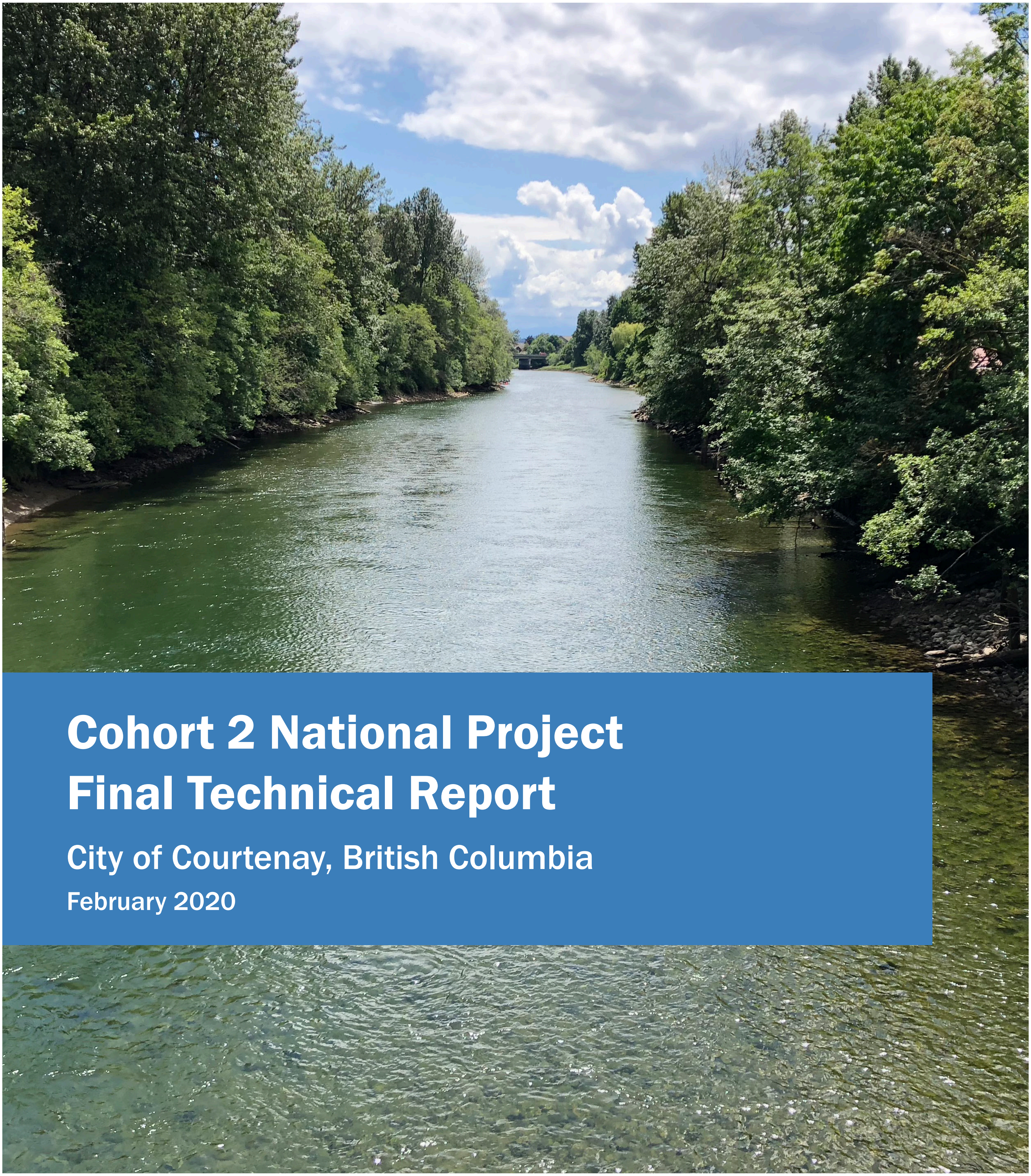

Cohort 2 National Project Final Technical Report

City of Courtenay, British Columbia

February 2020

Municipal Natural Assets Initiative

Mnai

Making Nature Count

INVEST IN NATURE

The Municipal Natural Assets Initiative (MNAI) is changing the way municipalities deliver everyday services, increasing the quality and resilience of infrastructure at lower costs and reduced risk. The MNAI team provides scientific, economic and municipal expertise to support and guide local governments in identifying, valuing and accounting for natural assets in their financial planning and asset management programs and developing leading-edge, sustainable and climate resilient infrastructure.

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Cover Photo: MNAI

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Summary

The term "municipal natural assets" refers to the stock of natural resources or ecosystems that is relied upon, managed, or could be managed by a municipality, regional district, or other form of local government for the sustainable provision of one or more local government services (MNAI, 2017). Communities like the City of Courtenay recognize that it is as important to understand, measure, manage and account for natural assets as it is for engineered ones. The City of Courtenay applied to take part in the Municipal Natural Assets Initiative (MNAI) project to increase their understanding of the current and possible future roles of natural assets in the Courtenay River corridor in mitigating flood risks in the downtown core.

The City of Courtenay lies on the east coast of Vancouver Island in British Columbia within the traditional lands of the K'ómoks First Nation. The City is located at an estuary. The Tsolum and Puntledge Rivers converge into the Courtenay River, which flows into the estuary. The low-lying areas near the rivers and estuary comprise the flood plain, which is subject to both riverine and tidal flooding. Historically, much of the development of the City occurred in the floodplain and the City has a history of flood events. The goal of the Courtenay MNAI project was to understand the current and possible future roles of natural assets in the Courtenay River corridor in mitigating flood risks in the downtown core, including associated costs and benefits relative to engineered alternatives.

Modelling was completed to simulate the impact of three options for flood mitigation from natural assets: widening the Courtenay river; naturalization of a former sawmill site (referred to as the Kus Kus Sum project); and re-instating natural flow paths in the Courtenay river. These options were modelled individually and in combination. Managed retreat to remove at risk buildings from the floodplain was also considered. Two flood events were simulated. Flood Event A is based on the 2009 flood conditions. Flood Event B is based on 1:200 year flood events in Tsolum and Browns Rivers, maximum release rates in Puntledge river, Medium Water Large Tide conditions, and no storm surge of climate change.

The project found that in the case of Flood Event A, natural asset improvements reduce flood damages by $723,000. Considering the larger, more extensive Flood Event B, natural asset improvements reduce flood damages by $2.4 million. The assessment of the retreat option examined the cost of relocating any building impacted by the Flood Event A. The total assessed value of impacted properties is estimated at approximately $6.8 million dollars.

This project demonstrates that natural asset solutions can play an important role in flood management, however, in this case, such solutions are not sufficient alone. Natural asset solutions need to be considered as part of a comprehensive and phased flood management strategy for the City that assesses and prioritizes the use of a wide range of strategies, including: natural assets, engineered assets such as dikes, and soft-path options like bylaw or policy changes to incorporate flood accommodation or managed retreat.

Introduction

The term "municipal natural assets" refers to the stock of natural resources or ecosystems that is relied upon, managed, or could be managed by a municipality, regional district, or other form of local government for the sustainable provision of one or more local government services (MNAI, 2017). By conceptualizing nature as an asset, we can codify, measure, and monitor the ways in which we depend on and impact the environment. Business and economic activity depends on natural assets to provide important inputs into production such as clean water, minerals, and timber. Natural assets are also important to human physical and social well-being. Benefits in terms of better air quality, water quality and climate stability as well as protection from flood and erosion impacts of extreme weather events are well established. Urban greenspaces, parks, wetlands and protected areas provide important recreation spaces and buffer the effect of extreme heat in urban settings reducing the prevalence of respiratory infections and heat related illnesses. If natural assets are not managed responsibly, their value depreciates as does their ability to provide services from which humans benefit. Indeed, like any asset, natural assets need to be carefully managed to ensure a sustainable supply of services.

Communities like the City of Courtenay recognize that it is as important to understand, measure, manage and account for natural assets as it is for engineered ones. The City of Courtenay applied to take part in the Municipal Natural Assets Initiative (MNAI) project to increase their understanding of the current and possible future roles of natural assets in the Courtenay River corridor in mitigating flood risks in the downtown core. This report summarizes the results of the Courtenay project. It is organized as follows:

- This **Introduction** chapter describes the project objectives, the project area and provides a brief overview of the relevant natural assets.
- The **Approach** chapter describes the modelling approach that was employed to assess the contribution of the natural assets to flood mitigation as well as key data sources that informed the analysis.
- The **Natural Assets Assessment** chapter describes the quantity and condition of natural assets in the project area.
- The **Planning for Natural Assets** chapter provides direction on how to manage the natural assets for improved flood attenuation.
- The **Implementation of Natural Assets Plan** chapter describes specific actions that should be considered as a natural asset plan to protect the natural assets of interest.
- The **Conclusion** chapter summarizes the important findings and outcomes of the project and articulates next steps and key priorities for the City of Courtenay.
- **Appendices** at the end of the report contain additional information of relevance to the project and associated outcomes.

Project Context

The City of Courtenay lies on the east coast of Vancouver Island in British Columbia within the traditional lands of the K'ómoks First Nation, situated 108 kilometers northwest of Nanaimo. It is the largest community in the Comox Valley, supporting a population of 25,559 (Comox Valley Regional District, 2019). As the economic hub of the regional district, it hosts a vibrant and growing business community, an arts centre, and is a destination for recreational activities.

History of Flooding

The City is located at an estuary. The Tsolum and Puntledge Rivers converge into the Courtenay River, which flows into the estuary. The low-lying areas near the rivers and estuary comprise the flood plain, which is subject to both riverine and tidal flooding. Historically, much of the development of the City occurred in the floodplain and the City has a history of flood events.

Climate change is expected to increase the frequency and magnitude of flooding, as precipitation patterns change and sea levels rise. Throughout the last 10 years, increased flooding in the Courtenay River system has demonstrated local vulnerabilities, and the need to assess and improve existing levels of flood protection. Flood events in 2009, 2010 and

2014 affected key transportation corridors, Lewis Park, the Ryan Road commercial area, and other private and public properties.

In response to the flood events in 2009 and 2010, the City conducted a Flood Management Study in 2012/2013, funded by a grant from Emergency Management BC. This study included an analysis of flood flows and tide levels at various flood return-periods.

Flooding tends to occur in the downtown core with flood events greater than 1:20 years. Preventing damages from present-day and far greater 1:200 year flooding events will take a concerted large-scale, community-wide effort. The figure below depicts 2014 flooding in the downtown area.

The City experiences multiple flooding scenarios including those resulting from:

- high tides / storm surges coming inland,
- high water flows coming downstream as a result of precipitation, and
- river flows influenced by BC Hydro dams

These events can happen simultaneously during winter months or individually. Practically, this means that flooding can come from upstream or downstream of the business district.

Figure 1: 2014 flooding in downtown Courtenay, BC.

Orthographic information suggests that the flow of the river has been constrained and diverted from its historical trajectory. This may contribute to the scale and nature of the flooding and also present options for its relief.

Previous Flood Management Work

The 2013 Flood Management Study[1] (the Study) assessed three engineered infrastructure options (dikes) to mitigate flood impacts. The options focused on providing flood protection for the Ryan Road commercial area. They are:

1. Tsolum River flood wall: a constructed floodwall to provide protection for smaller and more frequent events (1:20 to 1:50 year events) but not protection for the larger 1:200 year event.
2. Ring dike: raising old island highway and Highway 19A to provide improved flood protection for extreme events (1:200 year event). Properties outside the dikes would require managed retreat, and the dikes may create increased flood depths upstream.
3. Partial ring dike option: similar to the ring dike (option 2 above), with the addition of a floodway over Comox Road. The floodway would allow overland flooding to neighbouring agricultural lands.

The Study did not model the impacts of natural solutions for flood mitigation, such as providing alternate river flow paths or channel widening. Stakeholder consultation conducted during the study demonstrated strong interest in natural flood management solutions.

1 City of Courtenay, 2013

Opportunity for Natural Assets

The City has focused on building a strong asset management program for several years. Thus, it wanted to participate in the MNAI project as an opportunity to build upon the 2013 Flood Management Study and learn more about the potential benefits of natural assets for flood management.

The overall goal of the City is to minimize current and predicted future flooding in the downtown core, thereby minimizing damages and losses. This will be achieved through the development of actionable plans that incorporate both natural and built assets. The MNAI project is positioned within the context of this broader effort.

Natural Asset Focus

The Courtenay River, in particular the parts that transit the downtown core of the City, is the primary natural asset of interest. Various areas of the river have been channelized by construction of an ad hoc mix of privately and publicly owned dykes, berms, seawalls and two sets of bridge abutments.

Specific questions that were explored through the MNAI project with the City of Courtenay include:

- Whether the Courtenay River geometry can be changed/improved to reduce flooding risks.
- Whether the Courtenay River can be widened and/or whether natural asset storage capacity can be added along the river or in Lewis or Simms parks.
- What prospects there are to accommodate/channel overland flooding using a natural asset approach.
- How the cost of employing a natural asset approach compares to strictly engineered solutions.

Project Goal and Objectives

The City of Courtenay wants to reduce flood risk in the Courtenay River Corridor and understand the potential role, and associated costs and benefits, of natural assets in doing so.

Accordingly, the goal of the Courtenay MNAI project was to understand the current and possible future roles of natural assets in the Courtenay River corridor in mitigating flood risks in the downtown core, including associated costs and benefits relative to engineered alternatives.

The objectives of the project were to identify/prepare:

- An inventory of natural assets in the project area and potential for actions that would enable them to reduce flood risks.
- A capital cost calculation for natural assets within the identified area.
- An operating cost calculation for flood attenuation services from natural assets within the identified area (e.g. maintenance, monitoring and operating).
- Scenario analysis to determine the marginal change in flood attenuation services associated with changes to land use and/or environmental management, and future climate scenarios.
- A comparison of the value of flood attenuation services provided by natural assets (including wetland water storage and groundwater infiltration) under different planning scenarios and/or environmental management scenarios.
- Project outputs in a format that can support related modelling and decisions (e.g. aquifer protection, flood mitigation).
- How the project findings can be scaled to other relevant areas.
- Strategies and approaches for natural asset management that deliver reliable and cost-effective services.
- A public report and related communications materials.

This project was undertaken in parallel with a number of other initiatives at the City, including a flood management and mitigation project, and the development of an integrated rainwater management plan. In addition, master plans for sewer, water, transportation, and recreation and culture were underway and were anticipated to be finalized in 2019. The MNAI technical team worked closely with Urban Systems, the company completing modelling for some of these other initiatives. As the timelines for the flood management and mitigation study and the integrated rainwater management plan are dictated by City Council input and approval are thus longer than the timeline for the MNAI project, the modelling for the MNAI project, which relied upon the outputs of Urban Systems' modelling, progressed slower than originally anticipated. This report presents early modelling results and economic valuation findings to inform these ongoing initiatives.

Project Approach

This section of the document describes the approach employed for the City of Courtenay MNAI project. An overview of the MNAI approach is provided along with a more detailed description of the modelling work that was completed.

MNAI Approach

MNAI's natural asset methodology is rooted in modern, structured asset management processes. The methodology generally follows the standard asset management assess, plan and implement steps, highlighting novel considerations required for local natural assets and associated services.

MNAI has a range of tools, including templates and guidelines, that are configured for use according to local government needs. The methodology and tools are delivered through ongoing support from the MNAI technical team over the project life. The levels and details of this support are described in a Memorandum of Understanding that MNAI signs with local government partners.

Asset management strategies require a multi-disciplinary, team-based approach. The MNAI process begins with an initial engagement session with community representatives from across a range of disciplines. This includes, for example, representatives from Parks, Public Works, GIS (Geographic Information Systems), Engineering, Planning, Water and Wastewater, and Finance. During the initial engagement session, plans and priorities of the community are discussed, and key natural assets within the jurisdictional boundaries of the community are identified along with the important services they provide. Site visits to the natural assets may be undertaken and key geospatial features observed and documented. The objectives of this initial engagement session are to identify:

- the natural asset/s that will be the focus of the MNAI project,
- the geographic boundary(ies) of the focus assets,
- the skillsets and expertise of relevance to the natural asset assessment,
- community personnel that will engage in the assessment process, and
- data needs of the assessment and the sources for the relevant data.

The initial community engagement session for the City of Courtenay project took place on June 1, 2018. It was attended by representatives from numerous departments including Engineering, Recreation and Culture, Asset Management Technical Services, and Public Works, as well as representatives from Urban Systems. Appendix A contains the agenda for the session along with a list of participants. At the completion of the session, the focus on the role of natural assets in supporting flood attenuation along the Courtenay River corridor was established.

Following the initial community engagement session, the MNAI team works with the target community to complete as a first step natural asset assessment, which generally involves:

1. Defining the scope of the natural assets.
2. Inventorying the natural assets by collecting and organizing existing information about the assets.
3. Conducting a condition assessment of the assets.
4. Conducting a risk assessment of the assets.
5. Quantifying existing service levels from the assets.
6. Developing scenarios to explore alternative management plans and future implications to existing service levels.
7. Quantifying service levels under alternative scenarios.
8. Developing operation and management plans based on existing conditions, risks, and desired service level trajectories.

The steps above were completed for the City of Courtenay with a focus on flood attenuation. The asset inventory was informed by existing conditions along the river seawall, dykes and banks. The task of defining the alternative management scenarios and future implications to existing service levels were conducted in consultation with City and Urban Systems. The modelling was completed by Urban Systems and utilized to quantify the service levels under the alternative scenarios (step 7 above) as described below.

Modelling Approach

The modelling objective was to understand and quantify the current services provided by natural assets in the project areas and the potential for flood risk reduction by increasing their function, for example, by naturalizing the Courtenay River floodplain area that transects the City of Courtenay. MNAI utilized modelling completed by Urban Systems as part of the City's ongoing flood management and mitigation study. The modelling work led by Urban Systems is reviewed below and is followed by the MNAI modelling approach.

The flow dynamics in the three rivers and the estuary are complex, and flood conditions incorporate several variables:

- flow events in the Tsolum, Browns, and Puntledge Rivers,
- tide conditions [Note: MWLT = Tide of Medium Water Large Tide; HHWLT = The average of the highest high waters, one from each of 19 years of predictions],
- storm surge, wind conditions, and wave run-up, and
- climate change (likely to impact precipitation and riverine flow levels, sea levels, and wind/wave run-up).

These variables can be combined in many ways, leading to several scenarios for analysis (Table 1).

TABLE 1 – SCENARIOS FOR PRELIMINARY PERFORMANCE MODELLING

	Tsolum River	Browns River	Puntledge River	Tide	Storm Surge / Wind / Wave	Climate Change
Scenario 1A	1:200 year	1:200 year	Max Release Rate	MWLT	No	No
Scenario 1B	1:200 year	1:200 year	Max Release Rate	MWLT	No	Yes – Flow and Tides
Scenario 2	1:200 year	1:200 year	Max Release Rate	HHWLT	No	No
Scenario 3	1:200 year	1:200 year	Max Release Rate	HHWLT	No	Yes – Flow and Tides
Scenario 4	1:200 year	1:200 year	Max Release Rate	HHWLT	Yes	Yes – Flow and Tides
Scenario 5	Observed 2009 Event	Observed 2009 Event	Observed 2009 Event	Observed 2009 Event	N/A	N/A
Scenario 6	Observed 2010 Event	Observed 2010 Event	Observed 2010 Event	Observed 2010 Event	N/A	N/A
Scenario 7	1:50 year	1:50 year	1:50 year	HHWLT	Yes	Yes – Tides
Scenario 8	Observed 2014 Event	Observed 2014 Event	Observed 2014 Event	Observed 2014 Event	N/A	N/A

The flow and tidal conditions developed in the 2013 Flood Management Study were used for initial performance evaluation of the natural asset solutions. The preliminary performance modelling indicated that even the full combination of natural asset solutions (with the exception of managed retreat) resulted in only minor reductions in the total extents or depths of flood when considering the 1:200 year events.

Based on these preliminary results, two flow scenarios were selected for further performance and economic modelling: scenarios 1A and 5.

Scenario 1A was selected to evaluate the performance of the natural asset solutions in an extreme event situation. This scenario was selected because it represents an extreme event (the 1:200 year return period for river flows) but not the most extreme event (does not include the high-high water level tide or climate change).

Scenario 5 was selected to evaluate the performance of natural asset solutions in a smaller and more frequent flood situation. Scenario 5 represents the observed 2009 flood event, which is recent enough to provide a tangible understanding of how the natural solutions would impact flooding in the city.

Natural Asset Options Assessed

Four options for flood mitigation from natural assets were identified for assessment:

1. **Courtenay River widening:** This option requires removal of existing sheet pile dikes and sloping the banks of the Courtenay River to widen and naturalize the full length of the river channel. This option would potentially allow for additional water storage and conveyance capacity to the estuary, while also reducing some of the City's responsibilities for maintaining the existing dikes.
2. **Kus Kus Sum:** This option involves the naturalization of a former 3.36 hectare sawmill site to reinstate the natural foreshore and water flow paths (a project known as Kus Kus Sum). This project is currently being led by the K'ómoks First Nation, the City of Courtenay and Comox Valley Project Watershed Society together with Interfor Corporation (who currently owns the property). There are many environmental and social benefits related to this project, but specific benefits to flood mitigation have not been modelled. Kus Kus Sum could potentially allow for additional water storage and conveyance capacity to the estuary.
3. **Re-instate natural flow paths:** As identified previously, much of the historic development in the City occurred in the flood plain, leading to channelization and in-fill of the Courtenay River. This option involves opportunities for re-instating natural flow paths or connecting new flow paths. This option could potentially allow for additional conveyance capacity to the estuary.
4. **Managed retreat:** This option involves a gradual managed retreat of the full impacted floodplain over time, and allowing only land uses compatible with flooding in the floodplain. It would require extensive land acquisition and remediation but would mitigate undesirable impacts of flooding.

Although the options are described separately, they can be combined. This project evaluated each of the options separately as well as the first three options combined to understand the full extent of benefits that could be achieved through natural asset solutions.

The flood modelling conducted by MNAI produced flood depth surface outputs for a series of flooding scenarios. For the scenario analysis, the following two flood events were defined:

1. Flood Event A - based on the 2009 flood conditions.
2. Flood Event B - based on the following assumptions:
    a. 1:200 year flood conditions in Tsolum and Browns Rivers
    b. Puntledge river under maximum release rates
    c. Tide of Medium Water Large Tide (MWLT)
    d. No storm surge and no climate change

From these two flood events, four flood depth surfaces were developed to create the following scenarios:

- Flood extents and depths under current conditions for a Flood Event A.
- Flood extents and depths with natural asset solutions implemented for the 2009 flood event. The natural asset solutions assumed were:
  - A 20m widening of the Courtenay River. This width was based on removing existing sheet-pile dikes and sloping the sides to a 1:1 slope,
  - Naturalization of the Kus-Kus-Sum property, and
  - Addition of a diversion channel from the end of small craft harbour along Lewis Park.
- Flood extents and depths under current conditions for Scenario 1A flood event.
- Flood extents and depths under current conditions for Scenario 1A flood event with same natural asset solutions as above.

A fifth scenario was also defined assuming retreat and relocation of properties impacted by the 2009 flood event. In this scenario, no additional flood depth surfaces were required. However, this scenario would significantly mitigate flood risk, while providing an opportunity to improve the natural assets within the City of Courtenay.

Natural Asset Assessment

This section of the report presents the results of the assessment of natural assets within the City of Courtenay project area. As is noted in the Approach section, the natural asset assessment process begins with the completion of an asset inventory.

Asset Inventory

An asset inventory was developed for the section of the Courtenay River and related floodplain that transit the City of Courtenay. The inventory considers natural and built assets within the Courtenay River-shed that increase water storage and reduce total and peak water flows during rainfall events to prevent flooding of the downtown core and Lewis Park Commercial Area. Figure 1 above shows the impact of the 2014 flood on the Lewis Park Commercial Area.

Within the City of Courtenay there are limited wetland or riparian areas that can provide flood water storage. Restoring existing riverbanks and flattening riverbank slopes have been identified as opportunities to improve flood water control. Figure 2 distinguishes natural riverbank and retainer wall/dike zones along the sections of the Courtenay River that are prone to the most frequent flooding. Along the identified riverbank, 1,292 meters are seawall or dike and 2,116 meters are natural riverbank. Table 2 provides a basic inventory of the engineered infrastructure along the river corridor.

While a condition and risk assessment are generally completed as part of the MNAI process, in the case of the Courtenay project, they were not deemed necessary at this time.

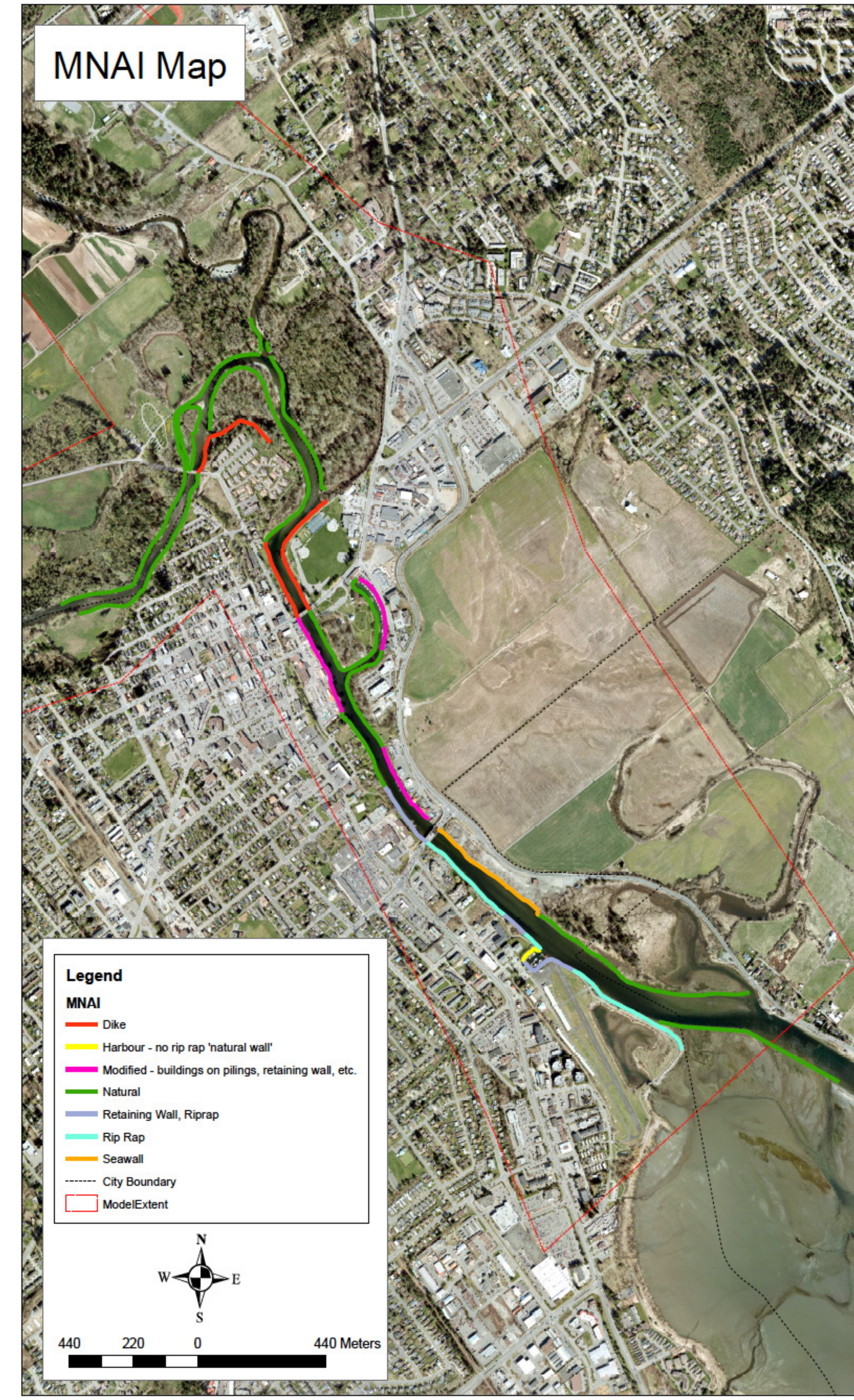

Figure 2. Courtenay River, riverbank, flood prone section

TABLE 2 - DIKE, SEAWALL, RIP RAP INVENTORY		
Asset component	**Description**	**Comments**
South of 17th street bridge	Former sawmill site, seawall	The sawmill site expanded the Property over 20 years ago. The sea-wall was built approximately 3 years before the site was closed.
North of 17th street bridge	Commercial zone, parking lot and buildings adjacent to the river edge, dike	
Wharf	Alongside Comox road	Old gabion block construction
Seawall, Lewis Park	Seawall starting on the North side of 5th street bridge and running along Lewis Park	
Anderton Dike Wall	North of 5th street bridge, runs along Anderton Avenue	Rip rap buttress placed in 2016. The Kona Hostel and Anderton Arms Apartments are located beside the bridge.
3L Development Dike	West of the Condensory Bridge (South side of Puntledge River)	
Private Dike	East of the Condensory Bridge (south side of the Puntledge River)	Built as part of the private development.
South of 5th Street Bridge		Three structures built on pilings.

Flood Control Benefits

This section summarizes the modelling analysis that quantified the flood control benefits provided by the natural features within the floodplain of the Courtenay River that transect the City of Courtenay. Based on the modelling approach summarized in Section 2, a series of flood depth surfaces were provided by Urban Systems.

TABLE 3 – NATURAL ASSET INFLUENCE ON FLOOD CONDITIONS			
Scenario	**Total flood extent area including the area of the river (ha)**	**Number of properties affected**	**Area of properties affected (ha)**
Current conditions under Flood Event A	116.5	18	8.4
Naturalized conditions under Flood Event A	96	12	7.7
Current conditions under Flood Event B	192.9	49	21.2
Naturalized conditions under Flood Event B	187.2	44	19.8

While the flood extents are not significantly impacted by the natural solutions, there is some reduction in depth which translates to fewer properties impacted (6 fewer for Flood Event A and 5 fewer for Flood Event B). Fewer properties and lower flood depths result in flood damage reductions, which are summarized in the next section.

Valuation of Flood Control Benefit

This section of the document summarizes the estimated flood damages that could be avoided if natural asset improvements are made throughout the Courtenay River floodplain within the City of Courtenay.

Flood depth surfaces provided by Urban Systems for Flood Events A and B, with and without natural asset improvements, were overlaid with building footprint data available from the City of Courtenay. Table 4 summarizes the relevant data sources. Using this information, for each building impacted by flooding, the average flood depth within the building footprint was calculated. The main floor of each structure was assumed to be 200 mm above the LiDAR ground surface estimated using Google Streetview. Data on the presence or absence of basements for each flooded building was not readily available. To ensure conservative valuation estimates, buildings were assumed to have no basements. Therefore, valuation estimates should be assumed to be a lower bound. Depth-damage curves from the "Provincial Flood Damage Assessment Study" for the Government of Alberta (IBI Group, February 2015) were used to estimate the damages to structures and contents for each building. The curves show the replacement costs, expressed in dollars, as a function of flood depth for a wide range of building types. Note that this approach does not explicitly account for the assessed property values – it estimates damage costs as a function of flood depth.

TABLE 4 – DATA SOURCES USED TO SUPPORT THE FLOOD DAMAGE ASSESSMENT		
Data Item	**Description**	**Source**
Building footprints	Building footprints established from Lidar data. Spatial data depicting the surface boundaries of buildings within the City.	City of Courtenay Open Data: https://data-courtenay.opendata.arcgis.com/datasets/buildingfootprints
Zoning	City of Courtenay Zoning Bylaws. Spatial data defining what type of land use is permitted and where (e.g. residential, commercial, industrial, etc.).	City of Courtenay Open Data: https://data-courtenay.opendata.arcgis.com/datasets/zoning-map
Depth-damage curves	Structural damage curves indicate the cost to repair the structure, based on the flood depth. Contents damage curves indicate the cost to replace the damaged contents, based on the flood depth.	IBI Group (February 2015). "Provincial Flood Damage Assessment Study" for the Government of Alberta.
Ground elevation	Lidar generated estimates of the ground elevation within the City of Courtenay.	Provided by Urban Systems
Flood depth surfaces for the 4 flood scenarios	Model generated outputs defining the depth of flood above ground elevation across the entire flood extent area.	Provided by Urban Systems

Tables 5 and 6 summarize the results of the flood damage assessment. In the case of Flood Event A (the 2009 flood conditions), natural asset improvements reduce flood damages by $723,000. Considering the larger, more extensive Flood Event B, natural asset improvements reduce flood damages by $2.4 million. While the natural asset improvements defined in these scenarios do not solve the flooding issues faced by the City of Courtenay, they do serve to provide some damage reduction. This avoided damage can be interpreted as the flood control benefits provided by the natural assets.

TABLE 5 – SIMULATED FLOOD DAMAGES FROM FLOOD EVENT A	All properties including KFN properties	Properties excluding KFN properties
Estimated Damage for Current Conditions	$1,896,000	$1,519,000
Estimated Damage With Natural Asset Improvements	$1,173,000	$796,000
Contribution of Natural Asset Improvements	$723,000	$723,000

TABLE 6 – SIMULATED FLOOD DAMAGES FROM FLOOD EVENT B	All properties including KFN properties	Properties excluding KFN properties
Estimated Damage for Current Conditions	$11,735,000	$9,740,000
Estimated Damage With Natural Asset Improvements	$9,319,000	$8,110,000
Contribution of Natural Asset Improvements	$2,416,000	$1,630,000

Given the significant flood risk exposure to built assets within the City of Courtenay, a managed retreat and relocation of the built environment would dramatically reduce flood risks. This was the focus of the 5th scenario. In this scenario, it was assumed that any building impacted by the Flood Event A (the extent and depth of the 2009 flood) would be relocated. The total assessed value of impacted properties is approximately $6.8 million dollars. This is a rough indication of the cost to purchase these properties. These properties represent a total of 8.4 ha of land that could be naturalized under the retreat scenario.

Additional costs associated with this scenario include:

- demolition costs,
- costs of reconstruction outside of flood risk zones (however, the purchase of the existing properties should provide significant capital to property owners to offset some of the reconstruction costs), and
- naturalization costs

Natural Asset Co-benefits

It is important to consider co-benefits when incorporating assets into an asset management plan. Economic and policy decisions that focus narrowly on the economic trade-offs between conventional infrastructure and natural assets may overlook a number of benefits associated with natural assets. While time and capacity restrictions did not allow the City to identify relevant co-benefits for the natural assets under consideration, such co-benefits likely include access to green and recreational space for residents, hydraulic detention, and water quality functions. A summary of other important benefits offered by rivers and riparian buffers is provided in Appendix B and is adopted from The Economics of Ecosystems and Biodiversity (TEEB) 2009; Daly and Farley, 2004; and de Groot 2002.

The estimated values presented in this document only account for the cost of providing equivalent flood management services with engineered assets. A more detailed analysis of co-benefits would identify trade-offs in flood protection for future community discussions. For example, returning some portions of the river corridor to its natural condition may reduce recreational opportunities.

Planning for Natural Asset Management

As discussed in the Project Goals and Objectives section, the City of Courtenay's flood management and mitigation study and integrated rainwater management plan are in development. As such, the City is still exploring a range of options for the best approach to mitigate flooding in the project area.

This analysis demonstrates that natural asset improvements alone are not sufficient to significantly reduce flood risks for the City. Engineered and natural asset management strategies are required, with three options being possible:

1. Option A: Fully engineered - Ignore natural assets, and focus solely on major engineered flood protection infrastructure.
2. Option B: Engineered and Natural approach - Leverage natural assets to the extent possible to minimize the level of engineered flood protection required.
3. Option C: Full Natural approach (i.e. retreat/relocation) - Invest significantly in restoring the natural floodplain by retreating/relocating in the areas of the City that are at the greatest risk.

Recommendations for completing a broader economic assessment of the options are articulated below.

Option A: Fully engineered

A fully engineered scenario would entail high costs, loss of environmental amenities, loss of community connection to the River, and a high level of community safety. This scenario also results in an engineered asset that will require maintenance, repairs and upgrades over time.

Costs:

- dike replacement/wall (or engineered alternative),
- loss of riverbank infrastructure (if the engineered alternative would encroach upon the riverbanks),
- environmental costs (loss of habitat, nutrient cycling, erosion),
- recreational/social/cultural benefits (community connection to the river, etc.), and
- on-going maintenance costs.

Benefits:

- reduced flooding costs (to buildings, infrastructure - streets, sidewalks, storm sewer systems, etc.), and
- community safety.

Option B: Engineered and Natural

A mixed grey-green approach would utilize engineered options in high risk locations, with natural asset options in areas that have high capacity to reduce flood risks and ones that have high value to community for recreation and other reasons.

Costs:

- dike construction and maintenance,
- possible limited relocation,
- dredging, vegetative planting,
- community disruption, and
- property purchase for widening river.

Benefits:

- community safety,
- environmental benefits (improved habitat; social, cultural and recreational opportunities; mitigate flooding events, etc.), and
- limited community disruption.

Option C: Fully natural approach (i.e. retreat/relocation)

A key advantage to relocation is the opportunity to naturalize the flood prone areas, which would serve to provide further flood control benefits and protect the built assets that are not relocated. In addition, it would bolster the natural asset co-benefits (e.g. increased recreational opportunities). It also removes the liability and financial burden on the City to operate and maintain engineered flood defences.

Costs:

- property purchase,
- community disruption,
- dredging and rehabilitation,
- demolishing costs, and
- naturalization costs.

Benefits:

- community safety, and
- environmental, social and recreational benefits.

Implementation of Natural Asset Plan

This project demonstrates that natural asset solutions can play an important role in flood management, however, such solutions are not sufficient alone. Natural asset solutions need to be considered as part of a comprehensive and phased flood management strategy for the City that assesses and prioritizes the use of a wide range of strategies, including: natural assets, engineered assets such as dikes, and soft-path options like bylaw or policy changes to incorporate flood accommodation or managed retreat.

The City is currently undertaking further study and development of a comprehensive approach to flood management, which will incorporate the results of this natural assets assessment. This further work is being funded by a grant from the Community Emergency Preparedness Fund, a grant provided by the Province and administered by the Union of BC Municipalities.

Conclusion

This analysis applied an avoided cost approach to determine an economic value for the flood attenuation services provided by the natural assets of the Courtenay River corridor. The project found the natural asset improvements as defined in these scenarios do not solve the flooding issues facing the City of Courtenay, but they do provide some damage reduction. This avoided damage can be interpreted as the flood control benefits provided by the natural assets.

The flood modelling conducted by MNAI produced flood depth surfaces for a series of flooding scenarios. From these scenarios, four flood depth surfaces were developed. The modelling results of the flood damage assessment revealed that under the 2009 flood conditions, natural asset improvements would reduce flood damages by $723,000. Considering a larger, more extensive flood event, natural asset improvements would reduce flood damages by $2.4 million dollars.

The values presented above exclude a range of important co-benefits. The values alone also do not speak to the ongoing monitoring, operating and maintenance costs associated with each scenario modelled.

Appendix A: Launch Workshop Agenda

Municipal Natural Assets Initiative (MNAI) – Cohort 1 Launch Workshop

For Courtenay

June 1 2018 - 0800-1700

Location:

Draft Annotated Agenda

Meeting purpose

Launch MNAI project.

Objectives

1. Ensure common understanding of: MNAI method, process & milestones; project details; roles, responsibilities and expectations
2. Develop detailed roadmap towards Milestone 1, including understanding of roles and responsibilities

Anticipated outputs

1. Final project document (although some details may continue to evolve)
2. Roadmap towards Milestone 1* including specific dates and times for regular check-ins and product deadlines[1].
3. Description of next steps

Meeting documents (available at https://tinyurl.com/y8ynjjvu)

- Signed MOU
- Project document
- MNAI introductory presentation
- MNAI presentation on data needs and collection
- Enlarged maps of site (provided by local government)
- Workplan template (to fill out at end of meeting)
- MNAI guidance document
- MNAI Communications plan
- ***Note on Milestone 1**
- Milestone 1 needs to be reached by Week 1 of September 2018.
- The Milestone is: *Creating foundation: biophysical characteristics and condition of municipal natural assets are understood and documented, all data is gathered.*
- Milestone 1 webinar will occur in first 2 weeks of September with objective of extracting and sharing key lessons or findings from data gathering (e.g. are there particular challenges or opportunities in terms of finding good data, and lessons that can be shared.
- MNAI team will provide help desk support between launch workshop and Milestone 1 webinar to make sure Milestone is reached.

AGENDA			
Time	**Item**	**Lead**	**Outcome & Comments**
Part 1: Creating a common understanding			
0800-0815	Welcome and introductions	Local government	
0815-0900	Overview of MNAI process: how we got here and what to expect	Roy	Objective: ensure participants understand have shared understanding of MNAI and what to expect
0900-1030	Overview of project document: goals, objectives, outputs of project	Local government with Michelle and Jeff	Objective: ensure common understanding of project
1030-1230	Visit site	Local government	Objective: gather additional information/ context on site
1230-1330	Working Lunch	All	Discussion: did the site visit change anyone's understanding of the project? Lunch provided by local government
Part 2: Roles, responsibilities and actions			
1330-1430	Introduction to goals, objectives and activities towards Milestone 1	Michelle & Jeff	Objective: ensure common understanding of what is required for effective data gathering to meet project goals
1430-1530	Discussion on roles and responsibilities towards Milestone 1	Michelle & Jeff with support from Roy	
15h30-16h30	Conclusions, next steps	Roy, Michelle, Jeff	[This part can be shortened or used to cover additional issues raised during the day]

List of Participants:

Ryan O'Grady - Director of Engineering Services, City of Courtenay

Rod Armstrong - Manager of Asset Management Technical Services, City of Courtenay

Craig Perry - Manager of Transportation and Utilities, City of Courtenay

Dave Snider - Director of Recreation and Culture, City of Courtenay

Glen Shkurhan - Senior Engineer and Principal, Urban Systems

Ehren Lee - Water Strategy Consultant, Urban Systems

Roy Brooke – Executive Director, MNAI

Michelle Molnar – Technical Director, MNAI

Jeff Wilson – Technical Support, MNAI

Josh Thiessen – Technical Support, MNAI

Appendix B: Ecosystem Services of Rivers and Riparian Areas

ECOSYSTEM SERVICES OF RIVERS AND RIPARIAN AREAS

Service	Description	Applicability to City of Courtenay	Rivers	Riparian Buffers
Food	Biomass for human consumption.	Food provisioning through agricultural lands and fisheries.	x	x
Water supply	Water for human consumption.	City responsible for provision of drinking water.	x	
Raw materials	Biological and geological materials used for fuel, art and building.	May be of particular importance to K'ómoks First Nation.		x
Medicinal resources	Biological materials used for medicines.		x	x
Genetic resources	Important for continuum of genes and species.	Biological diversity in the City.	x	x
Carbon sequestration	The removal of carbon dioxide (CO_2) from the atmosphere (gas regulation).	Important to City's climate targets and adaptation strategy.	x	x
Carbon storage	The storage of greenhouse gases that contribute to the build-up of carbon "stocks".		x	x
Air purification	The ability of forests to clean the atmosphere by intercepting airborne particles and absorbing pollutants.	Likely a regional mandate, but also important for livability of Courtenay residents.	x	x
Disturbance regulation	Protection from storms and flooding, drought recovery.	Flood protection of high importance to the City.		x
Soil erosion control	Erosion protection provided by plant roots and tree cover.	Important for maintenance of infrastructure, biodiversity.	x	x
Water regulation	Water absorption during rains and release in dry times, temperature and flow regulation for plant and animal species.	City mandate	x	x
Biological control	Natural control of pest species.	To support community health and livability.	x	x
Waste processing	Absorption of organic waste, filtration of pollution.	To support community health and livability.	x	x
Soil formation	Formation of sand and soil through natural processes.	To support ecosystem health.		x
Pollination	Fertilization of plants and crops through natural systems.	May be of importance to agricultural areas.		x
Habitat refugium & nursery	Providing for the life-history needs of plants and animals.	Supports biodiversity	x	x
Aesthetic information	The role natural beauty plays in attracting people to live, work and recreate in an area.	To support community health and livability.	x	x
Recreation & tourism	The contribution of intact ecosystems and environments in attracting people to engage in recreational and tourist activities.	Likely of high importance to community.	x	x
Science & education	Value of natural resources for education and scientific research.	High percent of residents with science training.	x	x
Spiritual & religious	Spiritual and religious use of nature for religious or historic purposes.	May be of particular importance to K'ómoks First Nation.	x	x

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