Growing pains: Overcoming barriers to nature-based coastal adaptation projects through collaboration

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored; see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

This thesis follows the manuscript option for master's students in the Department of Geography and Environmental Management at the University of Waterloo. This thesis comprises two distinct manuscripts that will be submitted to refereed journals. I am the principal author of all chapters; however, Dr. Andréanne Doyon and Dr. Brent Doberstein made contributions to both manuscripts, and Dr. Sarah Burch to one.

The first manuscript, *Identifying enabling conditions for a nature-based coastal adaptation project in British Columbia, Canada* is co-authored with Dr. Andréanne Doyon (10%) and Dr. Brent 10%) Doberstein. Both co-authors contributed to concept refinement, structural suggestions, and editorial support. This manuscript is ready for submission to *Regional Environmental Change.*

The second manuscript, *Understanding actors' contributions to a nature-based coastal adaptation project through roles,* is also co-authored with Dr. Andréanne Doyon (8%) and Dr. Brent Doberstein (8%) and Dr. Sarah Burch (4%). The co-authors provided conceptual feedback, structural suggestions, and editorial support. This manuscript is ready for submission to *Earth System Governance*.

Abstract

Coastal climate impacts have evolved so that the solutions that infrastructure managers have historically used to adapt to flooding may no longer be sufficient. Consequently, many have begun to consider alternatives to conventional grey infrastructure, including nature-based coastal adaptation (NBCA) projects. NBCA projects, a subset of nature-based solutions, have several characteristics that provide additional benefits compared to grey infrastructure, but those same characteristics and the novelty of the solutions can make NBCA challenging to implement. To overcome those challenges, collaboration has been suggested as a way of drawing on multiple perspectives, skillsets, and knowledge bases. To examine the ability of collaboration to advance NBCA projects, I conducted a case study of the Boundary Bay Living Dike (BBLD), one of the first NBCA projects in the Canadian province of British Columbia. I conducted interviews with 32 individuals who had been directly involved with the BBLD project to understand participants' perspectives on 1) the barriers to BBLD, and 2) the ways in which collaboration interacted with those conditions. In examining the interview data and building on the barriers to adaptation literature, I developed a conceptualization of enabling conditions: factors that help or hinder a project based on the degree to which they are present, the timeframe over which they are available, the presence of actors who can make use of them, and the conditions' interactions with each other. In doing so, I found that the most significant hindering factors were institutional (such as jurisdiction and mandate, assumptions and paradigm, and regulations) and systemic (influenced by conditions such as the Covid-19 pandemic and high inflation). I then examined the ways in which collaboration interacted with those conditions by applying a framework of action-based roles to characterize the collaborative process surrounding the BBLD, finding that collaborators were able to both support the project within formal structures and fill the gaps left by systems not designed to accommodate NBCA. These findings contribute conceptually to the barriers to adaptation literature, and practically to both those looking to implement NBCA and those with the ability to develop systems to enable them.

Acknowledgements

For an ostensibly individual project, I've come to appreciate that a thesis does not happen without the support of a shocking number of people. I'd like to start by thanking my co-advisors, Dr. Brent Doberstein and Dr. Andréanne Doyon, for keeping me pointed in the right direction and being supportive even when I wasn't making any sense. Brent, redirecting me onto this project is one of the best things you could have done for me. You have a knack for getting immediately to the heart of problems that have been puzzling me for weeks, which I find unendingly impressive. Andréanne, thank you for keeping me focused and accountable, while reminding me that grad school is a learning exercise. You have a blend of enthusiasm and mildly intimidating efficiency to which I aspire, and your students are lucky to have you. I also gratefully acknowledge the support of my committee member, Dr. Sarah Burch, and my reader, Dr. Johanna Wandel, whose feedback helped me strengthen my work.

Over the course of this project, it has been a privilege to work in in the company of two wonderful research communities. The Living with Water project at the Pacific Institute for Climate Solutions is made up of an incredible group of people, and I am a better researcher for having worked with them. I especially want to acknowledge Dr. Vanessa Lueck for her unflagging leadership, and Matt Osler, for helping me find practical research questions and putting up with me while I tried to answer them. I would also like to acknowledge to Society, Environment and Emotions Lab for being my academic home, especially during the pandemic. I particularly want to thank Dr. Sarah Wolfe for teaching me the skills to succeed in grad school and the self-confidence to use them, and Dr. Lauren Smith for keeping me accountable, encouraged, and entertained in equal measures. I will spend the rest of my life paying back the kindness I was shown.

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intelligence and insight, but also for adventures, whether around the corner or across the country; Sam, for the masterful puns and giving me somewhere to send those Monday morning affirmations; Alastair, for precisely 186 trees, or, letting me borrow some self-discipline when I was in short supply; and Nina, for making Waterloo home.

Finally, I know that I would not have made it this far in the first place without my wonderful family. To my parents and siblings, thank you for your unending love and support. I will never say it enough, but everything I am or will be is because of you first.

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Chapter 1 – Introduction

Coastal areas are some of the most vulnerable when it comes to the impacts of climate change (IPCC, 2014; Rahman et al., 2019). In the lower mainland of British Columbia (B.C.), a province on the west coast of Canada, sea level rise and other impacts of climate change will worsen coastal flooding in the near future (Ramm et al., 2018). The risk from flooding will be exacerbated by the poor state of the infrastructure meant to protect against it; in 2015, a report found that only 4% of dikes in B.C. were high enough to protect against the current design event, let alone withstand climate change conditions (Vass, 2015). Because of this, B.C. will need significant investments in coastal defense infrastructure over the coming years. Those investments will shape B.C.'s adaptation trajectory for decades, so infrastructures managers are beginning to consider a broader spectrum of potential strategies to address the risks (Government of B.C., 2023).

One alternative to conventional coastal protection infrastructure is nature-based coastal adaptation (NBCA) projects. NBCA are a subset of nature-based solutions (NBS), which are actions that rely on ecosystem processes to address societal challenges (Cohen-Shacham et al., 2019; European Commission, 2015) and which can be valuable complements to conventional infrastructure in adapting to climate change. Like other kinds of NBS, NBCA are unique to the contexts in which they are implemented but share some common strengths: they are based in systems thinking, which can help them address highly complex challenges like climate change (Frantzeskaki & Bush, 2021); they are inherently adaptable as living systems, which is valuable when coping with uncertainty (Van Loon-Steensma & Vellinga, 2019); they actively pursue co-benefits[1] (Giordano et al., 2020; Hamin et al., 2018); they can produce fewer negative environmental impacts during construction (Van Loon-Steensma & Schelfhout, 2017; Woroniecki et al., 2020); and they do not depreciate in the same way as built infrastructure (Gailis et al.,

[1] Co-benefits can be defined as the goals of project that are additional to that project's primary function, but complementary to its overall objective – in this case protecting against climate-affected hazards (Jones & Doberstein, 2022).

2021). That is not to suggest that NBCA are the best solution for every situation (Eggermont et al., 2015). There are many limitations of NBCA: innovation can mean contending with limitations in knowledge (Kabisch et al., 2016; Mehan, 2010; Nesshöver et al., 2017); ecosystems are adaptive, but only to a certain threshold (Adger et al., 2009; Martin, Specht, et al., 2021); their reliance on living systems adds extra layers of uncertainty (Bouma et al., 2014; Cohen-Shacham et al., 2019); and new solutions are riskier than well-tested solutions (Persson et al., 2015). Understanding both these advantages and limitations is necessary for NBCA projects to be considered as viable alternatives to conventional infrastructure.

In B.C., a province reliant on over 1,000 kilometers of dikes, living dikes are one kind of NBCA being considered to help protect coastal communities from flooding (Serralheiro-O'Neill, 2020). Living dikes, sometimes called green dikes, are coastal flood defenses that use living ecosystems to provide flood protection by absorbing wave energy (Van Loon-Steensma & Schelfhout, 2017). They are generally wider than a conventional dike, with a gradual seaward slope that allows the ecosystem to migrate inland as the sea level rises. Living dikes are not yet common but have been successful along the coast of the Wadden Sea in Germany and the Netherlands (Van Loon-Steensma & Vellinga, 2019), and have attracted interest in B.C.

The Boundary Bay Living Dike (BBLD) project is a living dike pilot project being undertaken by three co-proponents: the City of Surrey, the City of Delta, and Semiahmoo First Nation (henceforth referred to as 'the co-proponents'). The co-proponents have worked with an unusual number of different groups and with an unusually high degree of involvement, drawing on many sources of expertise as they attempt to implement an innovative project. The utility of collaboration in designing effective nature-based projects is well-documented (Costa et al., 2020; Frantzeskaki & Bush, 2021; Meerow & Newell, 2019; Nelson et al., 2020). The BBLD project is one of the first of its kind, and the first in the conditions of B.C. (Readshaw et al., 2018), making extensive consultation with both technical and community experts necessary for both technical feasibility and project acceptability to rights holders and stakeholders

(Osler & Demsar, n.d.). In this research, I aimed to explore what the co-proponents' process of collaboration entailed, whether it helped the BBLD overcome barriers to implementation, and whether the process of collaboration could provide a model for other NBCA projects that will follow.

1.1 – Research objectives and questions

The primary research question of this thesis was: in what manner does collaboration impact the adoption of nature-based coastal adaptation projects? In the context of my case study, this necessitated focus on two key areas of inquiry: 1) what the barriers to the project were, and 2) how collaboration interacted with those barriers. To that end, we identified the following sub-research questions and objectives.

Sub-question 1: Has the BBLD co-proponents' collaborative approach facilitated the project's progress or success?

Objective 1a: Identify the various barriers to the BBLD project.

Objective 1b: Establish how collaborators define success for the BBLD project in general, how they define successful collaboration in particular, and by what metrics that success can be evaluated.

Objective 1c: Explore whether the collaborative approach described in O2a is helping the co-proponents overcome the barriers to the BBLD project identified in O1a or otherwise achieve success as defined in O1b.

Sub-question 2: What are the main features and types of collaboration used in the BBLD project?

Objective 2a: Describe 'collaboration' in the BBLD context by mapping the co-proponents' collaborative process (i.e., the roles of actors).

Sub-question 3: In what ways could the BBLD co-proponents' collaborative approach be a model for others looking to implement nature-based solutions?

Objective 3a: Describe the advantages and disadvantages of the collaborative process (O1a) as perceived by individuals who were involved in that process.

Objective 3b: Assess the ability of the collaborative approach (O1a) to facilitate the implementation of other nature-based solutions by comparing the barriers identified in O2a to the scholarly NBS literature.

These questions and objectives led to two distinct manuscripts, organized around the research sub-questions above. The first manuscript emerged from a desire to understand the barriers that the BBLD faced, addressing sub-questions one and three. The second manuscript explored how the co-proponents' collaborative approach to project design and management interacted with those barriers, focusing on sub-questions two and three. Together, the two manuscripts tell one cohesive account of the potential of collaboration to help an NBCA project navigate complex conditions to reach implementation.

The first manuscript, entitled '*Identifying enabling conditions for a nature-base coastal adaptation project in Surrey, British Columbia*' began with the need to understand the barriers that the BBLD was facing, in order to analyze the ways in which collaboration interacted with those barriers. However, we found through our primary data collection that focusing solely on barriers presented only part of story. Consequently, we expanded our discussion of barriers to look at enabling conditions, the series of interconnected conditions that characterize a project's context and influence its chances of success. Our conceptualization of enabling conditions builds on the barriers to adaptation literature and aims to represent the complexity and changeability of these conditions, setting the stage for us to understand how collaboration interacted with those conditions.

Building on the findings regarding enabling conditions, the second manuscript, '*Understanding actors' contributions to a nature-based coastal adaptation project through roles*' moves from the high-level view of the BBLD's context explored in the first manuscript to focus in on the individual actors within the project. In this manuscript, we examined collaboration through the lens of action-based roles,

analyzing the various roles that individuals and organizations played within the BBLD project. We extended an existing framework of roles (Hilger et al., 2021) with additional roles that we identified in our data, and used these roles to discuss how future NBCA proponents might use that information to build effective and efficient teams.

1.2 – Thesis organization

This thesis is organized according to the requirements for the manuscript option for master's students in the Department of Geography and Environmental Management. It is comprised of two independent manuscripts that together represent the findings of one, cohesive research project on the potential of collaboration to support nature-based coastal adaptation projects[2]. The first manuscript (Chapter 3), *Identifying enabling conditions for a nature-based coastal adaptation project in British Columbia, Canada,* is ready for submission to *Regional Environmental Change.* The second manuscript (Chapter 4), *Understanding actors' contributions to a nature-based coastal adaptation project through roles,* is ready for submission to *Earth System Governance.* Both are formatted according to University of Waterloo standards and will be adjusted when submitted for publication based on journal requirements. Chapter 5 summarizes findings from both manuscripts and outlines areas for future research.

[2] Across this thesis, I will switch between the use of the first person singular (for any chapters that belong solely to this thesis, of which I am the sole author) and the first person plural (which is appropriate for the manuscripts which have been prepared as co-authored publications).

Chapter 2 – Methodology

While Chapters 3 and 4 of this thesis are both self-contained manuscripts containing explanations of the methods used, in this chapter I will present an overview and justification of the methods for this study overall. This research was conducted as part of the Pacific Institute for Climate Solutions' Living with Water (LWW) project, which influenced both research question development and guiding values. To identify research questions, LWW researchers were encouraged to partner with 'solution seekers': practitioners working in the climate space who could bring local, practical insight and potentially make use of the resulting research. Through LWW, I partnered with a solution seeker from the City of Surrey who was able to provide insight into the BBLD project, though my research question was my own and my process was independent. Also as part of LWW, I was involved in a collaborative process to identify our values as researchers within this project. These values include engaging in reconciliation with Indigenous peoples through research practices; recognizing that there are multiple ways of knowing and relating to the world; and recognizing the interconnectedness of land, water, and people over time and space. This values process was consistent with research informed by a pragmatist worldview, acknowledging that research exists in a particular social, historical, and geographic context (Cresswell & Cresswell, 2018) and recognizing that adaptation is a normative problem, wherein what constitutes 'good' adaptation is dependent on the values and priorities of the community in which it occurs (Adger et al., 2009).

This research was comprised of one mixed methods case study. Focusing on a single case study (the BBLD) allowed me to pursue the depth of analysis needed to draw a justifiable conclusion about a complex process (Bryman, 2012). The BBLD makes a strong case study because of both project and process characteristics. As a project, the BBLD is novel for the province of B.C. (Readshaw et al., 2018), but is representative of the province's growing interest in nature-based approaches to adaptation (Government of B.C., 2023). The BBLD was also identified as being undertaken by an unusual (in this case, highly collaborative) process in informal meetings with research partners early in the development of our research question. To best study the BBLD and the context in which it was operating, I used

triangulation to increase the validity of our findings. This included triangulation both of data from multiple data sources (including purposive sampling of interview participants with different perspectives, priorities, and degrees of power over the project) and by multiple methods (including semi-structured interviews, document analysis, and participant observation) (Natow, 2019).

2.1 – Data collection

Semi-structured key informant interviews formed the bulk of the data collection for this study. Key informant interviews are appropriate for this study because my research question is concerned with specialized knowledge deriving from direct involvement in the BBLD project. A semi-structured format ensured that the discussion covered key areas of interest while allowing the expertise, perspectives, and interests of the participants to shape their responses. This method is consistent with existing collaboration-focused climate adaptation research in British Columbia (Burch, 2010).

Taking a stratified sampling approach ensured a balance of perspectives on the co-proponents' process of collaboration (Bryman, 2012). I recruited interview participants from following strata: municipal government, provincial government, federal government, other government organizations, civil society organizations, academia, industry, and subject matter experts. More information on these strata is available in Appendix A. Participants from these groups held diverse priorities (e.g., public safety, biodiversity), degrees of power, and levels of familiarity with the project, which provided insight into the process from multiple perspectives. This sampling approach helped to mitigate potential downsides of the key informant approach, which can privilege some voices and knowledge systems over other (Lokot, 2021). I identified participants through publicly available project documents and through the suggestions of other participants, obtaining contact information through organization websites or other online sources. Potential interview participants were limited to individuals who were personally involved in the project, apart from subject matter experts who were not required to have direct involvement but who were able to

provide other relevant insight. These participants were contacted by email[3] and invited to participate either in person or through an online meeting platform (Zoom or Microsoft Teams). A responsive interview model was used to refine questions and core themes between interviews to pursue trends or capture inconsistencies (Cresswell & Cresswell, 2018). A total of 32 interviews were conducted; each was audio-recorded and automatically transcribed using the transcription software Otter.ai. I then cleaned the auto-generated transcripts, and where requested, allowed participants to review and revise the cleaned transcript. For more detail on the interview process, please see Chapters 3.3.2 and 4.3.2.

The semi-structured interviews were supported by two other methods of data collection: short term participant observation and content analysis. Participant observation is a qualitative research method in which a researcher immerses themselves in a social setting that they seek to describe (Bryman, 2012). While often a long-term exercise, participant observation in this study was intermittent and brief, including attending project meetings and a field site visit. These observational opportunities shed light on interpersonal and interorganizational dynamics, as well as points of contention and agreement, and served to validate findings from the interviews. Content analysis involved reviewing project documents to verify facts given in interviews.

2.2 – Data analysis

Data analysis for this study was qualitative. Interview transcripts were thematically coded using NVivo through an iterative process described in further detail in Chapters 3.3.3 and 4.3.4. Coding has several advantages as a method of data analysis: it provides a method of sorting and structuring data; it allows the researcher to trace important ideas through the data, improving analytical depth; and it ensures transparency and credibility of findings (Linneberg & Korsgaard, 2019). I used a combination of inductive and deductive coding, beginning with inductive coding as to prevent existing theory from influencing my analysis of the themes present in the data. A flow chart of coding passes is available in

[3] This research was approved by the Waterloo Research Ethics Board (#44072). Recruitment materials and sample consent forms are available in Appendix B.

Chapter 4.3.4. While I conducted all coding, coding passes and outputs were reviewed with two of the manuscript co-authors (B. Doberstein and A. Doyon).

These methods, supplemented by a review of the scholarly literature, formed the basis for this thesis. The qualitative data provided by the semi-structured interviews and participant observation yielded multiple perspectives on enabling conditions and collaboration, and the methods of coding allowed me to explore those themes in a thorough way. These findings are discussed in Chapters 3 and 4.

Chapter 3 - Identifying enabling conditions for a nature-base coastal adaptation project in British Columbia, Canada

"[I don't think of them as barriers, exactly]… I think that's more… [the] growing pains of an idea - the unprecedented nature of it." Participant 3964P

3.1 – Introduction

In coastal areas, high densities of ecological significance, human population, and economic investment make adapting to the impacts of climate change an imperative (IPCC, 2014; Marijnissen et al., 2020). The increasing risks of flooding and other hazards to coastal areas compound the risk from aging infrastructure that is already insufficient for current conditions. To protect against flooding, the Canadian province of British Columbia (B.C.) currently relies on 1,100 kilometers of dikes (Serralheiro-O'Neill, 2020; Vass, 2015). However, in a 2015 study of 74 dikes in the Lower Mainland region, only 4% of dikes were buitl or maintained to a standard that would protect to the present design flood level (Vass, 2015). As infrastructure managers across the province confront the need for sufficient, affordable, and adaptable approaches to dealing with coastal hazards in the context of climate change, many are considering alternatives to conventional grey infrastructure.

One increasingly popular alternative is nature-based coastal adaptation (NBCA) projects. NBCA projects make use of living ecosystems to protect against climate-affected hazards and can be valuable complements to grey infrastructure in adapting to climate change (Rahman et al., 2021; Sutton-Grier et al., 2015). However, most NBCA projects are being proposed and implemented within environmental, social, political, economic, and institutional structures that were not designed to accommodate them (Rahman et al., 2019). Several of the characteristics that give NBCA projects an advantage over conventional infrastructure also make NBCA poorly suited to the systems that exist to support grey infrastructure projects (Bush & Doyon, 2019; Frantzeskaki & Bush, 2021). The degree to which this is true depends both on the project and the context within which it is operating, which means that even within the province of B.C., the degree to which these systems combine to create favourable or unfavourable conditions for NBCA projects is localized.

In this paper, our aim was to identify the enabling conditions for one of the first NBCA projects in B.C., the Boundary Bay Living Dike (BBLD). After first exploring the literature of barriers and enablers to adaptation projects, we then outline the methods by which we collected and analyzed our data. From there, we delve into our conceptualization of enabling conditions, which describes the helping and hindering factors[4] that influence project success (Huber-Stearns et al., 2017) through the lenses of degree, timeframe, actors, and interactions. Using the enabling conditions concept, we then examine the specific enabling conditions of the BBLD before discussing how the concept can provide insight for other projects. Finally, we address areas for future study.

3.2 – Literature Review

3.2.1 – Nature-based solutions and nature-based coastal adaptation

Nature-based Solutions (NBS) are one form of adaptation that has gained significant popularity in recent years. NBS are commonly defined as "actions to protect, sustainably manage, and restore natural or modified ecosystems, which address societal challenges… effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits…" (Cohen-Shacham et al., 2016). In concept and practice, NBS build off existing approaches such as ecological restoration (Clewell & Aronson, 2013; Cohen-Shacham et al., 2019), ecosystem-based adaptation (Nesshöver et al., 2017), green and blue infrastructure (Alves et al., 2018), and ecosystem services (Wainger et al., 2017), but emphasize addressing societal challenges (Cohen-Shacham et al., 2016; Faivre et al., 2017; Woroniecki et al., 2020). It should also be noted that the ideas and values underpinning those approaches are not new; Indigenous peoples have been living in, modifying, and maintaining environments since time immemorial (Maller, 2021). However, a confluence of academic research and practical programs to support NBS have significantly increased interest in using nature-based approaches to address the effects of climate change.

[4] Helping and hindering factors are synonymous with enablers and barriers, respectively. We chose these terms over the barrier and enablers language to keep the reader focused on enabling conditions as a spectrum rather than barriers and enablers as discrete categories.

NBS undertaken in coastal areas have to contend with particularly high levels of both vulnerability and complexity due to the concentration of competing interests (Rahman et al., 2019). In recognition of those challenges, here we will speak specifically about nature-based coastal adaptations (NBCA). Rahman et al. (2021) define NBCA as,

> "any coastal adaptation approach that involves both ecologically available adaptation options (e.g., natural space, ecological process and species) and socio-politically available opportunities (e.g., values, policy, rules and regulations etc.) to utilize natural capacity to buffer coastal climate change impacts like sea-level rise, considering societal demand for diverse ecosystem services (e.g., provisioning, regulating, cultural and supporting) and minimizing engineered construction as a supporting component" (p. 2).

NBCA is one subset of NBS characterized by the impacts and vulnerability of coasts under climate change conditions, as well as the unusually high density of competing interests (Rahman et al., 2019). NBS are beginning to be valued as alternatives to conventional infrastructure because of their ability to provide multiple benefits (Hamin et al., 2018; Pagano et al., 2019), including intangible benefits, such as cultural values (O'Brien & Wolf, 2010; Raymond et al., 2017). NBS can be cost-effective alternatives with fewer environmental externalities (Gailis et al., 2021; Van Loon-Steensma & Schelfhout, 2017). They also benefit from the dynamism of living ecosystems and can adjust to changing conditions (Frantzeskaki & Bush, 2021; Van Loon-Steensma & Vellinga, 2019).

3.2.2 – Enabling conditions for adaptation

While NBCA have several advantages over conventional infrastructure, they also have several challenges and limitations. Some limitations are inherent to NBCA; ecosystems have limits to how quickly they can adapt (Adger et al., 2009; Martin, Specht, et al., 2021), and they have higher levels of uncertainty than grey infrastructure (Bouma et al., 2014; Cohen-Shacham et al., 2019). Other challenges have to do with NBCA's relative novelty. A lack of knowledge and expertise can make effective, context-appropriate project design complicated (Kabisch et al., 2016; Nesshöver et al., 2017). NBCA's newness

also means that they are operating within governance structures that were not designed to accommodate them (Bush & Doyon, 2019; Faivre et al., 2018; Nelson et al., 2020), nor are there robust systems for managing risk through means such as insurance (Persson et al., 2015; Ramm et al., 2018). In order to give NBCA a fair chance of success, we can consult the literature on barriers and enablers of adaptation.

Challenges in implementing climate change adaptation projects are not unique to NBCA. A robust body of literature exists on the barriers to climate adaptation. Barriers to adaptation can be defined as "(1) an impediment (2) to specified adaptations (3) for specific actors in their given context that (4) arise from a condition or set of conditions. A barrier can be (5) valued by different actors, and (6) can, in principle, be reduced or overcome" (Eisenack et al., 2014, p. 868). Barriers are often combinations of climate and non-climate factors (Biesbroek et al., 2013), meaning that adaptations need to be consistent with approaches to manage non-climatic stresses (Burch, 2010). While some authors use barriers synonymously with constraints, where barriers are inherently negative (e.g., IPCC, 2014), here we use it in a value-neutral sense (e.g., Eisenack & Stecker, 2012; Moser & Ekstrom, 2010). In some cases, barriers can be positive, such as in creating adaptation interventions that, once implemented, are hard to reverse (Burch, 2010).

It is recognized that focusing on the positive aspects of a project can be helpful in motivating proponents to address barriers, but that has mostly been confined to outcome rather than process. For example, despite the pervasive desire to avoid the risk associated with innovative climate change adaptation approaches (Dorst et al., 2022; MNAI, 2023), the multiple benefits NBS can provide is commonly cited as a motivating factor in taking on the risk anyway (Choi et al., 2021; Frantzeskaki, 2019; Hanson et al., 2020; Kabisch et al., 2016; Kousky & Walls, 2014; McVittie et al., 2018). However, as the literature has focused mainly on overcoming barriers to achieve those benefits, with significantly less discussion about project enablers. While some barriers research does consider the presence of positive conditions (e.g., Burch, 2010; Eisenack et al., 2014; Rutledge, 2018), there has been a comparative lack of emphasis on identifying opportunities and sources of strength for NBCA projects

within the existing system, though that is beginning to change (Martin, Scolobig, et al., 2021; Sarabi et al., 2019).

Several authors have categorized barriers to adaptation, including NBCA projects specifically, taking a variety of approaches to explaining the diversity of challenges such projects can face. Broadly, these categories of barriers can be understood by either the area of impact of the barriers (Burch, 2010; Ekstrom & Moser, 2014; Moser et al., 2012; Rahman et al., 2021; Xie et al., 2022), or the factors that influence barriers across domains (Biesbroek et al., 2011; Kabisch et al., 2016). Focusing on areas of impact means that an organizational approach to barriers considers the sources of barriers within different systems, and typically uses categories such as institutional, economic or financial, political, and social or cultural. Organizational approaches to barriers cross-cut domains to focus on underlying factors that are common to all systems, considering barriers such as fear of the unknown (Kabisch et al., 2016) or fragmentation (Biesbroek et al., 2011).

While the literature reviewed previously provides several helpful ways of thinking about the contexts in which NBCA operate, we found no one framework that 1) accounted for the unique challenges of NBCA, 2) actively considered enablers as well as barriers, and 3) emphasized the interconnectedness of the barriers and enablers. Instead, drawing on the adaptation barriers literature, this paper expands on the concept of enabling conditions, as shown in Figure 3.1. Enabling conditions can be defined as "factors that increase the likelihood of an intended change in the governance approach, strategy, or management regime," (Huber-Stearns et al., 2017, p. 1). We will further explore the concept of enabling conditions in section 4.1.

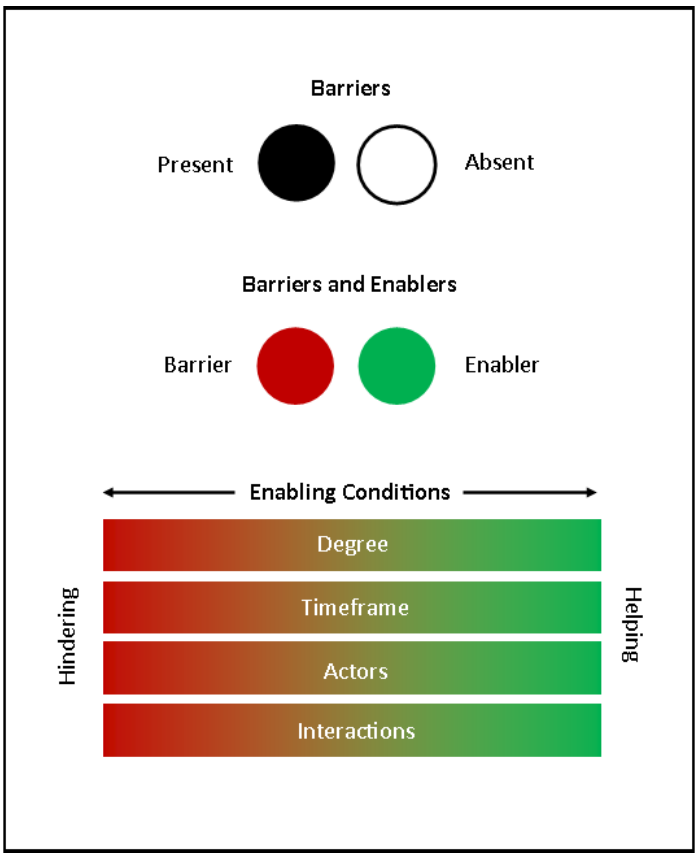

Figure 3.1: Moving from barriers to enabling conditions. At the most basic level, barriers can be seen as present or absent. Adding the concept of enablers provides another level of insight, considering the presence of positive conditions, not just the absence of negative ones. Enabling conditions goes a step further to present those conditions as a continuum rather than as two discrete categories, defined by four interrelated characteristics.

3.3 – Methodology

3.3.1 – Case study: Boundary Bay Living Dike

The Mud Bay Foreshore Enhancements project, shown in figure 3.2, more widely known as the Boundary Bay Living Dike (BBLD), is an NBCA project that is located within the territory of Semiahmoo First Nation in the lower mainland of B.C., on the border of the cities of Surrey and Delta (City of Surrey, 2022b). The goal of the living dike is to combine ecosystem protection with flood mitigation. The dike's gradual seaward slope allows the salt marsh to migrate inland with sea level rise, while the plants reduce the risk of overtopping by absorbing energy from the waves (Gailis et al., 2021;

Readshaw et al., 2018; Van Loon-Steensma & Schelfhout, 2017). Protecting the salt marsh is particularly important in Boundary Bay, which is a highly ecologically significant area for birds and fish; as such, it is protected by a provincial wildlife management area (Government of British Columbia, n.d.), and holds several international environmental designations including those under the Ramsar Convention, BirdLife International, and the Western Hemisphere Shorebird Reserve Network (Murray & Taitt, n.d.). The area's ecological importance and high density of rights holders and stakeholders make it a complex location for undertaking projects. However, this is where the cities of Surrey and Delta and Semiahmoo First Nation created a partnership to pilot one of the first NBCA projects in B.C. (City of Surrey, 2022a).

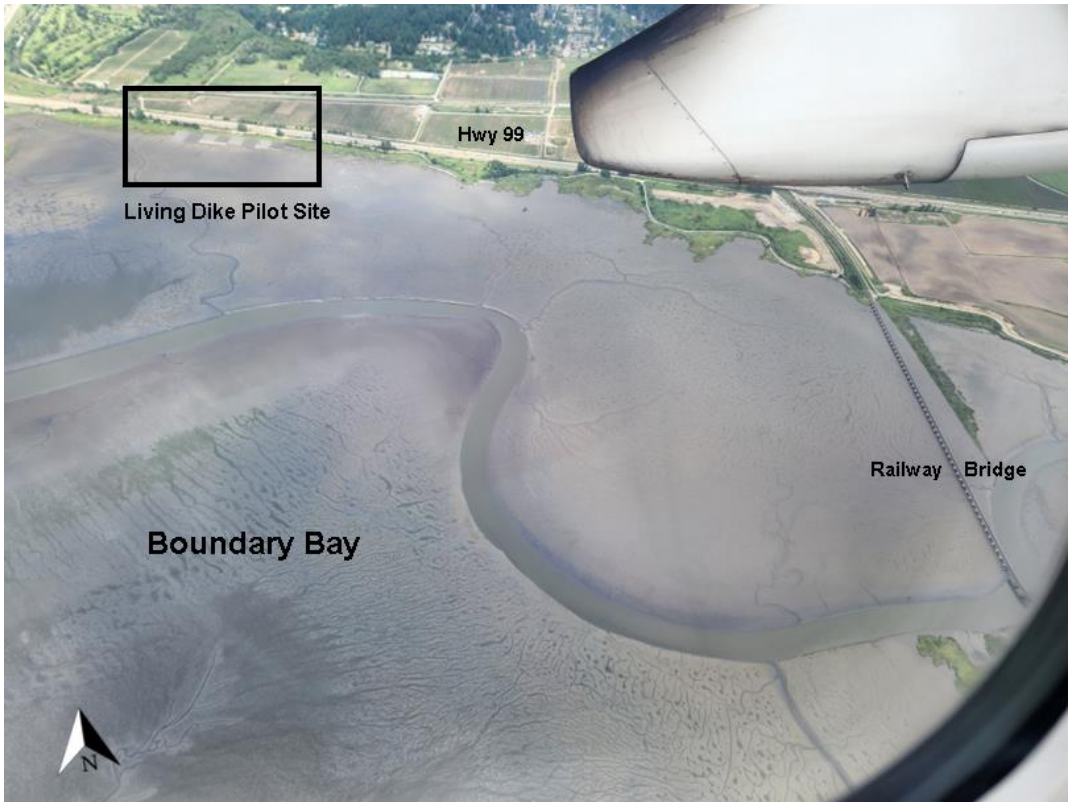

Figure 3.2: Aerial photo of Boundary Bay showing the eight test plots of the first living dike pilot site in Surrey

3.3.2 – Data collection

The aim of this paper is to understand the enabling conditions that allowed the BBLD to reach implementation despite being in a context that was not designed to accommodate NBCA. We conducted

semi-structured interviews with individuals who were personally involved with the project, or who were able to provide additional expertise. Participants were identified through public channels, including letters of support for the project and promotional materials, as well as through referrals volunteered by other interview participants. We categorized these participants into eight sampling strata[5] (academic, civil society[6], federal, industry, municipal, other governmental, provincial, and subject matter expert) and sought representation from each stratum to reflect the diversity of those involved with the BBLD. The research design was approved by the University of Waterloo's Office of Research Ethics[7].

We interviewed 32 key informants between June and December 2022. In those interviews, we asked participants a series of questions to capture their own role within the project, and their perceptions of the project and the context in which it was undertaken. All interviews were conducted virtually over Zoom or Microsoft Teams, and transcripts were generated and subsequently cleaned. Participants were given the opportunity to review their transcripts, and following this, 29 were kept for analysis; one participant declined to be recorded, another withdrew from the study, and the third was removed due to technical issues.

Table 3.1: Summary of interview participants by research strata

Stratum	**All interviews**	**Used in data analysis**
Academic	4	4
Civil Society	7	7
Federal	5	4
Industry	3	3
Municipal	6	5
Other Governmental	3	3
Provincial	2	2
Subject Matter Expert	2	1
Total	***32***	***29***

[5] Further information on these strata is available in Appendix A.
[6] The term 'civil society' has been criticized for obscuring power differences between non-governmental and non-market entities (Avelino & Wittmayer, 2015). However, in this context, the organizations classified as civil society are similar in reach and influence.
[7] The documents for participant communications and consent that were approved by the Office of Research Ethics are available in Appendix B.

3.3.3 – Data analysis

To analyze the interview data, we took an iterative, qualitative thematic coding process in three passes using NVivo. An initial round of attribute and structural coding provided the scaffolding of our analysis. Next, we used deductive coding to explore participant perceptions of the barriers to and enablers of the BBLD, as well as their definitions of success for the project. Coding units were defined by the length of time over which a participant discussed a particular theme, meaning that they ranged from fragments of sentences to entire paragraphs. A coding unit of text could be assigned to multiple codes if relevant, which allowed us to examine the interrelationships between themes and emphasized the lack of utility of treating barriers and enablers as mutually exclusive categories. This informed our use of the enabling conditions concept that is discussed further in Section 4.1. A final coding stage let us refine our themes and improve our coding reliability.

3.3.4 – Limitations

While we made an effort to present a rigorous analysis of a well-balanced set of perspectives, there were limitations in our data collection and analysis. Firstly, we had no formal input from Semiahmoo First Nation or the other Indigenous communities affected by the project. While their involvement was central to BBLD project design and was widely acknowledged as a significant factor of success, we did not have enough time to build a reciprocal relationship with the community and aimed to prevent extractive research practices (Tri-Council Panel on Research Ethics, 2022). To mitigate this shortfall, we actively recruited interview participants who worked closely with First Nations in the Lower Mainland. However, those individuals and organizations did not speak on behalf of any one First Nation. Another limitation was the use of a single coder: all transcripts were coded by one author, preventing inter-coder reliability checks. We attempted to minimize the impact of this by conducting multiple passes to review and refine the codes, and by reviewing the process and outputs with multiple authors.

3.4 – Results

3.4.1 – Conceptualizing enabling conditions

In completing our multiple passes of coding, we found that discussing barriers and enablers as two distinct categories prevented us from preserving the nuance in our findings. Consequently, we chose to think about the factors that helped or hindered the BBLD in terms of enabling conditions. In doing so, we attempted to capture the value of both of the approaches to organizing barriers described in our literature review (areas of impact and influence across domains), and to acknowledge that barriers and enablers are never as simple as a binary presence or absence. Our concept of enabling conditions involves organizing information in two complementary ways. Interview participants discussed a wide range of conditions influencing the success of the BBLD, which we summarized as 51 enabling conditions and organized into six categories, as shown in Figure 3.2:

Environmental – The ecological, geomorphological, climatological, or land use factors shaping a project's success.

Financial – The financial means needed to undertake, support, and protect a project.

Institutional – The laws, policies, and formal and informal rules and assumptions that shape a project.

Operational – The tools and capacity that are the means of planning and executing a project.

Political – The perceptions and priorities of decision-makers at all levels, as well as the priorities of the communities they serve, relating to a project.

Systemic – The high-level conditions beyond the control of a project that impact its success by influencing priorities and the availability of resources

Figure 3.3: Enabling conditions for the Boundary Bay Living Dike. Red boxes denote hindering factors, yellow are neutral, and green boxes show enabling factors.

Next, we deepened each of those categories by considering four characteristics that determine the actual effect they have on a project: Degree, Timeframe, Actors, Interactions. Instead of seeing barriers and enablers as two discrete categories, we viewed enabling conditions as a matter of 'Degree'; exist along a continuum from helping to hindering. The conditions that are necessary for success is also a matter of project stage, so 'Timeframe' examines whether a condition is available at the right phase of the adaptation project, and whether it lasts for an appropriate length of time. Even if the conditions are in place for success, a lack of individuals or organizations with the vision, skills, and capacity to undertake the project, or 'Actors', will prevent the opportunity from being seized. And finally, no enabling condition exists in isolation. Several researchers have argued that barriers cannot be considered independently (e.g., Eisenack et al., 2014, Sarabi et al., 2020). Raška et al. (2022) described the interactions between barriers by borrowing the concept of cascading and compound interactions from the field of disaster risk reduction[8]. Enabling conditions can support or counteract the effects of one another, making it essential to examine 'Interactions' in context.

3.4.2 – Enabling conditions of the Boundary Bay Living Dike

Environmental

Environmental enabling conditions describe what it means for a site to be conducive for project success, both in the present and in the future. Choosing environmental optimal conditions is not always feasible; interview participants acknowledged that the BBLD project site in the City of Delta was chosen for convenience, as it fit in with their existing dike update plan (2571M, 3964P)[9]. While this was a practical decision, several participants had concerns about the erosion and sediment transport processes in

[8] Cascading barriers refer directly or indirectly amplify other related barriers in a mostly linear way, with possible offshoots. Compound barriers operate in amplifying feedback loops.

[9] To give a sense of the roles and expertise of individuals who were interviewed, Appendix C outlines the general position and organization type of each participant.

that area (1485A, 3096A, 3964P). Multiple interview participants also raised concerns about possible future conditions including disease (3148C), predation of plants and invasive species (6918O, 3148C) affecting the viability of the project, as well as concerns about increased incidence or severity of storms (1225F, 1485A, 3428A, 7492A), and uncertain amounts of sea level rise (6918O, 8427F). The real impacts of these conditions cannot be assessed at this stage, but participants emphasized the climate-related changes they were seeing, as well as the uncertainty associated with them, as key project environmental enabling conditions affecting project design.

Financial

The availability of sufficient funding was foundational to the BBLD project reaching implementation, but available capital funding alone was not sufficient for a novel project requiring extensive engagement and careful design. The core funding for the BBLD came from the Canadian federal government's Disaster Mitigation and Adaptation Fund (DMAF). The program's granting criteria, which treated both co-benefits and innovation favourably, were seen as significant benefits to the project (3964P, 4081S, 8831C, 7602C), while the unusually long funding timeline was seen by some as a notable enabler (8831C) and by others as a source of concern from an implementation and monitoring perspective (3004M). The DMAF program had minimum funding requirements (CAD$1 million in total eligible project costs (Infrastructure Canada, 2022)) that would have prevented the living dike from being funded alone , but the project was bundled with 12 others in the City of Surrey's overall Coastal Flood Adaptation Strategy (CFAS), and the inclusion of the BBLD project in the overall 'package' was very helpful in securing funding (3964P, 5827O, 8831C, 7602C). Participants noted that the inclusion of the BBLD in CFAS also benefited the other projects by providing the innovation and creativity the DMAF program was looking to support, thereby making the strategy more attractive to funders overall (8831C).

Despite the significant benefit of the DMAF core funding support, there were several funding shortfalls for the BBLD that collaborators were mostly able to fill through a patchwork of grants and other funding. This included finding additional funding to: 1) convene the Living Dike Roundtable and

Technical Working Group, and; 2) ensure full participation from Semiahmoo First Nation, particularly in navigating the Environmental Assessment process (8831C, 5827O, 2571M). Nonetheless, there were still concerns about both the amount and timeline of the funding available for ongoing maintenance and adaptive management, which was not covered by the core funding (5827O). A lack of funding was also blamed for a perceived lack of appropriate data collection, leading some individuals to take on work themselves (3096A).

Insurance was also identified as an important enabling condition of NBCA but was not yet in place for the BBLD at the time of interviews. New forms of NBCA-appropriate insurance products that account for the project's resilience to storms and other stresses are not yet well-developed (2571M, 5531I), meaning that proponents have to work with insurance providers to develop custom-made solutions that suit their needs. However, multiple participants reported seeing recent changes in the insurance sector's interest in nature-based infrastructure (2394C), particularly motivated by the emerging investment by the federal government (5531I).

Institutional

Generally, institutional conditions were most commonly reported as hindering rather than enabling factors in the BBLD project and included both intangible conditions such as institutional paradigms and assumptions, and more tangible conditions such as institutional jurisdictions, mandates, and related regulations. Institutional paradigms represent the limitations and opportunities arising from how an institution defines problems, and the solutions that the institution considers to be acceptable to address that problem. The clearest example of this was reported in interviewee comments about the perceived limitations of the BBLD engineering consultant contract. The conventions that this contract followed were designed to suit well-established, standard engineering projects rather than an NBCA, which resulted in challenges for the BBLD that were discussed by multiple participants (1485A, 3096A, 5733I, 5827O, 7492A). For example, participants had concerns about the limited amount of time the consultants had budgeted for collaboration, and the resulting impact that had on their ability to

incorporate feedback (3096A) and conduct the necessary background work (1485A). Underlying this were institutional and disciplinary assumptions about what a project should be, and the role of an engineering consultant in executing it. Some engineers were uncomfortable with the idea of working on a novel project, believing that "engineering industries [are] not at all set up to do experiments" (5733I). The assumptions of individuals, and its impact on their motivation, was seen as critical; some participants directly linked the departure of a project champion within the consulting company with the wholesale rejection of a mid-stage project design by the Living Dike Roundtable because of its heavily reliance on conventional, grey infrastructure components.

Institutional jurisdictions and mandates also had a notable influence on the BBLD project, both hindering and helping in different cases. For the municipalities, the BBLD is within their jurisdiction (8831C), and they have been given a specific mandate to adapt to climate change by the provincial government (2571M). In the early days of the project, the complex jurisdictional situation on the coast made it difficult for champions of the living dike concept to find proponents who could take on the project; the project dealt with municipal infrastructure, but on provincial crown land (8831C), and within the jurisdiction of the federal Fisheries Act and Navigable Waters Act, among others. As the project progressed, jurisdictional fragmentation manifested as conflicting requirements and incompatible timelines for regulatory approvals (7492A).

Finally, the regulations governing the BBLD posed challenges to progress, but some are beginning to show signs of improvement for future projects. It should be noted that regulations are *intended* to be barriers; they make it more difficult for projects to go forward for the sake of protecting humans and ecosystems. Participants' concerns were largely to do with regulations lagging behind NBCA innovation. There was widespread frustration with the Dike Maintenance Act for its narrow definition of the term 'dike' (5827O, 3004M), its stringent design guidelines (3964P, 5733I, 8502M), and its maintenance requirements that actively discourage vegetation (3004M, 4081S), even though building by those principles to climate-ready standards is unfeasible in most places (5858O). Other regulators,

however, were able to work with the project co-proponents to pursue shared goals and offer expertise. The managers of the nearby Boundary Bay Wildlife Management Area (governed by the provincial Wildlife Act) worked with the co-proponents to develop a memorandum of understanding to offer the project team confidence in moving forward with their design, and to intentionally reward proactive adaptation (3964P, 8831C, 8502M, 3004M, 7602C). Another facet of regulatory conditions was concern about the precedence that the BBLD project might set. As the project pursues an exemption to the provincial environmental assessment requirements, some parties expressed concern about the precedent that could be set for other projects being approved without due diligence (5827O).

Operational

Operational conditions deal with the practical challenges of implementing NBCA. This includes the capacity of actors to take the project on and the availability of the knowledge that those actors need to succeed. While time and financial resources were identified as a significant part of capacity, interview participants consistently emphasized the role of less tangible resources including organizational culture, employee empowerment, and individual enthusiasm and interest. Organizational culture and employee empowerment were particularly evident as enablers in one of the proponent municipalities, where senior staff had made a concerted effort to build a culture of collaboration within their organization and to empower their employees to take on opportunities that let them see beyond institutional silos (2571M, 3004M). These opportunities included networking, where employees were able to initiate and establish a variety of strong working relationships long before the BBLD project was underway (5858O, 8831C, 3004M). Another less tangible resource that contributed significantly to the BBLD project was the enthusiasm and interests of the individuals involved; passion for the project and the desire to be involved in something innovative played a notable role in every stage of the project, from determined individuals advocating for a novel idea, to the high degree of participation of assorted experts in the Living Dike Roundtable (2571M, 3004M, 3632O, 5733I, 5827O, 8502M). However, that enthusiasm was not always to the project's benefit. In some cases, personal investment in the project led to conflict (1485A, 3096A),

and the departure of key individuals (along with their intrinsic motivation) led to project setbacks (7492A). The degree to which enthusiasm is an enabler may also fluctuate over time; interview participants expressed concern about collaborator burnout over the length of the project (5733I, 2394C).

Another facet of organizational capacity was the education and experience of actors to undertake the work effectively. Educational opportunities focusing on NBCA are significantly lacking in Canada, meaning that practitioners have to learn as they go, which was noted as a limitation of the consulting engineers in particular (7492A, 8427F, 3428A). One interview participant emphasized that the potential of actors in the region to carry out NBCA projects is significant, but that they lacked examples to follow, hindering NBCA uptake (7492A).

In the face of this lack of precedence, the BBLD project was made possible by the support of many actors other than the project co-proponents, particularly civil society and research actors. The Living Dike Roundtable and Technical Working Group, which provided both technical and logistical support, were both run by two civil society groups. These actors, and other civil society actors, were able to support the project by convening a broad range of experts to inform the project (5827O) and by identifying additional funding opportunities to fill the gaps in core funding (2394C, 5827O). However, interview participants noted that the presence of external actors as organizers sometimes lead to a lack of defined responsibility and unclear communication (3428A).

Research actors (both academics and individuals who work in research capacities within various level of government) were similarly invaluable in supporting the project. Not only were they able to bring their own expertise, funding, and research capacity to support the BBLD (2571M, 8427F, 7602C, 3428A, 5858O), they were able to leverage their networks to mobilize expertise where it was lacking (5858O, 2571M), and they used their external position to undertake side projects and build out the knowledge base (5858O, 3428A). For the BBLD, this included support from international experts, facilitated by the Consulate General of the Netherlands in Vancouver. The consulate was able to provide a small amount of

funding to make Dutch experts, who have worked on similar projects before, available to the project team (5858O, 3004M).

Political

Political enabling conditions represent the values and priorities that define the political agenda surrounding NBCA. Political conditions are shaped by the historical choices and legacy of past decision-making priorities related to socially acceptable levels of risk and approaches to adaptation. They also encompass the perceived legitimacy of a project and the process by which it is undertaken, as well as the factors influencing political priorities. The research revealed a strong connection between historical political conditions, path dependency, and the cumulative effects of those politically-determined decisions. These political factors shape the current physical and collaborative landscape of NBCA; the colonial history of B.C. has been dominated by an approach to flood management that prioritized dikes and other grey infrastructure, which in turn shaped development in the region and impacted the solutions that are deemed feasible for the area today (8831C). The cumulative effects of that history also posed a challenge to regulators who were attempting to evaluate the impacts of the BBLD (8493P).

Political enabling conditions also encompass the perceived legitimacy of a project and the process by which it is undertaken. Perceived legitimacy, or the acceptability of a project based on observers' and decision-makers' confidence in its validity as a solution, makes up one branch of political enabling conditions. At a broad level, the BBLD benefited from the recent increase in acceptability of nature-based solutions, including interest from the international community (7602C, 4081S), the Insurance Bureau of Canada (3428A), and recent support from the federal government (4081S, 2394C). While NBCA are still quite new to Canada in their current form, interview participants reported that emerging support for nature-based approaches helped to enable the BBLD. At the project level, the BBLD was perceived as well-designed and was undertaken through a process of engagement and collaboration that increased confidence of regulators and other observers (3004M, 7602C).

The political landscape and the various priorities at play also impacted the feasibility of the BBLD. The support of Semiahmoo First Nation as a co-proponent of the project along with the two municipalities, as well as the resulting design of a project that was in line with the Nation's priorities, were both considered significant enabling conditions (2571M, 3964P, 5827O, 8493P, 5827O). The BBLD was also in line with broader community values, which participants believed enhanced project acceptability and political support (7602C, 8831C, 1485A). Those values were in part shaped by widespread awareness of and sense of urgency around climate change, which interview participants also felt had facilitated the BBLD (1225F, 1485A, 3004M, 7602C). The community values were further reinforced by political direction at the international level urging governments to take action on climate change (1485A). Collectively, those priorities manifested in political support from local, provincial, and federal government (5858O), despite legacy effects of former government priorities (7602C) and the challenges of a short-term election cycle (6318C).

Systemic

Systemic conditions are the factors that go far beyond a single project and define the experience of a given time and place. This includes societal stability, market forces, including the ability to procure materials, and systemic forces related to injustice. The Covid-19 pandemic was arguably the most significant example of a factor affecting stability for the BBLD[10]. The pandemic altered actor capacity, public priorities, supply chains, and methods of engagement and collaboration, among other components of project design (5827O, 8398M). While participants did not believe that the pandemic had significantly hindered the BBLD's implementation, they acknowledged that it shaped the process that the co-proponents took to reach implementation (5827O). This process was also influenced by market and supply chain conditions, which are closely related to stability conditions. An example of this was high inflation; one participant argued that an NBCA project, which can take longer to design and implement, is

[10] While the pandemic was a significant, societal-scale disruption, the BBLD has benefitted enormously from the comparative stability of the Canadian context. In areas of political and economic instability or conflict, NBCA projects may face challenges on a very different scale.

at an inflation disadvantage compared to conventional grey infrastructure (2571M). Systemic conditions also include systems of oppression. Colonialism defines the coastal management paradigm within which the BBLD is being undertaken; there can be no discussion of the current coastal management practices in BC without the acknowledgement that such practices are contrary to the practices of local Indigenous peoples and was enacted through their dispossession. This came to bear on the BBLD in different ways, including an historical lack of dialogue between municipalities and First Nations which resulted in a lack of precedent for collaboration in the present (8427F, 5827O), in addition to the ongoing tensions between Semiahmoo First Nation and the municipal governments operating on their traditional territory (5827O).

3.5 – Discussion

3.5.1 – Reflection on the case study

Thinking about the 51 enabling conditions above as enabling conditions, rather than simply potential barriers, gives us a systematic way to explore the effect that they had on the BBLD. One example of this is the insight gained from considering the influence of external actor capacity on the BBLD project. The BBLD was heavily driven by the interests and abilities of actors beyond the three co-proponents, especially those actors from civil society organizations. Examining that capacity through the four characteristics of enabling conditions (degree, timeframe, actors, and interactions) helped us to understand the multifaceted ways in which the capacity of these groups acted as a highly beneficial enabling condition for the BBLD. The overall degree to which external actor capacity was present for the BBLD was heavily influenced by the number of groups available, and the associated time, resources, staff skills, and collective experience and extended social networks that allowed the groups to contribute efficiently. In addition to bringing valuable social capital to the BBLD, these civil society groups also had the capacity to champion the BBLD project over the entire lifespan of the project thus far, from idea inception to the present, providing support over a sufficient timeframe for project success. Civil society organizations were both crucial actors themselves and leveraged their social capital to identify other beneficial actors. Additionally, the capacity of the civil society organizations interacted with several other

enabling conditions, including funding and convening other experts. This example shows how degree, timeframe, actors and interactions shed light on the extent to which and the mechanisms by which enabling conditions influence project success.

3.5.2 – Applying the concept of enabling conditions

Our approach to conceptualising and understanding enabling conditions can support those who are trying to implement NBCA in two ways. Firstly, an understanding of enabling conditions can inform the design of structures that will enable NBCA at the institutional level. Secondly, until those more formal systems can be put in place, enabling conditions can help those implementing NBCA to understand and communicate the conditions surrounding their project.

To support lasting change, funders, regulators, and infrastructure managers hoping to implement NBCA projects can identify shortcomings in the existing systems by applying the concept of enabling conditions. By examining the state of the enabling conditions for frontrunning NBCA projects, these actors can consider where informal approaches are filling gaps left by formal structures (e.g., where personal knowledge of regulations helped navigate bureaucracy). To reduce the need for these informal solutions, findings on enabling conditions collected for the BBLD and other projects could help inform how regulations, funding programs, and other structural supports will be adjusted to better accommodate NBCA. This, in turn, would increase the viability of nature-based projects as an alternative to grey infrastructure (Bulkeley et al., 2015; Xie et al., 2022). For example, in looking at funding for the BBLD through the lens of degree, timeline, actors, and interactions, our research found that both formal supports and patchwork solutions were necessary to fund the project. The research also has implications for the design of future NBCA funding programs: if the federal government were to design a future NBCA funding program, they might choose to retain the lengthy funding window seen in the current DMAF program, and to continue using the inclusion of co-benefits and innovation in granting criteria. However, they might also allow proponents who are introducing a nature-based project to a new area to request additional funding specifically to kickstart the collaboration needed to support locally appropriate design.

However, systems can be slow to change, so before there can be the deeper shifts required to mainstream NBCA, the concept of enabling conditions can help those who would attempt NBCA projects in the current systems to understand and communicate their own conditions to funders and regulators. If the enabling conditions are largely positive, potential NBCA proponents could make a clear case for their chances of success and could proactively identify areas of concern, both important steps given the uncertainty and novelty of NBCA projects (Ekstrom & Moser, 2014). If the enabling conditions are largely absent, the proponent could use the concept of enabling conditions to explain the gaps in their conditions and make the case for funding or other support to address those specific needs. When implementing untested NBCA projects, all parties are accepting some degree of uncertainty about how the project will function in its particular social, environmental, and governance context (R. Biesbroek et al., 2011; Rahman et al., 2019). Proving that a proponent has systematically considered the conditions in which they are operating, and the possible interactions between those conditions, will provide additional confidence to both the proponent and those from whom proponents need support.

3.5.3 – Response to the literature

This concept of enabling conditions works integrates well with the existing barriers to adaptation literature; it can both support and be supported by existing frameworks. We can see examples of this in degree, timeframe, actors, and interactions. In building on the concept of degree, a model that accounts for the tractability of different conditions, such as an adaptation of the model proposed by Anantharajah (2019), would provide additional insight into those conditions. Similarly, research on the roles of various actors in adaptation has shown that the individuals and organizations that are involved or not involved in a project matter greatly (Brown et al., 2013; Fischer & Newig, 2016; Frantzeskaki & Bush, 2021; Nyström et al., 2014). Frameworks of actor roles (e.g., Hilger et al., 2021) can deepen analysis of the various ways that actors interact with enabling conditions for NBCA. Similarly, for the characteristic of timeframe, using existing insights into the adaptation process can help pinpoint key times in a project's development. For example, Ekstrom et al. (2011) present a framework of five phases of adaptation

projects (awareness, assessment, planning, implementation, and monitoring and evaluation). This framework can provide additional detail to the use of the enabling conditions concept, and the enabling conditions concept broadens the focus to include other, interrelated considerations such as actors. Finally, there is existing research on that supports our assertion that interactions between enabling conditions are critical for project success, as each condition can amplify or dampen the effects of others (Attri et al., 2013; Sarabi et al., 2020). One way to describe these interactions is by viewing them as compounding or cascading (Raška et al., 2022). By integrating with other concepts and frameworks in the literature, our concept of enabling conditions can be adapted to provide a level of detail that is appropriate for various purposes.

3.6 – Conclusion

NBCA projects are only one approach to adapting to climate change, but they are gaining substantial interest across B.C., and beyond. The success of those projects depends on many closely interrelated factors that operate at various spatial and temporal scales. The concept of enabling conditions is a way of systematically considering those factors, of stepping back from the close-up view of an NBCA project to examine the broader context in which it is operating, and how that context might influence project outcomes. In this paper, we focused on a single NBCA project, the BBLD, identified 51 enabling conditions, and through our analysis, expanded our concept of enabling conditions to encompass the characteristics of degree, timeframe, actors, and interactions. We used these four latter characteristics to explore when and how conditions that existed for the BBLD influenced the project's success, and extended the idea to consider how the concept of enabling conditions could inform future NBCA projects, both in navigating the systems as they currently are and in fostering more favourable conditions in the future.

Through the concept of enabling conditions, we present a way of describing the context within which NBCA operate and the impact that that context has on project success. The concept can help identify where formal structures fall short of meeting NBCA needs by showing where front-running

projects like the BBLD have turned to informal solutions to fill structural gaps, informing how those systems could be most effectively adjusted to support NBCA. Before those structural changes can be made, the enabling conditions concept can provide potential proponents with a way to systematically consider and communicate their conditions to funders and regulators, highlighting strengths and proactively identifying areas of concern.

There are several areas of further research on enabling conditions that could build on this work. First and foremost, our list of enabling conditions should be tested against other projects to validate its applicability to other NBCA, and possibly to other kinds of nature-based solutions. A multi-case study comparison would be of value, where the success of multiple projects, ostensibly within the same governance landscape, could be compared. A longitudinal analysis of how enabling conditions might change over the course of a project, extending into monitoring and adaptive management, would also be useful. Additionally, future research may consider whether there are differences in the enabling conditions that exist for NBCA undertaken by actors other than traditional infrastructure managers.

Chapter 4 - Understanding actors' contributions to a nature-based coastal adaptation project through roles

"... this is just the story of meeting people, basically." Participant 8831C

4.1 - Introduction

In the context of climate change, coastal areas are some of the most vulnerable locations for people and ecosystems (Ramm et al., 2018). The risks posed by coastal flooding from sea level rise and storms, combined with increasing density of people and economic investment (often in areas of high ecological and cultural significance), make adaptation to coastal climate change both necessary and complex (IPCC, 2014; Marijnissen et al., 2020). In response to these competing priorities, adaptation professionals have begun to consider forms of adaptation that can provide more co-benefits than conventional grey infrastructure (Rahman et al., 2021; Sutton-Grier et al., 2015). Many professionals have begun to look to nature-based coastal adaptation (NBCA), a subset of nature-based solutions that uses ecosystems and natural processes to protect against coastal climate impacts, that is gaining popularity as a way of addressing concurrently multiple human and ecosystem needs (Cohen-Shacham et al., 2019; Rahman et al., 2021). However, NBCA projects face multiple barriers to implementation, particularly due to entrenched assumptions about what the problems are and what solutions are appropriate or desirable to address them in existing governance structures (Bush & Doyon, 2019; Frantzeskaki & Bush, 2021). Consequently, for NBCA to become broadly viable options to address climate risks on the coasts, there is a need to identify and pilot potentially effective methods for overcoming barriers to NBCA.

One promising way to address barriers to NBCA is through collaboration between project proponents and other others who might have the expertise to help the project succeed. Collaboration can bring together individuals and organizations from different jurisdictions, industries, and backgrounds to provide multiple complementary sources of knowledge and experience (Bauer & Steurer, 2014; Meerow & Newell, 2019). These sources of knowledge, particularly local and Indigenous Knowledge, can help prevent maladaptive NBCA by raising multiple perspectives (Frantzeskaki & Bush, 2021). Our focus here

is to see whether bringing together a group of actors in a collaborative manner may also be able to support a NBCA project in overcoming other logistical and governance barriers.

The aim of this paper is to examine whether, and in what ways, collaboration can enable the design and implementation of nature-based coastal adaptation (NBCA) projects. To do that, we apply an action-based framework of roles to the case study of the Boundary Bay Living Dike in Surrey, British Columbia (B.C.), one of the first NBCA in Canada. We expand the framework to better represent the case study and examine how actors interacted with barriers to this NBCA project arising from its particular social, environmental, and governance context. Finally, we discuss the implications of those findings for others looking to implement NBCA projects and identify areas for future research.

4.2 - Literature review

4.2.1 - Nature-based climate adaptation

Nature-based coastal adaptation (NBCA), a subset of nature-based solutions (NBS), has become an increasingly popular green alternative to conventional grey infrastructure in managing climate change-related coastal hazards (Rahman et al., 2021). Rahman et al. (2019) define NBCA as:

> "any coastal adaptation approach that involves both ecologically available adaptation options (e.g., natural space, ecological process and species) and socio-politically available opportunities (e.g., values, policy, rules and regulations etc.) to utilize natural capacity to buffer coastal climate change impacts like sea-level rise, considering societal demand for diverse ecosystem services (e.g., provisioning, regulating, cultural and supporting) and minimizing engineered construction as a supporting component" (p. 2).

The recent popularity of NBS, including NBCA, can be attributed to several general advantages. On a practical level, projects can benefit from the dynamism of nature-based interventions that can adjust to changing conditions (Frantzeskaki & Bush, 2021; Van Loon-Steensma & Vellinga, 2019) and provide co-benefits (Hamin et al., 2018; Pagano et al., 2019), including co-benefits that are difficult to monetize

but which support community values (O'Brien & Wolf, 2010; Raymond et al., 2017; Watkin et al., 2019). Nature-based projects can also produce fewer environmental externalities and GHG emissions than conventional grey infrastructure construction, be cost-effective choices, and do not depreciate in the same way that built infrastructure does (Gailis et al., 2021; Van Loon-Steensma & Schelfhout, 2017). From a more theoretical perspective, NBS are rooted in systems thinking and can represent a worldview shift away from engineered approaches that reflect the human domination of nature (Albert et al., 2019; Mehan, 2010).

Despite their reputed benefits, NBCA projects are not without controversy and should be carefully designed to prevent adverse outcomes for people and ecosystems. NBS overall have been criticized as anthropocentric and utilitarian; some scholars allege that they perpetuate an extractive relationship with nature and often prioritize human interests over ecosystem needs (Eggermont et al., 2015; Maller, 2021; Martin et al., 2014). Even in prioritizing human concerns, NBCA can fail to provide just and equitable benefits for all and lead to "nature-enabled dispossession" through gentrification and land speculation (Anguelovski & Corbera, 2022). So, NBCA are not inherently positive; achieving positive outcomes requires a commitment to just and equitable solutions and intentional inclusion of diverse knowledges and perspectives (Maller, 2021; Seddon et al., 2020; Woroniecki et al., 2020). NBCA are also not necessarily transformational adaptations as they often fit Kates et al.'s (2012) description of incremental adaptation or "slightly more of what is already being done". Many NBCA may provide additional co-benefits to human and ecosystem health, quality of life, and place attachment as compared to conventional grey projects without challenging the underlying paradigm of coastal management (Raymond et al., 2017). In some cases, this can be counterproductive to holistic resilience building since incremental solutions can prevent the consideration of deeper, necessary change such as managed retreat[11] (Hofstede, 2019; Van Loon-Steensma & Vellinga, 2019). Consequently, care must be taken in choosing

[11] Managed retreat is the practice of relocating homes and infrastructure at risk from hazards to safer areas (Doberstein et al., 2020). As a non-structural adaptation option, it represents a significant change in the existing adaptation paradigm, which prioritizes physical protection over accommodation, retreat, or avoidance.

NBCA when appropriate, designing the projects to provide benefits while avoiding maladaptation, and considering the potential benefits and drawbacks.

4.2.2 - Barriers and enablers to NBCA

Even the most carefully designed NBCA will face challenges. Every adaptation project is embedded in environmental and governance systems that can create barriers or enablers to its success, but NBCA have additional barriers associated with their novelty and dissimilarities to conventional infrastructure. Barriers and enablers are highly context-specific, but there are commonalities identified in scholarly literature. Barriers to climate adaptation can be defined as "(1) an impediment (2) to specified adaptations (3) for specific actors in their given context that (4) arise from a condition or set of conditions. A barrier can be (5) valued by different actors, and (6) can, in principle, be reduced or overcome" (Eisenack et al., 2014, p. 868). A robust body of literature on the barriers to and enablers of climate change adaptation emerged in the early 2010s as a response to climate-affected catastrophic events and increased consensus about the necessity of adaptation (Biesbroek et al., 2013). While some authors use the term 'barrier' as synonymous with constraint (i.e., something that cannot be overcome) and inherently negative (e.g., the IPCC), we use it here to mean a condition that hinders project progress for any reason (Eisenack & Stecker, 2012; Moser & Ekstrom, 2010). While barriers are most often seen as negative, they can also be beneficial, such as preventing maladaptive projects from moving forward and even creating adaptation interventions that are hard to reverse (Burch, 2010).

While all adaptation projects face barriers, many are specific to nature-based adaptation. For example, knowledge barriers arise where knowledge, experience, and expertise on NBCA are lacking due to novelty (Kabisch et al., 2016; Nesshöver et al., 2017). Even when an NBCA is designed well, ecosystems themselves have limits to adaptation and may not be able to keep pace with changing conditions outside of a certain threshold (Adger et al., 2009; Martin, Specht, et al., 2021). NBCA are also subject to governance barriers, where governance structures, including formal regulations and informal conventions, have not been designed to accommodate NBCA projects (Bush & Doyon, 2019; Faivre et

al., 2018; Nelson et al., 2020). These barriers are exacerbated by higher levels of uncertainty in NBCA, which are more dynamic systems coping with external pressures compared to conventional grey infrastructure (Bouma et al., 2014; Cohen-Shacham et al., 2019) and the lack of established systems to deal with the associated risk (Persson et al., 2015; Ramm et al., 2018).

4.2.3 - Collaboration

A large part of examining barriers in real-world contexts involves grappling with the fact that coastal climate adaptation transcends civic boundaries, fields of practice, and societal domains (Bauer & Steurer, 2014). This complexity means that broad collaboration can be critical to successful adaptation. That need is compounded with NBCA, where many kinds of knowledge are needed to move beyond siloed thinking and consider adequately how the various facets of a system could be impacted by an intervention (Costa et al., 2020; Frantzeskaki & Bush, 2021; Meerow & Newell, 2019; Nelson et al., 2020; Wamsler et al., 2020). This means that, to prevent maladaptation, NBCA are dependent on processes of co-operation and collaboration (Frantzeskaki & Bush, 2021; Hegger et al., 2017). Bringing together disparate groups helps broaden the knowledge base, and each group brings their own assumptions, ontologies, methods, and language to the process. Although translating among those differences can be challenging (Kabisch et al., 2016; Nesshöver et al., 2017), Mehan (2010) describes the resulting pluralism as ‘symphonic’; diverse actors playing distinct roles and coming together to form a complex, occasionally dissonant but ultimately cohesive outcome. To understand the role of collaboration in advancing NBCA, we need to understand which actors were involved, how they exerted agency to take up roles, and how their actions interacted with barriers to and enablers of the project.

Despite the documented importance of multiple sources of knowledge for NBCA success, not all processes of stakeholder collaboration and engagement are created equal. The International Association for Public Participation (IAP2) Spectrum of Public Participation describes different levels of involvement and power that actors can have within a project (IAP2, 2014; Leitch et al., 2019). Within that spectrum, “collaboration” describes a partnership between the project proponent and other process participants,

where participants are involved in "each aspect of the decision including the development of alternatives and the identification of the preferred solution" (IAP2, 2014). While the IAP2 Spectrum of Public Participation was designed for use in public engagement processes, it also provides useful insight into the extent of stakeholders' opportunities to shape projects (Bammer, 2019; Leitch et al., 2019) and helps to standardize our terminology.

Understanding collaboration in adaptation is not as straightforward as listing the organizations present in a meeting; all actors combine professional responsibility and personal inclinations when working on a project (Nyström et al., 2014). Through a combination of structural expectations and individual agency, actors' behaviours and contributions define their impact on NBCA projects (Brown et al., 2013; Fischer & Newig, 2016). Those behaviours can be grouped into generalized roles. While there are several theoretical approaches on how actor's roles are created and used (cf. Nyström et al., 2014), we focused on an action-based approach to roles: those that are defined by the actors' behaviours (Heikkinen et al., 2007). This approach can help represent the dynamism of roles in processes of innovation, showing how roles develop over time and are based on common goals of the collaborators (Nyström et al., 2014). The following section explains how we applied an action-based framework of roles in the context of the Boundary Bay Living Dike (BBLD) project.

4.3 - Methods

The aim of this paper is to better understand in what ways, if any, collaboration can support nature-based pilot projects in the face of a variety of barriers. A case study allows us to examine one project within its specific social, governance, and environmental context of the Lower Mainland of British Columbia, a province on the west coast of Canada. By focusing on one of the first nature-based climate adaptation pilot projects in the region, we can better understand what such a project needs to succeed, what factors might impede that success, and how those factors might be overcome.

4.3.1 - Case Study: Boundary Bay Living Dike, Surrey, British Columbia

With sea level rise, the risk of the existing Boundary Bay dike being overtopped is expected to increase, and the salt marsh in front of the dike will suffer coastal squeeze, a process in which an ecosystem drowns when it is prevented by hard structures from migrating inland (City of Surrey, 2022a; Readshaw et al., 2018). The loss of this salt marsh would be particularly significant due to the ecological significance of the area, particularly for birds and fish. Boundary Bay is protected as a provincial Wildlife Management Area (Government of British Columbia, n.d.), and has various international environmental designations including those under the Ramsar Convention, BirdLife International, and the Western Hemisphere Shorebird Reserve Network (Murray & Taitt, n.d.). The site's environmental importance, as well as other characteristics, make it an area of interest for a diverse range of rights' holders and stakeholders.

To address these risks, the cities of Surrey and Delta and Semiahmoo First Nation (whom we will call 'the co-proponents') formed a tripartite partnership to pilot one of the first NBCA projects in British Columbia (City of Surrey, 2022a). The Boundary Bay Living Dike (BBLD), officially known as the Mud Bay Foreshore Enhancements Project, is a nature-based coastal flooding adaptation project located in the core territory of Semiahmoo First Nation, and on the border of the cities of Surrey and Delta (City of Surrey, 2022b). A living dike is a protective structure that uses an ecosystem (in this case, a salt marsh) to absorb energy from the waves, reducing the likelihood of flood water overtopping, while the very gradual slope of the dike allows the ecosystem to migrate inland with sea level rise (Gailis et al., 2021; Readshaw et al., 2018; Van Loon-Steensma & Schelfhout, 2017). Construction began on a pilot site of the BBLD in May 2023, with a larger-scale project contingent on further approvals.

While the co-proponents are the core actors in the BBLD project, the project is unusual in the depth of involvement of other collaborators. The idea for the living dike did not start with any of the co-proponents, but rather, it was an idea that was passed between individuals at several organizations until they found a municipality with the willingness and the capacity to take it on. In particular, an

environmental law firm and an organization representing several local First Nations had an immense impact on the project by jointly convening the Living Dike Roundtable in 2018. The Roundtable, and its more detail-oriented off-shoot the Technical Working Group (TWG), are the key fora for collaboration on the BBLD. These groups are comprised of a wide variety of practitioners and experts who contributed to the design of the project. While the membership of both groups is fluid, we identified 128 named collaborators, most of whom are involved in one or both groups. Understanding how collaborators interacted with the barriers they identified to the BBLD provided insight into whether, and in what ways, collaboration can advance NBCA.

4.3.2 - Data collection

To capture the perspectives on the BBLD project and the collaboration that surrounded it, we conducted 32 semi-structured interviews with individuals who were directly involved in the BBLD project, or, in the case of subject matter experts, who were able to provide supplementary expertise[12]. Participants were identified through publicly available information, such as letters of support for the project or online promotional materials, and through comments volunteered by other interview participants. To ensure that our sampling reflected the diversity of individuals involved in the projects, potential participants were sought from each of eight sampling strata[13]: academic, civil society[14], federal, industry, municipal, other governmental, provincial, and subject matter expert.

We interviewed these key informants between June and December 2022. In those interviews, we asked participants a series of questions[15] to establish their role in the project and their perceptions of both the project itself and the process by which the project was being undertaken. We conducted interviews

[12] Information relating to the ethics clearance for this process is available in Appendix B.
[13] Further information on these strata is available in Appendix A.
[14] While the term 'civil society' has been criticized for obscuring differences in power between non-governmental, non-market entities (Avelino & Wittmayer, 2015), at this scale, the organizations classified as civil society are relatively comparable in reach and influence.
[15] A sample list of questions is available in Appendix D.

virtually[16] over Zoom or Microsoft Teams, after which participants were given the opportunity to review their transcript. One interview participant declined to be recorded, one withdrew from the study after reviewing their interview transcript, and one interview was removed from analysis due to technical issues that prevented us from creating a transcript, leaving 29 interview transcripts for analysis.

4.3.3 - Framework

When searching for an appropriate case study evaluation method, we sought an action-based actor roles framework that could provide insight into a case study where an unconventional group of actors worked together to design, pilot, and deploy an NBCA. We chose Hilger et al.'s (2021) framework, which was designed to evaluate the roles and activities found in transdisciplinary (td) and transformative (tf) research processes, asserting that pilot projects are a specific subset of tf/td research. We additionally chose the framework for its rigorous grounding in the literature, comprehensive detail, and attention to non-scientific actors (particularly adaptation practitioners) in research. Hilger et al. (2021) based their research on a systematic review of 11 studies with interdisciplinary participation or collaboration to address sustainability problems, grouping 72 observed activities into 15 roles that could be played individually or in combination through a hierarchical cluster analysis. These roles are:

- Application Expert;
- Choreographer;
- Communicator;
- Coordinator;
- Data Supplier;
- Facilitator;
- Field Expert;
- Intermediary;

[16] The impact of the Covid-19 pandemic on collaboration was significant and remarked upon by several participants and had continued effects (as reflected in our own data collection process) even after restrictions were lifted.

- Knowledge Collector;
- Knowledge Co-producer;
- Practice Expert;
- Results Disseminator;
- Scientific Analyst; and
- Troublemaker.

The roles were characterized by between two and 13 actions (i.e., behaviours or tasks that define a named role), which we matched to activities described by our interview participants.

4.3.4 - Data analysis

To analyze the interview data, we undertook an iterative, qualitative thematic coding process in NVivo in five passes. Over these five passes, we used both deductive and inductive coding approaches. To begin, we used deductive thematic coding to explore barriers to the BBLD, among other themes, as identified by the interview participants. A subsequent coding stage allowed us to refine our initial themes and improve coding reliability. Next, we used inductive thematic coding by applying the existing framework of actor roles and activities from Hilger et al. (2021) to participants' descriptions of their involvement in the BBLD project. Because this inductive coding pass was intended to identify interview participants' own roles in the project, as well as their perceptions of the roles of others, the scope of this analysis was limited to interview participants who had been personally involved in the collaborative process surrounding the BBLD, as a proponent, a representative of an organization dealing directly with the co-proponents, or a member of the roundtable or technical working group (see Figure 1). Table 1 presents the number of interview participants by research strata.

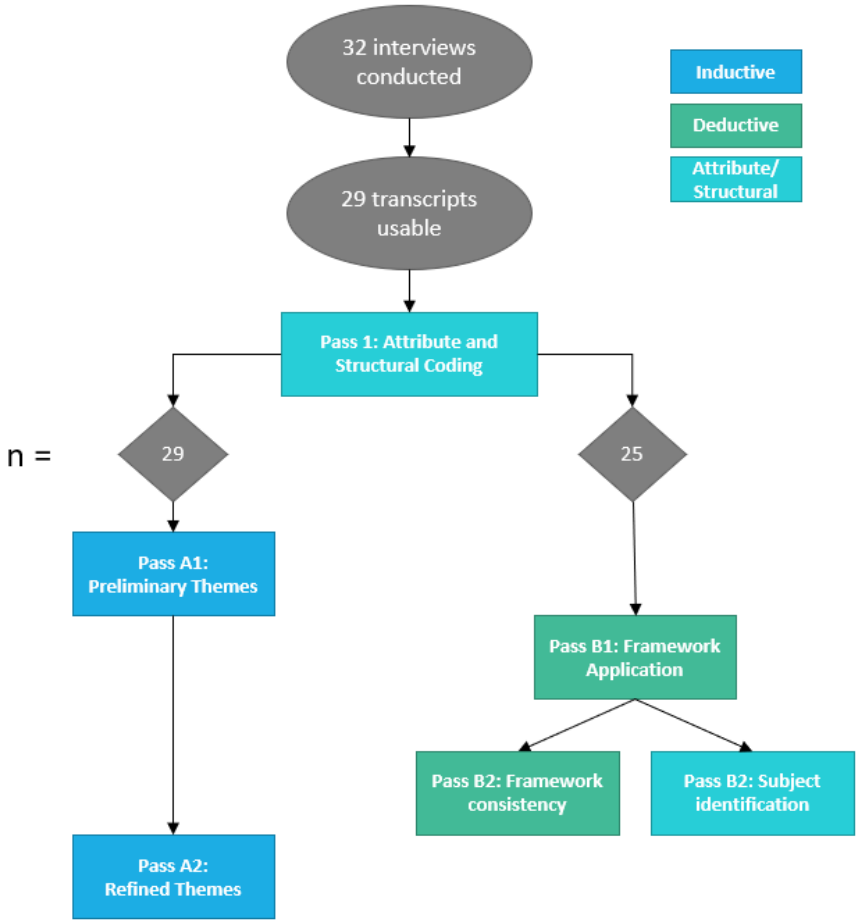

Figure 4.1: Iterative process of inductive, deductive, and attribute/structural coding

Table 4.1: Summary of interview participants by research strata

Stratum	**All interviews**	**Kept for Barriers**	**Kept for Roles**
Academic	4	4	4
Civil Society	7	7	5
Federal	5	4	4
Industry	3	3	3
Municipal	6	5	5
Other Governmental	3	3	3
Provincial	2	2	1
Subject Matter Expert	2	1	0
Total	***32***	***29***	***25***

4.3.5 - Limitations

Like any research, our process had limitations. One shortcoming of this work is the lack of representation from Semiahmoo First Nation and other affected First Nations. Because project time constraints prevented us from building a reciprocal relationship with the community, pursuing interviews with members of Semiahmoo First Nation would have placed additional pressures on the Nation and would have pursued data acquisition in an extractive way. While we did actively recruit interview participants who worked closely with Semiahmoo throughout this process, none of those people speak for the Nation and cannot provide the same insight into the integration of the community's values, Indigenous Knowledge, and priorities into the development of the Boundary Bay Living Dike. Another limitation of this study is the imprecision of actor role attribution language from interview participants. Participants often used an imprecise ‘we’ or ‘they’ when describing actions taken by groups. Where attribution was unclear, it was not coded. Otherwise, it was coded to the smallest known unit (either organization, department, or individual). This also meant that, in most cases, we were unable to differentiate personal agency from professional obligation. The exceptions to this were cases where a participant specified that they or the person about whom they were speaking were acting outside of their official capacity. With these limitations and methods in mind, we next present the findings our interviews produced.

4.4 - Results

To achieve our overall aim of understanding how actors took on different roles to overcome barriers to the BBLD project, we first examined how well the Hilger et al. (2021) framework fit our data. When interviewees described actions that were not captured by the Hilger et al. framework, we expanded it to capture three new roles. Next, we used this expanded framework to describe how actors took on various roles through which they interacted with barriers to the living dike.

4.4.1 – Framework Results

The framework of action-based roles designed by Hilger et al. (2021) was created in order to provide insight into transdisciplinary and transformative (td/tf) research[17]. As a pilot project, the BBLD project shares many of the characteristics of td/tf research despite being an incremental, rather than transformational, adaptation. However, its practitioner-led process and its practical nature also make it different from many conventional research projects. As such, our first aim was to examine how the actions of BBLD actors aligned with the Hilger et al. (2021) framework, and how the framework could be adjusted to better reflect a pilot project.

When examining the roles of actors within the BBLD project, we considered several factors, including:

- whether the actor in question was an individual or an organization;
- which role(s) that actor played;
- how many roles that actor played;
- how actors saw their own roles compared to how they were seen by others; and
- which combinations of roles occurred most often.

Interview participants identified 34 organizations that played at least one role in the BBLD project and named 31 individuals at those organizations. Of those 31 named individuals, 21 were part of our interview pool, representing 18 organizations. Recognizing that individuals do not always function in ways strictly defined by their organizational role or position, we differentiated between roles that were specifically ascribed to named individual actors, and those that were ascribed to an organization (i.e., where individuals were unnamed, where responsibility was unclear, or where the organization as a whole

[17] By Hilger et al.'s (2021) definition, research is transdisciplinary when it takes "a critical and self-reflexive research approach, which integrates different interdisciplinary scientific and extra-scientific insights to co-produce new knowledge to tackle complex problems" (p. 2050). Conversely, they define transformative research practices by the intent behind it; transformative research has an explicit aim to impact society and catalyze social change (Hilger et al. 2021, p. 2050).

played more roles than any individual member). Additionally, while there were instances of interview participants explicitly differentiating between actions driven by personal inclination and actions taken within their official capacity, we have made the assumption that roles filled by an individual can be said to be filled by the organization that the individual represents, but that the converse (i.e., that all organizational roles are represented by all individuals who work there) is not true.

4.4.1.1 - Existing roles

The interview participants involved in the BBLD reported 55 of the 72 actions identified by Hilger et al. (2021), which those authors had organized into 15 roles[18]. We coded 525 instances of actions that the interview participants said that they took themselves, or that others had taken. Because participants were being actively prompted to reflect on their own behaviour as part of the interview, actions relating to Hilger et al.'s "Self-Reflexive Participant" role were not included, leaving 14 roles for analysis (see Tables 2 and 3), for named individuals and organizations, respectively.

Table 4.2: Roles attributed to named individuals involved in the BBLD project, after Hilger et al. (2021)

Role	**Only Self-Attributed**	**Only Other-Attributed**	**Self- and Other-Attributed**	**All Roles**
Application Expert	1	0	0	1
Choreographer	8	2	6	16
Communicator	7	4	3	14
Coordinator	3	3	0	6
Data Supplier	2	0	0	2
Facilitator	4	2	4	10
Field Expert	3	1	2	6
Intermediary	4	2	0	6
Knowledge Collector	3	0	0	3
Knowledge Co-Producer	8	6	5	19
Practice Expert	5	2	0	7
Results Disseminator	2	0	0	2
Scientific Analyst	5	3	3	11
Troublemaker	4	1	0	5

[18] For a complete list of the actions we took from Hilger et al. (2021) and our definitions of them, as well as examples interview quotes, please see Appendix E.

Table 4.3: Roles attributed to organizations involved in the BBLD project, after Hilger et al. (2021)

Role	Only Self-Attributed	Only Other-Attributed	Self- and Other-Attributed	All Roles
Application Expert	3	0	0	3
Choreographer	2	3	9	14
Communicator	2	7	5	14
Coordinator	1	2	2	5
Data Supplier	3	1	0	4
Facilitator	3	1	3	7
Field Expert	2	5	3	10
Intermediary	2	3	2	7
Knowledge Collector	2	2	1	5
Knowledge Co-Producer	4	7	7	18
Practice Expert	2	5	3	10
Results Disseminator	2	2	0	4
Scientific Analyst	4	3	4	11
Troublemaker	1	3	1	5

The most common roles played were Knowledge Co-Producer (61% of named individuals; 53% of organizations), Choreographer (52%; 41%), and Communicator (45%; 41%). While a large number of Knowledge Co-Producers would be expected in a highly collaborative project, the prevalence of Choreographers was significant to this project. According to Hilger et al. (2021), the role of a Choreographer is broadly to organize and structure a research process (in this case, a pilot project) and to identify and involve participants. The interview data suggest three reasons that this role was so common: the BBLD's non-traditional path from idea to implementation, its three co-proponents, and the empowerment of the Roundtable actors. The BBLD project began with "[a legal organization and an engineering firm that] had this great idea, they were trying to… shop it around for implementation…" (3964P). The idea changed hands and responsibility shifted among actors between the conception of the idea and its implementation, allowing multiple actors to act as Choreographers. Having three project co-proponents was identified as similarly unusual. However, this emphasis on collaboration empowered some actors to identify remaining gaps in the Roundtable knowledge base and invite others to participate.

The three least common roles were Results Disseminator (7%; 12%), Data Supplier (7%; 12%), and Application Expert (3%; 9%). It should be noted that all three of these roles are not normally expected in the early stages of a project. Several interview participants clarified that implementation had not yet begun at the time of their interview but described anticipated future actions for themselves and others.

The roles presented in Hilger et al.'s (2021) framework provided a strong foundation for understanding how actors contributed to the BBLD project. However, we found two general areas where the original framework did not fully align with our data. Firstly, we identified three additional roles that were not previously captured in Hilger et al.'s framework. Secondly, we coded four types of contextual, non-role information to supplement Hilger et al.'s framework.

4.4.1.2 - Additional roles

We identified three additional roles that collaborators had taken on that were not represented in the Hilger et al. (2021) framework. Not only are these roles based on participant-reported actions, but their inclusion is further justified because interview participants identified these roles as important project enablers. These three additional roles, summarized in Tables 4 and 5, were labeled Funders, Champions, and De-Riskers.

Table 4.4: Roles not included in Hilger et al. (2021) attributed to named individuals involved in the BBLD project

New Role	Only Self-Attributed	Only Other-Attributed	Self- and Other-Attributed	All Roles
Funder	5	4	1	10
Champion	2	3	3	8
De-Risker	1	0	0	1

Table 4.5: Roles not included in Hilger et al. (2021) attributed to organizations involved in the BBLD project

New Role	Only Self-Attributed	Only Other-Attributed	Self- and Other-Attributed	All Roles
Funder	2	7	5	14
Champion	0	6	3	9
De-Risker	1	0	0	1

The most common of the new roles was that of the Funder. Funders are those who seek out, provide, obtain, or administer funding. Their contributions are central to project success; funding was the second most commonly cited enabler of the BBLD. Funder role-related actions interview participants described included identifying potential funding, applying for funding, designing funding programs (including evaluation criteria, timelines, reporting requirements, and other attached obligations), providing funding, and using funds to secure goods and services for the project. The number and diversity of Funders are reflective of BBLD being comprised of multiple overlapping projects and interests. Some actors secured research funding to support knowledge development. Others obtained financial support to facilitate the collaborative process and encourage participation from groups that did not otherwise have the means. The scale of the funding ranged from a few thousand dollars to engage international expertise, to multi-million dollar federal funding to support the project construction.

Next, Champions are those who leverage their social or political capital to advance or protect the project, and/or who take on risks to their social or political capital by supporting the project. The precise actions of Champions varied by the degree of their involvement. For some actors, the extent of their Championing was using the influence of their position to express approval for the project through letters of support to a funding agency. For others, taking on the role of Champion meant advocating for the project within and beyond their organization, incurring social risk to their professional reputation and financial risk to their organization's interests. Champions often self-attributed through a simple statement of action. They said that they had written a letter, or that they had pushed for X solution. However, when others discussed Champions, in addition to discussing their actions, they tended to talk about the individual themselves and their contributions to the project. For example, one federal staff member said:

> "… it strikes me that well, if you didn't have [this engineer], or if you didn't have… [this municipal staff member] … if you didn't have [this lawyer] would the project have gotten done in a similar way at all? Who knows? … in an ideal world, we shouldn't be relying on individuals…

and the power of their conviction to move these types of massive scale projects forward… but of course, in the real world, that's not the case." (8427F)

Participants regarded Champions in largely, but not universally, positive terms. One actor, for example, was described by multiple participants as a vocal champion of the project, but one whose ideas may not have been in their best interest. Participants also emphasized the idea of a sphere of influence; a champion may not necessarily have far-reaching influence but can effect meaningful change within their network.

The final role that we identified was that of De-Risker. Managing risk for NBCA projects, which involves significant uncertainty and can be especially vulnerable in the early years while the ecosystem matures, is crucial. Participants talked about de-risking as the creation of a safety net that encourages innovation. This includes the development of new kinds of insurance arrangements and risk management approaches that account for NBCA needs and characteristics. This role was the least common of the three we identified; only one participant, who represented an insurance company, acted as a De-Risker in our study.

4.4.1.3 - All Roles

With the inclusion of the three new roles above, we have a fuller picture of the 17 roles and numerous actions that actors contributed to the BBLD. Having examined *which* roles were being played, we continued to consider how different roles were often bundled together for particular actors. Ten was the largest number of roles held by any named individual; three individuals played ten roles each, two of whom were municipal staff members closely involved with the project, and one of whom worked for the provincial government. The municipality to which those staff members belonged had the most wide-ranging roles of the organizations, playing 15 of the possible 17 roles, significantly more than any other organization. The average number of roles for named individuals and organizations were quite similar, at just over 4 each, and the range and distribution of numbers of roles can be seen in Figure 2 below. As might be expected, most actors were only peripherally involved, playing one or two roles that fell within

their expertise, rather than the many roles which usually denoted both deeper and longer-standing involvement.

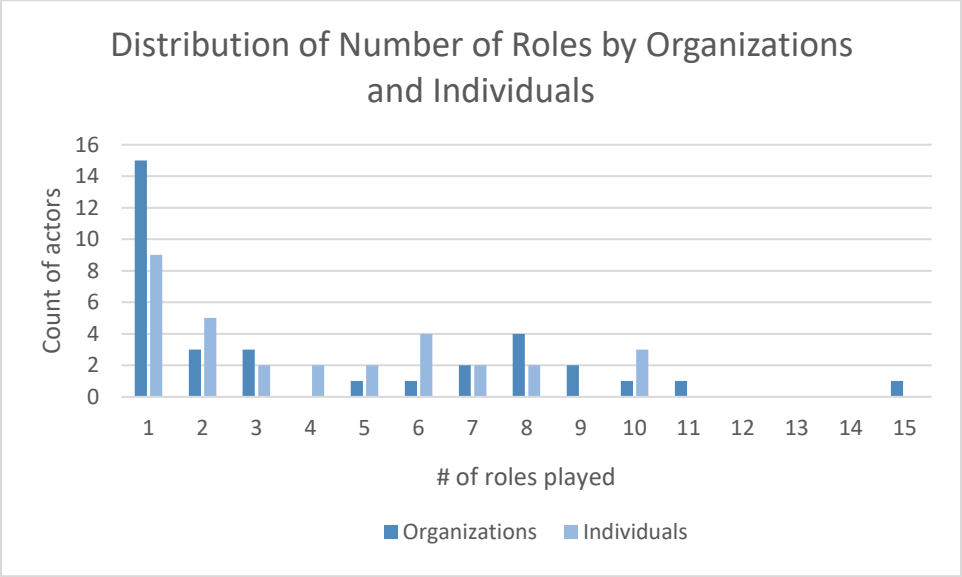

Figure 4.2: Distribution of number of roles played by organizations and individuals

Another way of looking at the relationship between roles played in the project is by examining the co-occurrence of roles held by the same actor. Table 6 shows how many instances in which at least two roles were played by the same actor, with the intersection of each role with itself (highlighted in grey) representing the total number of times each role was held overall. The most common pairing of roles was of Knowledge Co-Producer and Choreographer (which is unsurprising, given that they are the two most common roles overall), followed by Communicator and Choreographer, and Knowledge Co-Producer and Funder. In this data set, De-Risker had no overlap with any other roles as it was held by only one individual who played no other roles in the BBLD project.

*Table 4.6: Count of roles, either self- or other-attributed or both, occurring together in the same organization. *Role not in Hilger et al. (2021)*

	Application Expert	**Champion***	**Choreographer**	**Communicator**	**Coordinator**	**Data Supplier**	**De-Risker***	**Facilitator**	**Field Expert**	**Funder***	**Intermediary**	**Knowledge Co-Producer**	**Knowledge Collector**	**Practice Expert**	**Results Disseminator**	**Scientific Analyst**	**Troublemaker**
Application Expert	**3**	1	3	2	2	1	0	2	3	2	1	3	1	3	0	2	1
Champion*	1	**9**	7	7	4	3	0	5	6	7	5	7	3	2	1	3	3
Choreographer	3	7	**14**	10	5	4	0	7	8	9	7	13	5	8	4	7	3
Communicator	2	7	10	**14**	4	2	0	4	6	9	6	9	3	6	3	6	2
Coordinator	2	4	5	4	**5**	1	0	5	4	5	4	5	2	3	1	2	1
Data Supplier	1	3	4	2	1	**4**	0	3	3	2	3	4	3	2	1	2	2
De-Risker*	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0
Facilitator	2	5	7	4	5	3	0	**7**	5	5	5	7	4	4	2	3	2
Field Expert	3	6	8	6	4	3	0	5	**10**	7	4	8	2	4	1	5	3
Funder*	2	7	9	9	5	2	0	5	7	14	6	10	2	5	2	4	2
Intermediary	1	5	7	6	4	3	0	5	4	6	**7**	7	3	4	3	3	1
Knowledge Co-Producer	3	7	13	9	5	4	0	7	8	10	7	**18**	4	7	3	7	3
Knowledge Collector	1	3	5	3	2	3	0	4	2	2	3	4	**5**	3	2	3	2
Practice Expert	3	2	8	6	3	2	0	4	4	5	4	7	3	**10**	4	4	1
Results Disseminator	0	1	4	3	1	1	0	2	1	2	3	3	2	4	**4**	2	0
Scientific Analyst	2	3	7	6	2	2	0	3	5	4	3	7	3	4	2	**11**	2
Troublemaker	1	3	3	2	1	2	0	2	3	2	1	3	2	1	0	2	**5**

4.4.2 – Case Study Results

The interview data gave us several ways to expand the Hilger et al. (2021) framework that were particularly relevant to a pilot project as a specific kind of td/tf research. Having confirmed the applicability of the framework to our data, we now turn our attention to the insight the framework provides on the case study. In the following section, we explore the perspectives of actors on the benefits and drawbacks of collaboration. We also examine how the actors in the BBLD project, acting within the roles as explained above, interacted with the barriers to the project.

Participants identified several advantages and disadvantages of the collaborative approach taken with the BBLD. The most commonly reported advantages were the many bodies of knowledge and expertise that collaborators contributed, the diversity of priorities and perspectives that allowed the team to consider the project from many angles, and the perceived increase in the legitimacy of the planning process. Conversely, the time cost of collaboration was by far the most commonly reported disadvantage, followed by the propensity of some individuals to dominate conversations[19], and the difficulty in reaching a collective vision. There were also instances where decisions were both helpful and unhelpful in different ways; an organic approach to identifying potential collaborators allowed actors to draw on their own considerable networks and expertise but led to a feeling of disorganization. Similarly, the passion and curiosity that brought many collaborators to the table occasionally hindered progress in the Roundtable by focusing on technical minutiae rather than high-level objectives. The first was seen as the cost of flexibility, but the second was resolved through the creation of the Technical Working Group (TWG) as a designated space for those discussions. Overall, most collaborators spoke positively about the highly collaborative experience and saw it as being advantageous to the project overall.

[19] While no participants directly addressed the issue of power dynamics, the concerns raised about individuals dominating the conversation had consistent themes of gender, seniority, occupation, and education. One participant remarked that "certain voices can be far more either far more articulate or just far more emphatic" (3964P) and another that "the loudest voices carry" (1485A).

We can look more closely at how collaboration was advantageous to the BBLD project by identifying the barriers that the actors confronted. The barriers most discussed by participants were legislation, jurisdictional fragmentation, funding, and the constraints of the engineering contract. The most common barrier cited was the current state and flexibility (or lack thereof) of the legislation governing activities relating to the project, most notably the Dike Maintenance Act and the provincial Environmental Assessment Act. Next, funding, which includes associated obligations such as reporting and timelines, was reported as a barrier to project feasibility. Jurisdictional fragmentation was the next most commonly reported barrier, caused by mismatches of mandate and capacity, as well as a high density of often overlapping stakeholders and rights holders. Finally, the expectations and conventions that structured the engineering contract impacted the collaborative process and project design. While these barriers are inextricably linked, we can examine them individually to identify actors' interactions with them.

4.4.2.1 - Legislation

The constraints imposed by the legislation that govern the BBLD process were the most commonly reported barrier to the project's success. It bears repeating that barriers are not inherently negative; these pieces of legislation were created to protect people and ecosystems, though multiple participants felt that several of the relevant legislation were not keeping pace with modern challenges or practices. The most-discussed legislation for the BBLD project were all at the provincial level: the Environmental Assessment (EA) Act, the Dike Maintenance Act, and the Wildlife Act. Several individuals helped the project team navigate the nuances of those Acts by lending their strategic knowledge. We have represented those individuals as Field Experts, as their knowledge of the regulatory environment is analogous to familiarity with a physical environment. Several of those Field Experts became involved in the Roundtable out of personal curiosity rather than (or in addition to) professional necessity and were able to provide informal support before formal regulatory support could be sought or expected. In the case of the Wildlife Act, securing a memorandum of understanding (MOU) with those in

charge of the Wildlife Management Area was identified by participants as a significant benefit. The MOU was facilitated by a Champion at the province who was also closely involved with the Roundtable, and it provided some welcome confidence for the co-proponents to take on the financial risk of the BBLD before official permits could be expected. So, by both providing information and championing support to the project co-proponents, collaborators were able to address the legislation barrier.

4.4.2.2 - Jurisdictional fragmentation and mandate

Jurisdictional fragmentation, and the overlapping responsibilities and requirements of various governmental bodies, was also a barrier to the BBLD. While the content of some impactful legislation was discussed above, the uncertainty arising from inconsistent or conflicting information and requirements between different departments and organizations stood out in our analysis as a challenge in itself. One example of this was tension over the right of way and access to the property where the BBLD would be constructed. One municipal staff member recalled that "… the ministry responsible for flood control, would like us to have a right of way on this property, but then the highways groups mandate is not to give right of way…" (2571M). Another barrier arising from jurisdictional fragmentation is the timeline mismatch between different permits or requirements. A participant noted the difficulty of meeting requirements for "… the monitoring… in terms of timing of the year when you're even allowed to do that. So the bird window doesn't match the fish window… that is more of a challenge than a regular project," (3004M). No participants identified any ways that collaboration interacted with these barriers.

Jurisdictional fragmentation may, however, have impacted the need for collaboration. "What we found with flooding… is that First Nations and local governments often agree because they often face the same challenges, which is… lots of responsibility, no funding, and no authority," (5827O). One interview participant noted that the project co-proponents (a First Nation and two municipalities) were able to work together despite tension at the political level because of shared goals. In this instance, shared frustration at regulatory barriers may also have contributed to productive working relationships.

4.4.2.3 - Funding

Funding was recognized by several interview participants as a significant barrier to the success of the BBLD, both for capital works and to support the collaborative planning process that many considered foundational to a successful project. The ways that actors interacted with funding can be subdivided into concept and design, development and construction, and engagement and collaboration.

From the BBLD's inception, the ability to identify and secure funding was central to the project's success. The project idea did not originate with any of the three current co-proponents; its first champions, actors from a law firm and an engineering firm, obtained funding to create a preliminary design report for the living dike concept (Readshaw et al., 2018). This preliminary design made the project more appealing to proponents working within a grant-based approach to adaptation where short timelines create a preference for "shovel-ready adaptation projects" (7602C). Multiple participants identified the design concept as an important starting place for conversations, and one participant already plans to replicate it as a best practice (3964P). Our analysis suggests that this project beginning, defined by actors not belonging to a conventional infrastructure-owning entity, had an impact on how the project progressed. By the time the project had reached the design phase, there was a constellation of overlapping projects run by individuals and organizations with their own agendas coming together to provide what expertise they could offer. This included independently funded federal research organizations providing technical guidance, academics and students providing research outputs, and foreign governments providing funding to support the dissemination of technical expertise from their country and fostering working relationships.

While the diverse sources of smaller-scale funding were impactful, the BBLD needed sufficient capital funds to be piloted and potentially deployed at a larger scale. One of the project proponent municipalities secured this funding by including the BBLD in a collection of 13 coastal flood-related projects that they submitted to a major federal funding program, receiving $76.6 million for the 13 projects overall (City of Surrey, 2022c). This was seen as particularly significant because the funding

program recognized and funded the BBLD as infrastructure (8831C), rather than as a restoration project, which some participants perceived as a shift in the perceived legitimacy of NBCA. With the federal funding in place, the patchwork of smaller funding opportunities identified by various actors, including over one million dollars in research funding on nature-based infrastructure in the area from two federal departments and smaller grants from private foundations, was able to fill the remaining gaps between the formal funding programs and the needs of the BBLD (Osler, 2020).

The most notable gap identified by participants between the funding provided for the BBLD and the project's needs was the resources available to devote to a collaborative project design process. Above all other drawbacks of a highly collaborative process, time (and associated cost) was mentioned repeatedly by interviewees as being the most significant. Because the collaborative process was driven largely by the Roundtable, however, the responsibility of funding did not fall solely on the project co-proponents. Various organizations (particularly civil society organizations) found additional funding to cover some costs of convening the group, which participants saw as particularly necessary to enable meaningful involvement from local First Nations, which often have significant demands on their time and resources (5827O). Our analysis showed that the ability of collaborators to fill this gap in the formal funding enabled them to undertake the collaborative process as they saw fit.

Despite this outside funding, several of the actors mentioned that they were not able to resolve all funding-related issues. The availability of funding for monitoring and adaptive management remains a concern for some participants, particularly over the long term (5827O). Additionally, if the project fails to secure the Environmental Assessment (EA) exemption that they are pursuing for the full-scale project that will follow the pilot, the full EA process would likely prove cost-prohibitive, leading to possible project abandonment (5827O; 2571M). Despite these continued challenges, the collaborators on the BBLD were able to find significant support beyond the core project funding.

4.4.2.4 - Engineering contract

Another barrier to the BBLD that participants identified was the assumptions behind and structure of the contract with the engineering firm responsible for the project's design. The consultants budgeted a certain amount of time for meetings and responding to input, but their estimate was perceived by Roundtable members as insufficient for such a highly collaborative project (3096A), particularly when the initial design was not one with which the Roundtable members were satisfied (5827O). Some participants pointed to a lack of clarity on expectations around collaboration arising from a disconnect between the proponent municipality that was procuring the consultant's services and the Roundtable convenors, who were leading the collaborative process (4336I). The consultants saw the value in the Roundtable, but its departure from their normal working process appeared to be a challenge.

The Roundtable's influence on the design came to a head approximately halfway through the design process. Roundtable members acting as Knowledge Co-Producers, Practice Experts, Scientific Analysts, and Field Experts, were able to provide expert feedback on the submitted design, but the process of refining that design and incorporating the feedback was time-intensive for an already time-constrained consulting firm. Those constraints led some actors to feel that their concerns were not heard (3096A). However, when the initial design was not to the satisfaction of the Roundtable, the combined influence of those actors and their commitment to a more nature-forward vision of the project gave the co-proponents the encouragement and backing to tell the consultants to start over when they might not have done so otherwise. One municipal staff member said "… when the first attempt at designing it came together, we probably would have been like, well, it's okay, let's, let's just carry on with that. But the Roundtable really pushed us to say, 'No way, that's completely wrong, what's been put forward. So you need to essentially start over'. So yeah, really, fundamentally changed things up for us," (2571M). A commitment to pursuing the most natural solution possible was a priority of several individuals on the Roundtable, and it was one that they were able to achieve by exerting their collective influence.

Engineers' expectations concerning their roles also shaped the involvement of the consultant firms in this project. Multiple interview participants from engineering firms described discomfort with the experimental nature of the BBLD project. One said:

> "I think experiments are good to do in labs, and to have be done by academics, it's a little harder to run an experiment using the conventional, 'I'm gonna hire a consulting engineer to design something and then build it'. So I don't think that was a mistake, it was just… did feel a little bit like a barrier… Getting us to do the research, is... it takes a little bit more skill, and it just means it needs a little time and love and effort," (5773I).

That engineer felt limited by their contract but was excited about the inclusion of research actors from academic and governmental organizations who could "broaden the spectrum" of experiments that could be done (5773I). In this way, having Knowledge Co-Producers from various fields allowed for both rigour and flexibility in designing the project.

It is worth noting how participants' descriptions of the collaborative process and their role within it were shaped by their variable understanding of the project as a pilot. This was most evident in participants described how a lack of locally-applicable knowledge and regulatory precedence made diverse voices and perspectives invaluable to the BBLD (2564F), but also because the process of collaborating on a project perceived as an experiment built up the capacity of the network of adaptation actors involved. The BBLD Roundtable was perceived as an arena for learning, as well as a chance to build legitimacy for a nature-based project and to develop working relationships between the collaborators. "[You're] trying out things and you go through the whole storming and norming stuff..." (7602C). 'Storming and norming' refers to a psychological framework describing four stages of development through which a team goes when undertaking a project (Tuckman & Jensen, 1977); more than one participant saw the Roundtable process as a way to build relationships that would be useful beyond the BBLD project.

In these ways, collaboration interacted with and to some extent mitigated each of the most significant barriers to the BBLD project. While collaboration did not resolve all challenges, the Roundtable actors were able to fill several of the gaps in the formal funding and regulatory systems to advance the project. Participants considered the Roundtable's ability to do so both a success in itself and as a potential model for future NBCA projects in B.C.

4.5 - Discussion

As a novel project for B.C., participants considered it a success for the BBLD project to achieve implementation within a system that was not designed to accommodate it. Part of that implementation was dependent on high-level change, such as the recognition of a nature-based project as 'infrastructure' within a major federal funding program. However, most systemic change is slow, and the changes that are being made at the high level are new and incomplete. Collaboration was a major way in which the co-proponents of the living dike were able to bridge the gap between formal structures and systems designed for other purposes and newer NBCA needs. However, several participants noted that the BBLD's novelty, as a pilot project (i.e., impact-driven experimentation providing an opportunity for both research and non-research actors to engage in tf/td research as described in Hilger et al. (2021)), was responsible for the degree of interest shown by the diverse actors that made up the Roundtable. Future projects cannot expect the same level of support. With that reality in mind, we can broadly categorize the findings on the role of collaboration in advancing NBCA into two themes. Firstly, other early adopters of NBCA can learn from the BBLD's process of collaboration to promote both effectiveness and efficiency. Secondly, those looking to change underlying systems to promote NBCA at a larger scale can look to informal engagement to identify gaps in the formal structures, so that future projects are less reliant on small groups of highly driven individuals than the BBLD was.

The living dike is a first for the province of B.C. and is a pilot-scale project. Its success in reaching the implementation phase is significant, but other early adopters will need to overcome several of the same barriers that hindered the BBLD. Our results suggest that assembling individuals who play

specific roles can help. To some degree, the focus on roles in examining collaboration is reductive. The value of collaboration, of the shared learning and working of a particular group of people, goes beyond what roles can capture. It is particularly inadequate in representing the value of Indigenous Knowledge and relationships with the land, which may reinforce a colonial view of Indigenous Knowledge in decision-making (Latulippe & Klenk, 2020). However, the complexity and novelty of NBCA projects put them at a disadvantage compared to grey infrastructure projects, and they are being undertaken by time- and resource-constrained proponents (Nelson et al., 2020). Because of this, action-based roles can be a useful way to understand who is present and what skillsets or perspectives might be missing.

The research finding that actors typically had a co-occurrence of multiple roles could help proponents fill multiple needs within their project team, particularly through the involvement of actors who would not conventionally be involved in an infrastructure project. For example, academic actors often played several roles, and on the BBLD were able to provide scientific expertise, data, strong professional networks, and external funding. The involvement of researchers also adds the opportunity for post-secondary student involvement, which has the dual benefits of research output and the opportunity for the practical training of a new generation of adaptation professionals on NBCA projects. Similarly, engaging civil society actors who have the expertise to facilitate collaboration, strong local networks, a focus on human and other ecosystem well-being, and experience in securing grants can be invaluable in a room dominated by technical experts. For the more technical actors, it would be valuable to seek experts with local knowledge; while the application and practice expertise is still being developed for most NBCA, having individuals who are able to bring in local knowledge is valuable for designing context-appropriate solutions. In the core team, having project proponents who are willing to act as Troublemakers and Champions is invaluable; there is risk in these projects, and while they are still new, they will require the driving force of individuals who are willing to take risks and challenge the status quo.

The motivation and skill of individual actors were significant driving forces behind the BBLD project, and often in informal ways, but dependency on that type of collaboration expertise is not a solution suited to scaling up NBCA. Ideally, as NBCA projects become more common, the formal systems that variously enable and hinder these projects may begin to account for and adjust to their needs. For example, in the early stages of scaling up NBCA deployment in B.C., this might look like government funding specifically for collaboration and engagement to replicate a Roundtable such as the BBLD used. Concurrently, governmental support for training engineering professionals on NBCA could increase local skills and promote collaboration-forward design practices as a norm. As those early projects are undertaken, project proponents can work with the insurance industry to develop approaches to risk management that suit the challenges of NBCA, such as the Natural Assurance Scheme suggested by (Denjean et al., 2017). Additionally, individual projects could benefit from the development of regional strategies for adaptation that facilitate knowledge sharing and build working relationships between adaptation professionals before they are needed on any one project, potentially including a compendium of local NBCA knowledge similar to the ReNature project (Sapundzhieva et al., 2020). Finally, as scientific and technical knowledge improves, developing standards for NBCA could increase confidence in design and building, and lower barriers for infrastructure-owning entities without the capacity to take on experimental projects. All of these solutions would reduce the burden on individual actors when undertaking NBCA projects.

4.6 - Conclusion

In our analysis of the extent and ways in which collaboration can enable the design and implementation of nature-based pilot projects for coastal climate adaptation, we found that collaboration had a positive impact on several of the barriers facing the Boundary Bay Living Dike project. Through an action-based evaluation framework of roles, we examined how actors took on various roles within a project that had significant differences from the conventional infrastructure it was designed to replace. We also added to that evaluation framework to better represent the roles found in pilot projects as specific

kinds of transdisciplinary or transformative research. These findings have practical applications which might allow for the creation of smaller teams undertaking NBCA when facing similar barriers. Overall, this contributes to the ability of smaller or more-resource constrained infrastructure-owning organizations to consider options beyond conventional grey solutions.

To continue supporting that goal, we identified several areas of further research. Research examining how unique individuals exert agency within predefined roles, and the impact of those individuals on driving NBCA processes, is one. There is also utility in considering which roles are not transferrable between groups, particularly on the contributions of Indigenous collaborators and the ways that Indigenous Knowledge and practices may be able to promote NBCAs that prioritize justice, equity, and reconciliation. Relatedly, further attention is merited to research on capacity-building for NBCA, since this would benefit infrastructure owners looking to develop competent teams and to understand which roles are most effectively filled internally versus which roles are best played by contracted external actors. Finally, as more NBCA projects begin to emerge, researchers should consider differences between pilot-scale and full-scale projects in terms of collaboration needs and effective upscaling.

Chapter 5 – Conclusions

This study examined the role of collaboration in overcoming barriers to NBCA projects. While Chapters 3 and 4 both have self-contained discussions of the findings relevant to each manuscript's aim, here I will discuss how both manuscripts achieved the overall study's objectives. Figure 5.1 shows how each of the objective was met by one or both of the manuscripts.

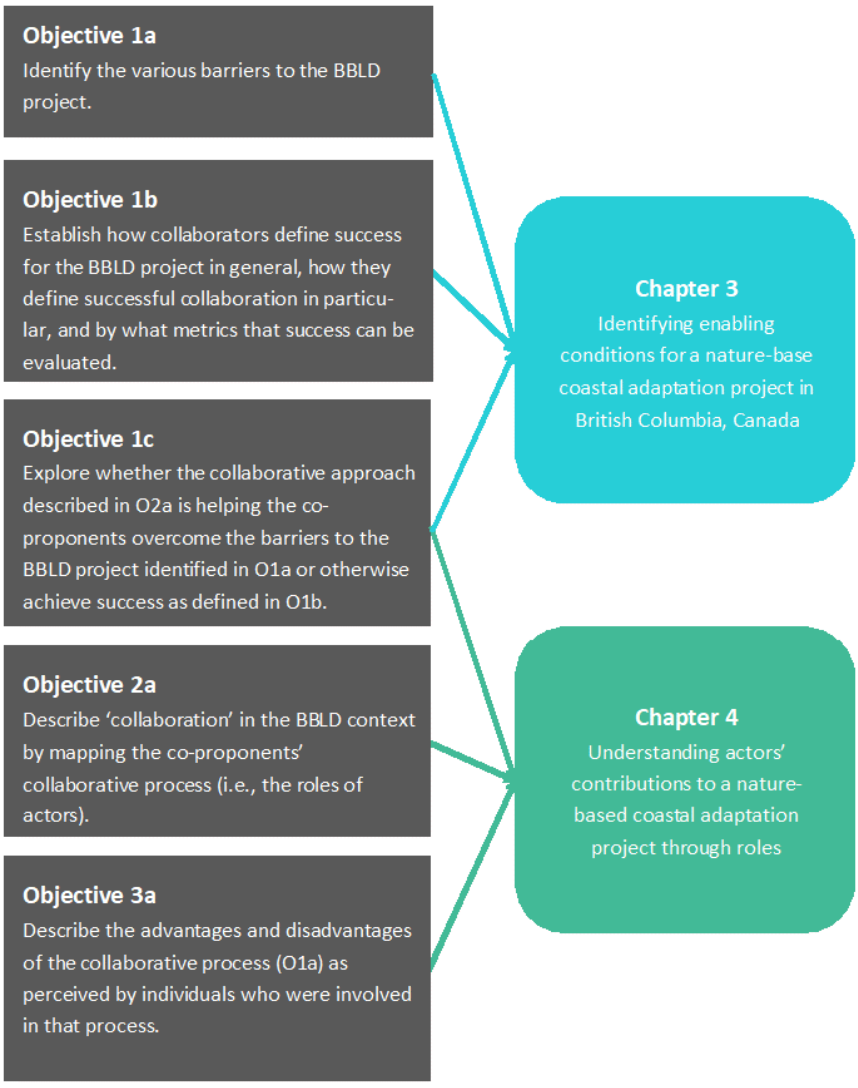

Figure 5.1: Study objectives as addressed in the two manuscripts that make up this thesis

The results discussed in Chapter 3, *Identifying enabling conditions for a nature-based coastal adaptation project in British Columbia, Canada*, deal with the objectives associated with research sub-

questions 1 and 3, outlined in Section 1.1. In aiming to identify the barriers to the BBLD project (Objective 1a), I found that the concept of barriers alone was not representative of the ways in which interview participants talked about the project. Consequently, drawing on the literature, instead I examined the enabling conditions of the BBLD project through four key characteristics: the degree to which the condition was present, the timeframe over which it was available, the actors' abilities to make use of the condition, and the interactions between that condition and others (Objective 1c); this was done for the 51 enabling conditions I identified from participant comments, including their understandings of success for the project (Objective 1b). One key finding from this chapter in relation to the overall question of the role of collaboration in enabling NBCA is that actors (and their capacity and willingness to take advantage of conditions) interact with every kind of enabling condition as one of the four characteristics of enabling conditions. In the case of the BBLD, the individuals and organizations that the co-proponents assembled extensively influenced the degree to which the project's conditions were helping rather than hindering.

Chapter 4, *Understanding actors' contributions to a nature-based coastal adaptation project through roles*, also addressed several of the research objectives for this study overall. The aim of this manuscript was to explore the BBLD co-proponents' collaborative approach to the project. To that end, I applied a framework of action-based roles to the actions of known collaborators (Objective 2a), and then integrated those findings with the four most reported barriers to the BBLD (Objective 1c). This manuscript directly showed how collaboration can advance NBCA projects by showing the ways that actors fulfilling different roles helped the BBLD overcome several barriers to implementation. In this manuscript, I also acknowledge some of the challenges of a highly collaborative process (Objective 3a), including the time and financial cost. By identifying commonly co-occurring roles that a single actor can play, this research can potentially inform the development of effective teams within resource-constrained environments.

The findings of this study can be of use to several groups. Infrastructure managers who are looking to implement NBCA, particularly in B.C., will find useful information in both Chapters 3 and 4. The conceptualization of enabling conditions from Chapter 3 will be beneficial for infrastructure managers who are looking to understand and communicate their own conditions as they consider implementing NBCA. Likewise, the findings from Chapter 4 can help them understand how actors contribute to a project through different roles, information which can be used to build effective teams for undertaking NBCA projects. Another group that may benefit from this research is decision-makers in B.C. and across Canada who are able to influence the systems within which NBCA operate. Using the concept of enabling conditions and drawing on the areas in which the BBLD project had to resort to informal solutions to do structural shortcomings in particular, these decision-makers can use the findings of this study to adapt systems to account for the needs of nature-based projects more equitably.

Together, these manuscripts present a consistent narrative that affirms the utility of collaboration in advancing NBCA projects. Bringing together individuals with diverse priorities, values, skill sets, and knowledge bases can help proponents of projects like the BBLD consider their project from many angles, identifying co-benefits and possible challenges before they arise. NBCA projects that follow the BBLD will operate within many of the conditions, both those that help the project succeed and those that hinder project success, and the actors that will be involved in those future projects will have significant influence on how those conditions are navigated. As NBCA projects become more common, collaboration will likely become less extensive, as proponents aim to build efficient teams where actors can play multiple roles, and ideally where the need to fill gaps in the formal structures has been reduced. Until those structures are adapted to consider NBCA, however, collaboration will help those who are seeking new ways to adapt to a changing climate use all of the tools at their disposal.

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Appendix A – Research strata

To ensure fair representation across different groups of collaborations that interacted with the Boundary Bay Living Dike project, Interview participants were selected from 8 strata.

Academic – Interview participant works for a university or other research organization separate from the government and has been directly involved in the Boundary Bay Living Dike project.

Civil Society – Interview participant is a member of an organization representing local community or environmental interests.

Federal – Interview participant is employed by the Canadian federal government.

Industry – Interview participant is employed in a technical capacity for a company providing services to support the governmental experts (e.g., consultants).

Municipal – Interview participant is employed by one of the municipal government project proponents (Surrey or Delta).

Other Governmental – Interview participant is employed by a foreign government or by arms-length government companies (e.g., port authorities).

Provincial – Interview participant is employed by the province of BC.

Subject Matter Expert – Interview participant is a subject matter expert on technologies or processes relevant to this case study but has had no direct involvement with the Boundary Bay Living Dike project (as opposed to those in the Academic stratum).

Appendix B – Ethics documents

Email participant recruitment letter

UNIVERSITY OF WATERLOO | FACULTY OF ENVIRONMENT
Department of Geography and Environmental Management

Month XX, 2022

Hello,

My name is Devon Jones and I am a master's student working under the joint supervision of Dr. Brent Doberstein (Department of Geography and Environmental Management, University of Waterloo) and Dr. Andréanne Doyon (Resource and Environmental Planning Program, Simon Fraser University). I am contacting you because of your involvement with the Mud Bay Foreshore Enhancement Project in Boundary Bay, part of the City of Surrey's Coastal Flooding Adaptation Strategy. The reason I am contacting you is that I am conducting a study of collaboration in implementing nature-based solutions. I aim to learn about how the City of Surrey has worked with other organizations to design and plan a living dike, how those collaborations impacted the project, and if a similar approach could help other municipalities implement nature-based climate adaptation solutions as well. I am currently inviting people to participate in this study.

Participation in this study involves an in-person or virtual (Zoom) interview discussing the Mud Bay Foreshore Enhancements Project and your involvement in it. There will be a list of guiding questions, but you will be free to shape the conversation with your perspective and share your expertise. The interview would take approximately 45 minutes to an hour of your time.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board.

I would like to interview you at your convenience between May 6 and June 30. If you are interested in participating, please contact me at devon.jones@uwaterloo.ca and suggest a date and time and note whether you would prefer to meet in person or on Zoom. I will then send a confirmation email and provide you with further information concerning logistics. If you have to cancel your appointment, please email me at devon.jones@uwaterloo.ca.

Sincerely,

Devon Jones, BES
devon.jones@uwaterloo.ca

Letter of Information

UNIVERSITY OF WATERLOO | FACULTY OF ENVIRONMENT
Department of Geography and Environmental Management

University of Waterloo

Month XX, 2022

Dear **PARTICIPANT**,

This letter is an invitation to consider participating in a research study I am conducting as part of my Master's degree in the Department of Geography and Environmental Management at the University of Waterloo under the joint supervision of Dr. Brent Doberstein (Department of Geography and Environmental Management, University of Waterloo) and Dr. Andréanne Doyon (Resource and Environmental Planning Program, Simon Fraser University). This study will be part of the Pacific Institute for Climate Solutions' (PICS) *Living with Water* project, an interdisciplinary research program aiming to broaden the solution space for coastal adaptation on the lower mainland. I would like to provide you with more information about this project and what your involvement will entail if you decide to take part.

The unprecedented rate of human-induced climate change means that the ways we have solved problems in the past may no longer be enough. For coastal communities like Surrey, British Columbia, climate change looks like rising sea levels and changing storm patterns that threaten aging infrastructure. Significant investment will be needed to address that infrastructure deficit, but what that investment will look like is still being decided. While heavily engineered, conventional infrastructure will undoubtedly be needed, the City of Surrey is looking at a nature-based form of protection against coastal flooding: the Mud Bay Foreshore Enhancements. The purpose of this study is to examine how the City of Surrey undertook this new kind of project and whether their process could be useful for similar projects in the future.

This study will look at if and how the City of Surrey used collaboration to overcome barriers to implementing a nature-based solution for coastal climate change adaptation. I want to understand how different groups contributed, whether and why collaborators feel that it has been successful, and how a similar approach could help other municipalities implement nature-based solutions for climate adaptation. I would like to include your perspective, as someone who was directly involved in the collaborative process, to develop the most comprehensive and balanced understanding of the that process as possible.

Participation in this study is voluntary. It will involve an interview of approximately one hour in length to take place either virtually through Zoom, or in a mutually agreed upon location. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time until the results of the study are published without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis. If the interview is conducted virtually and you choose to leave your video on, video will also be recorded, but will not be used for analysis. The video file will be deleted as soon as the video file can be converted into an audio file for transcription, within 7 business days. After the interview has been completed, I will send you a copy of the transcript to give you an

opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. I will endeavour to keep your identity confidential, but because of the detailed nature of the information I am collecting, it is not possible to guarantee complete anonymity. Your name and exact job title will not appear in any thesis or report resulting from this study, however, with your permission, quotations may be used. Unless you specifically wish to be named, the quotations will be unattributed. Data collected during this study will be retained for at least seven years in an encrypted digital folder. This study is funded in part by PICS. The completed thesis resulting from this research will be shared with PICS and *Living with Water* project partners, including the City of Surrey and others. There are no known or anticipated risks to you as a participant in this study.

The interview may be conducted over an online platform, Zoom or MS Teams. Both Zoom and MS Teams have implemented technical, administrative, and physical safeguards to protect the information provided via the Services from loss, misuse, and unauthorized access, disclosure, alteration, or destruction. However, no Internet transmission is ever fully secure or error free.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB 44072)**.** If you have questions for the Board contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or reb@uwaterloo.ca. For all other questions contact Devon Jones by email at devon.jones@uwaterloo.ca.

For all other questions or if you would like additional information to assist you in reaching a decision about participation, please contact me at [redacted] or by email at devon.jones@uwaterloo.ca. You can also contact my supervisors, Dr. Brent Doberstein at [redacted] or by email at bdoberst@uwaterloo.ca, and Dr. Andréanne Doyon at andreanne_doyon@sfu.ca.

I hope that the results of my study will benefit the organizations directly involved in the study, other government and civil society organizations, and the broader community of research and practice.

I very much look forward to speaking with you and thank you for your assistance in this project.

Yours sincerely,

Devon Jones

Consent of Participant

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study being conducted by Devon Jones of the Department of Geography and Environmental Management at the University of Waterloo. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted. I am aware that I may withdraw from the study without penalty at any time by advising the researchers of this decision.

I am aware that my interview will be audio recorded to ensure an accurate recording of my responses and may be video recorded if the interview takes place over MS Teams or Zoom.

I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research. While efforts will be made to protect my identity by omitting name and exact job title, I understand that the researcher cannot guarantee total anonymity because of the specialized nature of the information being collected.

I was informed that I may withdraw my consent at any time without penalty by advising the researcher.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB 44072)**.** If you have questions for the Board contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or reb@uwaterloo.ca. For all other questions contact Devon Jones by email at devon.jones@uwaterloo.ca.

By providing your consent, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.
☐YES ☐NO

I agree to have my interview audio recorded.
☐YES ☐NO

For online interviews only — I agree to have my interview video recorded.
☐YES ☐NO ☐NOT APPLICABLE

I agree to the use of unattributed quotations in any thesis or publication that comes of this research.
☐YES ☐ I wish to have my quotes attributed ☐NO

I would like to have my organization's participation in this study acknowledged in the resulting thesis.
☐YES ☐NO

I would like to review the transcript of my interview.
☐YES ☐NO

Participant Name: _____ (Please print)
Participant Signature: _____

Witness Name: ________________________________ (Please print)
Witness Signature: ______________________________
Date: ___________________________

Verbal consent statement

Participants will be sent a letter of information and written consent form prior to the interview.

Can you confirm that you have read and understood the consent form?

> *Participant answers yes or no.*

Do you have any questions relating to the consent form or the study?

> *Participant answers yes or no, and any outstanding questions are addressed before the interview begins.*

Do you agree to have your audio (and video if you choose to leave it on) recorded?

> *Participant answers yes or no.*

Unless you specifically ask to be named, any quotes used from this interview would be unattributed. Do you agree to have unattributed quotations used in any thesis or publication that comes out of this research?

> *Participant answers yes or no. If yes, the interview will proceed. If no, a note will be made that no direct quotes may be used from that transcript. If the participant asks to have their quotes attributed, a note will be made so that their transcript will not be anonymized.*

Would you like to have your organization's participation in this study acknowledged in the resulting thesis?

> *Participant answers yes or no.*

Would you like to review the transcript of your interview?

> *Participant answers yes or no. If yes, a note will be made to follow up with participant by email.*

Do you agree to participate in this study under the conditions outlined in the consent form?

> *Participant answers yes or no. If yes, the interview proceeds. If no, the interview is terminated with no penalty to the participant.*

By providing your consent, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

Appendix C – List of Interview Participants (Anonymized)

Stratum	Organization	Individual	Participant ID
Academia	BC University	Researcher*	1485A
	BC University	Researcher*	3096A
	Canadian University	Researcher*	3428A
	BC University	Researcher*	7492A
Civil Society	Policy Organization	Technical Director*	2394C
	Community Environmental Organization	President	3148C
	Community Environmental Organization	President	5547C
	Environmental Organization	Executive Director*	6318C
	Environmental Organization	Program Manager*	7602C
	Legal Organization	Staff Lawyer*	8831C
Federal	Federal Department	Biologist*	1225F
	Federal Department	Senior Analyst^{+}	1918F
	Federal Department	Director*	2564F
	Federal Department	Senior Biologist*	2706F
	Federal Agency	Senior Engineer*	8427F
Industry	Engineering Consultant	Engineering Manager*	4336I
	Insurance Company	Vice President*	5531I
	Engineering Consultant	Engineer	5733I
Municipalities	Municipality	Utilities Engineer*	1649M
	Municipality	Project Engineer*	2571M
	Municipality	Director^{+}	2844M
	Municipality	Engineering Manager*	3004M
	Municipality	Manager*	8398M
	Municipality	Sustainability Planner*	8502M
Other Government	Regional Governance Organization	Biologist	3632O
	Regional Governance Organization	Coordinator*	5827O
	Foreign Government	Trade Officer*	5858O
	Other Governance Agency	Manager*	6918O
Provincial	Provincial Authority	Coordinator*	3964P
	Provincial Authority	Regional manager	8493P
Subject Matter Expert	Research Institute	Director	4081S
	International University	Researcher^{+}	9968S

***** Discussed their own personal role(s) in the BBLD project

[+] Not included in analysis

Appendix D – Sample Interview Questions

Involvement with the case study in question (nature, extent)

- What was your role in this project?
- How did you become involved?
- How extensively were you involved, and since when?
- Have you found your collaboration on this project similar or different from other coastal adaptation projects?

Perception of barriers to nature-based solution implementation

- What do you think makes this project different from other coastal adaptation projects that you have worked on or seen?
- Would you say that there are barriers and/or enablers to implementing this kind of project?

Opinion on broader applicability of the collaborative process

- From what you saw of the process of collaboration here, what do you think are the advantages and disadvantages of working with so many different groups?
- If another municipality wanted to implement a nature-based coastal adaptation solution, what do you think they could learn from Surrey?
    - Project coordination, leveraging funding, having a project champion

Perspective on the collaborative process (description of process, definition of success)

- How would you define success for this project? What are the metrics of that success?
- What factors do you think will help the project to be successful, or stop it from achieving success?

Do you think this project could have happened 10 years ago?

Appendix E – Description of activities organized by role as outlined in Hilger et al. (2021)

Role	Activity	Further description (where required)	Example Coded Text
Application Expert	Test and adapt the project results in the application context	Actor was (or will be) involved in the application of the project, including adapting the project as necessarily based on preliminary findings.	"And then we are going to design and build the larger scale project based on what we learned in those experiments." (4336I)
	Apply process results or potentially introduce them into the decision-making process	Actor used (or will use) findings from the project to inform other projects or processes.	"…there's been some feedback that's been incorporated." (4336I)
Choreographer	Select and invite participants (to take part in the process)	Actor identified and/or invited potential participants to join the process.	"I have worked with [this individual]. I was involved in a publication with her. And so she invited me to be involved in the living dike." (1485A)
	Generally: organise and structure the process (and/or project)	N/A	"… the Emergency Planning Secretariat is, for the most part, running the process and deciding who is consulted and when, including ourselves." (4336I)
	Network with potentially relevant actors	Actor built or maintained relationships with potentially relevant actors through other projects, processes, or communication.	"…we do also actively sort of reach out to groups and like, I guess just myself, like, and other staff have, have made it a priority to you know, make it make that effort to, like, meet with people like yourself and sort of agreed to be part of research initiatives and in many cases, give letters of support and that kind of thing." (2571M)
	Review/discuss needs and expectations for the process/project	Actor communicated needs from and expectations of the project from their point of view as a stakeholder, or of the process from their point of view as a participant.	"Or not necessarily should be, but you know, what people's expectations are, or even just demonstrating what's possible, or setting precedent." (2571M)

Role	Activity	Further description (where required)	Example Coded Text
	Adjust the process design as a response to process developments	Actor incorporated feedback and modified the process.	"But some were just, basically the group was starting to grow, we had more of these regular people who attended. And at some point, we kind of realized that we needed to have a bit more of that distinct kind of, I think, like governance structure." (8502M)
	Write observation protocols or research diaries on the interaction	N/A	*No coded examples.*
	Involve participants/community in designing/developing the process	Actor solicited feedback on the process of project design.	"… there's clearly been a lot of work from the City of Surrey in terms of engaging multiple levels of regulatory and community stakeholders." (7602C)
	(Potentially) End collaboration or threaten to do so	N/A	*No coded examples.*
	Plan/develop the process or project with practice partner	Actor engaged with the planning or development of the process or project in collaboration with others.	"… we're not used to work so closely and share some of that decision making and governance with other partners on projects. Typically, you know, this is the projects that the city does, don't necessarily involve that many partners in such a collaborative way. It's usually the city needs to do something. And then we do consult partners." (8502M)
	Establish working structures for the project	Actor contributed to the development of set rules and expectations governing the process of collaboration.	"…working with the city of Surrey, actually, with a consultant that's that we're trying to share, that's a different, different part, right, having a single consultant across two jurisdictional boundaries" (1649M)
	Plan/develop the process or project without practice partner	Actor engaged with the planning or development of the process or project unilaterally.	*No coded examples.*

Role	Activity	Further description (where required)	Example Coded Text
	Negotiate the conditions of being part of the process	Actor set the boundaries for engagement for participants who were involved in the process.	*No coded examples.*
Communicator	Engage in informal communication	Actor engaged in informal communication, including personal communication between participants within or outside of the official process.	"And then we just we met quite regularly for coffee and asking him all these questions like, What could we do? How could we do it?" (8831C)
	Engage in formal communication	Actor engaged in formal communication, including the writing of official documents, participating in formal processes of engagement, or creating other authoritative communications.	"And we had a huge communications thing, a lot of CFAS was just communications." (3004M)
Coordinator	Lead the tr/td process or case study	Actor lead (officially or unofficially) the collaborative process or project itself.	"…it seems like the people who are running the working group discussions in the advisory consultation are the NGOs and not the city of Surrey." (1485A)
	Be the contact person for the project (coordinator)	Actor functioned as the officially recognized project proponent.	"…then kind of being a bit of a point person for the city, when they had requests that we needed to go through basically, kind of they went through me, but I wasn't necessarily providing comments on the design itself or the process like so much the process, so more so in a coordinating role." (8502M)
Data Supplier	Respond to surveys or interviews (be interviewed)	N/A	*No coded examples.*
	Provide information or data and support data collection	N/A	"…but the city actually set up monitoring equipment, we have video cameras watching the waves, 24 hours, the shoreline, we had our own monitoring system working with people there." (3004M)

Role	Activity	Further description (where required)	Example Coded Text
Facilitator	Moderate meetings or workshops	N/A	"And then as well sort of facilitate the roundtables and making sure that the people at the roundtable get a chance to review what's going on. (5827O)"
	Initiate and facilitate learning processes	Actor initiated and facilitated learning processes, including knowledge sharing between participants, site visits, and other learning opportunities either for themselves, select others, or all participants.	"I conducted two site visits with him to the field sites." (3964P)
	Build trust and confidence about the project and between actors	N/A	"…it really took us quite a long time to be able to put together that agreement…" (8502M)
	Balance different interests and potential conflicts	Actor made decisions that acknowledge the competing interests of various parties, including their own when applicable, and sought to balance considerations.	"But what I think the City of Surrey is doing really well is thinking about, well, what are all the benefits, the clean air, the biodiversity, clean water? The benefits to the coasts, you know, the coast itself, and what are the long-term ramifications of this?" (5531I)
	Bridge cultural and language differences	Actor bridged cultural and language differences between various groups, whether cultural, professional, or disciplinary to improve mutual understanding.	*No coded examples.*
	Encourage expressions of all viewpoints	N/A	"I guess, from my perspective, this is one way that we make change in a way that works for multiple groups, is that we bring lots of people to the table, we have lots of conversation, we work through problems together…" (5827O)
	Consider and balance power hierarchies and dynamics	Actor actively acknowledged and accounted for power hierarchies and	"And trying to do the work in a good way. But we have many... we have a lot of baggage from the colonial

Role	Activity	Further description (where required)	Example Coded Text
		dynamics in the process of collaboration and the project design.	system to contend with." (8831C)
	(Aim to) Empower process participants/community	Actor empowered or encouraged participants to contribute.	And then like, she was like, quite a big, like, opener of the box… I kind of just got more and more comfortable doing this type of stuff… I can't undo that that mentality once it's formed. (2571M)
	Organise meetings or workshops	N/A	"So we help to coordinate regular core team meetings…" (5827O)
	Provide space deliberately for critical reflection	Actor specifically instructed collaboration participants to engage in critical reflection within a set time frame.	*No coded examples.*
	Formulate future ambitions and follow up activities	Actor envisioned potential future outcomes or considered future impacts from the project or process, with or without concrete plans for bringing those outcomes about.	"And I'm really hoping things work out, we can do more widespread implementation." (1649M)
	Generally: facilitate and encourage knowledge integration	N/A	"So they, their goal, I guess, was to bring together folks with sort of similar interests, surrounding nature-based solutions, and the living dike project, to sort of act to promote that sharing of information and making sure everyone is on the first on the same page." (8427F)
Field Expert	Contribute (local) context-specific knowledge on a specific case	N/A	"…and so as, as someone who's looked at the site..." (1485A)
	Contribute experiential, tacit, or traditional knowledge	N/A	"…people bring in with different perspectives and especially in really important to have, like Indigenous partners to on this project some things that it's one of very few projects that, really,

Role	Activity	Further description (where required)	Example Coded Text
			we're so lucky to have their presence and their, them sharing their knowledge with us for this project…" (8502M)
	Provide contacts/access to persons in the field	N/A	*No coded examples.*
	Contribute strategic knowledge (organisational, functional, network)	Actor contributed to the project's strategic knowledge of the physical, social, or regulatory landscape.	"…what is like, would that be something that we would, you know, authorize? Is that something that we're going to provide advice on is strictly, you know, the construction and the potential…" (1225F)
Intermediary	Mediate between different perspectives and viewpoints	Actor sought to increase mutual understanding between themselves and others, or between other participants, by sharing perspectives and viewpoints.	"… so I guess my role at that stage was kind of describing some of the… needs, the… mandate, ensuring that any of these projects would reach that and also providing support from the… managers." (3964P)
	Guide/apply integration methods/workshop techniques		"When we started, we had no idea where we wanted to head to but we didn't really know. So we kind of let the process kind of was very fluid. And it changed as we were going through it, especially the engagement parts and things like that." (3004M)
	(Aim to) Give affected or underrepresented people or groups a voice		"From the point of view of the way it's been handled, again, through the roundtable, because West Coast Environmental very well, and the people running the roundtable are very much- of whether they're First Nation, they're supported by First Nations, or they have a direct relationship with First Nations." (2564F)

Role	Activity	Further description (where required)	Example Coded Text
	Make thought styles or different perspectives explicit	N/A	*No coded examples.*
	(Aim to) Integrate different thought styles	N/A	"I guess the only thing is, I would like to see, one of the things we'd like to do more is to decolonize our approach a little bit right now…. But in the future, we want to sort of have this have the project partners determine how we meet and how we, how we move forward in our process…" (5827O)
Knowledge Collector	Collect data (e.g. interviews, observations, surveys)	N/A	"They're collecting wave data and tide data over the course of a year." (3096A)
	Document and present the knowledge brought into the process	N/A	"It's a new technique for here on the on the Pacific coast and that's, that's going to be super exciting to document how and also be able to utilize that information and share it so that perhaps we can do this in other… places." (6318C)
	Participatory observation of the field and its developments	Actor gathered and reflected on knowledge being generated by the process or project as an active participant in the process, situating it in broader context.	"And, like, it's not really a lesson learned, but just the general capacity of the industry, whether it be construction, or like, greenhouse production, and the consulting industry, insurance industry, like, all those regular regulatory, like, you know, decision makers, like everyone is learning from this project that the next your section to follow will have, you know, access to." (2571M)
Knowledge Co-producer	Discuss (final) results and/or derived recommendations	Actor was involved in a retrospective discussion on the results of the project or process, including the development of recommendations	*No coded examples.*

Role	Activity	Further description (where required)	Example Coded Text
		deriving from those results.	
	Contribute or discuss a suggested solution or strategy	Actor contributed or discussed a solution or strategy relating to overcoming a challenge encountered in the planning or design. This includes both tangible and process solutions and strategies.	"But I have been privy to a number of meetings where we have discussed next stages and where the where the project should go." (3428A)
	Select, discuss, or develop research methods/instruments	Actor selected, discussed, or developed options relating to the implementation of the project, including methods, tools, instruments, or processes.	"And those metrics helped us like, prioritize, like how we designed the pilot experiment, but it's very focused on the pilot." (2571M)
	Contribute own view/opinion/interpretation of the case/scenario	Actor voiced their view, opinion, or interpretation of a situation as an individual, apart from their official role if applicable.	"And I think some people from the province as well, who were just kind of more of their own interest, wanted to be a part of to see where this is going, but not necessarily there to represent their organization or weren't able to necessarily comment on any sort of regulatory stuff." (8502M)
	Be involved as a potentially affected person/group	Actor engaged with the process or the project as an individual or member of a group that may be affected by the outcomes of that process or project.	"And then Semiahmoo First Nation has reserve lands in Boundary Bay or Mud Bay. So they're involved in pretty much every meeting as a partner." (4336I)
	Agree on a common problem focus/problem perception	N/A	"… the [province] has recognized, there is a big need for trying things out. And thus, the need for a pilot project, you know, where we don't have everything sorted out there is a certain degree of risk for these ecosystems." (3964P)
	Define or agree on process/research goals	N/A	"So the roundtable is sort of like the higher level kind of group, I guess, that meets and

Role	Activity	Further description (where required)	Example Coded Text
			looks at the big ideas and the directions." (8831C)
	Discuss and validate (preliminary) research results	Actor discussed or validated preliminary results of a project or process, possibly with a view toward adjustment if necessary.	*No coded examples.*
	Engage in a visioning process or share a vision	Actor engaged in a visioning process or shares a vision, either independently conceived or collaboratively.	"And it was also a test area. So we could expand this, depending how it works in the future, could be expanded to other areas of the bay." (3004M)
	Develop and bring ideas to the process	Actor contributed ideas and suggestions for the process or project. This could include ideas relating to either the technical or process components.	"And then then there was a proposal phase where we actually proposed specific ideas and how much it would cost and that kind of stuff within our proposals." (5733I)
	Define or agree on a common research question	N/A	*No coded examples.*
	Generally: contribute knowledge (not further specified)	N/A	"Present at this meeting, talked to the engineering firm, who essentially said, oh, yeah, we'd love to see your data."
	Generally: engage in knowledge co-production processes	N/A	"… so there's been a couple of, a couple of ministries that have come to the table…" (5827O)
Practice Expert	Contribute expertise and application-oriented knowledge	Actor contributed application-oriented knowledge or expertise derived from practical experience.	"My collaborators and I… we've been working for the last 20 years in implementing these types of solutions… perhaps they saw value in the experience that I have…" (3428A)
	Engage in or support an experiment/a real-life change	N/A	"…we're experimenting with different methods to build salt marsh…" (4336I)
Results Disseminator	Translate and disseminate results and raise awareness	Actor aimed to communicate results effectively to various audiences and raise	"… the ultimate goal of our research is to generate guidance that will be, you know, the communities across Canada can use, right, so to

Role	Activity	Further description (where required)	Example Coded Text
		awareness about the project or process.	take the lessons learned from the work of the living dike and to disseminate that to other communities." (8427F)
	Produce policy-relevant knowledge, recommendations, or tools	Actor used, or planned to use, policy-relevant knowledge gained through their involvement with the project or process to inform policy recommendations or develop tools.	"So having a study that comes out of it so that this project, and the benefits associated with it, can be shared with cities around Canada and other investments that Infrastructure Canada is making and provincial governments are making to do natural infrastructure projects so those investments are protected and more resilient to the the impacts of extreme weather and other adverse events." (5531I)
	Participate in writing popular science articles or reports (PR)	N/A	*No coded examples.*
Scientific Analyst	Contribute scientific knowledge (based on analysis)	Actor contributed scientific (including technical or theoretical) knowledge.	"And as a scientist who's worked in the area, I don't think he's correct at all." (1485A)
	Evaluate the process, project, or intervention	Actor used scientific (technical, theoretical) to evaluate the process, project, or intervention	"…there is a student that helped with I think you saw that helped do some work on the wave tank." (7492A)
	Carry out a system or actor analysis	N/A	"And then later, another group, a lot of different groups found out we were going to implement this, and they started tagging on to like this monitoring committee out of the Feds and different things like that. So it's kind of bloomed over the years…" (3004M)
Self-Reflexive Participant	Generally: engage in a process of (self-) reflection	Removed for the purposes of this paper.	
	Self-reflect upon own normative orientation		
	Self-reflect upon internal and external power dynamics		

Role	Activity	Further description (where required)	Example Coded Text
	Raise/thematise roles and self-awareness		
Troublemaker	Maintain previous relationships and conflicts with others	Actor was antagonistic toward other process participants.	"But the roundtable really pushed us to say, 'No way that's completely wrong, what's been put forward. So you need to essentially start over'." (2571M)
	Negotiate and contest rules of interaction	Actor contested the rules of interaction as defined by the choreographers and the other participants.	"…we're going against provincial regulations…" (3004M)
	Obstruct the supply, use, or extraction of data from the field	N/A	"…in some ways, I guess in other ways, you could frame it as an opportunity, like, it was enough that we kind of paused this project for a few years." (2571M)