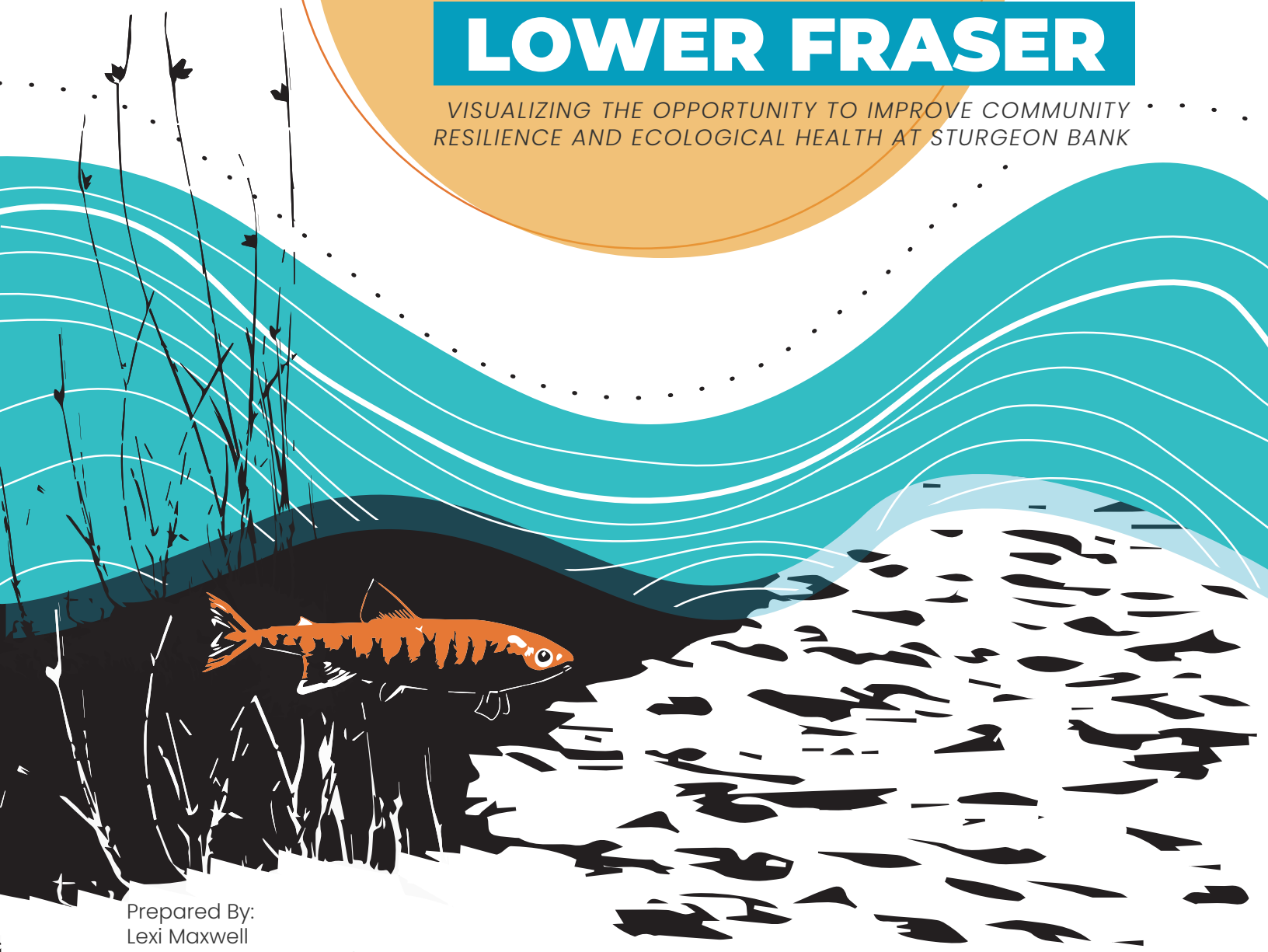
A VISION FOR A RESTORED LOWER FRASER

VISUALIZING THE OPPORTUNITY TO IMPROVE COMMUNITY RESILIENCE AND ECOLOGICAL HEALTH AT STURGEON BANK



Prepared By:
Lexi Maxwell
Sustainability Scholar | 2020

Prepared For:
Justine Nelson | Executive Director | Rivershed Society of BC

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ACKNOWLEDGMENTS

The author would like to begin by acknowledging her position as an uninvited guest, living on the ancestral and unceded territory of the Sḵwx̱wú7mesh (Squamish), Stó:lō and Səl̓ílwətaʔ/Selilwitulh (Tsleil-Waututh) and xʷməθkʷəy̓əm (Musqueam) Nations. This report explores stewardship of the area now called the Fraser River Basin and recognizes the continuing colonial legacy exerted upon these lands.

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DISCLAIMER

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of Rivershed Society of BC staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of Rivershed Society of BC or the University of British Columbia.

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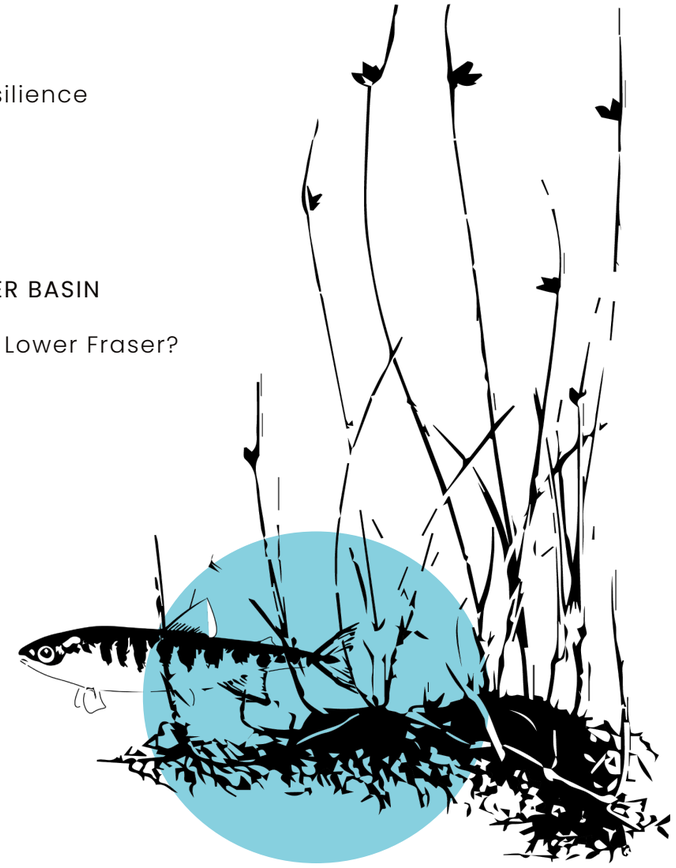


EXECUTIVE SUMMARY

RESTORATION OF LOWER FRASER RIVER ECOSYSTEMS POSES THE OPPORTUNITY TO IMPROVE THE RESILIENCE OF COMMUNITIES AND THE ECOLOGICAL HEALTH OF THE FRASER RIVER BASIN.

The Fraser River is one of British Columbia's most precious environmental assets, inextricably linked to the health of Fraser Pacific salmon. Due to the crucial role that salmon play in communities and ecosystems throughout the Fraser River Basin, the restoration of salmon habitat has widespread benefits for ecological and community resilience.

The Lower Fraser River Region contains some of the most significant ecological features of the Fraser River, such as the Fraser River Delta. The complex makeup of ecosystems found here, such as tidal marshes, mudflats, sandflats, floodplains, sloughs, and river channels, play a vital role in the development of salmon as they transition between freshwater and marine stages of their life cycle.

160 hectares of the 543 ha Sturgeon Bank tidal marsh died between 1989 and 2011. Ongoing river maintenance activities and river training structures have fundamentally altered the development of the Fraser Delta by preventing the delivery of sediment and freshwaters to the delta front. Sediments are the foundational materials that allow the marsh platform to grow vertically, keeping ahead of rising sea levels. Lack of sediment deposition inhibits the ongoing expansion of the delta and resilience of tidal ecosystems.

The Sturgeon Bank Sediment Enhancement Pilot Project is an opportunity to test, refine, and evaluate a method of restoring tidal marsh and supporting ecological resilience. The primary objectives of this pilot project are to demonstrate concept feasibility, evaluate the environmental response, and enhance the resilience of the Fraser delta foreshore biophysical system through an innovative approach to restoring tidal marshes.

Sediment deposition is expected to increase marsh elevation, which:

- Reduces inundation stress on low elevation tidal marsh vegetation, enabling growth in areas where the marsh had previously receded
- Provides an elevation buffer for the existing tidal marsh to remain resilient with the anticipated increase in sea level over the coming decades

At present, there is no plan to ensure the tidal marshes of the Fraser Estuary will persist into the 22nd century and beyond. This is short-sighted, given the ecological benefits and coastal flood protection contribution of the marshes. Testing a locally-customized sediment enhancement method with a pilot project provides an opportunity to evaluate the feasibility and efficacy of an innovative sea-level rise resilience strategy. As a nature-based solution, the Sturgeon Bank Sediment Enhancement Pilot Project demonstrates how restoration can simultaneously support ecological resilience and community goals.

Outside of the inherent value of Lower Fraser ecosystems, the services provided by restored ecosystems could be leveraged to incite restoration projects throughout the Lower Fraser and Fraser Basin. Visuals are powerful tools that can be used to connect resources and mutual interests, building the capacity of restoration efforts in the Lower Fraser River Region.

PROJECT INTENT

THIS PROJECT AIMS TO VISUALLY COMMUNICATE THE IMPORTANCE OF RESTORATION IN THE LOWER FRASER RIVER REGION AS PART OF A BROADER STORY FOR THE FRASER RIVER.

Multiple organizations, agencies, and governments support efforts to address threats to the Fraser River, however, there is currently no cohesive plan to restore the Lower Fraser River Region (Lower Fraser) to health. This report serves as a demonstration piece to illustrate how visuals may be utilized to create a vision for a restored Lower Fraser, increasing public support and capital investment for restoration efforts in the region.

PROJECT OBJECTIVE:

COMMUNICATE THE POTENTIAL OF RESTORATION WORK IN THE LOWER FRASER AND SUPPORT PARTNER ORGANIZATIONS IN ACHIEVING THE RIVERSHED SOCIETY OF BC'S (RSBC) GOAL TO RESTORE 5% (1 MILLION HECTARES) OF THE FRASER WATERSHED.

The primary focus of this project is to visually communicate the importance of restoration work completed by non-profits, First Nations, and local governments throughout the Lower Fraser. To achieve this objective, research of past and potential restoration work in the Lower Fraser was required. An inventory of Lower Fraser restoration projects was created to categorize and prioritize restoration efforts, developing a preliminary understanding of cumulative restoration efforts in the Lower Fraser. The inventory was built using information from online sources, government inventories, and interviews with RSBC partners.
This research informed the selection of the Sturgeon Bank Sediment Enhancement Pilot Project as the focus of a graphic rendering.

Informal interviews were conducted with partner organizations and environmental experts to investigate the technical requirements and limitations of identified restoration projects and priorities. Ultimately, the Sturgeon Bank Sediment Enhancement Pilot Project was selected as it demonstrates a collaborative approach between Lower Fraser organizations committed to the ecological health of the region. It represents one of many projects in the Fraser Estuary that could benefit from a graphic representation due to the technical nature of its components and pending funding.

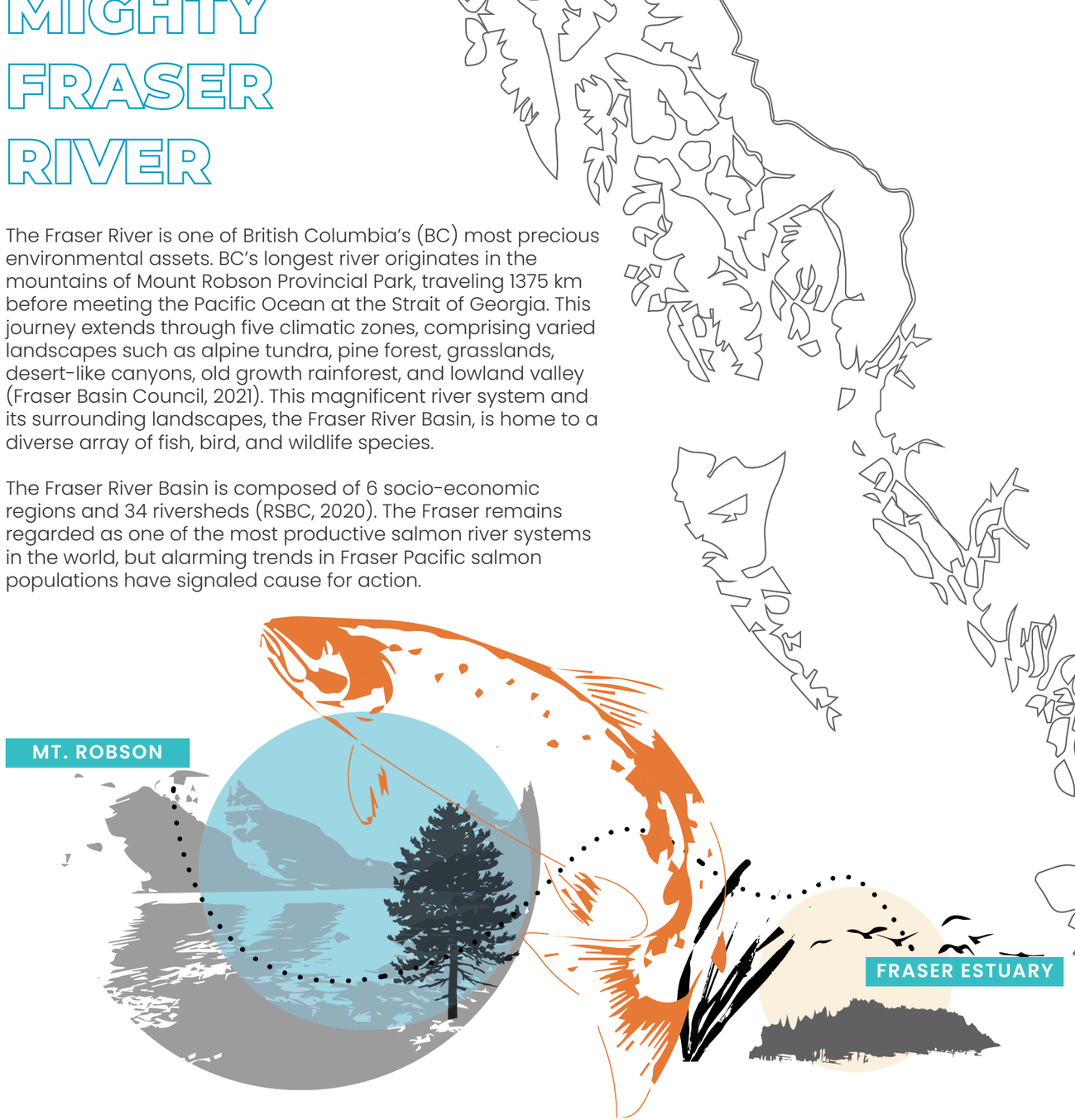
IMPORTANCE OF VISUALS FOR RESTORATION

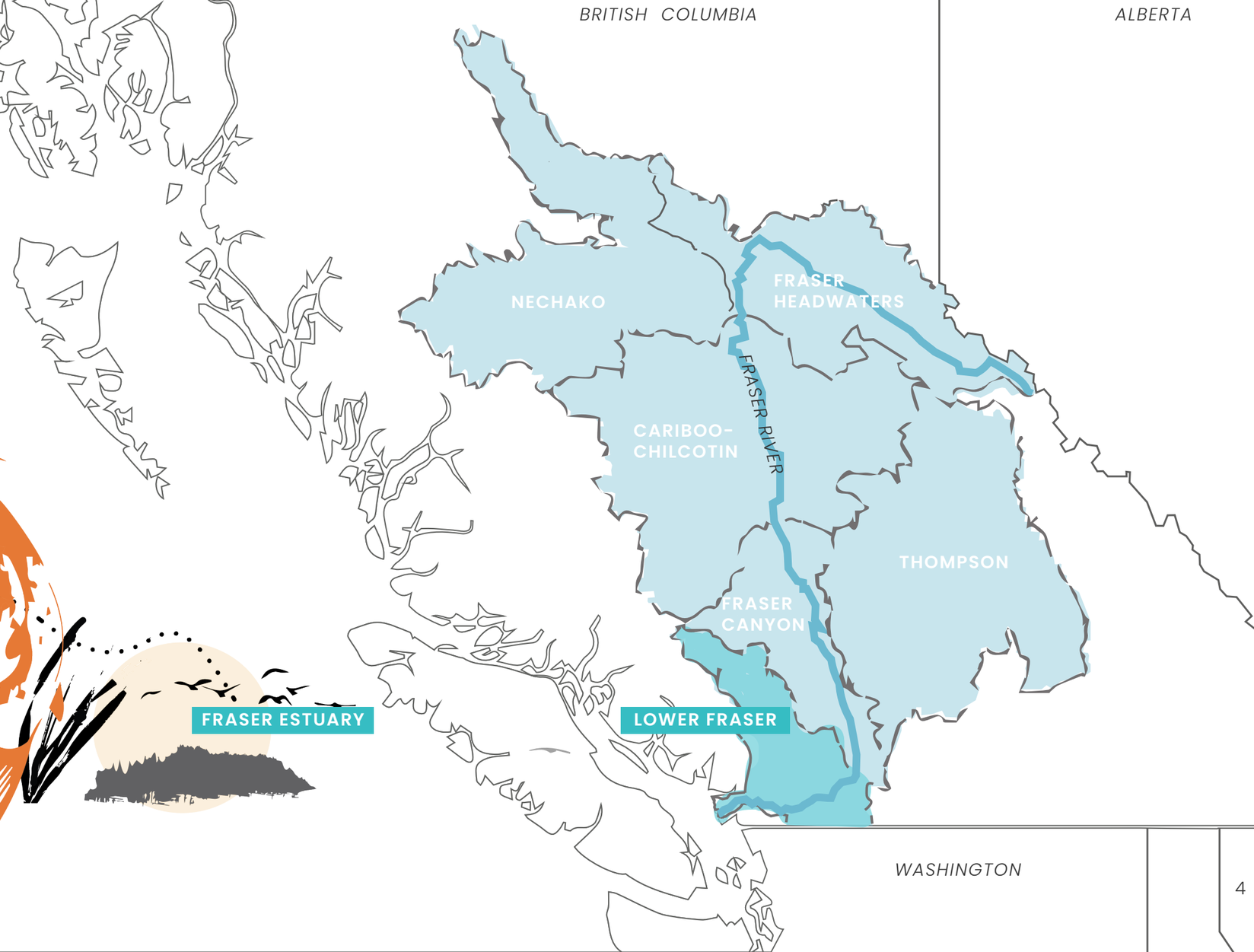
Visualization of restoration projects allows for the project to engage a broader audience that extends beyond the immediate players in restoration. Visuals typically evoke a stronger emotional response and level of understanding than quantitative modes of delivery. Due to the complexities and magnitude of damaging anthropogenic actions, a broader audience must be included to address the increasing threats Lower Fraser ecosystems face.

THE MIGHTY FRASER RIVER

The Fraser River is one of British Columbia's (BC) most precious environmental assets. BC's longest river originates in the mountains of Mount Robson Provincial Park, traveling 1375 km before meeting the Pacific Ocean at the Strait of Georgia. This journey extends through five climatic zones, comprising varied landscapes such as alpine tundra, pine forest, grasslands, desert-like canyons, old growth rainforest, and lowland valley (Fraser Basin Council, 2021). This magnificent river system and its surrounding landscapes, the Fraser River Basin, is home to a diverse array of fish, bird, and wildlife species.

The Fraser River Basin is composed of 6 socio-economic regions and 34 riversheds (RSBC, 2020). The Fraser remains regarded as one of the most productive salmon river systems in the world, but alarming trends in Fraser Pacific salmon populations have signaled cause for action.





FRASER SALMON

ECOSYSTEMS AND COMMUNITIES ARE BUILT AROUND SALMON IN THE FRASER RIVER BASIN. DUE TO THE CRUCIAL ROLE THAT SALMON PLAY IN ECOSYSTEMS THROUGHOUT THE FRASER RIVER BASIN, THE RESTORATION OF SALMON HABITAT HAS WIDESPREAD BENEFITS.

Salmon are recognized as some of the most iconic species found in the Fraser River Basin, as a result of their immense cultural, ecological, and economic value. Prior to the colonization of Canada, the Fraser River was the most productive salmon river in the world, home to populations of Chinook, chum, coho, pink, and sockeye in the millions (Slaney et al., 1996).

Since time immemorial, First Nations have inhabited the Basin cultivating a steadfast relationship with these species, the land, and water. Salmon were prized above all, embodying the cultural and spiritual heart of First Nations in the Fraser River Basin (Fraser Basin Council, 2013). Although the Fraser Basin has dramatically changed, salmon still play an essential role in many BC communities and ecosystems.

LIFE IN THE FRASER

Fraser River salmon migrate through a diverse landscape of tributaries, lakes, and ocean habitats throughout their life cycle (Macdonald et al., 2019). As an anadromous species, salmon are born in freshwater, migrate to the ocean, then return to their natal stream to spawn (Macdonald et al., 2019). The migration of Fraser Pacific salmon to their spawning grounds is awe inspiring. For hundreds of kilometers, these fish fight powerful river currents, navigate rapids, and leap waterfalls, returning from the Pacific Ocean to BC's interior. During this incredible journey, salmon nourish the surrounding landscape and the species that inhabit it, including humans. The time spent in freshwater and marine environments differs for each species of Fraser Pacific Salmon (Moore et al., 2016). However, all salmon that spawn in the Fraser Basin migrate through the Fraser Estuary, using the Lower Fraser River as a migration corridor (Scott et al., 2020).

REBUILDING ECOSYSTEMS THROUGH SALMON HABITAT

As a keystone species, salmon are integral to the health and function of coastal and riparian ecosystems as they move through their life cycle (Wilson & Halupka, 1995). When juvenile salmon return to the ocean, over 50% of their diet is composed of insects, acting as important regulators of insect populations (Allan et al., 2003). The endangered Southern Resident Killer Whale depends on salmon as a primary food source during the adult stage of the salmon life cycle. In 2015, Killer Whales and pinnipeds, like harbor seals, consumed 15,200 metric tons of salmon (Chasco et al., 2017). Areas where salmon complete their life cycle are more likely to host an abundance of wildlife due to this ecological link (Fields & Reynolds, 2012). Bald eagles prey on the remains of salmon that have been scavenged or killed by large predators, such as bears or wolves, illustrating the interdependence of salmon food webs (Fields & Reynolds, 2012).

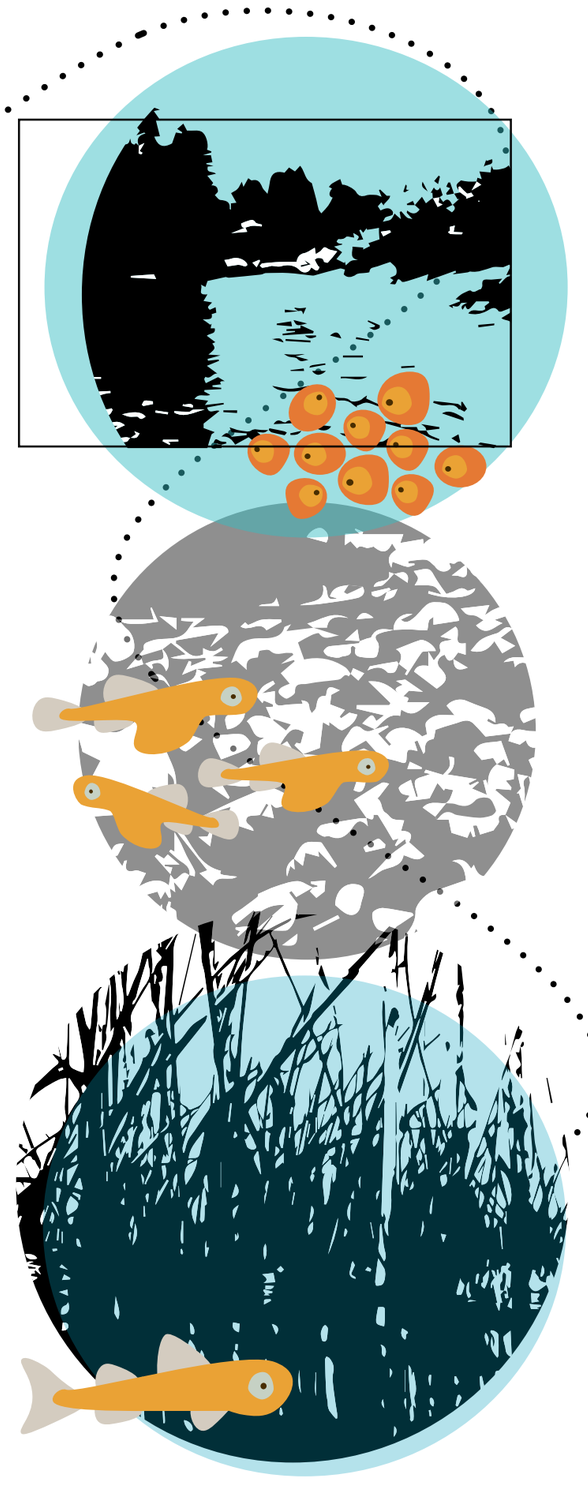
The survival of salmon is key to the survival of BC's most iconic wildlife. Salmon play an essential ecological role throughout their life cycle, acting as prey and predator. Without salmon and their habitats, the Fraser Basin would be unrecognizable.

THE LOWER FRASER RIVER REGION

The Lower Fraser is a confluence of salmon, water, and people. With over 2.3 million people, it is the most densely populated region of the Fraser Basin (Experience the Fraser, 2011). The Lower Fraser contains some of the most significant ecological features of the Fraser River, such as the Fraser River Estuary and "the Heart of the Fraser", the stretch of river from Hope to Mission.

The Heart of the Fraser represents some of Canada's most biologically significant riparian and aquatic ecosystems (Rosenau & Angelo, 2007). This can be attributed to the floodplains and channels that host spawning grounds, fry rearing areas, and migration routes for more than thirty different species of fish. Notably, this stretch of river includes the largest spawning population of salmon in BC (Rosenau & Angelo, 2007). Millions of salmon, Steelhead and Cutthroat Trout migrate through the Heart of the Fraser each year on their way to the Fraser Estuary. Along with serving as a critical salmon spawning habitat, this stretch of the river is home to one of North America's only three remaining populations of threatened white sturgeon.

The final leg of this migration route terminates at the Fraser Estuary, the largest Class 1 estuary in BC (Pacific Estuary Conservation Program, 2021). Although these areas comprise a small portion of BC's coastline, estuaries are some of the most productive ecosystems in the province; they are seasonally or annually important to an estimated 80% of all coastal wildlife (Pacific Estuary Conservation Program, 2021; Austin et al., 2008). The mix of fresh and saltwater form a unique brackish water habitat where many animal and plant species flourish.



THE ESTUARY

THE FRASER ESTUARY PLAYS A KEY ECOLOGICAL ROLE IN THE LOWER FRASER, PARTICULARLY FOR SALMON AND MIGRATORY BIRDS.

Estuaries and wetlands are some of the most productive ecosystems in the world. The mix of fresh and saltwater form a unique brackish water habitat where many animal and plant species flourish. At 21,696 hectares, the Fraser Estuary contains 36% of the province's estuarine area (Pacific Estuary Conservation Program, 2021). The significance of the wetland spans provincial borders, as it has been designated nationally as an Important Bird Area and internationally as a Western Hemisphere Shorebird Reserve Network (WHSRN) site of hemispheric significance to migratory shorebirds and a Ramsar Wetland of International Importance (Ramsar, 2012; WHSRN, 2021).

The Fraser Estuary is recognized for the critical role that this area plays in the life cycle of all five Fraser Pacific salmon populations. The estuary is home to millions of juvenile salmon during the final stage of their migration to the Pacific Ocean. The mosaic of tidal marsh, seagrass, sand flats, mud flats, and tidal channels that permeate through marsh vegetation provide refuge for salmon as they transition to ocean conditions (Chalifour et al., 2019). Chinook salmon in particular rely on this area, with some individuals spending up to 54 days in the estuary before completing their ocean migration (Moore et al., 2016). The tidal marshes of the Fraser Estuary are extremely productive ecosystems - a dynamic system where freshwater, nutrients, and sediments from the Fraser River meet the ocean (Balke, 2017).

Along with serving as a staging ground for juvenile salmon, the Fraser Delta is crucial to many bird species as they migrate on the Pacific Flyway. This mass migration route from Russia to South America attracts millions of shorebirds to the Fraser Delta each year (WHSRN, 2021). It is estimated that over 500,000 Western Sandpipers can be found in the Fraser Delta on a single day during spring migration (WHSRN, 2021). Several provincial conservation lands and federal protected areas, such as Sturgeon Bank Wildlife Management Area (WMA), Roberts Bank WMA, South Arm Marshes WMA, Boundary Bay WMA, Serpentine WMA, Alaksen National Wildlife Area, and George C. Reifel Migratory Bird Sanctuary have been designated in an effort to maintain the rich landscapes and diverse species the estuary is known for.

THE MIGHTY FRASER IS IN TROUBLE

ANTHROPOGENIC ACTIVITIES HAVE FUNDAMENTALLY ALTERED THE FORMATION OF THE FRASER DELTA AND INHIBITED THE RESILIENCE OF THE FRASER ESTUARY.

The health of Fraser Pacific salmon populations is inextricably linked to the health of the Fraser River. Without key habitat areas like the Fraser Estuary, salmon are unable to flourish. The 2020 season experienced the worst recorded return of Fraser Sockeye in history (Taylor, 2020). As of 2018, more than one third of the unique populations of Fraser River salmon and trout were considered at risk of extinction (Martin Conservation Decisions Lab, 2020).

Two-thirds of BC's population calls the Lower Fraser home, leading to a number of negative consequences for salmon habitat (Scott et al., 2020). Competing interests threaten the marshlands, old growth rainforests, and lowland valleys which the Fraser River, its tributaries, and salmon once travelled through freely. Habitat loss and degradation due to forestry, anthropogenic barriers in streams and rivers, and industrial development in critical salmon habitat have been identified as key stressors on Fraser Pacific salmon populations (Walsh et al., 2020). The severity of these stressors on salmon populations is exacerbated by impacts of climate change on marine and freshwater habitats (Walsh et al., 2020; Scott et al., 2020). The resulting net loss of quality habitat area poses a significant threat to the success of salmon.

DISAPPEARANCE OF TIDAL MARSH

250 hectares of tidal marsh at the delta front died and converted into mudflats, including 160 hectares of the 543 ha Sturgeon Bank foreshore marsh (Balke, 2017). The 5 km of tidal marshes, mud, and sand flats adjacent to present-day Steveston, represent a key piece of the Fraser Estuary. Disappearing tidal marsh at Sturgeon Bank is of particular concern, as this coastline comprised approximately 25% of the total Fraser River estuary marshes in the 1970's - essential habitat for birds and salmon (Boyd, 1983).

Research has not been able to identify a single cause of marsh recession, rather several factors have likely contributed to the recession:

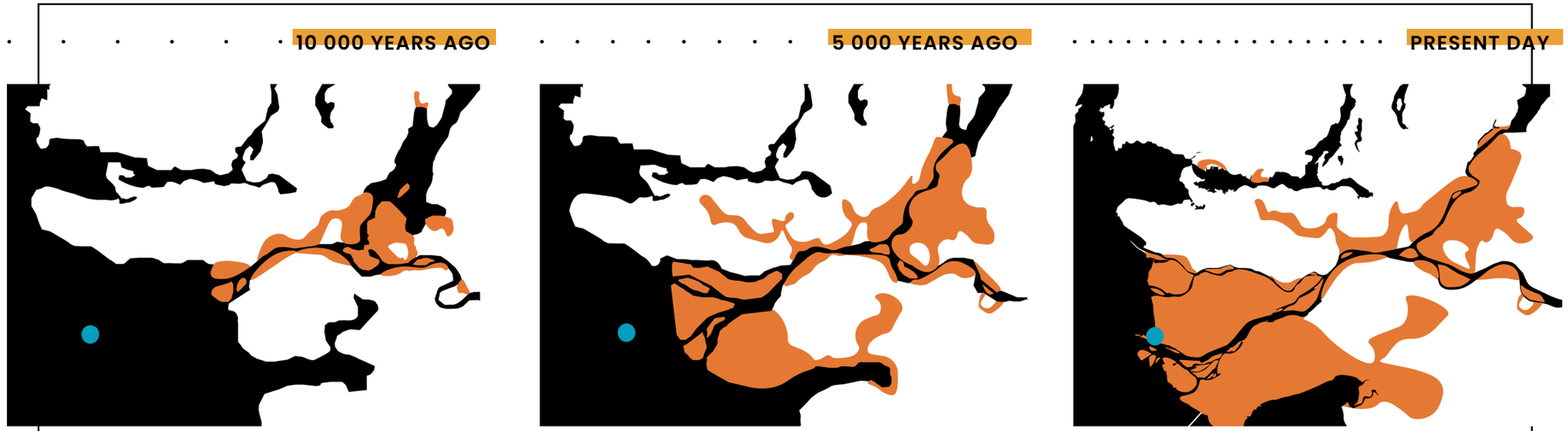
- Relative sea-level rise due to a combination of global sea-level rise and local land subsidence
- Changes in salinity and sediment regimes due to river training jetties, dredging, and dikes
- Foraging by Snow Geese and Canada Geese (Balke & Boyd, 2020).

SEDIMENTS AND THE FORMATION OF THE FRASER RIVER DELTA

The importance of sediment deposition is evident when examining how this area was formed over the last 10 000 years following glacier retreat (Clague & Turner, 2003). The formation of the Fraser Delta began with sediment deposition near the confluence of the Pitt and Fraser Rivers (Finlayson et al., 2019). Over thousands of years, the delivery of sediment from the Fraser River enabled the development of the land mass where present day Burnaby, Richmond, Delta, Surrey, New Westminster, Vancouver, and Steveston are located (Clague & Turner, 2003).

Dikes, river training jetties, and dredging have fundamentally altered the development of the Fraser Delta. Although these structures may appear to pale in size when compared to the immensity of the Fraser River, river training structures have inhibited flooding and sediment deposition on the delta plain leading to slow subsidence (Mathews & Shepard, 1962). These anthropogenic activities annually redirect 17 million tonnes of sediment, mostly into the Strait of Georgia, which would otherwise be delivered by the river to the delta annually (Attard et al., 2014).

By training the course of the river, the flow of sediment and freshwater is prevented from reaching the delta front, inhibiting ongoing expansion of the delta and resilience of ecosystems (Atkins et al., 2016; Marijnissen, 2017; Balke, 2017). Since the 1980's we have lost approximately 250 hectares of tidal marsh throughout the delta front, including at least 160 ha at Sturgeon Bank (Balke, 2017). Given the ways in which tidal marsh resilience to sea-level rise is inhibited at Sturgeon Bank and the scale at which this occurring, more ambitious and comprehensive efforts are necessary for the marsh to keep pace with sea-level rise (Balke & Boyd, 2020).



FORMATION OF THE FRASER DELTA

- Present day location of Steveston
- Deltaic Sediments

(Modified from Clague & Turner, 2003)

160 HECTARES OF TIDAL MARSH HAS BEEN LOST AT STURGEON BANK

Over a hundred years of river training and dredging have changed the natural distribution of sediments at Sturgeon Bank (Atkins et al., 2016). The Sturgeon Bank foreshore is bound by the North Arm Jetty to the north, the Steveston North Jetty to the south, the City of Richmond Dyke, and West Dyke Trail landward. Some of these systems were constructed over 100 years ago to expand agriculture in the region and prevent flooding (Atkins et al., 2016). These structures ultimately prevent the natural migration of the river and resulting sediment deposition. Marsh ecosystems rely on sediment deposition, as it allows the marsh platform to grow in elevation and persist as sea levels rise. Action is required if the Sturgeon Bank foreshore is to support the many species that rely on his area.

1989 LEADING EDGE
Leading marsh edge based on 1980's comparative aerial imagery (Balke, 2017).

2020 LEADING EDGE
Leading marsh edge based on 2020 Google Earth aerial imagery

WEST DYKE TRAIL

STEVESTON

STEVESTON NORTH JETTY

FRASER RIVER

THE STURGEON BANK SEDIMENT ENHANCEMENT PILOT PROJECT

PROJECT OVERVIEW

PROJECT PARTNERS:
Ducks Unlimited Canada (Project Lead), Raincoast Conservation Foundation, Lower Fraser Fisheries Alliance, and Tsawwassen First Nation

SIZE:
Up to 40 hectares

TIMELINE:
2021 -2024

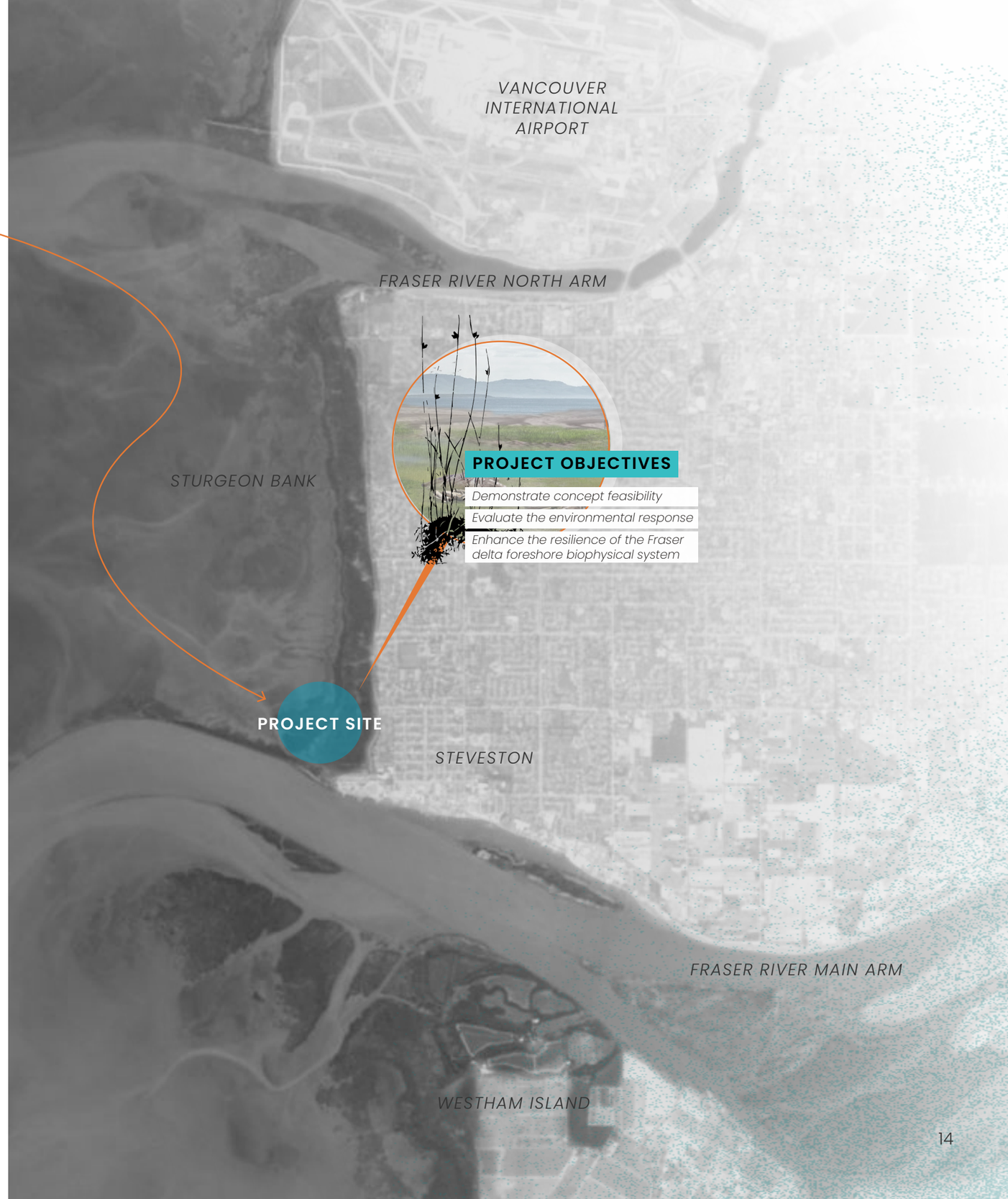
KEY SPECIES:
Fraser River salmon, steelhead trout, white sturgeon

The Sturgeon Bank Sediment Enhancement Pilot Project is an opportunity to test, refine, and evaluate an innovative method of restoring tidal marsh. This project simultaneously supports ecological resilience and the protection of our communities from coastal flooding. This project seeks to restore and increase the resilience of tidal marsh along the Sturgeon Bank foreshore, by re-purposing dredged sediment from the Fraser River to raise the marsh platform. Sediments are the foundational materials that allow the marsh platform to grow vertically to keep ahead of rising sea levels (Balke & Boyd, 2020). Along with providing critical habitat to many Fraser Estuary species, this pilot project may improve the capacity of tidal marshes along Sturgeon Bank to act as a form of green infrastructure.

Ducks Unlimited Canada, Raincoast Conservation Foundation, Lower Fraser Fisheries Alliance, and Tsawwassen First Nation have proposed, under the title Fraser River Estuary Salmon Habitat (FRESH) Restoration Projects, three ambitious projects in the Fraser Estuary from 2021-2024. As one of three large-scale FRESH Restoration initiatives proposed, the Sturgeon Bank Sediment Enhancement Pilot Project seeks to mimic natural sediment deposition processes that have been disrupted by human interventions to the Fraser River.

PROJECT PARTNERS

Each of the FRESH project partners offers a wealth of knowledge, providing an exciting opportunity for a collaborative restoration approach. As the project lead, Ducks Unlimited Canada has carried out tidal marsh



restoration projects in the Fraser Estuary for over 12 years, while Raincoast Conservation Foundation's ongoing Fraser Estuary Connectivity Project has demonstrated great success for juvenile salmon (Raincoast, 2018). The Lower Fraser Fisheries Alliance and Tsawwassen First Nation will collaborate on project delivery and monitoring, in addition to incorporating indigenous knowledge and priorities.

This project will also rely on scientific partnerships with the Pacific Salmon Ecology and Conservation Lab at UBC and Ecological Restoration program at SFU and BCIT, informing the effectiveness of past and proposed restoration actions (Balke & Boyd, 2020).

PROJECT TIMELINE

Project partners have applied for funding from the British Columbia Salmon Restoration and Innovation Fund, a key funding source for many restoration projects in British Columbia. Announced in 2019, this contribution program is funded jointly by the federal and provincial government and will grant $142.85 million until 2024 (Fisheries and Oceans Canada, 2021). If funding is secured, the pilot project is anticipated to begin as early as the fall of 2021 and conclude in 2024.

PROJECT EXECUTION

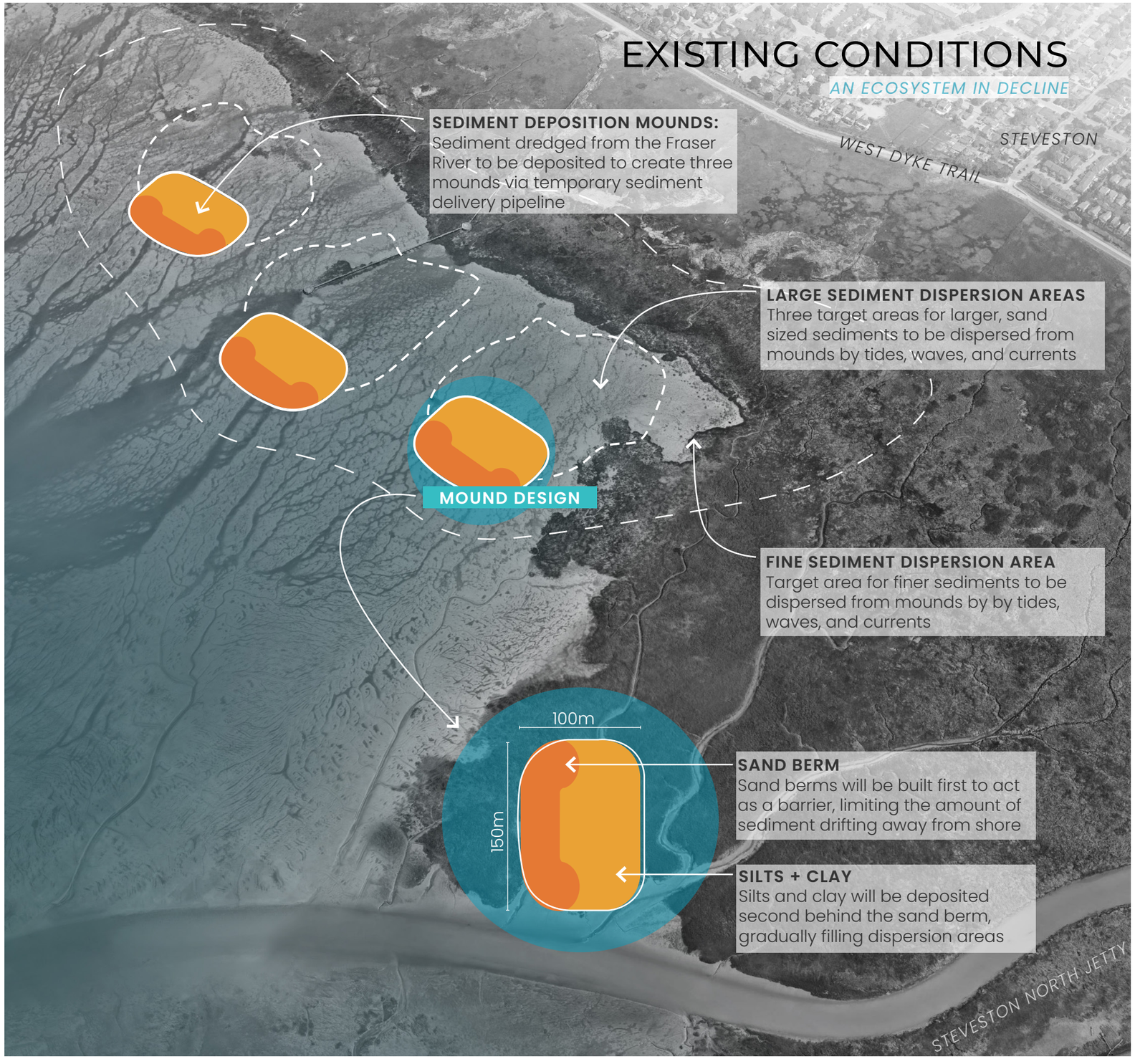
This pilot project will demonstrate a proof of concept, which could be scaled up to the remainder of the Sturgeon Bank foreshore and applied to other locations in the Fraser delta front and other estuaries throughout BC. The objective is to mimic natural riverine sediment delivery processes by using a temporary sediment delivery pipeline to pump sediment dredged from the Fraser River directly onto the southwestern Lulu Island foreshore of Sturgeon Bank. Three 150 m long by 100 m wide mounds will be initially formed. This would be accomplished incrementally over at least three consecutive years. The location of these mounds, about 700 m from the dyke, was selected to maximize the distribution of sediments to areas of receded marsh. The target area for sediment deposition could encompass up to 40 hectares, depending on the movement of waves and currents to distribute sediments (Balke & Boyd, 2020).

Sediment deposition is expected to increase marsh elevation, which:

- Reduces inundation stress on low elevation tidal marsh vegetation, enabling growth in areas where the marsh had previously receded
- Provides an elevation buffer for the existing tidal marsh to remain resilient with the anticipated increase in sea level over the coming decades (Balke & Boyd, 2020).

PROJECT LIMITATIONS

This pilot project provides a controlled opportunity to monitor and evaluate a promising, locally-customized ecological restoration approach. The biophysical response of the Sturgeon Bank foreshore to this method of sediment enhancement is unknown. Areas have been



identified where different sediment sizes will likely settle, however, the natural processes that will distribute the sediment are difficult to predict. High resolution hydrological modeling of sediment dispersion can only provide limited insight into these patterns, thus project partners determined it would be wiser to invest resources in conducting the project (E. Balke, personal communication, 2021). Ambitious projects like this often cannot be undertaken without significant government investments in ecological restoration in the Fraser Estuary.

SUPPORTING COMMUNITY RESILIENCE

This pilot project provides an opportunity to implement and evaluate an ecosystem-focused solution to coastal flooding, providing a locally-proven coastal flood adaptation alternative to traditional hard infrastructure approaches (Balke & Boyd, 2020). The province of British Columbia has instructed coastal communities to prepare for a 0.5-metre rise in sea levels by 2050, and 1 metre by 2100 (Vadeboncoeur, 2016). However, sea-level rise will not affect all of BC's coastlines equally, with the Fraser Delta identified as an area of particular concern as a result of its low elevation (Vadeboncoeur, 2016). All levels of government are making significant investments in protecting communities from coastal flooding, however many of these solutions involve simply building dikes higher rather than incorporating ecosystem resilience into coastal flood defences.

Due to the ecosystem-building and coastal flood protection functions of tidal marshes, there are synergies and cost-savings with efforts to protect the adjacent communities of Richmond and Steveston from the rising tides (Balke & Boyd, 2020). At present, there is no plan to ensure the tidal marshes of the Fraser estuary will persist into the 22nd century and beyond. This is short-sighted, given the ecological benefits and wave attenuation contribution of the foreshore marshes (E. Balke, personal communication, 2021).

Tidal marsh ecosystems act as a form of green infrastructure, dissipating up to 20% of wave energy and reducing wave heights, even in storm conditions (Forysinski, 2019). The persistence of these ecosystems is therefore a key piece when considering the impacts of sea-level rise on coastal communities. As a nature-based solution, this pilot project explores a potential solution to improve the resilience of estuarine ecosystems and communities vulnerable to sea-level rise.

MEASURING SUCCESS

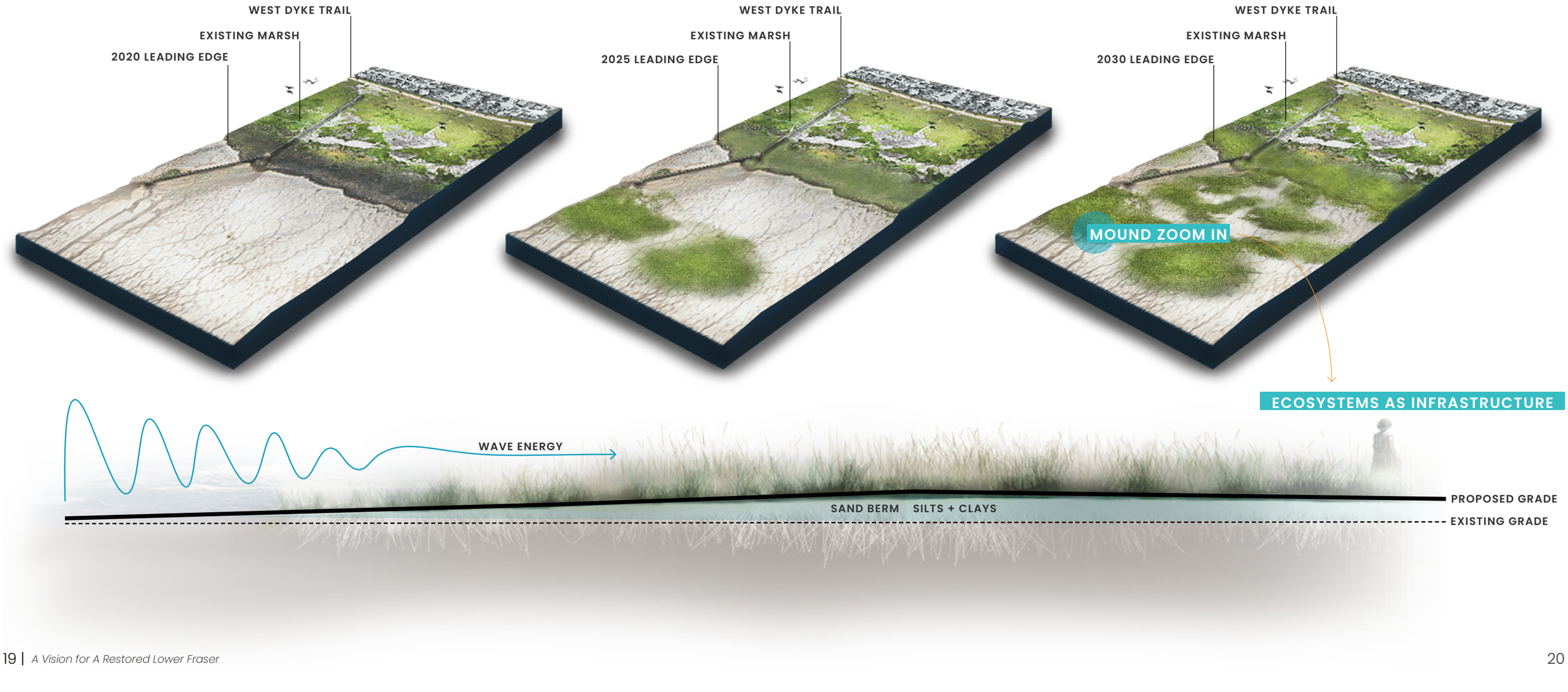
Monitoring will be essential to understand how this restoration technique may be applied along the remainder of Sturgeon Bank or other areas in the estuary experiencing tidal marsh recession. Project unknowns, such as the rate at which the mounds will be eroded and the extent of sediment redistribution, will be closely measured. The project area is expected to occupy about one sixth of the length of Lulu Island's western foreshore, allowing the remaining area to be compared and assessed for success.

MARSH PROGRESSION

DEVELOPING RESILIENT ECOSYSTEMS AS INFRASTRUCTURE

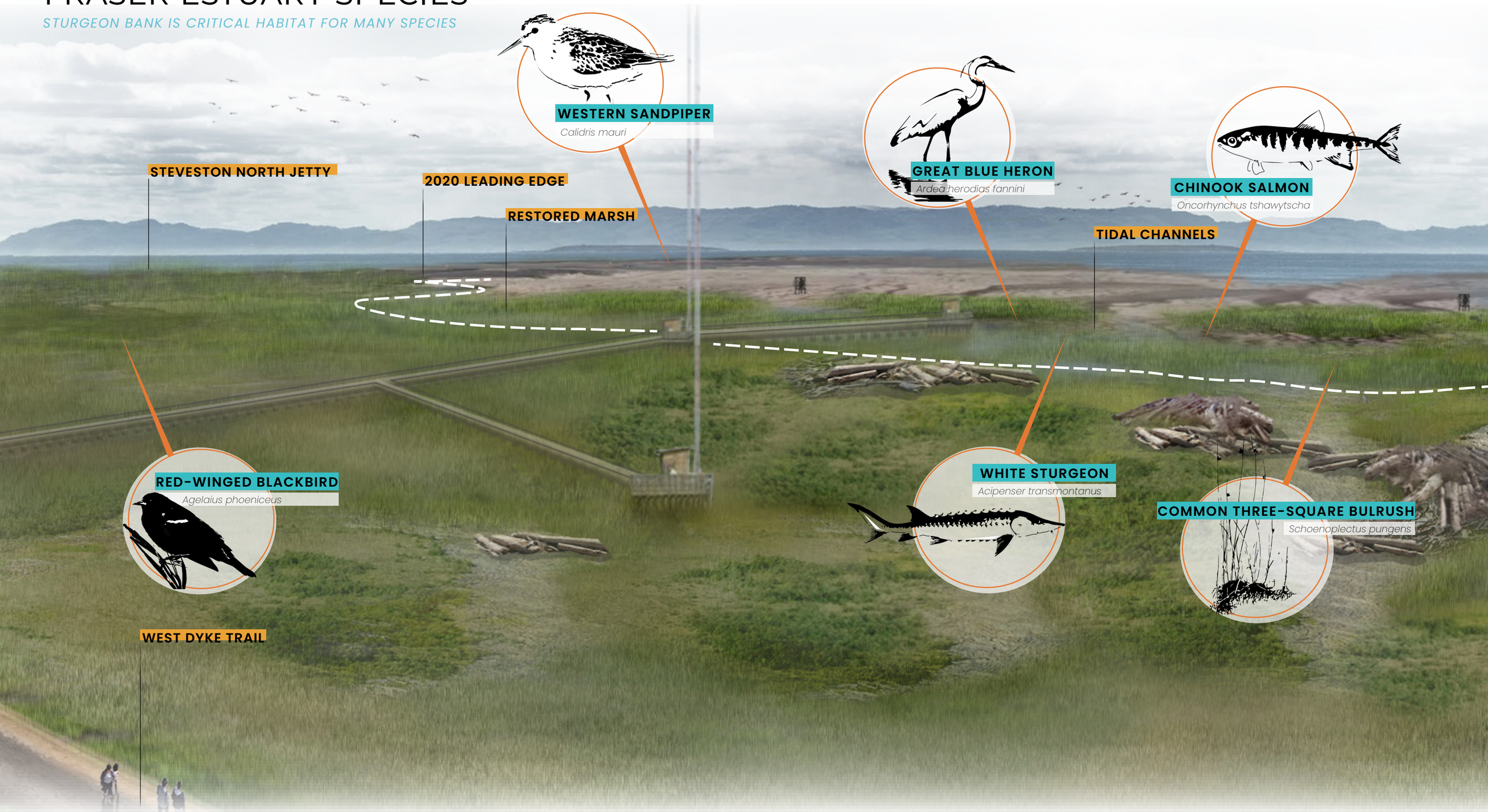
Vegetation will likely take hold first on the mounds, where larger-grain sediment will be directly deposited and the elevation has experienced the largest increase. (E. Balke, personal communication, 2021). Common three-square bulrush (*Schoenoplectus pungens*) is expected to spread to these areas due to its hardy nature. This bulrush species grows in soils ranging from coarse gravels to clays and has been a pioneer species of Pacific Northwest estuary marshes with fluctuating sediments and high wave energy, similar to Sturgeon Bank (Balke, 2017). These extreme conditions are not suitable for most other vegetation types, therefore, common three-square bulrush will likely compose a large proportion of the restoration area.

CURRENT CONDITIONS · · · · · · · · **1–2 YEARS POST RESTORATION** · **3–5 YEARS POST RESTORATION**



FRASER ESTUARY SPECIES

STURGEON BANK IS CRITICAL HABITAT FOR MANY SPECIES



SIGNIFICANCE TO THE FRASER BASIN

RESTORATION OF LOWER FRASER ECOSYSTEMS POSES THE OPPORTUNITY TO IMPROVE THE RESILIENCE OF COMMUNITIES AND ECOSYSTEMS THROUGHOUT THE FRASER BASIN. MAPPING AND VISUALS ARE POWERFUL TOOLS THAT CAN BE USED TO SUPPORT THESE EFFORTS.

Testing a locally-customized sediment enhancement method with a pilot project provides an opportunity to evaluate the feasibility and efficacy of an innovative sea-level rise resilience strategy. Additionally, such an approach helps to manage uncertainty by enabling adaptive management to improve project design during the pilot project stage before possibly scaling up to a larger project (Balke & Boyd, 2020). Outside of its impact on ecosystems at Sturgeon Bank, the sediment enhancement technique may be a more comprehensive approach to sea-level rise mitigation, in contrast to hard infrastructure that can exacerbate pressures on tidal marshes.

This pilot project offers the potential for a scalable "win-win-win" solution to address three challenges that exist throughout the estuary (E. Balke, personal communication, 2021):

- The lack of planning for estuary tidal marsh ecosystems to persist as sea levels rise
- The impending threat of sea-level rise for coastal communities
- The minimal re-use of large quantities of sediment dredged from the Fraser River - millions of cubic meters annually (Bros, 2007).

The Sturgeon Bank Sediment Enhancement Pilot Project is complementary to other ongoing projects in the Estuary and Lower Fraser Region. Raincoast Conservation Foundation's Fraser Estuary Connectivity Project aims to improve habitat in the Fraser Estuary by creating breaches in the Steveston North Jetty, an adjacent river training structure. These breaches allow for the movement of fish, water, and sediments to flow into the project area (Raincoast, 2018). The unrestricted movement of sediments and water supports the natural processes of delta formation that were present prior to the construction of the sea dikes and jetties.

Due to the interdependence of natural systems, considering the cumulative efforts of multiple restoration projects creates a more holistic approach to restoration. Salmon are a prime example; each species requires a connected system of habitats to complete their life cycle, spanning hundreds of kilometers. When a restoration site is isolated from the flow of nutrients, energy, and species it is unable to function as part of the larger system. This understanding aligns with the Pilot Project's goal of developing a nature-based solution to combat sea-level rise within the Fraser Estuary.

NATURE-BASED SOLUTIONS

Nature-based solutions attempt to mimic natural systems to afford the ecosystem services provided by these systems. Ecosystem services are the ecological, cultural and economic benefits derived from the natural world (IUCN, 2016). Examples of ecosystem services include carbon storage, regulation of climate and water flow, provision of clean water, and maintenance of soil fertility (Benayas et al., 2009). Increases in biodiversity following restoration efforts are tied to increases in the ecosystem services provided by an area, providing increased motivation for restoration (Benayas et al., 2009).

While the Lower Fraser River possesses intrinsic value, independent of its use to humans, there is a growing understanding of the services provided to humans as a result of biodiverse, functioning ecosystems. The services provided by restored ecosystems could be leveraged to incite restoration projects throughout the Lower Fraser and Fraser Basin. As one of British Columbia's treasured landscapes, non-profits, First Nations, and local governments in the Lower Fraser have recognized the value in restoring what has been lost. However these initiatives require capital investment and public support.

WHY A VISION OF A RESTORED LOWER FRASER?

Although conservation and protection should be made a priority, the realities of persistent anthropogenic pressures on Lower Fraser ecosystems necessitate restoration as a critical tool in the pursuit of a healthy Fraser Basin. Visualization of restoration efforts in the Lower Fraser enables a network of restoration practitioners to connect mutual interests, funding sources, and the broader public.

Visual representations create an opportunity to:

1. DOCUMENT PAST RESTORATION SITES

As living systems, it is important to understand how restoration efforts have been developing over the years. Mapping creates an inventory of restoration information that can be documented geographically.

2. IDENTIFY PRIORITY RESTORATION SITES

Understanding the impact of restoration sites as part of a system.

3. CONNECT

Increased connection between practitioners, governments, non-profits, funding sources, and the public in the Lower Fraser builds capacity and opportunities for restoration.

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