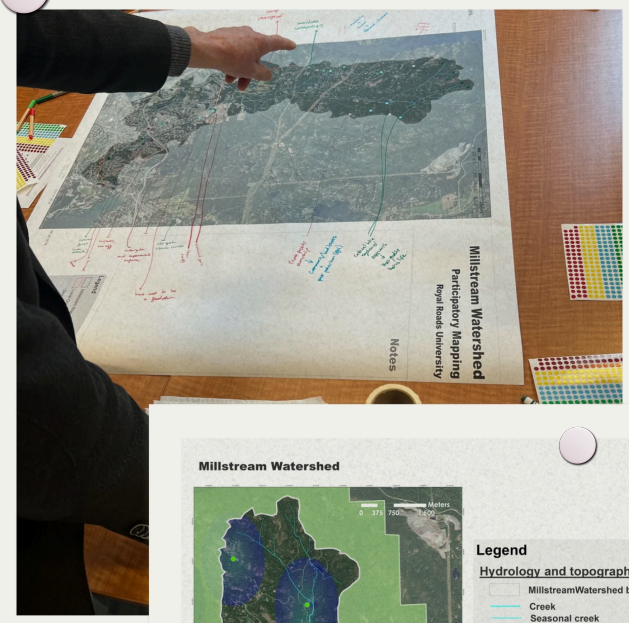

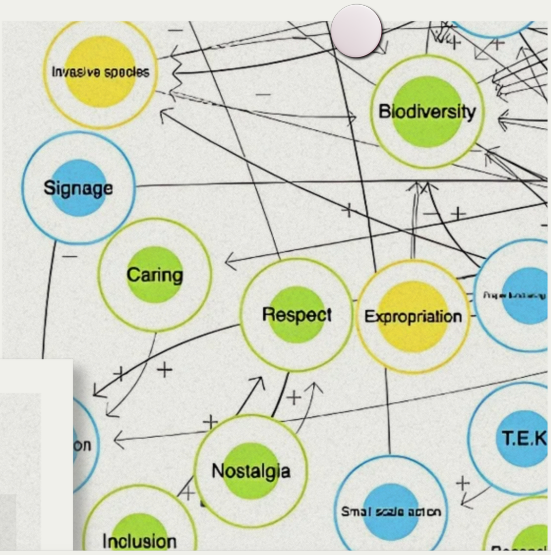

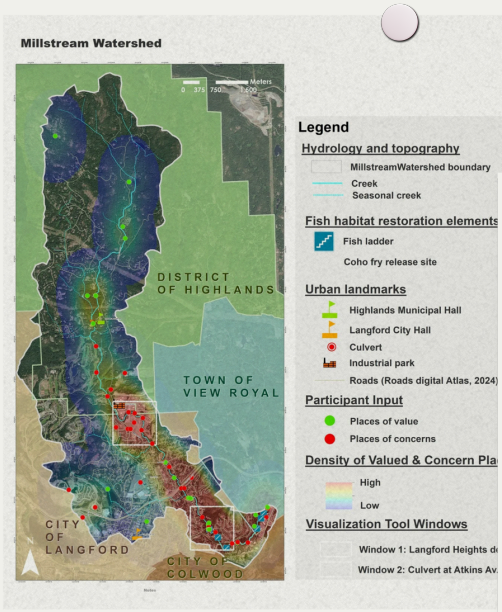

The Millstream Watershed Visualization Project

OUTCOMES AND RECOMMENDATIONS

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The report was produced by the Transdisciplinary Research on Integrated Approaches to Sustainability (TRIAS) lab (www.triaslab.ca), which is led by the Canada Research Chair in Climate Change, Biodiversity and Sustainability at Royal Roads University.

The study documented in this report is part of a larger research project: *The Systems-based Visualization Tools for Integrated Watershed Management.* The research develops and tests an experimental visualization tool for supporting participatory approaches to integrated watershed management planning.

We respectfully acknowledge that the Millstream Watershed is part of the unceded Lands of the Coast Salish Peoples. We specifically honour the Xwsepsum, Lekwungen, and Sc'ianew Nations, and the W̱SÁNEĆ Peoples, who include the Tsartlip, Pauquachin, Tsawout, Tseycum, and Malahat Nations. For countless generations, these communities have nurtured cultural, spiritual, and ancestral connections to this Land. They have been their stewards, protectors, and knowledge-keepers of this ecologically rich, vibrant, and biodiverse region. We are deeply grateful for the privilege of living, working, and learning in these traditional territories.

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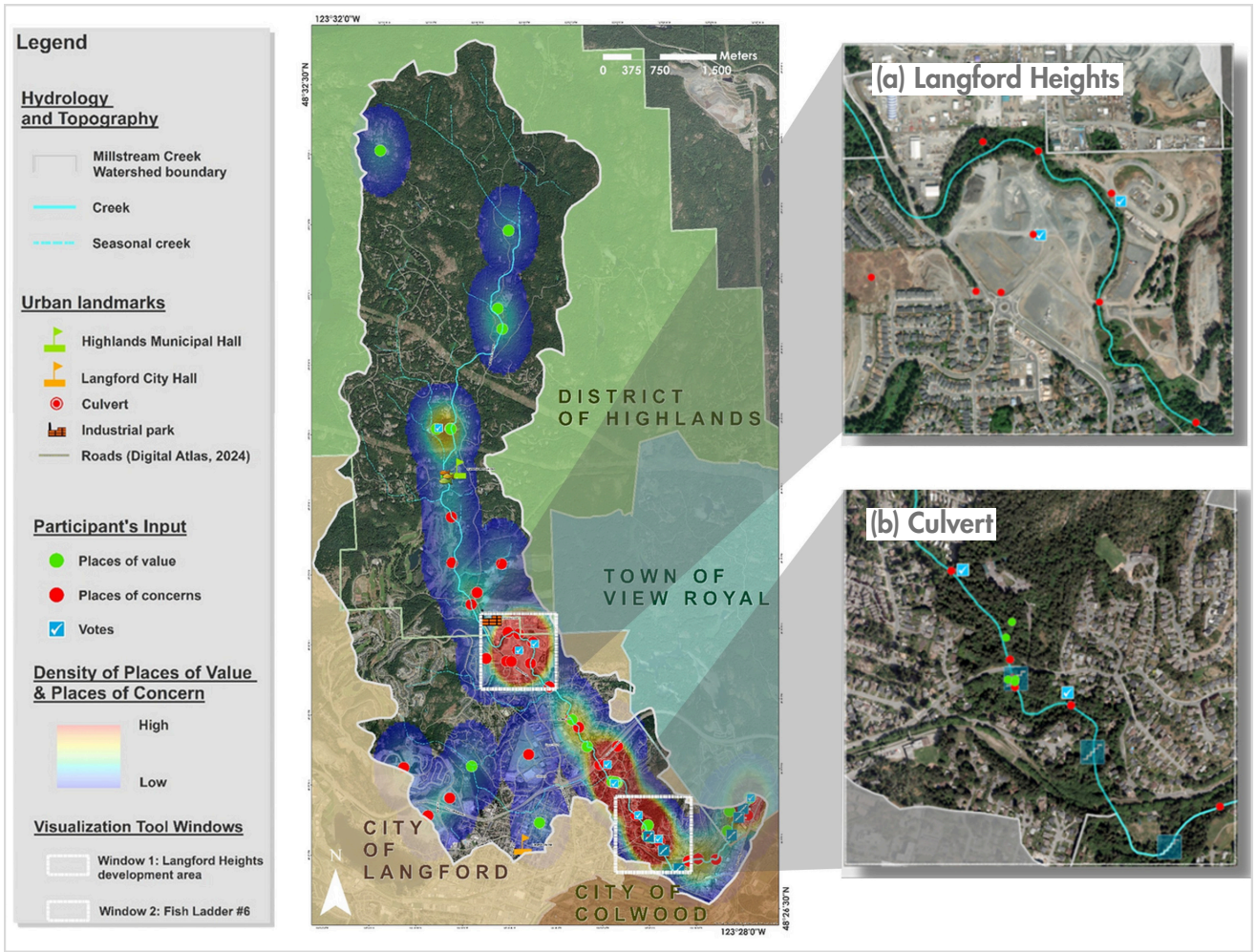
Table of Contents

1. Background

The Millstream Watershed is in the Capital Regional District on Vancouver Island, British Columbia, Canada. The watershed consists of an area of approximately 26 km^2, and it flows from the Gowlland Range to Esquimalt Harbour. The area is ecologically diverse, and local ecosystems face severe pressures from urbanization, altered land use, and infrastructure development (see Figure 1). Such pressures have degraded water quality and habitat connectivity, presenting a need for watershed management strategies that can preserve ecological integrity while also supporting human wellbeing. Designing and implementing these strategies is challenging because the watershed extends into four municipalities (i.e., the District of Highlands, Langford, Colwood, and View Royal), which creates complexities in terms of governing and managing the area across multiple jurisdictions. Such complexities present a need for developing tools and techniques that can support inclusive and collaborative approaches to watershed planning, management, and governance.

Figure 1. Sites of interest and concern in the Millstream Watershed

The map shows areas of great value and high concern within the watershed, as identified by stakeholders in a participatory mapping exercise. Hotspot analysis revealed two sites to be of particular interest in terms of watershed concerns: (a) Langford Heights, and (a) a culvert site near Atkins Road.



1.1 The Research Project

The aim of the *Systems-based Visualization Tools for Integrated Watershed Management* research project (www.triaslab.ca/watershed) is to develop and experiment with tools for facilitating collaboration in the planning, management, and governance of the Millstream Watershed. The project began by engaging local government officials, community members, and local conservationists in a series of three workshops held in March 2024, each lasting 2.5 hours. The workshops consisted of two main activities: participatory modelling and participatory mapping. In the participatory modelling activity, participants drew systems relationships among watershed values, challenges, and management strategies to create a systems map of these relationships. Participants also rated what they perceived to be the relative strengths or importance of the different relationships in the systems map. In the participatory mapping activity, participants used a map of the Millstream Watershed and coloured stickers to identify places of personal value and importance, sites where significant environmental concerns exist, and priority areas for targeting environmental management strategies. In addition, participants were asked to mentally visualize the future state of the watershed in the event that watershed management strategies were successfully implemented.

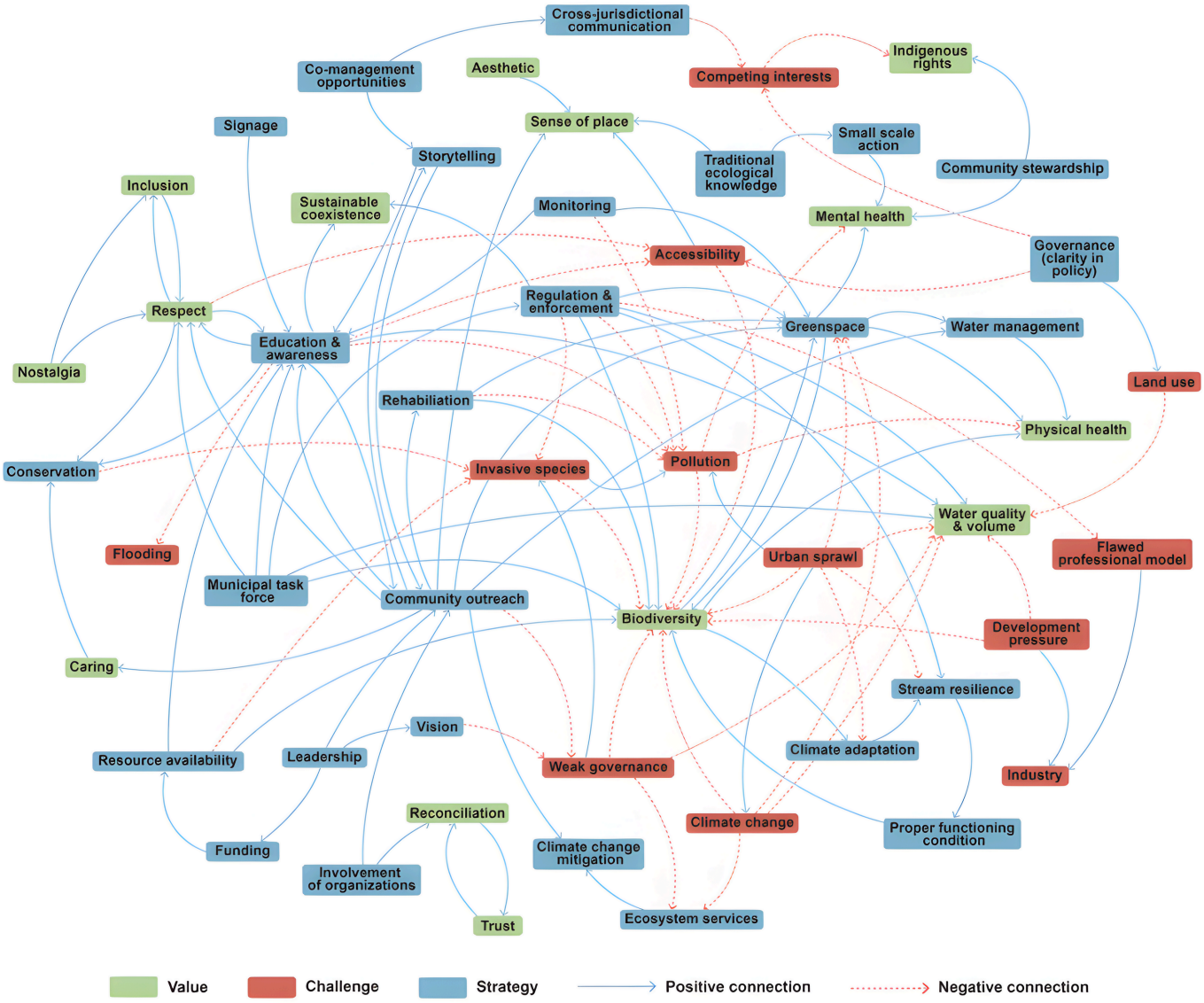
Following the workshops, the systems map was used to conduct a scenario analysis that simulated the effects of implementing different watershed management strategies with respect to outcomes related to watershed health and community wellbeing. The spatial maps were digitized and analyzed to identify areas where watershed values and concerns clustered. The outcomes of these analyses informed the creation of a visualization tool (built using video game development software), which allows users to virtually walk through two sites in the Millstream Watershed and explore different scenarios for improving watershed management and stewardship. These sites consist of (1) an under-construction business park in the Langford Heights neighbourhood, and (2) the location of a culvert and fish ladder near Atkins Road. This visualization tool also contains the systems map and outcomes of the scenario analysis, providing users with multiple types of information for assessing and thinking about the implications of different watershed management strategies.

The visualization tool was prepared in both virtual reality and conventional computer formats, and it can be accessed here: www.triaslab.ca/watershed#visualization. The tool was tested by local government and community members through an open house event and a series of workshops. Participants provided feedback on both the usability of the tool and their impressions of the different watershed management strategies. This report summarizes the outcomes of the research and provides recommendations for planning and management in the Millstream Watershed, based on these outcomes.

2. Watershed Systems

The participatory modelling activity resulted in a system map of the relationships among values for the watershed, challenges and issues that threaten the watershed's health, and strategies for protecting the values and addressing the challenges (Figure 2). The map consists of values such as biodiversity, water quality, mental wellbeing, and Indigenous rights. The challenges and threats to these values include environmental pressures, governance shortcomings, and land use conflicts. The strategies proposed to protect/enhance the values and to address the issues include education, restoration, environmental regulations, and co-management practices.

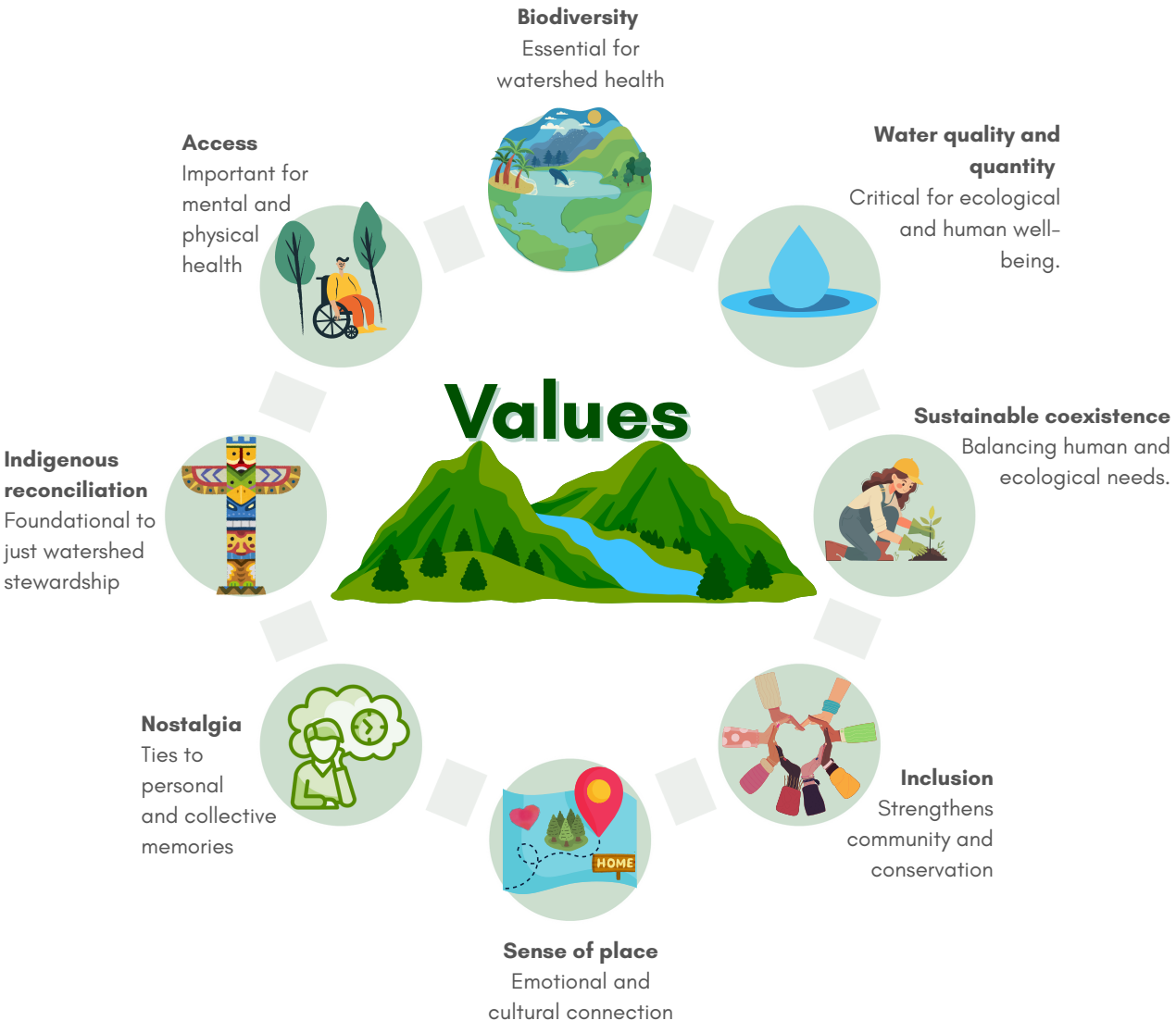
Figure 2. Systems map of values, challenges, and strategies in the Millstream Watershed



2.1 Summary of Values

- Biodiversity is essential to the watershed's health.
- Water quality and quantity are critical for ecological health and human well-being.
- Sense of place and local aesthetics support emotional and cultural ties to the watershed.
- Access to natural spaces is important for mental and physical health.
- Indigenous rights, reconciliation, and respect are required for just watershed stewardship.
- Inclusion, trust, and caring strengthen community connectivity and conservation efforts.
- A sustainable coexistence involves balancing human and ecological needs.
- Nostalgia is an emotional value that is tied to personal and collective memories.

Figure 3. Overview of the Millstream Watershed values, as identified by local stakeholders



2.2 Summary of Challenges

- Pollution and invasive species are severe threats to ecological integrity.
- Flooding, climate change, and urban sprawl are significant environmental challenges that disrupt watershed functions.
- Weak governance, policy ambiguity, and heavy reliance on professional advice and recommendations are institutionally related barriers to watershed management.
- Increasing public access to natural areas can impact the local environment.
- Development pressures (and influence from the development industry) create challenges for conservation efforts.
- Competing interests among stakeholders cause tensions in terms of what to prioritize in planning and management.
- Expropriation and unclear land use policies are drivers of environmental strain.

Figure 4. Overview of the Millstream Watershed challenges, as identified by local stakeholders

2.3 Summary of Strategies

- Ecosystem restoration and climate resilience planning can address hydrological risks.
- Education and awareness, along with storytelling and signage, are tools for building public support for and knowledge of watershed stewardship.
- Community outreach promote local engagement and a sense of ownership.
- Establishing greenspaces improves ecological and social wellbeing.
- Effective regulation and enforcement can address pollution and development risks.
- Municipal task forces and cross-jurisdictional communication can strengthen governance.
- Funding mechanisms and ensuring the appropriate resources are available are required for implementing and sustaining watershed management strategies.
- Co-management practices and inclusion of traditional ecological knowledge in planning are ways of centering Indigenous leadership in watershed management and stewardship.
- Clarity in policy and alignment in policy across different levels of government improve coordination in watershed planning and management.
- Small-scale actions facilitated by local organizations are practical steps toward watershed health that can be implemented immediately.

Figure 5. Overview of the Millstream Watershed strategies, as identified by local stakeholders

3. Watershed Management Scenarios

The systems map was applied in a scenario analysis exercise, which involved running systems simulations to explore how different watershed management strategies and approaches affect other systems components. The results of the simulations revealed to what degree (if at all) the strategies protect/enhance watershed values and address watershed challenges. The strategies can be organized into two categories: (1) governance-based strategies, and (2) engagement-based strategies.

3.1 Governance-based strategies focus on improving decision-making entities and structures, resource allocation, and collaboration among organizations. The strategies include:

- ***Co-management opportunities*:** Co-management improves communication and coordination among different jurisdictions and stakeholder groups. When done effectively, it can support shared decision-making and knowledge exchange among governments, Indigenous communities, environmental groups, and private actors. These arrangements can help address issues related to competing interests, as well as align priorities around watershed protection.

- ***Involvement of organizations*:** Involving local conservation groups, residents, municipal governments, and development actors in watershed planning and management efforts is important for the Millstream Watershed. The watershed spans across four municipalities, and coordinated action across these jurisdictions can help align goals and address competing interests effectively.

- ***Municipal task force*:** A dedicated municipal task force for watershed protection can help to identify ways of enforcing environmental regulations. This type of entity can help in efforts toward reducing pollution, limiting development pressures, and preventing further environmental degradation.

- ***Funding*:** Consistent funding is essential for effective watershed management in order to support ongoing environmental education, climate adaptation, and community engagement programs. Reliable and stable financial resources also make it possible to conduct environmental monitoring efforts, build local capacity, and implement and test new watershed management strategies.

3.2 Engagement-based strategies enhance public awareness, communication, and community participation in watershed stewardship. These strategies include:

- ***Community outreach:*** Community outreach is central to mobilizing residents and stakeholders toward active participation in watershed conservation. Effective outreach initiatives raise public awareness about watershed issues and stewardship, build trust, and encourage collective action. As a result, these initiatives have the potential to lead to robust and sustained conservation efforts.

- ***Education, awareness, and signage*:** Education and public awareness programs, supported by effective signage, play a significant role in improving watershed health. These efforts help communities understand the importance of water quality and conservation practices, thereby encouraging environmental stewardship. Well-designed and well-positioned signage raises awareness at locations that are critical for addressing watershed concerns by guiding responsible behaviour and reinforcing key messages about stewardship practices.

- ***Storytelling*:** Storytelling serves as a powerful tool for enhancing people's connections to places within the watershed and to their community. Through storytelling, complex environmental information can become accessible and relatable to a variety of different groups and audiences.

4. Scenario Visualization

4.1 Langford Heights

Langford Heights is a rapidly urbanizing area currently undergoing extensive construction. Its accelerated development poses significant threats and challenges to the Millstream Creek Watershed, including increased runoff, erosion, and habitat disruption. The Langford Heights area has a history of watershed challenges and impacts, beginning about fifty years ago when the creek was diverted and the wetlands were filled with gravel. This created a fragmented, overgrown corridor that now makes it hard to restore the ecosystem or build a trail, creating ongoing problems for managing the area and public access. The visualization tool features two scenarios in Langford Heights: (1) the existing conditions of a site where a business park is being developed, and (2) a future scenario that features riparian habitat and public greenspace.

In the existing conditions scenario (Figure 6), visualization users encounter large areas of impervious surfaces and an active construction zone, with noisy sounds of machinery and construction. As users follow the Millstream Creek corridor, they witness signs of environmental degradation, such as eroded stream banks, disrupted riparian vegetation, and degraded habitats. Sparse vegetation and exposed soil surfaces indicate a lack of ecological buffer. The surrounding landscape feels fragmented, with minimal integration of stormwater infrastructure or green design elements. The scene demonstrates how construction and development practices can contribute to hydrological and ecological impacts.

Figure 6. Existing conditions scenario for Langford Heights site, as shown in the visualization tool

The riparian greenspace scenario presents a vision for the Langford Heights business park, which involves nature-based solutions for supporting sustainable development. In the scenario, green infrastructure and dense and diverse riparian vegetation have been established along Millstream Creek to stabilize streambanks and enhance ecosystem health. Throughout the scenario visualization, users encounter signs of ecological recovery, such as birds occasionally flying overhead, bird songs within the ambient noise, and small mammals in the grasses and shrubs. These ecological elements suggest that the site can be a functioning and viable habitat. The scenario also includes community-oriented amenities that support multifunctional land use. A playground, dog park, and pedestrian pathways are in the park, and these amenities are featured in the scenario in support of an overall vision for the site, that is, a place that comprehensively supports urban development, environmental stewardship, and community wellbeing.

4.2 Atkins Road

The visualization site near Atkins Road has both a culvert and a fish ladder situated in the Millstream Creek watercourse. The fish ladder serves to support passage for native fish species, in particular migrating salmon. The visualization tool features two scenarios for this site: (1) the existing conditions, and (2) an improved access and public education scenario.

In the existing condition scenarios (Figure 7), the site is largely undeveloped and in a natural state. Users can walk down a steep slope to reach the edge of Millstream Creek, where they can observe the culvert and fish ladder infrastructure. The streambanks are vegetated with native plant species, birds can be seen flying between the trees, and mammal species can be seen in the area. The visualization of this site aims to convey a sense of natural seclusion and limited human intervention.

Figure 7. Existing conditions scenario for the Atkins Road site, as shown in the visualization tool

The access and public education scenario features infrastructure added to the site that is related to accessibility, education, and responsible public use. A series of steps is added to make the steep slope more navigable by visitors and to allow users to more easily reach the creekside area. Benches and a picnic table have been placed in the area for public use. Educational signage has been installed to provide visitors with information about the site's ecological features. In addition, signage is placed in the site to share information on local ecosystems and biodiversity and to remind users to stay on designated trails in order to avoid disturbing sensitive natural areas. The scenario demonstrates how the site can be modified to develop it as a park and public greenspace.

5. Participant Feedback

5.1 Feedback on the Scenarios

The feedback below was given in response to the question:

What does the visualization show you about the challenges and management priorities in the Millstream Watershed?

Langford Heights

Challenges

- ***Ecosystem degradation and habitat loss*:** The natural landscape has been significantly altered, leading to widespread ecosystem disruption. Habitat loss for fish and wildlife is evident, and the removal of vegetation has resulted in both soil erosion and streambank degradation, contributing to sediment accumulation throughout the watershed.

- ***Development pressure and landscape fragmentation:*** Large-scale development projects and expanding road infrastructure have fragmented the watershed and placed stress on the ecological system. Ongoing construction activities require long-term ecological restoration, yet development continues in the absence of adequate environmental safeguards. The lack of eco-based infrastructure limits both the protection of the creek and opportunities for public access and engagement. The construction noise present in the visualization tool further illustrates the extent of environmental disturbance.

- ***Water quality decline*:** The Langford Heights site is experiencing a decline in water quality, raising concerns about the long-term health of the watershed.

- ***Limited awareness*:** There is a general lack of awareness and public recognition of the ecological (and social) value of the watershed, which hampers efforts to promote conservation and stewardship.

- ***Unclear planning and governance challenges*:** The future scope and timeline for watershed management planning and implementation remain undefined. In addition, the risk of repeating past human-use impacts persists due to gaps in long-term strategic planning.

Management priorities

- ***Ecosystem restoration and habitat protection*:** Priority should be given to restoring ecological integrity through the reshaping of altered landscapes and the replanting of native vegetation. Stream bank stabilization is also essential to reduce erosion and support habitat resilience.

- ***Sustainable development and infrastructure integration:*** Development decisions should explicitly incorporate ecological considerations to reduce future impacts. In addition, eco-based amenities, such as green corridors and nature-friendly access points, should be introduced to balance environmental protection and community usage.
- ***Improved planning and governance*:** Clear planning frameworks and implementation timelines are needed to guide future actions. Strategies should also be developed to prevent the recurrence of prior ecological and land use issues, ensuring that lessons from past development are integrated into future management efforts.

Atkins Road

Challenges

- ***Ecosystem and habitat disruption*:** Biodiversity and fish habitats in the site (and surrounding area) are increasingly at risk due to land use pressures and ecological fragmentation.
- ***Infrastructure-related flow barriers*:** The existing culvert interferes with natural stream flow, causing erosion in upstream sections and sediment buildup downstream. These conditions create physical barriers that impede fish migration, impact connectivity, and disrupt aquatic ecosystem functions.
- ***Limited public access and site understanding*:** Restricted physical access limits community interaction with the site. Additionally, the absence of interpretive signage, such as explanations of fish ladder functions, hinders public understanding of key ecological features and local restoration efforts.

Management priorities

- ***Ecosystem and habitat protection*:** Watershed management efforts should focus on protecting critical land areas to maintain animal movement corridors and ecological connectivity. Supporting broader biodiversity and habitat conservation goals is essential to safeguard long-term ecological functioning.
- ***Infrastructure improvements for natural flow and fish passage*:** The culvert should be redesigned to better mimic natural stream flow conditions. Improvements must also enable effective fish passage to address current migration barriers caused by erosion and sedimentation.
- ***Enhancing public understanding and engagement*:** Installing interpretive signage can improve public awareness of the site's ecological features, such as fish ladders and restored habitats. Such signage is useful for making progress toward education, stewardship, and long-term community engagement objectives.

5.2 Feedback on the Visualization Tool

The feedback below was given in response to the question:

What do you like about the strategies shown in the visualization? What does the visualization reveal about the shortcomings or weaknesses of the strategies?

Langford Heights

What participants liked

- The incorporation of native plants and protected riparian zones are appreciated.
- The visualization is detailed and includes helpful storytelling.
- Community amenities (playground, dog park, trails, signage) are valuable.
- The virtual reality immersion vividly shows degradation and restoration.
- The contrast between scenarios is strong and noticeable (industrial wasteland versus riparian greenspace).
- The embedded audio clips of narrations about site's features and issues were helpful, and the ambient noises improved the visualization's realism.

Perceived shortcomings

- The tool featured limited Indigenous presence and traditional ecological knowledge.
- Key issues need to be communicated in more detail (e.g., water quality, invasive species).
- Recreational infrastructure (e.g., dog park, playground) may impact wildlife habitat.
- The tool required excessive walking, and some text pop-ups were hard to read.
- Users need more guidance in terms of where they should go and what they should view.

Culvert Site

What participants liked

- The presentation of the fish ladder effectively shows support for species movement.
- The ambient sounds enhance sense of presence and immersion in the visualization.
- The pop-up text helps guide users through the visualization tool and scenarios.
- The tool is easy to operate and navigate.
- The scenario toggling features work well for visualizing proposed strategies.
- The signage in the scenario is modelled well, and the virtual scene is realistic.

Perceived shortcomings

- It is hard to see the big picture in terms of issues and strategies in the entire watershed.
- Visualization does not capture and show habitat impacts upstream and downstream.
- More strategies are needed to foster respect, ecological awareness, and cultural values.
- The visualization does not show a culvert redesign for eco-friendly water flow.
- The visualized scenarios have limited flexibility in terms of adding more elements.
- The scenario differences are subtle compared to Langford Heights (perhaps too subtle).

6. Recommendations

1. Increase access to greenspaces while ensuring the increased access is complemented by educational strategies

Improving access to the watershed is valuable for recreation, public awareness, and community engagement; however, access points and routes must be carefully planned and complemented with educational programs and strategies to mitigate the impacts that increased access may have on ecologically-sensitive and culturally-significant areas. Educational programming needs to be comprehensive in ways that effectively communicate information about the entire watershed ecosystem rather than just single species (e.g., fish species), as well as Indigenous place-based relationships and perspectives. This approach to public education ensures that visitors appreciate the significance of the ecosystems and cultural places with which they are interacting, and it clearly presents a message that recreational use needs to be aligned with responsible stewardship. Municipalities and the regional government should collaborate with Indigenous partners to co-develop interpretive signage, guided tours, and other educational programs that include both ecological and cultural knowledge.

2. Create a watershed governance body that consists of both governmental and non-governmental groups

A significant challenge for planning and management in the Millstream Watershed is that the governance of the watershed is fragmented and siloed. The watershed extends across multiple municipal jurisdictions, including Langford, Colwood, the District of Highlands, and View Royal. Zoning and land use policies differ between municipalities, which creates inconsistencies among policies and challenges to enforcing regulations for protecting the watershed. A governance body should be developed that can facilitate coordination across municipalities and non-governmental groups. Such a body would provide a platform for sharing resources, knowledge, and strategies. It would not replace existing local stewardship groups; rather, it would connect and coordinate watershed initiatives and efforts to increase effectiveness and consistency across the region, thereby reflecting the nested, multi-scalar structure of watershed geography and ecology.

3. Develop and implement an eco-centric policy framework for watershed planning and management

Effective watershed management requires policy frameworks that place ecological values at the centre of decision-making, in recognition of the fact that social and economic benefits derive from a healthy ecosystem. In the Millstream Watershed, such a framework would result in substantial riparian buffers (i.e., beyond the standard 30m and closer to a 100m target) that support native vegetation and high habitat quality for native species. In addition, under such a framework, recreational trails and park amenities would be positioned at the periphery of the riparian buffers rather than near waterways, and park and trail designs would incorporate ecological functions, such as planting shade-providing trees along creeks to regulate water temperatures. Policies should be developed that establish clear ecological standards for water quality, habitat connectivity, and biodiversity health, which must be maintained for new development or recreational expansion to be approved. This policy approach ensures that ecosystem health and functioning are prioritized above development and recreational uses.

4. Improve connectivity and develop a storytelling strategy that follows this connectedness

Connectivity throughout the watershed should be improved for both people and wildlife. Improved landscape connectivity requires ensuring that wildlife can move through the watershed effectively, with passages protected from human disturbance. Monitoring programs (e.g., camera traps, citizen science initiatives, etc.) can be implemented to track the effectiveness of connectivity strategies and efforts. Connectivity also involves improved human movement through green spaces within the watershed, and such connectivity opens opportunities for developing a storytelling strategy as part of the watershed's educational programming that communicates to visitors how the watershed is a connected system rather than a series of isolated places and green spaces. Trails and interpretative signage can serve as tools to convey this understanding, as they can be designed to cohesively communicate linkages among ecological features, historical sites, and Indigenous cultural significances for places throughout the watershed.