Klohn Crippen Berger

# SKINS LAKE SPILLWAY PLUNGE POOL REHABILITATION

BC, CANADA

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CANADIAN CONSULTING ENGINEERING AWARDS 2020

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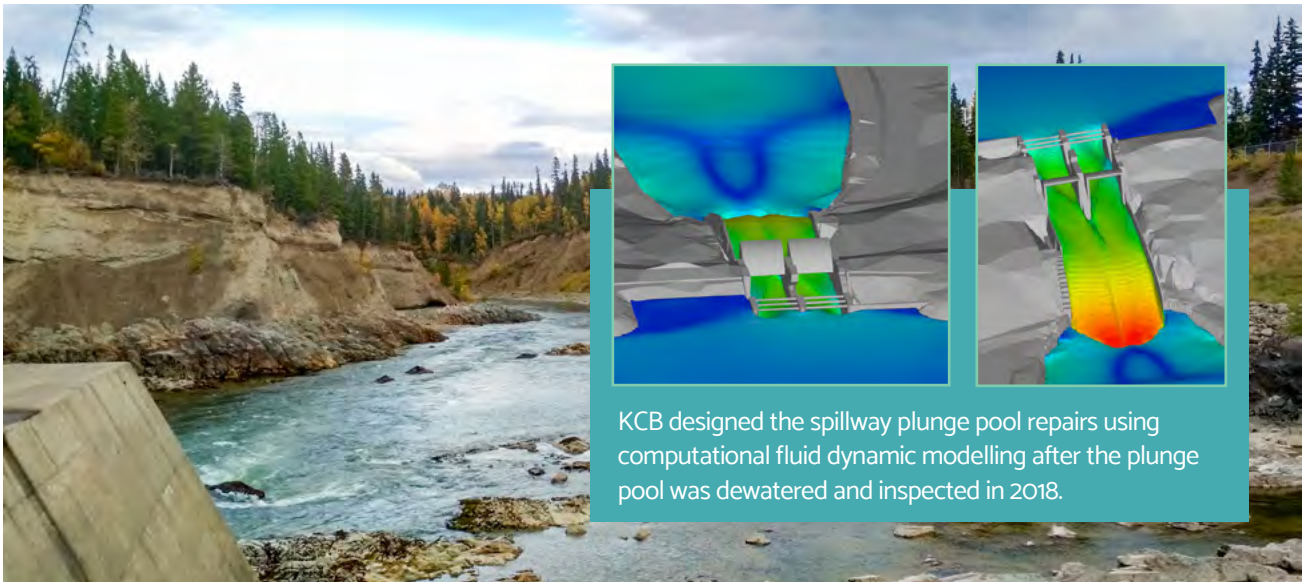
| PROJECT NAME | Skins Lake Spillway Plunge Pool Rehabilitation |
| LOCATION OF PROJECT | 200km west of Prince George, BC |
| YEAR COMPLETED | 2019 |
| CATEGORY OF ENTRY | C. Water Resources |
| ROLE IN PROJECT | Prime Consultant |
| PROJECT OWNER / CLIENT | Rio Tinto |
| PROJECT SUMMARY | The Skins Lake Spillway (SLS) near Prince George, B.C. is a critical flood regulating structure for the Nechako Reservoir. Rio Tinto required repairs of the spillway plunge pool due to continuing erosion. Klohn Crippen Berger's repair design used the latest shotcrete technology adapted from highway and tunnel designs. The remediation of SLS addresses dam safety concerns, allows uninterrupted release of flows downstream to an important ecosystem, and regulates flood discharges, improving the safety of downstream communities. |



KCB designed the spillway plunge pool repairs using computational fluid dynamic modelling after the plunge pool was dewatered and inspected in 2018.

# INNOVATION

The Skins Lake Spillway (SLS), built in 1952, is located 200 km west of Prince George, British Columbia. The spillway is a critical flow regulating structure for the 890 km² Nechako Reservoir, which supplies water to the 896 MW Kemano Generating Station, providing power to the Kitimat aluminum smelter, both of which are owned by Rio Tinto (RT). The SLS is classified as "Extreme" consequence under the 2016 B.C. Dam Safety Regulation.

The SLS and plunge pool performed relatively well under normal flow conditions since their reconstruction 20 years ago. However, a few flood events progressively led to partial erosion and degradation of a protective shotcrete layer and its underlaying rock foundation, to a point that in 2019, RT decided to dewater the plunge pool to perform comprehensive repairs. Klohn Crippen Berger (KCB) was retained by RT for the repair design, including project tendering and quality compliance field services for a short seasonal construction window, while meeting minimum riparian flow requirements.

### Key project successes included:

1. The Client's understanding of the importance to maintain critical structures of their hydro assets.
2. KCB's experienced engineering team assessed the condition of the plunge pool walls and the adjacent spillway.
3. KCB's creativity in adopting the latest shotcrete application techniques based on experience from highway and tunnel projects.
4. KCB's risk-based thinking helped the client understand the risks related to the project, leading to their approval of independent quality control and a full-time presence for field review during construction, and more importantly agreeing to hire a reputable contractor and perform a pre-dewatering in 2018.
5. KCB designed practical repairs that could be implemented effectively in a very short construction window while achieving the project objectives.

KCB selected "dry-mix" shotcrete for the repairs, using pre-mixed bags and a compact hopper to deliver the shotcrete. Using dry-mix shotcrete was more efficient and cost effective for this remote site, compared to the alternative which would have involved setting up a small batch plant or delivery of shotcrete by heavy equipment. Before construction, the shotcrete method was tested to meet the design specifications, by applying the same materials and using the same equipment and operators at an off-site location. The shotcrete was applied more safely and efficiently by an operator on a "zoom boom" or telescopic handler, rather than from a scaffold platform.

Construction of the spillway plunge pool repairs were accelerated by adopting the latest shotcrete application techniques from highway and tunnel construction.

Two steel pipes integrated with the spillway stoplogs were used to bypass the 32 $m^3/s$ environmental flow during construction.

# COMPLEXITY

The rehabilitation of the Skins Lake plunge pool was a complicated project because of its remote location, short construction window, extensive rehabilitation work on existing infrastructure, and the site's environmental sensitivity. Specific work procedures were developed to minimize potential environmental impacts.

To complete the project within the designated time frame, the careful scheduling of crews and timely delivery of materials and equipment to site was complicated by the remote location, with primary access to the site by ferry. A work camp was also required, and the contractor established one nearby at the unoccupied Ootsa Lake summer camp, reducing commuting times and the likelihood of worker fatigue.

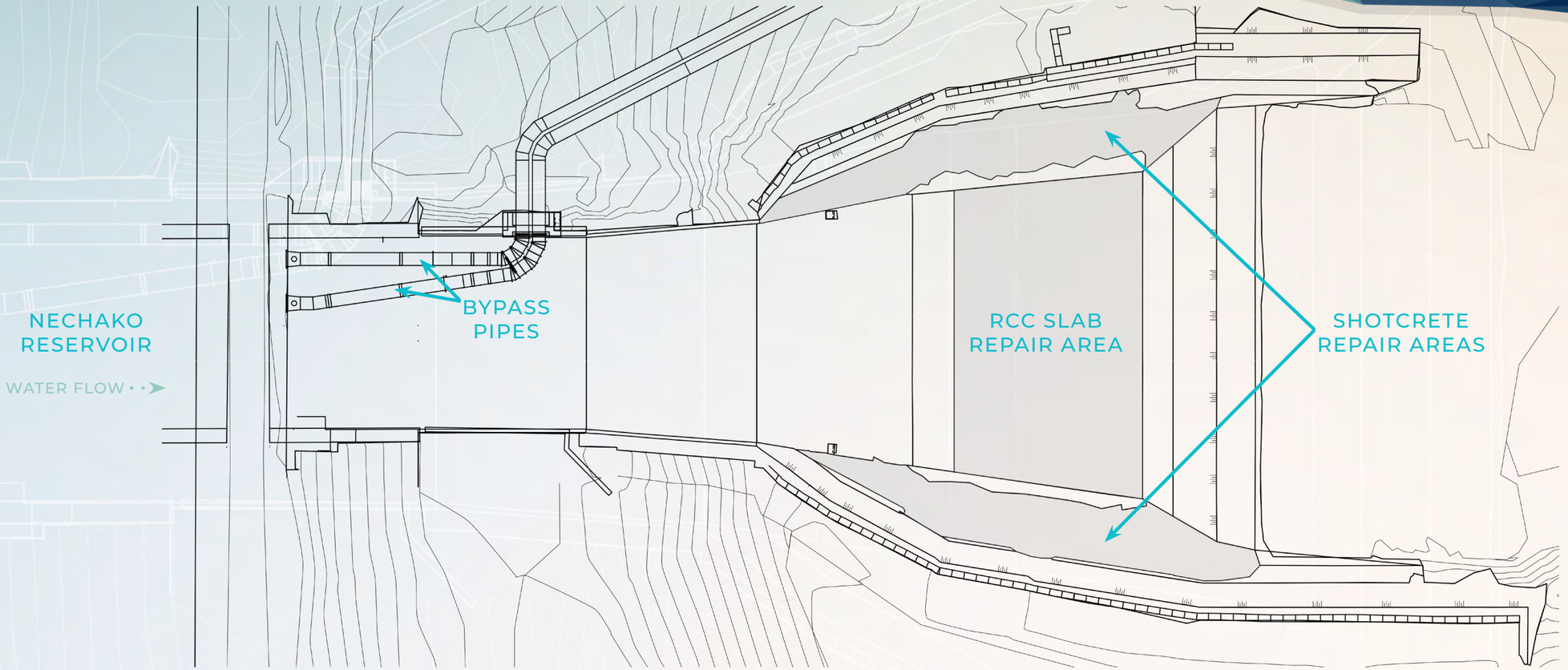
A 24/7 shift schedule was implemented gradually. Night shift work was implemented after crews were familiarized with the site, and construction activities were limited to those that could be performed safely under limited lighting conditions.

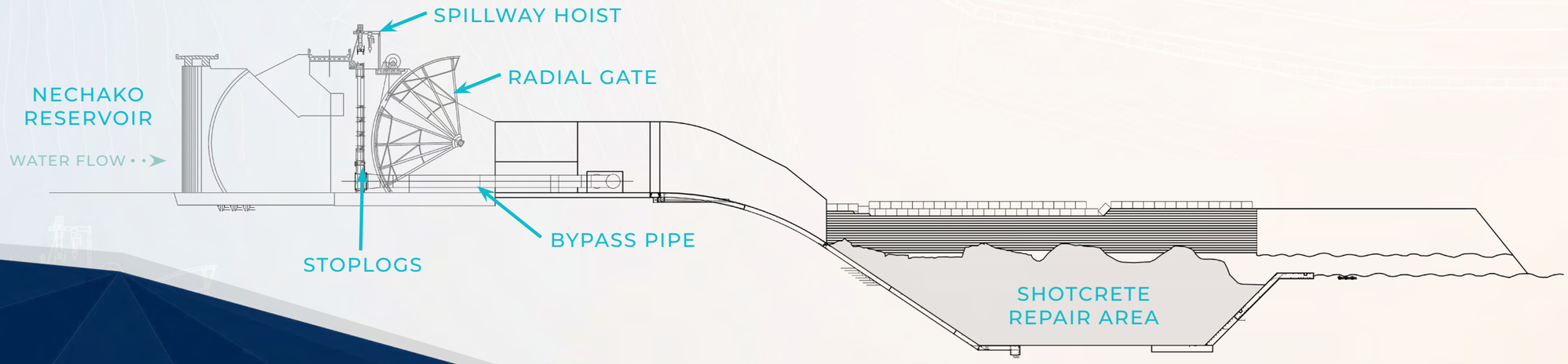
Project risks were mitigated by dewatering the plunge pool a year before repairs started, in 2018, to fully assess the extent of erosion, determine the water bypass requirements for flow, and the proper methods for recovering and transporting fish downstream during construction.

The rehabilitation of the plunge pool, procedure for bypass installation and dewatering, repair design, and construction plan were developed with an emphasis on safety, minimal environmental impacts, and quality of work.

The effective collaboration between the project owner, contractor and designer allowed for the project to be completed within schedule, under budget, and before the start of winter.

# ILLUSTRATIONS



# SOCIAL AND/OR ECONOMIC BENEFITS

The SLS is the only flow regulating structure for controlling the water levels in the Nechako Reservoir and the downstream flow of the Nechako River. The maximum design discharge is 2000 $m^3/s$ (which is the estimated Probable Maximum Flood). The SLS also needs to release a minimum flow for compliance with the Summer Temperature Management Program for the protection of sockeye salmon migrating through the Nechako River.

Remediation of the SLS means that it will maintain the safety of downstream communities by controlling flood discharge from the reservoir during unusual inflow events.

The construction crew was housed in the Ootsa Lake camp, which was closed during the construction season, thus minimizing traffic and disturbance to nearby campgrounds and other recreational areas. The short construction window minimized closures to the spillway deck bridge, which is a primary route used by the surrounding community. The contractor also hired aboriginal workers from the local Cheslatta Carrier first nation community.

By keeping their dam well maintained and compliant to tight riparian constraints, RT is ensuring the safety of the downstream communities and the environment.

# ENVIRONMENTAL BENEFITS



The SLS remediation project was planned with sustainability in mind and addressed dam safety concerns by ensuring the continued uninterrupted release of environmental flows downstream to an important ecosystem.

RT's preventative maintenance of the SLS enables a sustainable and safe supply of hydropower to local industry. Prior to construction, downstream flow requirements were successfully established using a bypass system and closely monitored throughout construction for water quality. At the completion of construction, the plunge pool was thoroughly cleaned with pressure washers, power sweepers and magnet trollies to pick up steel fibers, preventing their release downstream.

The construction schedule was adapted to minimize impacts to local bird nesting populations and the salmon spawning season. Approximately 1,100 fish were salvaged from the dewatered plunge pool and safely transported downstream. Wastewater from construction activities was collected and treated to meet the goal of zero discharge downstream.

The SLS plunge pool rehabilitation project illustrates how the art and science of engineering is alive and well. KCB worked with RT as a valued partner by communicating and assessing the risks and planning effectively for risk mitigation as a team. KCB's design team considered the surrounding community during construction, including environmental requirements, technical specifications and communication with numerous stakeholders. The project would not have been a success without the project team expanding the role outside of the technical and construction components of the project.

# MEETING CLIENT'S NEEDS

The primary goal of the SLS plunge pool repairs was to address the dam safety concerns related to on-going erosion of the plunge pool walls and roller-compacted concrete slab.

Additional goals included:

- minimizing environmental impacts;
- maintaining required downstream flows;
- minimizing the impact on and maximizing the benefits to the surrounding community; and
- finishing the project within a single construction season.

KCB applied the following practical solutions to the repair design to meet the project goals:

1. Optimized the design of the spillway repair using computational fluid dynamics (CFD) to model the discharge velocities in the plunge pool and compared these results with the results of analyses done in 2000.
2. Specified fibre-reinforced shotcrete rather than conventional cast-in-place concrete for the repair.
3. Specified careful preparation of the plunge pool surface before applying shotcrete, with additional quality control and quality assurance steps for checking the work progress.
4. Retained a shotcrete specialist and consulted a reputable construction contractor to assess project constructability to better plan the work.
5. Utilized a tall stationary crane that could reach the entire work area to minimize the number of equipment in a congested area.
6. Identified the need for dewatering equipment redundancy to maintain schedule.
7. Specified full-time field review for construction and environmental monitoring.
8. Additional planning phase after contract awarded to refine the execution plan using the combined experience of the stakeholders.
9. Specified off-site shotcrete testing to ensure suitability of the methodology to meet the project requirements prior to mobilizing to site.

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