GLOBAL COMMISSION on the ECONOMICS OF WATER

Indigenous and Western Knowledge: Bringing Diverse Understandings of Water Together in Practice

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Executive summary

The importance of multiple perspectives in understanding human-nature relationships and associated benefits for biodiversity, ecosystems and overall quality of human life, is underscored by Indigenous Peoples' values, worldviews and knowledge systems. Indigenous Peoples, while geographically, linguistically and culturally diverse, share common cultural and spiritual beliefs that elevate the value of water beyond material function. For many Indigenous Peoples, water is a living entity with inherent value to be revered and protected – an essential relationship that extends beyond dominant Western approaches that value water as a resource only for the economic, social and environmental benefits provided to humans. While efforts are being made to bring diverse Indigenous and Western values, worldviews and knowledge systems together to restore freshwater systems, on a practical level the question remains: "how to do so?" in an ethical and responsible way.

This report responds to that gap by synthesising insights gained through a review of documented experiences from projects across the area currently known as Canada and the United States. After a brief introduction to set the context, we present insights in two primary sections on principles and practices. The report is intended to be a resource for Indigenous and non-Indigenous Peoples engaged in the co-development of context-specific approaches that aim to heal social-ecological freshwater systems and essential reciprocal relationships.

Key summary points: Principles

- The water-focused acronym EAUX captures the importance of Equity, Access, Usability and eXchange when braiding Indigenous and Western knowledge systems.
- Activating the EAUX principles requires collaborative and continuous engagement – starting with project objectives that are responsive to Indigenous interests and needs and developing agreement on how the collaboration(s) will unfold.
- **Equity** includes honouring Indigenous Peoples' sovereignty, recognising and responding to power imbalances within project activities, valuing Indigenous knowledge systems, and ensuring projects have demonstrable benefits for Indigenous Peoples
- **Access** involves recognising and affirming Indigenous rights to manage their cultural and intellectual property, recognising that not all knowledge is meant to be shared publicly, and ensuring that Indigenous Nations have free and independent access to information produced through collaborative projects.
- **Usability** ensures that Indigenous communities and/or organisations benefit from projects. Collaborative development of goals and objectives, which requires time and openness, is needed to make sure a project has outcomes that a community can use. Projects may evolve and this should occur in ways that are responsive and accountable to Indigenous partners. Project outcomes need to be accessible and in forms that facilitate use.

- **eXchange** refers to the continuous flow of information between parties. If the relationship is new, time and trust-building activities will be needed to foster active dialogue. Different approaches are needed to promote eXchange between different groups (between generations – Elders to youth; between cultures; between disciplines or community groups that may approach projects with different lenses).
- In many contexts, further work is needed to build the foundations to realise the EAUX principles for respectful and ethical braiding of Indigenous and Western knowledge systems.

Key summary points: Practices

- In our A to A (Axiology to Application) Framework for braiding knowledge systems, braiding can occur at any stage or throughout the project. The Two Row Wampum (Haudenosaunee) and Mi'kmaw Elder Albert Marshall's Two Eyed Seeing offer Indigenous guidance for bringing knowledge systems together.
- The A to A Framework identifies stages – Axiology and Ontology, Epistemology and Methodology, Data Gathering, Analysis and Synthesis, and Application – at which braiding can occur, and highlights opportunities and concrete examples for braiding at different project stages.
- **Axiology and Ontology.** This foundational stage is about deep appreciation of diverse values and worldviews as a basis for developing project objectives and processes. Reflexivity can enrich this experience.
- **Epistemology and Methodology.** This stage of braiding is concerned with the nature of knowledge, recognising there are different ways of knowing, different sources of and ways to generate knowledge, and different perspectives on the limits of knowledge. Shared understanding of what constitutes knowledge, and how best to access it, can allow for the cocreation of culturally appropriate methodologies.
- **Data Gathering.** Data gathering refers to the information collecting stage. Here, braiding helps to ensure that usable information is gathered and cared for in appropriate, culturally safe and mutually beneficial ways.
- **Analysis and Synthesis.** At this stage, shared meaning is attributed to the information gathered during the project. Dialogue during analysis and synthesis is important to ensure there remains continuous consent, and mutual agreement that the proposed outputs align with intended goals and objectives, and that Indigenous Peoples retain control over the representation of their data. Braiding at the analysis and synthesis stage takes many forms depending on the nature of the project.
- **Application.** Projects that braid knowledges aim for new understandings that can be applied to decision-making and adaptation of practices, with initiation of a new cycle of learning.
- Freshwater stewardship, restoration and adaptation strategies are inextricably linked with the well-being of Indigenous Peoples and communities.

Acronyms

AFA	annual funding agreements
CBM	community-based monitoring
IKS	Indigenous knowledge systems
OCAP®	Ownership, Control, Access and Possession
SWP	source water protection
TK	traditional knowledge
WKS	western knowledge systems

1 Introduction

Water has undeniable value – direct and indirect, economic but also ecological, social, spiritual, and cultural – to humans. Regardless of how broadly these values are interpreted, Western society's anthropocentric lens emphasises water's benefits to humans, although these benefits are often not equitably distributed. This value system places humans at the top of a hierarchy; ecosystems are important because humans benefit from them.

Indigenous Nations, although immensely diverse in their cultures and beliefs, often have values that differ from those of Western society. For many Indigenous Peoples, humans are no more important than other creatures; they are just one element of a complex interconnected system. Rather than being passive beneficiaries of nature, Indigenous Peoples often view themselves as caretakers of the land. They participate in reciprocal relationships, with responsibilities to care for the beings that have ensured their well-being from time immemorial, and to ensure the continuation of all life for the next seven generations (King, 2007; Sioui et al., 2022). This often translates to how Indigenous Peoples value water: not as a resource to harness for human benefit but as a spirited being to be revered and protected.

From this relational and reciprocal perspective on human-nature relationships and well-being, water has intrinsic value. Intrinsic value, as explained in the recent Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), means that something has inherent or moral value that is not tied to human purposes (De Vos et al., 2018), where "other-than-human entities like rivers or biotic communities are subjects with rights and duties" (Anderson et al., 2022: 6). This is embedded in Indigenous worldviews, cultural context, knowledge systems and language, and provides the moral principles for how to interact with nature.

This report reorients water experts, decision makers and practitioners educated in Western institutions toward how Indigenous Peoples value water, and how Indigenous knowledge systems (IKS) can be brought together with Western knowledge systems (WKS) in more equitable ways. It draws on a body of literature that documents experiences with freshwater-focused restoration efforts on Turtle Island, within the area currently known as Canada and the United States. In this report, braiding knowledge systems refers to the process of bringing Indigenous and Western knowledge systems together in ethical and respectful ways to achieve something richer than could be achieved in isolation. Key to ethical processes is benefit to Indigenous Peoples. In contrast to "blending", metaphors like "braiding" or "weaving" convey that the integrity of individual fibres or strands is maintained through the collaborative process. Terms like "integration" are avoided because they connote assimilation of Indigenous knowledges into colonial frameworks and processes, which is antithetical to our goals. Braiding knowledge systems acknowledges and affirms and underscores the importance of diverse societal systems that produce, maintain, apply and transmit knowledges (McGregor, 2021).

Preferred methods for braiding will vary depending on the context and nature of the project. Braiding will take different forms along the spectrum from non-Indigenous-led to Indige-

nous-led projects. Weaving may even occur naturally because of an individual's tacit knowledge. In this report, we focus on braiding in projects that engage both Indigenous and non-Indigenous peoples in processes of knowledge sharing and co-production for mutual learning and application (Henri et al., 2021). Knowledges may be brought together at all stages of a project or at selected stages, just like hair may be braided from the root, middle or at the ends. The term "braiding" is chosen for this work because it also suggests care – braiding another's hair, braiding sweetgrass, caring for Mother Earth – and reinforces the spirit of reciprocity (Kimmerer, 2013).

This report begins with a brief overview of Indigenous knowledge systems, describes why braiding knowledge systems is important, and offers a glimpse into decolonising methodologies. We share insights gained from a review of academic and grey literature, on braiding Western and Indigenous knowledge systems to manage and restore freshwater ecosystems in ways that both work towards UN sustainability development goals (SDGs) and benefit Indigenous Peoples on Turtle Island.

The insights fall into three areas: principles of good braiding, foundations for braiding and methods of braiding. We organise the principles of, and approaches to, braiding knowledge systems according to two frameworks developed in previous work. The EAUX framework highlights the importance of equity, access, usability and exchange in collaborations between Indigenous and non-Indigenous partners. The Axiology to Application (or A to A) framework structures the discussion of methods according to project stage. The report culminates with a series of illustrative examples to show how knowledge systems can be brought together to better reflect the many ways water is valued by Indigenous Peoples. While we present considerable insight from a large body of text, without an openness to elevating different value systems and without the humility to recognise the richness of Indigenous ways of knowing, readers may not walk away with all that this report has to offer. As you read this report and encounter different values, and ways of doing project work, do so with an open mind, and do so humbly.

1.1 Valuing water and indigenous knowledge systems

To maintain an open mind, one must remember that knowledge is culturally constituted. What we, as human beings, claim to "know" and how we formulate "truth" is heavily influenced by the political, legal, economic, cultural and value systems in which our information is produced (McGregor, 2021).

Within many Indigenous Nations,[1] water is an agent or spirited being (Craft, 2019; Craft and King, 2021; Johnston, 1976). Rivers and lakes can have personality and be known for their calm or violent demeanour. Water can exercise will, eroding shorelines and depositing silt. Many Indigenous persons acknowledge their complete dependence on water. Teachings shared by Anishinaabe women and Elders remind us that "water is sacred, the life blood of Mother Earth" and that water flows throughout all of Mother Earth (and all living beings) in its

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[1]This report focuses on Indigenous Peoples in what is colonially referred to as "Canada and the United States". In Canada, "Indigenous Peoples" is a collective term for the original peoples. The Canadian Constitution groups Indigenous Peoples into First Nation, Métis and Inuit, although it is important to note that there are over 600 culturally and linguistically distinct Indigenous Nations across Canada (Government of Canada, 2022). In the United States, most Indigenous Peoples identify as Native American or Alaska Natives. The authors recognise that the global diversity of Indigenous Peoples is not represented by this small sample; however, many of the principles and strategies of braiding Indigenous and Western knowledge systems may still apply beyond this geography.

various forms (Longboat, 2015: 6). Haudenosaunee "wisest grandmothers tell us; women are the water carriers … the embodiment of Mother Earth" and Haudenosaunee law "includes the rights of the natural world, and our responsibility is to uphold those" (Sioui et al., 2022: 6).

Ojibway Elder Thomas Peacock similarly notes that human beings are made up of water (Peacock and Wisuri, 2011). Mohawk Elder Jan Longboat asserts that "water is what sustains us. Water is what brings us into this world and water is what keeps us in this physical world" (Anderson, 2010: 7). For these reasons, across Turtle Island[2] many Indigenous persons teach that "Water is life!" To care for water is to sustain creation – or, as Métis scholar Kim Anderson warns, to behave disrespectfully or carelessly with "this life force" is to "put ourselves at risk" (Anderson, 2010: 31).

Water values vary across cultures. As settler scholars Nancy J. Turner and Darcy Matthews remind us, "a primary tenant of [settler] society is that humans represent the pinnacle of life, and that through this special status we can rightfully use any and all of earth's resources for our own [human] ends" (Turner and Mathews, 2020: 3). Many settlers assume that nature can be controlled by human beings, that water does not have a soul-spirit and is, instead, a substance that can be manipulated. Risk can therefore be managed with and through scientific study and Western management systems. There is little sense that water might refuse miscreant humans whose past (or present) activities caused (or cause) harm.

In settler societies, individuals are taught to understand water as a resource, even property, and as such, they ask questions like, "How can we manage water?", or "How can we optimise the allocation of water?" Research flowing from these questions reinforces understandings of water as a tangible asset. Indigenous Nations may seek answers to different questions like, "What are my relationships to water? What responsibilities must I fulfill to maintain this relationship?"

Neither approach should be classified as "good" or "bad". And yet the history of settler-colonialism on Turtle Island has contributed to such designations. To assert their claims to territory, settler-colonists argued that Indigenous Nations were less competent, less able to care for their ancestral lands and waters. Settler-colonists claimed control over Turtle Island in ways that countered its very nature. Today, Indigenous and settler nations like Canada must reckon with flows that challenge artificial distinctions between "Crown," "Indian," and "private"[3] lands and waterways. Collaborative projects are one avenue through which new relationships with water, and between Nations, can be formed. This involves multiple knowledges which, when brought together, can support an enriched view of complex social-ecological systems (Tengö et al., 2014). Furthermore, they can support science-policy arenas, agreements and actions such as the Inter-governmental Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES) and the Convention on Biological Diversity (CBD), which acknowledge the diversity of knowledge systems, and the significance of Indigenous and local knowledges (Tengö et al., 2017).

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[2]"Turtle Island" refers to the land mass that is colonially referred to as North America. The name comes from a belief that this land was formed on the back of a turtle (Robinson, 2018).

[3]Within Canada, "Crown land", also sometimes referred to as public land, is the term used to describe land currently owned and managed by the federal or provincial governments under colonial law ("Crown Land", 2011). "Indian Land" refers to reserve land. A reserve is a parcel of land under colonial law for the use and benefit of a particular First Nation as set out by the Indian Act 1985 (Government of Canada, 1985). Private land is owned by an individual or group of individuals (such as a company or corporation), rather than by the government as entrusted by the Crown.

1.2 Why bring knowledge systems together?

Together, multiple knowledge systems offer many benefits to relate to, care for and restore freshwater social-ecological systems. Broadly speaking, diverse knowledges can "improve understanding of social-ecological connections, build trust in research findings, and help implement evidence-based action towards biodiversity conservation" (Henri et al., 2021: 1). Yet knowledge alone is insufficient. Henri et al. (2021) cite numerous studies that evidence an increasing push for interdisciplinary practices that weave Indigenous knowledge systems[4] and Western sciences[5] (Henri et al., 2018, 2020; Johnson et al., 2016; McGregor, 2004; Popp et al., 2019; Tengö et al., 2014, 2017). Foundational is an Indigenous relational worldview that values water beyond intrinsic and instrumental values common to Western science and refocuses emphasis on relational values – those that are tied to respectful and reciprocal relationships among people with and as part of environment (Pascual et al., 2017).

Braiding diverse knowledge systems can improve problem solving by tackling complex questions that a single knowledge system alone is insufficient to address (Johnson et al., 2016). Consider climate change and unprecedented responses to anthropogenic impacts. Indigenous knowledges of the reciprocal connections between humans and nature is seen as essential for solving global climate change and biodiversity loss, and is garnering increased recognition by governments, academics, and non-governmental organisations (Reed et al., 2022). In Canada, arguably driven by reconciliation commitments and Indigenous rights and governance, a recent increase in mechanisms for Indigenous knowledge to guide decision-making within "regulatory decisions, project reviews, environmental research and governance" includes amendments to federal water-related legislation (e.g. Fisheries Act, Impact Assessment Act, Canadian Energy Act and Canadian Navigable Water Act) (Alexander et al., 2021: 3). Similar actions can be seen in provincial-level governments, where implementation of the United Nations Declaration on the Rights of Indigenous Peoples is becoming institutionalised (British Columbia) or in-process (Ontario) within provincial legislation, policy and practice.

As Alexander et al. (2021) note, multiple ways of knowing can strengthen the evidence base for federal policy, practice and decision-making around freshwater research, monitoring and management. Perhaps most significant are local and place-based benefits. In their experience with knowledge co-evolution and fisheries management in the Arctic, Cooke et al. (2020) observe local benefits (beyond the initial aim to characterise and protect the fisheries) such as community capacity building, empowerment and self-determination. Marshall et al. (2020), through an academic partnership with the Chippewas of Nawash Unceded First Nation, found that no single approach to source-water protection fits diverse First Nations. Nevertheless, they concluded that development of an Indigenous-led, community-engaged, context-specific source-water protection framework, including both Indigenous and Western approaches,

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[4]We borrow Alexander et al.'s (2021: 3) definition of Indigenous knowledge systems: "A cumulative body of knowledge, practices and beliefs, evolving and governed by adaptive processes and handed down and across (through) generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment … An Indigenous knowledge system may be further defined as "a 'high-context' body of knowledge built up over generations by culturally distinct people living in close contact with a 'place'" … that includes Indigenous science and improves through processes of addition and revision."

[5]We borrow Alexander et al.'s (2021: 3) definition of Western science: "With roots in Greek philosophy and the [European] Renaissance, Western Science is a fluid and evolving body of knowledge that tends to favour objectivity and reductionism . . . Western science includes knowledge appropriated over the ages from many cultures, and such knowledge was modified sufficiently to fit Eurocentric worldviews, metaphysics, epistemologies and value systems."

can respond to community water challenges and concerns within Anishinaabe territory. In the Slave River Delta, Northwest Territories, a community-based monitoring program that brought together Indigenous and Western knowledges yielded a more holistic understanding of the cumulative effects on drinking water, fish and wildlife, and overall ecosystem health (Mantyka-Pringle et al., 2017). The authors emphasise the importance of knowledge-inclusive partnerships in "operationalising the integration and complementarity of traditional knowledge and scientific knowledge and natural resource decision-making" (p. 126).

Despite increasing mechanisms and numerous benefits, "developing and implementing inclusive approaches that bridge multiple ways of knowing remains a challenge" (Alexander et al., 2021: 1). A commitment to weaving together Indigenous and Western ways of knowing must address issues of trust, and it must overcome the ongoing impacts of colonialism, epistemological differences and the perceived superiority of Western science, power imbalances that suppress Indigenous knowledge in policy making and practice, differing objectives and differences in worldviews, and limited time and resources (Sha, 2021). In their study of declines in freshwater mussels, Hopkins et al. (2019) emphasise the importance of prioritising Indigenous knowledge when braiding to arrive at a more meaningful understanding of complex problems among Indigenous community members, scientists and other researchers. They assert an essential ethic of "learning together" that moves beyond "attending to colonial legacies" (Hopkins et al., 2019).

1.3 How to bring knowledge systems together

When attending to colonial legacies, bringing knowledge systems together can perpetuate harms to Indigenous Peoples if Indigenous knowledges are extracted in the service of non-Indigenous (rather than shared) needs (Whyte, 2018). There is a long history of mistreatment, objectification and dehumanisation of Indigenous Peoples by settler-colonists (Tuhiwai Smith, 1999). Indigenous persons were viewed and treated as lesser beings for generations, and this misconception extended to the (re)framing of Indigenous worldviews and knowledge systems as inferior in settler-colonial societies. Although reconciliation with Indigenous Peoples is of critical importance, colonial structures persist. Western knowledges, especially Western science, are still thought of by many as superior and preferable to Indigenous knowledges (Frideres, 2019). Indigenous knowledges are often "integrated" into university- or state-funded projects, reinforcing the negative stereotype that Indigenous knowledges hold no value without settler substantiation or validation.

Through decolonisation movements, such as bringing Indigenous research paradigms to the forefront of research practices with Indigenous communities (Wilson, 2008), terminology has been refined, frameworks have been developed, and progress is being made toward bringing knowledge systems together in a good way.[6] Here, we choose to use the term "braiding", but terms such as "weaving", "pairing" and "coexistence" are also common (Buell et al., 2020; Reid et al., 2022). Many frameworks exist for braiding knowledge systems, such as Mi'kmaw Elder Albert Marshall's "two-eyed seeing" (which originated in what is colonially known as eastern Canada); the *Kaswentha* or Two-Row-Wampum treaty between the Haudenosaunee

[6]"In a good way" refers to the Anishinaabe philosophy of living "in a good way". To do so involves aligning one's daily actions with Anishinaabe values and worldviews in which humans are in relation with all beings (animate and inanimate). The Anishinaabe believe that while Mother Earth cares for them, they also have a responsibility to care for Mother Earth and all her creatures. See Mikraszewicz and Richmond (2019) for a discussion of Mino *biimadisiwin* (living the good life).

Confederacy and Dutch (in what is now eastern New York State) (Ransom and Ettenger, 2001) and "two ways" from the Yolngu People (a method from what is colonially known as north-eastern Australia) (Reid et al., 2020). Although the frameworks use different visuals to convey the concept of braiding knowledge systems (Figure 1), they all recognise that each knowledge system – Indigenous and Western – is independent and valid without the other. It is by bringing knowledges together that more can be learned, that understanding can be enriched.

Knowledge braiding is difficult without examples to follow. But review papers that synthesise and draw conclusions across applications of knowledge braiding (Alexander et al., 2021; Reid et al., 2020; Stefanelli et al., 2017) can help those starting collaborative studies with Indigenous communities. For example, Alexander et al. (2021) is one of a trio of systematic mapping reviews seeking to answer questions about how to bridge Indigenous and Western sciences. The review focuses on freshwater systems and reveals fifteen different methodologies, including four culturally distinct Indigenous methodologies, to mobilise Indigenous science and conduct Western science. The review progresses from decolonising theory and braiding frameworks to their application. But it does not investigate how knowledge systems are brought together in practice. Indeed, Alexander et al. (2021: 13) call for "insights from a more in-depth and nuanced analysis … [to] provide guidance to practitioners." To this end, this report shares insights from a scoping review of an updated and expanded body of literature.

Figure 1. Image unmodified from Reid et al. (2020: 6) published in Fish and Fisheries, Volume: 22, Issue: 2, Pages: 243-261, First published: 19 October 2020, DOI: (10.1111/faf.12516), Caption in Reid et al. (2020) reads: "Indigenous conceptual frameworks for promoting knowledge coexistence: (i) the "Two Row Wampum" or Kaswentha in Haudenosaunee; (ii) the "Two Ways" or Ganma in Yolngu; (iii) the "Double-Canoe" or Waka-Taurua in Māori; and (iv) "Two-Eyed Seeing" or Etuaptmumk in Mi'kmaw. Refer to main text (section 3) for full descriptions of each framework (Subsections 1–4, respectively), Artwork by Nicole Burton."
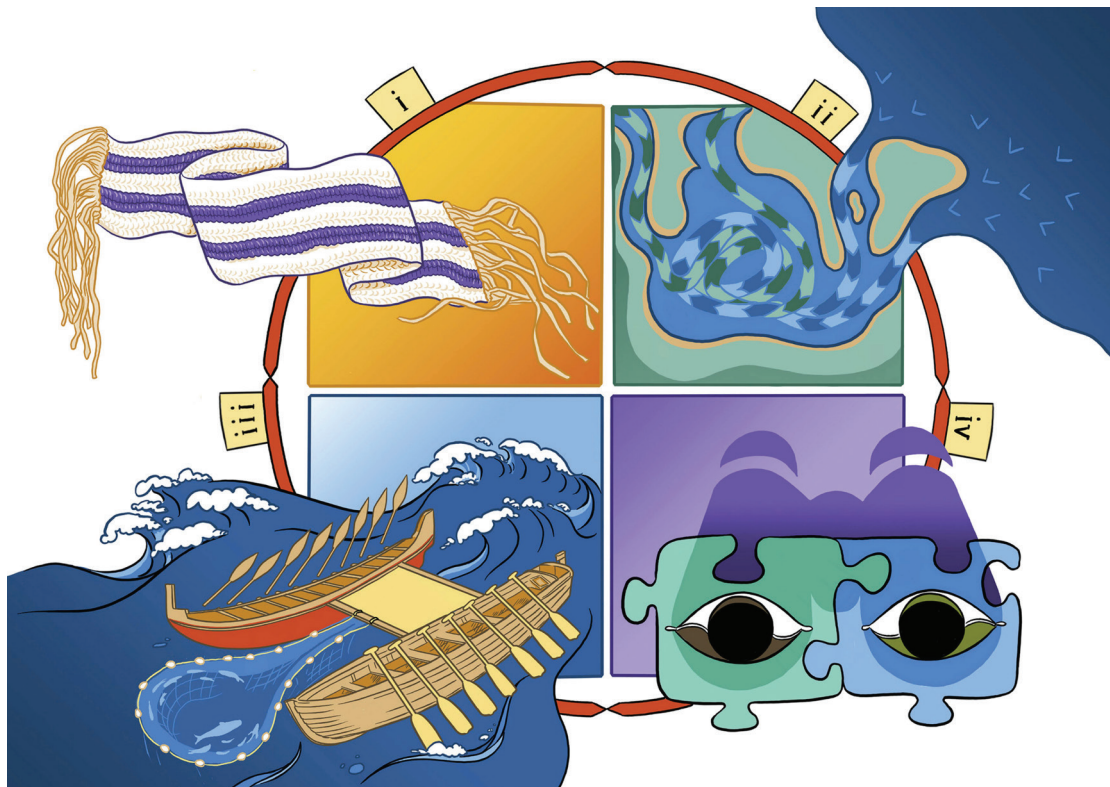
2 Positionality and approach

This technical report was commissioned by R. Quentin Grafton, Lead Expert and Commissioner of the Global Commission on the Economics of Water. It provides a synthesis of the literature, practice and understanding of Indigenous water values and knowledge to inform possible pathways for improved water outcomes by bringing together Indigenous and Western knowledge systems. The report is one of six technical reports available online and from which information is drawn and incorporated into the phase I review and findings report.

In Indigenous cultures, individuals often include their familial relations and cultural background when they introduce themselves. This not only reflects the importance of relationships for many Indigenous Peoples, but it also illustrates their tendency to self-locate and show respect to their ancestors (Kovach, 2010). As Kovach (2010: 111) paraphrases, "Our ancestors gave us membership into nations and traditions; location both remembers and 're-members' us to those things." Self-locating also provides clarity on an individual's values and worldviews, providing insight into how the person's experience influences their interpretation of the world (Kovach, 2010). Although less common in most Western science domains, positionality statements are becoming more common in qualitative research, as a researcher's values and worldviews are intimately connected to their epistemological assumptions and, thus, their research methodology. This transparency helps demonstrate the authors' expertise and the limits of their knowledge, while addressing potential biases. We offer the following positionality statement in the spirit of transparency.

The authors of this report work at the same public university in what is currently known as Guelph, Ontario, Canada. Two of the authors (AB and SM) are settler researchers with largely Western science upbringings and educational backgrounds. They work in the field of water resources and environmental engineering and seek to understand the ecological – and, more recently, the social and cultural – needs of fluvial and wetland systems. Although trained in Western natural science and engineering, AB and SM commonly employ more holistic approaches to understanding complex systems. BL is an Indigenous scholar of Anishinaabe descent whose expertise lies in treaty making and environmental history in Anishinaabe-Aki (or the Land of the Anishinaabeg). As the surname "Luby" suggests, BL also has European ancestors. In 2018, BL brought AB and SM to her ancestral community of Niisaachewan Anishinaabe Nation (NAN) to support NAN's desire to restore *manoomin* (inaccurately known as "wild rice" in English) on the Winnipeg River. SL, also an Indigenous scholar, mixed-race Haudenosaunee Mohawk from Six Nations of the Grand River and settler Ukrainian, brings an academic background in the fields of physical geography, water governance, management and planning.

Although everyone on the team currently works in academia, AB and SM also have experience working in private engineering consulting and, in AB's case, government. BL has worked for First Nations as a contract historian, producing reports for First Nations, specific claims and class action lawsuits. Additionally, SL has more than 25 years of practical experience working with and within Indigenous communities as a member, employee, consultant and

researcher. Together, the team represents several academic disciplines, sectoral experiences and cultural backgrounds. They have a common interest in bringing together Indigenous and Western knowledges to solve water problems and in sharing their learnings.

This report is limited to Turtle Island – the land mass colonially referred to as continental North America. But just as North American Indigenous Peoples cannot speak for Indigenous Peoples on other continents, Turtle Island is home to many unique Indigenous Nations and Anishinaabeg, say, cannot speak for Tlingit. Nevertheless, more than a century of international organising by Indigenous groups, such as the Assembly of First Nations and the National Congress of American Indians, has led to and encouraged transnational knowledge exchanges. This report has been conducted in the spirit of transnational exchange.

2.1 Scoping review methodology

The insights shared in this report are drawn from a scoping review conducted as part of SM's doctoral research. A scoping review maps literature on a particular topic when a research question requires a variety of study types (Pham et al., 2014). Like in a systematic review, the search strategy is defined *a priori,* and all relevant records are screened based on clearly defined criteria (Marshall et al., 2018). Unlike in a systematic review, the research question can benefit from inclusion of diverse publications, and thus quantitative data synthesis is often not feasible (Marshall et al., 2018). A scoping review was used because Indigenous and Western knowledges have been brought together in many ways and disseminated in a variety of publications (e.g. reports, studies, theses, etc.). Further, qualitative results offer a contextually rich understanding of how to bring knowledges together. The scoping review sought to answer the question:

> How are Indigenous and Western knowledge systems brought together to better understand, manage and restore freshwater social-ecological systems within parts of Turtle Island (the portion colonially known as Canada and the United States)?

The scoping review methodology is described in detail elsewhere (e.g. Mehltretter, forthcoming PhD dissertation). In brief, the search strategy used academic and Indigenous databases, along with Google Scholar and Google Advanced Search, to find primary, secondary and grey literature. The search string included terms for Indigenous knowledges, aquatic ecosystems, study applications or project outcomes, and the geography of interest. It captured records over a 15-year period, beginning in 2007. The initial search returned 7,585 unique records, and after screening based on title and abstract, 906 records were passed to full paper screening, which yielded 143 records for data extraction.

Sources were excluded from further consideration based on geographic location, lack of forward looking or solutions-oriented content, focus on engineered infrastructure rather than freshwater systems, or content related to marine systems, species that do not use freshwater at any life stage, or freshwater species with no or little focus on habitat. Sources that focused on terrestrial ecosystems or land management without a clear connection to freshwater were excluded. Judgments were applied during screening in recognition that many references to land and land management are inclusive of freshwater. An effort was made to remain open to very different types of projects aimed at managing or restoring freshwater social-ecological systems, or adapting to changes in these systems. Records that had a primarily legal or

educational context were considered beyond the scope of the review. Sources with no or very little IKS, or insufficient detail to inform practices for braiding Indigenous and Western knowledge systems, were also removed. For example, the initial search returned records that included nothing more than Indigenous representation at a meeting. The search also returned projects that included Indigenous Peoples through constitutionally mandated consultation. Consultation, however, does not necessitate active participation in decision-making (Craft and King, 2021), making such pieces inappropriate examples for respectful braiding – consultation can allow inequities to persist. The researchers engaged in regular dialogue to clarify and refine the inclusion criteria throughout the screening process.

The projects described in the 143 records retained after full-paper screening were not without weaknesses. These records included examples of projects that respectfully braided knowledges, but most were retained because they included content that might inform principles or practices for braiding in ethical ways, not because they were exemplars themselves. The idea of braiding or weaving had not entered the narrative at the time of the early records, but some of these sources still offered insights. The focus during data extraction was on the most promising elements for future projects that involve ethical braiding of knowledges in the management and restoration of freshwater systems.

Over half of the 143 records included were peer-reviewed journal articles, but dissertations, government reports, consulting reports and other forms of writing were also included. Many disseminated projects or studies originated from the Arctic (or Subarctic), the Great Lakes Basin and the Pacific Northwest, while there were a few records from the eastern and southeastern United States. The records represented a variety of freshwater topics, including fisheries management, dam regulation and removal, impact assessments, source-water protection, and climate-change monitoring and adaptation. They included a variety of principles for braiding knowledge systems. For example, many records mentioned the importance of establishing relationships with communities before commencing research or projects (Febria et al., 2022; Fox et al., 2017; Gérin-Lajoie et al., 2018; Wray et al., 2020).

2.2 Frameworks used to structure report

This report shares insights from Mehltretter's scoping review and cites additional literature to support the discussion. It organises the insights using two frameworks previously created by the authors. Principles for braiding are presented using an easy-to-remember framework: EAUX, the French word for waters. The plural form is used to reflect the multitude of ways water is in our lives, and the many ways in which we value it. The "E" in "EAUX" refers to "equity", or the importance of valuing different knowledges by staying humble, remaining open to different ways of knowing and challenging colonial hierarchies that privilege Western teachings. "A" is for "access", which is attained when collaborative projects respect data sovereignty and cultural and intellectual property. "U" is for "usability", the principle that the project will benefit Indigenous Peoples and that project partners will be responsive to community needs. Finally, "X" is used to highlight the importance of partnership "eXchanges". There must be ongoing communication between project partners, prior and continuous informed consent, and relationship building and maintenance.

The second framework is based on Brown and Dueñas's 2020 paper on research paradigms. Although set within the medical sciences, the paper illustrates how values and worldviews

influence research (Brown and Dueñas, 2020). This is especially meaningful when discussing bringing Western and Indigenous knowledge systems together, because Western science is often viewed as objective and, as such, superior to other forms of knowledge in settler-colonial societies. But, in fact, all ways of knowing are influenced by what we deem important (axiology) and how we see reality (ontology).

The Axiology to Application ("A to A") framework identifies different stages when knowledges may be brought together in a project: axiology and ontology; epistemology and methodology; data gathering; analysis and synthesis; and finally, application. Although this is a linear framework, in some instances the application of knowledge systems may reinforce or shift values and worldviews, creating a cyclical framework, more in line with Indigenous knowledge systems, and concepts of holism and relationality (Figure 2). The proceeding section presents explicit principles and methods for braiding knowledge systems, organised using the EAUX and A to A frameworks, with references to diverse projects where these principles

Figure 2. Axiology to Application (A to A) Framework (Mehltretter et al., forthcoming publication), Indigenous and Western knowledge systems (IKS and WKS) may be brought together at different stages of a project. Working to align, or at least understand different values (axiology) and worldviews (ontology) at the beginning (or before) a project helps to reveal where and how to braid knowledge systems. Application of new knowledges may include adapting values and worldviews resulting in a circular rather than linear model.
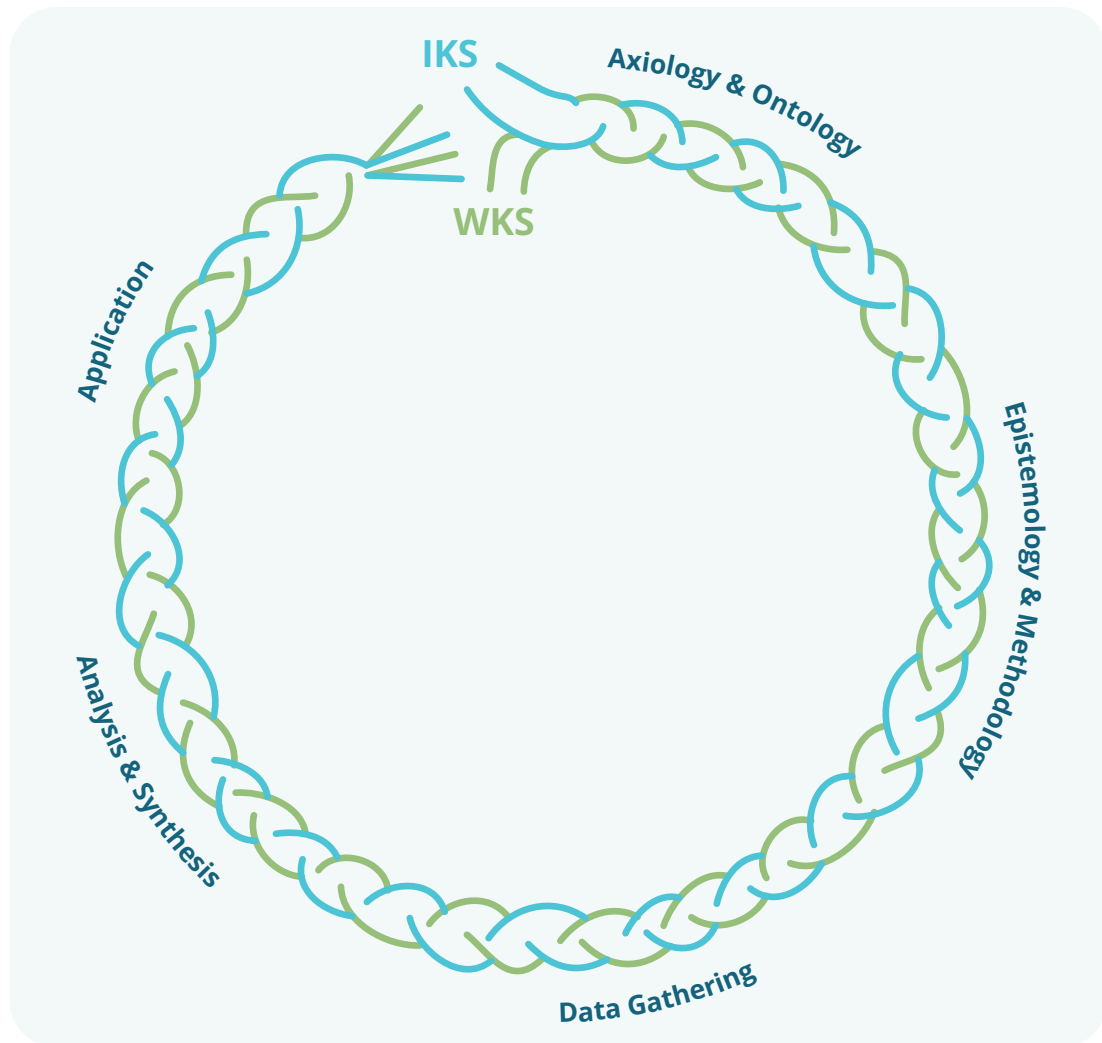
and methods have been developed. Readers are encouraged to consult the original sources for more context-specific information. Every project and community is unique, and while our report is intended to provide a helpful starting point, preconceived notions of what a community wants can be detrimental (Reo et al., 2017). It is critical to engage with Indigenous Peoples early, take a listening stance, and seek ongoing clarification and consent from each Indigenous group or community involved in collaborative work.

3 Discussion

Drawing on the Mehltretter scoping review, this discussion presents: (1) principles for braiding organised according to the EAUX framework, (2) foundations that support braiding, and (3) methods that have been used to braid knowledges at different project stages, from Axiology to Application. The final section provides illustrative examples to demonstrate knowledge braiding with more contextual detail.

3.1 EAUX principles

Nearly all the records studied included principles for working collaboratively with Indigenous Peoples. There are many acronyms to remember the principles (Carroll et al., 2022; Levac et al., 2018; Wilson, 2008), but for the purposes of this report the water-focused acronym EAUX captures the importance of Equity, Access, Usability and eXchange in collaborative projects, and especially when braiding Indigenous and Western knowledge systems. In some cases, further work is needed to build the foundations required for more aspirational dimensions of some of the principles.

3.1.1 Equity

Historically, Indigenous Peoples have been under-represented as investigators, or persons involved in shaping water projects. They were most likely to be invited into a project after the goals and methods were established by settler scholars and appeared only as informants (i.e. individuals whose primary data is analysed by investigators). The knowledge they shared with settler partners, used to fill gaps in Western science, reinforced hierarchical perceptions that IKS is less valuable than WKS (Wilson et al., 2015). This method betrayed a lack of respect for Indigenous knowledge systems, perpetuated colonial harms, and failed to honour Indigenous Peoples' sovereignty. In projects where Indigenous sovereignty is not accepted, Indigenous Peoples are not recognised for their intellectual contributions, and project decisions are not made equitably with Indigenous partners. The failure to honour Indigenous sovereignty discourages Indigenous partners from participating in future projects (e.g. Middleton et al., 2019) and hinders advances in establishing and maintaining respectful relationships.

In *equitable* projects, all collaborators honour Indigenous sovereignty. As Chief and Meadow (2016: 4) explain, "Tribes are sovereign nations who have the right to freely participate or disengage, and to fully know how their knowledge will be applied." Appreciating Indigenous sovereignty means understanding the community's history, including their cosmological views (Houde, 2007); recognising that Indigenous Peoples have their own governance structures

(Reo et al., 2017); and observing subtle changes in Indigenous Peoples' territory (Gill et al., 2014). Further, methods should align with sovereignty and self-determination (Fillmore and Singletary, 2021). For example, community-based monitoring programs that respond to the community's specific needs assert sovereignty (Wilson et al., 2018). The process of braiding Indigenous and Western knowledge systems itself can support sovereignty and self-determination (STACCWG, 2021), but only when Indigenous Peoples and their knowledges are respected and valued equitably (Reo et al., 2017).

Respecting Indigenous Peoples also means managing power imbalances that exist because of colonial histories. A first step toward equitable water projects is for non-Indigenous partners to recognise that power imbalance and to spread power among partners more fairly (Armitage et al., 2011; Mitchell, 2018). This means co-developing study protocols and including Indigenous Peoples in projects from the beginning (Reid et al., 2022; Reo et al., 2017). As Reid et al. (2022: 720) write, "Negotiating what constitutes, "good" research protocols in a specific community context is an important first step in challenging existing power imbalances, it emphasises self-determination and opens up lines of communication between the researcher and the community." Further, engaging in community cultural practices and ceremonies and following cultural norms in Indigenous territories demonstrates that partners respect their collaborators' different worldviews and ways of knowing, further balancing power structures within the team (Fox et al., 2017).

Fostering equity depends on recognising the contributions of Indigenous Peoples in water projects. Knowledge keepers in communities should be shown the same respect as Western science experts (BCEAO, 2020). It is up to the community, not external partners, to validate their credentials and assess their knowledge (BCEAO, 2020). Providing honorariums or some form of compensation is part of acknowledging the time and expertise knowledge keepers bring to the project (Gill et al., 2014; Goldhar et al., 2014; Herman-Mercer et al., 2019; Reid et al., 2022). For example, Goldhar et al. (2014) provided gas or food vouchers to thank community members for participating.

Contributions should be recognised in an equitable way when disseminating results. Authorship should include all Indigenous Peoples and organisations that make intellectual contributions to the project unless it is the individual or organisation's choice to be recognised in a different way. It is not possible to assess the inclusivity of authorship in the scoping review records. However, many of the documents did include Indigenous Peoples in the byline, and some also included Indigenous governments or organisations (e.g. Brunet et al., 2020; Febria et al., 2022; Fox et al., 2017; Gill et al., 2014; Hopkins et al., 2019; Hovel et al., 2020; Menzies et al., 2022; Sanderson et al., 2015; STACCWG, 2021; Wray et al., 2020). The nature of contributions made by Indigenous partners can be articulated in acknowledgement sections (Ermine et al., 2007; Lea et al., 2021; Strangway et al., 2016; Wilson, 2014), and there are ways to make recognition for these contributions more apparent. For example, Ermine et al. (2007) include the Elder acknowledgements on the first page of their document, immediately under the title. Kozich et al. (2020) acknowledge walleye, illustrating the authors' respect for worldviews in which fish are recognised as their own agents. Finally, a diverse bibliography can subtly suggest a belief that both settler and Indigenous thinkers produce work that can and should influence analysis.

Perhaps one of the most important ways to promote equity is by valuing each knowledge system equally (Abu et al., 2020; Baldwin et al., 2018; Gill et al., 2014; Knopp et al., 2017). BCEAO (2020: 7) explains that the two knowledge systems are "viewed as both equally valid and distinct ways of knowing that do not always align, overlap or necessitate validation from the other." Menzies et al. (2022: 518) quote a workshop participant who explains that collaborators should "never reduce Indigenous knowledge down to data." Others refer to the concept of ethical space as an approach to foster environments where both knowledge systems can be considered equally (Fox and Hatcher, 2022; Hopkins et al., 2019; Menzies et al., 2022; Sanderson et al., 2015). Knowledge equities can also be supported by using Indigenous words in dissemination, such as Indigenous place names on maps (Byam, 2013), fish names in studies (Kozich et al., 2020), or a glossary of Indigenous terms (Kuzivanova, 2016).

Ultimately, project equity is achieved by including Indigenous partners throughout the entirety of a project (see section 3.3 below) (Armitage et al., 2011; Chila et al., 2021; Gérin-Lajoie et al., 2018; Grimwood and Doubleday, 2013; Haring et al., 2021; Houde, 2007). Engaging with Indigenous Peoples from the beginning of a project demonstrates not only that partners value their expertise and knowledge systems but also that they recognise Indigenous sovereignty and rights to determine research with and for their Nation (Latulippe and Klenk, 2020; Reo et al., 2017).

3.1.2 Access

Access involves culturally appropriate project and data management that operates with respect for land, ancestors and all beings, but makes respect for Indigenous data sovereignty and cultural and intellectual property paramount. Indigenous data must be understood broadly. According to Stephanie Russo Carroll, these data include information "in any format that impacts Indigenous Peoples, nations and communities at the collective and individual levels" (*The CARE Principles of Indigenous Data Governance,* 2021). It can include information about Indigenous resources such as water-quality parameters, data about individuals such as health records and/or data about Nations such as ancestral boundaries.

A common approach to access applies the First Nations Information Governance Centre's OCAP® (Ownership, Control, Access and Possession) principles to protect knowledge holders and systems (FNIGC, n.d.). OCAP has quickly become the standard for data collection, research and governance of First Nations information. OCAP also aligns with the UNDRIP principles of free, prior and informed consent (Reid et al., 2020) and aims to ensure that research is "by, for and with Indigenous Peoples, and not just about Indigenous knowledge" (Fox and Hatcher, 2022: 2). OCAP principles are summarised here from the First Nations Governance Centre's website, which offers training and further resources.

Ownership means a First Nation, community or group owns information collectively in the same way that an individual owns his or her personal information. Control affirms that First Nations, their communities, and representative bodies are within their rights to seek control over all aspects and projects that impact them, extending to control of resources, review processes, and planning and management of information. Access asserts First Nations must have access to their information and data, regardless of where they are held, and have rights to manage and make decisions regarding access to their collective information. Possession or stewardship refers to the physical control of data. Possession is the mechanism by which

ownership can be asserted and protected. OCAP in what is currently known as Canada provides principles and sets a standard for relationships. However, each Indigenous Nation, community, or representative organisation will have varying capacity, whether it be human resources or financial for example, to implement some or all of the principles.

Depending on the type of project and scope of knowledge braiding, other instruments can be used (e.g. community protocols and approvals, university research ethics, government guidelines, and best practices for sensitive data). It is critical that project teams formalise agreements on data ownership and sharing (Matson et al., 2021), and understand that some traditional knowledge is sacred and not meant to be shared outside of families and communities (Sanderson et al., 2015). Indigenous control over data and information can be made explicit through a data availability statement in the backmatter of academic publications (e.g. Bingham et al., 2021).

The movement toward open-access publishing can also help to ensure that Indigenous Nations have free and independent access to information produced through collaborative projects. Results published behind a paywall can result in research inequities as university researchers are more likely to have free, ongoing access to the results through academic libraries whereas Indigenous collaborators are rarely afforded library privileges.

3.1.3 Usability

Another important principle for ethical braiding is *usability*. This means that the work must be "usable" by the community. When projects are initiated by Indigenous Nations in response to their interests, needs and priorities (Fox et al., 2022; Gérin-Lajoie et al., 2018; Hopkins et al., 2019; Shandro et al., 2017) then the benefit to the community is central to the project. When non-Indigenous partners eager to collaborate with Indigenous Nations initiate projects, it is easy to create projects that reflect settler needs and values but do not serve the Indigenous community. Instead, all project partners should be involved in identifying research questions, project goals and desired outcomes (Fillmore and Singletary, 2021). As Gérin-Lajoie et al. (2018: 392) explain, "The utility of information may vary for academics who may use it for research, communication and teaching, and for communities who may use it for decision-making, influencing policies, and protection of their living environment and lifestyle."

Making sure that projects are usable for communities may require several iterations of goals and objectives, which requires partners to be patient and adaptable. For example, Gill et al. (2014) adapted their community-based monitoring plan when the Gwich'in people of the Lower Peel River Watershed requested objectives centred on intergenerational knowledge exchange and youth training. Sometimes objectives such as these may feel somewhat tangential to a Western audience; however, for the community, achieving these goals is central to a project's success. Gill et al. (2014: 308) explain that "our trips were not highly structured, and land users often included breaks to warm up by a fire, have a snack or meal, or harvest traditional foods. Youth volunteered or were encouraged to pick berries, shoot ducks, build fires, chop wood and camp on the land with the guidance of more experienced land users." Being flexible and responsive to Indigenous collaborators' needs is essential to successful knowledge braiding.

Even in projects involving multiple communities, it is important to facilitate the opportunity for each community to centre their own priorities. For instance, Parlee et al. (2021) report

on a network of community-based monitoring programs in the large interjurisdictional Mackenzie River Basin in what is currently known as Canada. Although the objective was to establish a network of monitoring programs that could be synthesised to understand environmental change in the basin, each community was encouraged to include their own program priorities and objectives. General terms of reference were provided to participating communities to ensure some level of consistency; best use of the results, however, was determined at the local level (Parlee et al., 2021).

Usability is also important in later stages of a project, even after goals and priorities have been aligned among partners. Further, it is important to disseminate project results in a way that is accessible and useful to the community. Eisner et al. (2012) developed a web-based geographic information system (GIS) to return the study results to the community in a format they could interact with online. The "Iñupiaq Web GIS" was designed to perform when band-width is limited and on older computers. It included a tutorial so those unfamiliar with GIS could learn to navigate the website (Eisner et al., 2012). Using open-access publications (e.g. Donkersloot et al., 2020; Luby et al., 2021), making data available online (e.g. Gill et al., 2014; Hayman et al., 2017), or sharing knowledge through alternative forms of dissemination, can also make information more usable.

As with the other EAUX principles, ensuring usability requires that Indigenous communities be involved in the project from the beginning or, better, that the project be initiated by the community (Gérin-Lajoie et al., 2018; Hopkins et al., 2019; Menzies et al., 2022; Reid et al., 2020; Sanderson et al., 2015). Non-Indigenous collaborators must acknowledge that the needs and priorities of their Indigenous partners may differ from their own, and they should not assume that a project will benefit the community. When projects are "responsive and accountable to community priorities [they can] help build capacity and ensure greater autonomy among Indigenous Peoples" (Day et al., 2020: 12) in decision-making processes related to water.

3.1.4 eXchange

There should be continuous *eXchange* among groups throughout a project. If relationships are new, additional time will be needed to build trust. Early involvement is key and connects to the other EAUX principles. Project objectives that are responsive to Indigenous interests can be developed, and it can be determined how the collaboration will unfold. Reo et al. (2017: 65) found that "memoranda are effective ways of ensuring that Indigenous Nations' expectations for fledgling partnerships are fully understood." Matson et al. (2021: 112) remind us that meeting the obligations of established protocols, "even a tribally established process – is a floor and not a ceiling for respectful partnerships."

Reciprocity includes ensuring that Indigenous Peoples are fairly compensated for their time and contributions. In studies of muskrat and whitefish, described by Hovel et al. (2020), community-based researchers and knowledge holders were hired or awarded honorariums at daily compensation rates set by community Renewable Resource Councils, and this rate was consistent across communities. Matson et al. (2021) underscore the importance of compensating contributors – conference participants, youth drummers, Elders and others – to their collaborative manoomin project. Compensation should follow appropriate customs and can take a variety of forms, such as payments, travel reimbursements or gifts.

Indigenous communities and organisations have many demands on their time. While land users may be the very experts that can provide knowledge and guidance for a project or co-management board, the time it takes to engage in this work is time away from the land. There may also be cultural events that will take priority over other activities, and community tragedies that will require postponing work. Building trust requires respectful navigation of such challenges.

Following the cultural protocols of a host community helps with power dynamics and sets the tone for doing work in a good way (Fox et al., 2017). Creating unstructured spaces for ongoing dialogue, sharing meals and engaging in non-project-related activities are all valuable for developing respectful relationships (Gérin-Lajoie et al., 2018).

The best communication methods will depend on community preferences and the intended audience, and they will be subject to change. Sanderson et al. (2015: 141) describe a project that aimed to "achieve a transfer of knowledge between generations (Elders to youth), between cultures (Stellaquo and others), and across disciplines." Quaempts et al. (2018) hoped to share their First Foods approach to water management with a diverse audience, including nontribal students and adults, through outreach and education events, tribal members through open houses, General Council meetings, and feasts, and academic audiences through a peer-reviewed publication. Armitage et al. (2011) emphasised that co-management leaders wanted information to be presented verbally and in writing in a manner understandable to all; to that end, the language was kept simple, without scientific jargon.

3.2 Foundations for braiding

EAUX principles can be achieved and further enhanced within a stable socio-legal foundation for Nation-with-Nation projects, including four key components (1) recognition of Indigenous rights and responsibilities, (2) relationships between Indigenous and settler professionals, or time to build those relationships, (3) resources and funding that value different ways of knowing, and (4) protecting Indigenous knowledges in a rapidly changing environment. In many contexts, further work is needed to build the foundations to realise the EAUX principles required for respectful and ethical braiding of Indigenous and western knowledge systems.

3.2.1 Rights and responsibilities

Knowledge braiding can be enhanced through government policy commitments and legal structures that honour Indigenous Peoples' rights and institute mechanisms to involve Indigenous Nations in decision-making that impacts water. In their case study of the co-management of Dolly Varden Char in the Western Arctic, Armitage et al. (2011) found that the legislated co-management structure established under the Inuvialuit and Gwich'in land claims agreements enabled the bringing together of knowledge systems. In their discussion of three dam removals in the United States, Fox et al. (2022) reveal that a Tribe's recognition by the federal government determined its access to the funding needed to undertake studies or to work within existing Western legal structures, which were essential to restoring the Elwha, Penobscot and Ottaway Rivers (Fox et al., 2022).

Honouring inherent and treaty rights begins to lay the foundation for more recent efforts to bring knowledges together. Fisheries and Oceans Canada (2020) describes agreements, strategies and policies that implement the recognition of First Nations rights in fisheries

management. For example, many of the Yukon First Nation Final Agreements include frame-works for Indigenous representation on the Yukon Salmon Sub-Committee. For First Nations without formal agreements, the Aboriginal Fisheries Strategy (Government of Canada, 1992) recognises the Canadian government's obligation to provide "First Nations the opportu-nity to harvest fish for food, social and ceremonial (FSC) purposes." The Aboriginal Aquatic Resources and Oceans Management program provides funding for First Nations engagement in fisheries management, and seeks to connect First Nations with one another to develop fisheries management at the watershed or ecosystem scales (Fisheries and Oceans Canada, 2020). The "Indigenous Knowledge Policy Framework for Policy Reviews and Regulatory Deci-sions" (Government of Canada, 2021) provides another stone for the foundation. Legislation may articulate what should be done but much other work is needed to bridge the gap, or gulf, to implementation. The policy framework includes principles to guide federal officials in applying the Indigenous knowledge provisions of Acts, including the Fisheries Act. It suggests two-eyed seeing and ethical space as useful approaches to bring together Indigenous and western knowledge systems to better understand project impacts. It also identifies the need for federal agencies to develop clear guidance, processes and policies for the meaningful consideration of Indigenous Knowledge to support project reviews and regulatory decisions.

While legislation can encourage Nation-with-Nation consultation, it can also limit Indigenous Nations' governing authority. For example, the Integrated Fisheries Management Plan is approved by federal officials considering recommendations provided by the Yukon Salmon Sub-Committee, which includes First Nations representatives (Fisheries and Oceans Canada, 2020). This means that First Nations' wishes are presented to determining authorities through an intermediary body; First Nations may not have direct access to or influence over deci-sion-making authorities. While there is some recognition of Indigenous Peoples' Aboriginal Right to fish (e.g. access to traditional foods), this reporting framework reinforces rather than challenges Canada's so-called authority over fisheries. This is reflected, linguistically, in reports that identify fish as belonging to the *Canadian* government. Respectful and ethical braiding of knowledge is not achieved if Indigenous Peoples share knowledge without a subsequent influence in decision-making.

3.2.2 Relationships and understanding

Pre-established relationships facilitated many of the projects (Fillmore and Singletary, 2021; Fox et al., 2017; Herman-Mercer et al., 2019; Parlee et al., 2021; Wilson et al., 2018). Even for those without existing relationships, having a liaison, or someone both parties know and trust, was associated with improved project outcomes. For example, Wolfe et al. (2007) noted that while the research team had not worked with Dené and Métis near Fort Resolution before, some Elders had worked with a researcher, from the same research institution, in the 1970s. This common connection helped establish a relationship, which the authors believed was foundational to bringing together WKS and IKS (Wolfe et al., 2007). Similarly, graduate students' reflections on working with Indigenous communities reveal that leveraging their supervisor's relationships with communities helped accelerate the process (Wray et al., 2020: 12). For example, a student shared, "I have had the fortune to be in this situation ... When the trust has already been built up for you, it can be a great privilege to have yourself intro-duced by someone, or to introduce yourself and say that you're associated with people that community members or organisations already know." Even when strong relationships exist between collaborators, effective braiding is often supported by bridging organisations (Wilson

et al., 2018) or people who serve as cultural translators. Bridging organisations are those that connect groups, locations and worldviews (Tengö et al., 2017). Cultural liaisons or community-based researchers can help build understanding across cultural differences (Marshall et al., 2020; Reo et al., 2017).

Regardless of existing relationships or the presence of cultural liaisons, non-Indigenous project partners must start with at least a basic level of competency regarding cultural traditions and histories and values, and be committed to ongoing cross-cultural learning, which requires humility and openness (Reo et al., 2017). For example, in the removal of the Elwha Dam, the US National Park Service facilitated treaty training for all staff working with the Elwha Tribe in an attempt to better understand the values and rights of their collaborators (Harguth, 2013). Similarly, Indigenous awareness of institutional culture is associated with improved working relationships (Brunet et al., 2020).

Relationships must also be maintained and nurtured. Reo et al. (2017) investigated 39 case studies of multi-actor collaborations involving Indigenous Nations in the Great Lakes Basin to identify factors that helped Indigenous Peoples remain engaged in the project. The six factors identified were Respect for Indigenous Knowledges, Control of Knowledge Mobilisation, Intergenerational Involvement, Self-Determination, Continuous Cross-Cultural Education, and Early Involvement. Including these characteristics into a project not only helps keep Indigenous Peoples engaged throughout a project, but more importantly it demonstrates respect for their values and priorities, which reinforces positive long-term relationships. As Reo et al. (2017: 8) explain, the successful projects they investigated all "created structures that enable Indigenous participation on terms that respect their own conceptions of political authority, inclusion and culture."

3.2.3 Resources

Sufficient funding is essential for all projects; however, when it comes to braiding IKS and WKS, funding bodies must also support the time and resources required to do community-engaged work (Buell et al., 2020). Febria et al. (2022) explain that in Western science, grants often cover student stipends, research costs, publication costs and conference travel, but not the resources required to establish trusting relationships, hire community research assistants/connectors (full-time), or facilitate community engagement. Funding can help ensure that Indigenous Peoples engaging in the project – whether as consultants, translators, guides, knowledge keepers or researchers – are fairly compensated for their time and expertise. In some instances, Indigenous Nations may also commit these services as an in-kind donation to signal their investment in collaborative research (Luby et al., under contract). In long-term projects, such as community-based monitoring, funding that continues after non-Indigenous partners leave the territory is needed. Gérin-Lajoie et al. (2018: 393) comment that "long-term funding is an essential condition for making initiatives such as the IMALIRIJIIT program sustainable. It needs commitment from local and regional institutions as well as from government agencies, with academic institutions in support."

Although funding is an important resource, personnel and expertise are also necessary. In the networked, community-based monitoring program in the Mackenzie River Basin, when individual communities had insufficient experience or capacity to design and deliver the programs, the collaborating academic institutions sent researchers to support community

initiatives (Parlee et al., 2021). Training community members builds capacity within Indigenous Nations (Atlas et al., 2017; Chief and Meadow, 2016; Gérin-Lajoie et al., 2018) and helps to sustain long-term initiatives.

3.2.4 Protecting indigenous knowledges

Even with a solid legal, relational and financial foundation for braiding knowledge systems, applying Indigenous knowledge is no guarantee of mutually benefiting research outcomes. The environment is changing at an alarming rate, which raises concerns regarding whether Indigenous knowledges are still valid under ever-changing conditions (Kozich et al., 2020). This is not because Indigenous knowledges are static. In fact, Indigenous knowledges (IK) have adapted for millennia (Indigenous Corporate Training Inc., 2018). But it takes time to learn how different species (and their interactions) are affected by and respond to environmental alterations, and the rate of change may be outpacing relation-focused IK creation (Kozich et al., 2020).

At the same time, many Indigenous Nations are concerned that knowledge loss is outpacing intergenerational knowledge transmission, and projects are underway to document IK before knowledge holders pass on (Herman-Mercer et al., 2011, 2016). Protection and creation of Indigenous knowledge is intimately connected to the protection of Indigenous land, rights and languages (Latulippe and Klenk, 2020).

3.2 Axiology to application: The A to A Framework

When a foundation for braiding Indigenous and Western knowledge systems is set, braiding is possible at all stages of a project. Rather than starting at the data gathering stage where braiding may seem more obvious, it is preferable to align, or at least understand one another's different values and worldviews early in a project. This initial work facilitates braiding while developing methodologies, gathering data, analysing and synthesising information, and applying knowledges.

3.2.1 Axiology and Ontology

In the context of a freshwater project, "axiology" refers to values that motivate the project whereas "ontology" refers to a project team's beliefs about the nature of reality (Brown and Dueñas, 2020). Braiding at this foundational stage should not be neglected. How can a project be successful if it does not deliver what Indigenous Peoples' value in ways that are culturally grounded? Buell et al. (2020) describe differences in perception of risk between Transport Canada and the Saugeen Ojibwe Nation in relation to contaminated sediments in Owen Sound Harbour. Dismantling an existing environmental assessment approach and re-creating a new approach in partnership with Saugeen Ojibwe Nation required going back to the values of each knowledge system. Atlas et al. (2022) contrast values in Western management with Indigenous caretaking of fisheries, and stress the need to centre Indigenous values, which emphasise multi-generational sustenance and reciprocity. The belief that water is a spirited being – a relation – is at complete odds with the settler-colonial view of water as a resource, and this disharmony must be quieted if not resolved in projects that aim to braid knowledges. For Indigenous Peoples, who do not place humans at the top of a hierarchy of beings, source-water protection that does not consider an ecosystem's needs is misguided. Leonard (2021: 844) notes that hard engineering and built infrastructure adaptation strate-

gies "are misaligned with Indigenous ways of knowing as they do not … prioritise non-human relations and environment over human benefits and use." Leonard (2021: 843) also explains that the militarised language used in predominantly western adaptation strategies (such as the "attack" response) is "antithetical to Indigenous epistemologies for adaptation to environmental change that centres on kinship, relationality and ecocentric value systems."

Non-Indigenous participants should be well informed about worldviews and values related to water that cross Indigenous cultures. They will then be in a better position to understand distinctive aspects of the Indigenous Peoples with whom they are working. Matson et al. (2021: 113) recommend listening carefully, "because stories are a way for Indigenous collaborators to subtly but meaningfully inform researchers about cultural codes, expectations and priorities." Participating in traditional activities alongside knowledge holders is a way to learn about the practices and Indigenous values (e.g. Bolton and Davidson-Hunt, 2014). Without these culturally rich experiences, contextualised Indigenous knowledge may not be translated successfully across cultural boundaries (Bolton and Davidson-Hunt, 2014). When invited, participating in ceremonies and community events is another important way to gain an understanding of beliefs and values (e.g. Fox et al., 2017; Wray et al., 2020).

Perhaps braiding at this stage can be described as reflexive thinking and respectful dialogue (which emphasises listening) with a conscious effort to continually centre Indigenous perspectives. In a study of freshwater mussel health in the Lower Athabaska region led by McMurray Métis, it was found that "beginning with reflexivity regarding our knowledge systems, including the ways in which they may collide or converge, the Clam Team creates a safe, ethical space in which we 'learn together' about freshwater mussel health" (Hopkins et al., 2019: 327). The Clam Team recognised that "various ways of knowing and understanding our world may be incongruent and distinct, and in areas where we cannot braid our knowledge systems, we can still learn together, which includes a large dash of humour, laughter and fun" (p. 328).

In consideration of Indigenous Cosmos views, in which everything is connected, more holistic, systems-based approaches, including ecosystem-based management which considers more than a single species, may be better aligned than the reductionist approaches commonly employed in Western science. For example, "The Wuikinuxv Nation envisions an approach to a fishery that aligns with the Nation's values to sustain its people and provide for bears and the ecosystem" (Adams et al., 2021: 365). The Fond du Lac Band of Lake Superior Chippewa recognises the importance of *baapaagimaak* (also known as black ash) to the hydrology of the watershed that feeds and drains manoomin lakes. The emerald ash borer, a wood-boring beetle, is devastating baapaagimaak, and the loss of transpiration is expected to exacerbate water-level fluctuations, to which manoomin is sensitive (STACCWG, 2021). Matson et al. (2021) also note that Tribes favour holistic approaches to care for manoomin, whereas state agencies focus on single, isolated stressors.

Indigenous Peoples' relationship with the land is important to their physical, mental and spiritual health and well-being (Galway et al., 2022), and in many cultures the well-being of people is deeply connected to their ability to fulfil their responsibilities as caretakers. Approaches that "centre connectedness and reciprocity with the land and natural world, nourish Indigenous Peoples' resilience" (Galway et al., 2022: 2).

Menzies et al. (2022) prioritised more holistic approaches to climate-change research. Some participants recognised the need to study the system rather than simply the species, and some participants viewed holistic approaches as those that promote environmental, physical, emotional, spiritual and cultural well-being. In a study identifying the impacts of climate change and the capacity for adaptation in two Saskatchewan First Nations, Ermine et al. (2007) used a holistic framework that emphasised interconnections between social, cultural and natural systems. In recognition that tribal worldviews, experiences and responses embody interconnectedness, STACCWG (2021:12, 13) recommends that researchers, "when developing climate-change solutions, recognise the interconnectedness of systems and consider strategies that achieve multiple objectives"; "connect solutions to tribal values and priorities"; and "recognise the tangible and intangible significance of climate change impacts." Water-based social-ecological systems have emerged as a framework for assessing resilience and adaptive capacity but may need to be extended to embrace spiritual connections. Craft and King (2021) document the process of developing the Nibi Declaration, which advances watershed planning and ensures the spirit of Nibi is central to decision-making within Treaty #3 territory.

3.3.2 Epistemology and methodology

The next stage of braiding – epistemology – is concerned with the nature of knowledge, recognising that there are different ways of knowing, different sources of and ways to generate knowledge, and different perspectives on the limits of knowledge. Epistemology is intimately connected to methodology, which can be defined as the approaches taken to access knowledge.

Land and water are spirited beings recognised as teachers by many Indigenous Nations. Other-than-human beings are sometimes acknowledged in papers and reports (e.g. walleye in Kozich et al., 2020), and occasionally as a co-author (e.g. river in Manikuakanishtiku et al., 2021), suggesting their agency. Thus, it is not surprising that Indigenous knowledge is generated through intimate interactions with the land, and is embedded in language and place names. Spending time on the land, in a place, with knowledge holders, is a common approach to learn about Indigenous knowledge systems. Activities such as shore lunches, forest walks and paddling rivers with knowledge holders, help build respectful relationships and are opportunities to learn about values and cultural practices. "There are more ways to see, hear, learn and engage" (Matson et al., 2021: 113) than Western training, which prioritises lectures and book learning, suggests. In addition to learning from the land, in some cultures Elders or knowledge keepers may gain knowledge from the Creator or ancestors through ceremonies or other spiritual means. Indigenous knowledge systems are often described as place-based, but STACCWG (2021) emphasises that they are far from static or limited in their geographic usage.

Braiding at this stage, at least in projects that are non-Indigenous led, includes co-developing methods to ensure projects are culturally relevant. Indigenous-based epistemological tools provide a strong basis for projects aiming to braid knowledge. Dumont's Indigenous Intelligence, which uses intelligence of the mind, heart, body and spirit as a unique way of seeing, relating, thinking and being, was used as a conceptual framework in an exploration of humanity's relationship to water (Chiblow, 2021) and could be employed in projects that braid knowledges. Reid et al. (2022: 723) found that a salmon's life cycle and migratory path

provided an "insightful means of connecting with cultures and communities". Donkersloot et al. (2020), a cross-disciplinary, cross-cultural team, use a well-being framework to assess the sustainability and equity of salmon fisheries. The Confederated Tribes of the Umatilla Indian Reservation developed a First Foods (including fish) management approach based on reciprocity and the desire for a resilient and functional ecosystem to sustain people according to the Creation Story (Quaempts et al., 2018). A variety of frameworks – for example, Indigenous decolonisation or Indigenous agency – have been used to assess climate-change impacts through an Indigenous lens (STACCWG, 2021).

There is an excellent opportunity for braiding in the selection of project metrics. The Great Lakes Wild Rice Initiative (2020: 15) selected 12 metrics to describe how manoomin "contributes to maintaining connections with the Anishinaabe culture, how ecological functionality is supported and resilient to changing conditions and how continued learning and sharing of Anishinaabe values are promoted." Displayed in the form of a dream catcher, the nine cultural and ecological metrics appeared inside the hoop around the Anishinaabe metric; three cultural and ecological education metrics hung below. In their multiple case-study analysis of river-restoration activities, Fox et al. (2017) found healing rivers and Indigenous communities to be inseparable. Restoration requires paying attention to cultural and spiritual understandings of the rivers and human dimensions that extend beyond values that can be measured, modelled and optimised.

The concept of cultural keystones has been used for species that have particular importance to the integrity of social-ecological systems. According to Noble et al. (2016: 1), cultural keystone species "influence the cultural identity of a group of people via the species role in subsistence, spirituality and/or Indigenous economies … Maintaining connections to these species through traditional practices is crucial for the social-ecological resilience of indigenous cultures." Pacific salmon are cultural keystone species for many Indigenous Nations, but they are also recognised as ecological keystone species and the focus of management because they are important to settlers. In other cases, identifying cultural keystone species is a way to bring species into focus that would not be recognised in Western science and colonial structures. In the environmental-risk assessment described by Buell et al. (2020), whitefish was chosen because of its cultural and economic importance to Saugeen Ojibwe Nation, rather than salmon, a species introduced into the Great Lakes. Pacific Lamprey are a culturally significant species to the Yurok and Karuk Tribes in the Klamath River Basin (Peterson Lewis, 2009). Similarly, Mi'kmaq, in what is currently known as Atlantic Canada, value the American Eel (Ka't) for the nutrition it provides their people, notably as First Foods (for babies) and Last Foods (for the elderly) (Noble et al., 2016). Noble et al. (2016) suggest that recognising cultural keystone species could be a step toward increased adoption of IKS in co-management and Indigenous custodianship. Cultural keystone species may also be useful in projects aiming to braid knowledges.

When methods are co-developed, they are more likely to be culturally appropriate. For example, some Western sampling methods can be disrespectful to other-than-human beings. Elders of the Niisachewan Anishinaabe Nation requested that sampling of manoomin be done at the end of the growing season to help ensure the plant could live the fullest life possible (Luby et al., 2021). The Anishinaabe protocol followed by Buell et al. (2020) requires that sampled fish be used completely so no part is wasted. Similarly, Knopp (2017: 4) noted that "the community requested that sampled fish . . . be returned for human consumption" in

the Inuvialuit Settlement Region. Wolfe et al. (2007) implemented a traditional knowledge (TK) study in concert with ongoing hydroecological studies in the Slave River Delta. The authors describe the development of the TK component as collaborative and incremental. Although there was support for the project, there were concerns about how TK would be used, so a steering committee developed a protocol. Protocols may include offerings to Elders and other-than-human beings to give thanks for the knowledge shared (e.g. Luby et al., 2021).

Although we provide several examples of co-developed methodologies, they are not comprehensive. It is of the utmost importance that Indigenous Peoples have the opportunity to take the lead in developing methods that are suited to their communities. Craft (2017) describes how the methodology in the *Anishinaabe Nibi Inaakonigewin* (Water Law) project changed with time as relationships evolved. She emphasises that "listening to those who have sacred, ancient and cultural knowledge and allowing them to define the process for learning" (Craft 2017: 116) was instrumental to their approach. She concludes, in fact, that the methods used for knowledge exchange, such as ceremony, song and storytelling, are not actually the methodologies, but rather the methodology is creating the space for knowledge transmission and generation to happen. Latulippe and Klenk (2020) describe this as "making room and moving over" so that Indigenous knowledge systems are centred.

3.3.3 Data gathering

In projects that involve bringing together Western and Indigenous knowledges, both Western and Indigenous methods may be used to gather data. Ideally, the braiding will begin at earlier stages so that methods can be co-developed to ensure cultural relevance and appropriateness. Here, we identify common approaches with the caveat that data cannot be separated from their context without a risk of misinterpretation and harm.

Workshops or meetings are sometimes used to gather data. During these events, facilitators can provide additional explanations to participants and make adjustments to their delivery if concerns are voiced. The Magnetawan First Nation hosted a two-day "Guardians in a Changing World" workshop (Menzies et al., 2022). Each day opened and closed in ceremony. The 37 participants were divided into four sharing circles, "an Anishinaabe data gathering and knowledge sharing method allowing for non-hierarchical, open conversation that facilitates a transfer of knowledge, storytelling about lived experiences and observations" (Menzies et al., 2022: 513). Facilitators met and reported back the five most common responses for each theme, and allowed participants to place a sticker on the response they thought was most important. This approach extended into the analysis to ensure that the knowledge and views shared were not misinterpreted.

Semi-structured interviews are common; some structure helps to draw out information relevant to project goals but leaves space for rich narrative and storytelling. Visual prompts, such as maps and photos, can elicit knowledge sharing. Individual interviews are most common, but small groups of Elders or other knowledge holders can discuss how to convey knowledge in a non-native language in a way that loses as little meaning as possible (Morrison, 2012). Hopkins et al. (2019) describe land-based interviews, where the project team goes to current or historical sites of freshwater clams and listens to place-based stories and the lived experiences of Elders and land users.

Many studies incorporate data gathering (through observations and conversations) while participating in cultural activities such as fishing or ricing. Peterson Lewis (2009: 6) noted that "while a person was in the act of eeling, making an eel basket, or cleaning a lamprey, it often triggered thoughts and ideas about the species and the river system that they may not have thought of during a more formalised interview." Despite engaging with 18 First Nations, Reid et al. (2022) recognised the importance of spending time in fish camps. In work with Inuit in Ulukhaktok, Pearce et al. (2010: 162) found that experiential trips on the land "helped contextualise information shared by interviewees about the local environment and harvesting activities." These activities provide the opportunity not only to learn from knowledge holders but also to learn directly from other-than-human beings. Fox et al. (2017) identified the need to listen carefully to the patient – the river – before considering diagnosis or treatment.

Projects that braid Indigenous and Western knowledges often incorporate community-based monitoring. Ideally, Indigenous partners will lead or at least co-develop the monitoring program so that the data gathering is relevant and culturally appropriate. However, some of the projects reviewed were weak at the axiology and epistemology stages before coming together at the data gathering stage. Some projects relied heavily on Western metrics and methods, but at least included training the community members responsible for the monitoring. Although not ideal, Indigenous Peoples who engage in monitoring using Western approaches bring their worldview to the field, so braiding may happen on the ground. Stenekes et al. (2020) found that members of the Kátł'odeeche First Nation used smell and taste as well as visual observations to monitor fish health. Engaging in monitoring is a way for Indigenous Peoples to enact their caretaking responsibilities with benefits for communities (Wilson et al., 2018). They can also trust the data that they have gathered (Brunet et al., 2020). These are among the goals of Indigenous-led Guardians programs, which are expected to be key initiatives for stewardship and conservation as well as community healing (Reed et al., 2022).

Concerns have been raised about the use of maps to gather Indigenous knowledge. One challenge is that part of the meaning of recorded knowledge is lost if it is extracted from its holder and the context in which it was created (Houde, 2007). However, new approaches are emerging. In a project to document Gwich'in observations of environmental change, participatory multimedia mapping was used (Gill et al., 2014). Pairs of youth and experienced land users made on-the-land trips and geotagged photo and video observations. This approach is culturally coherent because it connects with the everyday activities of land users. The photos and videos served as prompts for in-depth, semi-structured interviews. Content from the interviews was added to the web-based mapping after participants reviewed it. A steering committee reviewed the results and provided direction on the project methodology and outcomes (Gill et al., 2014).

3.3.4 Analysis and synthesis

Braiding at the analysis and synthesis stage takes many forms depending on the nature of the project. In several projects, braiding was absent or weak at the analysis stage. Indigenous partners reviewed analyses or reports prepared by Western partners and identified misinterpretations or culturally inappropriate conclusions, but "braiding" requires something more. Western and Indigenous observers often make similar observations, but the context for interpreting their significance differs (Cochran et al., 2013). Successful braiding requires

collaborative approaches that actively engage and centre Indigenous voices or, better yet, Indigenous-led approaches.

Workshops are commonly used at this stage, and some methods of delivery are more likely to achieve co-interpretation of results. A series of workshops promotes continuous exchange throughout a project and breaks the work up into smaller packages. Some workshops include presentations to share information but also give many opportunities for participants to be heard in break-out groups or similar forums. In their study of climate change and water at Stellat'en First Nation, Sanderson et al. (2015) used workshops and small groups to discuss climate impacts, potential solutions, strategies for action, and the needs for further education and research. Day et al. (2020) describe two water gatherings with First Nation, Inuit, Métis and non-Indigenous participants at the Wabano Centre, which has Indigenous-inspired architecture. Respectful engagement was achieved in sharing circles, "an approach to group dialogue and healing that is based in ceremony, in which each person has a turn to speak and be heard free from judgement, and where all voices and knowledges are valued equally" (Day et al., 2020: 4).

Braiding can be propelled by team members who already walk with a foot in each world and who may have struggled to integrate worldviews during their lives. Shultz et al. (2022) consider restoration strategies within the Western resist-accept-direct framework alongside Indigenous teachings. "The [Lac du Flambeau Band of Lake Superior Chippewa] Tribe relies on *ogaawag* in the Ceded Territories of the Upper Midwest for cultural, spiritual, ceremonial and subsistence needs, so the reaction by tribal members and leadership was to resist these changes" (Shultz et al., 2022: 395). To honour the teaching to maintain resources for the next seven generations, a rehabilitation plan was implemented in the Minocqua Chain of Lakes. Unfortunately, results suggested that it may not be possible to achieve the goals on all the lakes. Shultz et al. (2022: 403) acknowledge that "accepting ecological transformations may be difficult for Ojibwe Tribes" but posit that harvesting *ashiganag* (largemouth bass) instead of *ogaawag* (walleye) may be considered consistent with the teaching to "accept the gift that was given".

The Assembly of First Nations (2008) identifies climate-adaptation strategies that may be more culturally appropriate in various contexts. A participant at the "Tribal Leaders Summit on Climate Change: A Focus on Climate Adaptation Planning and Implementation," hosted at Arizona University in 2015, commented, "We have always adapted using traditional knowledge. The challenge now is to record it and integrate Western science into our adaptation. We also need to help the rest of the world understand our knowledge and priorities" (Chief and Meadow, 2016: 5). Leonard (2021) presents "adaptation principles reflective of Indigenous resilience" (p. 842) and the WAMPUM adaptation framework that embraces "eastern coastal Indigenous knowledge systems and ways of knowing" (p. 843).

Mapping and spatial analysis are used in diverse freshwater projects. The EAUX "access" principle is critical; Indigenous partners must control what is mapped and who will have access to the information. As stated by Chief and Meadows (2016: 2). "Each tribe has their own unique authority for traditional knowledge, how the knowledge is transferred through time and space, and who may hold that knowledge." Some knowledge is sacred, and it may be culturally inappropriate to include such information on maps. Indigenous communities may not want to reveal the habitats of species that have subsistence, spiritual, cultural and economic

values. Nevertheless, spatial analyses are commonly used. Some authors have considered ways to apply approaches, such as qualitative GIS (Byam 2013), that expand "the use of digital mapping to bring together multiple epistemologies, analytic approaches and modes of knowledge formation" (Byam, 2013: 72) and multimedia extensions of Google Earth (Hayman et al., 2017: 71) that enable place names to be spoken and heard. Multimedia mapping can also be used to document information that is highly descriptive, context-rich and culturally rooted.

Outputs were given special attention in the studies reviewed, including the following: texts that incorporate visual elements, such as a Dreamcatcher to illustrate the study's culturally relevant metrics (Great Lakes Wild Rice Initiative, 2020); a quilt with squares illustrating Elders' messages (Galway et al., 2022); and podcasts that feature Indigenous voices (Day et al., 2020). Reports authored by both Indigenous and non-Indigenous agencies intended for broad audiences often included text boxes or coloured text elements to educate readers about Indigenous knowledge and provide content in the voices of Indigenous Peoples. A message that emerged is the extent to which knowledge is embedded in original languages; important nuances of Indigenous languages may be lost in translation to English. A number of the reports, dissertations and journal articles, included species names and water-related terms in original languages (e.g. Byam, 2013; Kuzivanova, 2016; Morrison, 2012; Noble et al., 2016).

3.3.5 Application

Before deciding on a path, Indigenous Peoples may consult with ancestors or other spiritual beings. The development of the Nibi Declaration was led by women who have a "sacred responsibility to water and a relationship to Creation because of their ability to give life" (Craft and King, 2021: 532). Elders provided guidance for a "community and nation-based engagement that was rooted in ceremony" (Craft and King, 2021: 532). The Declaration was "taken to ceremony and feasted" (Craft and King 2021: 532).

Knowledge may also be applied through ceremony. A specific example is the First Salmon Ceremony practiced by many Indigenous communities from Alaska to California. Atlas et al. (2021) describe how a short-term suspension of fishing following the ceremony will allow the first returning fish to reach their spawning grounds. Such practices maintain sustainable harvests and fulfill caretaking responsibilities to ensure that salmon continue to give themselves in a reciprocal relationship essential to the survival of the people.

We only reviewed projects if they articulated their benefits for Indigenous Peoples and communities. In many cases, the process of conducting the study was beneficial in itself (Dubé et al., 2013). Knowledge co-developed in braiding projects may be applied in many ways by various groups. Waskaganish First Nation used the results of a community-based monitoring program to identify mitigation measures to restore a cisco fishery after diversion for a hydroelectric project (Strangway et al., 2016). Wabaseemoong Independent Nation implemented aspects of a manoomin ecocultural restoration plan (Kuzivanova, 2016). Chippewas of Nawash Unceded First Nation developed an Anishinaabe water-protection process based on Elder Keeshig's Medicine Wheel teachings (Marshall et al., 2020), and Muskowekwan First Nation applied parallel planning to enact local water security for restorative land-management actions (Patrick, 2018). Dam removals were initiated by the Grand Traverse Band of Ottawa and Chippewa Indians, the Penobscot Indian Nation, and the Lower Elwha Klallam Tribe (Fox et al., 2022). Fox et al. (2017) explored how Indigenous knowledges are enacted

through river restoration and found that embedding long-term care relations into notions of restoration promotes healing in ecosystems and communities.

Indigenous knowledge is dynamic and, as the climate and environment changes, cultural practices continually evolve to meet community needs while honouring traditional teachings and inherent responsibilities. Adaptive co-management approaches similarly involve implementing practices (based on knowledge from multiple knowledge systems) and learning through experience (Grimwood and Doubleday, 2013; Lea et al., 2021). This aligns with many Indigenous philosophies in which everything is interconnected (Baldwin et al., 2018; Cochran et al., 2013; Donkersloot et al., 2020; Holtgren and Auer 2016; Menzies et al., 2022), but it is at odds with Western worldviews where linear and discretised models are used to understand our world (Baldwin et al., 2018; Hayman et al., 2017; Menzies et al., 2022). In fact, in many Indigenous worldviews, axiology, ontology, epistemology and methodology are interrelated such that "how one knows is inseparable from what one knows." (Latulippe and Klenk, 2020: 3). Thus, the A to A framework may appear to organise braiding strategies linearly, but it is cyclical and iterative, as each project stage is connected. Indeed, sometimes co-generated knowledge is applied by adapting the axiologies, bringing us full circle.

3.4 Illustrative examples

Given that Indigenous knowledge is inextricably linked to context, the following section provides illustrative examples to demonstrate how braiding principles, foundations and methods can be applied in specific contexts throughout a project.

3.4.1 Community-based monitoring

Community-based monitoring (CBM) initiatives are excellent avenues for braiding Indigenous and Western knowledge systems to track changes in freshwater ecosystems. Indigenous knowledge systems hold land-based knowledge that informs what, when, where and how monitoring should occur (Gill et al., 2014); for many Indigenous Peoples, monitoring is what they do to live on the land (Parlee et al., 2021). To live off the land, you must be attuned to nature, "watching, listening, learning and understanding change" (Parlee et al., 2021: 4). Thus, CBM programs that braid IKS and WKS can benefit from IKS's nuanced, rich and long-term understanding of the ecosystem, and from the data collection and analysis tools of WKS.

As with any collaborative work, CBM exists on a spectrum (Hovel, 2020), Some initiatives may be externally led, while others are community initiated, designed and run. For example, Gérin-Lajoie et al. (2018) describe a CBM project that was initiated by university researchers. The Inuit community of Kangiqsualujjuaq (Nunavik, Quebec) decided to collaborate with researchers on a proposed land camp, but indicated they wanted to establish a long-term environmental monitoring program in anticipation of a proposed mine. Although the program objectives were responsive to community needs, the program was more on the "researcher-led" side of the spectrum with community participation (Gérin-Lajoie et al., 2018). In contrast, when university researchers initiated a pilot CBM project with the Gwich'in Social and Cultural Institute, Elders made the decisions about what, where and how to monitor (Gill et al., 2014). The pilot project may have been externally initiated, but community involvement in the program development, along with a bridging program for continuing the program after the researchers left (ability to sign out equipment, providing compensation for travel, etc.),

meant that the CBM program may soon be entirely community run. To some extent, where a CBM program lies on the spectrum depends on the community's capacity, resources and experiences with CBM programs.

Each community has different capacity and resources available to engage and successfully deliver and maintain these programs. For example, in Parlee et al.'s (2021) networked CBM in the Mackenzie River Basin, diverse legal settings in the inter-jurisdictional basin influenced whether colonial governments were required to involve Indigenous Peoples in monitoring fisheries and water quality and, therefore, whether resources (funding and personnel) were used to establish formalised environmental monitoring programs that include IKS. In communities that did not have existing CBM programs, or the resources to design one, researchers were sent to support program development and implementation (Parlee et al., 2021). It is important to remember, however, that when the researchers leave, sufficient resources are needed to sustain the program. In Gill and Lantz (2014), when the researchers completed a pilot CBM program in collaboration with Gwich'in First Nation, they left monitoring equipment (e.g. digital cameras, GPS) with the Band Office for community members to sign out to continue monitoring, and they received travel compensation for their efforts. Even if sufficient resources exist for data collection, data management often requires different expertise than that held in many remote Indigenous communities. Gill and Lantz (2014) discuss the desire for the CBM program in Gwich'in First Nation to be completely community owned and implemented; however, one barrier is that managing the CBM database requires spatial data management skills and knowledge of certain software. Training community members for this purpose, most notably youth, is a possible solution, so long as funding is available and so long as funding partners recognise that training may need to reoccur as people relocate or pursue other work (Gérin-Lajoie et al., 2018; Gill et al., 2014).

Many of the EAUX principles and methods from the A to A framework, from the earlier discussion on braiding IKS and WKS in freshwater ecosystem projects, are relevant to CBM programs. For example, it is essential that project partners recognise the intellectual property of the data collected through CBM programs. Even when external partners are heavily involved in the creation of the program, the data are the intellectual property of the community, and this fact should be outlined in written agreements (Gérin-Lajoie et al., 2018; Parlee et al., 2021). When community members are involved in CBM program design – identifying monitoring goals, providing culturally relevant indicators, and revealing places that should be monitored – their work is not only "usable" but also promotes community commitment and engagement with the project (Parlee et al., 2021). Further, developing unique CBM programs that reflect the knowledge, needs and interests of the local community demonstrates respect for the community's IKS, and reinforces the value of their place-based knowledge in monitoring their lands and waters (Stenekes et al., 2020), reinforcing principles of equity among knowledge systems. Finally, as a collaborator, it is important to be flexible when designing and implementing CBM programs. Often, the purpose extends beyond environmental monitoring to intergenerational knowledge exchange, youth training and relationship building (Atlas et al., 2017; Gérin-Lajoie et al., 2018; Gill et al., 2014; Strangway et al., 2016).

Sometimes the data collected come from predominately Western methods, predominately Indigenous methods, or some combination of the two. For example, Wilson et al. (2018) present the Indigenous Observation Network (ION), an Indigenous-led community-based water-quality monitoring network in the Yukon River Basin, where research scientists from

the United States Geological Survey and the Yukon River Inter-Tribal Watershed Council train community members in Western field methods and monitoring protocols.

Sometimes, the IKS came through fishing and trapping knowledge. For example, Atlas et al. (2017) describe a traditional fishing weir that community members used to monitor sockeye salmon populations. Chila et al. (2021) describe a monitoring approach where fishers are compensated for bringing Pacific salmon heads to the federal government to monitor the species' expansion into the Western Arctic. In other examples, digital cameras, GPS, and other Western science equipment are given to community members to record observations and tell stories about environmental change (Gill et al., 2014; Parlee et al., 2021). In one example, Elders and youth were paired up for monitoring trips. The Elder chose culturally relevant locations and shared stories about environmental change, while the youth asked questions, took photos and recorded their own observations (Gill et al., 2014). This approach not only contributes to monitoring environmental changes, but also fosters intergenerational knowledge exchange.

3.4.2 Multi-actor manoomin stewardship

STACCWG (2021: 125) describes manoomin as "a being so central to Ojibwe culture that tribal members fear a loss of identity if wild rice … declines or disappears." A characterisation study done under contract for the Great Lakes Wild Rice Initiative (2020 p. 6) refers to manoomin as a sacred symbol and animate being that provides "food and habitat to endemic and migratory species" within the Great Lakes region. Matson et al. (2021) identify manoomin (*Psiŋ* to the Dakota) as being integral to Indigenous food sovereignty for Ojibwe, other Anishinaabe and Dakota peoples across the Great Lakes region.

Manoomin grows naturally in shallow lakes and streams, but environmental degradation – including changes in water levels, contamination and invasive species – has caused stands to decline throughout the Great Lakes region. Voluntary multi-actor regional environmental governance initiatives (Reo et al., 2017) and research collaborations, which involve Indigenous partners and respect different ways of knowing, have emerged to reverse these declines.

Matson et al. (2021) describe a collaboration between an interdisciplinary group from the University of Minnesota and American Indian Tribes and intertribal organisations. The project included eight formal tribal partnerships and a broader network of participants who joined activities such as biannual collaboration conferences hosted at tribal venues. Participants included leaders, Elders, tribal natural resource managers, rice Chiefs (tribally appointed Elders or knowledge holders who guide manoomin stewardship and harvesting), ricers and youth. The process of collaborative community-based research in environmental science and policy is just as important as the product: "Based on our collective experience, we are confronting the injustices that continue to afflict Indigenous Peoples worldwide, and we are developing ways to translate complex ideas between worldviews. By doing so, we are finding ways to work together toward a more complete understanding of manoomin and its relationship to the broader environment." (Matson et al., 2021: 109). Recommendations from this collaboration have been shared throughout the report.

The Great Lakes Wild Rice Initiative (2020) comprises a group of Lake Superior Basin Anishinaabe communities and federal and state agencies who have support from Abt Associates

and a Great Lakes Restoration Initiative grant. The study originated in annual (2017–19) Lake Superior Manoomin Restoration Workshops, organised to discuss the need for wetland restoration in places where manoomin is or was harvested. The group developed criteria to evaluate different methods for characterising manoomin's cultural and ecological importance. Among them, methods should be "based, at least in part, on Indigenous methodologies, or research for and by Indigenous People using techniques and methods drawn from their traditions and knowledge" (Great Lakes Wild Rice Initiative 2020: 7). The project team chose, by consensus, a combined approach that included case-study analysis, Indigenous metrics and habitat equivalency analysis.

The Great Lakes Indian Fish and Wildlife Commission is a common actor in these manoomin initiatives, and in many other projects cited in this report. With a mandate to assist member Tribes in the implementation of treaty rights and self-regulation in ways that are both ecologically sound and culturally appropriate (Shultz et al., 2021), the commission appears to be an influential bridging organisation.

3.4.3 Dam removal on the Elwha River

Dams have many negative ecological (Baxter, 1977; Kubasek and Giles, 2001; Poff et al., 2007) and social (Lovisek et al., 1995; Luby, 2020; Nega, 2008; Rosenberg et al., 1995; Strube and Thomas, 2021; Thompson, 2015) consequences, upstream and downstream (Baird et al., 2021; Mei et al., 2018; Richter et al., 2010). Indigenous Peoples, however, feel the negative impacts more and the benefits less than other populations (World Commission on Dams, 2000). While dams may control flooding, produce electricity, and create reservoirs for recreation, they also flood Indigenous territories, increase food insecurity, and harm other-than-human relations (Luby, 2020; Strube and Thomas, 2021; Thompson, 2015). The Lower Elwha Klallam Tribe (the Elwha Tribe) is no exception and experienced dramatic losses when the Elwha and Glines Canyon Dams were installed on the Elwha River, in 1913 and 1926, respectively (Fox et al., 2022). Before the dams were installed, the Elwha River was known for its plentiful salmon and steelhead runs (Fox et al., 2022; Harguth, 2013), which the Elwha Tribe not only relied on for food but also valued culturally. After the dams were installed, the fisheries depleted drastically. The Elwha Tribe advocated for the dams' removal ever since they were installed, but it was not until the late 1960s that conditions made dam removal possible.

A series of events in the mid- to late 1900s increased the Elwha Tribe's influence on the decision to remove the Elwha and Glines Canyon Dams. First, the Tribe was recognised federally in 1968. As in other dam-removal case studies in the United States, federal recognition started the long process of getting large dams removed (Fox et al., 2022). Tribes were eligible for funding from the Bureau of Indian Affairs, and they could engage in legal structures to advocate for the dams' removal (Fox et al., 2022). Not long after, in 1974, the Boldt Decision in Washington State entitled the Tribes to act as co-managers of state fisheries (Fox et al., 2022; Harguth, 2013). To act on these rights, the Elwha Tribe needed fish in the Elwha River, so it became clear that the river needed to be restored (Fox et al., 2022). The final catalyst came when the Elwha Dam failed a safety inspection in 1978. The inspection created the opportunity the Tribe needed to get the dams removed. The Elwha Tribe hired an engineering firm to model maximum flood scenarios, the risk of failure and the consequences should the dam fail; it financed other studies to demonstrate that dam removal was not only the most favourable solution for restoring the river's fisheries but also the most economical (Fox et al., 2022).

Following an Environmental Impact Statement and the passing of the Elwha River Ecosystem and Fisheries Restoration Act, the decision to remove both dams was made in 2005.

After decades of struggle, it still took several years to get the dams removed. The Elwha Tribe worked collaboratively with federal and state governments to plan and execute the removal (Harguth, 2013). Most notably, the National Park Service (NPS) worked with the Elwha Tribe because the upper Elwha River is within Olympic National Park. Unfortunately, early on, Congress appointed the NPS as the final decision maker and allocated funds to them rather than the Elwha Tribe. This caused conflict, but both parties eventually recognised that they were dependent on each other. While the NPS had funding, the Tribe had place-based knowledge, alongside contracted research, to argue for dam removal (Harguth, 2013). Despite the authority granted by Congress, the NPS appreciated the Tribe's ownership and control over their IKS and data from previous studies, and realised it could not make decisions without the Tribe. The collaborators used annual funding agreements (AFA), which required annual negotiations to establish tasks and responsibilities, gave each group autonomy on certain pieces of the project, enabled the exchange of funds, and reminded both groups of shared goals (Harguth, 2013). The AFAs increased *eXchange* and *equity* between the partners. The independence this provided between AFAs also enabled *usability*, because the Tribe could make decisions based on their own needs when it came to tasks under their control.

In addition to following EAUX principles, the collaborators worked to understand one another. Harguth (2013: 180) quotes an NPS staff member: "There were differences of worldview in the past, but both parties have worked hard to understand the other; it's one thing to draft a MOU, which occurred later in the process, but it's another thing to understand the whys and wherefores [of the Tribe]." NPS staff underwent treaty training, which taught them the history and rights of their counterparts (Harguth, 2013). Braiding axiologies and ontologies at the beginning of a project can facilitate braiding later in the project, even when collaborators work independently through other project stages (Figure 3). For example, when the NPS and Tribe, as well as other actors, came back together to make decisions, they did so based on consensus, which required clear communication and negotiating (Harguth, 2013). Braiding occurred once again as each group applied all they had learned and done independently to make decisions to move forward. One interviewee from Harguth's (2013: 151) study said, "You go in there knowing that there is some give and take, you have to negotiate. You need to hold your ground, but you need to have flexibility and know where you'll bend a little." This mentality supported collaborative decision-making based on both knowledge systems and ultimately led to the removal of the Elwha and Glines Canyon Dams in 2012 and 2014.

3.4.4 Planning and source-water protection

Water planning activities, including watershed planning, community planning, and source water protection planning, further illustrate knowledge braiding in practice. Patrick and Baijius (2021) describe a water stewardship planning process for the Saskatchewan River Delta with the Cumberland House Cree Nation. Here, a "parallel planning" approach was used to bring together Western scientific "rational planning" with Indigenous water planning principles and knowledge systems to support community priorities around river health and well-being and Indigenous livelihoods within Traditional Territories. Of concern, as expressed by an unidentified community member, "The delta is suffering. It has been suffering ever since the dam went up. The delta needs our help, the water and animals need our help. We

Figure 3. This modified version of Figure 2 illustrates how knowledge system braiding occurred early in the dam removal project, with attempts to understand one another's values and worldviews. Tasks were then split, and each knowledge system continued independently, but came back together to make decisions regarding the dam removal.
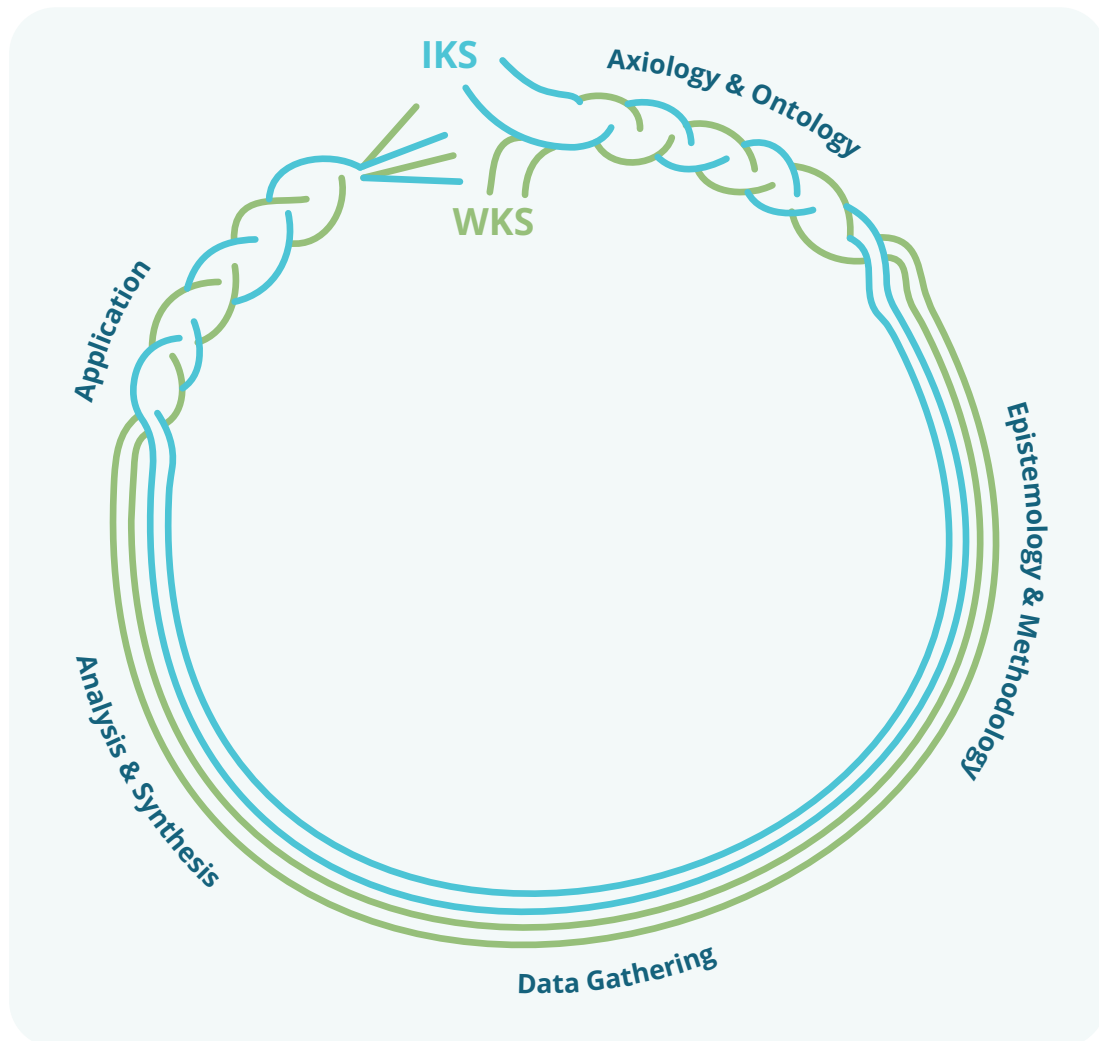
just can't sit here any longer, we have to do something" (Patrick and Baijius, 2021: 6). The absence of a government watershed plan and upstream development activities were further motivators for community members whose lives, livelihoods, practices and cultures were and are tied to traditional land and water use.

The planning activities were part of a broader five-year collaborative watershed research project and were strengthened through existing relationships between researchers and the Cumberland House Cree Nation. At the onset, an oversight working committee was established that included Elders, elected officials from the First Nations, and non-Indigenous groups in the watershed. The committee developed the guiding principles for the plan and oversaw all stages of the planning activities. University researchers provided support to the working committee, attended meetings, and covered the cost of meals at community meetings. Plan development was guided by traditions and practices, which included "ancestral relationships to land (and water), intimate knowledge of human-environment conditions,

distinct cultural practices, and long-term, intra- and inter-generational perspectives on deci-sion-making" (Patrick and Baijius, 2021: 6).

In addition to developing a water stewardship plan as envisioned by the community, the plan based on *Mino-Pimatisiwin*, or "good life" in Cree, identified management actions to mitigate community concerns about the impacts of the dam, and contributed to community empow-erment and self-determination. This study is an interesting example of braiding parallel planning approaches within a multi-stakeholder collaborative context. Rather than integrating or positioning one knowledge system as dominant over the other, they applied a two-way or two-eyed seeing approach by drawing upon First Nations and local lived experiences and scientific knowledge to inform analysis, interpretation, risk assessment, and decision-making on actions and strategies at each stage of the planning process. This included the sharing of stories, perceptions and experiences including ancestral relationships to the land and water, cultural practices and inter-generational perspectives on decision-making (Patrick and Baijius, 2021). Patrick (2018) describes a similar approach for source water protection planning among six First Nations in Alberta and Saskatchewan aimed at community adaptation to climate change. Here, knowledge braiding focused on risk assessment, identification of threats to drinking water and identification of culturally and context-appropriate adaptation strategies.

Another source water protection (SWP) example comes from the province of Ontario, where the establishment of plans to protect the quality and quantity of drinking water sources is required under law. Through the *Ontario Clean Water Act* (OCWA) (*Clean Water Act*, 2006), conservation authorities created watershed-based source water protection plans for desig-nated watersheds by integrating a science-based approach with both public and private water actors. However, First Nations communities were generally excluded from this process because they fall under federal jurisdiction, due to Constitutional divisions of federal and provincial jurisdictional powers in Canada. While the OCWA included provisions for First Nations to opt into the provincial process through amendments to regulations, this was not a legal requirement, and only three of the twenty-seven eligible First Nations (those within conservation area source protection regions) chose to create source water protection plans (Collins et al., 2017). The federal government also established requirements for First Nations to generate SWP plans to address drinking water threats within their communities within the Protocol for Centralised Drinking Water Systems in First Nations Communities (AANDC, 2014). In 2014, it released the First Nations On-Reserve Source Water Protection Plan Guide and Template. The limitation of this approach, or the disconnect in values and worldview, is that both the provincial and federal governments narrowly define source water as water used for human consumption, rather than as water as a source for all living beings.

The Chippewas of Nawash Unceded First Nation (CNUFN), called Neyaashiinigmiing, meaning "point of land surrounded on three sides by water," located in Georgian Bay, southern Ontario, opted for a third SWP planning option. CNUFN chose "to develop a source water protection plan for the community that included both technical and Indigenous knowl-edge"; in doing so, it created a framework structured around the Anishinaabe teachings of Elder Joanne Keeshig (Marshall et al., 2020: 2). The approach aligned with Anishinaabe values and worldviews; water is sacred, and water is connected to everything. This collabo-ration involved university researchers and the CNUFN and addressed all principles of EAUX knowledge braiding. As described by Marshall et al. (2020), the researchers understood the

drinking-water crisis, the effects of colonialism, jurisdiction issues, the need for consultation, and the principles of relationship, respect, relevance, reciprocity and responsibility. *Access* was demonstrated as the project adhered to OCAP principles. *Equity* was shown through joint approval of the research by both the University's Research Ethics Board and Chief and Council. The project's outputs directly addressed the community's need for a *usable* plan, and the results had shared authorship and were disseminated at community events and academic conferences. The project also aligned with A-to-A framework strategies. Mainly, it used a two-eyed-seeing approach and was overseen by the Anishinaabe water protection committee, who co-created the interview guides and were involved in all stages of the project, including analysis.

4 Conclusion

Globally, there are numerous Indigenous Nations, and each has its own unique value system, worldview and approach to living with water. Consequently, there are many ways to bring Indigenous and Western knowledge systems together to understand, care for and restore freshwater ecosystems. This report presents a sample of these methods based on a scoping review of projects in Turtle Island. Drawing upon 143 records of diverse freshwater projects, the authors organise the principles of and approaches to braiding knowledge systems according to two frameworks they developed in previous work. The EAUX framework highlights the importance of equity, access, usability and eXchange in collaborations with Indigenous partners. The Axiology to Application, or A to A framework demonstrates that braiding can occur at all stages of a project, if desired by those who share knowledge and benefit from the exchange. Braiding from A to A requires early involvement of Indigenous partners so that Indigenous values, worldviews and project goals support the methodologies, data collection methods, analysis, synthesis and application of knowledges. Four examples illustrate the complexities of braiding knowledge systems but also reveal the value added when taking the time to do it.

4.1 Recommendations

Collaborating with Indigenous Peoples and braiding Indigenous and Western knowledge systems are important approaches to solving water challenges holistically. Braiding knowledge systems can be mutually beneficial while supporting Indigenous well-being, Indigenous self-determination and reconciliation. For readers interested in applying the knowledge shared in this report, the authors leave you with the following recommendations:

■ Ensure that all Indigenous-Western collaborative projects incorporate EAUX principles (equity, access, usability and eXchange).

■ Start collaborative projects with discussions about disparate axiologies and ontologies, and work together to better understand each other.

■ Engage with partners from the beginning to choose and develop project methods that are culturally safe and can be adapted to the specific peoples and locations.

- Centre Indigenous values and voices in both primary and secondary data as well as during the stage of knowledge generation and transmission.
- Braid in a way that maintains the integrity of each knowledge system while cocreating new knowledges that benefit from the strengths of each.
- Commit to continuous learning, self-reflection and growth.
- Accept challenges and celebrate successes. Reflect on both roadblocks and "wins" to innovate and improve methods for braiding knowledge systems.
- Be open and humble. There is a lot to learn from one another to solve global water challenges.

Although we present these principles, foundations and methods, this report does not replace collaborative work among Indigenous and non-Indigenous partners to codevelop culturally appropriate and relevant methods for water projects. Finally, readers are encouraged to go to the original sources cited in this report to better understand the contexts and limitations associated with each.

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