Kelso Dam—
Urgent Repairs and Rehabilitation Project

2021 Canadian Consulting Engineering Awards

HATCH

Project Name: Kelso Dam—Urgent Repairs and Rehabilitation Project

Location of Project:
Street: 5234 Kelso Road
City: Milton
Province: Ontario
Country: Canada

Category: C. Water Resources

Entering Firm
Firm Name: Hatch Ltd
Street Address: 4342 Queen Street, Suite 300
City: Niagara Falls
Province: Ontario
Postal Code: L2E 7J7

Completed By : August 2020

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Project Summary:

In 2015, turbid foundation seepage was observed which, can indicate potential dam failure/breach. To address these urgent concerns, Conservation Halton contacted Hatch who responded immediately, recommending reservoir drawdown and increased surveillance/monitoring. Subsequent risk assessments and designs for emergency remedial works included geotechnical monitoring, design of an energy dissipating stilling basin, and emergency spillway enhancements.

Completed in 2020, this project significantly improved the dam's reliability and safety and reduced risks to downstream communities and the environments.

Built in 1962 in response to Hurricane Hazel, the Kelso Dam, within the Kelso Conservation Area, is significantly important for recreation, flood control, and low-flow augmentation.

Project highlights

Innovation

Conservation Halton engaged Hatch to address the known dam safety deficiencies and rehabilitate the Kelso Dam so that it met current regulatory guidelines and standards, in particular so that the reservoir could be returned to its normal operating range and the dam could again serve its combined purpose of flood control, recreation, and flow augmentation. Through all phases of the work, Hatch provided services, which included:

- Initial inspections, assessments, instrumentation reviews, surveillance instructions, risk studies, and advice to Conservation Halton on the dam condition and the risks it posed
- Design and construction management for a reinforced concrete stilling basin to dissipate the significant energy within spillway flow releases and thereby avoid significant erosion at the toe of the dam that could lead to dam failure
- Remedial grouting within the body of the dam to enhance the seal between the concrete box culvert and the adjacent sheet pile cut-off wall
- Construction of erosion protection at the emergency overflow spillway
- Critical review of dam health monitoring instrumentation

Repair designs included carefully engineered foundation filters to address seepage and piping concerns, a new energy dissipating spillway stilling basin developed using state-of-the-art computational fluid dynamics (CFD) modeling, remedial grouting to augment a local sheet pile cut-off and automation of selected instrumentation for performance monitoring.

Simultaneously, mitigation plans were developed to protect the cold-water fishery downstream of the dam during construction.

Technical excellence and innovation

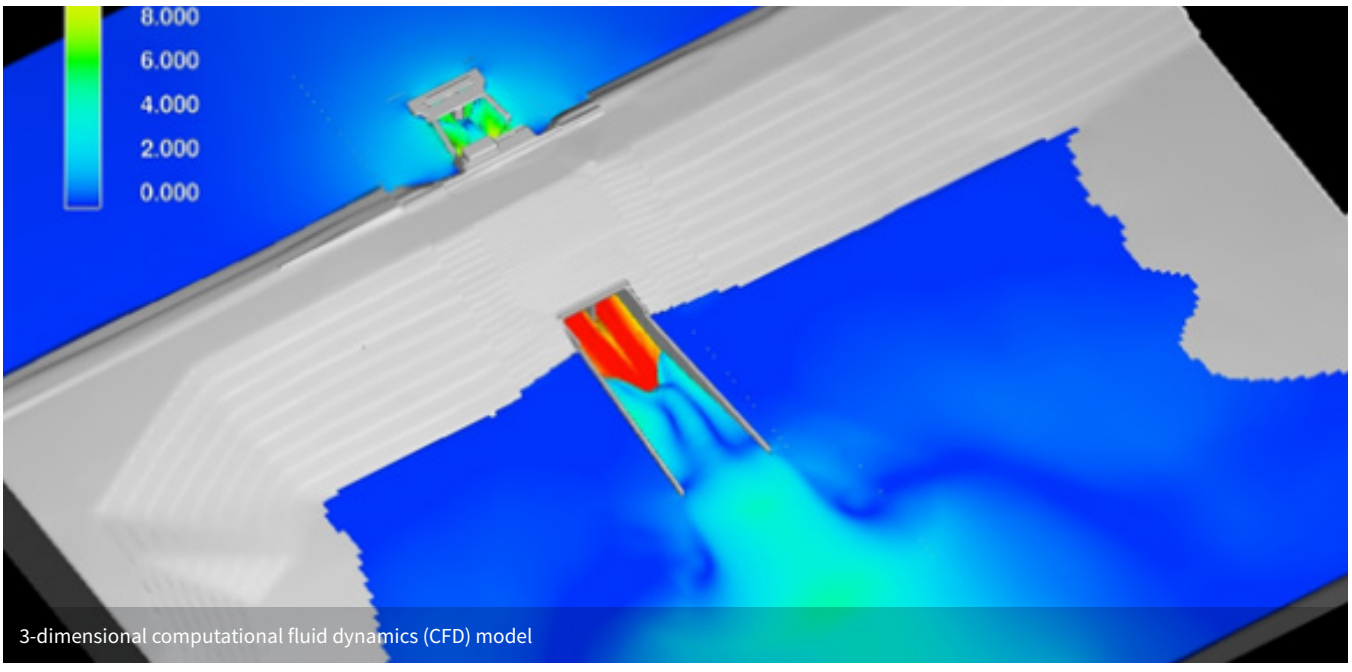
Existing spillway terminus structures were known to be inadequate with concerns focused on downstream channel erosion and the potential for erosion of the embankment dam during a large flood event, potentially causing significant damage, and possibly a dam failure. An energy dissipating stilling basin was prescribed, the design flood being the Probable Maximum Flood (PMF) at 360 m^3/s.

Stilling basin design arrangement

Hatch engineers used 3-dimensional computational fluid dynamics (CFD) models of the main spillway and connecting conduit structure to evaluate discharge capacity and flow and simulate options for optimal arrangements.

In order to dissipate the energy of the water exiting the outlet conduits and reducing erosion, Hatch presented an innovative design for a stilling basin downstream of the spillway structure. This new design prevents significant erosion in the downstream area and reduce the potential risk to the integrity of the embankment dam.

The stilling basin arrangement and transition section presented in the image below reflect the simulated model that showed the best hydraulic performance in terms of the analysis.



3-dimensional computational fluid dynamics (CFD) model

Complexity

Risk assessments

Hatch, working for provincial utilities and the Ontario Ministry of Natural Resources and Forestry, has pioneered quantitative risk assessments for dams. These unique dam assessment tools were applied to inform Conservation Halton of the risk profile and potential loss-of-life consequences resulting from potential dam breach in this highly populated, urban area.

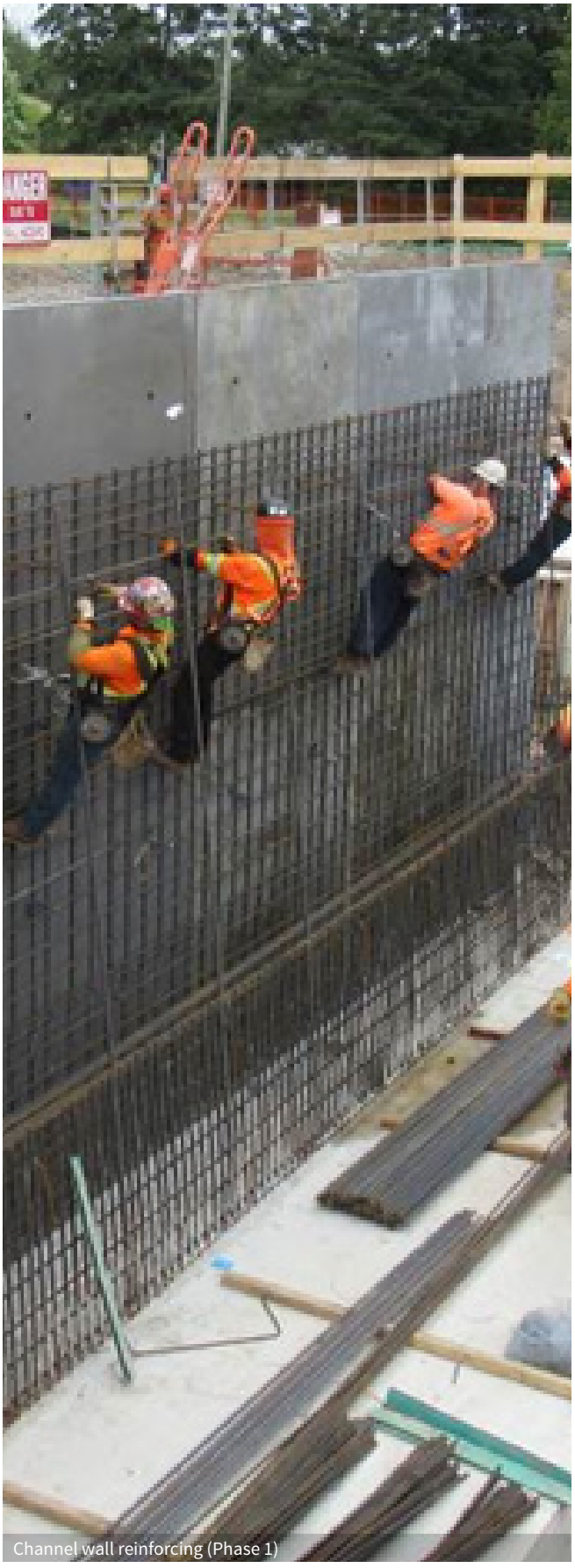
Construction diversion flood and excavation

Dewatering for construction was performed during the dry summer season and part of the wet, fall season. A risk-based approach was adopted to determine an appropriate flood magnitude for flow diversion during this period. Hatch designed the preliminary diversion channel scheme and construction sequencing, which was adopted in the construction phase.

The significant excavation for the stilling basin, at the downstream toe of the dam, required a matrix of dewatering well-points to locally draw the water table down. This was a critical and technically challenging task since the native foundation soils consisted of highly permeable, unconfined aquifers, producing vast amounts of water. This was complicated by the fact that site of the construction was close to the municipal water wells for Milton which rely upon this same aquifer. Vigilant water table monitoring was specified.

A provincial permit to take water (PTTW) was a project requirement and a significant undertaking since dewatering of the construction excavation was estimated to involve the pumping of up to 26 M l/day. During the construction program, this was increased to 45 M l/day with appropriate permit adjustments.

Sheet pile installation



Channel wall reinforcing (Phase 1)

Social and/or Economic Benefits

The Kelso Dam, within the Kelso Conservation area, was built in 1962, in response to Hurricane Hazel. The dam is significantly important for flood control, seasonal low flow augmentation, and recreation. Flooding and erosion, in particular, are natural hazard concerns in Conservation Halton's watershed and the Kelso Dam is one of four flood control structures maintained and managed by Conservation Halton.

The Kelso Conservation Area is of environmental and recreational significance. Enjoyed by visitors from the local community and beyond, it is valued for its natural beauty and ecological resources. Located within this conservation area, near the community of Milton, Ontario, the Kelso Dam serves not only recreational purposes but critically as a flood control structure in a watershed where concerns of flooding and erosion recurrent are natural hazards.

The Kelso Reservoir is used for boating, swimming, and is highly valued for supplying water to the adjacent ski hill for artificial snowmaking. Hatch's engineering intervention delivered a critical improvement project that restored the reservoir to its full recreational potential and significantly improved reliability and dam safety, reducing risks to the natural environment and downstream communities.

The dam rehabilitation project and associated enhancements now allow safe discharge of 360 m^3/s for the extreme flood case (the Probable Maximum Flood – PMF).

Environmental Benefits

To ensure the health of the stream and its inhabitants for the duration of the construction period, Conservation Halton was required to block some Lake Ontario migratory fish (i.e., Rainbow Trout) from entering the construction area for spring spawning to ensure no harm to the adults, eggs, or juveniles occurred. Conservation Halton ecologists tracked the movement of these species in the weeks prior to construction to ensure that no spawning fish had entered the construction area and before spawning occurred, netting was placed downstream of the construction area to isolate the work area. Prior to dewatering the work site, Conservation Halton completed a fish rescue of 1,076 individual fish for relocation comprising 20 species.

Water levels, turbidity (clarity of water), and water temperatures were monitored for the duration of construction.

Additional measures to protect the environment from construction impacts included the implementation of sediment and erosion controls to help prevent silt entering the creek from the construction area.

Diversion channel operation

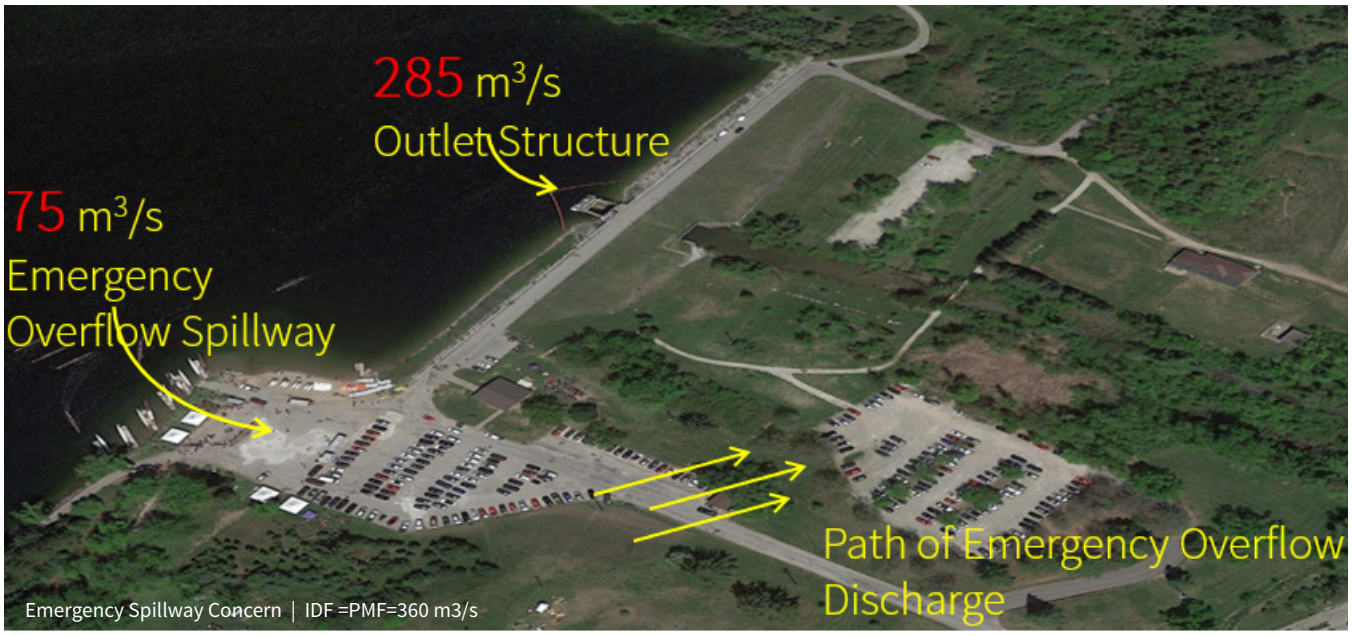
Meeting Client's Needs

Hatch's innovative engineering solutions, dam safety leadership, and design expertise resulted in risk management solutions and successful delivery of the overall project. Project highlights included:

- Rapid response on notification of the piping incident
- Decisive instructions to lower the reservoir level in an urgent but controlled manner to reduce the risk of dam failure
- Engineering support through permitting and funding processes
- State-of-the-art risk assessments with the target of reducing the risk to as-low-as-reasonably-practicable (ALARP)

Hatch was instrumental in the successful delivery of this project. The project was completed within the approved timeframe and budget with Hatch providing professional support throughout the life of the project, including during the planning, design, and construction stages. This project is both an example of engineering innovation and an illustration of the engineer's role in the community for dam safety, the protection of the public, and care for the environment.

Stilling basin looking upstream

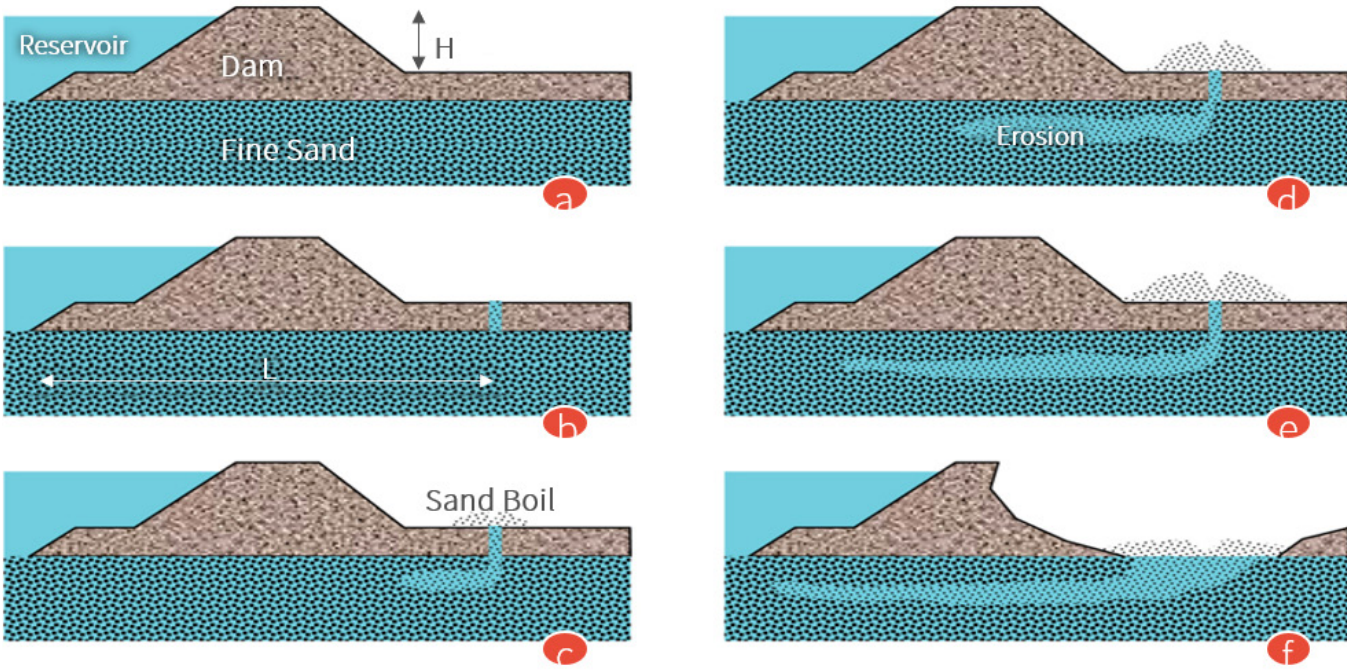


Emergency Spillway Concern | IDF =PMF=360 m3/s

Project images

Fish rescue during drawdown

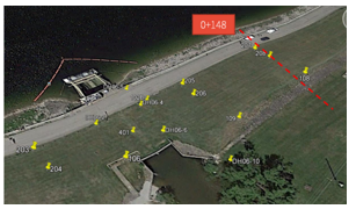
Drilling setup



Piping Beneath a Dam (Internal Erosion)

Name: Riprap
Model: Saturated Only
K-Sat: 0.01 m/sec
Ky'/Kx' Ratio: 1

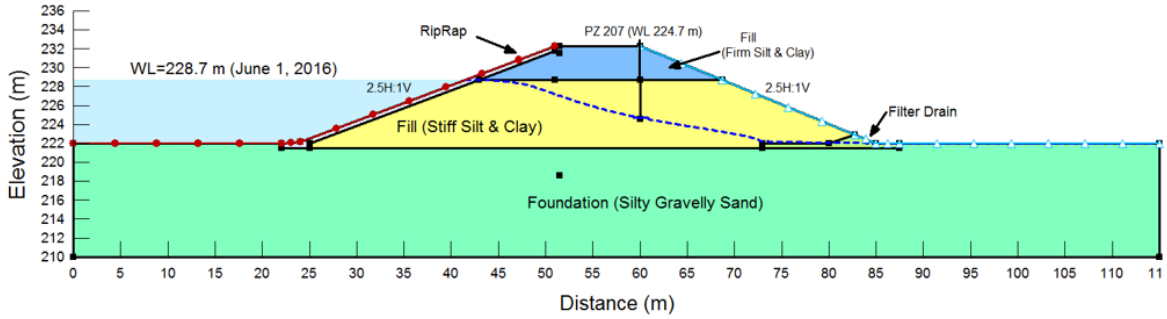
Name: Embankement Fill (Stiff)
Model: Saturated / Unsaturated
K-Function: Clay/Silt, Ksat = 2.5e-08 m/s
Ky'/Kx' Ratio: 1



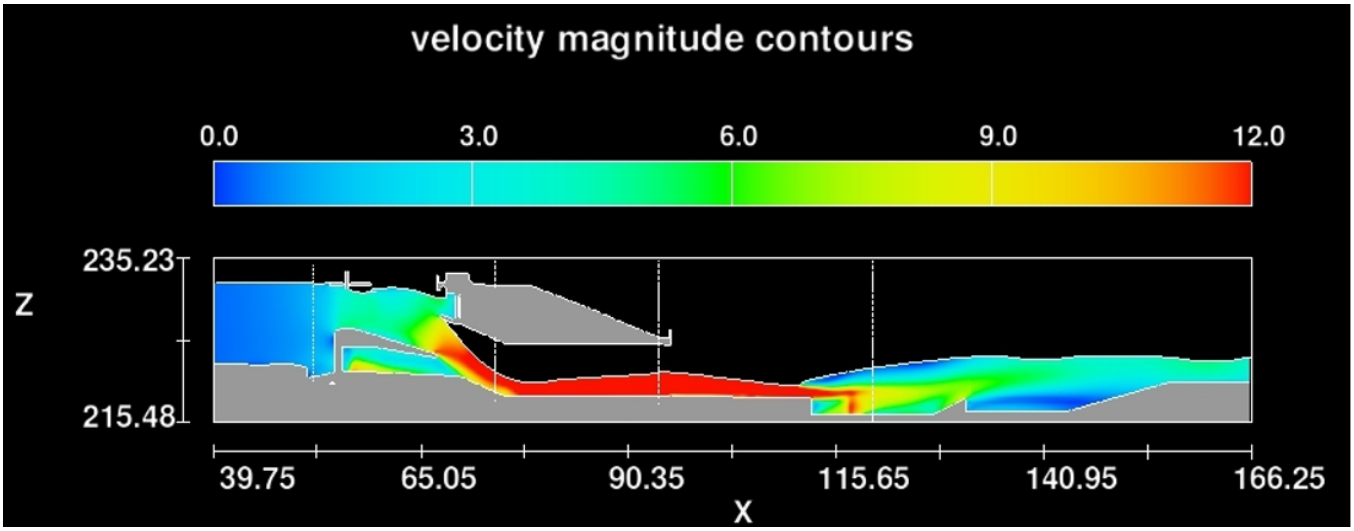
Name: Filter Drain
Model: Saturated Only
K-Sat: 0.0001 m/sec
Ky'/Kx' Ratio: 1

Name: Emabnkement Fill (Firm)
Model: Saturated / Unsaturated
K-Function: Clay/Silt, Ksat = 2.5e-07 m/s
Ky'/Kx' Ratio: 1

Name: Foundation Materials
Model: Saturated Only
K-Sat: 1e-006 m/sec
Ky'/Kx' Ratio: 1



Embankment: Section 0+148 (With No Sheet Pile)



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Appendix _A

Client's consent approval

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Appendix B

Payment receipt