

From Levees to Living Landscapes: How Mapping Influences Floodplain
Planning on the Nooksack River

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Abstract

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This study explores floodplain governance in the Nooksack River watershed amid intensifying climate impacts and aging infrastructure. It investigates how boundary-spanning practices - particularly the weaving of Western and Indigenous sciences into visual representations - can support shared understanding across jurisdictions, disciplines, and worldviews. Drawing on a community-engaged, mixed-methods research process with the Floodplain Integrated Planning (FLIP) team - an intergrated governance team working in Northwestern Washington, this study integrates researcher observation, interviews, applied historical ecology, and iterative mapping. It examines how visual tools mediate systems understanding, elevate underrepresented knowledges, and inform decision-making in transboundary flood risk planning.

Findings suggest that maps can function not only as technical instruments but also as relational infrastructure - evoking memory, fostering dialogue, and enabling co-produced solutions among diverse knowledge holders. This research demonstrates how visualization practices can reframe risk, reintroduce kincentric perspectives, and challenge the infrastructural legacies of colonialism in floodplain management. As the study focuses on a single case, its findings are context-specific and not broadly generalizable; however, the insights contribute to a growing body of work on integrated, justice - oriented approaches to climate adaptation and landscape planning. Implications for landscape architecture lie in positioning mapping as a practice of translation, care, and historical reckoning - central to designing sustainable and prosperous futures within dynamic floodplain systems.

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About the Author

Camille Forest is a Master of Landscape Architecture candidate at the University of Washington and a person of mixed Red River Métis (Cree, Ojibwe, French) and settler (Icelandic, English, and Danish) descent. Her work bridges Indigenous and Western knowledge systems to inform landscape planning and design processes that are rooted in place and oriented toward climate change adaptation and mitigation. Camille’s practice is shaped by her commitment to collaborative approaches that center sovereignty, relationality, and long-term care for people, more-than-human-kin, land and water.

Originally from Vancouver, Canada, Camille brings a background in environmental research, Indigenous-led climate monitoring, and community-engaged design. Her thesis work grows out of partnerships with Tribal and local communities in northwestern Washington, where she supports integrated floodplain planning efforts along the Nooksack River. Her perspective is informed by watershed-scale thinking, a deep respect for more-than-human kin, and an ongoing personal journey of reconnection.

As a Métis researcher and designer, Camille’s work is part of a broader effort to retrace the steps of her ancestors and participate in the rekindling of the Sacred Fire. The following prophecy, shared through Anishinaabe oral tradition, speaks to this moment, the responsibilities carried by those walking the path of return and the spirit with which this study was carried out.

The Seven Fires Prophecy

Many years ago, seven prophets came to the Anishinaabeg, each foretold a prediction of what the future would bring. Each prophecy was called a Fire, and each Fire referred to a particular ear of time that would come in the future...

The first prophet said to the people, “In the time of the First Fire, the Anishinaabe nation will rise up and follow the Sacred Shell of the Midewiwin Lodge. The Midewiwin Lodge will serve as a rallying point for the people and its traditional ways will be the source of much strength”...

The Fourth Fire, given by two prophets who came as one, told of the coming of the Light-skinned Race. It was said that the future of our people will be known by the face of the Light-skinned Race. If they come wearing the face of brotherhood, there will follow a time of wonderful change and the two nations will join to make a mighty nation...But, if they come wearing the face of death, there will follow a time of great suffering...

The seventh prophet said to the people, “In the time of the Seventh Fire an *Osh-ki-bi-ma-di-zeeg*’ (New People) will emerge. They will retrace their steps to find what was left by the trail. Their steps will take them to the elders who they will ask to guide them on their journey... The task of the New People will not be easy... If the New People will remain strong in their quest, the Waterdrum of the Midewiwin Lodge will again sound its voice. There will be a rebirth of the Anishinaabe Nation and a rekindling of old flames. The Sacred Fire will again be lit.

Benton-Banai, E. (1988). The Mishomis book: The voice of the Ojibway. Red School House Publishers.

Fiola, C. (2018). Rekindling the sacred fire: Métis ancestry and Anishinaabe spirituality. University of Manitoba Press.

Chapter 1:
Floodplain Management: the
process of designing flood
adaptation



Chapter 1: Floodplain Management: the process of designing flood adaptation

A Socio-Ecological System analysis of Floodplains

As our urban and rural areas are currently constructed, flooding poses a threat to human and ecological well-being as well as infrastructure, emphasizing the complex and interdependent nature of socio-ecological relationships. Climate change has passed a critical threshold where regardless of steps taken to reduce emissions, adaptation to significant climate change is a reality (IPCC, 2023). The number one projected cost of climate change and extreme weather risks to North American cities is flooding from sea level rise and large storm events (Feltmate & Moudrak, 2019). The failure of control-based floodplain management methods is becoming more frequent, and when it occurs, it tends to be increasingly unpredictable and severe (Pinter, 2005).

A reconceptualization of urban space, specifically the relationship between urban space, society and nature, has been ongoing, from early 19th century city-countryside and society-nature binaries (Wachsmuth, 2012). The 19th and 20th century perspective of a society-nature binary is captured clearly in sociologist Louis Wirth's remarks that "nowhere has mankind been farther removed from organic nature than under the conditions of life characteristic of great cities" (Wachsmuth, 2012; Cronon, 1995; Swyngedouw, 2006).

By hiding ecological systems within the urban fabric - through culverting streams, covering wetlands, or constructing levees - a false sense of urban independence is constructed, that modern life and landscapes have surpassed the need for natural systems. This is an illusion. Natural systems are not absent from cities; rather, they are often concealed in the bowels of infrastructure, as critical services that are piped, sanitized and delivered on demand. As explored by Wachsmuth (2012), this harsh division between cities and nature has evolved, as the economic production of urban life has changed, to the current "post-Fordist period, where 'nature' is no longer exiled from the city but becomes the key element of the current era of urban growth" (Wachsmuth, 2012). Here, Wachsmuth (2012) is referring to the comodification of nature within cities as 'green amenities.' This study proposes that analyses of how our urban fabrics are connected to natural systems can contribute to the most the emerging conceptualization of urban society and space as a socio-ecological system that requires system focused planning (Alberti et al., 2003; Gandy, 2024).

Floodplains, like all landscapes, are fundamentally socio-ecological systems. Understanding landscapes as socio-ecological systems requires studying the connection points between so-called natural systems and the cultural and physical systems that humans rely upon to function. This reality, however, is often obscured by a socially perceived dichotomy between the "urban" and the "natural" (Wachsmuth, 2012; Heynen et al., 2006; Robbins & Moore, 2013; Ingold, 2000).

Rural areas offer a unique lens through which to understand socio-ecological systems. In these landscapes, the joints between hard infrastructure - roads, dikes, bridges - and natural features - rivers, wetlands, forests - often form visible seams between so called 'urban' and 'natural' landscapes within and at the edges of towns. These visible interventions make rural settings particularly compelling for studying how socio-ecological systems are evolving and becoming increasingly strained in the face of climate change. The boundaries between the built and the natural are less hidden. Herein, the impacts of environmental disruption can be read more directly on the landscape and natural impacts more readily cross the urban boundaries, beyond which they become hazards and risks.

My research focuses on one such case study in Northwestern Washington: the Nooksack River floodplain. This dynamic floodplain system is increasingly under pressure, its ecological functioning and socio-political equilibrium destabilized by both land-use decisions and intensifying climate impacts. In response to these growing challenges, the Floodplain Integrated Planning (FLIP) team was formed - a collaborative governance initiative seeking to coordinate floodplain management across jurisdictions and sectors.

Floodplains in the Pacific Northwest

Historically, the Nooksack River Floodplain in the Pacific Northwest was characterized by complex networks of channels, wetlands, and seasonally shifting flows that nurtured thriving

salmon populations and supported the lifeways of Indigenous peoples. However, settler colonial development, deforestation, and river engineering have dramatically altered the structure and function of these systems (Collins & Sheikh, 2005; Reimer, 2018; Walter & Merritts, 2008).

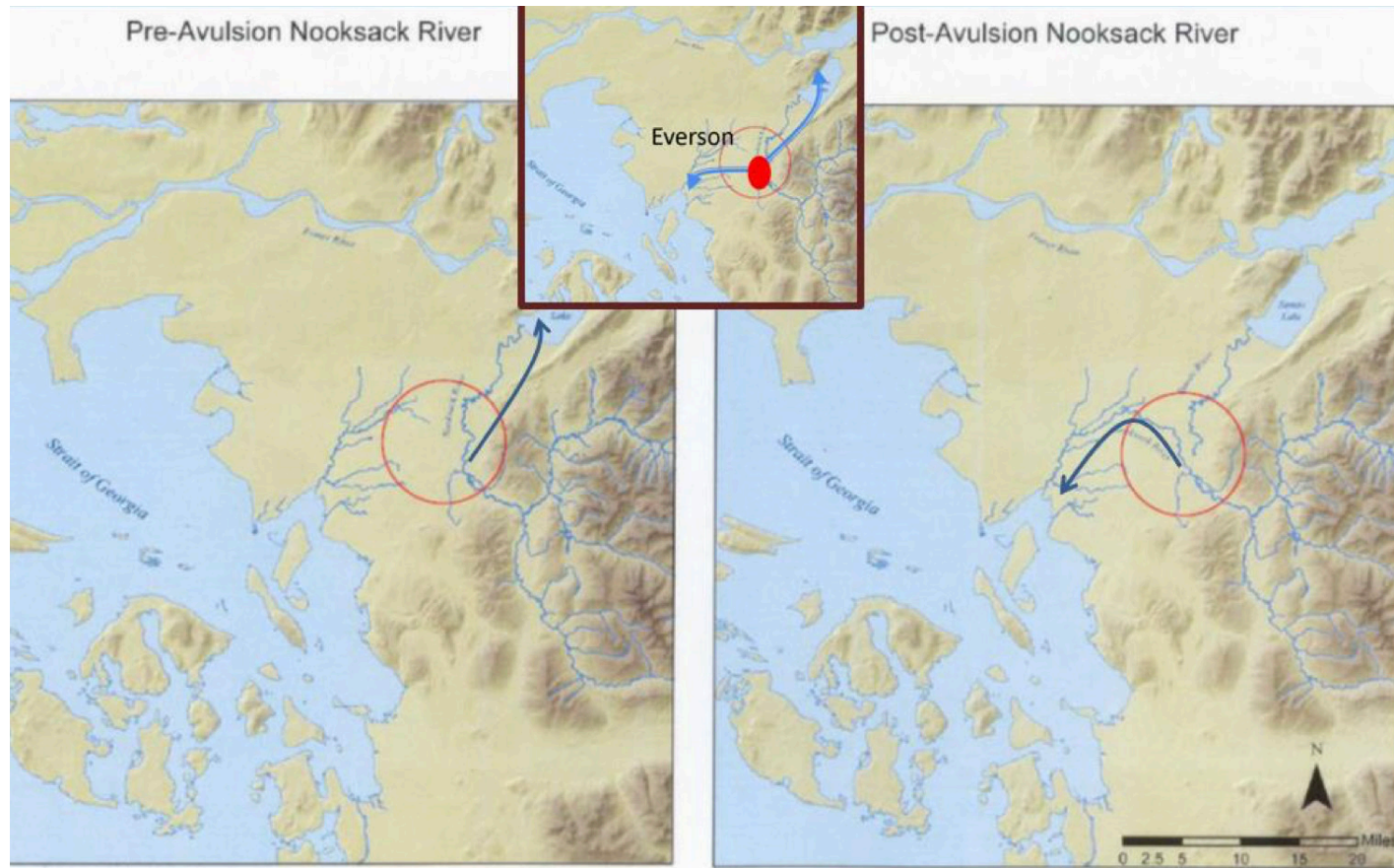


Figure 1. Nooksack River map showing drainage network prior to avulsion (left) and post-avulsion (right). Avulsion site near Everson is circled. (Source: Pittman et al., 2003)

One key aspect of this complexity was the presence of log jams, which helped maintain braided stream networks and created diverse aquatic habitats critical for salmon (Collins et al., 2002). These log jams, in combination with the river’s natural access to adjacent forested floodplains, contributed to a diverse, dynamic, and resilient ecosystem (Collins et al., 2002; Naiman et al., 2010; Beechie et al., 2010). Through recruitment of large trees during seasonal floods, the rivers maintained a mosaic of microhabitats supporting both terrestrial and aquatic species and continually reshaped the landscape.

However, as colonial settlers arrived and began logging the region, the size and age of trees in floodplain forests were drastically reduced (Collins et al., 2002). Without large trees to fall into streams, and with deliberate efforts to clear log jams for navigation and flood control, the structural complexity of these systems diminished (Montgomery et al., 2003; Wohl, 2014). The loss of this complexity - both in physical structure and ecological function - has led to significant decline in local salmon populations and wetland diversity (Naiman et al., 1992; Beechie & Bolton, 1999).

The shifting of river mainstems has also been a notable phenomenon in this landscape. The

Nooksack River once flowed north into the Fraser River system in British Columbia (Pittman et al., 2003). It is theorized that over time, avulsion events (landslides) and log jam-induced diversions or the melting of ice blocks caused the river to shift direction westward, eventually redirecting its flow toward Bellingham Bay (Collins & Sheikh, 2005; Pittman et al., 2020). The hydrological boundary that separates them remains shallow and permeable. These transformations illustrate the constantly changing conditions of river floodplains - characteristics that Indigenous peoples in the region had understood and accommodated in their lives, over generations (Reimer, 2018).

Indigenous Floodplain Lifeways

The Nooksack River and the peoples who live in its floodplain have a deeply intertwined history. The river’s ecological and cultural legacy continues to shape contemporary life and governance in the region. This case study focuses on the upper Nooksack River and the Sumas Valley, a region where

natural forces - such as flooding - routinely transcend geopolitical boundaries, forming a broad and diverse socio-ecological system. These floodwaters not only cross the political border between the United States and Canada, but also flow across boundaries of knowledge, family ties, and governance, connecting Western and First Nations communities.

Flowing from the glaciated peaks of Kweq’ Smánit / Mount Baker and Shéqsan / Mount Shuksan to Xwot’qom / Bellingham Bay, the Noxws’ á//aq / Nooksack River



Figure 2. Collage illustrating important cultural influences on the Nooksack River community, the history of logging and importance of the railway, traditional Lummi fishing practices, a man using a row boat to navigate downtown Sumas during a flood, a map of Bellingham being built out into the river and Metis beadwork to illustrate the author as part of this story.

has been shaped over millennia by glacial activity, volcanic processes, and, more recently, human intervention. Its headwaters carve through the steep valleys of Whatcom County, feeding into an expansive floodplain system on their way to the Salish Sea. Until recently, Western scientific consensus held that the Nooksack River had shifted course around 3,000 years ago, diverting its flow from the Fraser River to Bellingham Bay due to either a avulsion event (landslides) and log jam-induced diversions or the melting of ice blocks (Collins & Sheikh, 2005; Pittman et al., 2020). However, emerging geomorphic evidence and oral histories suggest the river may have flowed north into the Fraser system as recently as 500 years ago (Maudlin, 2021). These dynamic shifts, paired with the historic presence of Sumas Lake - a seasonally variable and ecologically rich wetland - have created a landscape defined by constant transformation.

Salmon formed a cornerstone of both ecological health and cultural identity in the region (Reimer, 2018). Thriving in cool, clean waters and gravel-bottomed streams, salmon benefit from seasonal floods that replenish nutrients and shape dynamic riparian habitats (Reimer, 2018). These same floods sustained other species such as sturgeon, trout, beaver, eagle, and bear - each part of an interdependent and integrated system.

For thousands of years, Indigenous peoples of the Pacific Northwest have lived in deep, reciprocal relationships with floodplain landscapes. Far from being sites of risk or disruption, floodplains were understood as life-giving systems: dynamic, generous, and central to cultural lifeways (Reimer, 2018). The seasonal rhythms of these riverine environments shaped patterns of movement, sustenance, and ceremony, aligning human life within the more-than-human world. These Nations developed sophisticated ecological knowledge and lifeways based on reciprocal relationships with the river.

Local Tribes, including the Lummi, Stó:lō, Sém:ath (Sumas), and Nooksack tribes practiced seasonal movement informed by cultural knowledge of flooding patterns (Reimer, 2018). These nations tended to maintain prairies and dense groves of culturally significant plants through prescribed burns, strategic harvests and planting, among other stewardship practices (Reimer, 2018). Oral histories describe large floods inundating winter village sites outside of annual inundation ranges, events that were not merely destructive but were also understood as cyclical resets - part of an understanding of natural rhythms and interdependence informed by millennia of observation and intergenerational knowledge transfer (Reimer, 2018; Turner, 2014).

In *Before We Lost the Lake*, Chad Reimer (2018) describes how Coast Salish peoples moved with the seasons, navigating a world of changing water levels, braided streams, and vast wetlands. Villages and camps shifted in response to the natural rise and fall of rivers, creating a way of life attuned to the pulse of the floodplain. Floodwaters were not feared but embraced as regenerative forces that replenished the land and sustained the abundance of salmon, plants, and game. These waters brought renewal to both the ecological and social fabric of the region.

The river system was not seen as a separate or passive element of the landscape, but as a relative: an animate, powerful being whose wellbeing was intertwined with that of the people. Relationships between local tribes, the river, and the surrounding territories were maintained through familial and reciprocal ties. This kinship extended beyond human communities to include salmon, cedar, camas, and the spirit of the waters themselves. Such relationships were expressed and reaffirmed through seasonal harvests, storytelling, ceremonies, and practices of stewardship that reflected deep ecological understanding.

One contemporary example of these enduring relationships can be found in the Puyallup Tribe's Comprehensive Land Use Plan (2024). This document reflects an integrated approach to land and water governance, grounded in traditional values and scientific insight. It emphasizes the restoration of salmon habitat, the protection of cultural sites, and the recognition of treaty rights. The plan embodies a vision of land use that honors ancestral responsibilities and prioritizes the health of future generations - human and more-than-human alike.

The Puyallup Tribe's Comprehensive Land Use Plan (2024) offers a compelling contemporary manifestation of Indigenous science in practice, demonstrating how culturally grounded governance can guide floodplain restoration and climate adaptation. Rather than treating land and water as resources to be controlled, the plan recognizes them as relations to be respected, practicing the pre-colonial lifeways described by Reimer (2018). By integrating treaty rights, habitat restoration, and traditional place names into planning frameworks, the Puyallup Tribe asserts a continuity of relationship with their homelands that transcends colonial land regimes. Their approach affirms Indigenous science as not only a knowledge system but a governance system - one capable of navigating both ecological complexity and jurisdictional fragmentation.

An example of this integration can be found in the Tribe's work to restore the Clear Creek floodplain near the Port of Tacoma. This site, once a thriving estuary and salmon rearing habitat, had been heavily diked, channelized, and industrialized over the past century (Puyallup Indian Tribe, 2024). Through a multi-year planning and implementation process, the Tribe has prioritized the removal of tide gates and levees, the reconnection of historic flow paths, and the planting of native species to support salmon recovery - all while engaging tribal members and youth in cultural revitalization and environmental education (Puyallup Indian Tribe, 2024). This work not only rehabilitates essential ecological functions but re-establishes cultural relationships with the land and water (Puyallup Indian Tribe, 2024). It reframes flood risk not solely as a technical problem but as a relational challenge, one requiring reciprocal engagement with place and kin. As such, it serves as a guidepost for efforts to reimagine floodplain governance through principles of relationality, responsibility, and care.

In this thesis, I use the term "Indigenous science" to refer to knowledge systems that are place-based, relational, and holistic, and held by Indigenous peoples. Indigenous science is grounded in millennia of observation, experiential learning, and intergenerational knowledge transfer (Fiola, 2018; Ludwig & Poliseli, 2018). It does not separate the physical from the spiritual, or the

human from the ecological, but rather understands knowledge as a process of relationship and responsibility. Indigenous science is not static or uniform; it is diverse, evolving, and rooted in specific cultural contexts and ecosystems (Ludwig & Poliseli, 2018). Importantly, it is not simply a set of “alternative” practices, but a fully formed and rigorous epistemology of understanding that has enabled Indigenous peoples to care for and thrive within their homelands since time immemorial.

As Reimer (2018) and others point out, the systems of care and kinship that sustained these landscapes for millennia were not lost - they were forcibly removed and persist in modern Indigenous peoples who continue to carry their cultural stories and are alive and strong (2018). In the face of ecological and climatic uncertainty, recognizing Indigenous floodplain lifeways and knowledge systems is essential for creating more resilient futures (Hankins, 2024). This is supported by the World Bank Study, which found that although Indigenous Peoples comprise only approximately 6% of the world’s population, we steward 80% of the world biodiversity (Hankins, 2024; World Bank, 2025). As climate change continues to unsettle the assumptions of Western management, there is a growing imperative to listen to and learn from the knowledge that has evolved with these lands since time immemorial. Indigenous science and the Indigenous people that carry it hold not only insight into how to live with rivers, but a radically different orientation to land, water, and kinship - one that honors the complexity of life and the responsibilities that come with it.

Chad Reimer’s aforementioned, *Before We Lost the Lake*, traces the colonial disruption of these relationships (2018). Settlers initially gained interest in Sumas Valley because of its fertile floodplain soil for farming and large density of waterfowl and mammals attracted by the lush wetlands surrounding Lake Sumas (Reimer, 2018). They initially engaged in trade with the local tribes but quickly moved to remove the tribal people to claim and convert the land for agriculture (Reimer, 2018). The draining of Sumas Lake in 1918 - an abundant wetland system and cultural hub - was emblematic of this shift. Over the course of a century, settlers constructed levees, dikes, and tide gates to drain Sumas Lake and attempt to control the water for farming, all while forcibly removing Indigenous stewards from their homelands and marginalizing their knowledge systems. The management approach that emerged was one of command and control, rooted in the logic of domination over nature, which I will be referring to in this thesis as “Western floodplain management.”

This transformation reflects the shift from Indigenous floodplain lifeways to Western floodplain management prevailing within the Nooksack River floodplain.

Western Floodplain Management

Western floodplain management has historically prioritized flood control and short-term economic productivity (White, 1945; Pinter, 2005). Through these practices, it seeks to uphold an illusion of control over nature and an urban/nature dichotomy (Wohl, 2014; Galloway, 2005). Infrastructure

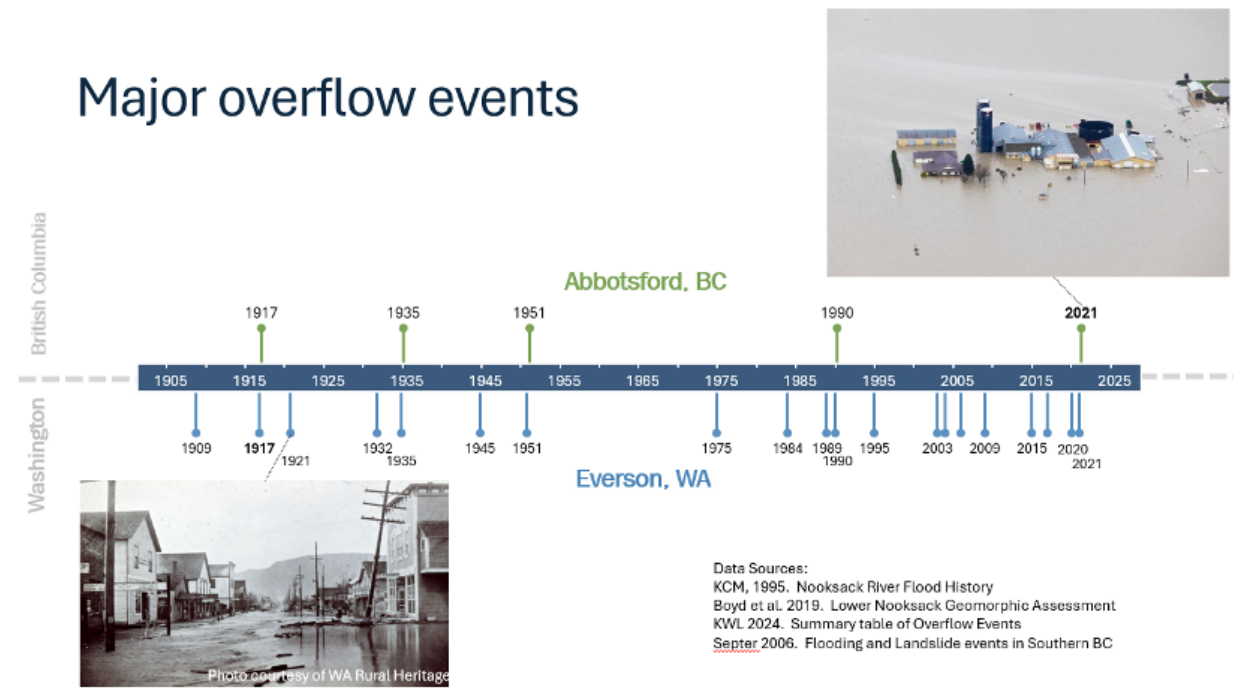


Figure 3. Timeline of flooding events along the Nooksack River since 1905. Floods that overflowed from Nooksack, through Everson and the Sumas Valley to Abbotsford in green. (Source: Julie Morse, Wash. Dept. Ecology)

such as levees and tide gates became and remain common tools, justified by the fertility of floodplain soils, the perceived lack of value in wetlands, and the impediment that seasonal inundation poses to year-round settlement in this floodplain.

Wetlands were drained, and rivers were straightened to increase flow efficiency, all under the guise of progress (Collins & Sheikh, 2005; White, 1995). These efforts substantially change both the ecological functions of floodplains, and the cultural and relational ties that Indigenous communities held with them (Deloria, 1973). By creating areas that remain artificially dry until flood prevention infrastructure is overtopped, planners inadvertently encourage development that is not compatible with periodic inundation. When levees, dikes, or dams fail or are exceeded, the resulting damage is often catastrophic (Pinter et al., 2008; Galloway, 2005), highlighting the limitations of infrastructure-centric approaches to floodplain management. As evidenced in Figure 3, when a levee, dyke or floodwall is eventually overtopped, catastrophic impacts to infrastructure and peoples’ homes, often the people with the least monetary capital who bought the cheapest, lowest lying land, are devastated by flood waters that carry toxic materials and sewage through entire towns (Wills & McDowell, 1982). Through these ecological impacts, we can see that this Western approach to floodplain management is still a socio-ecological system, however it attempts to control or ignore its connections to ecological systems. This makes a system particularly vulnerable when the ecological conditions fluctuate beyond the expected range or when one action has unexpected impacts on another part of the system (e.g. Levees causing losses in channel length and reduced river capacity over time (Mauger & Kennard, 2017)).

In this thesis, I’m inspired by Bruno Latour’s theorizations, which inform my definition of “Western science” not as a monolith, but as a historically constructed system of knowledge rooted in

Enlightenment rationalism, objectivity, and the presumed separation between humans and nature (Latour, 1993). While this framework has generated valuable ecological insights, it often fails to account for the entanglement of social, cultural, and spiritual dimensions in environmental knowledge. Latour critiques the “modern constitution” that allows nature and society to be treated as fundamentally distinct domains, arguing that this artificial separation obscures the networks and relationships that sustain knowledge production (Latour, 1993). As a result, Western science tends to marginalize other ways of knowing - particularly Indigenous epistemologies - that do not conform to its dualistic logic or claims of universal objectivity.

Clarence Glacken’s (1967), *Traces on the Rhodian Shore*, similarly interrogates the intellectual lineage of Western environmental thought, following its roots to classical and Christian traditions that framed nature either as a divine design to be deciphered or as a backdrop for human dominion. Glacken (1967) reveals how Western environmental reasoning historically revolved around three core ideas: the Earth as designed for human use, the influence of the physical environment on human culture, and the capacity of humans to alter nature. These foundations contributed to a utilitarian and anthropocentric worldview that persists in many contemporary land management paradigms. Taken together, Latour (1993) and Glacken (1967) highlight that the limitations of Western science are not only epistemological but also ethical, in that they often fail to recognize the relational responsibilities embedded in place-based knowledge systems. This critique underscores the importance of engaging with Indigenous science not as supplementary but as epistemologically distinct and necessary for more holistic and adaptive responses to environmental change.

Integrated Floodplain Governance

Today, climate change impacts are increasing the frequency with which the weaknesses in Western Floodplain management strategies are exposed (Pinter, 2005; Di Baldassarre et al., 2013; Kundzewicz et al., 2014). Herein, increasingly variable and intense flooding events are challenging the sense of control that Western floodplain management has provided over the past century (Galloway, 2005); what once appeared stable now appears porous and uncertain. For practitioners engaged in the frontlines of climate change adaptations, there is a growing recognition of the limits of western approaches to floodplain management (Interview, March 2025). This is prompting a shift in governance, as decision-making bodies begin to embrace more collaborative, cross-jurisdictional, and interdisciplinary strategies for floodplain adaptation.

Governing bodies responsible for making floodplain adaptation decisions are independently recognizing the need to coordinate floodplain adaptation decisions across levels of governments and between governments (both western and tribal) as well as to consult a diversity of disciplines in the process. Herein, a new approach to living within floodplains is emerging.

One of the most prominent examples of this shift is Washington State’s Floodplains by Design

program. Developed by The Nature Conservancy, the Washington Department of Ecology, and the Puget Sound Partnership, Floodplains by Design funds and supports integrated floodplain management efforts that align flood risk reduction with ecological restoration and community priorities. It is widely recognized as one of the most innovative floodplain adaptation programs in the United States. The Floodplain Integrated Planning (FLIP) process in Whatcom County is a direct result of this program’s funding and philosophy, representing a regional effort to coordinate across governments, including Tribal, municipal, and county entities.

Known as integrated floodplain governance, this approach works across disciplines, jurisdictions and worldviews to coordinate human actions within a given floodplain. While its development was necessitated by the urgent need to address the wicked and evolving challenge of increased flooding from climate change, this integrated process fosters cross disciplinary communication. Such interdisciplinary and inter-epistemological collaboration often reveals the weaknesses in Western floodplain management’s focus on controlling environmental systems rather than working with them (Lutz, 2024).

These integrated processes bring together technical experts and stakeholders who each bring differing frameworks to understand what the problem to be solved is; is the fact that there is development in a floodplain, or that the levee isn’t high enough, is it the accumulation of sediment reducing the river’s capacity to hold water. Often each differing perspective has some truth to it. The integration of technical, governance, and local knowledges is simultaneously this governance model’s most transformative strength and most complex hurdle. Differing definitions of the “problem” reveal underlying values, power dynamics, and historical land use decisions (Brugnach et al., 2008). Local expertise is engaged in two ways: (1) gathering representatives from local communities into regular meeting processes and (2) bringing technical and governance work out to

Chapter 2:
Floodplain Integrated Planning
(FLIP) Team Case Study





Figure 4. The Nooksack River is a river in Northwestern Washington.

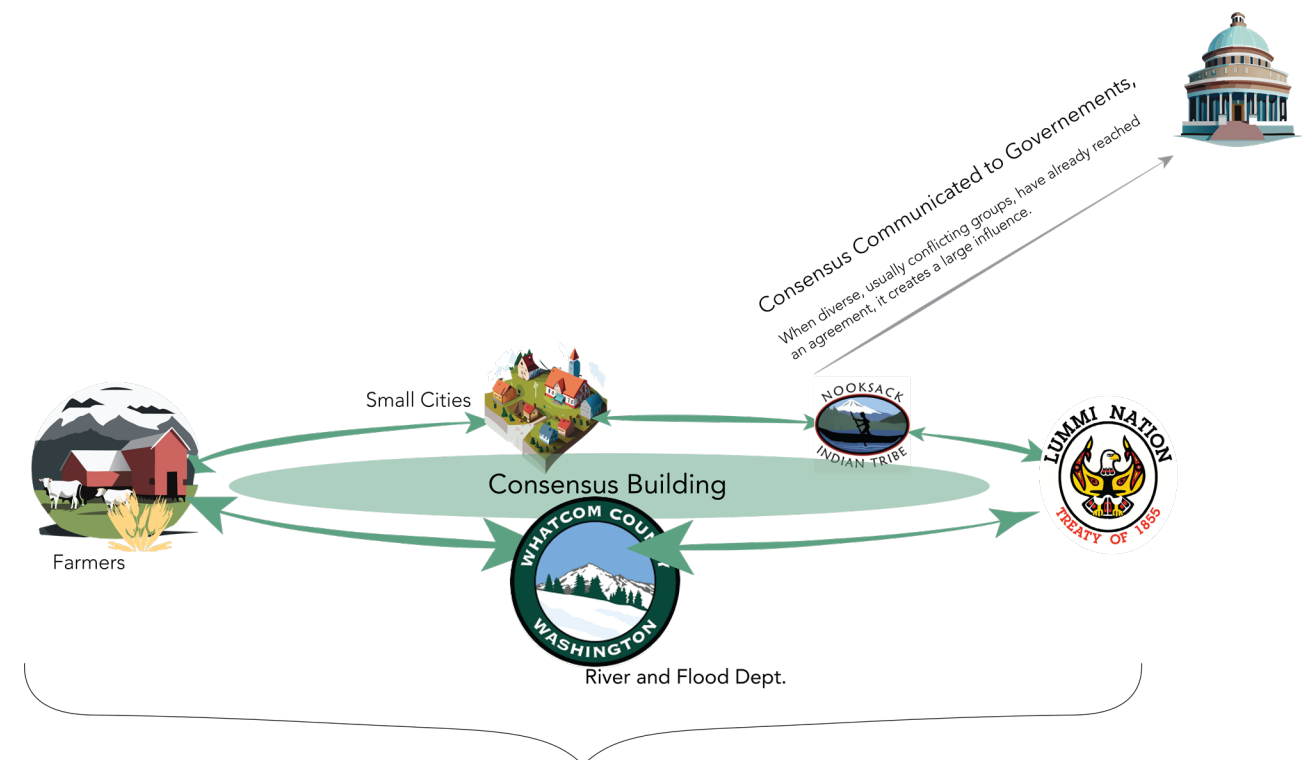
local stakeholders to digest and respond to, referred hereafter as Community Engagement.

Chapter 2: Floodplain Integrated Planning (FLIP) Team Case Study

FLIP team's Current Work

The FLIP Team is a collaborative, multi-jurisdictional group initiated by Whatcom County in 2019. It brings together representatives from Whatcom County River and Flood Department, all municipalities within the Nooksack River floodplain – hereto referred to as Small Cities, private landowner agricultural stakeholders, the Lummi Nation, the Nooksack Indian Tribe, and non-voting insights from the Washington Department of Ecology. Although FLIP is not a decision-making body, it facilitates communication and coordination among diverse actors who each hold distinct governing authority. The group's dual mission is to align floodplain decisions and build consensus around long-term adaptation strategies. This consensus-based approach amplifies their collective influence on regional and state-level governance. This approach to governance I term Integrated, bottom-up governance (see Figure 5).

Since its inception, FLIP has focused on technical analysis, trust-building and relationship development, working to bridge historical divisions and foster mutual understanding among parties with conflicting priorities. Their collaborative work involves negotiating levee setbacks, identifying opportunities for salmon habitat restoration, engaging in wetland and riparian buffer restoration,



Floodplain Integrated Planning (FLIP) Team

Figure 5. FLIP Team Structure.

coordinating voluntary buyouts of flood-prone properties, and even considering managed retreat options for highly vulnerable towns and communities.

One focus of FLIP's planning work is the hydrological connection between the Nooksack River and the Sumas Valley - especially where floodwaters breach international boundaries and impact the City of Sumas in Washington state and Abbotsford City, British Columbia, Canada. This work has informed broader efforts under the Transboundary Flood Initiative (TFI), which seeks to address cross-border flood risks collaboratively. The purpose of this case study was initially intended to focus on FLIP's work in and around the town of Sumas, Washington. However, in studying the social, cultural and ecological connections within the Sumas Valley, the entire Nooksack River watershed proved to be relevant in terms of being impacted by and effecting the Sumas Valley.

The City of Sumas is a small border town, with a population of approximately 1,600 people, that does not regularly experience flooding from the Nooksack River (Census.gov, 2025). However, when the levees in the town of Everson are breached or overtopped, the town of Sumas experiences catastrophic flooding. During major events like the one in November 2021, floodwaters reached depths of six feet or more in the town center (Sumas Charette, 2025).

As part of their integrated approach, FLIP held a value-planning charrette with local stakeholders, elected officials, and technical advisors in March of 2025. This collaborative planning session aimed to share out technical findings of potential future flooding and adaptation alternatives, and to explore a range of adaptation options, including but not limited to elevating structures, restoring floodplain function, constructing new berms, determining how high the levees around Everson

should be and potentially facilitating the gradual westward migration of the town to higher ground. The planning process is intentionally participatory but also sensitive; invitation lists are curated to build trust and foster meaningful dialogue.

Planning documents and vulnerability assessments developed by FLIP and its partners offer insights into the kinds of floodplain interventions under consideration. For example, the Whatcom County Compound Flood Vulnerability Assessment (Flier, 2023) provides data-driven analysis of compound flood risks in the Nooksack system. These reports help ground FLIP’s efforts in both scientific and community-informed understandings of vulnerability, equity, and resilience.

Mapping’s Role in Climate Change Adaptation

As communities like Sumas and governing systems like FLIP navigate these newly emerging processes, mapping is a key method of communication. Maps are relied upon to communicate model findings, flooding extents and depths between technical consultants, to community and between communities, plans for future community growth, ecological and cultural resources, and critical infrastructure. What is mapped supports these integrated conversations as fact-based references, either in what’s presented or what community members and designers draw upon to frame discussions and decision-making.

When engaging in interdisciplinary work, one quickly recognizes that words can have vastly different meanings across disciplines. As a result, during interdisciplinary conversations, people may think they agree or are discussing the same idea, only to realize - when it comes time to interpret a map or decide on a course of action - that they have been speaking in different disciplinary languages (Cash et al., 2003). In this way, maps and other visual renderings that ground ideas in physical manifestations can support clearer communication. The visual and spatial representation of maps enables a more shared understanding of the conditions being assessed across disciplines by concretizing abstract concepts and depicting them in ways that resonate with diverse epistemological frameworks (MacEachren et al., 2004).

As both adaptation and retreat enter the discourse and practice of landscape architects, urban designers and planners (Yarina et al., 2019), critical analysis of how communities are navigating these difficult decisions is essential to support the potential that community resilience is achieved equitably and in the long term. While sea level rise (SLR) poses a major threat to North American cities, to date most buyout programs for flood prone land in North America have been inland sites hit by riparian flooding (Yarina et al., 2019) indicating that major coastal cities threatened by sea level rise are primarily adopting strategies to adapt to SLR instead of programs focused on retreat and relocation.

Further, retreat projects in the U.S. and Canada rarely have plans to relocate impacted communities, and when they do offer only the simple solution of a cash sum for the relocation (O’Donnell, 2022).

This approach neglects the importance of place and community connections, and the cash sums are most often far less than the costs related to relocation. As a result, the removal and displacement of flood-prone communities can increase the vulnerability of ‘retreates’ with low socioeconomic status (Yarina et al., 2019). Displacement can decrease both individual and community resilience through decreasing social capital therefore increasing individual and community vulnerability to displacement and injury in the aftermath of a flooding event (Yarina et al., 2019). Herein, while retreat is one tool for mitigating effects of increased flooding, how it is done, with an eye towards

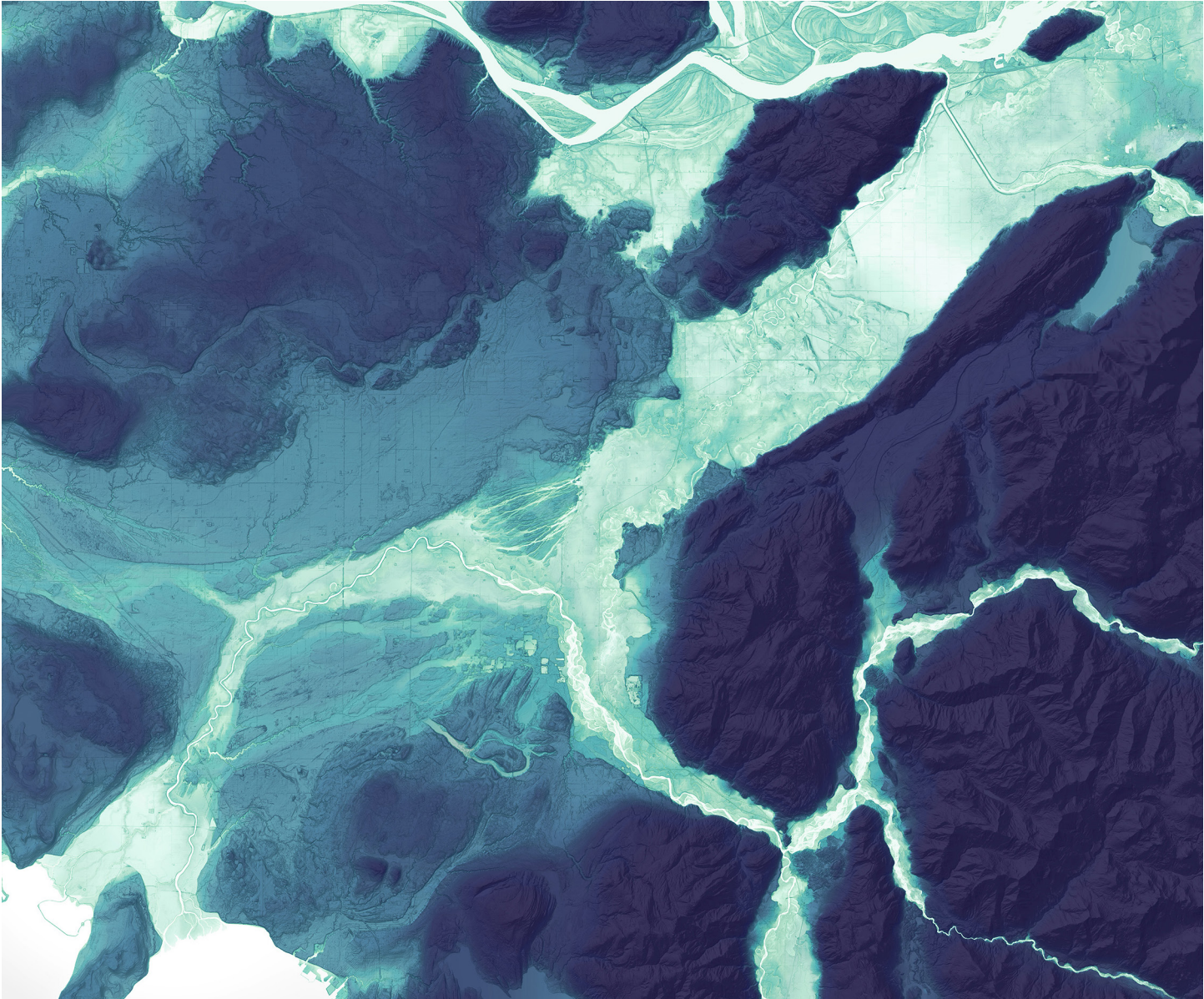


Figure 6. A relative elevation map, to a geomorphologist or someone who is very familiar with it, they can see – an intermingling of current waterways and historic imprints left on the land, even after infrastructure is built and changes the course of waterways these historic clues remain and contribute to modern-day flooding patterns. Much of this story is not legible to someone unfamiliar with a relative elevation map. (Julie Morse, Wash. Dept. Ecology)
community level-planning can improve long term outcomes for individuals (O’Donnell, 2022).

Mapping is not a neutral act. As the field of critical cartography has long emphasized, maps do not simply reflect the world - they shape it (Harley, 2001). They carry embedded assumptions about what matters, who counts, and what kind of knowledge is deemed authoritative (Crampton, 2001).

In the context of floodplain adaptation, mapping is a powerful tool for communicating risk and shaping future interventions, yet the way maps are produced often mirrors the disciplinary silos of the institutions that generate them. This poses a particular challenge to emerging integrated processes like the FLIP team. Hydraulic models, ecological surveys, cultural resource inventories, and land use plans are frequently represented through separate mapping processes, each grounded in different epistemologies and design languages. These silos limit the potential for holistic understanding and shared planning across the complex, interdependent systems that comprise floodplain landscapes. As a result, maps may serve technical purposes while remaining illegible or inaccessible to other disciplines or community members. This reinforces hierarchies of expertise and restricts who gets to participate in shaping adaptive futures.

One example of this dynamic can be seen in the use of relative elevation maps. Figure 6 shows such a map, which visualizes subtle shifts in ground elevation relative to the surrounding landscape. To a geomorphologist or someone trained in fluvial processes, this map tells a layered story: traces of historic river courses, remnant flood channels, oxbow scars, and the enduring geomorphic memory of the topography (Interview, February 2025). Even after infrastructure has altered the water's path, the land bears witness to the patterns of flow and flooding that shaped it. As Julie Morse of the Washington Department of Ecology notes, these "historic clues remain"- etched into the terrain, visible in micro-topographies that defy modern land use boundaries and inform where future floods will occur (Interview, February 2025).

Yet this kind of story is not easily accessible to someone without disciplinary training. To a community member, planner, or a designer unfamiliar with this type of map, the image may appear abstract, disconnected from the realities of the place. Without context or interpretation, the map functions more as a barrier than a bridge, excluding rather than inviting participation. This example illustrates how mapping practices that are not designed for legibility across audiences can reproduce knowledge hierarchies and limit the co-creation of adaptive strategies.

In this way, critical cartography calls for a more reflexive and inclusive approach to mapping - one that is attentive to who can read, interpret, and contribute to what is shown. If Integrated Floodplain Planning seeks to engage across disciplines and worldviews, maps, as fundamental documents of communication to be used for shaping planning decisions, must be more than technical illustrations. They should be tools for dialogue, co-learning, and storytelling, supporting shared visions of resilience that emerge from multiple ways of knowing. Layered maps, annotated overlays, and participatory mapping methods offer one path forward. Maps tailored to the audience and their intended purpose, practitioners can begin to undo the siloed nature of cartographic representation and support more innovative governance processes. In this sense, mapping becomes a practice not of reduction, but of synthesis, inviting users to hold multiple truths at once and recognize how overlapping social, ecological, and infrastructural systems shape the lived realities of floodplain landscapes.

By visualizing connections between broader goals and local realities, mapping enables shared understanding across communities, decision-makers, and practitioners (Sheppard et al., 2011). It can also serve as a form of critical pedagogy, challenging dominant narratives and supporting emancipatory engagements with land and water systems (de Souza et al., 2025). Yet, significant barriers persist. Gaps in perception, scale, and disciplinary language hinder the integration of science and design (Moosavi et al., 2023). Visualization tools - such as scenario modelling, design renderings, and participatory mapping - can help overcome these barriers by making complex climate impacts and adaptation options legible across different audiences (Walton & Bosomworth, 2017; DeCock-Caspell & Vasseur, 2021). These tools not only aid in communicating scientific knowledge to communities, they enable the return flow of community insights to decision-makers, fostering iterative, co-produced solutions. In this way, mapping becomes not just a tool for representation, but a practice of relationship-building and systems change.

Moosavi's (2023) work in Genoa, Italy exemplifies how participatory mapping can bridge disciplinary divides and enhance communication in climate adaptation planning. In the flood-prone district of Sampierdarena, researchers integrated technical hydrological assessments with community input to identify appropriate locations for Sustainable Urban Drainage Systems (SUDS). This process created a georeferenced database that captured both physical data and the lived experiences and priorities of residents, enabling shared spatial understanding among engineers, planners, and local stakeholders. By grounding design interventions in both scientific evidence and community knowledge, the project fostered mutual learning and improved the legibility of adaptation strategies across sectors (Moosavi et al., 2023). However, while this case illustrates the value of interdisciplinary mapping in an urban European context, it does not address the complex jurisdictional and cultural dynamics at play in Indigenous-settler floodplain planning in North America. My research addresses this gap by exploring how mapping can support integrated floodplain governance that respects Indigenous ways of knowing, fosters equitable participation, and builds shared capacity for adaptation in the Nooksack River floodplain.

This thesis explores how mapping can serve this function through a community engaged mixed

Chapter 3:
Methods



methods approach.

Chapter 3: Methods

This research is grounded in a community-engaged approach that centers reciprocity, respect, and co-creation with partners from the FLIP Steering Committee (FLIPSC) and the broader community. I draw on the guidance of Singeo and Ferguson (2023), whose work critiques extractive research practices - often described as “parachute science” - in international conservation contexts. Singeo and Ferguson (2023) proposes five principles to guide ethical and equitable research partnerships, including the commitment to “come with an empty basket” (Singeo & Ferguson, 2023,pg. 3) This principle, which I have adopted in my own work, emphasizes approaching the work without pre-determined agendas and instead listening to my community partners and remaining accountable to them as I determine research outcomes. In the context of my collaboration with FLIPSC, this has meant supporting the identification of project priorities and deliverables that directly serve their goals, rather than imposing my own.

Weekly Meetings

Throughout this process, weekly meetings with the FLIPSC and key Tribal partners have been

essential for cultivating trust and establishing shared purpose. These meetings have not only been a logistical tool but also a relational space for listening, learning, and aligning the research process with community needs. The goal of my engagement is to ensure the research produces benefits for the community and avoids causing harm, both materially and relationally. This commitment to reciprocity is expressed through co-designed research products and iterative feedback loops, enabling transparency and community control over the direction of the work.

Value Planning Charette

A major component of this research involved participating in and observing a Value Planning Charette in the City of Sumas. This two-day event was structured to bring together local stakeholders, members of the FLIP process, Tribal representatives, and local government to collectively envision flood risk reduction strategies rooted in shared values.

The charette was structured as follows:

Day 01: Most participants traveled in two shuttle buses; some drove their own vehicles. Participants met at City Hall at 12:00-12:15

Tour stops included:

- The streets and buildings surrounding City Hall and Johnson Creek – City representatives discussed how deep the flood water was in November 2021, where large volumes of sediment deposited on city streets and business parking lots when the railroad embankment breached, how much more of the city was inundated than in past floods. The peak of flooding occurred in mid to late morning, at a much higher flow rate than was forecasted in Sumas. Water levels rose so quickly, in part due to the railroad breach, that Sumas residents had no opportunity to evacuate once the flood wave arrived. Everyone was stuck in place for deep water flooding that lasted for 2+ days.

- A local business owner described effects on their business experienced during and after flooding in November 2021, including the challenge of continuing to provide feed for livestock prior to repair of the rail lines and resumption of rail deliveries. They also discussed measures they have taken to limit future flood damage to their business operations, including a flood wall made of Ecology blocks that cost \$70,000 to construct.

- City water towers near residential area on a hill accessed via Arthurs Way west of downtown, City representatives gave an overview of how the City is involved in water supply for the City and how they have a separate agreement for electricity and don’t rely on Puget Sound Energy. This area of high ground is within the current City limits.

- City groundwater well site on May Road – Sumas public works director described the well system that supplies groundwater for domestic and commercial uses, without need for chemical

treatment, to Sumas and surrounding areas. He also described the wastewater system in the area and how wastewater is piped to Abbotsford for treatment. Utility rates for customers are quite affordable compared to other communities in Whatcom County and elsewhere in western Washington. Flooding in November 2021 threatened to damage utility infrastructure and foul the water supply. This site is in a large area where Sumas proposes to expand its Urban Growth Area boundary, but there are numerous wetlands and stands of forest trees in it, which will affect the amount of developable land.

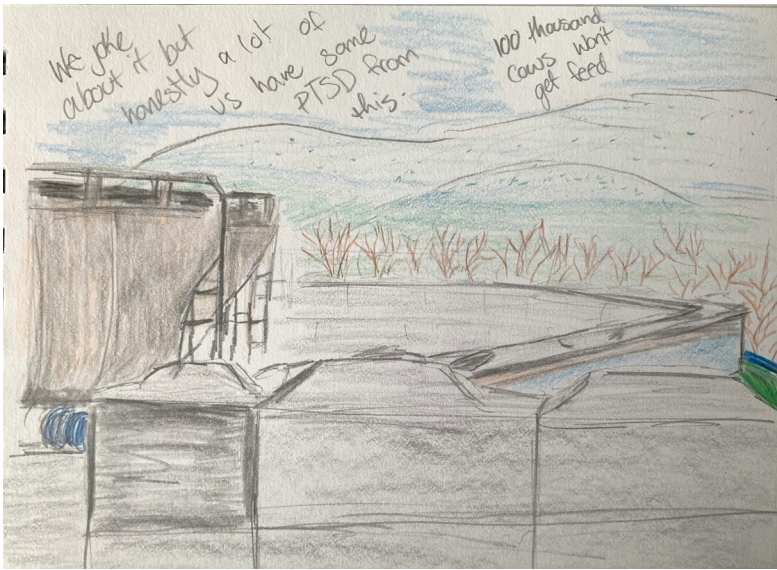


Figure 7. Site sketch during Day 1 of value planning charrette with quotes from community guides.

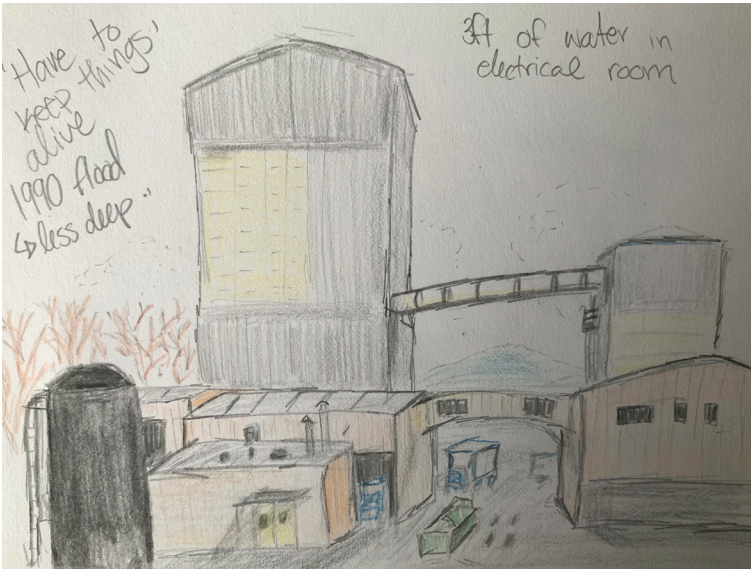


Figure 8. Site sketch during Day 1 of value planning charrette with quotes from community guides.

on Beaver Road to the south. It was miraculous that no deaths occurred in the Sumas area given how dangerous the floodwater conditions were.

Day 2: Summary of Design Charrette

Participants wrote down their personal values (in the context of this workshop) on small sticky-note paper and they were then sorted on a wall of the conference room by a representative from the Whatcom Family Farmers association into thematic groups:

Safety; Family/Community; Justice/Fairness/Equity;

- Clearbrook Road west of Lynden-Sumas Highway – Police and Fire Chiefs described how deep and fast the water was in this area in November 2021 compared to past floods. Residents launched a speed boat to get across inundated farm fields to the south of Clearbrook Road to rescue motorists trapped

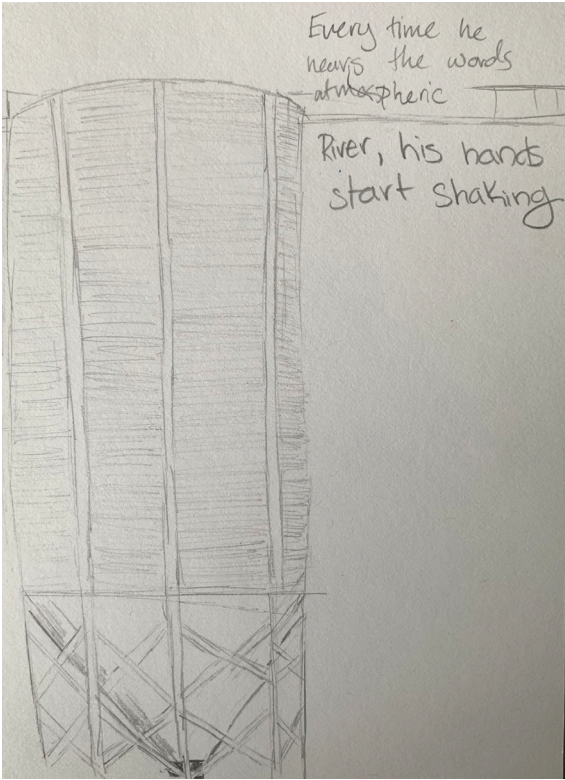


Figure 9. Site sketch during Day 1 of value planning charrette with quotes from community guides.

Ecological Health and Natural Area Recreation; Vitality for City Businesses and Agriculture; Action; Truth/Root Causes; Cultural Resources

These values form “success criteria” with which to evaluate potential solutions developed during



Figure 10. Word cloud generated from Day 2 of the Value Planning Charrette Value exercise.

the day. Detailed values in Figure 10.

A Whatcom County River and Flood Engineer, the lead modelling consultant, a Nooksack Tribe member and employee, and a landscape architecture and planning consultant presented information that is relevant to defining viable flood risk reduction solutions for the Sumas area, including:

- “Buckets of actions” defined in a Nooksack River “flow split” design charrette in April 2022.
- Specific flood mitigation options identified at the charrette and a description of the evaluation process used to screen the options into a subset that is proposed to be carried forward. These included:
 - A study of options for storing water upstream of the flow split was completed in 2024, which did not identify any options that can substantially reduce flood overflows affecting Sumas
 - Hydraulic modeling of the effects of raising Emerson Road to prevent overflows through Everson to Sumas in a 100-year flood event in the Nooksack River show that it would cause 2+ feet of increased water depths along the river’s floodplains in areas downstream of Everson all the way to Puget Sound, indicating that stopping all overflows to Sumas would cause new life safety impacts

to thousands of downstream property owners and residents.

- “Widen the Funnel” (WTF) concept – a variety of actions in and adjacent to the river upstream of the Everson bridge are being evaluated in detail, with promising results that would reduce the frequency and volume of overflows to Sumas. Key elements include remove/set back/ lower Twin View Levee; set back bank armor on the north side of the river channel; build/encourage formation of side channels; widen Everson Bridge hydraulic opening; sediment management as may be needed to retain conveyance in the widened funnel; and improve habitat.

- Berms surrounding developed areas of the cities of Everson and Nooksack would reduce risk in those areas, and hydraulic modeling indicates they would not increase flood risks to Sumas and Abbotsford (could slightly reduce peak flow through Sumas)

- Changing climate conditions make future increases in atmospheric river intensities and flood flow magnitudes more likely

- The Nooksack Indian Tribe has thousands of years of experience and familial connections to the land in the Sumas area and remains committed to working together collaboratively to respectively address today’s shared challenges now and into the future

Observations of the value planning charette were captured in three ways. On day one, – the field tour day - community stories and local landscapes were captured through (1) pictures, (2) notes and (3) field sketches with quotes from the community. On day two, observations were captured through (2) personal notes, with functional details from the day supplemented from the publicly available notes taken by the researcher and the modelling technical consultant.

Social Landscape Mapping

To better understand and communicate the structure and function of the Floodplain Integrated Planning (FLIP) process, I adapted the Mapping Connectivity approach from the Mapping Social Landscapes guide developed by the World Resources Institute (Shames et al., 2018). This method provides tools for tracing relationships and flows of information among individuals and organizations engaged in landscape restoration and planning.

This approach was particularly relevant to the FLIP context, where multi-jurisdictional coordination and cross-cultural collaboration - especially with Tribal Nations - are central. By focusing on both social connectivity and the values that underpin participation, the methodology supports a more nuanced understanding of institutional and interpersonal dynamics across the floodplain.

To map connectivity within the FLIP network, I compiled data from planning documents and meeting observations. I focused on identifying:

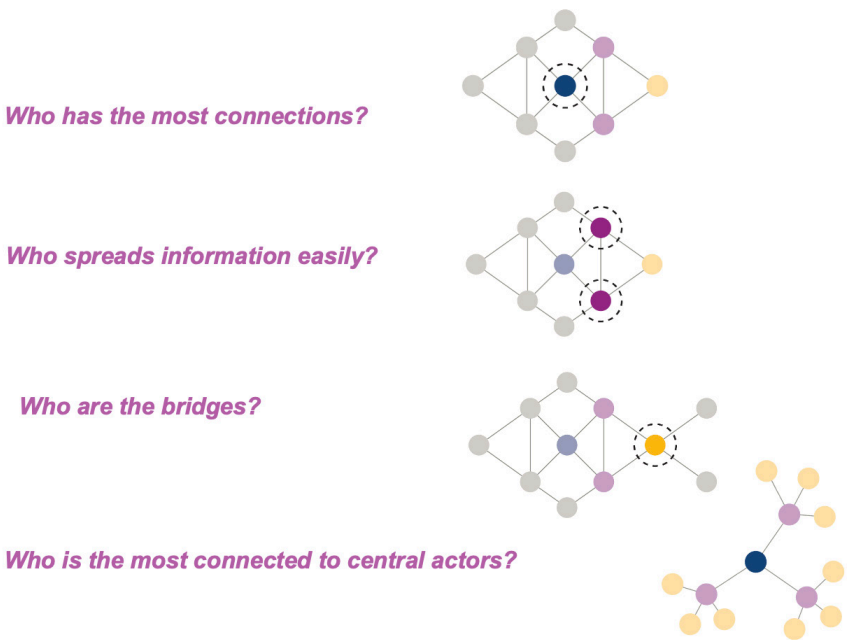


Figure 11. Social landscape mapping methodology. (Source: Shames et al., 2018)

- Formal and informal relationships between individuals and organizations.
- Flows of information, such as who shares data, who facilitates coordination, and who communicates decisions.
- Key roles and influence, including which actors help bridge jurisdictions, mediate conflict, or amplify specific interests.

Interviews & Iterative Mapping Guidance

Following the social network mapping, a purposive sampling approach was employed for interviewee selection (Tracy, 2020). The purposive sampling is guided by the social network mapping process (SNM). SNM identified FLIP participants who are engaged in mapping but lack working connections with one another and I considered these key potential interviewees in the SNM process. Potential interviewees were then contacted and interviewed in order of their availability.

During interviews, I asked each participant to reflect on what they believed was most important to map in the Nooksack River floodplain, especially with the goal of fostering systems understanding and meaningful community engagement. This often initiated a discussion, with key takeaways from each interview summarized in Table 2 in Chapter 4.

Since I began creating the first draft map based on conversations during the weekly FLIP meetings, this initial draft of the 1880 historic ecology map was presented to the community by the Director of Cultural Resources for the Nooksack Indian Tribe during the Sumas Value Planning Charette.

Many weekly meetings occurred before the Sumas Charette occurred. As a result there was the opportunity for the 1880 historic ecology map to be shared. Other draft maps were shared with interviewees during interviews for feedback, questions and to prompt ideas of what was missing.

Applied Historic Ecology

Following the practitioner guidance during the interviews, I used applied historical ecology to understand and depict environmental change in the Nooksack River floodplain since contact, industrialization and urbanization has begun in the region. This approach blends natural and documentary records to reconstruct past ecosystems. The core natural record in this analysis is a relative elevation model that reveals the geomorphology of the Nooksack River and Sumas Valley. This model highlights historical river channels, alluvial fans, and flood-prone lowlands, providing a physical framework for interpreting human-environment relationships.

To complement this, I consulted six historical maps ranging from early settler cartography to U.S. Geological Survey documents (See Table for all maps consulted). I cross-referenced these with

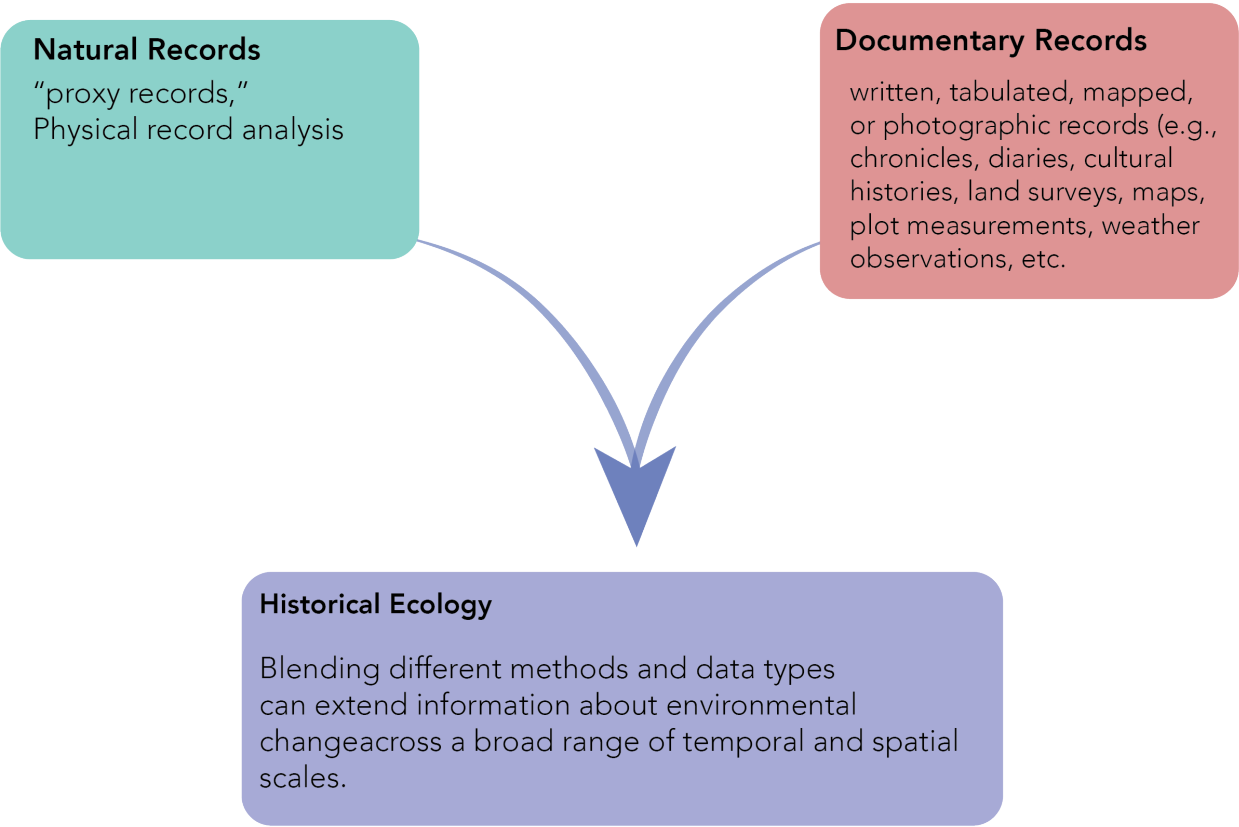


Figure 12. The core methodology involved in applied historic ecology methodologies.

Indigenous documentary records, specifically the book *Before We Lost the Lake*, a collection of stories shared by Stó:lō and Semá:th elders and historical records, and the *Nooksack Tribe Place Names* book, which I was granted permission to use by the Head of Cultural Resources for the Nooksack Indian Tribe. These sources offer insight into locations of prairies, the vegetative make-up of wetlands, changes in water flow, and other ecological features that settler maps omit or

misrepresent. By comparing these layered records, I created two composite historical basemaps representing land and water conditions circa 1880 and 1939. These maps reflect a synthesis of geomorphological evidence and historical perspectives, offering snapshots of the Nooksack river and Sumas Valley through time, illustrating the changing nature of change within this valley.

The use of applied historical ecology in this project is significant for its ability to inform contemporary ecosystem management by contextualizing present-day landscape patterns within a longer temporal frame. By reconstructing past environmental conditions using both natural and documentary records, this method provides a critical frame of reference for assessing modern ecological processes. As mentioned in Chapter 1, Floodplain Governance Systems that have provided a sense of safety and stability for the past century are being challenged. Herein, broadening our frame of reference for Floodplains beyond the most recent century can support in reframing both physical and governance designs for the next century. Importantly, an understanding the longer timescale of a floodplain supports understandings of the dynamic nature of the Nooksack River floodplain—revealing that what is often perceived as stable or degraded may instead be part of a broader, ongoing transformation shaped by both natural forces and human intervention.

Map Author	Year	Citation
North West Boundary Survey	1868	"The Northwest boundary from Point Roberts to the Rocky Mountains" (1868) [nara, rg 76, cs66, Map 7]
North West Boundary Survey	1860	"Native Place Names" (1860) [nara, rg 76, cs68, Map 1]
Land Title and Survey Authority of British Columbia	1886	"Plan of Township N° 23 East of Coast Meridian" (1886) [New Westminster, Plan 8 Tray 8]
Land Title and Survey Authority of British Columbia	1892	"Plan of Township N° 19 East of Coast Meridian" (1892) [New Westminster, Plan LTSA5725-150305]
United States Geologic Survey	1939	Timeless Maps. (1952). Sumas, Washington [Topographic map, 1:24,000]. United States Geological Survey. Retrieved from https://www.alamy.com/sumas-washington-map-1952-124000-united-states-of-america-by-timeless-maps-data-us-geological-survey-image414295221.html
Tribe, Sheikh & Montgomery	N/A	Tribe, N. I., Collins, B. D., & Sheikh, A. J. Historical riverine dynamics and habitats of the Nooksack River.

Table 1. Historic maps consulted.

This research employs a weaving methodology, an approach that brings together Indigenous and Western scientific knowledge systems in ways that preserve their epistemic distinctiveness while enabling mutual validation and dialogue. As articulated by scholars including Robin Wall Kimmerer (2013), Linda Tuhiwai Smith (1999, 2021), and Miriam-Rose Ungunmerr-Baumann (2017), weaving involves holding multiple ways of knowing alongside one another—recognizing that each arises from different relationships, responsibilities, and modes of verification.

Weaving Knowledge Systems: An Inter-Epistemic Methodology

In this work, weaving is not framed as a means of achieving justice or inclusion, though these are meaningful outcomes. Rather, it is grounded in the understanding that Indigenous science is a rigorous, place-based system of knowledge, developed through millennia of observation, experimentation, and intergenerational transfer (Kimmerer, 2013; Ludwig & Poliseli, 2018). It offers insights into ecosystem dynamics, resilience, and adaptation that can enrich and strengthen environmental design and planning outcomes, particularly in floodplain systems shaped by dynamic and interdependent processes.

This methodology explicitly avoids assimilation. Indigenous and Western sciences are not merged into a single framework, but instead are held in relationship, each informing, challenging, and enhancing the other to form a more robust and contextually grounded understanding of socio-ecological systems. As Métis scholar Dwayne Donald (2012) suggests, this requires cultivating “ethical relationality,” a way of engaging across difference that is rooted in respect, non-hierarchical exchange, and accountability to place.

In practice, weaving occurred at several levels of this research. Mapping processes combined:

- Geomorphic and hydraulic models with
- Oral histories, Indigenous place names, and cultural landscapes, and
- Community feedback and local observational knowledge.

For instance, meander scars and sediment deposits were interpreted not only through LiDAR and flow models but also through Indigenous understandings of past salmon pathways and seasonal cycles. Historical basemaps were enriched through stories of culturally significant forests, wetlands, and prairies no longer visible in settler cartography.

Throughout the process, reciprocity and iterative co-development were emphasized. Draft maps were reviewed with Tribal partners, who offered not only technical and cultural insight but emotional and relational context, demonstrating how maps could serve both analytical and restorative functions. This process acknowledges that knowledge is not only cognitive but also relational and affective, particularly when working in landscapes marked by deep histories of disruption and care.

By centering a weaving methodology, this research aims to contribute to planning and design approaches that are ecologically attuned, culturally grounded, and methodologically plural, while remaining accountable to the specific communities and knowledge systems they engage.

For creating modern socio-ecological maps, I utilized a research process that weaves outside technical expertise in the form of flood modelling, geomorphology, planning, and ecology;

local knowledge in the form of county officials and resident feedback from the value planning charette; and Indigenous Science in the form of text records and an interview. Interviews, technical documents, conversations in weekly meetings, observations, and stories informed a list of different data sets that each expert suggested (see table 2 for a list of these key takeaways from the interview process). From these various channels of feedback, I worked to bring all these data sets together into legible maps of connected systems. Since the Nooksack River watershed crosses

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Integrating adaptation across
jurisdictions, disciplines and
worldviews



the U.S.A – Canada Border, this involved finding data sets from both sides of the border that were relevant to one another. Once all the data was obtained, the process of mapping involved applying the insights of key social and ecological connections from the interviews to create maps of infrastructural and ecology systems relevant to one another.

Chapter 4: Integrating adaptation across jurisdictions, disciplines and worldviews

Weekly Meetings

Attending, mostly in an observational capacity with occasional updates on my process, the weekly FLIP ‘Coffee Chat’ meetings over a period of six months played an important role in understanding who the members of FLIP are, their roles and relationships, what technical consultants are involved and what types of technical analysis are being communicated out to community, in what form. Not only were these core operating functions of the FLIP revealed through the observations, but important relationship building of introducing myself, my personal and disciplinary background and ethical approach to research when I presented at a FLIP Steering Committee Meeting, asking for permission to join these weekly, more informal meetings. Finally, attending these weekly meetings and providing updates created an environment of ongoing accountability across the FLIP team.



Figure 13. Top: Railroad through Sumas, WA, looking South. November 2021. Source: LSMR. Bottom: Railroad Looking North, Sumas WA. March 13th 2025. Source: Camille Forest

Hearing their conversations as they worked through the process of adaptation governance in politically diverse communities and highly flood prone regions provided the consistent reminder to try and understand more before forming critiques of their approach.

Observations of Sumas Value Planning Charette

Day 01:

The first day of the Sumas Value Planning Charette involved a local public works official, the police chief, the mayor and a private land owner giving the FLIP steering committee and local community members a tour of the City of Sumas, pointing out key sites of flooding impacts. Some notable examples of this include the site where the railroad that runs through town and acts as a levee for



Figure 14. Top: Building with watermarks from November 2021 flood. Tour of private business.

Bottom: Tour of private business. Sumas WA. March 13th, 2025.

the more populated East side of Sumas failed (see Figure 13), a building where the watermark from standing flood water (not high water) that lasted days in the town is still visible, and the property of a private land owner who experienced catastrophic flooding that threatened the viability of their business (see Figure 14).

Beyond the physical impacts the flooding, this field tour conveyed both the deep emotional scars from the flooding in this region and the importance of the strong social ties and commitment to community in the City of Sumas. Some notable examples of stories of emotional scarring are reflected in the field sketches in Figures 7, 8 and 9, where gruff farmers and tradesmen shared anecdotes like “whenever my operations manager hears the words atmospheric river, his hands start shaking”, another resident shared that his wife will still wake up at night from dreams of drowning in their bed, and finally, after joking around, one property owner shared that “we joke about it, but honestly a lot of us have PTSD from this” (Sumas Charette, 2025). The community also shared their pride that despite little notice before 6 feet of water was rushing through the homes across Sumas, there were no human fatalities (Sumas Charette, 2025). Due to the gap in flood gauges between the City of Everson and the City of Sumas, In the lead up to the flood, the local police chief would drive out to the road at the edge of town to check on the progression of flood waters (Sumas Charette, 2025). Once the flood hit, residents with large tractors and motorboats used their equipment to rescue people who had not evacuated from the second story of their homes. Several pieces of equipment were destroyed by the flood waters (Sumas Charette, 2025).

The opening hour of the second day of the Sumas Value Planning Charette served to communicate the FLIP team’s understanding of local ecological and

infrastructural conditions, as well as broader global climate change trends. This portion of the process effectively distilled months—if not years—of technical analysis conducted by specialists across disciplines, often represented through technical maps and software-generated outputs. It also implicitly set the boundaries for what tools were available and what kinds of problem-solving approaches were encouraged. The FLIP team presented several alternatives for flood protection on the main stem of the Nooksack River and introduced “Widen the Funnel” as the overarching adaptation strategy for the flow split—the area where the Nooksack River historically flowed north through the Sumas Valley but has since been rerouted.

Following this context-setting presentation, the broader group (FLIP team + Sumas community) engaged in a process to identify shared values. When the session moved to small group work to develop design responses to the challenges discussed, the Sumas community focused exclusively on decisions made at the Everson Bridge, which they identified as the root cause of the increasing size and frequency of their flood events.

The community arrived with independently commissioned flood modeling—analyses they were not yet willing to share with FLIP. Whether due to a lack of trust or another reason, they had concluded that the worsening flooding in Sumas was primarily due to gravel bars behind the Everson Bridge. Based on materials reviewed in advance, it was clear that many community members came with questions about why gravel removal was not being pursued along this section of the river.

One emergent concept during the session was that of “equitable flooding.” Rather than viewing flooding as a purely technical challenge to be eliminated, this framing—surfacing through community dialogue - posed critical questions about how much water was being directed down the main stem of the Nooksack and how impacts were distributed.

These discussions illustrate how people’s understandings of the connections between local infrastructure and ecological systems shape how problems are defined—and what solutions are deemed viable. For example, the FLIP team’s preferred approach, “Widen the Funnel,” aims to restore the Nooksack River’s natural capacity to transport sediment past the Everson Bridge over the medium to long term. This strategy treats sediment build-up not as a static problem but as a symptom of altered river processes. Through floodplain reconnection, the goal is to reduce sedimentation over time. However, despite being presented during the opening hour, community members spent the entire day focused on sediment concerns at the flow split, and the mayor later joined a technical sediment meeting with FLIP’s geomorphology consultant.

From my perspective -shaped by two days of intensive engagement and an 18-month relationship with FLIP members - this dynamic reflects the intersection of two mismatched processes. First, although the Sumas community is nominally represented on the FLIP Steering Committee by their mayor, his inconsistent attendance left community members feeling sidelined by regional decision-making. Throughout the charette, participants expressed frustration, describing the meeting as

“three years too late” or “long overdue” (Sumas Charette, 2025). While there was one meeting with Sumas after the 2021 flood, an additional meeting focused more on listening to community concerns - and less on presenting FLIP findings- may have helped establish a more collaborative tone for the 2025 session.

Second, from the FLIP side, years of work had gone into synthesizing diverse technical expertise. This process involved building a transdisciplinary network that included urban and natural resource planning, hydraulic and sediment modeling, ecology, tribal perspectives, and geomorphology. In doing so, the FLIP team was establishing a shared systems-based understanding of the Nooksack River floodplain. However, in communicating their findings, the team prioritized presenting conclusions rather than first building shared understanding with the communities being asked to provide input. This limited opportunity for collaborative meaning-making and reinforced the perception that key decisions were already made.

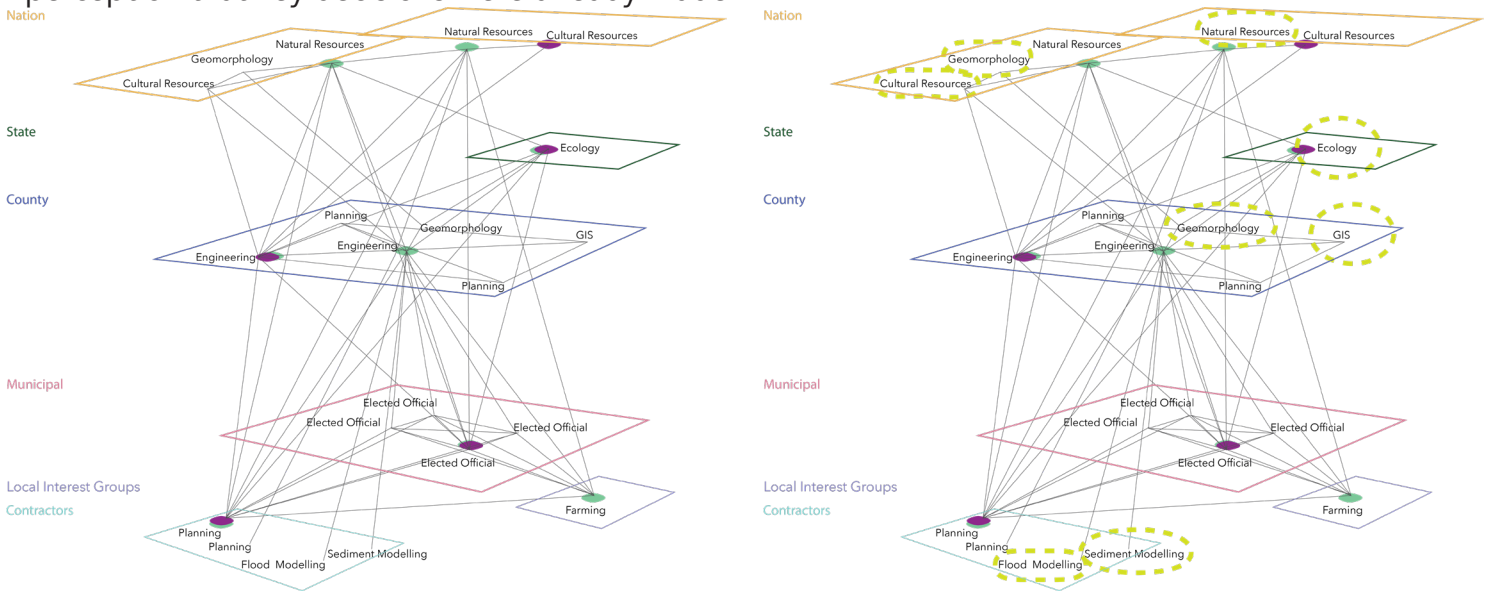


Figure 15. Left: Results of social landscape mapping for the FLIP team. Right: Highlighting technical participants involved in mapping.

Social Network Mapping

The social network analysis revealed that the FLIP (Floodplain Integrated Planning) process has strong connections across various levels of government. These vertical relationships support coordination and resource-sharing between federal, state, and local agencies. However, the mapping also exposed a lack of lateral and horizontal connectivity as it relates particularly to those involved in technical mapping and analyses. This gap limits the integration of different expertises and may hinder the development of a systems-level understanding of the floodplain.

Interviews

In response to the social network mapping, I selected interview participants who represent different forms of knowledge - tribal, scientific, governmental - that did not have existing working

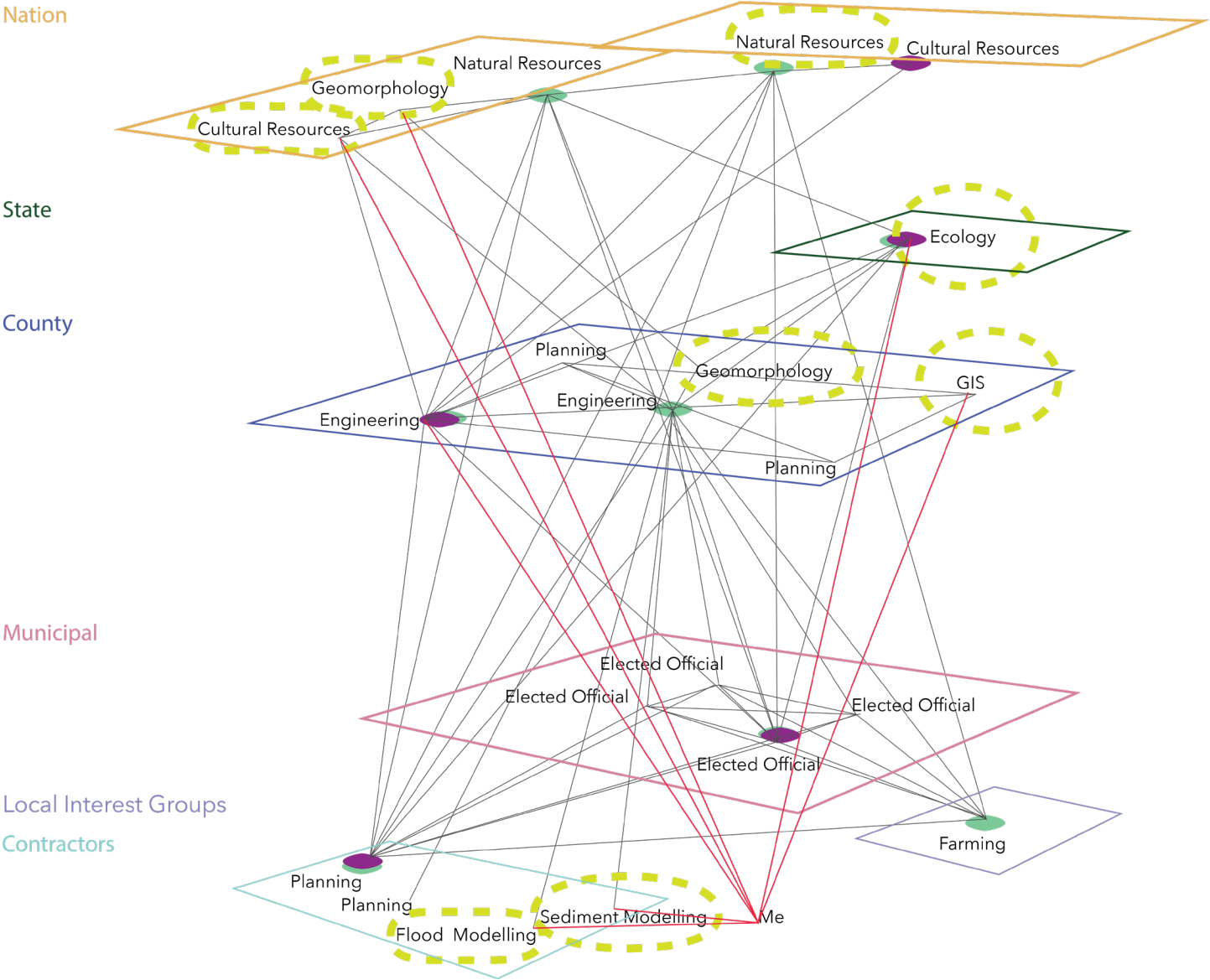


Figure 16. The goal of the interviews is to understand what these participants are mapping, what they view as important about their maps, and what questions they have to figure out if new knowledge can be generated through intergation. connections and asked them: what do you think is most important to map in the Nooksack floodplain to support a systems-level understanding with community? Their answers varied,

Type of engagement	Organization	Position	Role in FLIP	Key Interview Takeaways
Interview	Nooksack Indian Tribe	Tribal member and employee	Voting Member	Cultural connections were as strong as the ecological connections
Interview	Washington Department of Ecology	Environmental Planner	Non-Voting Member	Salmon still migrating to Johnson Creek,
Interview	Whatcom County River and Flood	River and Flood Engineer	Voting Member	That almost the whole Nooksack River is lined with either levees or Riprap
Interview	Herrera Environmental Consultants	Environmental Engineer	Hydraulic Modelling Consultant	The pivotal role that the Everson bridge plays in both sedimentation and current conceptions of flooding.
Presentation	Unnamed private company	Geomorphologist	Sediment Modelling Consultant	The ways levees and bank armoring change sedimentation patterns

Table 2. The Interviewees for this project.

but together they pointed to the need for maps that reflect historical depth, cultural presence, ecological flows, and power dynamics.

The environmental planner described the value of incorporating heat maps that track species migrations—such as sturgeon, ducks, and geese—toward historic lake systems. They emphasized the importance of integrating hydrography across the U.S.-Canada border, citing features such as Barrowtown, the fish weir, and the remaining forested riparian buffers. They also noted the absence of riparian vegetation in many areas due to historic clearing. Key elements for the modern map included stream flows connecting the Fraser River to Johnson Creek, and critical infrastructure like pipelines. Their perspective highlighted the need for integrated ecological and hydrological mapping that recognizes border-transcending systems and their disruptions. In response to sharing my draft maps, this prompted a discussion of representation methods for static data sets versus flows of people, animals and water fluctuation and applying a method I was using to depict the flows of people to depict migration flows.

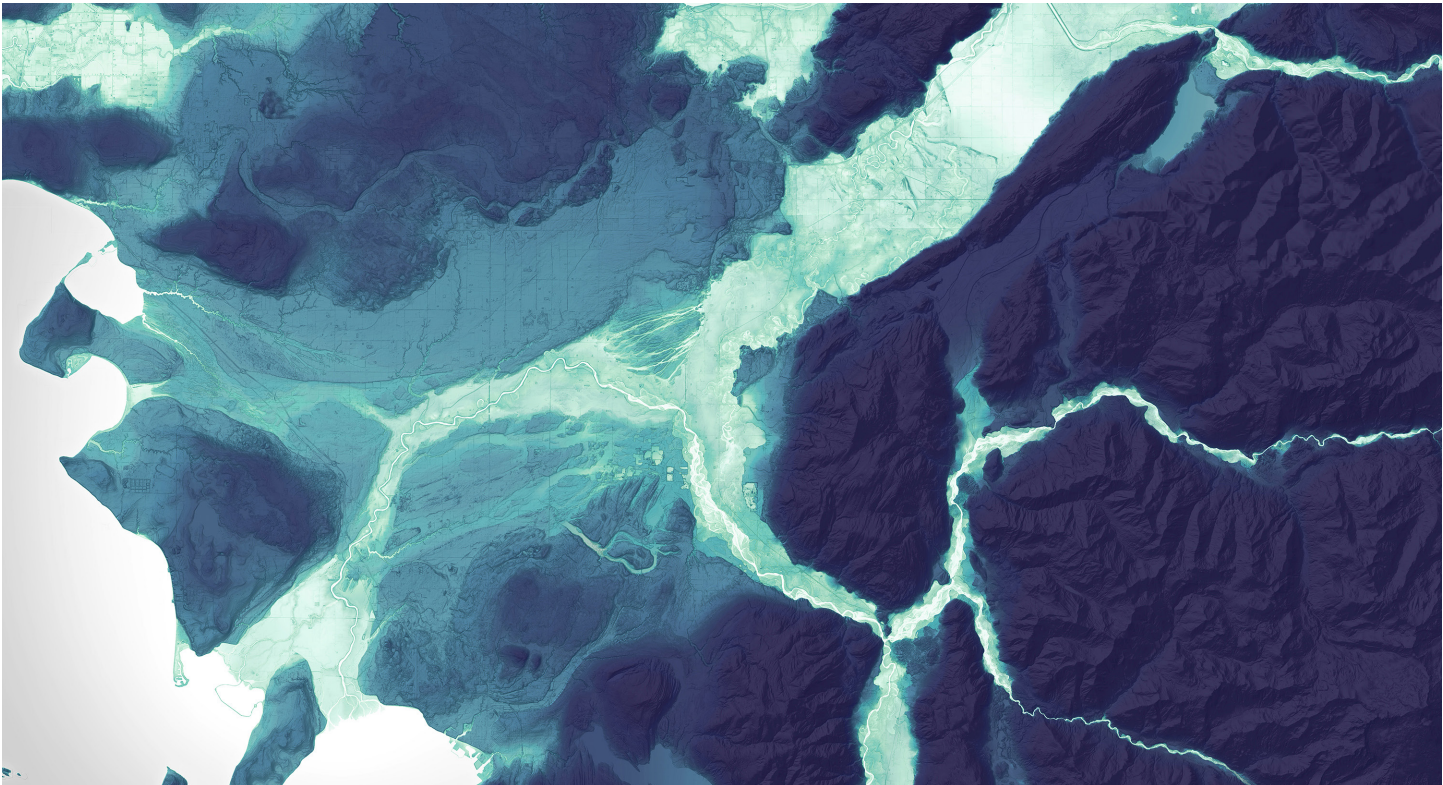


Figure 17. Relative elevation map of Nooksack River and Sumas Valley. (Source: Julie Morse, Wash Dept. of Ecology)

The Nooksack Indian Tribe member and employee offered a vital reminder that the absence of documentation does not equate to the absence of cultural resources. He emphasized that it is not a question of whether cultural resources will be encountered during planning and construction processes, but when. The local community spoke about the emotional trauma triggered by previous planning efforts, such as the Linden Charette, and called for a representation of relationships - not just features - across the border. Their perspective underscored the continuity of Indigenous presence in the region and the role that water bodies, including the flow from the Nooksack to the Fraser River, played in the historical movement and establishment of villages.



Figure 18. Hillshade map of Nooksack River and Sumas Valley, since Nooksack Indian Tribe did not want a map of their place names shared publicly.

The environmental engineer brought attention to the geomorphological evolution of the Sumas River. They described “meander scars” that indicate the river once had the scale and maturity of a much larger system. They advocated for a medium time-step map, capturing the transition from historic ecology to the present, layered with infrastructure changes like railroads and levees. One example they gave was a Native American footpath that later became a railroad and now exists as a

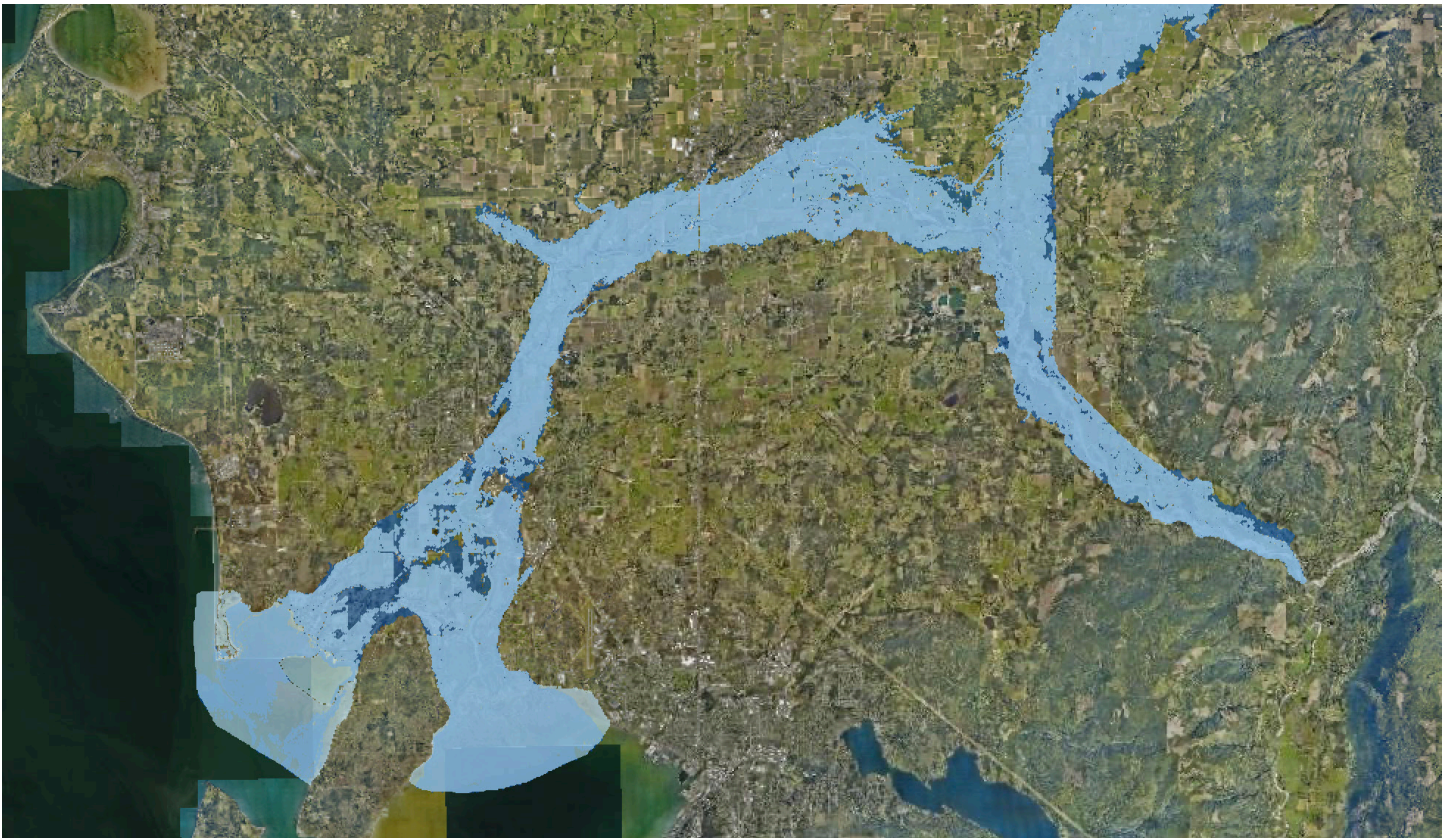


Figure 19. Rendering of the flooding extent of the November 2021 Nooksack River Flood. (FLIP, 2025)

gravel path. This railroad embankment functions as a de facto levee, creating large gravel bars and increasing overflow risk near Everson. Despite its critical influence on flood behavior, this structure is not actively considered in current planning due to its familiarity and perceived permanence. The environmental engineer also referenced key resources by Paul Pittman, Mike Maudlin, and Karen Boyd, including geomorphic assessments and flood modeling data that point to flows 20% greater than 2006 levels.

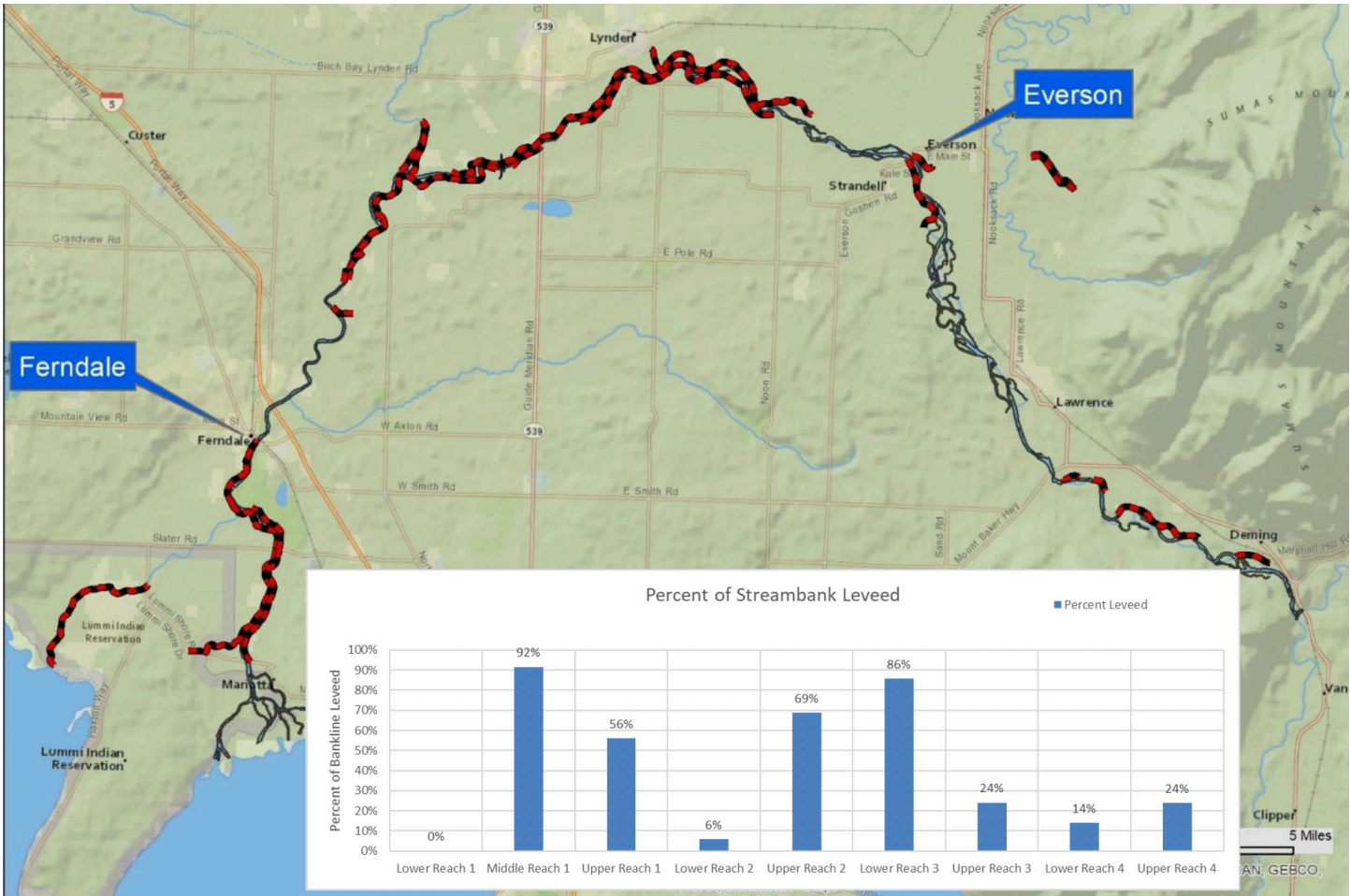


Figure 20. Levees along the Nooksack River. Lower Nooksack River Geomorphic Assessment, 2019.

The river and flood engineer focused on how riverbank infrastructure - particularly bank armoring, riprap, and levees - interacts to shape the river’s behavior. They expressed interest in seeing how these interventions overlap spatially and influence one another, particularly in the context of sediment transport and erosion. Their insights reinforced the need for multi-layered mapping that can expose the cumulative impacts of piecemeal infrastructure development over time.

The presentation from the sediment-specialized geomorphologist provided an overview of how levees influence river morphology, especially when placed along the outside edges of meanders. Over time, such levees alter sedimentation patterns and cause rivers to straighten, affecting flood dynamics, habitat structure, and bank stability. This geomorphic perspective further emphasized the importance of visualizing change over time to understand present-day risks and opportunities.

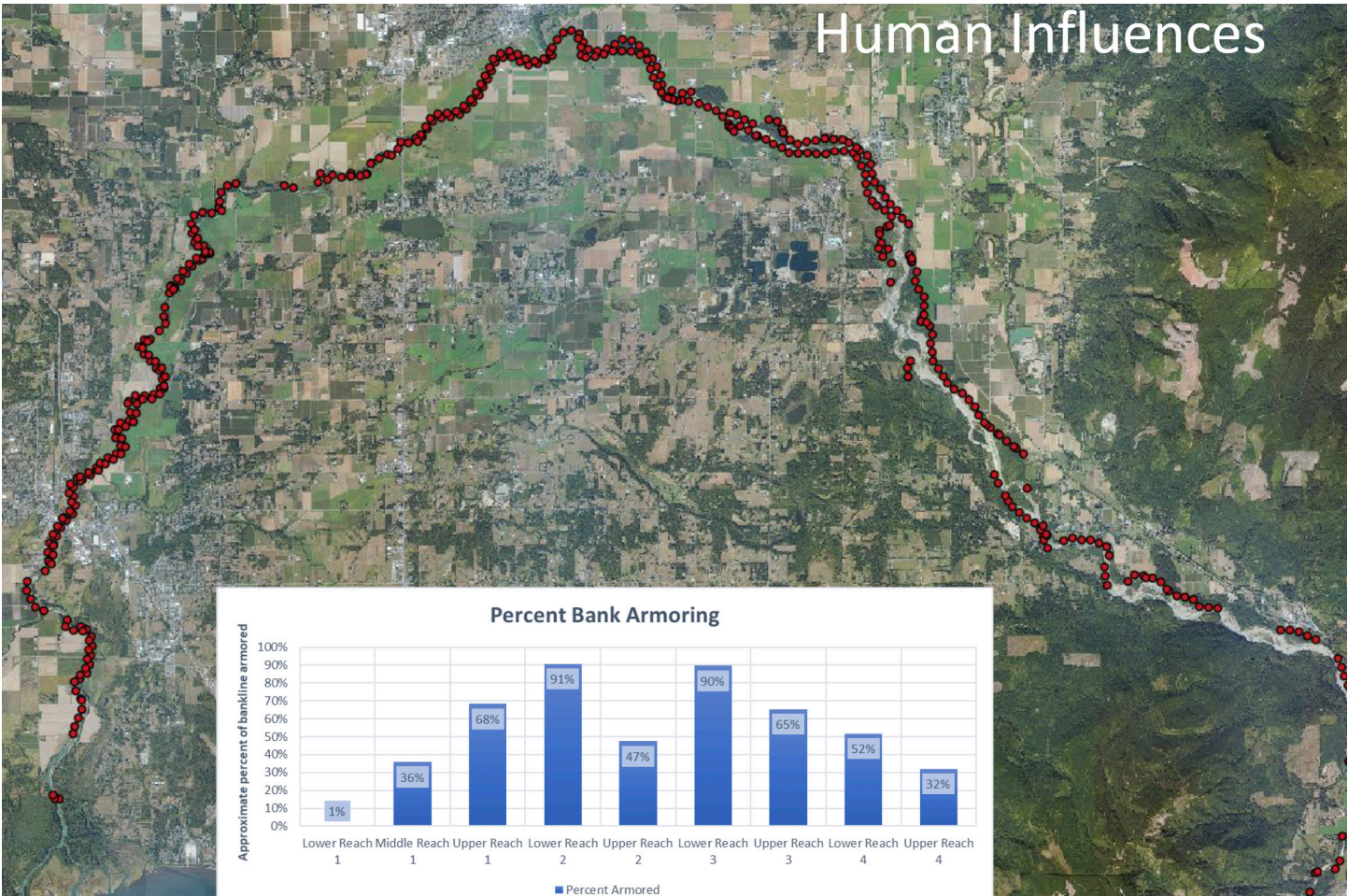


Figure 21. Bank Armoring along the Nooksack River. Lower Nooksack River Geomorphic Assessment, 2019.

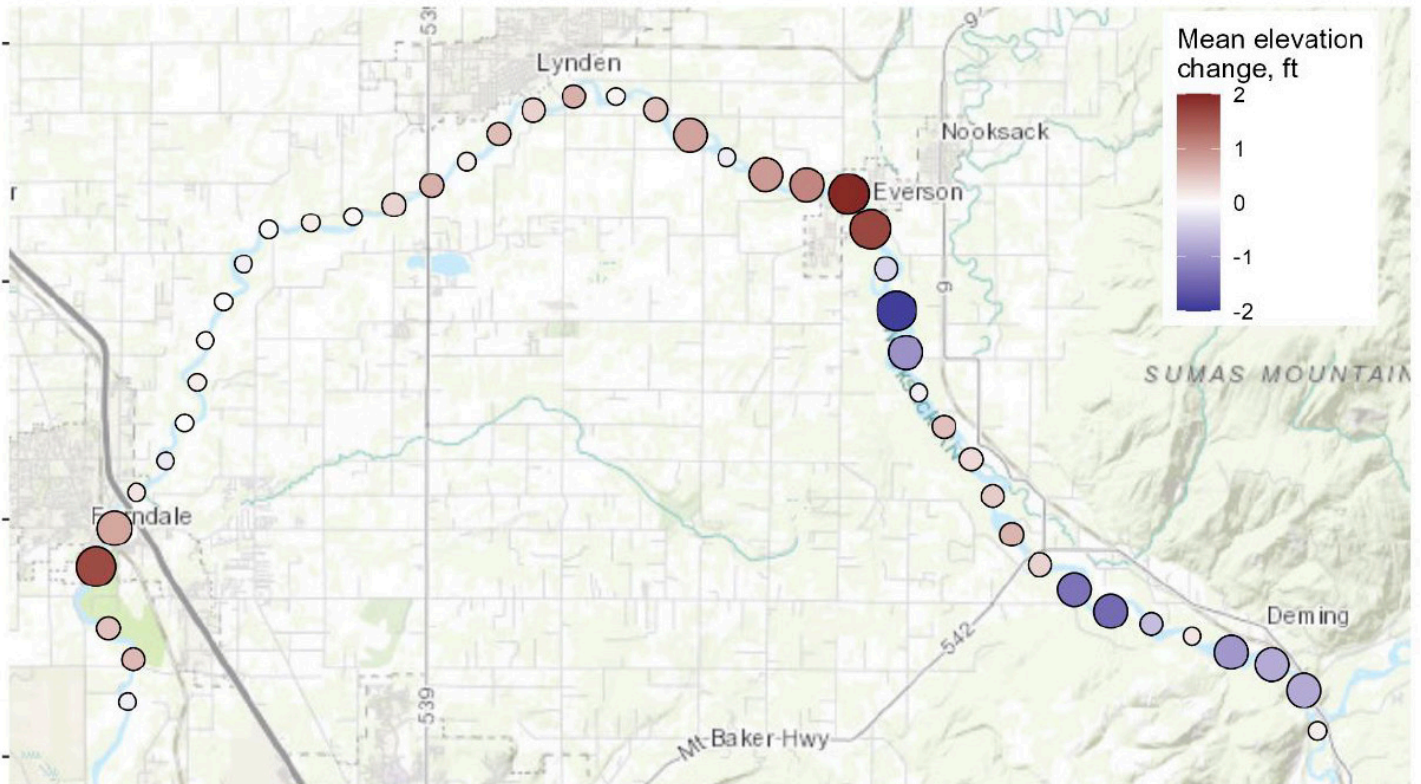


Figure 22. Sedimentation and erosion along the Nooksack River main stem from 2006 to 2016. Lower Nooksack River Geomorphic Assessment, 2019

Following the interviews with technical experts across ecology, hydrology, and Indigenous cultural knowledge, I developed composite applied historic ecological basemaps of the Nooksack River and the Sumas Valley. These maps represent both ecological characteristics and, where applicable, land use patterns around the periods of European contact - approximately 1880 - and a second time point in 1939. Rather than serving as static illustrations, these maps became springboards for dialogue, enabling interdisciplinary and intercultural conversations about landscape change, memory, and adaptation.

Hydrology of Change

Figure 23. presents a rendering of the historic ecology of the Nooksack–Sumas system in 1880, with the intent of making legible the complex hydrological and ecological histories of the area to a broad audience. By visually reimagining the region’s past, the map served as a powerful storytelling device, eliciting strong emotional and intellectual reactions during interviews. For instance, the Director of Cultural Resources from the Nooksack Indian Tribe expressed deep emotion upon seeing a landscape he had heard about in oral histories, but had never seen reconstructed so vividly.

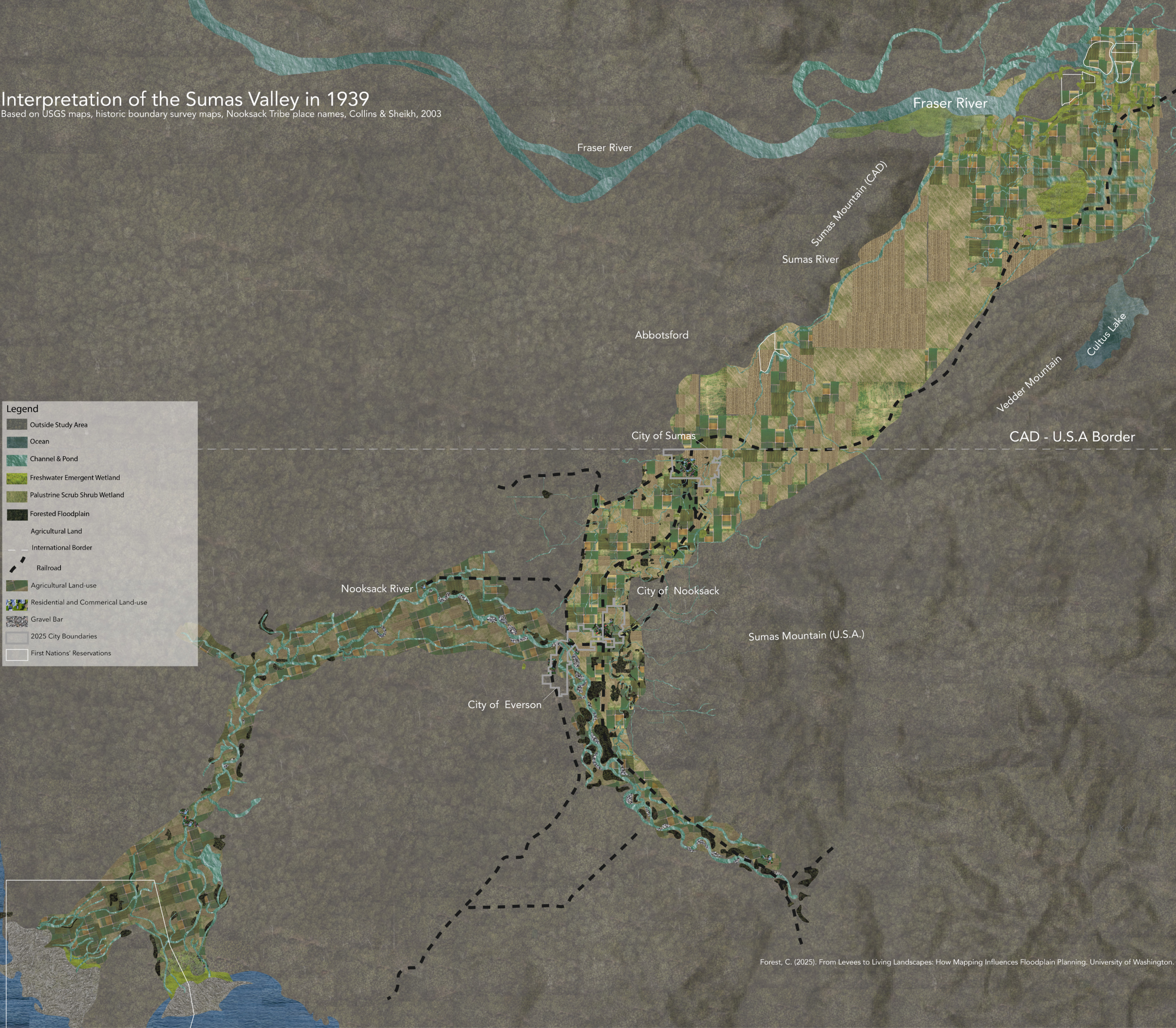
The density of forest cover in the Sumas Valley as depicted in the map sparked debate and curiosity. Some ecological experts were initially skeptical of the extent of forested areas. However, this representation resonated

Figure 23. A historic ecological map of the Nooksack River and Sumas Valley, making the historic imprints visible to ecologists and geomorphologists in Figure 17 legible to a wider range of audiences.



Interpretation of the Sumas Valley in 1939

Based on USGS maps, historic boundary survey maps, Nooksack Tribe place names, Collins & Sheikh, 2003



with stories shared by the Nooksack Cultural Resources team—accounts of traveling through forests so dense the sky was obscured. These traditional stories provided a powerful cross-validation of the mapping’s accuracy.

Geomorphic features also told compelling stories. The width and meandering of the Sumas River bore the signature of a much larger, more mature river system. These characteristics supported existing theories from researchers such as Pittman and Maudlin (2003), suggesting that the Nooksack River historically flowed through the Sumas Valley. Additionally, the multi-threaded upper stem of the Nooksack and the complex, branching structure of the river delta highlighted the region’s dynamic hydrological past. The reconstructed extent of Sumas Lake’s annual flooding around 1880 was particularly notable, oral histories from *Before We Lost the Lake* (Reimer, 2018) describe a floodplain so expansive that coniferous forests did not reach annually. By integrating these narratives with historical cartography and ecological indicators, the flood extent was mapped with a level of detail previously unavailable.

Other features of ecological significance emerged. A wetland west of modern-day Sumas caught the attention of interviewees from ecologists. Historical prairies along the Nooksack River, while not visible in archival maps, were identified through *Nooksack Place Names* and confirmed through site geomorphology. These landscapes, though often invisible in Western cartographic records, were remembered through stories and oral

Figure 24. Map of the Nookack River, it's floodplain and the Sumas Valley in 1939, illustrating the ecological impact of the railway, agriculture and draining Sumas Lake.

Forest, C. (2025). From Levees to Living Landscapes: How Mapping Influences Floodplain Planning. University of Washington.

tradition. As one interviewee remarked, the Sumas Valley historically functioned like the “I-5 of the time”—a critical corridor of movement for people, goods, animals, and migratory birds, rich in food and material resources.

Changing the Hydrology

Overlaying the historical landscape with patterns of modern development revealed the extensive transformations that have occurred in the hydrology and ecology of the Nooksack River system. Major changes included widespread deforestation and agricultural conversion, which significantly altered runoff patterns and soil retention. The construction of the railroad bridge at Everson unintentionally created a levee effect, contributing to the formation of upstream gravel bars, an example of infrastructure inadvertently reshaping river morphology.

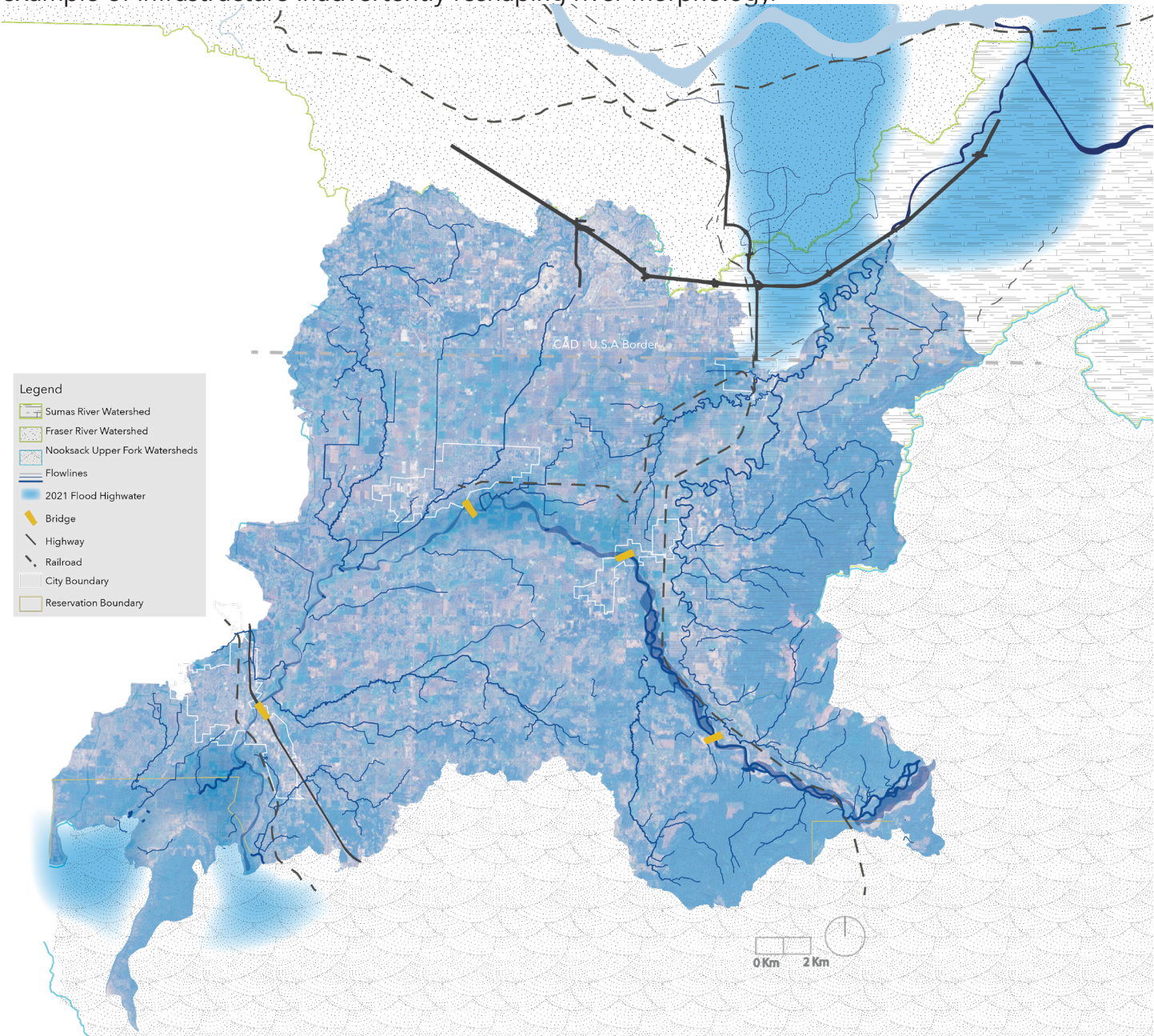


Figure 25. Mapping of the hydrography and human transportation infrastructure in the Nooksack River watershed and Sumas Valley, connecting hydrography across the political border and creating a socio-ecological basemap for further analysis.

Perhaps the most impactful change was the deliberate draining of Sumas Lake, a vast wetland complex that once dominated the valley. This act not only altered the flood regime but also severely restricted Indigenous access to, and stewardship of, traditional lands and waters. Drainage ditches - dug throughout a landscape once so saturated that even shallow cuts filled with water - marked the remaking of a wet floodplain into arable land (Collins et al., 2008). These hydrological transformations occurred in parallel with the political imposition of the U.S.–Canada border, a line that fractured ecological systems and cultural connections alike.

Weaving modern ecological context, flood infrastructure and Indigenous Sciences to map current socio-ecological system of the Nooksack river

Building from this historic baseline, I turned to the present-day socio-ecological configuration of



Figure 26. The pink arrows depict the last remaining hydrological connection between the Fraser River and Jhonson Creek without a fish weir. This is therefore the likely path of Salmon migration to Johnson Creek.

the Nooksack River. A layered mapping approach was used, incorporating modern hydrography, jurisdictional boundaries (including city limits and reservation borders), flood infrastructure, and data from recent high-water events. Highways, railroads, and bridges were also included, revealing the entanglement of transportation networks with river systems.

During the environmental planner’s interview, a key question arose: how are salmon reaching Johnson Creek despite the presence of the Barrowtown fish weir? The interviewee was aware that salmon came from the Fraser River but was uncertain about their route. By integrating U.S. and Canadian hydrographic data, I identified small streams connecting the Fraser River to Johnson Creek, many of which run through culverts beneath multilane highways and rail lines. This confirmed that fish passage, though not obvious, persists in these heavily modified corridors.

The next layer added to the modern socio-ecological map is sediment deposition along the Nooksack Main stem (Boyd, 2025). Here, a phenomenon that was initially visible in the 1939 mapping, the establishment of upstream gravel bars, has evolved to the establishment of

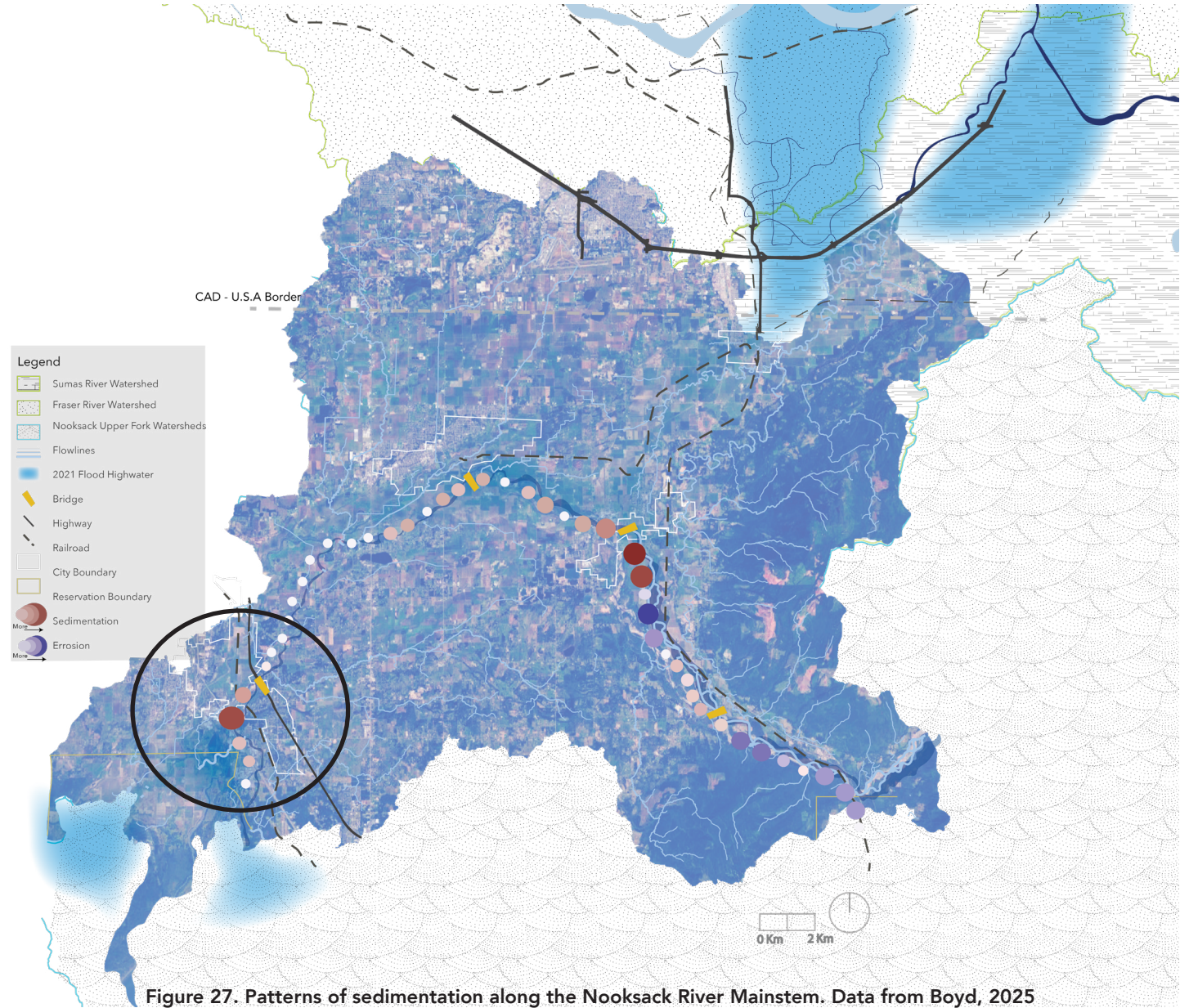


Figure 27. Patterns of sedimentation along the Nooksack River Mainstem. Data from Boyd, 2025

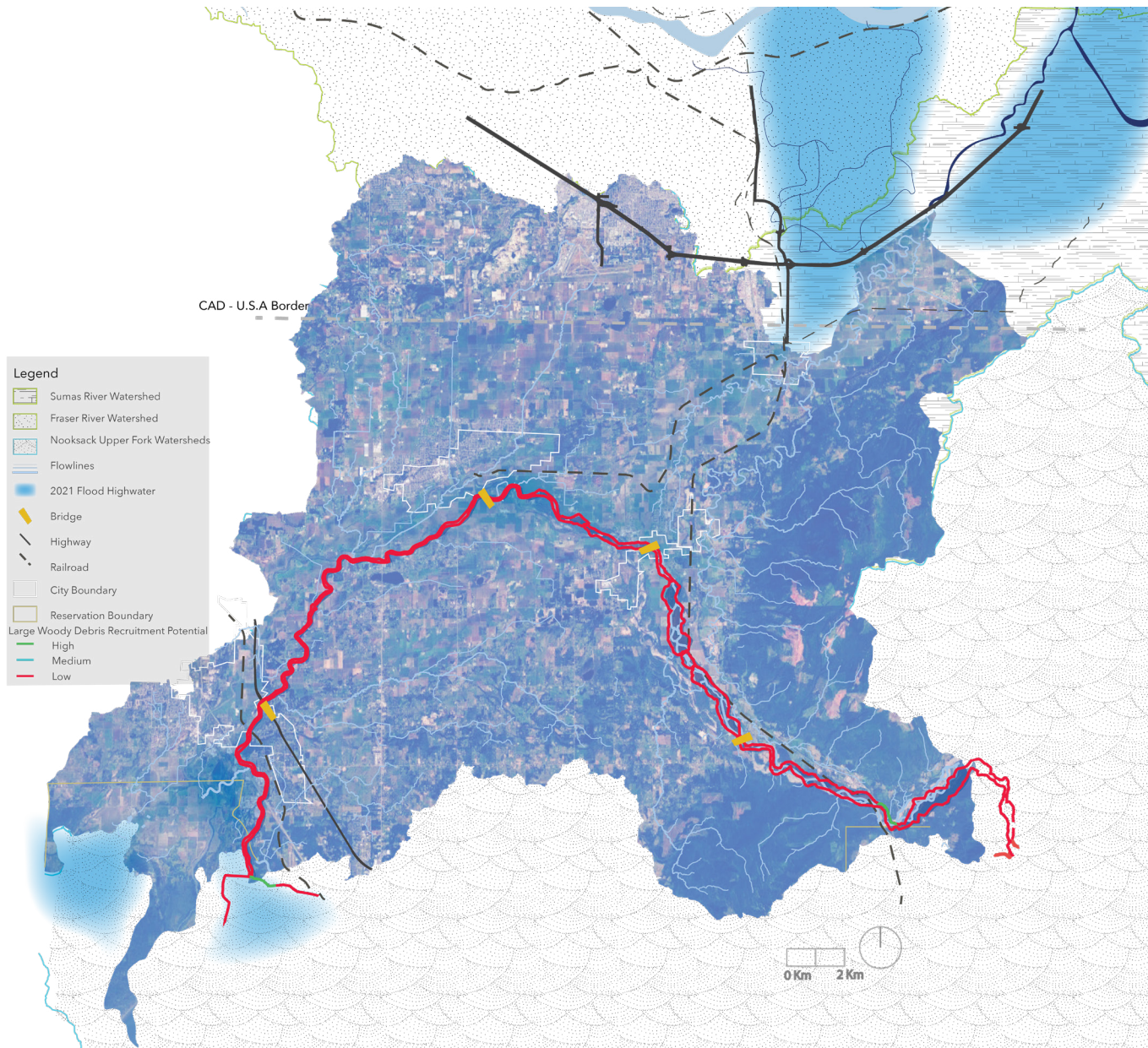


Figure 28. Large woody debris (LWD) recruitment potential along the main stem of the Nooksack River. Data from Coe, 2001.

vegetation, and thus no longer part of the river channel, on these gravel bars. Although the railroad that initially necessitated the Everson bridge has been moved, the informal levee still exists in its place, with a gravel walking path on top, an infrastructural legacy that informs river morphology and flooding vulnerability around the Nooksack Floodplain.

A particularly striking observation emerged downstream of the Ferndale bridge, where a large sediment deposit was identified. Because the river’s gradient remained consistent before and after this point, the question arose: What is causing this unexpected sediment accumulation?

During the interview with the environmental planner, they raised riparian buffer health as an important consideration for flooding and salmon habitat. Although no comprehensive habitat assessment exists for the Nooksack River, I located a watershed-scale analysis of Large Woody Debris (LWD) recruitment potential by the Nooksack Indian Tribe. According to this analysis, high

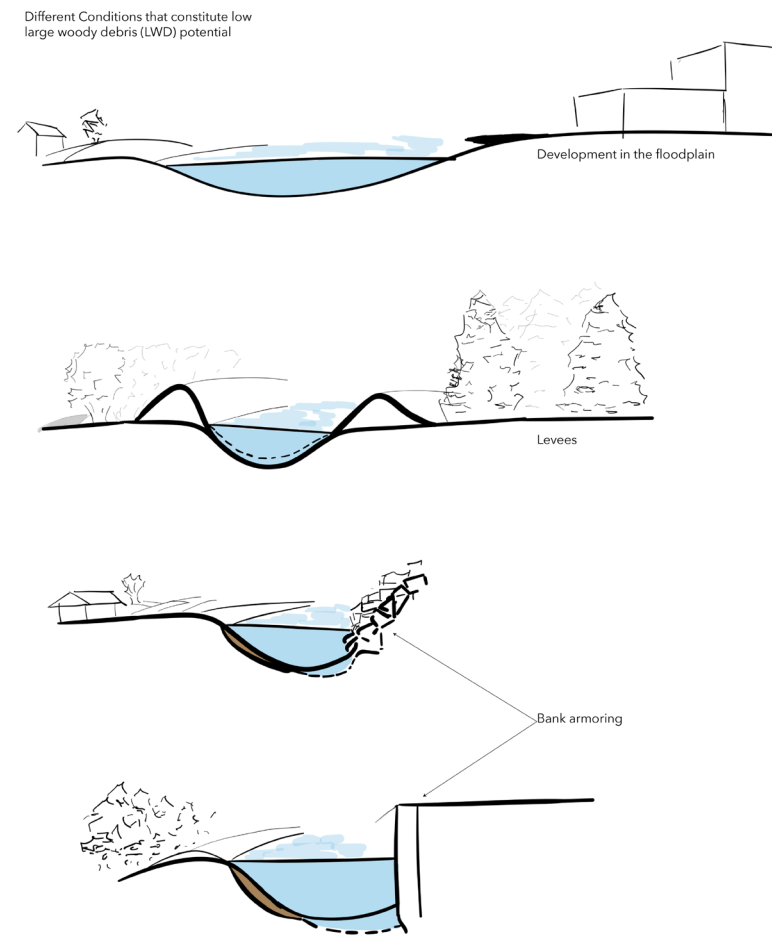


Figure 29. Depiction of the various conditions that can constitute low large woody debris recruitment potential.

LWD recruitment potential requires both annual hydrologic access and the presence of mature riparian vegetation. While this metric does not capture healthy buffers that are hydrologically disconnected (e.g., by levees), it served as a useful proxy for riparian health in this context.

To validate the use of LWD recruitment as a proxy, I first tested known segments of the river: only two stretches of the Nooksack's mainstem lack levees, riprap, or bank armoring. These same areas corresponded to the only locations with high LWD recruitment potential, confirming the approach's reliability.

Expanding the analysis across the watershed, attention returned to the sediment deposit downstream of the Ferndale bridge. A tributary joining the river just upstream of the deposit was almost entirely classified as having low LWD recruitment potential. This suggests that the tributary is likely either bordered

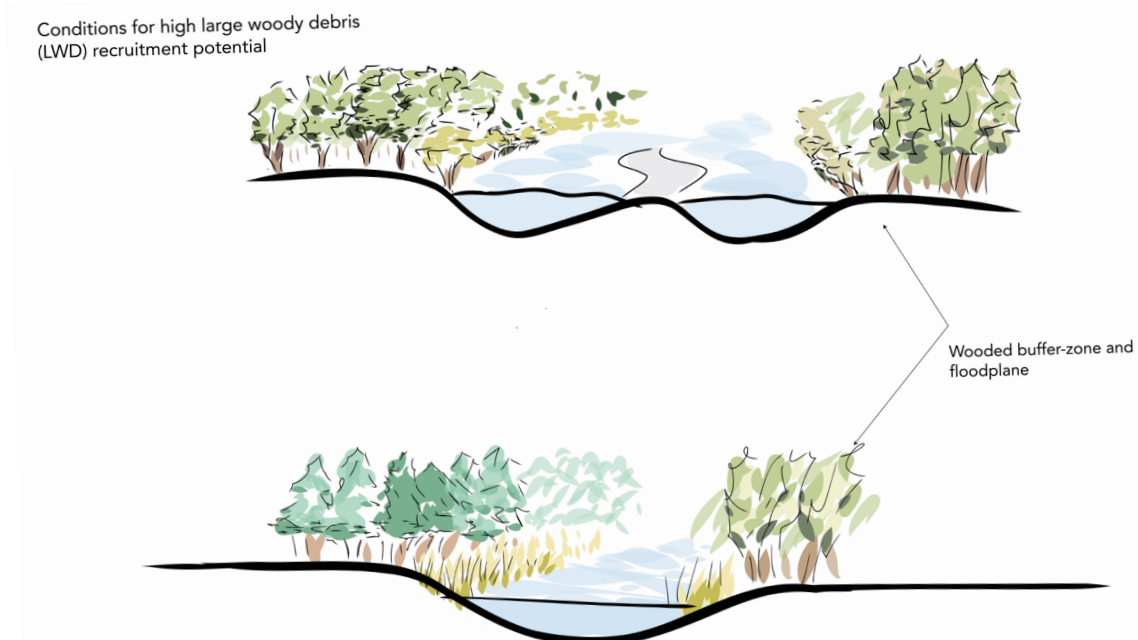


Figure 30. Depiction of the conditions that can constitute high large woody debris recruitment potential.

by degraded riparian vegetation or has become hydrologically disconnected, reducing its capacity to trap and stabilize sediment. The lack of healthy, connected buffer zones could therefore be a primary contributor to the sediment accumulation observed downstream.

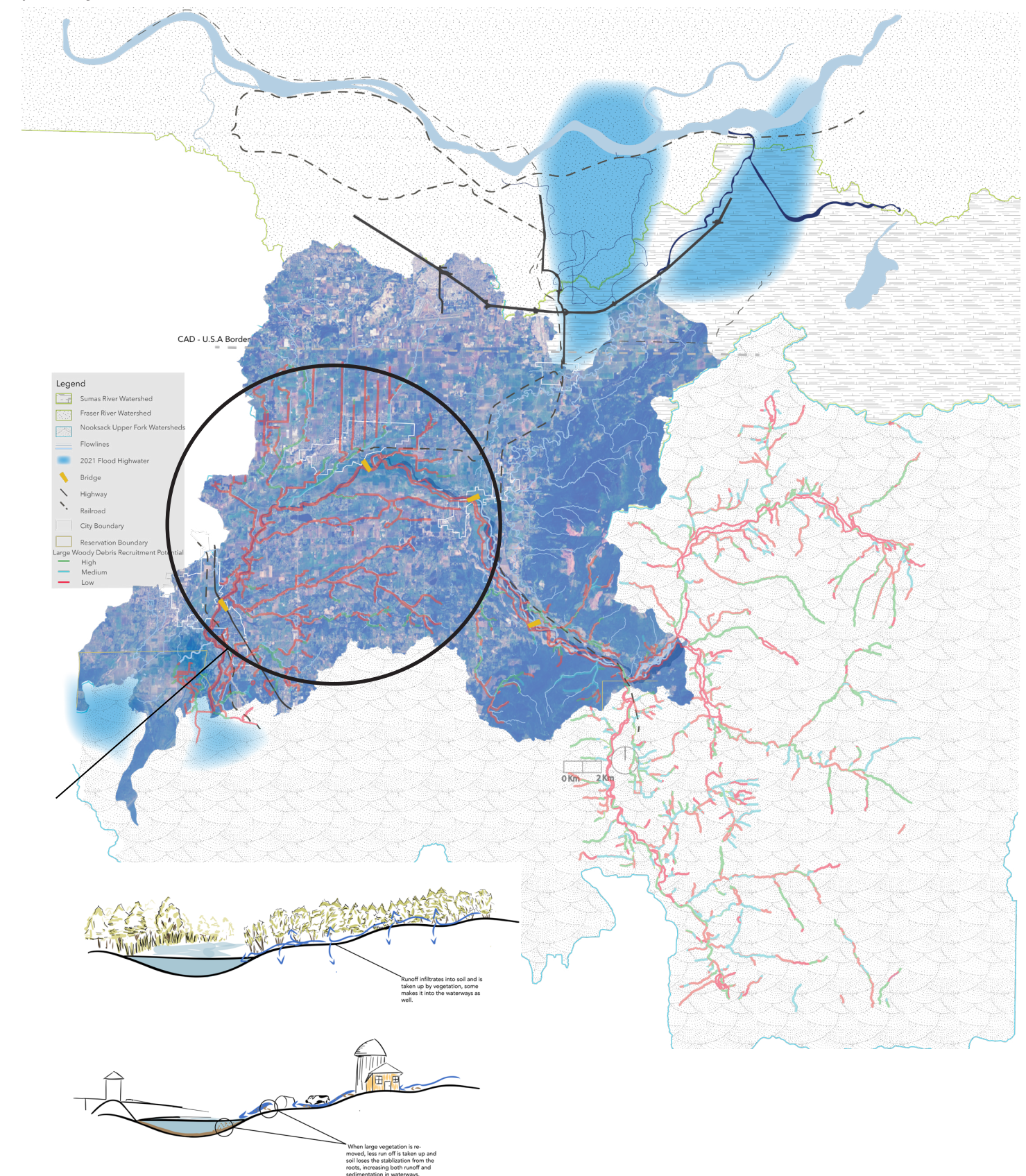


Figure 31. Depicting the conditions of the land surrounding the tributaries that may be contributing to the sediment pattern after the Ferndale bridge. Data from Coe, 2001.

Chapter 5:
Reimagining Floodplain Futures:
Kinship, Systems, and Historical
Reckoning



Chapter 5: Reimagining Floodplain Futures: Kinship, Systems, and Historical Reckoning

Reframing Landscape through a Kincentric Lens

The results of this research suggest that mapping can be used not only as an analytical tool but also as a relational and affective medium. In particular, the historic ecological maps of the Nooksack River and Sumas Valley created emotional resonance among participants, particularly Indigenous collaborators, who saw the maps as a form of validation and remembrance. Director of Cultural Resources from the Nooksack Indian Tribe described seeing, for the first time, a realistic rendering of a landscape he had only heard about through stories. This underscores the potential for mapping to act as a kincentric practice, reconnecting people to place, memory, and more-than-human relations. These participatory cartographic practices support what Potawatomi scholar Robin Wall Kimmerer (2013) might call a “grammar of animacy” - ways of seeing land not just as backdrop, but as kin. This aligns with Anishinaabe writer Patty Krawec’s (2022) call to recognize kinships and relearn how to be good kin through unforgetting, a process of remembering and reckoning with histories of colonial disruption to rebuild relationships grounded in responsibility and reciprocity. Mapping, in this context, becomes a site of relational reactivation, not just representation. This

aligns with work in emotional geographies and critical cartography that highlights maps as co-constructors of meaning rather than neutral reflections (Crampton, 2010; Harley, 1989).

Just as maps can evoke emotional and cultural memory, their layered histories also reveal the nonlinear rhythms of ecological and colonial transformation.

Layering Histories of Change

By creating consecutive maps that can be layered from 1880, 1939, and 2025, this research highlights how change in the floodplain is not linear but instead reflects entangled and recursive temporalities. The shifting course of the Nooksack River, sedimentation patterns, and the presence and absence of ecological features like forested buffers tell a story of both sudden infrastructural intervention and slow ecological transformation. These maps reveal the sedimented histories of colonialism, industrialization, and ecological decline - what Rob Nixon (2011) has termed “slow violence.” Alongside Nixon, Indigenous scholars such as Leanne Betasamosake Simpson (2017) remind us that colonial time is not universal; recognizing Indigenous temporalities means attuning to cycles of care, ceremony, and return. This view is echoed by Rifkin (2017), who describes how settler time flattens Indigenous temporal sovereignty. Yet they also point to the persistence of certain hydrologic and cultural features, like the shape of old meanders or the memory of trade routes, which remain legible in the landscape. This awareness invites planners to prioritize restorative, long-term processes rather than quick fixes—grounding future interventions in layered historical understanding.

Infrastructure as Colonial Legacy and Agent of Hydrologic Change

Railroads, levees, and other forms of infrastructure in the Nooksack and Sumas watersheds function not only as material objects but also as enduring agents of colonial imposition. The construction of the Everson railroad bridge, for example, inadvertently created a levee that has since altered sediment transport and flooding dynamics. This legacy infrastructure continues to shape vulnerability and hydrologic behavior, yet is often treated as an unchangeable feature in contemporary planning. Moreover, these interventions also limited Indigenous stewardship and access, cutting off communities from the very lands and waters they had long cared for. This has resulted in a kind of path dependency in floodplain governance, where colonial-era decisions constrain what is considered feasible or legitimate in the present (Hughes, 1987; Cowen, 2014). A relational and decolonial approach to floodplain management must therefore contend with these infrastructural inheritances, not as neutral backdrops but as central to understanding current conditions and imagining alternative futures (Todd, 2016). As Krawec (2022) argues, becoming kin with the land means not only acknowledging these violent disconnections but actively working to restore ethical relationships disrupted by colonialism.

Decentering the River Channel: Thinking with the Floodplain

Traditional floodplain management often prioritizes the river channel as the focus for intervention, emphasizing control and containment. However, decentering the channel in mapping floodplain considerations invites a broader view of the floodplain as a relational landscape where water, land, species, and people coexist and impact each other in dynamic ways. Iterative, engaged mapping becomes a vital practice in this shift—it moves beyond static data collection to a collaborative process that centers multiple ways of knowing, including Indigenous knowledge. Such mapping practices serve as a form of relational reactivation, creating space for remembering and rebuilding connections fractured by colonial histories for both Indigenous peoples as well as settlers that are living with such broken relationships (Krawec, 2022). Through ongoing dialogue and adaptation, mapping supports the co-creation of shared understandings that honor cultural, ecological, and historical dimensions of the floodplain. By foregrounding relationships between ecological systems and infrastructure, a socio-ecological map that captures multiple disciplines or ways of knowing can disrupt dominant narratives that treat flood control as a technical problem divorced from social context.

Implications for Equitable and Relational Floodplain Futures

The findings of this study hold important implications for ongoing collaborative planning efforts such as the FLIP process and the Reach One working group. The integration of Indigenous place-based knowledge, technical expertise, and socio-hydrologic systems mapping can support more equitable and resilient floodplain futures. Specifically, recognizing the cultural and ecological histories embedded in the land fosters a deeper understanding of what is at stake in current adaptation decisions. Equitable flooding, as articulated in charette discussions, involves not only fair distribution of risk but also expanded definitions of value—encompassing cultural meaning, ecological interdependence, and relational responsibilities (Schlosberg & Collins, 2014; McGregor, 2012). Equitable flooding reframes the issue not only as a question of where water goes, but of who gets to decide, whose knowledge counts, and whose relationships with land and water are respected in adaptation planning.

This research also finds that the sequencing and framing of communication in collaborative processes strongly shape participation outcomes. In the case of the Sumas Value Planning Charette, the FLIP team prioritized presenting conclusions derived from multi-year technical analyses, rather than beginning with shared framing of the problem. This approach constrained opportunities for collaborative meaning-making and reinforced the perception that key decisions had already been made. This dynamic highlights the need for adaptation planning to start with communities, not merely report to them—building shared understanding early on to foster more meaningful co-production of floodplain futures. As Krawec (2022) reminds us, reimagining futures rooted in kinship requires that settlers and institutions participate in the labor of forgetting—recovering and

honoring suppressed histories, while committing to a future of relational accountability and mutual care. As such, this research supports a paradigm shift in floodplain management: from protecting assets to restoring relationships. This requires power-sharing with Indigenous Nations and local communities, where planners, engineers, and designers engage not as experts imposing solutions but as listeners, learners, and co-stewards of place.

These dynamics were vividly illustrated during the Sumas Value Planning Charette, where deep emotional trauma from the 2021 floods intersected with community-driven calls for more responsive governance. Despite FLIP’s technically sophisticated and systems-oriented presentation, Sumas community members remained focused on specific infrastructure issues—particularly sedimentation behind the Everson Bridge—which they viewed as immediate and unresolved. Their concerns were grounded in lived experience, underscoring that equitable adaptation planning must go beyond presenting technical conclusions. It must create space for collaborative meaning-making, particularly in communities that have felt marginalized or misrepresented in past processes. Trust-building requires not just the sharing of data but the co-construction of problem definitions and priorities.

Similarly, my participation in weekly FLIP Coffee Chats over six months fostered a nuanced understanding of the relationships, roles, and technical communication pathways that shape the adaptation process. These informal meetings provided a forum for building mutual accountability, while also revealing how adaptation governance is shaped by interpersonal dynamics and disciplinary boundaries. The Sumas session, by contrast, revealed what happens when that relational groundwork is insufficient—when communities arrive with divergent understandings and time is needed to co-learn about place and engage in collaborative problem definition before moving to design.

Supporting Systems Understanding of Flooding Problems

Systems mapping plays a critical role in deepening our understanding of flooding as a complex, socio-ecological problem. Rather than isolating single causes or treating symptoms - such as overtopped levees or inundated properties - systems mapping allows practitioners and communities to visualize the broader web of interacting factors that shape flood risk. This includes long-term shifts in land use, sediment deposition patterns, changes in hydrologic connectivity, and the legacy impacts of infrastructure decisions. Unlike conventional engineering analyses that focus on hydraulics and hazard, this form of systems mapping surfaces historical relationships, colonial legacies, and community priorities - revealing deeper causes of vulnerability (Meadows, 2008; Sivapalan et al., 2012). By making these relationships visible, systems mapping supports a more holistic diagnosis of the problem and helps avoid misidentifying mid-stream outcomes, such as sediment build-up or drainage failures, as root causes. This broader framing enables communities

and decision-makers to move beyond reactive responses and toward proactive, systemic solutions rooted in a deeper temporal and spatial understanding of the watershed.

However, systems understanding alone is insufficient if not paired with relational accountability and community legitimacy. The Sumas Charette illustrated the limitations of top-down systems presentations, even those grounded in rigorous multi-disciplinary modeling. The FLIP team’s effort to communicate a synthesized vision - centered on the “Widen the Funnel” strategy - was met with skepticism, in part because residents felt excluded from prior stages of the process and remained unconvinced that their concerns, such as gravel bar sedimentation, had been taken seriously. While the technical team had invested years into building a shared internal understanding, the lack of co-created framing with community members resulted in a disconnect between systems logic and local priorities.

This tension speaks to a deeper issue: the need for adaptation processes to begin with, not simply present to, communities. Participatory systems mapping could serve as a bridge - helping uncover where framings diverge and enabling communities to articulate their own systemic insights, which may otherwise be treated as anecdotal or unverified. Integrating systems thinking into public engagement not only improves technical outcomes but also supports legitimacy and trust, key ingredients for long-term adaptive governance.

Mapping as Infrastructure for Integrated Governance

The findings of this research reveal that socio-ecological mapping is not merely a representational or analytical tool, but a form of governance infrastructure, a medium that facilitates shared understanding, supports trust-building, and enables coordination across jurisdictions, disciplines, and worldviews. In complex systems like the Nooksack River floodplain, where no single entity holds full authority and where stakeholders bring divergent priorities and knowledge systems, the act of mapping becomes foundational to integrated governance.

Maps in this context function as boundary objects - artifacts that are adaptable enough to be meaningful across different social worlds, while still robust enough to maintain a common identity (Star & Griesemer, 1989). The iterative, participatory, and multi-perspectival mapping practices described in this study helped bridge institutional silos and translate between technical models, cultural narratives, and lived experience. For example, the applied historical ecology maps prompted emotional resonance and memory recovery among Indigenous collaborators, while sediment transport overlays helped identify shared areas of concern between engineers and community members.

By visualizing both physical systems and relational dynamics, socio-ecological maps can:

- Make visible the interdependencies between flood infrastructure, ecological processes, and cultural values.

- Provide a shared reference for deliberation and negotiation.

- Highlight misalignments or gaps in understanding across stakeholder groups.

- Support iterative decision-making grounded in both science and place-based knowledge.

In this way, mapping supports the core functions of integrated governance: it scaffolds collaboration across jurisdictional and disciplinary boundaries, aligns multiple forms of expertise, and fosters accountability to communities and ecosystems. Rather than serving only as technical documents, maps become active participants in governance—enabling a shift from siloed, command-and-control paradigms toward relational, adaptive, and place-based decision-making.

Revisiting the Research Question

This thesis asked: how can mapping become a practice of relationship-building and support systems analysis of socio-ecological systems? Each of the themes discussed here - kin-centric mapping, entangled temporalities, colonial infrastructures, relational floodplain thinking, and systems mapping, demonstrates how mapping can exceed its conventional analytical role. It can become a process of remembering, reconnecting, diagnosing, and imagining anew. As such, mapping emerges not as a neutral technique but as a method of care, offering tools for co-learning, coalition-building, and designing floodplain futures that are equitable, relational, and place-based. This research contributes a novel framework for integrating kin-centric perspectives into landscape planning processes, offering a template for participatory and decolonial design practice in floodplain contexts. In the end, mapping is not merely about seeing the land, but about seeing with it - listening for the stories it holds and the futures it makes possible (Ingold, 2000; Pearce & Louis, 2008).

Chapter 6:
Conclusion



Chapter 6: Conclusion

This thesis has explored how integrated systems mapping - grounded in both Indigenous and Western sciences can support more equitable, ecologically attuned, and long-term approaches to floodplain adaptation in the Nooksack River watershed. Through a combination of qualitative interviews, participant observation, and the development of applied historic ecological basemaps, the research revealed how current planning processes often overlook key dynamics in both social and ecological systems. The findings underscore the importance of rendering histories of ecological transformation visible, including the deforestation, hydrological rerouting, and infrastructural legacies that continue to shape vulnerability today.

In attending to multiple worldviews and knowledge systems, this work highlights the limitations of narrowly technical or discipline-specific approaches to flood risk reduction in supporting integrated governance approaches. Historic and contemporary mapping efforts brought to light elements of the landscape, such as ancestral salmon pathways, the seasonal extent of Sumas Lake flooding, and the sedimentation patterns tied to past infrastructure, that remain critically important for present-day adaptation. The collaborative and iterative use of maps in interviews and charrettes also demonstrated how spatial tools can help bridge understandings across cultural, jurisdictional, and disciplinary divides.

A key finding of this research is that the form and sequencing of communication in collaborative governance processes significantly shapes the quality of participation. While the FLIP team invested considerable effort into building technical consensus and interdisciplinary understanding, the way this work was shared with community members often emphasized conclusions rather than inviting shared sense-making. In the case of the Sumas Value Planning Charette, this approach limited opportunities for collaborative meaning-making and reinforced perceptions that key decisions had already been made. This underscores the importance of not only what is communicated in floodplain planning processes, but how and when knowledge is introduced, particularly when seeking to build trust and foster equitable engagement across differently positioned stakeholders.

Another insight of this research is that many so-called “solutions” to flood risk may, if developed in isolation or without sufficient context, inadvertently reinforce systemic problems or create new forms of risk. Socio-ecological system mapping not only offers a way to visualize interactions across time and scale but also provides a platform for identifying key connections between systems, such as disrupted hydrological connectivity, degraded riparian buffers, or legacies of colonial land governance, that underlie present-day symptoms of flooding. In this way, the method serves both an analytical and pedagogical function, fostering shared understanding and collective ownership of adaptation strategies. As such, mapping practices that center relationships - cross time, knowledge systems, and landscapes - are essential not only for understanding the socio-ecological complexity of floodplains, but for enacting governance structures capable of responding to it. By extending beyond static representations, socio-ecological mapping supports the emergence of more integrated, responsive, and equitable floodplain futures.

Ultimately, this thesis contributes to the growing body of work calling for more relational and temporally expansive approaches to landscape planning. In floodplains, where natural and cultural histories are deeply intertwined, and floods are inescapable, adaptation cannot simply be about technical fixes or future scenarios. It must also be about remembering and rethinking our relationships with land and water - and with one another.

Future research

Future research should explore the integration of additional local knowledge and participatory mapping methods, including testing how different audiences interpret and engage with the visualizations. Further work could enhance temporal layering to represent change over time and strengthen the connection between narrative vignettes, sectional drawings, and plan-view maps to improve spatial storytelling and systems understanding.

Bibliography

- Ahern, J. (2011). From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world. *Landscape and Urban Planning*, 100(4), 341–343. <https://doi.org/10.1016/j.landurbplan.2011.02.021>
- Alberti, M., Marzluff, J. M., Shulenberger, E., Bradley, G., Ryan, C., & ZumBrunnen, C. (2003). Integrating humans into ecology: Opportunities and challenges for studying urban ecosystems. *BioScience*, 53(12), 1169–1179. [https://doi.org/10.1641/0006-3568\(2003\)053\[1169:IHIEOC\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2003)053[1169:IHIEOC]2.0.CO;2)
- Beechie, T., Pess, G., Roni, P., & Giannico, G. (2008). Setting river restoration priorities: A review of approaches and a general protocol for identifying and prioritizing actions. *North American Journal of Fisheries Management*, 28(3), 891–905. <https://doi.org/10.1577/M07-080.1>
- Beechie, T. J., & Bolton, S. M. (1999). An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds. *Fisheries*, 24(4), 6–15. [https://doi.org/10.1577/1548-8446\(1999\)024<0006:AATRSH>2.0.CO;2](https://doi.org/10.1577/1548-8446(1999)024<0006:AATRSH>2.0.CO;2)
- Berkes, F. (2012). *Sacred ecology* (3rd ed.). Routledge.
- Brugnach, M., Dewulf, A., Pahl-Wostl, C., & Taillieu, T. (2008). Toward a relational concept of uncertainty: About knowing too little, knowing too differently, and accepting not to know. *Ecology and Society*, 13(2), 30. <https://doi.org/10.5751/ES-02575-130230>
- Buckingham, K., Ray, S., Arakwiye, B., Morales, G., Singh, R., Maneerattana, O., Wicaksono, S., Chrysolite, H., Minnick, A., & Johnston, L. (2018). Mapping social landscapes: A guide to identifying the networks, priorities, and values of restoration actors. World Resources Institute.
- Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barrett, K., Blanco, G., ... & Péan, C. (2023). Climate Change 2023: Synthesis Report. IPCC. <https://doi.org/10.59327/IPCC/AR6-9789291691647>
- Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., ... & Mitchell, R. B. (2003). Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences*, 100(14), 8086–8091. <https://doi.org/10.1073/pnas.1231332100>
- Cattino, M., & Reckien, D. (2021). Does public participation lead to more ambitious and transformative local climate change planning? *Current Opinion in Environmental Sustainability*, 52, 100–110. <https://doi.org/10.1016/j.cosust.2021.08.004>
- Cloutier, G., Joerin, F., Dubois, C., Labarthe, M., Legay, C., & Viens, D. (2015). Planning adaptation based on local actors’ knowledge and participation: A climate governance experiment. *Climate*

Policy, 15(4), 458–474. <https://doi.org/10.1080/14693062.2014.937388>

- Collins, B. D., Montgomery, D. R., & Sheikh, A. J. (2002). Reconstructing the historical riverine landscape of the Puget Lowland. In *Restoration of Puget Sound Rivers* (pp. 79–128). University of Washington Press.
- Collins, B. D., & Sheikh, A. J. (2005). Historical reconstruction, classification, and change analysis of Puget Sound tidal marshes.
- Cowen, D. (2014). *The deadly life of logistics: Mapping violence in global trade*. University of Minnesota Press.
- Crampton, J. W. (2010). *Mapping: A critical introduction to cartography and GIS*. Wiley-Blackwell.
- Crampton, J. W. (2001). Maps as social constructions: Power, communication, and visualization. *Progress in Human Geography*, 25(2), 235–252. <https://doi.org/10.1191/030913201682688949>
- Cronon, W. (1991). *Nature’s metropolis: Chicago and the Great West*. W.W. Norton & Company.
- D’Alisa, G., & Kallis, G. (2016). A political ecology of maladaptation: Insights from a Gramscian theory of the State. *Global Environmental Change*, 38, 230–242. <https://doi.org/10.1016/j.gloenvcha.2016.03.006>
- DeCock-Caspell, M., & Vasseur, L. (2021). Visualizations as a tool to increase community engagement in climate change adaptation decision-making. *FACETS*, 6, 240–251. <https://doi.org/10.1139/facets-2020-0032>
- Deloria, V. (2003). *God is red: A Native view of religion* (30th anniversary ed.). Fulcrum Publishing.
- Di Baldassarre, G., Kooy, M., Kemerink, J. S., & Brandimarte, L. (2013). Socio-hydrology: Conceptualising human-flood interactions. *Hydrology and Earth System Sciences*, 17(8), 3295–3303. <https://doi.org/10.5194/hess-17-3295-2013>
- Feltmate, B., & Moudrak, N. (2019). Weathering the storm: Developing Canadian standards for flood resilient existing communities (Rep., pp. 1–51). Intact Centre on Climate Adaptation.
- Flier, M. (2023). Whatcom County compound flood vulnerability assessment. Coastal Geologic Services.
- Galloway, G. E. (2005). Learning from the past and present to prepare for the future. In *Floodplain Management: A New Approach for a New Era* (pp. 11–21). ASFPM Foundation.
- Galloway, G. E. (2005). Learning from the Mississippi Flood of 1993: Impacts, management issues, and lessons learned. *Water International*, 30(1), 11- 20. <https://doi.org/10.1080/14693062.2014.937388>

- org/10.1080/02508060508691857
- Gandy, M. (2024). Four urban ecologies: A working typology and alternative conceptual synthesis. *Urban Studies*. <https://doi.org/10.1177/00420980241248860>
- Giblett, R. (2014). *People and places of nature and culture*. Intellect Books.
- Harley, J. B. (2001). *The new nature of maps: Essays in the history of cartography*. Johns Hopkins University Press.
- Harley, J. B. (1989). Deconstructing the map. *Cartographica: The International Journal for Geographic Information and Geovisualization*, 26(2), 1–20. <https://doi.org/10.3138/E635-7827-1757-9B57>
- Heynen, N., Kaika, M., & Swyngedouw, E. (Eds.). (2006). *In the nature of cities: Urban political ecology and the politics of urban metabolism*. Routledge.
- Hügel, S., & Davies, A. R. (2020). Public participation, engagement, and climate change adaptation: A review of the research literature. *WIREs Climate Change*, 11(4), e645. <https://doi.org/10.1002/wcc.645>
- Hughes, T. P. (1987). The evolution of large technological systems. In Bijker, W., Hughes, T. P., & Pinch, T. (Eds.), *The social construction of technological systems* (pp. 51–82). MIT Press.
- Ingold, T. (2000). *The perception of the environment: Essays in livelihood, dwelling and skill*. Routledge.
- Kimmerer, R. W. (2013). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Milkweed Editions.
- Krawec, P. (2022). *Becoming kin: An Indigenous call to unforgetting the past and reimagining our future*. Broadleaf Books.
- Kundzewicz, Z. W., et al. (2014). Flood risk and climate change: Global and regional perspectives. *Hydrological Sciences Journal*, 59(1), 1–28. <https://doi.org/10.1080/02626667.2013.857411>
- Ludwig, D., & Poliseli, L. (2018). Relating traditional and academic ecological knowledge: Mechanistic and holistic epistemologies across cultures. *Biology & Philosophy*, 33, 43. <https://doi.org/10.1007/s10539-018-9655-x>
- Lutz, T. (2024). A review of the philosophy of flood risk communication and education: New insights informed by critical complexity. *Water*, 16(23), 3459. <https://doi.org/10.3390/w16233459>
- Mauger, G. S., & Kennard, H. M. (2017). Integrating Climate Resilience in Flood Risk. https://cig.uw.edu/wp-content/uploads/sites/2/2014/11/Mauger-Kennard_CIG-WASJ_2017_Final.pdf
- MacEachren, A. M., Gahegan, M., & Pike, W. (2004). Visualization for constructing and sharing geoscientific concepts. *Proceedings of the National Academy of Sciences*, 101(Suppl 1), 5279–5286. <https://doi.org/10.1073/pnas.0307904101>
- McGregor, D. (2012). Traditional knowledge: Considerations for protecting water in Ontario. *International Indigenous Policy Journal*, 3(3). <https://doi.org/10.18584/iipj.2012.3.3.11>
- Meadows, D. H. (2008). *Thinking in systems: A primer*. Chelsea Green Publishing.
- Montoya, M. I., & Ballesterio, M. A. (2019). Failures in flood control infrastructure: Risk, uncertainty, and adaptation. *Water*, 11(10), 2060. <https://doi.org/10.3390/w11102060>
- Moosavi, V., Canepa, E., Frigerio, S., Porta, A., & Gabbianelli, F. (2023). Mapping water resilience: An integrated and participatory GIS approach to climate adaptation in Genoa, Italy. *Environmental Science & Policy*, 141, 29–40. <https://doi.org/10.1016/j.envsci.2023.01.002>
- Moser, C., & Stein, A. (2011). Implementing urban participatory climate change adaptation appraisals: A methodological guideline. *Environment and Urbanization*, 23(2), 463–485. <https://doi.org/10.1177/0956247811418739>
- Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences*, 107(51), 22026–22031. <https://doi.org/10.1073/pnas.1007887107>
- Mouly, A., Kim, J.-H., & Beyea, W. (2023). The role of visual communication in community participation on developing a climate adaptation plan. *Journal of People, Plants, and Environment*, 26(2), 115–124. <https://doi.org/10.11628/ksppe.2023.26.2.115>
- Nadasdy, P. (1999). The politics of TEK: Power and the “integration” of knowledge. *Arctic Anthropology*, 36(1–2), 1–18.
- Naiman, R. J., Beechie, T. J., Latterell, J. J., & Van Pelt, R. (2010). Riparian ecology, conservation, and management: Past, present, and future. *Ecological Applications*, 20(1), 130–147. <https://doi.org/10.1890/08-1917.1>
- Naiman, R. J., Décamps, H., McClain, M. E., & Likens, G. E. (2005). Catchments and the physical template. *Riparia: ecology, conservation, and management of streamside communities*, 19–48.
- Nixon, R. (2011). *Slow violence and the environmentalism of the poor*. Harvard University Press.
- O’Donnell, T. (2022). Managed retreat and planned retreat: A systematic literature review. *Philosophical Transactions of the Royal Society B*, 377(1854), 20210129. <https://doi.org/10.1098/rstb.2021.0129>
- Pearce, M. W., & Louis, R. P. (2008). Mapping Indigenous depth of place. *American Indian Culture and Research Journal*, 32(3), 107–126. <https://doi.org/10.17953/aicr.32.3.q5m231762w2031j6>

Pinter, N. (2005). One step forward, two steps back on U.S. floodplains. *Science*, 308(5719), 207–208. <https://doi.org/10.1126/science.1109995>

Puyallup Tribe of Indians. (2024). Comprehensive land use plan. Puyallup Tribe Planning and Land Use Department. https://www.puyalluptribe-nsn.gov/wp-content/uploads/PTOI-Comp-Plan_Adopted-Version.pdf

Reimer, C. (2018). Before we lost the lake: A natural and human history of Sumas Valley. Caitlin Press.

Rifkin, M. (2017). Beyond settler time: Temporal sovereignty and Indigenous self-determination. Duke University Press.

Robbins, P., & Moore, S. A. (2013). Ecological anxiety disorder: Diagnosing the politics of the Anthropocene. *Cultural Geographies*, 20(1), 3-19. <https://doi.org/10.1177/1474474012452401>

Rogers, J., Bartkowicz, K., & Ramachandran, L. (2021). Collaborative design strategies for climate change adaptation. *Journal of Sustainability Research*. <https://doi.org/10.20900/jsr20210018>

Schlosberg, D., & Collins, L. B. (2014). From environmental to climate justice: Climate change and the discourse of environmental justice. *Wiley Interdisciplinary Reviews: Climate Change*, 5(3), 359–374. <https://doi.org/10.1002/wcc.275>

Sheppard, S. R. J., Shaw, A., Flanders, D., Burch, S., Wiek, A., Carmichael, J., Robinson, J., & Cohen, S. (2011). Future visioning of local climate change: A framework for community engagement and planning with scenarios and visualisation. *Futures*, 43(4), 400–412. <https://doi.org/10.1016/j.futures.2011.01.009>

Singeo, A., & Ferguson, C. E. (2023). Lessons from Palau to end parachute science in international conservation research. *Conservation Biology*, 37(1), e13971. <https://doi.org/10.1111/cobi.13971>

Simpson, L. B. (2017). As we have always done: Indigenous freedom through radical resistance. University of Minnesota Press.

Sivapalan, M., Savenije, H. H. G., & Blöschl, G. (2012). Socio-hydrology: A new science of people and water. *Hydrological Processes*, 26(8), 1270–1276. <https://doi.org/10.1002/hyp.8426>

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, “translations” and boundary objects: Amateurs and professionals in Berkeley’s Museum of Vertebrate Zoology, 1907–39. *Social Studies of Science*, 19(3), 387–420. <https://doi.org/10.1177/030631289019003001>

Sumas Charette. (2025, March 13–14). [Meeting notes or report not published].

Swyngedouw, E. (2010). Apocalypse forever? *Theory, Culture & Society*, 27(2–3), 213–232. <https://doi.org/10.1177/0264375810365570>

doi.org/10.1177/0264375810365570

Todd, Z. (2016). An Indigenous feminist’s take on the ontological turn: ‘Ontology’ is just another word for colonialism. *Journal of Historical Sociology*, 29(1), 4–22. <https://doi.org/10.1111/johs.12124>

Tubino de Souza, D., van Teijlingen, K., Boelens, R., & Ruales, G. (2025). Seeing rivers otherwise: Critical cartography as a form of critical pedagogy. *Geoforum*, 158, 104167. <https://doi.org/10.1016/j.geoforum.2024.104167>

Turner, N. J. (2014). Ancient pathways, ancestral knowledge: Ethnobotany and ecological wisdom of Indigenous peoples of Northwestern North America. McGill-Queen’s University Press.

Walter, R. C., & Merritts, D. J. (2008). Natural streams and the legacy of water-powered mills. *Science*, 319(5861), 299–304. <https://doi.org/10.1126/science.1151716>

Walton, R., & Bosomworth, K. (2017). Innovative or unrealistic: Reflections on the use of landscape architecture visualisations in climate change planning. *Australian Journal of Maritime & Ocean Affairs*, 9(2), 95–106. <https://doi.org/10.1080/18366503.2017.1278503>

White, G. F. (1945). Human adjustment to floods: A geographical approach to the flood problem in the United States (Research Paper No. 29). University of Chicago, Department of Geography.

White, R. (1995). The organic machine: The remaking of the Columbia River. Hill and Wang.

Whyte, K. (2013). On the role of traditional ecological knowledge as a collaborative concept: A philosophical study. *Ecological Processes*, 2, 7. <https://doi.org/10.1186/2192-1709-2-7>

Wilkinson, S. (1999). Focus groups: A feminist method. *Psychology of Women Quarterly*, 23(2), 221–244. <https://doi.org/10.1111/j.1471-6402.1999.tb00355.x>

Willis, G. H., & McDowell, L. L. (1982). Pesticides in agricultural runoff and their effects on downstream water quality. *Environmental Toxicology and Chemistry*, 1(4), 267–279. <https://doi.org/10.1002/etc.5620010402>

Wohl, E. (2014). River planet: Rivers from deep time to the modern crisis. University of Chicago Press.

Yarina, L., Mazereeuw, M., & Ovalles, L. (2019). A retreat critique: Deliberations on design and ethics in the flood zone. *Journal of Landscape Architecture*, 14(3), 8–23. <https://doi.org/10.1080/18626033.2019.1705570>