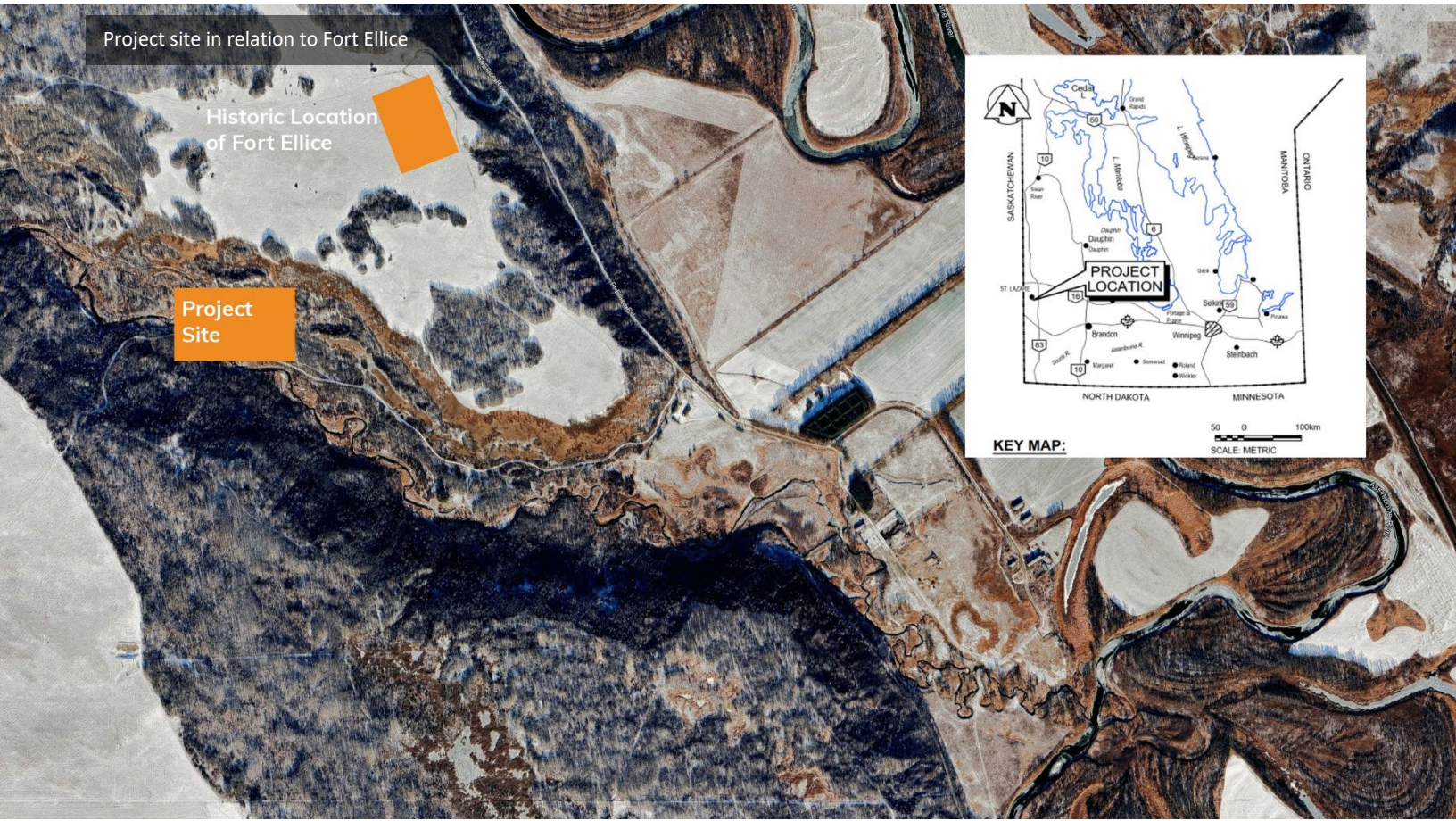
# Swimming Towards Sustainability: Crossing Enhancements on Beaver Creek at Historic Fort Ellice

## INTRODUCTION

Amidst parcels of land rich in biodiversity and Canadian history is the Nature Conservancy of Canada's (NCC) Fort Ellice property. Fort Ellice was established nearly 375 kilometers west of Winnipeg by the Hudson's Bay Company in the mid-19th century and was a vital trading post during Canada's fur trade era. It served as a key junction point for traders, explorers, hunters and Indigenous Peoples, facilitating the exchange of goods and cultural interactions. This historical importance is matched by its ecological significance, as the surrounding land features a rich and diverse ecosystem.

Beaver Creek, nestled in the lush landscapes southeast of St. Lazare, Manitoba, is more than just a waterway; it's a vital ecological artery running through the land conserved by the NCC as part of their Fort Ellice 3 project. Beaver Creek, which feeds into the Assiniboine River, faced a significant ecological challenge: a concrete ford crossing impeded the natural migration of fish. Recognizing the need to reconcile human infrastructure with the natural environment, the NCC engaged KGS Group to review options for responsibly modifying this crossing into a passage that will allow for bi-directional movement of fish. The project began as a conceptual design study to give the NCC a road map for navigating the work to be done. However, through close collaboration, it blossomed into a partnership that had KGS Group see the project through to the construction of a rock ramp, downstream of the ford crossing, which creates downstream conditions that allow fish to traverse the ford crossing.



## BACKGROUND

In recent years, the NCC has undertaken efforts to preserve the land around Fort Ellice that has been long synonymous with Canada's prairie provinces. This area is characterized by a unique blend of prairie grasslands, aspen parklands, sandhill prairie and riparian ecosystems, making it a habitat for a variety of wildlife. The NCC's conservation work focuses on protecting these natural landscapes, including endangered grass species that are found nowhere else in Canada, from threats of industrial development and environmental degradation. By doing so, the NCC not only safeguards the biodiversity of the area but also preserves an important part of Canadian history. The efforts at Fort Ellice exemplify the NCC's broader mission to conserve areas of natural significance across Canada and to preserve and honour the special connections they hold for people.

Beaver Creek and the surrounding riparian forest and grasslands

In 2013, Manitoba Fisheries and the NCC completed a fish and fish habitat survey, carried out at nine sites in Beaver Creek. These surveys collected 940 fish of 15 different species, some of which are endangered. The species collected included Darte and Benthic Dace minnows, as well as large-bodied fish such as White Sucker, Walleye, Northern Pike and Yellow Perch. Of the 940 fish collected, 311 fish were collected immediately downstream of the concrete ford crossing. This was an indication that many fish had reached a point where they could no longer move upstream, which can cause a disruption in populations of fish that migrate as part of their life cycle.

Permitting fish passage upstream restores natural migratory routes which is essential for breeding, feeding and spawning, leading to increased fish populations and biodiversity. Healthy fish populations are crucial for maintaining balanced aquatic ecosystems as they contribute to the ecosystem's natural cycle of food and nutrients. Additionally, unobstructed fish passage can lead to better genetic diversity among fish populations, enhancing their resilience to environmental changes and diseases. Overall, enabling fish to move freely in their natural habitat is vital for the health and sustainability of aquatic ecosystems.

## Existing Conditions

The existing concrete ford crossing was constructed by previous landowners to access farmland on the southwest side of Beaver Creek. Now owned by the NCC, this crossing remains essential for accessing the native grasslands they preserve through sustainable ranching practices. During summer flow conditions, the depth of water flowing over the concrete crossing is approximately 0.1 m and the total drop in water level between the top of the crossing and the downstream area was measured at 0.9 m. Due to these conditions, the existing ford crossing creates an obstruction to fish movement upstream. The creek is mainly supplied by groundwater and a minimum flow is always present.

Downstream view of the concrete ford

# CONCEPTUAL AND PRELIMINARY DESIGN

## Design Criteria

A critical aspect of the design solution was ensuring there is adequate water depth throughout the proposed structure to accommodate the size of the expected fish species, and that conditions will prevent them from becoming stranded. The proposed design needed to offer a natural, steady flow, while ensuring the velocities were manageable for fish; if the flow was too high it could exhaust the fish; too low and it may not provide adequate water depth for migration. The new structure's slope and gradient would also need to be gentle enough, as steep inclines could be challenging for the fish.

The new physical structure should mimic natural conditions as closely as possible. This included using materials that provided appropriate roughness and features that modulate water flow to help create favourable conditions by breaking up the flow of water and reducing velocity. The structure's materials also needed to be sized appropriately so they would not be washed away or eroded during high flow conditions. Finally, the new structure should blend seamlessly with the surrounding environment, minimizing ecological disruption while maintaining water quality.

## Challenges and Constraints

This project faced several design challenges and constraints from the start. First, the design had to ensure minimal ecological disruption in an area known for its diverse ecosystems and endangered species. This meant any construction and design activities had to be environmentally sensitive, preserving the natural habitats and biodiversity of the property. Another significant challenge was the technical aspect of facilitating fish passage while maintaining the structural integrity of the ford crossing and the creek banks. The chosen design needed to be robust enough to withstand various environmental conditions, including flood events, without causing erosion or other negative impacts to the creek's ecology.

The project's construction also had to adhere to environmental regulations and account for the potential impacts on archaeological sites in the area. Addressing these challenges required a multidisciplinary approach, including performing detailed assessments and

creating mitigation plans. It took balancing engineering expertise with environmental conservation principles to achieve a solution that was both technically sound and ecologically responsible.

## Hydrology Review

The hydrology assessment involved a comprehensive analysis of the creek's natural hydrology. This was crucial in understanding the hydraulic characteristics of the creek in the project area and in determining the optimal design for the new fish passage structure. KGS Group conducted a Regional Flood Frequency Analysis to understand the statistical distribution of the flows and how normal or extreme events could impact the functionality of the design.

Design flows for fish passage are typically based on the three-day delay flow event with a statistical return period of 1 in 10 years (3dQ10), consistent with the criteria defined by Fisheries and Oceans Canada (DFO) for the analysis of fish passage structures for freshwater species. The 3dQ10 represents the largest streamflow that must be considered when design fishways and fish passage structures. This statistical value corresponds to a natural flow that is equalled or exceeded for three consecutive days with a 10% chance of exceedance. In this case, a site specific 3dQ10 value was developed for the critical season for the target fish species, which considers the spring spawning and migration period for southern Manitoba (April 1 – June 15). The 3dQ10 flow was estimated at 13.8 $m^3/s$.

## Biological Design

The main goal of the project was to establish a passage that allowed fish to cross the concrete ford in either direction. It is important to note that the upstream movement may not always be achievable due to natural fluctuations in water levels and flow velocities; sometimes being too low to facilitate movement, or too high for certain fish species. A key aspect was using swim performance information to determine the minimum drop in water level and water velocity conditions that would still allow the weakest swimming fish to move upstream under certain flow conditions. Of all the fish species identified in Beaver Creek, Northern Pike was selected as target fish species for this project due to their weaker swimming abilities when compared to the other species.

To ensure the new design created specific flow conditions, KGS Group had to take into consideration the fish's size, swimming strength and behaviour. Factors such as water depth, current velocity and resting areas were carefully calibrated to match the swimming abilities of the fish, facilitating their natural migratory patterns without causing undue stress or hindrance.

It was determined that over a 10 m swimming distance, the maximum swimming speed that can be sustained by Northern pike is 1.7 m/s. Of this species, 50% can swim at 0.88 m/s for at least 10 m and 97.5% have a burst swimming speed of 1.39 m/s over a five

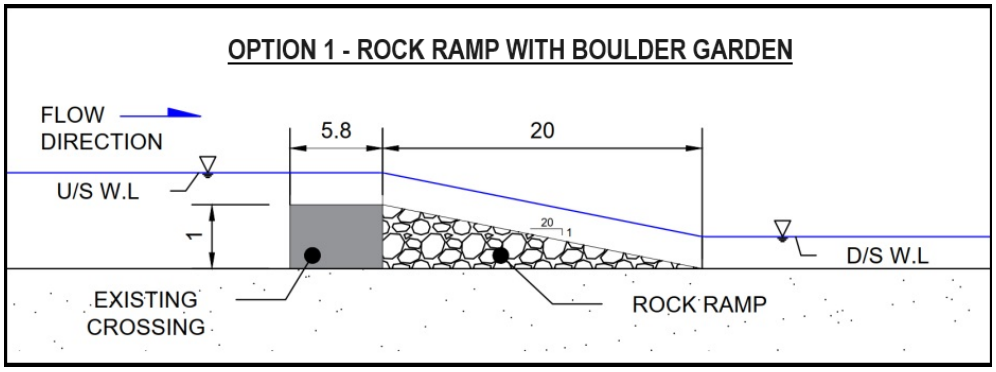
second period. Through understanding the swim performance of the Northern Pike, our team began developing concepts for the new structure that would create flow conditions suitable for all species that use the waterway.

## Conceptual Design and Assessment

KGS Group developed four modification options for the concrete ford crossing and evaluated each based on ecological/environmental impacts, technical feasibility, cost-effectiveness, schedule, operation and maintenance requirements and environmental/regulatory approval requirements.

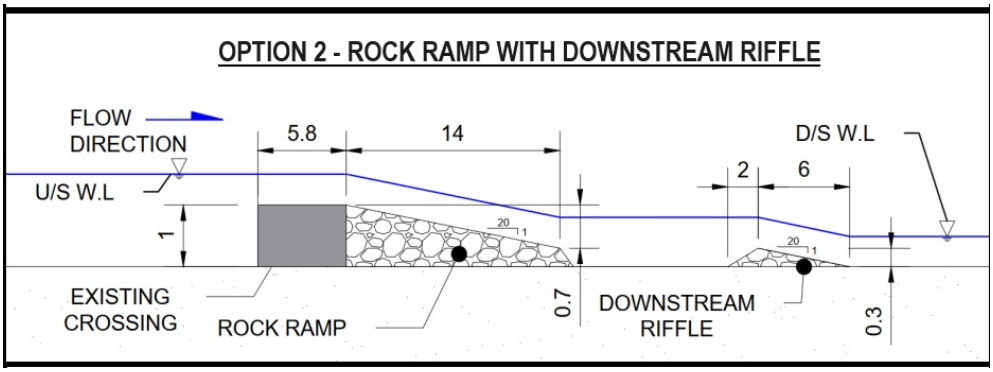
**Option 1 – Rock ramp with boulder garden**

The first option was to install a rock ramp with a boulder garden on the downstream side of the concrete ford crossing. It involved no changes to the existing ford structure and was anticipated to have no impact on upstream water levels. The downstream slope would be a near 20H:1V gradient, resulting in an approximately 20-metre-long rockfill structure that spans the entire width of the creek. This option was considered a low-impact option with a straightforward construction plan and a standard environmental and regulatory approval process.



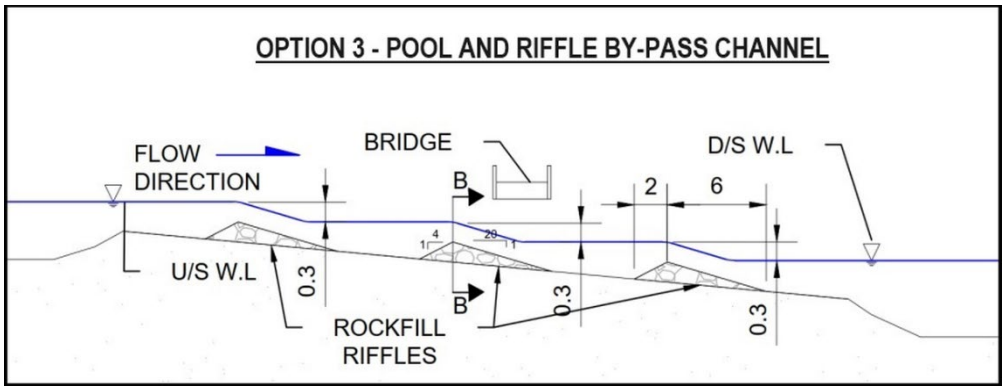

**Option 2 – Rock ramp with downstream riffle**

The second option was similar to the first but included a riffle, or small rock structure, downstream of the rock ramp to reduce the head difference (the height the fish must swim up) on the rock ramp. Like Option 1, this option would have no major changes to the existing structure and no impact on upstream water levels. The location of the downstream riffle would need to be determined, but it was anticipated to be at a location no further than 100 m downstream of the rock ramp. Impacts of Option 2 would only be in the areas immediately downstream of the crossing and at the location of the riffle. This option would have a straightforward construction and a standard environmental and regulatory approval process.



**Option 3 – Construction of a pool and riffle by-pass channel**

This option involved constructing a small by-pass channel on the north side of the concrete ford crossing with three 0.3 m high rock riffles along the channel. This option would require the construction of a single-span bridge crossing to permit access across the channel. The three rock riffles would play a crucial role in reducing the flow velocities in the channel, create resting areas for fish while allowing for a gradual elevation change. Instead of a longer, steeper climb as in Options 1 and 2, the fish would be able to navigate smaller, incremental changes in elevation as they move upstream. This option would have potential upstream hydraulic impacts due to the lower invert of the by-pass channel and would require more complex engineering and construction. Due the greater environmental impact, this option would have required a more involved environmental and regulatory permitting process.




**Option 4 – Removal of the existing structure**

The final option involved the complete removal of the existing concrete structure. This would have made the crossing unusable except for when the water was at its lowest. Benefits of this option would have been in its simplicity and that it would have restored the creek back to its original condition, however, it would have had a considerable impact on the creek's water levels and flow conditions, resulting in the loss of upstream aquatic habitat. Our team would have had to implement significant sediment mitigation measures upstream prior to decommissioning the current structure, due to the amount of sediment that has built up over decades.

KGS Group presented the modification options to the NCC, including estimated costs and schedules for the design and construction of each option, as well as the anticipated environmental and regulatory approvals required. The NCC chose to proceed with the detailed design and construction of Option 2, rock ramp with downstream riffle, because of the benefits it offered.

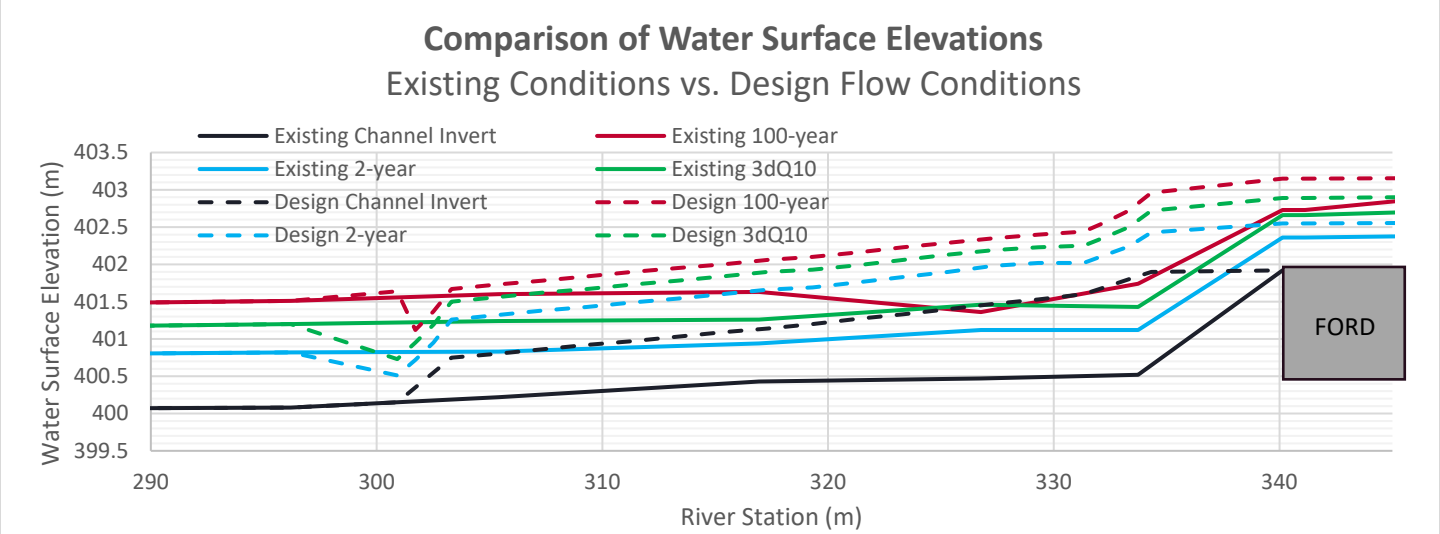
Option 2 provided an effective solution for enhancing fish passage while allowing the crossing to remain usable. The rock ramp combined with the downstream riffle reduced the head difference, making it easier for a variety of fish species, including those with lower swimming capabilities, to swim up. A determining factor for the NCC was that this option was also the most ecologically sensitive and offered improvements to fish mobility while minimizing disturbances to the creek's natural state and existing ecosystems. Option 2, when compared to other options that involved major structural changes, also presented a more technically feasible and cost-effective solution. Given its less-invasive nature, it was likely to face fewer environmental and regulatory hurdles and have lower potential for negative impacts. Finally, Option 2 was assessed to be more sustainable in the long term, with lower maintenance requirements compared to the other options.

## DETAILED DESIGN

### Hydraulic Modeling and Analysis

In the detailed design phase, a crucial component was hydraulic modelling and analysis using the Hydrologic Engineering Center – River Analysis System (HEC-RAS). This program allowed us to develop a detailed model and incorporate the creek's natural features and water depths, using surveys completed in March 2023. The focus of the analysis was on characterizing the flow patterns, specifically assessing flow velocities, depths and shear stresses under various conditions. This comprehensive modelling was essential to ensure the proposed rock ramp design would effectively support fish passage while maintaining appropriate flow speeds and turbulence levels. The design was improved using the results of the model and by checking that the results aligned with expected conditions. The ramp was designed as a 31 m long slope with variable gradients, averaging to approximately 20H:1V, with minimum rockfill thicknesses of 0.6 m. Crossfall slopes within the channel vary between 10H:1V and 20H:1V. The specific gradients were chosen to concentrate the flow of water to the centre of the ramp and maintain minimum water depth during low flow conditions.

Compared to existing conditions, the rock ramp's increased roughness and subsequent slope flattening would have a significant impact on water dynamics. The roughness created by appropriately sized rocks adds friction to the water's path, which in turn slows down the flow velocity. A flatter slope also contributes to this effect by reducing the water's momentum. As a result, these design choices increase water depths over the ramp, creating a more conducive environment for fish passage. Slower water velocities and greater depths make it easier for fish to navigate the structure, enhancing the ramp's effectiveness.




### Rock Sizing

The rock sizes were selected based on the results of the hydraulic modelling, which determined the shear stresses and flow velocities under a 1-in-100-year design flow. The maximum shear stress was determined to be 210 N/m$^2$, occurring within 3 m of the ford crossing. To account for tailwater levels, the energy grade slope was calculated using the equation recommended in the document Hydraulic Structures by C.D. Smith to determine median stone size. This method yielded a median stone size of 0.41 m to prevent rock movement under high flow conditions. This precise calculation ensured the rocks were adequately sized to maintain the structure's stability and effectiveness in enhancing fish passage.

Incorporating smaller stones with a median size of 250 mm into the rock ramp was a key design decision to achieving desired hydraulic performance. The smaller stones helped resist the flow of water through the rock ramp, ensuring the structure maintained its integrity during high flow conditions. They also filled in the voids which promoted surface flow over the ramp and created optimal conditions to facilitate fish passage.

## 2023 Spring Fish Use Assessment

A spring use fish assessment was completed by North/South Consultants Inc. to gain an up-to-date understanding of the populations and diversity of fish species that use Beaver Creek during the fish spawning season. Sampling was completed at six different sites from May 3 to May 5, 2023, and captured a total of 89 fish, representing nine different species. These species included large-bodied fish like Northern Pike, White Sucker and Shorthead Redhorse, as well as small-bodied fish such as Fathead Minnow, Longnose Dace, Western Blacknose Dace, Creek Chub, Brook Stickleback and Jonny Darter. The distribution of these fish varied, with more small-bodied fish captured upstream of the crossing and large-bodied species mainly found in the lower parts near where the creek flows into the Assiniboine River. Staff from the NCC supported North/South Consultants Inc. in their field program, giving the NCC staff the opportunity to expand their skills to be able to complete their own assessments, which helped reduce costs to the project.

NCC staff at the fish sampling site downstream of the ford crossing

## Environmental Planning and Heritage Considerations

The environmental planning for the project included a thorough assessment to address potential impacts on heritage resources and waterways. A Heritage Screening Request submitted to the Historic Resources Branch of the Province of Manitoba, identified concerns about disturbing archaeological sites near the ford. Consequently, a Heritage Resources Impact Assessment (HRIA) was conducted to mitigate these concerns. A Request for Review application with an accompanying aquatic habitat assessment was submitted to DFO to determine whether the project would cause Harmful Disruption or Destruction (HADD) of fish and fish habitat. To fully comply with the Canadian Navigable Waters Act, a Notification of Works to Transport Canada was submitted as well as posting the required public notices. The HRIA found no archeological concerns, and there were no objections through the Transport Canada and DFO submissions. With the regulatory approvals fulfilled, construction was allowed to proceed in an environmentally responsible manner, with adherence with environmental regulations.

## Design Finalization and Execution

The completion of the project design involved finalizing issued-for-construction drawings, which served as the definitive construction blueprints. Accompanying these drawings were technical specifications and final quantity estimates, which provided a detailed financial and technical overview of the required materials and resources. This ensured all aspects were meticulously

planned and budgeted for, which facilitated a smooth transition from design to construction. The precision in these final stages was key to the project's successful and cost-effective completion.

## CONSTRUCTION

The construction phase of the project was led by the NCC, who managed the tendering process for the project. Third Dimension Industries Ltd., the chosen contractor for the project, efficiently constructed the rock ramp in four days, purposely limiting the amount of time required for in-water work and reducing environmental disruption.

The contractor carefully worked around nearby tree roots, limbs and branches to maintain the integrity of the surrounding flora. The timing of construction, set in December 2023, was another testament to the project's alignment with ecological sensitivities. By scheduling the work outside the critical periods of fish spawning and plant growth, we were able to minimize its environmental impact. These decisions reflect the deep understanding of the ecological components of the Beaver Creek area and underscores the commitment to minimal environmental disruption in the area. Furthermore, the use of rock, free from silts and sediments, along with the implementation of effective sediment control measures, ensured that the construction activities did not adversely impact the downstream areas while maintaining the ecological balance of the creek.

The project site pre-construction – Dec. 13, 2023

The project site post construction – Dec. 19, 2023

KGS Group played a pivotal role in the construction phase, conducting inspections at the onset of the project and post-construction. While day-to-day inspections were completed by the NCC, our team provided technical support throughout construction. This was done to keep construction costs within budget and to enhance the technical capacity of the NCC staff. By actively participating in this phase, KGS Group facilitated skill transfer, empowering the NCC team with technical insights and expertise, crucial for the organization's future conservation projects. This collaborative approach not only guaranteed the project's quality, but also fostered a knowledge-sharing environment, reinforcing the project's commitment to sustainability and technical excellence.

## FUTURE IMPACTS AND OPPORTUNITIES

### Education and Stewardship

At NCC's foundation is the commitment to the interconnection of people and nature; the belief that we are all one with nature. This project closely aligns with the NCC's conservation goals. It also provides an opportunity to have the site included in programming

which focuses on education and cultural connection for communities, including the Park West School Division and the Waywayseecappo Off Campus School, and the community of St. Lazare. This endeavour highlights not only the project's ecological successes but also its potential role in maintaining and enhancing land-based community connections.

NCC's operational approach includes engaging with communities to address the dual crisis of climate change and biodiversity loss. In part, this includes working with communities in implementing programs with a focus on nature and conservation in a local context. These programs are designed to immerse people in their natural heritage and provide an opportunity for them to learn from each other about the local flora and fauna, the importance of ecological preservation and the human connection to the land. This project provides a potential opportunity for people to learn about Beaver Creek, and its importance to people in the area.

Working together with communities is an investment in the future of conservation. By building on a joint sense of responsibility and knowledge about environmental stewardship together, we will cultivate future leaders and caretakers of the land. This approach creates the potential for a future where respect for nature and its preservation are passed down, fostering a sustainable relationship between communities and their environment.

## Leaving Behind a Legacy

This project presents significant conservation opportunities for the NCC, most notably in enhancing upstream biodiversity. The work done directly influences the local ecosystem, positively impacting the at-risk native grasslands and bird populations in the area. The restored fish passage creates a thriving aquatic environment, essential for maintaining the health of the surrounding terrestrial habitats. The influx of diverse fish species upstream of the cement ford crossing can lead to a more balanced ecosystem, potentially attracting a wider range of wildlife and enriching the region's ecological fabric. This improvement supports the NCC's objectives of protecting and nurturing diverse and representative habitats that include both aquatic and terrestrial ecosystems and the wildlife that depend on them. The project exemplifies a harmonious balance between human intervention and natural preservation, embodying NCC's mission of safeguarding vital ecosystems for future generations.

# CONCLUSION

What began as a conceptual design study, evolved into a partnership between KGS Group and the NCC to determine the best solution to solve a significant ecological challenge: a concrete ford crossing impeding the natural migration of fish in Beaver Creek. Through every phase of the project from conceptual and detailed designs through to construction and knowledge sharing, KGS Group worked hand-in-hand with the team at NCC to ensure the environment was at the forefront of every decision. The end result was ecologically sensitive, offered improvements to fish mobility, minimized disturbances to the creek's natural state and existing ecosystems and was cost-effective while being minimally invasive to the surrounding environment. This project exemplifies a harmonious balance between human intervention and natural preservation, safeguarding vital ecosystems for future generations.

The finished product