul that is valuable because it promotes wide-ranging communications between people with different perspectives.

2.3 Data Analysis and Validation of the Project

My research used narratives and visual evidence as a qualitative community-engaged method to co-create data by focusing on the flow conditions and sediment dynamics in the Delta from the perspective of community members who have not conventionally had a voice either at the modeling table or at the water resources management decision-making table. The interviews with the participants were audio recorded and descriptive quotes used in the thesis were transcribed in the style of *intelligent verbatim* meaning the oral format of the interview is adapted into a written format (McMullin, 2021). My reason for choosing intelligent verbatim transcription was to convey the narratives and findings of the study directly and effectively to a broader audience of academics and decision makers.

The data (photos and narratives) were analyzed based on the emerging content rather than on a hypothesis, using a qualitative analysis software program, Nvivo12. I used open and thematic analysis (as per Williams & Moser, 2019) in which descriptive codes and themes were

identified and constructed from the content based on the concerns most often raised by participants. Thematic clusters were then organized with key quotations and supporting visual evidence to correspond to the research objectives. My research sought to answer three key questions about the flows in the SRD:

1. What are the issues in the Delta?

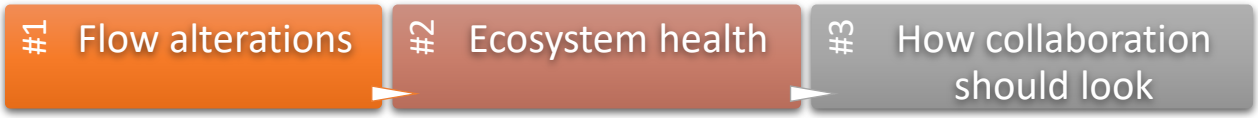
2. What are the impacts residents of SRD are seeing? And,

3. How can these impacts be communicated to the modelers who will be representing flows into the SRD?

Through analysis of the data, I found that the issues stem from flow alterations, that the impacts can be broadly seen in the ecosystem imbalance, and that there is a pressing need for collaboration in the SRD to happen through transparency and inclusion of place-based knowledge.

Research questions

Corresponding research findings



Having three main theme categories corresponding to my interview questions, while conducting the first round of data analysis with ten participants, I identified thematic saturation was reached for participant perspectives on water management and communication after eight interviews with no new themes identified (Creswell, 2003). I realized a gap in both identified flow complications and their impacts in the SRD in cold months; however, for this I made another trip to the Delta and conducted more interviews until saturation was reached in both categories.

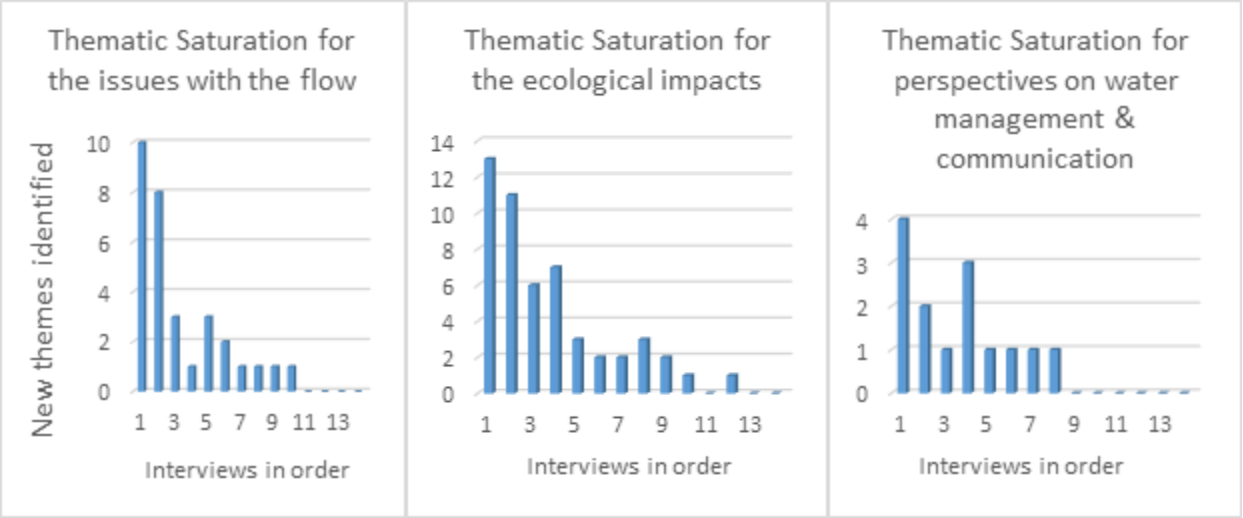


Figure 2.1 *Thematic saturation demonstration for the identified themes in three categories of research questions across 14 interview transcripts.*

A preliminary analysis of the content was presented to the community to give them an opportunity to discuss and validate the identified themes. However, the analysis of the emergent themes in the narratives using my approach was an iterative process, as I went back and forth between the codes, audios, and notes from the field observations to construct a comprehensive narrative about the flow in the Delta. Figure 2.2 is an example of a transcript coded under *Flow Alterations: Fluctuations,* with a picture and a field note annotated to it.

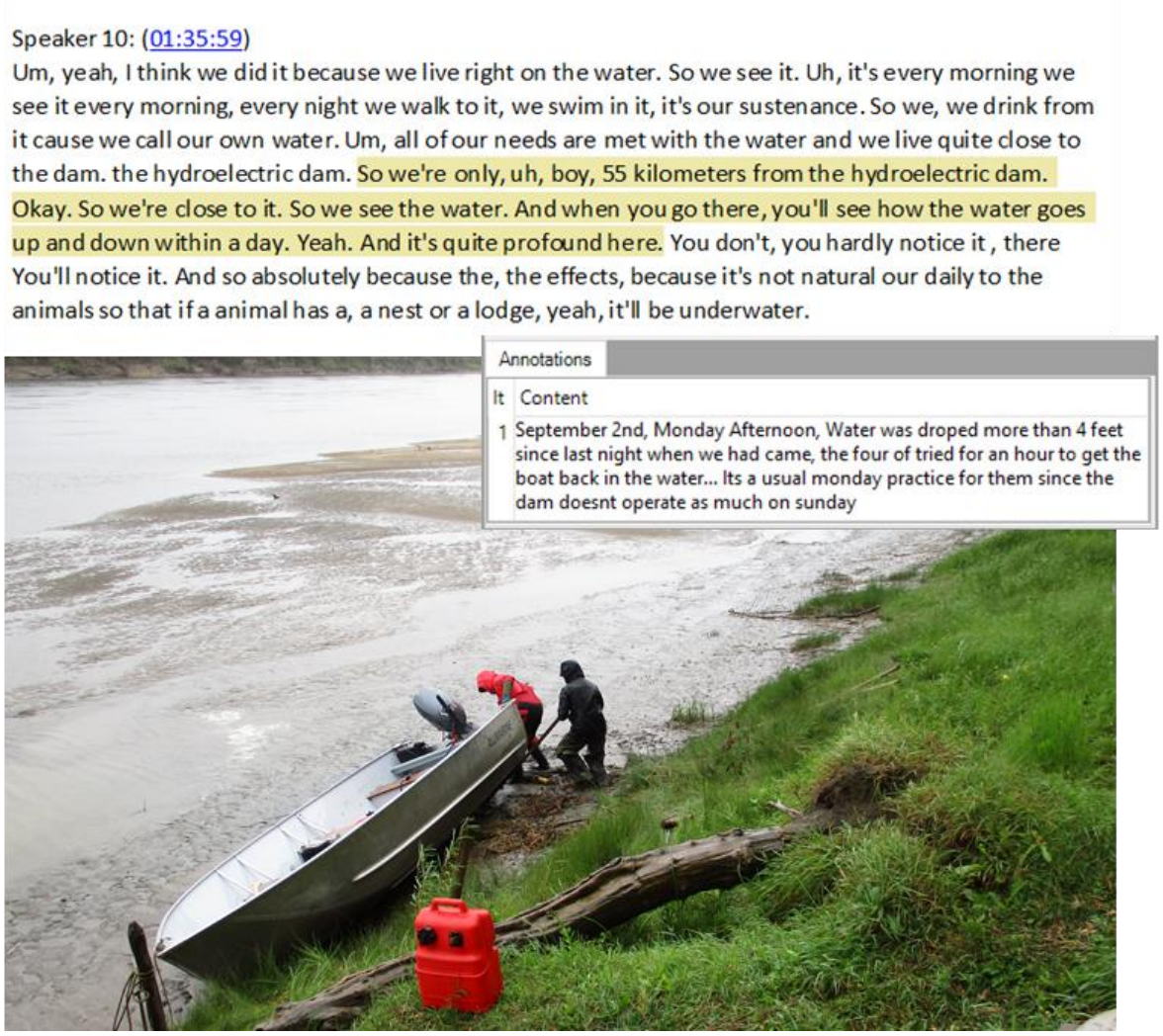


Figure 2.2 *Participant quotations supported by visuals and field notes capture a more comprehensive narrative of the flows in the SRD.*

As can be seen, details represented in the visual evidence and field notes are critical and valuable to the construction of the flow narrative from the participants' perspective. I was particularly careful to represent the true participant perceptions. For that, I did a second round of analysis using the audio clips rather than the transcripts to fully capture the essence of narratives that might have been lost in the words but still emergent in the tone of the voice (Abrahams, 2017).

CHAPTER THREE

RESULTS PART 1: AN EXHIBITION OF A DELTA'S VULNERABILITY TO FLOW ALTERATIONS

3.1 Chapter Overview

This chapter contains the research results of the 14 interviews I conducted with residents of Cumberland House. Ten interviews were conducted while I was staying in the community in August and September 2019 and the other four in November 2019. The interviews lasted from 40 to 130 minutes, were recorded, and transcribed using an automatic system. I, then verified the accuracy of the transcriptions by carefully listening to the audio recordings. Participants were asked 14 semi-structured questions about their perceptions of the flow and their involvement with the water stewardship group in the Delta. See Appendix I for the interview questions. NVivo 12 software was used to categorize and analyze the data.

This chapter is organized into three themes unpacked in the detailed analysis of quotes and narratives: perceived issues with flow, impacts of the E.B. Campbell Dam operations on the Delta, and the Community's vision and approach. All participant narratives were collected in 2019 and do not reflect the changes the SRD has seen in the following years.

Using participant narratives, the results of this study suggest that dams and upstream water demands within the Saskatchewan River Basin take precedence over downstream needs. As indicated in the interviews, the community perceives that the current flow of the water passing from the E.B. Campbell Dam is inadequate in quality and quantity for the needs of Delta's ecosystem. They believe the flow is unnatural, inconsistent, and lacks the sediment and nutrients required for a healthy ecosystem. Figure 3.1 provides a conceptual model of themes provided by the interviewees about their perspective of the water flows and the impact of flow changes on the Delta. This model provides an overview of participant ideas on how different aspects of the ecosystem are negatively affected by flow alterations from the dam. This chapter will unpack participant narratives on how alteration of the water flows in different ways have disrupted ecological relations, livelihoods and the overall balance of the Delta's ecosystem.

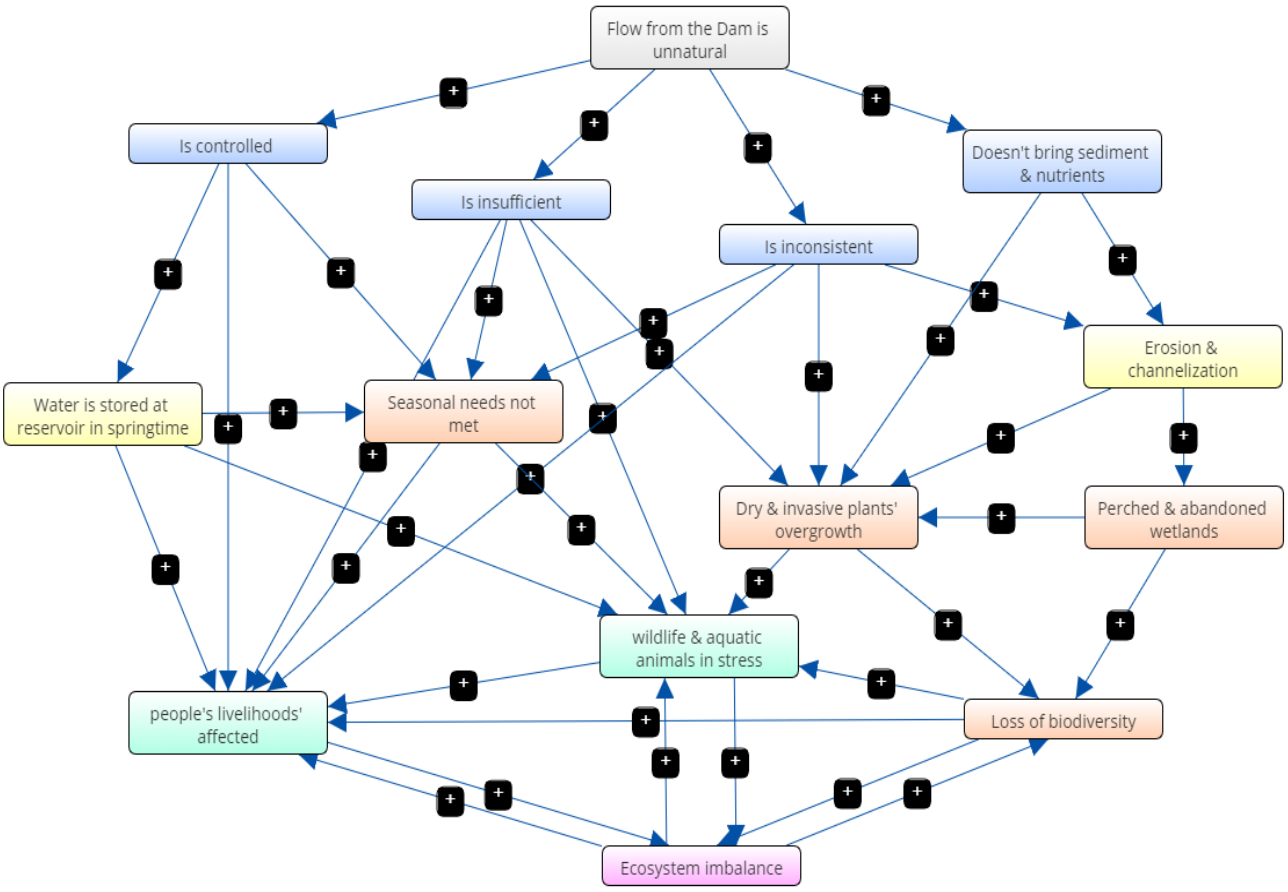


Figure 3.1 *Network of themes emerging from participant responses that unpack environmental relations in the Delta*

3.2 Perceived Issues with the Flow

A key interview finding was the perception that the E.B. Campbell Dam created lasting effects on the flow of the river into the Delta. Table 3.1 below provides sub-themes falling under the general theme of flow and quotations from the interviews that illustrate each theme. As seen in Table 3.1., the participants perceive changes in the flow in the Delta to be created by the E.B. Campbell dam operations.

Table 3.1 *Sub-themes under the Theme of Perceived Issues with the Flow*

Sub-themes Under the Theme of Perceived Issues with the Flow	Exemplary Quote
The Perception of Unnatural Flow	*"After 1963, the dam is there. So, then the water flow is unnatural,* *This is now a hydro dam…We can never change the purpose of the hydro dam. It will always give high and low water fluctuations regardless of what we think of it. That is how hydro dam works, but it's not a natural state of water flow" Elder Les*
The Perception of Inconsistent Flow	*"We need to run water more consistent like it used to. That's what the dams have taken away. That's taken away with the way they manage the water for the dams." Elder Solomon*
The Perception of Insufficient Flow	*"Well, that's [water] what's being held back. In the dam. Not only one dam but there are a bunch of them upstream, that's holding back our waters… There's only so much limited of water's being released to our region" Elder Ferlin*
The Perception that Flow Lacks Sediment and Nutrients	*"An important part of the whole system is trapped in the reservoirs. That's what fertilizes the delta… For this area, for the delta, the muddier, the healthier, because it's carrying the nutrients that the wetlands need. Okay." Elder Gary*

3.2.1 Water Flow: The Dams' Needs are met before the Delta's

Several participants said they believe that decision makers upstream have a major impact on the water that flows downstream. They maintained that the water flowing downstream is primarily stored and used at E.B. Campbell Dam to produce energy for upstream users and that people living downstream have to make do with what the decision makers choose to release. As participant Renee argued: "We believe they're withholding water on that side because they have several other events and they're always worried about the reservoir…They always have to have enough."

Several participants attributed the regulation of water in the Delta to decision makers at SaskPower. As Elder William indicated, "It's been all regulated by SaskPower," adding "They pretty much regulate how much they want to let go or how much they want to give us water. From the mountains up to here. There's quite a few dams." Elder Delores shared these views about SaskPower: "All summer they mostly held it [the water] all back. They [SaskPower] barely released from the dam. That is where our problem is, because [of] how much water they're not releasing."

This belief that the water needs of upstream people are prioritized is commonly held in the community. Elder Les spoke to this point: "We depend upon the E.B. Campbell dam utilizing the water as they see fit." In other words, the people at Cumberland House have no control over the water. The dam operators release the water only when there are sufficient resources for dam operation (e.g., when the reservoir is full). As Elder Les further elaborated, this controlled release severely influences those living downstream: "After 1963, the hydro dam [became] an impediment to that natural way of those fish populations living off the different water bodies."

Elder Solomon offered a specific example: The management of Tobin Lake, he indicated, does not favor the fish spawning in the spring, "Their [people at the dam who control the flow] interest is only in the power. The way they're doing it right now is efficient for them [SaskPower]. But is not for the fish." Other participants shared similar concerns about the ecosystem chain in the Delta, maintaining that it suffers from the current flow management at the dam. Elder Les put the issue in general terms:

> Obviously, E.B. Campbell Dam was the main deterrent which [stopped] the natural water flows [from coming] into the Delta [and] giving us the proper amount of water to replenish all those marshes because those marshes always needed a fresh amount of water coming in sort of spring, summer and fall months.

According to Elder Les, when water in the reservoir exceeds its capacity, water fluctuations and high flows can damage and flood the Delta:

> The E.B. Campbell Dam has given us floods in the meantime. Habitat that moose depends upon, which is the willows and all the Marsh vegetation, they will fluctuate from the hydro dam. The hydro dam will drown the willows and whatnot from severe flooding.

Participants revealed that they believed people in the Delta feel like their needs are lower priority or not even considered when compared to people's water resources or hydropower operation needs upstream, as demonstrated in this extract from Elder Gary:

> [Tobin Lake] It's a small little lake compared to the Delta. There's a lot of wildlife that are impacted in the Delta because of how… how they can convince government to control the timing of releasing water especially in springtime; our Northern pikes are no longer here because of what they're doing on Tobin Lake.

Because they consider that they are such a low priority, participants mentioned that residents of the Delta also live with a great deal of uncertainty about flow. As Elder Les stated, "It's evident that E.B. Campbell Dam is in charge of the amount of water we get. So, we are in a complete dependence upon the amount of water they will give us." There is also uncertainty about the reservoir operations with respect to moisture and rainfall. Elder Ferlin recalled, "Like sometimes, they will release water. Like this has been a good year, we got a lot of water because of the rain that we had in Alberta and southern Saskatchewan." *(2019)*

As the participants underscored, the current operation of the hydropeaking facility at E.B. Campbell Dam and Tobin Lake Reservoir does not consider seasonal needs and the damage to the Delta region. Flow alterations from the dam are reported by participants to affect the Delta seasonally, daily, and hourly, yet communities living in the Delta see themselves and their needs as easily dismissed as opposed to those upstream of the hydro dam. These communities stress that flow alterations are the root cause of the suffering of the Delta's ecosystem.

Several participants emphasized that they want to see fewer fluctuations in flow but also said that they know that little can be done. As Elder Les explained,

> We can never change the purpose of the hydro dam. The hydro dam will always give high and low water fluctuations regardless of what we think of it. That is how hydro dam

> works, but it's not a natural state of water flow… We have to live with it. So, we have learned to live with it, but it's still catastrophic.

As the quotations in this section illustrate, the participants in this research explained that E.B. Campbell Dam is the source of all the issues they perceive with flow in the Delta. Below these issues are broken down into further sub-themes.

3.2.2 Seasonal flow alterations are incompatible with ecological needs in the SRD

Residents of the Delta are concerned about the inconsistent, inadequate, and unequal water flows all year round in the Delta. They shared that flow regimes change from month to month. The participants provided different examples and perspectives on how these flow alterations affect the seasonal ecological needs of the Delta. As Elder Gary put it, "The change of waters from June to November varies." He added that the flow varies according to what "demand for water at that time [is]," for example, "in Alberta." Some participants specifically mentioned that releases into the Delta are inadequate in spring and summer, crucial months for many species in the Delta. Referring to the operators of the dam, Elder Delores said, "All summer they mostly held it [the water] all back."

Participants indicated that during fall the water released from the E.B. Campbell Dam decreases, and, as the temperature drops, the water starts freezing to the riverbed. In contrast, in winter months, with higher power demands, water is released more generously and goes on top of the ice, as Elder Gilbert noted:

> In the fall, it starts to go down, late fall. But during the winter, [when] they release water from the dam, because it's traveling on top of the ice, and it freezes. You have thick ice in pieces and there would be no water underneath, and nothing is going to survive down there.

Dominating the discussion during the interviews about winter flow were the following issues: water flowing over ice, animals, and residents' access to waterways. The participants stressed that water fluctuations on top of the ice create difficulties for residents of the Delta, as

well as for aquatic and land animals. The next subsections investigate the cold season (winter and spring) issues in the SRD in more detail.

3.2.2.1 Inconsistent flow in winter is detrimental for different species and residents of the Delta

According to the participants, the inconsistent flow in winter affected both aquatic animals and the users of the land. The flow may rise or drop substantially within a single day. Elder Les maintained that these changes are caused by dam operations: Because "the colder months demand higher electricity use," he explained, the [operators of the] hydro dams have to [oblige]. He told me a story to illustrate the inconsistency of the flow in winter:

> The power dam released this much amount of water [gesturing]. It probably went past a thousand cubic meters per second. And the water came up on top of the dry ground and it was three and a half feet deep, in January. So now you'll see how inconsistent the water flows are.

When a substantial amount of water is periodically released on top of layered ice, it creates slushy condition for the ice, as Elder Solomon explained, "I know that we are getting more water in wintertime, but still the level of water is too low. The slushy ice is the problem."

Elder William also talked about the slushy conditions, adding that they are harmful for aquatic animals,

> So, my understanding is that because the water goes up and goes down and it goes very down, then when the ice produces, and more water comes to it, it ices up again. That ice is slushy. And that kills.

In these layers of slushy ice is clay and sediment (Image 3.1). The suspended sediment that flows in the river gets into the slush, which freezes and locks up the sediment until spring when it contributes to increased erosion of riverbed. Elder William continued:

> The ice that's sitting on top there when the water [comes] it lifts up underneath. That is where the water is trickling through. It gathers the sand, and it also gathers the ice… it's a phenomenon that's been happening more.

Figure 3.2 is an example of a hazard faced by aquatic animals in the Mossy River Delta draining into Cumberland Lake, caused by sediment in the slushy ice.

Image 3.1 *A slushy hole with sediment in the ice in Mossy River Delta. Photo: Courtesy of Les Carriere*

Elder Les explained how the sediment formed in slush:

> That is just only three or four inches of ice that accumulated sedimentation underneath it… Think about it like a washing machine. What does a washing machine do? It agitates, but in this case, the high-water releases are powerful enough to cause such great agitation of the river bottom and the riverbanks.

These coarse particles in the slushy water become stuck in the lungs of fish and kill them, according to participants. Elder William, a commercial fisherman, shared with me the difficulties of ice fishing and reinforced the need for more consistent water flow:

> We need at least six, seven feet or eight feet of water in the wintertime and there was high water in some winters and then fishing was good. …but today can't even fish in our lake. Not enough water. Freezes to the ground. No oxygen for the fish.

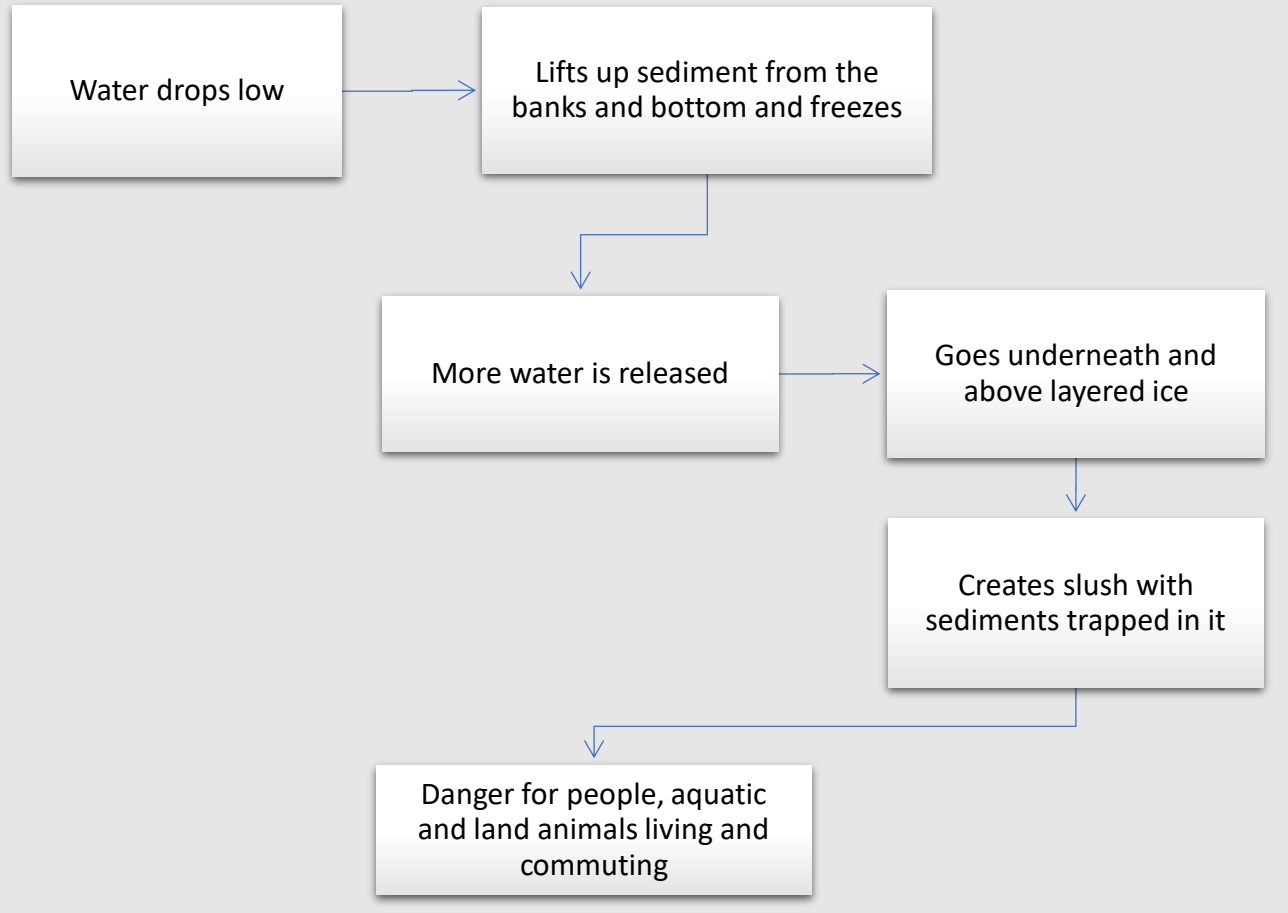


Figure 3.2 *A process model of the danger of low-flow sediment movement in cold seasons: Illustrating how releases from the dam harms people and animals.*

Transportation for both animals and people along the rivers and Cumberland Lake is another issue discussed by the communities living in the SRD. Inconsistent water flows create uncertainty for users of the land. It is not just the aquatic animals that are affected by the flow and its impact on ice but also the land animals.

Several participants talked about the effects of flow fluctuations in winter months on animals. Participant Michela discusses how animals are stuck in ice sheets:

> I mean, the biggest thing that I've seen is usually in wintertime, with the ice when the ice goes up and down. and it's not just moose, it's deer as well, but any big animals like that. So, when the ice freezes, it's flat. And then the water goes down and there's like these ice sheets along the riverbanks and sometimes a moose or deer will get stuck down here. And when they try and go up to their bank, they get stuck. Because it's just unnatural… to have like a [fracture], impossible for them to climb. So those kinds of things happen, the unnatural ice sheets in the winter.

Living by the Saskatchewan River, Michela witnessed these struggles daily:

> And that happens every day too. So, you'll come there in the morning and be like, okay, you can go across the ice and then you come back in the evening and the ice is like, so crazy dangerous crossing rivers.

This participant provided a photograph of dangerous ice layers and cracks. See Image 3.2.

Image 3.2 *Ice layers and cracks in the Saskatchewan River. Courtesy of Michela Carriere, March 2016*

Unsettled icy conditions create havoc for residents of the Delta and users of the land as well, to which Elder Mary Louise attested: "It is hard traveling… The water would come up on the ice and then they have to travel through it." Multiple Elders shared stories of being caught off-guard while traveling on waterways in winter. Elder William shared,

> Well, it's bad for us traveling… we don't fish in our lake in the wintertime cause it's shallow… when we go fishing in the Suggi and Windy Lake we have to pass through the river system. Going through the Pine Bluff; one day you'd be good on this snowpack trail with your skidoo and maybe two or three days later you when you come back from Suggi or Windy Lake all of a sudden, its slush, because they let water go and…It's like a trap. You just suddenly hit it. You don't see it. It is full of water and snow. And you have a hard time trying to get out of there.

These conditions happen also partly because residents of the Delta are not publicly notified of the daily water releases from the dam. "They don't give us the specific water release reports," said Elder Les.

Participants shared that these erratic ice conditions are more significant closer to the dam. As Elder Les exclaimed, "It is so negative that the resource user has [to] be knowledgeable about that" to be able to prevent incidents while traveling through ice. In this regard, land users in the Delta ask for daily water release reports to be given to this community. As Elder Les says, "Make people understand this is how much water you're getting right now, cause there's other people utilizing other different [resources]." Planning to use the land in winter and coping with changes in the weather are hard, particularly when fluctuations from the dam make it difficult for people and animals to navigate the changing conditions of the channels and lakes.

3.2.2.2 Ice breakup inundations and natural spring run-offs are controlled

Participant observations consistently demonstrate that in contrast to higher flow variations in winter, post-dam spring flows are held back by not only the E.B. Campbell Dam operations but at Lake Diefenbaker as well. Spring flows used to be typically higher in the Delta,

with the ice break-up inundations coming from the local land ruff-offs. As Elder Gary remembered, "In the springtime was when we had the local runoff. Like April and May. When the ice jams would happen, all these wetlands back in the woods would get flushed out." Elder Gary added, "That does not happen anymore because the breakup is controlled now." Elder Gilbert identified the issue in relation to the water passing from the dam: "But you don't see that [ice jams] anymore because there's less water, less water coming in through the dam" In other words, participants asserted that the high spring flows that used to occur in freshwater systems decades ago no longer occur because dams block the waterways.

These flows were deemed important by participants; that is, they said the flows were essential for people living in the north, indicative of a new season, broke up the ice, and opened waters, allowing residents to take boats on the water. The participants shared that high flows also carried nutrients to the Delta, filled little creeks and streams, fed higher areas, and flushed out marshes and lower tributaries, creating a pristine environment for growth. Elder Gilbert shared memories of the past:

> We used to get a lot of water in the spring breakup. …The ice would build up. And the water would go over land and it flooded the area.... We used to have little streams and it was always moving. Water was always moving from lake to lake, everything was thriving.

The natural flush into different lakes in the Delta is being blocked at multiple locations on the river, including at the E.B. Campbell Dam. Michela Carriere put it this way:

> Because I know there's a lot of little lakes that are all around the delta that would get fed by the natural spring floods, the natural spring high water. But when they hold back the water, it doesn't get water into those lakes.

Participants noted that because of lower water levels and less frequent high flows, that flush does not reach further and high-reaching landscapes. Its absence decreases the suitability of perched habitats and threatens aquatic animals (e.g., certain fish and muskrats) that depend on spring flows to thrive. Elder Gary contrasted this situation with what goes on in the reservoir and Tobin Lake:

> Well, I know in the springtime, because upstream from us on the reservoir and Tobin Lake, it's become a big sports fishery and they protect their fish very well to the point that they control what kind of water comes through at certain times and they don't know what kind of damages they are causing the fish downstream.

Elder Gary pointed to the power balance that now exists and compares it to the situation before the dam. The fish spawning agreement made for Tobin Lake allows the water to be held in the reservoir for 30 consecutive days in spring. This negatively affects the Northern pike:

> So, there is an agreement, I believe with SaskPower and Nipawin, that they do not disturb the water levels at Tobin Lake until the northern spawning is completed. So, when they cut down the flow on Tobin Lake, the Saskatchewan River Delta starts to recede and then their eggs get dried up, so they don't get to hatch. I think that is the problem there… And because we've taken away the pike, the sucker population has exploded because they do not have a predator in anymore.

Renee echoed this sentiment saying that the hydroelectric dam is "holding back" the fish population. She then continued, "So the fish have been stopped [by the dam] and [water] is fluctuating so those fish aren't spawning [in the Delta]", "we're not catching fish anymore" she followed. Elder Les noted the controls from the dam affecting other water dependent species such as ducks and geese stating that, "they need consistent amount of water" specifically in the breeding season.

Participants noted effects on animals and habitats as follows: fish, ducks, and geese are a few of the species subject to immense water fluctuations when they reproduce. The Delta marshes today are comparatively much drier than they were decades ago. This remarkable change in the habitats for animals, coupled with sudden, single floods puts the whole ecosystem chain in danger according to participants. They indicated that the Delta now, rather than its natural spring meltwater flows gets less frequent yet unexpected emergency floods. For example, the Delta had a number of major floods in 2005, 2011, and shortly after in 2013 that were destructive to the aquatic, wildlife, and human populations. As Elder John recalled, "After

five floods, everything died. The willows {drowned and] died. The rat root [roots muskrats feed on] is still not back. There is nothing left for us."

Community members in the Delta strongly believed that moderate flood cycles are essential for the ecosystem. Frequent natural floods not only provided seasonal wetlands and further spread habitats with nutrients, but they also stabilized geomorphological and chemical characteristics of the floodplains (MacKinnon et al., 2015). Participants' narratives provided supporting observations. As participant Renee stated,

> So, they [E.B. Campbell Dam] need to have a manmade flood, every year. Regardless of what is in the system, it has to happen and then they need to increase that minimum flow. So that would keep enough water within the system and to keep it consistent. So it's over a period [of time] not just a boom and bust.

It became evident from participant narratives that river regulations such as dams not only disrupt the amount and consistency of the flow, but also quality of the flow is noticeably affected once it is released from the dam, carrying lower loads of suspended soil and nutrients downstream.

3.2.3 Lack of a nutrient-rich sediment-rich flow

Residents of the Delta closely tied to life on land, view mud and sediment as fertilizers and essential for biodiversity and growth, along with riparian vegetation, and aquatic organisms. As Elder Gary said, "For this area, for the Delta, the muddier, the healthier, because it's [the mud] carrying the nutrients that the wetlands need." Michela Carriere had the same view: "I'd rather see muddy water around here and in rivers."

The participants' narratives and observations indicate their concerns about the dam blocking natural particles in the water from getting through. As Renee Carriere explained, "Well, the sediment's always within a system. So, it's coming through, but I know it's been blocked at the dam, or my understanding is it's blocked at the dam." Elder Delores commented, "You can't

say that it brings down mud from where the water comes from." Others corroborated this view. As Elder Ferlin explained, "This is mostly all sand that it's coming down from the dam." He added that the flow released from the dam lacks fine particles. Being a part of the river system, mud and sediment particles play a key role in the function and quality of the flow within the channel. Elder Solomon emphasized the need for natural particles in the water by saying: "Just bringing more levels of water in spring doesn't help them as much, rather bringing more sediment within the water." Elder William went deeper, outlining how other dams (i.e., beyond E.B. Campbell) are blocking sediment from moving naturally through the basin. Elder William summed up the problem: "We need the sediment to come flowing down to our lake, our rivers, and the dam is trapping all the sediment. At E.B. Campbell, but those other dams are too."

Water passes through without natural richness, participants attested. Therefore, the river is perceived to take sediment on its course after the dam resulting in cutting the riverbed deeper and leaving other channels high and dry. Eventually Elder observations in the Delta suggest that when water levels are significantly altered and lowered, food resources decline, side channels disconnect from the main river, and the region loses its vibrancy and biodiversity. As a result, spawning declines and fish habitats and marshland areas dry out, leading to losses in the populations of waterfowl and aquatic mammals. As well, the big game animals such as moose have undergone stress and declines in population. These impacts will be discussed in the following sections.

3.3 Impacts of the E.B. Campbell Dam Operations on the Delta

This section demonstrates the dynamics of the Saskatchewan River Delta's ecosystem from the perspectives of locals. As indicated in the image below, the participants addressed morphological changes in the Delta from two perspectives: 1) lack of sediment in the flow and 2) high fluctuation of the flow. These two are interconnected in terms of the consequences (Figure 3.3). Deltas go through constant change. Nevertheless, in the case of the Saskatchewan River Delta, its history and participants' testimonies reveal that the dams have accelerated

geomorphological change in many places. This section outlines the impacts seen in the Delta from a community perspective. In the following sections, I discuss harm caused to the Delta's ecosystem because of decades of unnatural, highly variable, low flow levels, and low-quality flows.

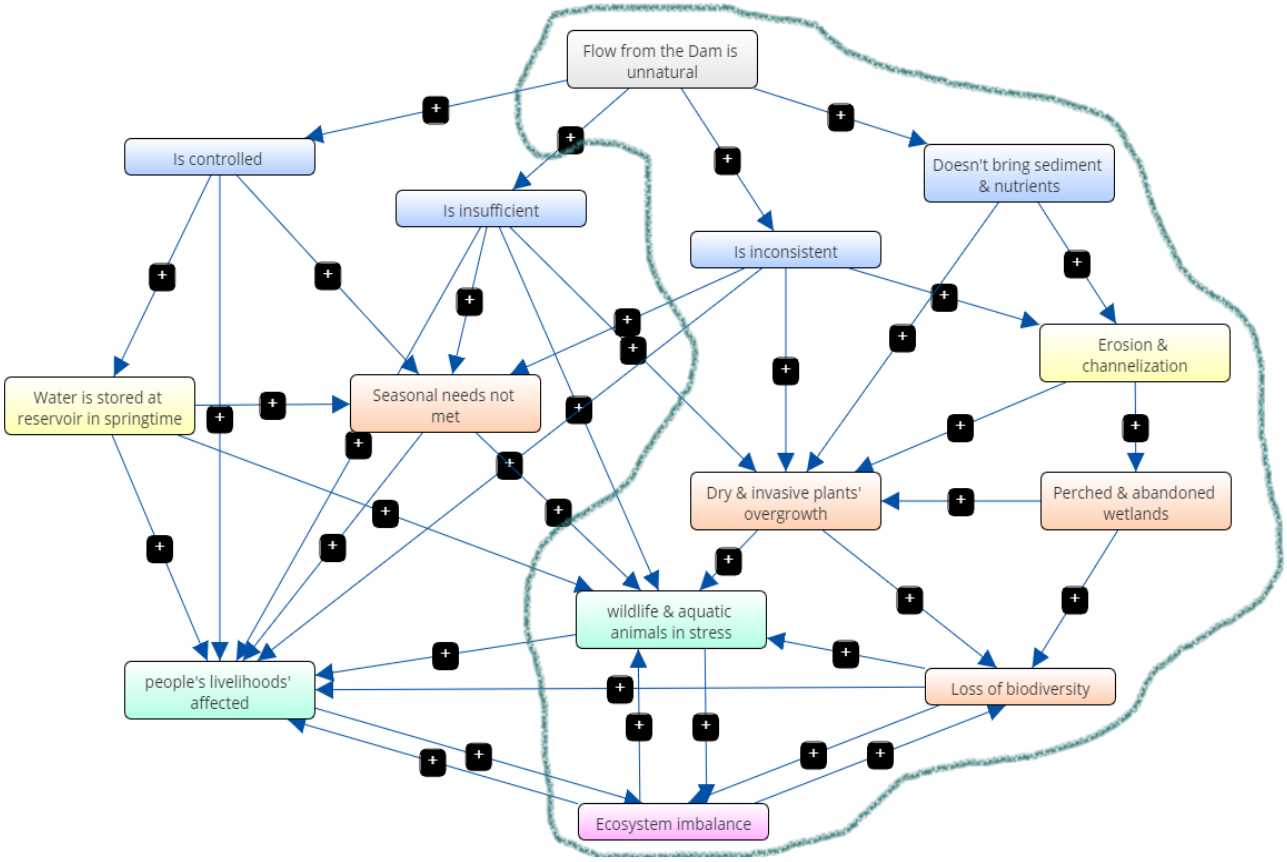


Figure 3.3 *Physical impacts emerging from the E.B. Campbell Dam operations on the Delta. The physical impact and the connections among them are shown within the green line.*

3.3.1 Erosion and geomorphological consequences for the channels

Elder Gary's testimonies suggest that the lack of sediment in the flow passing through E.B. Campbell Dam advances erosion rates in the Saskatchewan River Delta:

> By starving the rivers, It's the river is trying to find sediment and somehow It would try to get a sediment from the banks… you need to release the water with sediment because all

> you're going to do is increasing [erosion]. You're going to expedite the process and that's not good.

He then proceeded to explain the changes in the riverbed as water flows downstream of the dam:

> As you, start your tour from the dam and work your way down to Cumberland [Lake], you'll see what the river's been doing all along and you'll see how it cannot cut banks anymore. So, it's starting to scar [scour] at the bottom and the river is sinking, I guess going down, down.

Renee indicated that changes in the riverbed and banks are correlated to the frequent high-water releases from the dam. She believed that inconsistent releases from the dam have agitated the erosion process and deepened the river:

> When they [the dam] release unnatural, huge amounts of water, it has [been] dumped. So, you'll see it's altered where we are because it has [been] dumped, and then it hasn't been able to move the sediment naturally along. So, there is a lot more dumping [of sediment on different parts of the river]. So that mud is coming from much further upstream and then it is dumping it on the sides. It seems to be cutting the river much deeper.

People living along the river have observed an accelerated process of erosion caused by significant fluctuations in flow. As indicated earlier, participants specifically used the analogy of the river being “washed.” This happens closer to the dam, where the dam is sandier than the other parts of the river, indicating low sediment concentration in the water as it is released from the dam. Participant Michela put it this way:

> If you go like right below the dam, it's very sandy there and more sand is being kind of pushed. It is being pushed down. Never used to be that sandy. So just slowly, all the sediments that we do have are just being washed.

Image 3.3 *Below the E.B. Campbell Dam. Shows clear water with no sediment coming from the dam, September 2019*

When asked if the water carries mud, the participants collectively said they believed that the dam stops key nutrients from reaching the Delta. The flow released from the dam, starved of sediment, scours the banks and riverbed at a higher rate and transports what sediment there is further downstream into Cumberland Lake or deposits it on the shores and marshes in the Delta. As Elder Gary explained,

> The river is going to do whatever it takes to do its purpose because the river's purpose is to carry the sediment and nutrients to replenish wetlands. And that's not happening anymore because the man has put a dam on the river and trapped all of that sediment, so the river is not happy and anymore, so it's trying to find sediment as soon as it's released off the reservoir.

Participants declared that water from the dam is released periodically with momentum. And that this happens more often in late spring and summer (high water) seasons and in cold months of the winter. Extreme flow changes create an agitation and scouring of the riverbed. As

Elder Gary emphasized that, "you need to release the water with sediment because all you're going to do is you're going to expedite the process and that's not good." With dams occasionally flooding the area without needed suspended particles, water will increase disrupting the river habitats and its biological communities. Elder Gary explained where the mud comes from:

> "In this day and age, we figured that out [mud] comes from the banks of the river and the bottom of the river. When high water comes, it starts scarring [scouring] the banks or the bottom of the river and … when the momentum on the river builds up there, the turbulence starts scarring [scouring]. That's where the mud comes [from]."

Participants also mutually declared that as they paddle down the river from the E.B. Campbell Dam to Cumberland Lake, the water gets muddier as it picks up mud from the riverbanks, hence the erosion, as shown in Image 3.4.

Image 3.4 *Bank erosion along the Saskatchewan River, August 2019*

The scouring causes the main waterway to cut deeper, thus transferring and depositing the sediment downstream, which affects biological communities in riparian areas along the river. In addition to the scouring, Elder Gary pointed out several impacts:

> Only the big river can do that [scour and go deeper], all tributaries that run off from the main river are being disconnected with all the wetlands that they need to provide [for]. They can't provide with [adequate water for the] tributaries that branch off.

Image 3.5 *The Saskatchewan River trying to scar [Scour] the banks. August 2019*

To maintain a dynamic equilibrium, participants explained to me that, the water must flow all the time to prevent sedimentation from occurring. That once sedimentation occurs, the sediment slowly fills up the side channels, and the main river simultaneously becomes deeper, slowly disconnecting from the channel and its habitat. As close as 50 miles from E.B. Campbell Dam, channels can be seen to be plugged up, participants indicated. As Elder William stated,

> Of course, the water flows faster when it goes from the dam and it supposedly should be spreading out into our delta, but less water means less tributaries for the water to go, and

… it's not going in there and that's where most of our sediment comes out to. And it's up to where the beaver moves, they need that [water]. They need it back.

Image 3.6 *Low water levels at the mouth of Cumberland Lake draining into the Tearing River, June 2019*

As can be seen in Image 3.6, water levels are low in the body of the main river. Low levels are also seen in side channels and lakes. Lower water volume in the wet areas of the Delta is a major concern for residents. As Elder Les expressed, the operators of the dam allow the water to drop below the minimum requirements:

> We're not even going to talk about if it's true or not. We'll just accept the damn truth. They go below what they're supposed to give us and this has been going on since 1963. So, they've upset the land, and all the different rivers and the marshes and whatnot by being really stingy with water. So now they don't give us the proper water flow for us to be able to utilize all these marshes. So, what happens? Well, they're slowly drying up.

As mentioned by participants, sediment starvation plays a role in morphological changes that cause the loss of access in parts of the Delta. This, together with the loss of a yearly spring flush, is putting additional stress on tributaries further away from the main channel; as Elder Gary, explained, "But every now and then back in the days before the dams, these wetlands that we're talking about that are starting to stink now, they're not getting the flush that they used to get."

The South marshes of the Delta (known as Cumberland Marshes) are shown in Figure 3.4.

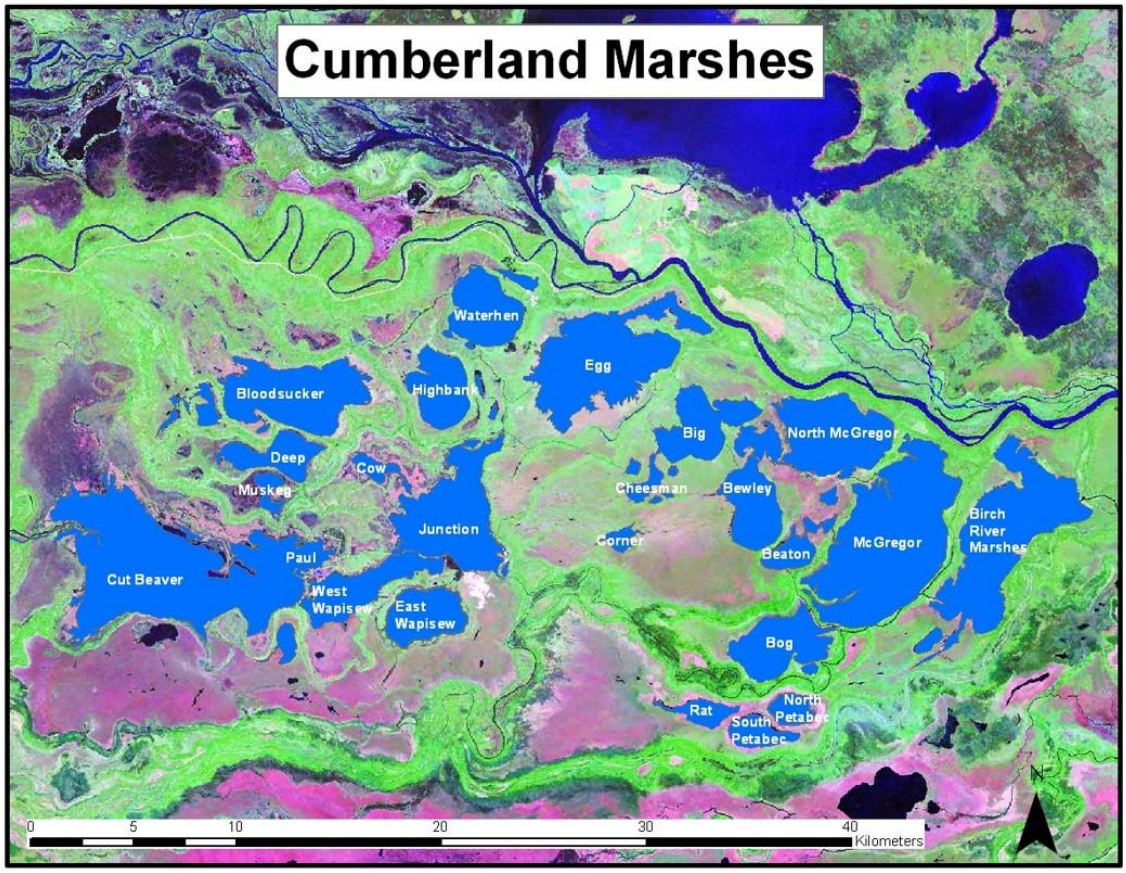


Figure 3.4 *Map of the Cumberland Marshes in the upper Delta, provided by Shaun Greer, Ducks Unlimited*

The old channel diverges from the Saskatchewan River about 40 kilometers from the dam and drains back into the river just upstream of Cumberland House. The channel feeds the south marshes and lakes but now receives a smaller proportion of the flow and can only do so during floods. As Elder Gary recalled, "I noticed that a different set of problem[s] we have on the South of the Delta, which is disconnecting from the main river system." He continued, "Now the river

in front of this old channel is deepening and leaving the old channel high and dry …those lands in the South used to be fed by the old channel." Elder Ferlin also commented on the dryness in the old channel, adding the reasons for why this is happening shown in the image 3.7:

> In the springtime, you can go up here in the old channel because the water is high. At this time of the year beginning of the fall) and the late fall you can't even travel on this old channel. Some places you can walk across. That's [how] low it is. The reason that's happening is when they release the water from E.B. Campbell, there's a big current that goes through the Saskatchewan river. It's cutting into the bank. So, it's getting lower and old channel is getting higher.

Image 3.7 *Low water in the Old Channel, September 2019*

Image 3.8 *Aerial photos of the Dragline channel diverging from the Old channel, June 2017*

Elder Gary later revealed that the Sipanok channel, which is the first to branch off from the old channel into the south of the Delta, is elevated and has lost its flow:

> Sipanok, used to feed the South Marshes. From the Sipanok, there was the Birch River. Birch River led to the marshes in the South. …that river was disconnected from the main river after they put the dam there, that river no longer got water. Because it's closest to the dam. So, it was the first victim of the dam... The next closest river is Morgan Creek. And that's dried too because the main channel has deepened its first 30 years or so, it's scarred [scoured] the banks. But after that, then the next years it started scarring [scouring] the bottom of the river because it became so wide, it didn't have the turbulence to scar [scour] the banks anymore. So, it started finding another place to scar

[scour]. It started meandering a small channel inside the big channel. So, now the old channel is the next victim, the next Sipanok.

Image 3.9 shows a snapshot of the sedimentation occurring and island being created at the opening of the Sipanok channel. Image 3.10 shows the opening of the dragline channel.

Image 3.9 *Sedimentation and island emerging on the opening of the Sipanok channel because of altered flows.*

Image 3.10 *The Dragline Channel showing sedimentation, May 2019*

Participants expressed that the larger ecosystem of the Delta is harmed from the erosion process of the main river, sedimentation of waterways, and low water in general. In addition to low water volume, other flow dynamics in play in the Delta do not favor the ecosystem balance. These side channels are effectively perched, with little to no water, they cannot support life year-round.

3.3.1.1 Abandoned Wetlands

Elder Les pointed when he said that the marsh vegetation that "the moose depend upon" in wetlands change according to water held back and released from the hydro dam. Severe floods cause debris jams and disconnect channels, when logs and sediment are dumped at the openings of side channels. Image 3.11 shows an elevated and disconnected channel caused by floating logs. As Elder William pointed out, "This one here is a dead river already; it's higher than the main river… logs and everything are jamming it up so it's a dead river now." He then suggested, "The only way we can restore it is [by] bringing higher water and [removing] these logs."

Image 3.11 *Jammed creeks and disconnected channels by the main River, September 2019*

Elder Gary explained the effect of the disconnected channels on the wetlands:

> The tributary being disconnected with the main flow. They become stagnant… And the same thing is happening with these little lakes in the back water because they're not getting the flush out or the current that needs to go through these wetlands are no longer there because that tributary has been disconnected already.

Elder Gilbert added that places in the Delta are filled with dead grass and logs. They are unsuitable for native animals and plants, which cannot thrive there:

> One time I was walking through a Bush. I got to this clearing, man it looked flat, real flat, all of it was dead grass like two feet high. … So I sat down there on one of those dead trees and I was curious. There's nothing growing, just a little bit of grass sticking out. So what I did was I opened that grass and There's five layers of dead grass… Water there is not moving. It sits in one place all the time. I don't know exactly what that does to the plants. it's something wrong. But there's nothing moving.

Wetlands provide aquatic needs of many native species of the Delta, including moose, beavers, ducks, and geese. With the destruction of the wetlands, their habitats are compromised. Elder William explained further:

> On the other side of Saskatchewan River, the Delta there, little lakes and rivers just, look dark and smelly. And I don't even know how, aquatic animals can live there…. the whole Delta on the other side of Saskatchewan needs freshwater year-round.

Participants described one example of abandoned lakes and wetlands is Bens Lake by Big Eddy Lodge, where residents of the area recalled that they used to canoe. In September 2019, however, as shown in Image 3.14 and 3.15, it has become so shallow we could wade in it. As Michela Carriere remembered,

> Like we had a lake out back here, it's called Bens Lake and used to be much more open, and you could get there and paddle there. So, Bens Lake used to be way more open and

there was a lot more ducks there. It is easy hunting, but now it's so bushy and so overgrown cause there's not as much water as there used to be. It’s not like it's attached by a constant river. It only fills during floods. And so, it hasn't been filled since the last flood… That’s very stagnant. So, it doesn't really have a lot of oxygen in it. So, it's not as vibrant or healthy as it as it could be.

Image 3.12 and 3.13 *Sediment, sand, and dead wood on the Saskatchewan River shore near Big Eddy Lodge. September 2019*

Image 3.14 and 3.15 *Stagnant and still water at Bens Lake, September 2019*

Elder Delores shared her concern for these lakes on the Delta:

> My husband and I were looking out for fishing [recently]. We didn't see any ducks. We even went into the creeks, now they're partially dry and it's already grown, trees are growing. They're what used to be a Lake. It's all grown out. Everything is starting to form into just that Saskatchewan River. Our lakes are drying out… Those lakes we used to go in, they're not there anymore, but we're saying, Oh what a big difference. The loss of our waterfowl, we used to see whooping cranes. They no longer exist. They don't stop here because there's nothing for them to eat. There's no vegetation for them to eat."

Participants noted many more examples of varied species, their decline in population, and their lack of vibrancy in the Delta, reflecting the negative habitat changes, which the locals describe as "damage." Elder Ferlin described what had happened to the waterfowl:

> At least thousands of waterfowls were here at one time. A lot of moose, at one time but our moose are decreasing of the water impact. What a damage. Same thing with the waterfowl. They're decreasing from our area …it's sad to see that more likely they have a different fly or now a different place to migrate... And for fishing it is decreasing too because they're holding back the fish at the dam. There's only so, so much limited of water's being released to our region.

Participants shared similar descriptions of and concerns about the general health of wildlife and the biodiversity of plants in the Delta, all linking the damage to the abandoned lakes and tributaries that have become overgrown and stagnant, resulting in low nutrient levels and low vibrancy. They said that water in most of the Delta is stagnant and stinks, its aquatics neither healthy nor thriving. Invasive dry species are growing in abundance. Altogether, if the water is low and there is less marsh habitat, a greater strain is exerted on the entire ecosystem.

3.3.2 Mudflat loss along the Saskatchewan River and shallow waters

Participants took me along the Saskatchewan River and the Mossy River Delta draining where it drains into the lake, and showed me how surface conditions have visibly changed. They noted that because shallow, open waters have dried out, they are filling with sand, and dry plants are growing there, resulting in less water access and drier lands in the Delta's ecosystem. One of the important habitats for nesting birds and waterfowl and a unique characteristic of the Delta was its aquatic beds and mudflats. These low-lying areas are not now as bountiful as they once were. As Elder Gary observed, "They still say that this is the largest reproductive area for waterfowl. But in our eyes, it's not telling us that anymore because there's less and less birds each year."

Because of low water levels, lack of natural spring floods, and sedimentation, participants unfolded that the mudflats have been transformed. In the words of Elder Gilbert, "I don't know what happened. The sand took over the mud somehow." Sandbars, which create conditions for plant growth, are not ideal for birds to feed. Elder Solomon, as well as other participants, indicated that waterfowl and other avian species have drastically decreased because of the transformation of the mudflats: "They are not having the mudflats anymore. We don't have the mudflats where it used to drain into the Lake. [And] There is nothing there for them [birds] in the bush… and the dam caused that" He added that he thinks this issue has to do with "the water management that comes through the Delta." He then recalled,

> We would have wonderful mudflats where all the food was for the birds. And this is what brought my father here to this place because of the waterfowl… but there's no more mudflats, no more places for the ducks and geese to feed. All the birds that we had in this area, they are getting less and less. …the conditions are changing for them. So, the birds are leaving.

Image 3.16 provided by Elder Solomon, is a photo of his father "on the mudflat behind would be Cumberland Lake on the other side behind them [in the 1970s]. Now the lake is about four kilometers away with willows covering the spot where they are standing," he said.

Image 3.16 *Former mudflats near the Cumberland Lake in the 1970s, where it is now dried out and covered with willows, Courtesy of Solomon Carriere*

Image 3.17 shows the reduced mudflats on the Saskatchewan River, while Image 3.18 depicts areas by the river that willows and Phragmites have taken over because of low water levels. Mudflats provide appropriate ground for birds to feed on. Reduced mudflats results in reduced number of birds as residents of the Delta report that there were once millions of birds nesting at a time, a huge difference to what is seen today.

Image 3.17 *Former mudflats on the Grassberry River near Pine Bluff, May 2019*

Image 3.18 *Water dropping lower than the bank of the river leads to the mudflats going dry*

Image 3.19 *Mudflats along the Saskatchewan River are replaced with eroded sand from below the dam*

Participants also linked loss of vibrant mudflats to the lack of yearly ice breakup inundations in the region. For example, Renee Carriere emphasized the importance of having a gushing flow in the Delta:

> Give it a chance to flood because right now you'll see how our home is, is absolutely altered even in a 40-year period because we now have a sandbar in the front where there was never ever, ever a sandbar. but it's now dumped all that sediment there. There are no mudflats for geese. Where we were, there was hundreds of thousands of geese. There's no geese anymore because they, there's no place for them.

With post-dam changes in the Delta mentioned above, participants continued by explaining that mudflats are pushed back into the shorelines, which have become dry ground for willows and invasive vegetation to grow. This, they said, means less habitat for avian species and aquatic animals. At the same time, willows are growing more prevalent according to participants. Elder Gilbert confirmed, "I have noticed a lot of lakes; they get growth along the shoreline and then they'll have willows growing and gets further and further out. That's what I see," as indicated in the Image 3.20.

Image 3.20 *Emerging islands with trees in Cumberland Lake, September 2019*

According to the participants, when mudflats become sandbars, it is not only birds relying on the mudflat habitat who are affected. Sandbars create islands and separate wetlands from the main source of water. Dry islands with willows growing will abandon higher floodplains in the region from the coming flow and may only pass water through in times of floods.

3.3.3 Drier wetlands mean more invasive species and more damage to biodiversity

Marshes are found along the shorelines of lakes and open waterbodies. Participants narrated that marshes in the Delta provide rich habitats for aquatic animals and insects, having flooded herbaceous plants with underground storage and reproduction as their main feature. Because of low water levels in past decades, the lakes in the Delta are beginning to be overgrown by Phragmites. Michela Carriere explained:

> If everything just dries out, then some of those plants that aren't native to the area are more successful. …the conditions have changed so much that the phragmites are thriving and they're kind of taking over. And what happens is when one plant takes over, you just have more environment for disease because [when] a disease comes in there it can take over easily. Um, so there's more opportunity for that and they're growing so much cause it's drier and they thrive in a little bit drier environment.

Downstream, Phragmites (or cane grass) grow as invasive grass species that mimic woody plant characteristics shown in Image 3.21. They have taken over, choking native growth, and affecting water animals. According to Michela Carriere, Phragmites has displaced several different muskrat food sources grown in the water, such as horsetail, rat root, and bull rushes. She pointed out that Phragmites does not provide nutrients for animals: "They've been pretty bad for muskrats because there's several different plants that muskrats like to eat. But when the phragmites come in there, it kind of chokes out the biodiversity."

Image 3.21 *Phragmites colonization of the marshes, March 2016, Courtesy of Michela Carriere*

As the local Elders explained, because Phragmites is a giant and invasive grass, it takes over what aquatic furbearers such as muskrats eat and threaten reproduction in the marshy habitat. Elder Gary has a camp on an island by Cumberland Lake, where the habitat used to be marshy along the shorelines of the lake. He pointed it out to me: "The Island over here where my lodge is, was just a little reef out in the Lake at one point in time... if we don't burn the phragmites, nothing else will grow. They grow too tall. They just took up everything and nothing eats phragmites."

Image 3.22 and 3.23 *Mossy River delta on the shore of Cumberland Lake, May 2019*

Elder James also talked about the characteristics of the marsh, now that the Phragmites are in abundance:

> There's other dead birds coming into [being found in] this Marsh because there is no new growth. There's nothing new growth. You know where this Lake used to be [mentioning an area] That's how far the water was, long time. But now it's all cane grass. All the way a mile away from the shoreline. Maybe two miles… it dries up and it's no good. Just a dead, vegetation for muskrats and stuff.

The quality of the water in these areas is also poor. As Elder William pointed out,

> No oxygen for the fish. And there's other invasive species too, but I don't know if that has to do with the river flow, but the phragmites definitely has to do with the water flow… We need you to learn how to live with them and learn how to manage them so that the real plants can grow in their real environments. So yeah, it's hard."

Looking at the south marshes of the Delta in particular, Elder Gilbert said that dead logs and phragmites contribute to a lack of a constant and gushing flow. He also pointed out, "You have all the dead weeds and whatnot building up there and [they start] to reek, [it] smells bad because it's not going anywhere. It's not moving at all." Additionally, in the drier environment, woody plants such as willow and poplar are expanding and growing larger on the shorelines, stopping the flow, silt, and sediment from reaching the lakes and replenishing wetlands. Image 3.24 shows willows and dry plants overgrown on previous marshy habitats.

Image 3.24 *Willows coming out on top of the phragmites, May 2019*

Elder Solomon expanded on the problems with willow and poplar:

> What's happening now is that the willows and the trees are getting bigger, so it stops all that stuff from reaching the lakes… the silt is getting stopped at the river. So that's what I observed…with that channel being deeper and the water is still in someplace getting into the marsh, but it's not bringing the nutrients because it's being stopped by the weeds and the big trees now, so I don't know.

The participants maintained that if more water and nutrients were available, not only would there be more plants but also more diversity. Thus, plants other than willows and phragmites would grow. Finally, according to the participants, dirty water filled with algae and dead plants is an indicator of the current water quality of the Delta. There is a need to study particles and natural nutrients coming through the E.B. Campbell Dam. This would require testing the water in distinct locations throughout the basin. On this point, the participants pointed to

the need for the authorities further upstream to take their concerns seriously. As Michela Carriere said,

> The animals matter, the fish matter and that having natural rhythm should be most important to them. That's very weird. That's the first thing we need to communicate that it matters, people matter too, that lived down here. …we don't want it to get to a point where we lose this ecosystem.

These results can be summarized to indicate that according to local participants and their Indigenous knowledge flow alterations are perceived as the biggest driver to negatively impact ecological dynamics in the SRD. In addition, they continue, since the community has only been minimally consulted and acknowledged, residents of the Delta argue that others—neither in the province nor the country—understand the importance of preserving the Delta.

3.4 Distressed Land, Culture, and Livelihood of Residents of the Delta

Besides the physical changes in the Delta's ecosystem, participants argue that community values and activities are affected, such as bartering, self-sufficiency, the ethics of using the resources on land, and culture, all of which are undergoing transformations. From the Elders and the stories of the past, this study captured the hardships they have gone through since the Delta has changed. The participants relayed that community resident livelihoods have traditionally been closely tied to the land and natural resources to meet their needs. The participants say that the nature of the Delta is a fixed part of their lives: a beautiful place and where they can spend peaceful and stress-free times. Participants value the rich history in the Cumberland House town and the region. It is the oldest settlement in Western Canada. As Elder Gary explained to me,

> There's a lot of things that have happened because we were the first people that were influenced by Europeans. We were the first victims and are still victims of it today because we're still living it. And you've seen it the little time that you've been in this community, you've seen it, you felt it.

Participants spoke of stories indicating that water served as a main transportation route for communities in the Delta in the past before the road was built. Participants were, or told me about many canoe racers and swimmers who conducted water activities with great passion. What is more, water has linked residents of the Delta to their livelihood, as an Elder Lily recalls:

> I remember from way back that when people went out hunting moose, they would go in a canoe and I remember very clearly there were hunters who went out in a green canoe, I remember the color cause a concern back then was that these men were lost. They were taking too long to come back. So, if they did return, their canoe was weighed down heavily. There were two of them, one in the front and in the back paddling home, they reached the shoreline here and people from the village went over there only to find that they killed a moose. Then, you know, it was lots of moose meat, enough to share with everybody. that would have been around 1965 or 66, right after the dam. I was holding like a kind of milk in one hand and some other ingredients from the store, and I had to get into the lineup and people were bartering. So, I would hand over whatever my mom sent me. And then I was given a chunk of moose meat. So, I came back up from the river and took that moose meat home and then my mom cooked it. So, everyone would take something from home to them and just get some moose meat. In our case with the dam, there has been noticeable changes in healthy waters and in water levels that were abundant enough for self-sufficiency.

Additionally, participants said that seasons and their specific time dictated which hunting and gathering activities occurred, and, according to Renee Carriere, determined the diet and income for people living in the Delta:

> We have to do it year-round because the social impacts are different because we are also seasonal hunters, fishers and gatherers. So, there was a very specific time that you went out and harvested muskrats. It's three weeks, it's done. It's really, really intense. People are getting food for their children. So, they're very focused on things. ...it's absolutely radical.

Participants said that Elders taught younger generations how to clean their hunt. Whatever prey was killed was used for survival. Stories told by participants indicated that those living in the Delta loved their animals, and they never misused them, taking only what they need, not wasting anything. Elder Lily explained how it used to be:

> We didn't have freezers back then, but we preserved the meat by, cutting it so that it was thin enough and then hanging it over the smoker to smoke. Yeah. So that means you would create dried meat and then you would use that to cook with... And over the summer when it was warm, you would also share a lot of that meat with other people in the community. Everything was used up and the bones were fed to the dogs. And the moose hide would be used. And that's what we would stretch out then smoke that too and make leather. And then that became the cloth or the fabric for the clothing.

She continued by talking about how in the springtime, families would move away to their trap lines and they would take all their families with them, even school-aged children. Their parents taught them how to trap muskrats, beavers, and other pelts that used to trap to help parents make a living to feed their families. It was important for children to know how to fish, hunt, and survive in the wilderness. An example of a culture that is almost faded out of existence today.

3.4.1 Changes residents have seen and the future they foresee for the Delta

Participants revealed beliefs that within the past couple of decades, communities living in the Delta have experienced social, cultural, and economic disruptions due to the impacts of climate change, population growth, and dam operations. In many of their stories, the participants emphasized how conditions have changed for the fish and those who make a living from commercial fishing. Bountiful amounts of fish were once caught, as Elder Delores remembered,

> My dad would set these nets and every time he pulled out that net you would see gold because they were full. The net would be just, full of gold of walleye. Because their color is gold. Dad would be throwing the gold like this [showing abundance with her hands].

That is a rare catch today for even expert fishers, she continued: "You can't do that today. You won't be able to catch the way it used to be. And just to think that would only be in January and May that they would do commercial fishing."

As the quotations throughout this chapter show, participants felt that it is not only fish that are declining but also other water-dependent animals, such as waterfowl and other avian populations, furbearing animals, and mammals. Therefore, hunting and trapping is not as rewarding as it was in the past. Participants indicated that transportation changed; that is, when the water was open, residents could travel through the water by canoe to hunt animals. During winter, they would take the sled dogs over the snow and go hunting. Now hunters need to go deeper into the forest to find prey, and that brings a new set of obstacles for the community.

While I was in the Delta, there were two hunters missing for more than two days. Elder Lily explained to me that changes in parts of the Delta create challenges for seasonal hunters and trappers.

> As we experienced two days ago, we had two men who were lost for 55 hours [about 2 and a half days] without food and they were out into the forest. They couldn't find their way back because the forest now is so dense; the brush is so thick that increases your chances of getting lost.

Elder Les narrated a story about ice fishing challenges due to the high and low water fluctuations:

> If you were coming on the Cumberland Lake shore that froze already and SaskPower gave this much amount of water. I know water went on top of that ground (gesturing), they were trying to go out onto the main Lake, and they didn't know that it was a very thin ice. So, the snowmobile went through the thin ice and completely submerged. All that was showing was the last three inches of the windshield. So, this would be about January. …What would you think immediately if you were the fisherman that was trying to utilize the Lake for fishing as it's kind of catastrophic event for me because now, I have to fix this snowmobile.

From the detailed observations and illustrations, Delta residents provided, it is clear the community is aware of the trends and impacts that have led to drying and harmed biodiversity. The participants of this study have lived through drastic changes in the Delta. They know that change is a natural process, but they also tell how some of the changes are created by manufactured structures, i.e., the E.B. Campbell hydro Dam, which has negatively impacted the people and their way of life. Elder William summarized the situation this way,

> Well, this is the second world's largest delta. It has to be revived for it to survive, not only for our kids but grandkids in future for them to keep using it, but it's mainly for the aquatic animals and the land animals that live around our river and lake system and the birds too. It is a beautiful place too, so somebody has to try keeping it alive. Before it shrinks to nothing.

In addition to geomorphological impacts and habitat conditions, the participants raised concerns about industrial and agricultural pollution that the river carries into the Delta from across the basin. As Elder Gilbert put it, "They don't care what they spray on the land. What kind of needles are given to the animals. I know all that will eventually sweep into the river and bring it this way." These agricultural contaminants and environmental risks will be exacerbated by the province's expanding irrigation project that is proposed to continue of the next decade. With expanded irrigation in the province, the outflow from Lake Diefenbaker and into Tobin Lake upstream of the SRD will change, reducing the flow into the SRD. Locals demand that their concerns about the changing quality of the water be addressed as well as the quantity and timing of the flows.

Stories of Elders are powerful in depicting their fear of future depletion. They told me about going out into the lake when they were young and seeing the wealth of distinct species of birds on the lake, the depth of the waters and compared their experience to the way it is now. They are startled by what they are seeing in front of their eyes. As Elder Gary put it bluntly,

> The knowledge has been here forever. The problem is to convince white man to believe in the Aboriginal people. Simple! I can't say it any simpler than that because that is the

> problem. We know what's going on. We know where it's heading... And then by working with these scientists, their prediction is as I'm seeing it right in front of my eyes, there will be just the one river flowing [in] the whole system.

Elder Les also warned about the wet areas of the Delta shrinking, as satellite images make clear:

> If you looked at the global satellite images of the Delta, you could see that snaking river channels [mossy river delta] are going further and further out in the lake.

As these quotations show, Elders are alarmed and trying to raise their voices to advocate for the Delta and its threatened wildlife and to inform decision makers in the province and in the country about the future of the Delta.

3.4.2 Community members are seeking attention and raising awareness on the Delta

Participants revealed that residents of the Delta have deep roots in maintaining and sustaining their surrounding landscape. Through their constructed ethics of nature and animals, participants said that they have kept a balance for many years between nature and the people's needs in the Delta, being mindful of their decisions' impacts on their neighbors and the wildlife. In the past several decades, as the effects of dams are increasingly felt, they perceive that there is a need to rise to collectively act to conserve their ecosystem. Elder Solomon, for example, shared valuable memories of being a part of a trappers' community from a young age:

> When I was a kid, helped my father and some of the trappers going to another trapper's area, and make a dam, make a channel so the water can go in there. Stuff like that. That's what I grew up doing

The residents I interviewed told me that they work hard to conserve marshes and to add water to the habitats of water-dependent animals such as muskrats. Elder Solomon described "a little project for the guys that were going into the areas":

> They were able to harvest animals there in the spring because we add enough water there. We kept enough water in there for those muskrats to have. And when you made

> these places viable [and] healthy, it wasn't only for the muskrats and it was for everything"

He also spoke about saving mudflats from invasive plants and restoring habitats for waterfowl:

> My dad and I tried to save the mudflat parts. We cut all grass … We exposed the dirt so the geese and the ducks could come there and sit on ground. And the shorebirds can come there and eat all the little bugs that we've exposed because it used to be a mudflat. My daughter now is trying to do that here. And she's doing a good job at it right now.

Residents of the Delta shared how they partake in the challenging responsibilities to conserve the land and water. I spoke with participants who shared personal experiences about the changes they have gone through or community efforts they have taken part in, as well as the difficulties of outreach and raising awareness to a broader audience. Canoe trips and other school activities for the youth to raise awareness about the Delta are a few public and youth engagement examples. Participant Renee, an educator at Charlebois School in Cumberland House, noted:

> So raising awareness, I have taken canoe groups out. We have a water probe by our place [to sample water for U of S]. When you go into the school, you'll see a large table. I actually had a science group build that table, that big table, which shows the hydroelectric dam. That 3D model and that was all built by students. So every day we're looking at the river system and what the dam sort of looks like.

Image 3.25 *A 3D model of the E.B. Campbell Dam in Charlebois School in Cumberland House*

She also continued,

> If you go down by the river, you'll see, we did research with students and there's a monument with fish on it. So they researched all the historical levels. We did the research and that's the actual marks of where the water was [every 10 years]. And that was a really interesting, fascinating project. Those are accurate levels, so those are all sort of small things.

Elder Clifford is pointing to the water level marked at the 2005 flood in Image 3.26.

Image 3.26 *Fish monument pointed at by Elder Clifford, at the Big Stone River in Cumberland House*

On a broader provincial and national level, one of the well-known advocates of the Delta, Elder Gary spoke about his personal challenges with raising awareness and communicating to external audiences:

> I was alone when I did this. When I got this documentary, I wasn't no leader or anything. Just an individual in the community that wanted to try and help the wildlife in this delta. I've done a lot to try and help make a change for the delta. I've committed a lot of my time to it a lot and I went all over, to speak about it. It wasn't easy because I was never a public speaker or anything like that. Just a trapper, fisherman that live off the land. And next thing I knew, I'm talking in front of hundreds of people, I know that they were all educated too. I even talked to the minister of environment of this country and like I told her about the delta.

Image 3.27 *Elder Gary, sharing stories and knowledge on the land, July 2019*

Participants said that the SRD, with its abundant resources for birds, furbearers, and other water dependent species, has received attention from different companies and organizations within the past century: The Hudson's Bay Company, The Prairie Farm Rehabilitation Administration, and Ducks Unlimited Canada, to name a few. Ducks Unlimited, for example, were considered helpful by participants because they have built dams and helped marshes keep a steady flow, which has helped waterfowl conservation in the SRD, both in the pre- and post-dam era.

Elder Solomon on the contributions of Ducks Unlimited (DU) recalled with humility:

> The E.B. Campbell Dam affected everywhere. And DU and our people made all kinds of little attempts making sure that we hold water back [in the marshes]. And DU does it in a big way because they have sponsorship money and they can utilize that money to buy material and to get good engineers to come in here and put them in the right places and they can afford to buy these structures. Us, we are too damn poor but we can still do these things.

As Elder Clifford explained, "This was made about 89, [and] this one has stopped logs. [but with] this you can't really have the fish moving back and forth easy." While he was appreciative of such structures built on back lakes with less access to the Saskatchewan River, he made a comparison to a weir structure saying, "While with the weir, fish is free to move in and out of here. Later on he suggested that a weir structure could be beneficial in parts of the Delta:

> Because weirs are there to make sure that you have a good balance of water behind and down below. It doesn't negatively affect the water source because you have a continuous flow out of there just like this.

Image 3.28 A dam structure built by Ducks Unlimited

Through the interviews, I noted that some participants were happy with DU involvement. Elder Gilbert expressed it this way:

> It's a good thing that they came in. I otherwise that uh, the Delta on the South side of Cumberland would've been pretty much dry already if they hadn't come there with all the dikes and whatnot or controls that they built to control water.

However, DU's involvement in the Delta didn't seem to last, as Elder Gilbert noted:

> [Things] started changing like something else would come up. There wasn't enough funding for ducks unlimited, as much as they wanted it to. Then slowly, everything was kind of going downhill.

Participants noted that after all, it was understood that this trend of abandonment in the Delta through the years has left its residents in despair and with feelings of being neglected. This directed my attention to follow up on the community's perspective on external engagement and collaboration in the SRB discussed in the next section.

3.4.3 From Forming a Stewardship Committee to a Broader Collaboration in the Basin

Participants expressed frustrations that after years of being neglected, ignored, and discriminated against, people in the Delta are disheartened by the dam operators' insensitivity and unresponsiveness from upstream sectors. For example, in the interviews in fall 2019 when participant Renee was asked about SaskPower's cooperation and understanding, she replied, "I can say with 100% [certainty] that there has never been any turn of action from SaskPower or [attempts at connection] or [say] let's talk. Never, never, never, never, never, no consultation or, no nothing." She continued:

> It's ridiculous that you're not listened to when this is where you live and its rules are made by somebody in Regina who has never set foot here. It makes no sense at all. And it makes no sense that there's no monitoring done here, you know, we should have people, local people hired to monitor the health of this ecosystem. Because it's also for the benefit of really the entire province.

Participants viewed the current decision making process as ignorant to their needs and discriminative. Twelve out of fourteen participants explicitly reported on the discrimination they have seen from upstream corporations and governing authorities. What's more, locals do not see many external faces visiting the Delta to cooperate with community stewardship activities. The following conceptual model identifies and weighs the community's perspective on external support or collaborations in the Delta (Figure 3.5).

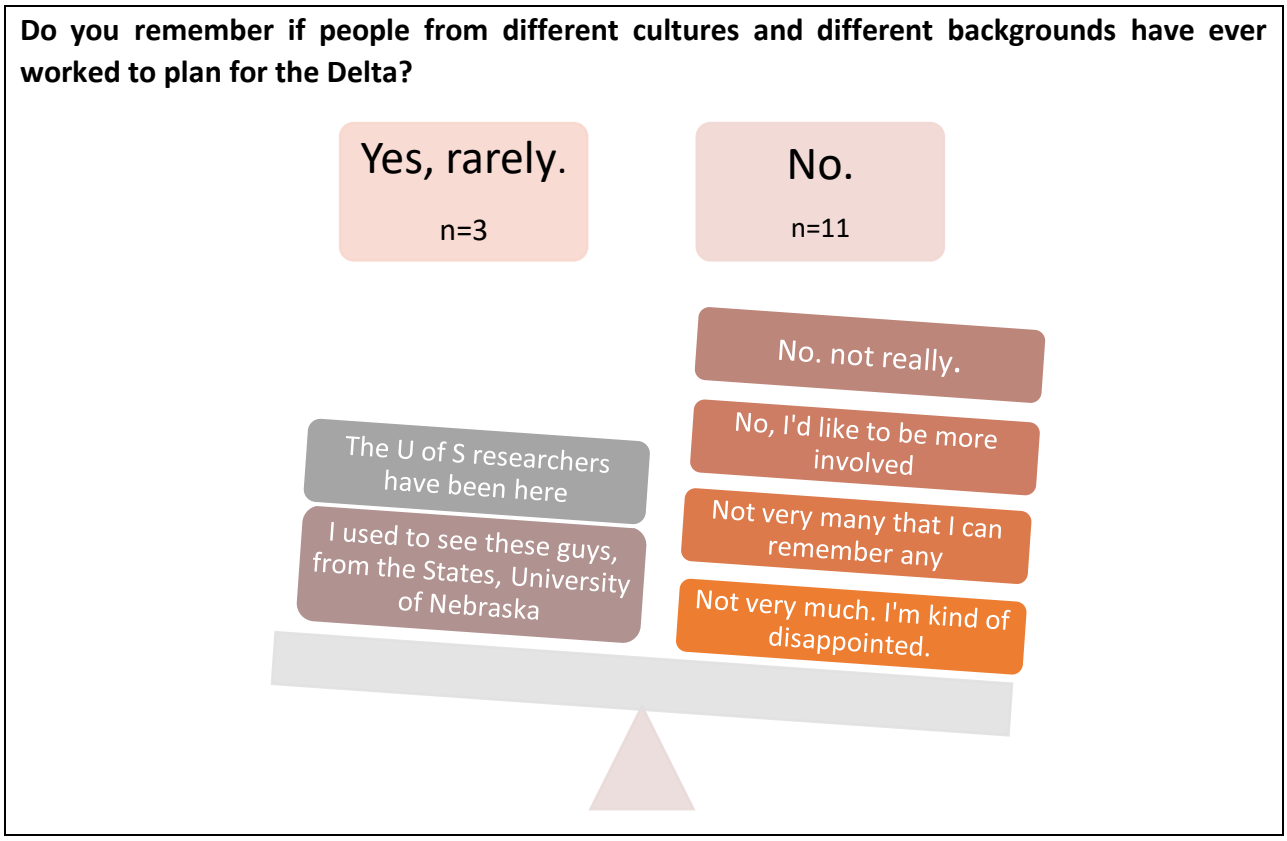


Figure 3.5 *Indicating the common perception in the community is there are insufficient external support and cooperation for the SRD (n= the number of participants who responded to the question)*

As Elder Lily briefed, "there's a lack of trust between people from the village and the Cumberland House Cree Nation, and SaskPower, because we've been poorly treated." Additionally, disproportionate attention in the province between upstream and downstream needs, absence of monitoring and documentation on the negative impacts of flow changes in the

Delta, a history of misinformation, deception, and negligence has left the community bitter and frustrated. "I'm bitter about it. How can you not be bitter when you know that there is such a huge imbalance of power?" Elder Lily continued.

However, in the past decade, participants noted that a few locals from Cumberland House have engaged in dialogue, carrying out activities and research with the University of Saskatchewan and other organizations. Following this trend, participants asserted that community-based efforts in the Delta have started seeing a shift to a more active and responsive management. Participant Renee, for example, noted, "As a result of some of the University of Saskatchewan [presence], like meetings and just sort of talking and formulating and maybe they, sort of nudged us in a certain direction." She added,

> We've worked really hard on [forming a] committee for the past four years now and just trying to sort of define what the Delta is, where is it, what can we do? It's been a really sort of very interesting process. Not long. Uh, but it, um, but it has started. It has started.

Though there has been sporadic efforts in the past, finally in 2019, residents of the Delta welcomed the opportunity to unify as a non-hierarchical circle of stewards and discuss the Delta in an established structured manner. They formed a stewardship committee and signed a memorandum of understanding with the University of Saskatchewan to voice their concerns about the Delta publicly and to their targeted audience. One of the committee's core purposes is finding ways to involve corporations and responsible organizations for water management in the basin to put themselves in a position of helping the community and to be part of a process of nation building. Elder Lily on that note with regards to the E.B. Campbell Dam's operation corporation (Saskpower) raised that,

> We started a committee here to look at, water. One of the questions that we've always had, is what do we do as a group within the community to address the fluctuating water levels and, negative impact of the dam and even the control of water, because the water flow is controlled.

Participants, some of whom are on the stewardship committee, revealed that the community has come together to discuss previous challenges and share their concerns and perspectives as a united organization. Residents of the Delta are eager to meet and discuss their points of view and concerns with upstream authorities. The key questions Elder Lily raised were, "How do we move forward? What are we talking about in terms of a long sustainable goals and sustainable improvement?"

Participants noted that today there is a particular focus on conversation and dialogue between upstream and downstream of the basin, because the community is now asking about the water resource management in the basin, and as a result, how the SRD should look going forward. Elder Delores suggested that more communication and collaboration was the key:

> You have to have more communication and be more brought up [to date]. But [also] more meetings to collaborate, to get everybody together to understand what they want and what we want… you have to have working groups strategized.

Delta residents want the quantitative modelers in the university and decision makers across the province to observe and reflect on the changes in the Delta and the changes imposed on it by upstream management. Calling to mind the winter challenges in the Delta due to dam operations, Elder Solomon said, "Nobody really knows that [immense alterations of the flow in winter], nobody comes here in the winter to study this place." He then followed with eagerness: "we need to know the technical side of things" Notwithstanding the University of Saskatchewan's attention to the SRD, community members in multiple instances established that the amount and efficiency of research done is unsatisfactory and inapplicable. They raised the need for more technical rigor and more scientifically backed and thorough data.

Participants also put forth that people in the Delta have been a self-sustainable society, and they see a problem with the way dams are operated and decisions made. Narratives of participants declare that they are well-meaning and want to be involved in responsive management practices. They understand that the dams supply the needs of the province and

they are not opposed to it, but rather they are eager to be a part of the team that brings solutions to a complex issue in the province. Yet, the results of this study conform to a narrative from participants that "Modelers don't understand us and we don't understand modelers". Respectively, the community raised the need for scientists, modelers, and decision-makers to be present in the Delta to observe and monitor the changes. Participant Renee addressed water resources modelers and experts in this statement:

> We cannot gain a full picture. I think you really need to bring people [scientists], because you're actually asking really hard questions because you need to be observant in the field. Springtime, summertime, fall time and wintertime.

The ecosystem dynamics in the Delta have changed, and to preserve and restore natural resources in the vast Saskatchewan River Delta, external support is needed: "Even though advocating for water, ideally should be done by the people who are here, there is still those supports that are needed from the outside. There has to be infrastructure in place, to continue for that advocacy." Elder Lily said. The residents believe that if the wildlife starts to recover, populations living in the region will be happy and thriving. But Elder Gary articulated the challenges involved:

> Nothing is going to change until we start putting it into action and try some pilot projects and monitor them. And we need to do that, but when you have a government that doesn't want to be in a part of it and then they just throw rules at us and we can't do what we want to try and do, it's hard. It's hard.

Underlying Elder Gary's view is that for river restoration efforts to be successful, researchers need to understand what the river morphology and function was like prior to human modification. "We need to educate the decision makers, whoever the prime minister or whoever the premier is, we need to reach out to them because they're the decision makers," added Elder Gary.

Thematic analysis of the interview results indicated that the issues can be framed as a wicked problem that has emerged from a failure to engage different groups of people involved in the impact cycles in the SRD shown in Figure 3.6.

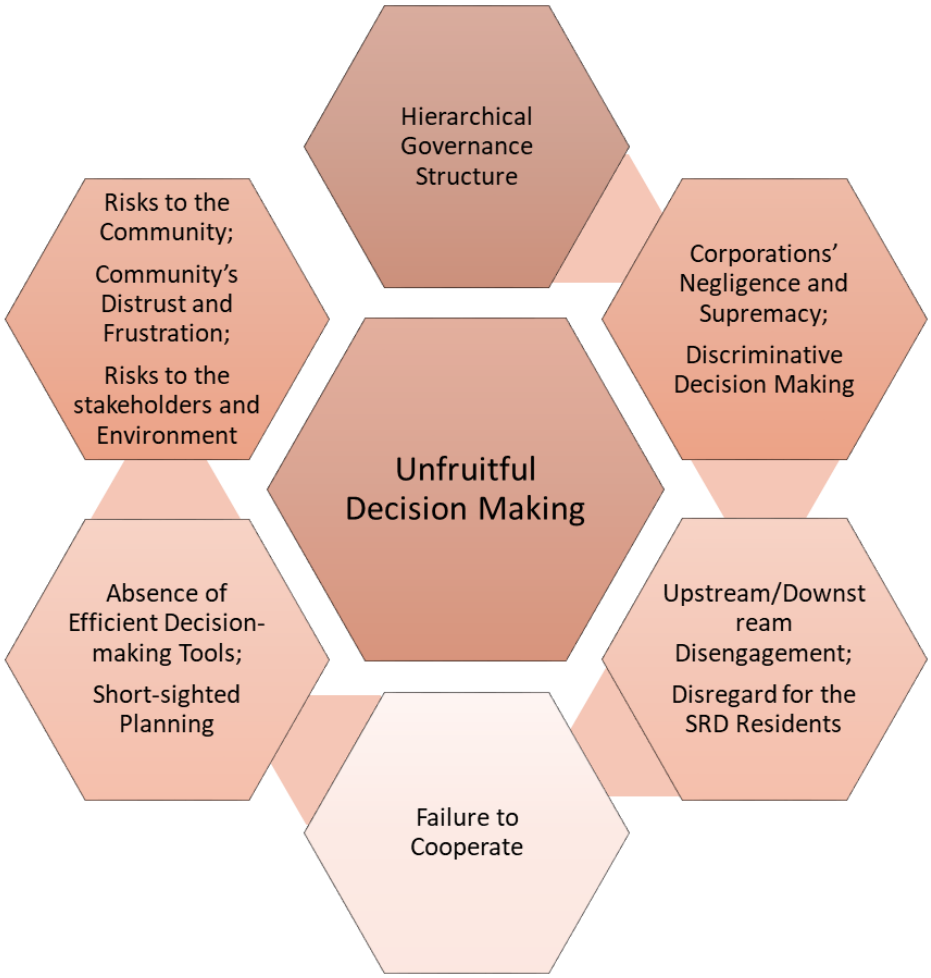


Figure 3.6 *Influencing elements of the current unfruitful decision-making practices for the SRD from the community's perspective*

Participants said that the community unanimously asked for recognition and inclusion of their views and land values in the decision-making process. Narratives shared above from this study described that there is a deep understanding of the impacts and a vision for the future amongst the residents of the Delta, and they are reaching out to upstream decision makers and academics to collaborate. Residents of the Delta cohesively believe that restoring the SRD can only become possible through a collaboration, and they are ready to be involved in non-hierarchal and collaborative water resource management in the province. In the following

chapter, I will continue to analyze the expressed community needs, reflect on the relevant literature and archival records based on my research findings, and discuss strategies for reaching a collaborative modelling integration for the SRD under the CES framework.

CHAPTER FOUR

RESULTS PART TWO: A FACILITATED DIALOGUE BETWEEN THE COMMUNITY AND MODELERS

4.1 Chapter Overview

In this chapter, I discuss my findings based on interviews with people who live in the Saskatchewan River Delta (SRD) in the context of community-engaged scholarship (CES). I also provide reflections on how community members perceive the current and desired roles of decision makers and quantitative modelers with respect to the SRD's water needs. Interviews based on CES were found to be an effective and useful way of collecting diverse viewpoints on similar issues and problems that each individual perceived differently. The results of this study are presented under three main themes, each addressing their corresponding objective: Perceived issues with the flow (objective one), impacts of the E.B. Campbell Dam operations on the Delta (objective two), and the community's vision and approach for future collaboration (objective three).

Centered on the scholarship of engagement, this study was the first of its kind to enable SRD community members to define their audience and ask solution-oriented questions from water resources modelers at the University of Saskatchewan. The study's participants noted that they appreciated this new level of engagement yet there is a long way to go for the dialogue to be effective. Engaging different individuals as participants in this research involved in-depth dialogues in which they shared their experiences and ideas and helped me understand and communicate their challenges. As well, it became evident through the interviews with Cumberland House residents that since E.B. Campbell Dam went into operation, flow alterations have been immense and have left drastic consequences for this ecologically rich Delta. I spent many hours with people trying to break down these consequences in relation to the flow alterations from the community's viewpoint while honoring the emerging themes. My research findings consolidate those of earlier studies: water management practices in the province have failed to satisfactorily engage the SRD community, but there are ongoing efforts to improve levels of engagement and relationship building.

4.2 Hydro-ecological Evaluation: Perceived Issues with the Flow

The results of this study join others in attesting that upstream dams control variabilities of the natural flow and floods in the Delta (Abu, 2017; Andrews et al., 2017). Through hydropeaking controls, daily and seasonal fluctuations become artificial and suspended sediments are blocked, causing morphological and biological disruptions in the Delta's river system. These narratives are validated in recent literature (e.g., Mihalicz et al., 2019; Toonen et al., 2016; and Smith et al., 2014).

The results of the current study suggest some additional details and trends not reflected in the literature or previous archival records. For example, emerging from this research are nuances of the relationships between complex ecological functions and human-made impacts from flow controls above the SRD. Moreover, findings of my study, through descriptive narratives, demonstrated that the hydropeaking operations induced daily and sub-daily fluctuations of the flow that have profound impacts on the Delta. These fluctuations, however, are currently overlooked in large-scale hydrological models. Previous documents and place-based knowledge from the Delta (Abu, 2017) explained that several lakes not fed by the main river have shrunk and gone dry in the recent decades. Our observations in the late summer and fall of 2019 are in line with archival records. Many lakes and wetlands were inaccessible to motorboats in September, when water levels typically start to drop. Another factor causing side wetlands to be separated from river bodies is inconsistent high flows alternating with low flows on the Saskatchewan River.

According to the participants in my study, abnormal low and high flows are byproducts of dam operations. The literature, however, has provided few details on inter-annual variabilities of the flow (Hassanzadeh et al., 2017). According to my research, the SRD community insists that although there is ample evidence of the harm that the dam operations have inflicted on the Delta, researchers have not accounted for daily and hourly variabilities in previous studies. Moreover, because evaluating flow specific to different times of the year is complex, researchers and water resources modelers have not yet provided a concrete assessment of the flow deviations (Pahl-

Wostl et al., 2013). Instead, conservative assessments (presumptive standards) are used to suggest ecologically acceptable deviations from natural flows for the Delta (Neachell, 2014; Richter et al., 2012), which according to the participants of this study are not currently met in any of the four seasons of the year.

4.2.1 Spring Flows

When it comes to spring flows, my research is consistent with previous studies that found that flows in spring are now altered (e.g., "held back"), whereas before the dams they were more naturally varied (Andrews et al., 2018). Sagin et al., (2015), also reported that compared with the pre-dam decades there is less spring surface water coverage in the Delta, which was highlighted by participants in this study. Although these changes might be alluded to in recent documents (e.g. Watkinson et al., 2020; Mihalicz et al., 2019), the pattern of alterations throughout the years has impacted the ecosystem, which, as the participants attest, has historically thrived on gradual spring inundations with higher flows and then a gradual drying which nurtured long standing mudflat ecosystems.

4.2.2 Summer Flows

My research on summer flow is also consistent with the literature, indicating post-dam/pre-dam differences (Watkinson et al., 2020; Sagin et al., 2015), where the post-dam flows are interfered and withheld based on Tobin and Diefenbaker Lake inflows and outflows (Hassanzadeh et al, 2016). For example, E.B Campbell Dam moderates high flows and occasionally releases rare emergency floods into the Delta. These erratic high flows occur unnaturally and often outside their seasonal period, which to participants' descriptions, "destroy" plants, trees, the habitat of fish and birds and the young of other wildlife (Renöfält et al., 2010).

4.2.3 Fall Flows

My thematic analysis of participants' comments about fall flow is also congruous with the literature (Abu, 2017; Carlson, 2016). According to the participants, the water level drops, water

freezes to the ground or becomes too shallow, and transportation is disrupted during October and November. Early fall disturbances subject the migratory birds stop-over sites (Asante et al., 2017) and the residents of the Delta to challenges during the important hunting and harvesting season. However, assessments of fall flow alterations and their effects on various functions in the Delta are currently thin; reported evidence from the Peace-Athabasca Delta indicated similar cold month challenges to its ecosystem imposed by hydropower disruptions (Beltaos, 2014). According to the participants, most research in the Delta has focused on peak flow seasons from May to September, largely leaving out the icy, cold seasons.

4.2.4 Winter Flows

For the winter months, there are fewer archival records than for the other months. Previous documents reported higher than normal flow fluctuations (Abu et al., 2016; Carlson, 2016), vulnerability of the floodplains and their aquatic species through reduced water quality (MacKinnon et al., 2015), and disrupted navigation and reduced mobility for residents of the Delta (Andrews, 2017) because of increased dam operations during the winter creates unstable and unsafe icy conditions.

Other themes and trends emergent from narratives that are not reflected in the scientific literature are layered slushy ice conditions in the river with trapped sediments between the ice layers. Such conditions are now created with the periodic water releases from the dam and result in low oxygen levels that are detrimental for fish and create havoc for other aquatic and land animals. Therefore, findings of my research confirm the Department of Fisheries and Oceans' (DFO) assessment of flow needs (2019) that there are empirical gaps of knowledge and observations on the health of fish and wildlife that are subject to the increased flow fluctuations from the E.B. Campbell Dam during the cold months. For example, participants suggested that research on sediment load relations with fish and wildlife should be expanded.

4.2.5 Flooding Patterns

Periodic floods occur in the SRD, which has multiple tributaries originating in the Rocky Mountains, on the prairies and on the boreal plain, where they join before draining into the Delta. However, river regulations across the basin interfere with these flood cycles that are essential for the ecosystem (Kornder et al., 2019; Mihalicz et al., 2019; Massie & Reed, 2013). In spring, instead of receiving its natural spring runoff flow, the Delta experiences infrequent and unexpected emergency floods that are destructive to the aquatic, wildlife, and human populations (Asante et al., 2017; Saskatchewan & Sub-basin, n.d.). Both the narratives from my research and several papers from the literature (e.g. Asante et al., 2017) indicate that the floods disrupt and displace the vast bird habitat in the Delta (Carriere et al., 2021) among other effects.

According to both participant narratives and MacKinnon et al. (2015), frequent natural floods provided not only nutrients to seasonal wetlands but also stability to geomorphological and chemical characteristics of the floodplains. Today, dams upstream of the SRD occasionally flood the area with water that lacks needed suspended sediment, disrupting the riverine habitat and its biological communities (Jardine et al., 2015). The Delta community wants to restore the more rhythmic flooding that characterized the pre-dam environment (Jardine et al., 2015). However, there is insufficient instrumental knowledge on how to achieve required flood peaks carrying adequate amount of suspended sediment loads without harming the ecosystem.

A number of participants expressed their experience with the recent flood in winter and spring of 2020, and provided perspective on better management approaches with the emergency high flows in the basin and “What makes a good flood?” One participant of the study pointed to unprecedented communication efforts from Saskpower as a starting point of continued knowledge exchange. However, the 30-day stabilizing agreement for fish spawning in Tobin Lake was brought to mind. This agreement results in compromised fish spawning and bird nesting downstream of the dam and increases chances of disruptive floods once high flows from mountain runoffs arrive. Rather, local knowledge holders indicated that a good flood comes with ice-breakups before the spawning and nesting of animals has occurred and requested controlled spring floods and a situation of trade-off between the reservoir and downstream needs (Renöfält et al., 2010). I argue in this thesis, that to achieve a more naturalized flow in the Delta requires

mutual understanding *and* “agreements” between the managers at E.B. Campbell Dam *and* Gardiner Dam, which are co-developed to satisfy the needs of downstream communities.

4.2.6 Wildlife Habitat and Biodiversity

Habitat and wildlife stress indicators in my study are similar to those identified in the recent literature (Abu & Reed, 2018). As a result of river regulations, flow regime alterations, and reduced water quality throughout the Delta, habitats for native plants and animals are affected (Mantyka-Pringle et al., 2017; Hassanzadeh et al., 2017; Watanabe, 2006). Several causes were associated with the reduced quality of the water by participants including agricultural and industrial residues such as metals and pesticides and obstruction of sediment transport by upstream dams. The literature recognizes river regulations as the largest indicating factor for unhealthy populations in the Delta (Bunn & Arthington, 2002; Partners FOR the Saskatchewan River Basin, 2009), and warning that the Delta is becoming drier, denser, and less vibrant (Abu, 2017; Mantyka-Pringle et al., 2017). The hydropeaking impacts of E.B. Campbell Dam have been more extensively studied recently (Watkinson et al., 2020; Watanabe, 2006), including its influence on riverbed morphology (Smith et al., 2014), fish stranding because of the high ramping rates (DFO et al., 2019), and the biotic community changes compared to above the dam (Mihalicz et al., 2019). My research demonstrated that although knowledge of the current operational impacts on the Delta’s ecology are established scientifically, the documents are inaccessible to people of the Delta and ignored by upstream managers.

As for the changes in the wildlife populations and vegetation in the Delta, findings from this research confirm previous studies and literature on the SRD (Mihalicz et al., 2019; Andrews et al., 2018). Carlson (2016) reported on the decline of habitat and compromised moose habitat because of insufficient flow in the Delta. Abu (2017) provided and compared different sources of knowledge, including Traditional Knowledge (TK) and archival records to establish changes in the animal populations and vegetation diversification in the SRD. The current study provided further emergent themes identified by local knowledge holders in the Delta. Residents of the Delta are of the belief that the amounts of flow passing should account for more than just the power needs,

rather they could account for the ecosystem and important ecological functions with it that largely rely on and are sensitive to flow conditions.

Participants in this research described how the challenges facing the wildlife in the Delta are the result of altered flows. Understanding these challenges provides insight that can be useful for modelers representing the flows into the SRD to make their work more salient, credible, and legitimate (Cash et al., 2003). Previous quantitative research and community interviews consistently suggested that seasonally specific "designer flows" (Poff & Olden, 2017) are needed to restore the ecological health and functions of the SRD.

4.2.7 Social Predicaments of Flow Regimes

Hydrological, biological, and ecological distress poses a predicament for communities in the Delta and takes a toll on their self-sustenance, a theme that this study highlights. Although the literature acknowledges the socio-hydrological impacts, it contains few explicit observations and community advice (Di Baldassarre et al., 2019). Community standpoint, however, is key to consolidate water resource solutions for the SRD.

Furthermore, as Andrews (2017) argues, an amalgamation of all obstacles and losses in the Delta amounts to a loss of culture (Andrews, 2017), which was emergent in my findings. My study found clear links between decreased food security, cultural and identity loss, and increased vulnerability to the hydropeaking changes from the narratives and stories. Two main issues with the public understanding of social impacts in the Delta became apparent: 1) Locals in the Delta have experienced losses and proactively adapted to the issues that they are rarely asked to speak about. Hence, the important cultural values are lost in water resources modeling and resource management practices; policy and decision-makers need to understand the value that community's lived experiences can provide to WRM in the basin. 2) Although researchers have warned about ecological malfunctions in the Delta, its residents have seen little response and action.

4.3 Finding a Balance Between Developments, Exploitation, and Environmental costs

Like the existing literature, the results of this study warn about the consequences of unequal power relations in water management for different sectors in the province of Saskatchewan, where the industry benefits the most and the downstream pays the highest environmental and socio-cultural cost (Carlson, 2016). This study further contends that from experience, residents of the Delta do not trust authorities, administrators, and corporations to balance their benefits and societal and environmental costs with the needs of others when making decisions. The narratives indicate that although the community is willing to accept conflicting interests and outcomes, they believe that the sectors upstream who are currently benefiting from the existing water management regime, are unlikely to cooperate, consult with the community, or seek their consent in decisions. Similar patterns of behavior are documented among other northern indigenous communities subject to colonial water resource management practices (Conallin et al., 2018).

The elephant in the room is first, there are different complexities and priorities in WRM and downstream communities' needs have only been marginally introduced and discussed; and second, depending on the model developer and what their interests are, their choice of input data can influence the range of outcomes (and their interpretations). This creates unequal power relations that continue to provide unequally desired outcomes for different groups. For example, as Carlson (2016) noted, the available historical data and modelers' optimization strategies favor industrial expansion outcomes rather than the environmental decline narrative.

Likewise, although the community has clear perspectives about how the Delta has declined since the constructions of the dams, the community claims there is not adequate scientific measures and observational data attributed to these views. Therefore, SRD community has not received adequate support or execution from scientific knowledge holders and decision makers in the province (Wheater, 2015). Taking the community's lead, this research reckons that community perspectives must be taken into account for effective policy and management practices to occur.

4.4 The Disconnect Between Place-based Knowledge; and, Water Resources Modelling and Decision Making

Previous studies have addressed power relations that fail to bring fairness to affected communities in the Saskatchewan river basin (Armitage et al., 2015; Lemoine & Patrick, 2014). Andrews (2017) addressed this lack of fairness in his research on the SRD and showed that power can enable or hinder certain influences in decision-making; however, the crucial role of water resources models that represent flows in the Saskatchewan River Basin and into the Delta and supporting tools used for decision-making were unexposed in his research (Andrews, 2017). Comparably my research found that community members largely focused on the need for government officials and corporations to be responsive, until they were introduced to water resources modelers and their role in effective decision-making through in-depth interviews. My research found that people in the Delta are generally unfamiliar with the influence of water resources modeling and modelers on decision making in water resources management. This lack of knowledge comes from the division that exists between place-based knowledge and decision making process, in which policies and water resources modeling capacities fail to incorporate place-based knowledge (Simms et al., 2016), specifically when it is in the form of narratives (Figure 4.1).

In many instances, the data and knowledge produced by scientists are intended to accommodate decision makers or facilitate their needs, largely neglecting the end users (including Indigenous communities or the public) who bear the impacts of these decisions. Although neglect of people's needs is a deficiency in the system rather than the scientific community's fault, the immediate repercussion is the public's lack of both confidence and trust in decision-making processes.

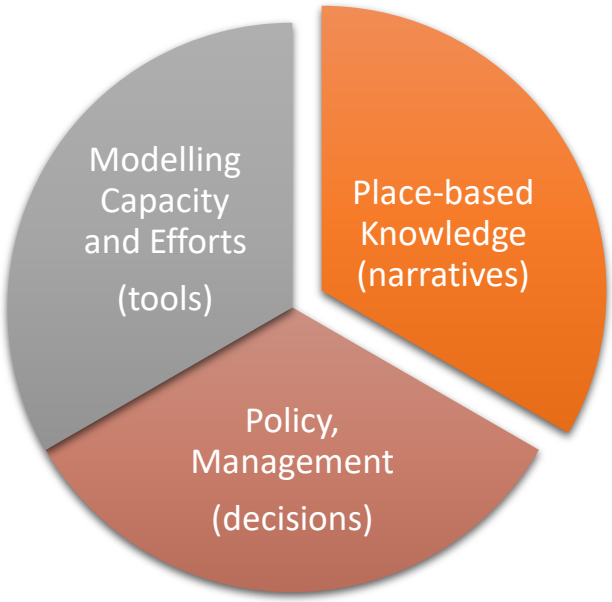


Figure 4.1 *The current dynamic of decision making with interconnectivity: between water resources modeling efforts to inform and be used by policies, but without a direct influence of place-based knowledge.*

Additionally, a lack of interaction between the two knowledge providers and shared decision-making authority have left all three groups (modelers, community members, and decision makers) restricted and deficient. The modelers and external decision makers could use the contextual observations provided by local experts to add value to the development of scientific tools and analysis. For example, participant observations in my research could add value for modelers and decision makers by providing a descriptive relationship between an issue with the flow and its short-term impacts and long-term ecological consequences in the Delta. Current water resources models, on the other hand, provide large-scale simulations of the flow regimes based on quantitative data and anticipate future conditions that could work as an "influence pathway" called for by Andrews (2017) in the decision-making system. Through analysis of participant narratives, this study calls for ongoing water resource modeling and management efforts to incorporate place-based knowledge in the SRD including hydro-ecological relationships and ecosystem needs indicated by SRD locals. This is the gap that Global Water Futures (GWF) and its sub-project, Integrated Modeling Program for Canada (IMPC), seek to fill to move towards fair and efficient decision making in the entire basin.

4.5 Inclusion of Traditional and Place-based Knowledge in Western Practices

A key to having an inclusive and healthy society is to make sure that fully informed decisions are being made. My study acknowledges the SRD communities' frustrations as they have been subjected to a wicked problem but shown little empathy by decision makers. Twelve out of the 14 members of the community who engaged with this study reported multiple instances of being undervalued, misinformed, and discriminated against by upstream authorities, industry, and government. Actions towards the community have been slow, fractured, and non-responsive as participants testified, emphasizing that water sectors upstream need to avoid making misinformed or under informed long-term and impactful decisions (e.g., relicensing a dam in perpetuity). Decisions made on partial information are likely to be bad decisions. Sound decisions are based on comprehensive information, including scientific papers and reports, place-based perspectives, and detailed observations (Wyllie de Echeverria & Thornton, 2019; Simms et al., 2016).

Community narratives show that there is a demand to "look back, re-enact, and find what is missing" to move forward with meaningful collaboration. This study supports communities' scholarship of engagement and argues that they not only should be informed in WRM but they should also be involved in every step because their perspective on the changes in the Delta provide guidance to ecosystem health and feedback to management practices. Traditionally, water resources models have not accounted for diverse ecological and social indicators that communities living in the region are experiencing and passing on generation to generation in the form of TK. As human footprints of development are posing greater and more complex harm on our surrounding habitats, the goal in environmental decision-making should be to balance human-derived interventions and wildlife habitat (Scolobig et al., 2016). This balance can be achieved through integration of regional TK in water resource planning and management.

One example of an integrated and informed resource-planning network is the Delta Stewardship Committee that has emerged as one entity of diverse perspectives and voices advocating for the health of the Delta, including for trappers, fishers, outfitters, educators, and community leaders (Patrick et al. 2018). SRD community is demanding, in a structured manner,

rethinking of Indigenous needs and contributions in WRM.

In the following chapter, I will further discuss the TK contributions of SRD residents in the socio-ecological understanding of the flows in the region. I will provide insight into adoption of interactive and balancing approaches such as Citizen Science that can lead to a collaborative modeling in the SRD. Next, I will draw on the past and current research-policy-community interface, which will illuminate areas where more attention to community involvement is needed.

CHAPTER FIVE

DISCUSSION AND CONCLUSION: A HEURISTIC DEVICE [3] FOR MEANINGFUL COLLABORATION

5.1 Overview of the Chapter

Under this theme, I discuss the community interaction preferences (meaningful collaborative engagements), reflect on the past and present practices in reaching higher levels of understanding in the SRD through a ladder of participation shown in Figure 5.1, and review efforts to convey community's stance to modelers and empower the conservation plan that community has initiated. The focus of this chapter is the level of participation and cooperation between the SRD community and academia and methods of enhancing it.

5.2 Rethinking Indigenous Needs and Contributions in Water Resource Management

An integrated and well-informed decision in WRM considers the past and present conditions and predicts the future based on observed and documented changes. This means combining stories and lived experiences with real time data, technical tools, and representative models. In light of the participant narrative analysis, this study presents the following reasons for integrating community narratives into robust decision making:

1) Narratives are important for capturing the patterns of change and details and can add value to models. Andrews (2017) stated, "The range of outcomes" are missed by western approaches (that are often large-scaled), if they are not enhanced by local Knowledge holders and their feedback. 2) Narratives of the Elders in the Delta provide invaluable lessons about ethics of the land, animals, and other details that can help decision makers address ecological uncertainties. 3) Congruent with literature, the narratives also reveal that community members are natural planners, as they have a long history of planning and adaptive response to nature (Abu, 2017). Traditional knowledge holders understand laws, regulations, and "nation building," and they want to partake in these practices. What is more, 4) through listening, communication

[3]A method of solving mathematical problems that cannot be solved in a finite number of steps. It involves progressively limiting the field of search by inductive reasoning from past experience. It involves the use of visual representations, additional assumptions, forward/backward reasoning and simplification.

channels can open, relationships built, social kinship strengthened, and, eventually, consensus-driven management reached (Conallin et al., 2018).

Through Indigenous ecological knowledge (narratives) in my research, it became apparent that the community identifies critical species of plants and animals as indicators of the ecosystem health and environmental flow needs in the Delta. These culturally important indicators are fish populations (such as northern pike and sturgeon), furbearers such as muskrats, a number of waterfowl species, and dry plants such as willows and poplars, which are affected by the modified flow regimes. These indicators can be used to assess interactive ecological impacts of flow alterations and to support decisions for adaptive water resource management in the basin (Armitage et al., 2009). Table 5.1 provides qualitative descriptions of the issues with the flows in SRD and their consequences for the ecosystem from participant perspectives linked to some measurable quantitative metrics that can inform modeling and management efforts by western scientists.

LOCAL OBSERVATIONS AND QUALITATIVE DESCRIPTION OF THE ISSUES WITH THE FLOW	MEASURABLE METRICS FOR FLOW ALTERATIONS IN THE SRD	LOCAL OBSERVATIONS AND QUALITATIVE DESCRIPTION OF THE IMPACTS AND CONSEQUENCES	MEASURABLE EVALUATION AND METRICS OF THE ECOLOGICAL IMPACTS	
			Evaluation of ecological processes	Ecological metrics
"There's only limited [amount] of water's being released to our region"	**Regulated river system with modified flow rates released into the Delta**	*"Creeks are partially dry and already grown, what used to be a Lake. It's all dried out, there is nothing for muskrats"*	**Reduced surface water availability is a threat to aquatic and water-dependent animals**	Counts of muskrat houses
"They [the dam] release unnatural, huge amounts of water"	**Extreme high discharge events followed by dry periods**	*"Habitat that moose depend upon, which is the willows and all the Marsh vegetation, they will fluctuate from the hydro dam"*	**Erratic daily flows with high velocities alter bio-ecological habitats, life patterns, and taxonomic compositions**	Proportion of live and dead vegetation
"They control what kind of water comes through at certain times and they don't know what kind of damages they are causing the fish downstream"	**Extreme high and low discharge immediately after ice out**	*"So, the fish have been stopped [by the dam] and [water] is fluctuating so those fish aren't spawning"*	**Interrupted natural and peak flows in spring result in reduced spawning opportunities and stranding of different migratory aquatic species**	Juvenile fish counts
"We need the sediment to come flowing down to our lake, our rivers and the dam is trapping all the sediment"	**Disruption of sediment transport and nutrient starvation downstream**	*"By starving the rivers, the river is trying to find sediment and somehow It would try to get sediment from the banks"*	**Geomorphological and structural distortion in the river system:** **1- Scouring and erosion of the riverbeds resulting in reduced connectivity**	Bed elevations of channels and tributaries
"The hydro dam will always give high and low water fluctuations"	**Extreme high and low fluctuation rates and disturbance frequency**	*"I don't know what happened. The sand took over the mud somehow."*	**Geomorphological and structural distortion in the river system:** **2- Mudflats replaced by sand bars resulting in emergent dry**	Sediment texture proportions

			islands and reduced connectivity	
"There's a lot of little lakes that would get fed by the natural spring high water. But when they hold back the water, water into doesn't get those lakes."	**Altered volume, velocity, and coverage of season-specific flows**	*"If everything just dries out, then some of those plants that aren't native to the area are more successful"*	**Non-native and invasive species growth as biotic responses to the modified flow regimes resulting in reduced native species**	Proportion of surface area occupied by Phragmites
"The hydro dam will drown the willows and whatnot from severe flooding"	**Occasional high volume and poorly managed flows above the environmental thresholds and insensitive to the ecosystem needs**	*"After five floods, everything died. The willows [drowned and] died. The rat root [roots muskrats feed on] is still not back. There is nothing left for us."*	**Jeopardized survival of native habitats with altered flow cycles and extreme flow regimes**	Proportion of live and dead vegetation
"We used to have little streams and it was always moving. Water was always moving from lake to lake, everything was thriving."	**Reduced longitudinal connectivity and wetland inundation frequency across the SRD**	*"Those lakes we used to go in, ducks and waterfowl are not there anymore, but we're saying, Oh what a big difference"*	**Reduced floodplain and wetland habitat diversification resulting in lower ecosystem well-being rates**	Waterfowl nest density

Table 5.1 *Summary of the perceived issues with the flow and their ecological consequences in the Delta from participants' perspectives, informing the quantitative metrics that are measurable in western science*

5.3 Adoption of Interactive Approaches: Citizen Science

The results of this study suggest that an effective balance can be achieved through continuous and transparent dialogue in an informed and engaging environment where different outcomes and scenarios are explored through mediation and negotiation. As mentioned, combining two views can trigger deliberative responses to a broader range of issues and concerns (Wheater, 2015). Effective water resource management efforts can still suffer from a lack of public reflexivity, participation, and general water awareness (Appels et al., 2017). One of the emergent strategies to engage public participation in this regard is incorporating Citizen Science (CS) (Minkman et al., 2016). Citizen Science is an ideal tool for animal species monitoring, estimating trends across broad-scale diverse landscapes, and providing opportunistic sources of

data for conservation (Leandro et al., 2020; Fink et al., 2020). Interestingly, citizen science is well conceptualized amongst Indigenous Peoples who have a long history of practicing landscape and species monitoring for their individual and collective decision-making purposes (Wilson et al., 2018). Citizen Science data are complementary to western science (WS) because they offer implementation and interpretation advantages to the formal sampling protocols in WS (Leandro et al., 2020; Abu 2017). Through CS practices, trust and sense of community is also enhanced as CS is based on public engagement and constructed throughout various stages of data collection, analysis, and presentation adding value to different modeling practices (Hamalainen, 2015).

A growing number of studies have sought to broaden understanding of hydrology and consolidate water resources modeling with citizen science tools (i.e., Q methodology, mobile technology…) (Appels et al., 2017; Minkman et al., 2016). In Cumberland House, community efforts in preserving the Delta and raising awareness on the value of water (Image 3.25 and Image 3.26) are examples of community-based citizen science approaches that have brought social learning and youth engagement for the community in the past decade. Other collaborative projects are taking place on scientific and individual levels that continue to expand the water quality and hydrological knowledge and generate legitimate data in the Delta (Jardine et al,. in press). Having shown enriched management outcomes in the literature and raised public awareness in Cumberland House, this research follows the CS principle in adding value to modeling practices through public engagement in the Delta; acknowledging the Indigenous sovereignty and community members' role not only as 'knowledge holders' but also as 'knowledge contributors'. This CS approach undeniably requires a considerable time commitment and effort as new relationships are built and new pathways to public collaboration reconciled. In the following sections, I revisit progress with community in communication and coordination within the past two years, make inquiries that the community posed for modelers, and specify a constructive approach (a visualization tool for the E.B. Campbell Dam operation) that is responsive to both stakeholders and residents of the Delta.

5.4 On the Community's Lead: A Collaborative Decision-Making Approach

Multi human-dimensional hydrological studies of the Saskatchewan River Basin (SRB) only emerged within the past decade. As population and water demands grow, more trans-disciplinary approaches are required to support various objectives in the province's water sector (Wheater, 2015). Trans-disciplinary approaches facilitate interactions and linkages between different stakeholders, enhancing decision making through the composition of knowledge from various sources, from local and place-based science to large-scale governance. Despite the challenges and nuances, these interactive approaches are gaining momentum among researchers and academic institutions, with energy sectors and corporations gradually following them (Evers et al., 2012).

While decision making can occur at any interaction level (Van Hove et al., 2018), colonial corporations and Indigenous communities hold different views of the meaning of participatory or collaborative interaction styles, to encourage and establish meaningful and trans-disciplinary collaboration. This research sees the need for external groups—i.e., academic researchers and provincial and federal decision makers—who have interests or done research in the SRD to reflect on how their interaction style with the community has evolved. Figure 5.1 adopted from Basco-Carrera et al.'s (2017) cooperative continuum provides a useful classification of stakeholder-model interaction styles. The value of this participatory ladder is that it applies across organizations and can be used as a guide for collaborative efforts in the SRD. Each column shows a type of cooperation, and each row represents the stakeholder participation level, which is indicated by color. Moving along the vectors, the stakeholder involvement indicates the level of cooperation. The goal is to reach the orange area at the top where key stakeholders (in our case the community and dam managers) are engaging in collaborative modeling.

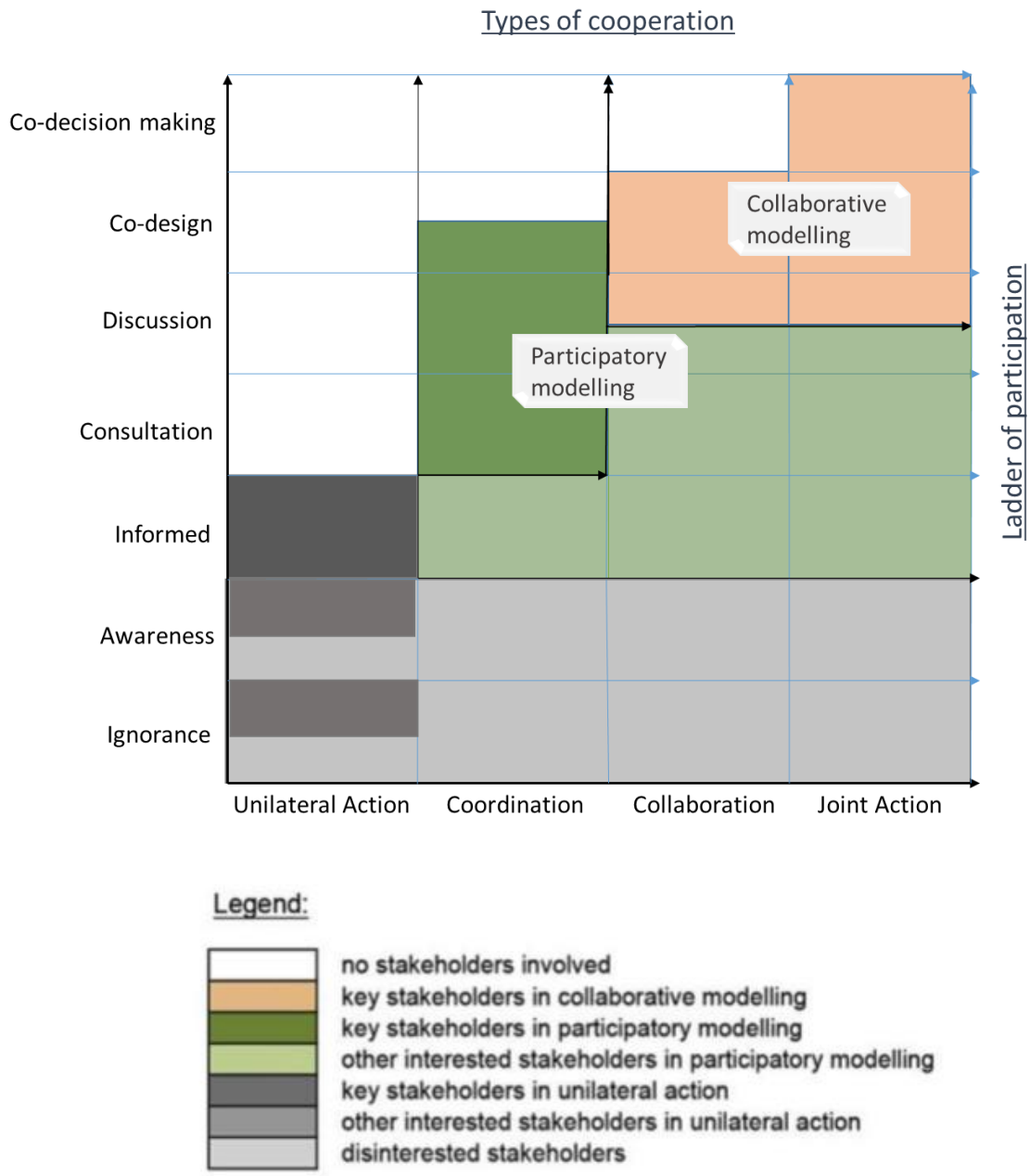


Figure 5.1 *Showing types of cooperation, as they advance into collaboration and joint action where collaborative modeling is accommodated.*

Using the continuum from this figure, this study categorized Saskpower and the government' interaction style as poor from the perspective of community members. Historically, upstream authorities have failed not only to engage the community in their decision making but also to take responsibility because of legal jeopardy and continue to point to other drivers in the basin as being responsible for ecosystem health decline.

Looking at the figure, today, after a decade of conversations and information exchange between the E.B. Campbell Dam management (SaskPower) and community, the cooperation type has shifted from unilateral action to coordination and community's involvement has grown from being aware to being informed but more importantly "listened to", entering the green area. Since 2020, Saskpower, the Water Security Agency, and other organizations have adopted a more engaging interaction style with CH community, although the extent to which each of these organizations have involved the community differs.

Knowledge exchange and consultations are key in a collaborative model and co-creation of polices around the environmental flow requirements in the SRD (Pahl-Wostl et al., 2013) because trusting and listening are the first steps to understanding, and communication is the first step towards responsiveness (Lemoine & Patrick, 2014). One level higher than participatory interaction, collaborative interaction (joint decisions, joint actions) can facilitate collaborative modeling. The advantage of the collaborative interaction style is that it stands against the competitive interaction style (Basco-Carrera et al., 2017). In competitive interaction style, different groups provide segregated solutions to the problems, information sharing is discouraged, and only a partial resolution is typically obtained.

To highlight the value and vital need for the TK of Indigenous Peoples in the decision-making process, I have added another dimension called "community involvement" to the Basco-Carrera et al.'s participation ladder (Figure 5.2). This figure is modified from the original principal of cooperation to accommodate the flow needs in the SRD, displaying only the processes that involve community members as key stakeholders. Although there are different degrees and levels of community involvement and some stakeholder groups have made progress in listening, collaborative modeling standards will only be met once community members are actively consulted and their needs reflected in ongoing decision making.

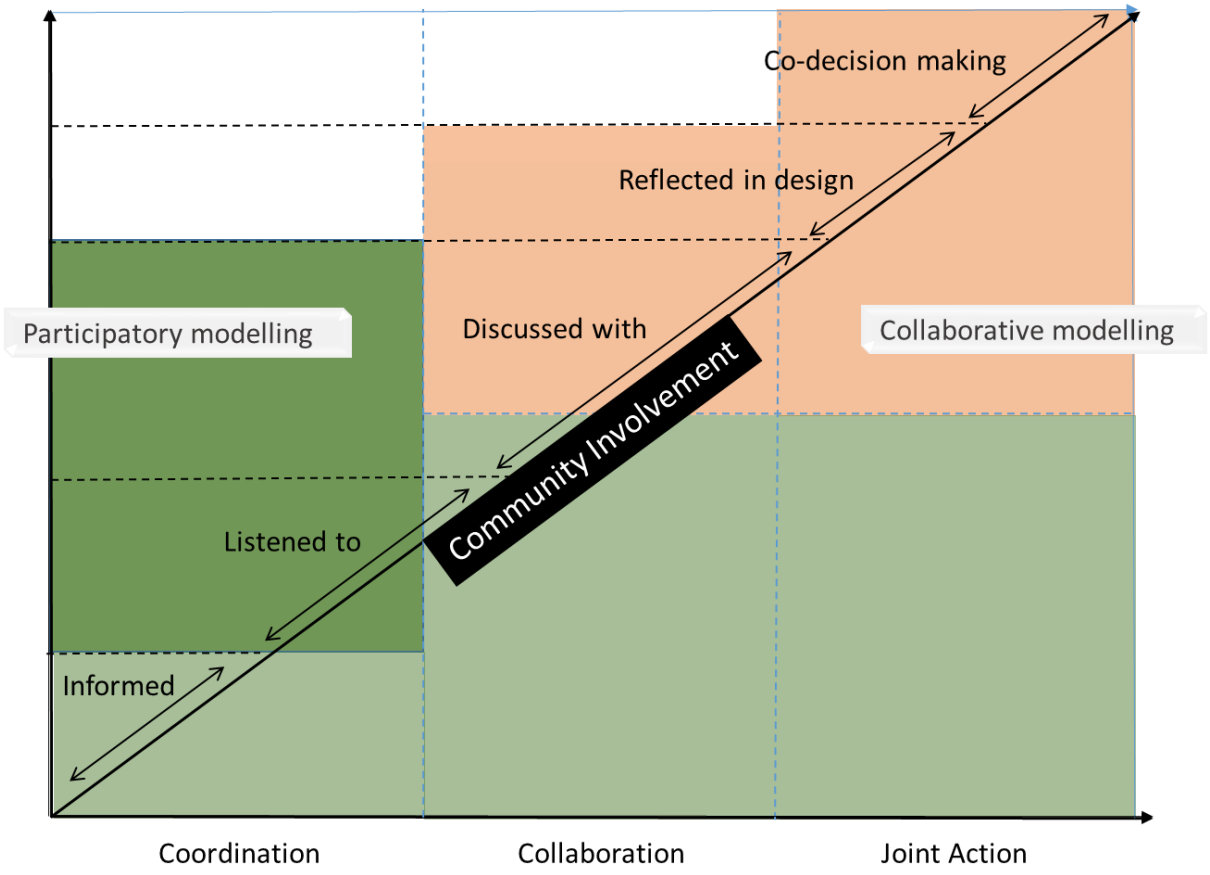


Figure 5.2 *Modified ladder of participation with added the dimension of community perspectives*

This integration of views is currently facing systemic obstacles within the SRB as its long-practiced water management policies are not designed to place downstream community needs on equal footing with the needs of those upstream. More upstream stakeholder groups, including dam management, need to listen, show interest in discussions with those downstream, and be willing to reflect downstream needs in collaborative efforts.

5.4.1 Steps toward Reaching a Collaboration in the SRD from Community's Perspective

Participants in my research pointed to the shortcomings of the current management strategy and demanded scientific assessments of the environmental flow needs and impacts in the SRD to be more closely linked to broad implementation of the policies. They also asked for external technical support, visuals, and reports such as maps provided by LiDAR technology to assist and calibrate the current understanding of the flow influences in the SRD. Community's

views and their demand for collaboration are presented in the results section and highlighted below:

1. Authorities and organizations can recruit community members as assets and use their first-hand experiences year round (which the university has been partially doing). The community provides a collective of peoples and views that are central to understanding and assessing the needs of the Delta.
2. The decision makers and water resources modelers should also consider visiting the Delta, being observant in the field, and having face-to-face meetings with community members, instead of sending third-level staff members who have little authority. Community members suggest that both researchers and authorities should visit at least twice per year to gain a better picture of hydro-ecological functions in different seasonal conditions.
3. Corporations such as Saskpower, agencies, and representatives of the government can provide transparent and frequent reports about how they are managing allocation and maintaining water at the reservoir, in addition to explaining short-term and long-term changes in dam operations that can affect the SRD.
4. Community members also suggest re-assessment of the flow conditions that have detrimental impacts such as severe flooding in the Delta (i.e., through flood maps and hydrology analysis). Additionally, they require higher minimum flow and less fluctuations from the dam, as current fluctuations are harmful and the minimum flow is insufficient for the ecological needs of the Delta.
5. Comprehensive interprovincial assessments of both the quantity and quality of the flow, including that above and below the SRD is needed to identify flow issues and its consequences in different temporal scales. Pushing a broader sustainability and conservation agenda with greater respect for cultural and ecological values in the Delta is due by governing sectors.
6. Simulation tools and different representative models should be advanced to predict the future of the Delta under different climate change and water supply/demand scenarios. Community members pointed that these tools will be most useful if they are user-friendly, meaning that they allow different users to contribute and interface with each other.

To combine and summarize the community recommendations, I have thematically categorized them into practical action items for specific groups of stakeholders or academics.

	BUILDING CAPACITY FOR TRADITIONAL KNOWLEDGE		COLLABORATIVE MODELING AND DECISION-MAKING
	Through Place-based Knowledge	Using Citizen Science	
DAM MANAGEMENT (GARDINER & E.B. CAMPBELL DAMS)	Visit the Delta and engage with its residents to arrive at Ecologically based and socially acceptable flow standards for their operations	Re-assess the flow conditions that have detrimental impacts (such as severe flooding in the SRD) based on the knowledge provided by local experts	Practice transparent and mutually informed and inclusive operational decision-making
PROVINCIAL AND TRANSBOUNDARY WATER MANAGEMENT AND POLICYMAKERS	Establish national recognition of the SRD's significance and protection of its ecologically important species	Carry out interprovincial assessment of both quantity and quality of the flow and identify upstream flow alterations impacts on the SRD	Co-create an ecologically responsive map of the SRD with local experts and stakeholders Implement conservation policies that account for environmental flows and Indigenous values
RESEARCHERS AND ACADEMIA	Personally visit the Delta and gain hydro-ecological understanding of the flows within the Delta	Recruit community members as assets, use their first-hand experiences year-round, and facilitate cross-cultural engagement with research	Make scientific tools more user-friendly and interactive across different organizations

Table 5.2 *Group specific action Items for building capacity for and collaborating with SRD community*

Today, SRD community, university researchers, and dam managers in the Saskatchewan River Basin are coming together in a forum to share information and form long-term committed projects that look promising for collaboration in the Delta. Ongoing discussions are happening at the community level, academic level, within industry, and in organizations on potential opportunities and projects to make the SRD's conservation and restoration plans a priority in the province. Information sharing and knowledge mobilization is encouraged more than ever and is perceived to be key for collaboration.

5.5 Development of Responsive Scientific and Knowledge Mobilization Tools

There are various scientific research projects ongoing in the SRD within the province and with Global Water Futures (GWF). The Integrated Modeling Program for Canada (IMPC) is a GWF-funded project operating out of the Global Institute for Water Security at the University of Saskatchewan with a mandate to engage with stakeholders and align research objectives to real world applications. Here I will focus only on three streams of work developed in collaboration with IMPC and with relevance to the SRD. These work packages include water quality sampling in the Delta, environmental flows, user-friendly visualization tools, and other knowledge mobilization efforts. Each work package informs the others while building capacity for community adaptation to changes and supporting decision making in the region. My research provides results about community engagement to inform water resources models and other work packages relevant to the SRD.

5.5.1 Environmental Flows

IMPC theme B2 (Integrating Aquatic Ecosystems) looks at past and future flows with respect to presumptive standards that provide deviations from natural flows (Richter et al., 2012) The findings show already highly modified flows in the SRB, with projections for earlier flow peaks, lower overall flow and more gradual declines in the future. These findings suggest great

ecological shifts will occur, causing stress to different aquatic and terrestrial species, and social livelihoods. These assessments will be integrated into IMPC visualization tools for outreach. The research is monitoring five sites in the basin for flow analysis and deriving ecological metrics, though in the future it will expand to more sites and the examined data will be linked to flow ecology hypothesis, which will be studied and evaluated. This work package faced many challenges and its community engaged assessments were particularly disrupted by the Covid-19 pandemic. Eventually, the outputs of the testing of those environmental flow hypotheses will be used to update and strengthen flow standards for the basin.

5.5.2 Mobilizing Knowledge through Engagement with the Community

Under theme D of the IMPC project, multiple pieces of work are contributing to mobilization of knowledge through engagement with the SRD community. An important piece is the Delta Dialogue meetings beginning in August 2020 with regular conversations to guide new scientific and management efforts. Projects under this theme seek to analyze and deliver enhanced means of engagement from different stakeholders, rights holders, and the modelers, but the interest lies particularly in downstream communities. Knowledge mobilization and use of engaging tools are impactful and essential in telling stories, as the participants raised in my study. Therefore, this theme addresses the efficiency and impact of communication and other activities to engage users and knowledge holders. Initial findings of my research were revealed at a stewardship committee meeting in March 2020, with participants of the study and key researchers and modelers present. Due to the Covid-19 pandemic, planned in-site workshops for the summer of 2020 were cancelled and further communication was rearranged online.

Since the fall of 2020, online Delta Dialogue meetings have been ongoing, where researchers and different modelers provide updates on their work in interdisciplinary groups and collectively learn how community raised questions in my research may feed into various work pieces. Attendees for this series of meetings include members from SaskPower, Water Security Agency, Ducks Unlimited Canada, DFO, etc. Despite uncertainties surrounding shifting Covid-19 circumstances in the community (and internet accessibility issues), several Cumberland House

community members regularly joined the online meetings. There were discussions on a set number of priority questions, and teams were formed to address them.

The IMPC has been hosting these Delta Dialogue meetings in coordination with the Delta Stewardship Committee, with the objective of holding space for interested parties to present their perspectives, provide everyone with the opportunity to respond to each other, and identify potential avenues for collaboration. Before these meetings with the community, engagement with local people in the Delta was infrequent, with researchers making siloed trips to Cumberland House a few times a year. Suggestions and ideas from community that seemed impossible to implement are now spoken of directly, and the IMPC can directly show progress in coordination efforts to both community members and stakeholders.

Now with Delta Dialogue meetings, E.B. Campbell Dam engineers and other industry and government representatives can retain momentum on their brand new engagement with communities in the SRD. This engagement enables them to negotiate better communication strategies, identify collective stewardship goals for the Delta ecosystem, and build stronger academic-industry-community relationships going forward. Although the engagement includes regular meetings and face-to-face calls where questions can be raised and addressed, we have yet to consult and co-design projects at every level of the process, not only at the implementation and execution stage but in sharing a vision and planning stages too (Conallin et al., 2018). Today we have various technologies and resources to facilitate these conversations, so promoting new ways of thinking and making long-term investments to make better decisions is within our grasp; if incorporated then conservation and mitigation will likely happen.

5.5.3 Visualization Tools and User-centric Decision Support System

A useful way to exchange knowledge and enhance understanding is for community members to see the flow alterations generated by models and for their effects to be felt and seen by the modelers. Theme D of IMPC is developing several visualization tools and decision support systems (DSS) that can support decision making for the SRD. A digital elevation model is used to simulate and visualize water and sediment levels interactively going up and down, to create flood

maps, and to explore different scenarios of interest (e.g., drought or wet conditions). A visualization tool specific to E.B. Campbell Dam and the SRD is also under development with simplified graphics and visuals for both community members and dam management to use in conversations with one another. This tool will provide access to a wide range of data (with different spatial and temporal scales), enabling enhanced understanding of the system. The IMPC's computer science modeling team has been developing the E.B. Campbell Flow Visualization tool as a boundary object to make connections between the reservoir water levels upstream and the SRD (at various locations like Niska Lodge, Big Eddy Lodge, and Cumberland Lake) easier to understand. Geo-tagged photographs from my study are included in the tool as a way to enhance meaning of water level changes produced by the tool.

Guided through communication and constructive dialogue, this stakeholder driven tool could help community members explore questions about how flows are related to flexibility in SaskPower operations at E.B. Campbell Dam and, potentially, to the operations and constraints existing further upstream. As of now, the EBC flow visualization tool is not connected to the other visualization tools under IMPC. In the future, such interactive tools with complex modeling capacities and feedback incorporated from different stakeholders both in the SRD and upstream will be particularly useful as a planning and emergency response tool for the community.

On a larger scale within GWF, a multi-user DSS is being developed under theme D and is available to the public on the web. This interactive platform sets out to tell a collaborative story of water resources modeling in the basin by looking at three key components: 1) optimization, 2) resource and allocation, and 3) tradeoffs. This tool gathers information from stakeholders, communities, policy makers, and academics, enabling them to interact with one another as knowledge is being produced. Hence, in addition to creating a holistic picture, the end results of this tool are useful for and can be reframed by the SRD community and different stakeholders. A good example of the progress on IMPC's end, this tool not only uses and is built on local perspectives, but also welcomes engagement and participation as the work is refined. More data will be added to this system, as the data collection in the Delta is ongoing and expanding. Visualizations and discussion tools within IMPC are validation of the team's knowledge mobilization efforts.

5.6. Summary of the Thesis and Concluding Remarks

Surface water is a public resource and a key to development. This century, water consumption has increased many times over. Most of the water is used by agriculture and industry, and while flow events such as precipitation, rainfall, and runoffs, are becoming less reliable, human activities and developments requiring water resources and withdrawals are increasing at the cost of the natural ecosystem balance. At the same time, climate change is threatening the northern landscapes, wildlife, and communities of Canada more rapidly than the rest of the country. In the SRD - homeland of Cree First Nation and Metis Peoples - the suitability and vibrancy of the ecosystem has declined due to the cumulative consequences of human developments and water shortages, but the vital perspectives of its residents on the land and water services have yet to be integrated into western scientific practices and policy. Through in-depth dialogue with Cumberland House community members, this research unpacked the ecological and social consequences of human developments in the SRD downstream of the Saskatchewan River Basin from the perspective of its residents, whose values and well-being are closely tied to natural resources and whose observations could indicate the decline of the entire basin.

This research took steps after methodological frameworks that Abu (2017) and Andrews (2017) used to reveal the invisible dimensions of water security in the SRD. In response to the SRD community's call, I used a community-engaged research approach to investigate the place-based knowledge, Indigenous values, and preferences of the SRD community and their quest to convey their views to water resources modelers and decision makers. This research was completed within a community-engaged scholarship (CES) framework, which brought attention to the SRD community's issues, enhanced their voice and agency, and paved the way for future knowledge integration not only in the SRD but also in other parts of the world, where interdisciplinary approaches to environmental sciences could protect both biodiversity and livelihoods.

In my research, I strived to explore questions such as these from the perspective of the people in the Delta: "How can we better understand the environmental needs of the Delta?" "What is an example of efficient management for the populations downstream of E.B. Campbell

Dam?" These questions directed me towards the methodological framework that best addressed my research objectives. This thesis is focused primarily on the flow conditions and impacts in the SRD from the community perspective and water resources modelers' understanding of place-based knowledge. My thematic analysis addressed the ecological impacts of flow alterations in the Delta. Participant narratives indicated that flow alterations have multiple negative impacts on the ecosystem chain and human well-being. In addition to dam-induced flow alterations, the position of the Delta downstream of the basin contributes to the cumulative and complex water resource issues this ecosystem is facing.

In this comprehensive study, my objectives were to understand and interpret people's recollections of altered flows and ecosystems in the SRD, and to convey these insights to decision makers and western scientists. To achieve my objectives, I listened to people's narratives and understood their relationship to water and land. I interpreted and reported ecologically important indicators of water issues for water resources modelers to use and learned about the attitudes of people in the Delta towards those who manage the water system. I set out to explore the use of place-based knowledge and its underestimated value in environmental science. The value of the narratives is the contextual understanding that it brings to water resources modelers as well as promoting collaborative approaches to manage water resources in the SRD, conforming with Gober et al. (2015) that dialogue helps identify areas of agreement between people. The ultimate goal of this research is contributing to improve water resource management in the Saskatchewan River Basin.

Findings of my study suggest that, first, current flow conditions in the SRD are far from natural or ideal and have had dire consequences for the health and well-being of the ecosystem and humans living in the area. Second, such socio-ecological consequences are not fully understood or even demonstrated by numerical models. These impacts on the Delta have not been prevented because the Delta is not treated as a priority in water resource policy making amongst many stakeholder groups. Third, SRD community wants to move past the conflicts with dam management and upstream sectors over water resources and be involved in modeling and decision-making processes as they adapt to the changes in the Delta. Fourth, therefore, ongoing and future modeling efforts need to factor in environmental flow as, under climate change, the

current water resource management approach in the basin will only lead to further declines in ecosystem health and in the well-being and livelihood of its residents. In achieving this goal, the academic community, which has traditionally specialized mainly in quantitative disciplines, needs to pay specific attention to Traditional Knowledge and community-engaged disciplines. As Mantyka-Pringle et al. (2017) argue single-method approaches rarely bring holistic environmental solutions.

In addition to the methodological framework, this research made a number of contributions to the scholarship on the SRD. First, my study established and mobilized knowledge about the flow alterations and ecological response relationships through the residents' place-based knowledge. Second, it built capacity and space for Traditional Knowledge and place-based views while acknowledging and revitalizing the non-academic experts' identity and livelihoods in the region. Third, it promoted the SRD community's engagement with scientific practices and collaborative modeling. Fourth, it advanced conversation and understanding of different knowledge formats among local people and water resources modelers. The scholarship of community engagement in my research was found to benefit the Cumberland House community as their voices and needs were heard, and the community began to trust that perhaps the upstream authorities were interested in their views. Finally, two-way and face-to-face conversation across disciplines was facilitated and social learning was fostered, taking the community involvement from "being listened to" to "discussed with" on the modified ladder of participation (Figure 5.2).

Perhaps the biggest takeaway message of this study is that if knowledge holders and quantitative modelers come together in collaboration for the Delta, the local knowledge holders can communicate their observations to the modelers, who can use this shared knowledge to generate mutually beneficial outcomes (Mantyka-Pringle et al., 2017). Both groups, then, could approach water sector management in the Delta as a team facing hydro-ecological issues, systematic power imbalances (Barber & Jackson, 2015), and climate change. Complementing western practices with qualitative components and local, socio-cultural views, as opposed to using a single method, will also take marginalized communities a step forward as they begin to trust and contribute to the system (Acosta et al., 2017).

Integration of different resources and forms of knowledge should be accounted for when making long-term decisions with high uncertainty levels in Saskatchewan's water sector (Strickert et al., 2016). I sought to deliver knowledge across disciplines, making sure data is accessible for different stakeholders, modeler groups, and broader watershed assessments. I also sought to provide space for discourse between Traditional Knowledge holders and scientists, so they can understand, negotiate, and co-develop new data formats and frameworks while co-planning solutions for future scenarios.

On that note, I would like to reflect on my positionality and experience conducting research and facilitation of cross-cultural views in an interdisciplinary context. From my data collection process and community-based activities in this research, I learned that conscious efforts are required to build relationship and learn the ethics of meaningful engagement with Indigenous partners. Learning how to recognize the non-academic partners' needs, understand, and respect their cultural values and perspectives are not only specific to the main interdisciplinary researcher but should be practiced by all members of the larger project if engagement with the community is the objective (Datta, 2017). From Delta Dialogue meetings with community members and stakeholders I found that use of appropriate tools to share knowledge across disciplines, full transparency, and patience proved to be key in achieving understanding and reciprocal interactions between different knowledge holder groups.

I agree with Finn and Jackson (2011) that even though its proven otherwise, Indigenous views and qualitative components are perceived intangible and of less scientific value for quantitative modelers, which continues to pose obstacles to inclusion of traditional and cultural values in their modeling efforts. Though it might be challenging and even uncomfortable for some, I suggest breaking down fixed western and hierarchical mindsets when engaging with Indigenous partners about land and water concerns. While balancing the expectations and needs is an inevitable challenge in interdisciplinary environmental decision-making, I argue that the research-policy interface will generate more effective and equitable outcomes when adaptability and connectivity of different knowledge sources is prioritized.

In essence, moving forward to a healthy and productive Delta is only possible through meaningful collaboration and appropriate technical tools that bring connectivity and harmony within different aspects of the SRD ecosystem discussed in relevance to each other in this study: Hydrological processes, ecological relations, and socio-cultural values (Figure 5.3).

Figure 5.3 *Collaboration and harmony between socio-eco-hydrological aspects of the ecosystem are the leading mechanisms to a healthy and productive Delta*

This thesis has several limitations. First, I encountered challenges in achieving the objectives of this interdisciplinary research, largely because of coordinating my work with different groups of people. Second, I faced obstacles in bridging two fundamentally different knowledge systems with such epistemological differences, as people from one system perceive events and experiences differently from those from the other (Brunet et al., 2020). Accommodating different forms of knowledge formats arising in the discussion was the major challenge in this research, requiring time and the cooperation of different academic and community members (Noble & Basnet, 2015). Third, despite the abundance of themes and data, I encountered little room for statistical maneuvering because A) the sample size was small, B) the

sample targeted a specific group of Elders in community meaning there was limited demographic diversity, and C) my data collection period was compressed into a short timeframe. Fourth, as an external researcher in a remote study area, constrained accessibility to my research participants and specific study locations in the Delta at a desired time were challenges that affected my temporal and special data collection. Fifth, I acknowledge that my lack of knowledge in the research participants' native language (Swampy Cree) and culture has limited my contextual understanding and analysis in the research.

The findings of this research in several forms—images, audio, and video—have been used to co-create a visualized tool that represents the challenges and struggles of the populations in the Delta. What we learned from the participants' narratives is that knowledge needs to be broadened to understand the effects of dam operations on the ecological functions of freshwater ecosystems. Especially important for the animal populations and life cycles in the SRD is identifying season-specific flow standards and thresholds. This research demonstrates that water resource management can be adaptive, sustainable, and responsive to the public. Other work has shown progress in including Indigenous Peoples' needs in water and environmental policies in the Canadian prairies (Brunet et al., 2020). This research has aimed to do the same for the SRD community.

The Stewardship Committee members in Cumberland House are beginning to see action because of partnership with academic and industry organizations. Local people are championing their own initiatives including revising burn plans for trap lines, training firefighters in the Charlebois Community School, securing federal funding to support engagement around the establishment of protected areas, re-establishing flows in the Cumberland Marshes, and generally raising awareness of the existence of the Delta. Channel clearing, as an example, in parts of the Delta has made positive changes such as restoring habitats and preventing the riverbed from cutting deeper. As for our continued work with the Cumberland House Community, future efforts involve more data collection and monitoring in the SRD, integrating place-based knowledge with visualization tools and scenario-based approaches to enhance restoration activities, and shared decision-making for the Delta.

Finally, I call for the E.B. Campbell Dam management team to operate their hydropower station in such a way to mitigate negative flow alterations for the biota downstream. A broader recommendation for multiple dam operations and resource management in the basin is to collectively restore the natural flow regime in the Saskatchewan River as much as possible. I suggest that the entire basin adopt the IMPC collaborative modeling initiatives occurring in the SRD and deepen the investigation of how the policy system and dam management can incorporate the needs of local people by using Traditional Knowledge and place-based observations in planning, policy, and industry in water resource management across the prairies. This change will require enhanced data collection efforts in remote locations, iterative public discourse, space for change, and collaborative and transparent planning and committed on-the-ground action across organizations and communities. A public mandate from the government requiring water sectors to enhance their resource use for the benefit of the sub-basins' sustainability is critical in advancing systemic change.

CHAPTER SIX: WORKS CITED

25 Year Saskatchewan Water Security Plan Report for 2019-20 Action Number Action Description. (2020).

Abrahams, H. (2017). Listen to me: A reflection on practice in qualitative interviewing. *Journal of Gender-Based Violence*, *1*(2), 253–259. https://doi.org/10.1332/239868017X15090095938377

Abu, R. (n.d.). *Understanding a hydro-socio-ecological system through two-eyed seeing*. 1–22.

Abu, R. (2017). *Knowledge , Use , and Change in the Saskatchewan River Delta : Assessing the Changing Livelihoods of Cumberland House Métis and Cree Nation*.

Abu, R., & Reed, M. G. (2018). Adaptation through bricolage: Indigenous responses to long-term social-ecological change in the Saskatchewan River Delta, Canada. *Canadian Geographer*, *62*(4), 437–451. https://doi.org/10.1111/cag.12469

Abu, R., Reed, M. G., & Jardine, T. D. (2016). *Understanding a hydro-socio-ecological system through two-eyed seeing : bringing together traditional and scientific knowledge to understand long-term change in the Saskatchewan River Delta*.

Acosta, T., Meltzer-Brody, S., & Tolleson-Rinehart, S. (2017). Academic and Community Partnerships. *Obstetrics & Gynecology*, *129*, 49S-50S. https://doi.org/10.1097/01.aog.0000514376.22234.00

Anderson, E. P., Jackson, S., Tharme, R. E., Douglas, M., Flotemersch, J. E., Zwarteveen, M., … Arthington, A. H. (2019). Understanding rivers and their social relations: A critical step to advance environmental water management. *WIREs Water*, *6*(6). https://doi.org/10.1002/wat2.1381

Andrews, E. J. (2017). *Environmental Justice and Dam Management: A Case Study in the Saskatchewan River Delta*.

Andrews, E. J., Reed, M. G., Jardine, T. D., & Steelman, T. A. (2018). Damming Knowledge Flows: POWER as a Constraint on Knowledge Pluralism in River Flow Decision-making in the Saskatchewan River Delta. *Society and Natural Resources*, *31*(8), 892–907. https://doi.org/10.1080/08941920.2018.1451582

Appels, W. M., Bradford, L., Chun, K. P., Coles, A. E., & Strickert, G. (2017). DIY meteorology: Use of citizen science to monitor snow dynamics in a data-sparse city. *Facets*, *2*(2), 734–753. https://doi.org/10.1139/facets-2017-0030

Armitage, Thomas and Levac, L. (2015). *the development of community-Engaged Scholars through course-Based learning : a Student Perspective*. 148–163. Retrieved from https://jmss.org/index.php/esj/article/view/61313/46433

Armitage, D., de Loë, R. C., Morris, M., Edwards, T. W. D., Gerlak, A. K., Hall, R. I., … Wolfe, B. B. (2015). Science–policy processes for transboundary water governance. *Ambio*, *44*(5), 353–366. https://doi.org/10.1007/s13280-015-0644-x

Armitage, D. R., Plummer, R., Berkes, F., Arthur, R. I., Charles, A. T., Davidson-Hunt, I. J., … Wollenberg, E. K. (2009, March 1). Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment*, Vol. 7, pp. 95–102. https://doi.org/10.1890/070089

Armitage, T., & Levac, L. (2015). Learning the Development of Community-Engaged Scholars Through Course-Based Learning: A Student Perspective. *Engaged Scholar Journal: Community-Engaged Research, Teaching, and Learning*, *1*(1). https://doi.org/10.15402/esj.v1i1.25

Asante, C. K., Jardine, T. D., Van Wilgenburg, S. L., & Hobson, K. A. (2017). Tracing origins of waterfowl using the Saskatchewan River Delta: Incorporating stable isotope approaches in continent-wide waterfowl management and conservation. *The Condor*, *119*(2), 261–274. https://doi.org/10.1650/condor-16-179.1

Baijius, W., & Patrick, R. J. (2019). “We don’t drink the water here”: The reproduction of undrinkablewater for first Nations in Canada. *Water (Switzerland)*, *11*(5), 1079.

https://doi.org/10.3390/w11051079

Barber, M., & Jackson, S. (2015). “Knowledge making”: Issues in modelling local and indigenous ecological knowledge. *Human Ecology*, *43*(1), 119–130. https://doi.org/10.1007/s10745-015-9726-4

Basco-Carrera, L., Warren, A., van Beek, E., Jonoski, A., & Giardino, A. (2017). Collaborative modelling or participatory modelling? A framework for water resources management. *Environmental Modelling and Software*, *91*, 95–110. https://doi.org/10.1016/j.envsoft.2017.01.014

Bateman, N. (2018). A Linguist’s Journey Toward Community Engaged Scholarship: Insights on Definitions, Practice and Evaluation Policies. *Gateways: International Journal of Community Research and Engagement*, *11*(1), 56–72. https://doi.org/10.5130/ijcre.v11i1.5579

Beltaos, S. (2014). Comparing the impacts of regulation and climate on ice-jam flooding of the Peace-Athabasca Delta. *Cold Regions Science and Technology*, *108*, 49–58. https://doi.org/10.1016/j.coldregions.2014.08.006

Blackstock, K. L., Kelly, G. J., & Horsey, B. L. (2007). Developing and applying a framework to evaluate participatory research for sustainability. *Ecological Economics*, *60*(4), 726–742. https://doi.org/10.1016/j.ecolecon.2006.05.014

Boydell, K., & Gladstone, B. (2012). The production and dissemination of knowledge: A scoping review of arts-based health research. *Sozialforschung/Qualitative Social Research*, *13*(1), Art 32. Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/1711/3329

Boyer, E. L. (1996). The Scholarship of Engagement. *Bulletin of the American Academy of Arts and Sciences*, *49*(7), 18. https://doi.org/10.2307/3824459

Bradford, L., Chun, K. P., Bonli, R., & Strickert, G. (2019). Does engagement build empathy for sharedwater resources? Results from the use of the interpersonal reactivity index during a

mobilewater allocation experimental decision laboratory. *Water (Switzerland)*, *11*(6). https://doi.org/10.3390/w11061259

Bradford, L. E. A., Ovsenek, N., & Bharadwaj, L. A. (2017). Chapter 15 Indigenizing Water Governance in Canada. *Water Policy and Governance in Canada, Global Issues in Water Policy 17*, (November 2016), 269–297. https://doi.org/10.1007/978-3-319-42806-2

Bradford, L. E. A., Vogel, T., Lindenschmidt, K.-E., McPhedran, K., Strickert, G. E. H., Fonstad, T. A., & Bharadwaj, L. A. (2018). Co-design of water services and infrastructure for Indigenous Canada: A scoping review. *FACETS*, *3*(1), 487–511. https://doi.org/10.1139/facets-2017-0124

Bradford, Thapa, A., Duffy, A., Hassanzadeh, E., Strickert, G., Noble, B., & Lindenschmidt, K. E. (2020). Incorporating social dimensions in hydrological and water quality modeling to evaluate the effectiveness of agricultural beneficial management practices in a Prairie River Basin. *Environmental Science and Pollution Research*, *27*(13), 14271–14287. https://doi.org/10.1007/s11356-019-06325-1

Brnhardt, & Kawagley. (2005). Indigenous Knowledge Systems and Alaska Native Ways of Knowing. *Anthropology <html_ent Glyph="@amp;" Ascii="&"/> Education Quarterly*, *36*(1), 8–23. https://doi.org/10.1525/aeq.2005.36.1.008

Brooks, D. B. (2015). Emma S. Norman Governing transboundary waters: Canada, the United States, and indigenous communities. *Water International*, *40*(7), 1074–1077. https://doi.org/10.1080/02508060.2015.1111715

Brukardt, M. J., Holland, B., Percy, S. L., & Zimpher, N. (2004). Calling the Question: Is Higher Education Ready to Commit to Community Engagement? *A Wingspread Statement 2004*. Retrieved from www.johnsonfdn.org.

Brunet, N. D., Jardine, T. D., Jones, P. D., Macdermid, F., Reed, G., Bogdan, A. M., … Natcher, D. C. (2020). Towards indigenous community-led monitoring of fish in the oil sands region of Canada: Lessons at the intersection of cultural consensus and fish science. *Extractive Industries and Society*, *7*(4), 1319–1329. https://doi.org/10.1016/j.exis.2020.06.014

Bunn, S. E., & Arthington, A. H. (2002, October 1). Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management*, Vol. 30, pp. 492–507. https://doi.org/10.1007/s00267-002-2737-0

Burke, A. (2013). *Water Quality in the South SK River Basin*. Retrieved from http://www.southsaskriverstewards.ca/reports.html

Calleson, D. C., Jordan, C., & Seifer, S. D. (2005). Community-engaged scholarship: Is faculty work in communities a true academic enterprise? *ACADEMIC MEDICINE*, *80*(4), 317–321. https://doi.org/10.1097/00001888-200504000-00002

Carlson, H. (2016). *How competing narratives influence water policy in the Saskatchewan River Basin*.

Carriere, M., Carriere, T., Carriere, S., & Carriere, R. (2021). *Observations from 2020 Flood Events and a Downstream Water Management Plan for the Saskatchewan River Delta Healthy Rivers Make Healthy Communities Saskatchewan River Delta Cumberland House , Saskatchewan Report Authors :* (January), 1–13.

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., … Mitchell, R. B. (2003). Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences of the United States of America*, *100*(14), 8086–8091. https://doi.org/10.1073/pnas.1231332100

Castleden, H., Garvin, T., & First Nation, H. ay aht. (2008). Modifying Photovoice for community-based participatory Indigenous research. *Social Science and Medicine*, *66*(6), 1393–1405. https://doi.org/10.1016/j.socscimed.2007.11.030

Castleden, H., Morgan, V. S., & Lamb, C. (2012). “i spent the first year drinking tea”: Exploring Canadian university researchers’ perspectives on community-based participatory research involving Indigenous peoples. *Canadian Geographer*, Vol. 56, pp. 160–179. https://doi.org/10.1111/j.1541-0064.2012.00432.x

Conallin, J., Campbell, J., & Baumgartner, L. (2018). Using Strategic Adaptive Management to

Facilitate Implementation of Environmental Flow Programs in Complex Social-Ecological Systems. *Environmental Management*, *62*(5), 955–967. https://doi.org/10.1007/s00267-018-1091-9

creswell. (2003). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (2nd Edition). In *Sage Publications*. https://doi.org/10.1080/14675980902922143

Datta, R. (2017). Decolonizing both researcher and research and its effectiveness in Indigenous research: *Https://Doi.Org/10.1177/1747016117733296*, *14*(2), 1–24. https://doi.org/10.1177/1747016117733296

Dempsey, S. E. (2010). Critiquing community engagement. *Management Communication Quarterly*, *24*(3), 359–390. https://doi.org/10.1177/0893318909352247

DFO, & Watkinson, D.A., Ghamry, H. K. and E. E. C. (2019). Assessment of the instream flow needs for fish and fish habitat in the Saskatchewan River downstream of the E.B. Campbell Hydroelectric Station. *Canadian Science Advisory Secretariat (CSAS) Science Advisory Report*, (2018/048).

Di Baldassarre, G., Sivapalan, M., Rusca, M., Cudennec, C., Garcia, M., Kreibich, H., … Blöschl, G. (2019). Sociohydrology: Scientific Challenges in Addressing the Sustainable Development Goals. *Water Resources Research*, *55*(8), 6327–6355. https://doi.org/10.1029/2018WR023901

Dirschl, H. J., & Coupland, R. T. (1972). Vegetation patterns and site relationships in the Saskatchewan River delta. *Canadian Journal of Botany*, *50*(3), 647–675. https://doi.org/10.1139/b72-080

Dressel, S., Ericsson, G., Johansson, M., Kalén, C., Pfeffer, S. E., & Sandström, C. (2020). Evaluating the outcomes of collaborative wildlife governance: The role of social-ecological system context and collaboration dynamics. *Land Use Policy*, *99*, 105028. https://doi.org/10.1016/j.landusepol.2020.105028

Evers, M., Jonoski, A., Maksimovič, C., Lange, L., Ochoa Rodriguez, S., Teklesadik, A., …

Makropoulos, C. (2012). Collaborative modelling for active involvement of stakeholders in urban flood risk management. *Natural Hazards and Earth System Science*, *12*(9), 2821–2842. https://doi.org/10.5194/nhess-12-2821-2012

Fikret Berkes, P., Ruddle, K., Hyogo-ken, N., Robert Johannes, J. E., Doubleday, N. C., McDonald, M., … Hanbidge, B. (1993). Traditional Ecological Knowledge: Concepts and Cases. In *International Program on Traditional Ecological Knowledge* (Vol. 369). Retrieved from http://library.umac.mo/ebooks/b10756577a.pdf#page=39

Fink, D., Auer, T., Johnston, A., Ruiz-Gutierrez, V., Hochachka, W. M., & Kelling, S. (2020). Modeling avian full annual cycle distribution and population trends with citizen science data. *Ecological Applications*, *30*(3). https://doi.org/10.1002/eap.2056

Finn, M., & Jackson, S. (2011). Protecting Indigenous Values in Water Management: A Challenge to Conventional Environmental Flow Assessments. *Ecosystems*, *14*(8), 1232–1248. https://doi.org/10.1007/s10021-011-9476-0

Fraser, K. D., & al Sayah, F. (2011). Arts-based methods in health research: A systematic review of the literature. *Arts & Health*, *3*(2), 110–145. https://doi.org/10.1080/17533015.2011.561357

Gober, P. A., Strickert, G. E., Clark, D. A., Chun, K. P., Payton, D., & Bruce, K. (2015). Divergent Perspectives on Water Security: Bridging the Policy Debate. *The Professional Geographer*, *67*(1), 62–71. https://doi.org/10.1080/00330124.2014.883960

Gober, & Wheater. (2014). Socio-hydrology and the science–policy interface: A case study of the Saskatchewan River basin. *Hydrology and Earth System Sciences*, *18*(4), 1413–1422. https://doi.org/10.5194/hess-18-1413-2014

Goulet, T. (2013). Revitalizing Cree Legal Traditions: Cumberland House and Pelican Narrows. *ProQuest Dissertations and Theses*. Retrieved from http://cyber.usask.ca/login?url=https://search.proquest.com/docview/1513578946?accountid=14739&bdid=6508&_bd=5Ku8MyghaiRyGrFxXSLEy%2B1Y1I0%3D

Hamalainen, R. P. (2015). Behavioural issues in environmental modelling - The missing perspective. *Environmental Modelling and Software*, *73*, 244–253. https://doi.org/10.1016/j.envsoft.2015.08.019

Hammel, J., Magasi, S., Mirza, M. P., Fischer, H., Preissner, K., Peterson, E., & Suarez-Balcazar, Y. (2015). A Scholarship of Practice Revisited: Creating Community-Engaged Occupational Therapy Practitioners, Educators, and Scholars. *Occupational Therapy in Health Care*, *29*(4), 352–369. https://doi.org/10.3109/07380577.2015.1051690

Hassanzadeh, E., Elshorbagy, A., Nazemi, A., Jardine, T. D., Wheater, H., & Lindenschmidt, K. E. (2017). The ecohydrological vulnerability of a large inland delta to changing regional streamflows and upstream irrigation expansion. *Ecohydrology*, *10*(4), 1–17. https://doi.org/10.1002/eco.1824

Haywood, B. K., Parrish, J. K., & Dolliver, J. (2016). Place-based and data-rich citizen science as a precursor for conservation action. *Conservation Biology*, *30*(3), 476–486. https://doi.org/10.1111/COBI.12702

Hitomi, M. K., & Loring, P. A. (2018). *Hidden participants and unheard voices? A systematic review of gender, age, and other influences on local and traditional knowledge research in the North*. https://doi.org/10.1139/facets-2018-0010

Jackson, S. E., Douglas, M. M., Kennard, M. J., Pusey, B. J., Huddleston, J., Harney, B., … Allsop, Q. (2014). We like to listen to stories about fish: Integrating indigenous ecological and scientific knowledge to inform environmental flow assessments. *Ecology and Society*, *19*(1). https://doi.org/10.5751/ES-05874-190143

Jardine, T., Reed, M., Strickert, G., Massie, M., McKay-Carriere, L., MacColl, I., Carriere, R., Carriere, S., Abu, R., and Steelman, T. (n.d.). Healthy Delta, Healthy People: The past, present and future of the Saskatchewan River Delta. In K. M. Wantzen (Ed.), *In River Cultures: Life as a dance to the rhythm of the water*. UNESCO Publishers, Paris.

Jardine, T., Baulch, H., Hobson, K., Janz, D., Lindenschmidt, K.-E., Wheater, H., … Steeves, K. (2016). *EB Campbell Dam and the Saskatchewan River Delta*.

Jardine, T. D., Bond, N. R., Burford, M. A., Kennard, M. J., Ward, D. P., Bayliss, P., … Bunn, S. E. (2015). Does flood rhythm drive ecosystem responses in tropical riverscapes? *Ecology*, *96*(3), 684–692. https://doi.org/10.1890/14-0991.1

Kornder, M., Guindon, J., Program, N. B., & Canada, D. U. (2019). *An Assessment of the Saskatchewan River Delta For Wetlands and related Ecological Goods & Services*.

Kurtz, D. L. M. (2013). Indigenous Methodologies: Traversing Indigenous and Western worldviews in research. *AlterNative: An International Journal of Indigenous Peoples*, *9*(3), 217–229. https://doi.org/10.1177/117718011300900303

Labadie, J. W., & Larson, R. (2007). MODSIM 8.1: River Basin Management Decision Support System, User Manual and Documentation. *Department of Civil and Environmental Engineering, Colorado State University.*, *123*.

Leandro, C., Jay-Robert, P., Mériguet, B., Houard, X., & Renner, I. W. (2020). Is my sdm good enough? insights from a citizen science dataset in a point process modeling framework. *Ecological Modelling*, *438*. https://doi.org/10.1016/j.ecolmodel.2020.109283

Lemoine, N., & Patrick, R. J. (2014). *Water Governance in Northern Saskatchewan: Opportunities and Challenges Nadine Lemoine and Robert J. Patrick Department of Geography and Planning*. *23*(1), 46–60.

MacKinnon, B. D., Sagin, J., Baulch, H. M., Lindenschmidt, K. E., & Jardine, T. D. (2015). Influence of hydrological connectivity on winter limnology in floodplain lakes of the Saskatchewan River Delta, Saskatchewan. *Canadian Journal of Fisheries and Aquatic Sciences*, *73*(1), 140–152. https://doi.org/10.1139/cjfas-2015-0210

Mantyka-Pringle, C. S., Jardine, T. D., Bradford, L., Bharadwaj, L., Kythreotis, A. P., Fresque-Baxter, J., … Lindenschmidt, K. E. (2017). Bridging science and traditional knowledge to assess cumulative impacts of stressors on ecosystem health. *Environment International*, *102*, 125–137. https://doi.org/10.1016/j.envint.2017.02.008

Markides, J. M. (2019). Towards a New Ethnohistory: Community-Engaged Scholarship among

the People of the River, by Keith Thor Carlson, John Sutton Lutz, David M. Schaepe, and Naxaxalhts'i (Albert "Sonny" McHalsie). *Qualitative Research in Education*, *8*(1), 122. https://doi.org/10.17583/qre.2019.4055

Marshall, A., & Bartlett, C. (2010). Two-Eyed Seeing for Environmental Sustainability. *Environment, Sustainability and Society Lecture Series*.

Marshall, R. E., Levison, J. K., McBean, E. A., Brown, E., & Harper, S. L. (2018). Source water protection programs and Indigenous communities in Canada and the United States: A scoping review. *Journal of Hydrology*, Vol. 562, pp. 358–370. https://doi.org/10.1016/j.jhydrol.2018.04.070

Massie, M., & Reed, M. G. (2013). Cumberland house in the Saskatchewan River Delta: Flood memory and the Municipal response, 2005 and 2011. In *Climate Change and Flood Risk Management: Adaptation and Extreme Events at the Local Level* (pp. 150–189). https://doi.org/10.4337/9781781006672.00011

McIntyre, A. (2008). Participatory Action Research - Alice McIntyre - Google Books. Retrieved September 24, 2021, from Sage Publications website: https://books.google.ca/books?id=w0xEe6I5hHUC&printsec=frontcover#v=onepage&q&f=false

McMullin, C. (2021). Transcription and Qualitative Methods: Implications for Third Sector Research. *Voluntas*, 1–14. https://doi.org/10.1007/s11266-021-00400-3

Mihalicz, J. E., Jardine, T. D., Baulch, H. M., & Phillips, I. D. (2019). Seasonal effects of a hydropeaking dam on a downstream benthic macroinvertebrate community. *River Research and Applications*, (March), 714–724. https://doi.org/10.1002/rra.3434

Minkman, E., Rutten, M. M., & van der Sanden, M. C. A. (2017). Acceptance of Mobile Technology for Citizen Science in Water Resource Management. *Journal of Irrigation and Drainage Engineering*, *143*(3). https://doi.org/10.1061/(asce)ir.1943-4774.0001043

Minkman, E., van der Sanden, M., & Rutten, M. (2016). Practitioners' viewpoints on citizen

science in water management: a case study in Dutch regional water resource management. *Hydrology and Earth System Sciences Discussions*, 1–25. https://doi.org/10.5194/hess-2016-463

Morway, E. D., Niswonger, R. G., & Triana, E. (2016). Toward improved simulation of river operations through integration with a hydrologic model. *Environmental Modelling and Software*, *82*, 255–274. https://doi.org/10.1016/j.envsoft.2016.04.018

National Centre for Truth and Reconciliation. (2015). Truth and reconciliation commission of Canada: Calls to action. Retrieved November 30, 2021, from Truth and Reconciliation Commission of Canada website: http://trc.ca/assets/pdf/Calls_to_Action_English2.pdf

Nazemi, A., Zaerpour, M., & Hassanzadeh, E. (2020). Uncertainty in Bottom-Up Vulnerability Assessments of Water Supply Systems due to Regional Streamflow Generation under Changing Conditions. *Journal of Water Resources Planning and Management*, *146*(2), 04019071. https://doi.org/10.1061/(asce)wr.1943-5452.0001149

Neachell, E. (2014). Book Review - Environmental flows: Saving rivers in the thrid millennium. *River Research and Applications*, *30*(January), 132–133. https://doi.org/10.1002/rra

Noble, B., & Basnet, P. (2015). Capacity for watershed cumulative effects assessment and management in the South Saskatchewan Watershed, Canada. *Canadian Water Resources Journal*, *40*(2), 187–203. https://doi.org/10.1080/07011784.2015.1019568

Pahl-Wostl, C., Arthington, A., Bogardi, J., Bunn, S. E., Hoff, H., Lebel, L., … Tsegai, D. (2013). Environmental flows and water governance: Managing sustainable water uses. *Current Opinion in Environmental Sustainability*, *5*(3–4), 341–351. https://doi.org/10.1016/j.cosust.2013.06.009

Partners FOR the Saskatchewan River Basin. (2009). *From the Mountains to the Sea; The State of the Saskatchewan River Basin*. 125–136.

Patrick, R., Quinney, K., Quinney, L., & Machial, L. (2017). Lessons Learned Through Community-Engaged Planning. *International Indigenous Policy Journal*, *8*(2).

https://doi.org/10.18584/iipj.2017.8.2.7

Poff, N. L. R., & Olden, J. D. (2017, December 8). Can dams be designed for sustainability? *Science*, Vol. 358, pp. 1252–1253. https://doi.org/10.1126/science.aaq1422

Poff, N. L., Richter, B. D., Arthington, A. H., Bunn, S. E., Naiman, R. J., Kendy, E., … Warner, A. (2010). The ecological limits of hydrologic alteration (ELOHA): A new framework for developing regional environmental flow standards. *Freshwater Biology*, *55*(1), 147–170. https://doi.org/10.1111/j.1365-2427.2009.02204.x

Quinn, F. (2013). To cite this article: Frank Quinn (1985) The Evolution of Federal Water Policy. *Canadian Water Resources Journal*, *10*(4), 21–33. https://doi.org/10.4296/cwrj1004021

Rawlyk, F. X., & Patrick, R. J. (2013). Capacity needs for source water protection plan implementation: Lessons from the South Saskatchewan River. *Canadian Journal of Urban Research*, *22*(1 SUPPL), 20–45.

Ray, L. A., Kolden, C. A., & Chapin, F. S. (2012). A Case for Developing Place-Based Fire Management Strategies from Traditional Ecological Knowledge. *Ecology and Society, Published Online: Sep 27, 2012 | Doi:10.5751/ES-05070-170337*, *17*(3). https://doi.org/10.5751/ES-05070-170337

Renöfält, B. M., Jansson, R., & Nilsson, C. (2010). Effects of hydropower generation and opportunities for environmental flow management in Swedish riverine ecosystems. *Freshwater Biology*, *55*(1), 49–67. https://doi.org/10.1111/j.1365-2427.2009.02241.x

Richards, C., Blackstock, K.L. e Carter, C. E. (2004). Practical Approaches to Participation. *SERG Policy Brief No. 1;*, (1), 23. Retrieved from http://www.macaulay.ac.uk/ruralsustainability/SERG PB1 final.pdf.

Richter, B. D., Davis, M. M., Apse, C., & Konrad, C. (2012). A Presumptive Standard For Environmental Flow Protection. *River Research and Applications*, *28*(8), 1312–1321. https://doi.org/10.1002/rra.1511

Robinson, C. J., Maclean, K., Hill, R., Bock, E., & Rist, P. (2016). Participatory mapping to

negotiate indigenous knowledge used to assess environmental risk. *Sustainability Science*, *11*(1), 115–126. https://doi.org/10.1007/s11625-015-0292-x

Robinson, J. A., & Hawthorne, T. L. (2018). Making Space for Community-Engaged Scholarship in Geography. *Professional Geographer*, *70*(2), 277–283. https://doi.org/10.1080/00330124.2017.1366775

Robson, J. P., Miller, A. M., Idrobo, C. J., Burlando, C., Deutsch, N., Kocho-Schellenberg, J. E., … Turner, K. L. (2009). Building communities of learning: Indigenous ways of knowing in contemporary natural resources and environmental management. *Journal of the Royal Society of New Zealand*, Vol. 39, pp. 173–177. https://doi.org/10.1080/03014220909510574

Rydin, Y., & Pennington, M. (2000). Public participation and local environmental planning: The collective action problem and the potential of social capital. *Local Environment*, *5*(2), 153–169. https://doi.org/10.1080/13549830050009328

Sagin, J., Sizo, A., Wheater, H., Jardine, T. D., & Lindenschmidt, K. E. (2015). A water coverage extraction approach to track inundation in the Saskatchewan River Delta, Canada. *International Journal of Remote Sensing*, *36*(3), 764–781. https://doi.org/10.1080/01431161.2014.1001084

Sandmann, L. R. (2003). Conceptualization of the Scholarship of Engagement in Higher Education : A Ten-Year Retrospective. *Journal of Higher Education*, *12*(1), 1996–2006.

Sandmann, L. R. (2017). Scholarship as Architecture: Framing and Enhancing Community Engagement. *Journal of Physical Therapy Education*, *20*(3), 80–84. https://doi.org/10.1097/00001416-200610000-00013

Sandmann, L., Thornton, C., & Jaeger, A. (2009). *Institutionalizing community engagement in higher education : the first wave of Carnegie classified institution /*. Retrieved from https://books.google.ca/books?hl=en&lr=&id=T5K7PIXwo8YC&oi=fnd&pg=PA25&dq=Saltmarsh,+J.,+Giles+Jr,+D.+E.,+Ward,+E.,+%26+Buglione,+S.+M.+(2009).+Rewarding+community-engaged+scholarship.+New+directions+for+higher+education,+2009(147),+25-

35.&ots=0CN8FC3VwZ&

Sauchyn, D. J., St-Jacques, J. M., Barrow, E., Nemeth, M. W., Macdonald, R. J., Sheer, A. M. S., & Sheer, D. P. (2016). Adaptive Water Resource Planning in the South Saskatchewan River Basin: Use of Scenarios of Hydroclimatic Variability and Extremes. *Journal of the American Water Resources Association*, *52*(1), 222–240. https://doi.org/10.1111/1752-1688.12378

Scolobig, A., & Lilliestam, J. (2016). Comparing Approaches for the Integration of Stakeholder Perspectives in Environmental Decision Making. *Resources 2016, Vol. 5, Page 37*, *5*(4), 37. https://doi.org/10.3390/RESOURCES5040037

Scolobig, A., Thompson, M., & Linnerooth-Bayer, J. A. (2016). Compromise not consensus: designing a participatory process for landslide risk mitigation. *Natural Hazards*, *81*, 45–68. https://doi.org/10.1007/s11069-015-2078-y

Shah, S. M. A. (2020). *Integrated water resources management in a transboundary river basin: model development and sensitivity analysis*. (December). Retrieved from http://hdl.handle.net/10388/12530

Simms, R., Harris, L., Joe, N., & Bakker, K. (2016). Navigating the tensions in collaborative watershed governance: Water governance and Indigenous communities in British Columbia, Canada. *Geoforum*, *73*, 6–16. https://doi.org/10.1016/j.geoforum.2016.04.005

Smith, N. D., Morozova, G. S., & Gibling, M. R. (2014). Channel enlargement by avulsion-induced sediment starvation in the Saskatchewan River. *Geology*, *42*(4), 355–358. https://doi.org/10.1130/G35258.1

Stanton, T. K. (2008). New times demand new scholarship: Opportunities and challenges for civic engagement at research universities. *Education, Citizenship and Social Justice*, *3*(1), 19–42. https://doi.org/10.1177/1746197907086716

Strickert, & Bradford, L. (2015). Of Research Pings and Ping–Pong Balls. *International Journal of Qualitative Methods*, *14*(5), 160940691562140. https://doi.org/10.1177/1609406915621409

Strickert, G., Chun, K. P., Bradford, L., Clark, D., Gober, P., Reed, M. G., & Payton, D. (2016). Unpacking viewpoints on water security: Lessons from the South Saskatchewan River Basin. *Water Policy*, *18*(1), 50–72. https://doi.org/10.2166/wp.2015.195

Strickert, G. E. H. (1994). Mixing With The Mountains.

Swainson, B. (2009). *Rivers at Risk: The status of Environmental Flows in Canada*. Retrieved from https://d2ouvy59p0dg6k.cloudfront.net/downloads/riversatriskfullreport.pdf

Toonen, W. H. J., van Asselen, S., Stouthamer, E., & Smith, N. D. (2016). Depositional development of the Muskeg Lake crevasse splay in the Cumberland Marshes (Canada). *Earth Surface Processes and Landforms*, *41*(1), 117–129. https://doi.org/10.1002/esp.3791

Van Hove, S., De Letter, J., De Ruyck, O., Conradie, P., All, A., Saldien, J., & De Marez, L. (2018). Human-computer interaction to human-computer-context interaction: Towards a conceptual framework for conducting user studies for shifting interfaces. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *10918 LNCS*, 277–293. https://doi.org/10.1007/978-3-319-91797-9_20

Wang, C., & Burris, M. A. (1997). Photovoice: Concept, Methodology, and Use for Participatory Needs Assessment. *Health Education and Behavior*, *24*(3), 369–387. https://doi.org/10.1177/109019819702400309

Wang, L., Fang, L., & Hipel, K. W. (2008). Integrated Hydrologic-Economic Modeling of Coalitions of Stakeholders for Water Allocation in the South Saskatchewan River Basin. *Journal of Hydrologic Engineering*, *13*(9), 781–792. https://doi.org/10.1061/(ASCE)1084-0699(2008)13:9(781)

Watanabe, A. (2006). *Modeling the Potential Downstream Impact of a Hydroelectric Power Station on the Saskatchewan River A Case Study*.

Watkinson, D. A., Ghamry, H. K., & Enders, E. C. (2020). *Canadian Science Advisory Secretariat (CSAS) Information to support the assessment of the Instream Flow Needs for Fish and Fish*

Habitat in the Saskatchewan River downstream of the E.B. Campbell Hydroelectric Station. Retrieved from http://www.dfo-mpo.gc.ca/csas-sccs/

Weber, M., & Cutlac, M. (2014). Economic and environmental tradeoffs from alternative water allocation policies in the South Saskatchewan River Basin. *Canadian Water Resources Journal*, *39*(4), 409–420. https://doi.org/10.1080/07011784.2014.965040

Wheater, H. S. (2015). Water Security - Science and management challenges. *IAHS-AISH Proceedings and Reports*, *366*, 23–30. https://doi.org/10.5194/piahs-366-23-2015

Williams, M., & Moser, T. (2019). The Art of Coding and Thematic Exploration in Qualitative Research. *International Management Review*, *15*(1).

Wilson, N. J., Mutter, E., Inkster, J., & Satterfield, T. (2018). Community-Based Monitoring as the practice of Indigenous governance: A case study of Indigenous-led water quality monitoring in the Yukon River Basin. *Journal of Environmental Management*, *210*, 290–298. https://doi.org/10.1016/j.jenvman.2018.01.020

Wyllie de Echeverria, & Thornton, T. F. (2019). Using traditional ecological knowledge to understand and adapt to climate and biodiversity change on the Pacific coast of North America. *Ambio*, *48*(12), 1447–1469. https://doi.org/10.1007/s13280-019-01218-6

APPENDIX I – Guide for semi-structured interviews

1. Tell me about yourself.
2. How long have you lived/ worked in this region?
3. Do you spend time out in the Delta? Is there a place there that is important to you?
4. Do people share stories of the Delta?
    a. Does any specific story stick out in your memory?
    b. When and where did that happen?
    c. Why do you think those (experiences, memories, stories) were useful to share?
    d. Why do you think you remembered that story in particular?
5. When you are out on the Delta, do you think about what the water that animals need?
6. What kinds of water flows do these animals need?
    a. Fish
        What time of year do the fish need high water?
        What time of year do fish need low water?
        What times of year do they need high and low water?
        Is there anything holding back the fish populations?
    b. Moose
        What time of year do moose need high water?
        What time of year do moose need low water?
    c. Muskrats
        What time of year do muskrats need high water?
        What time of year do muskrats need low water?
    d. Beavers
        What times of year do they need high and low water?
        What is holding back their numbers?
    e. Waterfowls
        What kind of water flows do ducks and geese need?
        What times of year do they need high and low water?
        Is anything holding back their numbers?
6. How do you want the water coming from the river to look and smell?
7. Do you ever think about mud that is carried by the water? Where does the mud come from? Where does the mud settle? What is better for the Delta - muddy water or clear water?
8. What does it mean to look after water? How can we better look after water?
9. Are you involved in the Delta Stewardship group or the management of water or waterbodies?
What activities have you worked on to improve the Delta or to protect water? Tell me more about your involvement in each activity.
10. Do you remember who worked with you on (that)? Where were they from? Tell me about others that helped with that activity.
    a. Do you remember if anyone's help in particular was key to make that happen?
    b. Do you recall if people ever struggled to see eye to eye during these activities?

11. In planning and decision-making, do people upstream ever need to be connected with people downstream? How do you think this need to be done?
12. Can you recall if people from different cultures and backgrounds have ever worked to plan for the Delta?
13. What do you think computer modelers need to know about the Delta's ecosystem?
14. What do you anticipate for the Delta in 30 years? How can we ensure/prevent that?