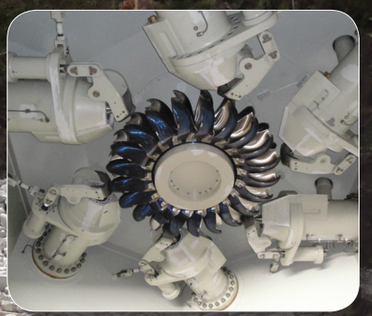
East Toba and Montrose Hydroelectric Project



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EAST TOBA AND MONTROSE HYDROELECTRIC PROJECT

PROJECT HIGHLIGHTS

The success of any project relies on the expertise and drive of the team assembled to complete it. In the case of the East Toba Montrose Hydroelectric Project, a diverse and innovative team of professionals came together to design, procure and construct all the necessary components for the largest run-of-river project in the history of British Columbia. Awarded an Energy Purchase Agreement (EPA) by BC Hydro in 2006, the East Toba and Montrose Hydroelectric Facilities are now a source of clean, renewable energy for generations of Canadians.

The East Toba and Montrose Hydroelectric Project is a 235 MW run-of-river Green Power development located approximately 100 km north of Powell River B.C. The Project was identified and permitted by Knight Piésold Ltd. (KP) for Toba Montrose General Partnership. KP was subsequently hired by Kiewit to perform detailed design of the Project under an EPC contract that guaranteed performance, schedule and price. The EPC design team, comprised of a perfect synergy of mechanical, electrical, structural, geotechnical and hydraulic specialists, was successful in meeting or exceeding all contractual guarantees.

Close coordination, innovative design concepts, and team work were key aspects to overcoming the numerous challenges encountered in developing these remote hydroelectric facilities in some of the country's most challenging terrain. Challenges, such as snow and debris avalanches, numerous river and stream crossings, slope instabilities, limited instream construction windows, remote location, and extreme weather were overcome in order to deliver 60 km of new access road, 11 major bridge crossings, 150 km of 230kV transmission line and two run-of-river hydroelectric facilities on budget and ahead of schedule.

Throughout the development, long-term working relationships were established and maintained with the local and three First Nations communities. Economic development opportunities within these communities expanded during construction and continue to expand beyond project completion.

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Project accomplishments include the design of the largest run-of-river project in B.C. history (East Toba Facility – 30.7 m^3/s design flow and 581.1m gross head); the design of the largest Coanda Screen installation in the world (Montrose Intake – 22.8m^3/s design flow); long standing relationships with the local communities and three First Nations groups; and the design of a 150 km transmission line through areas of active logging, high value recreation, sensitive habitats and numerous terrain hazards resulting in a robust and low impact alignment.

The Project, successfully commissioned in the summer of 2010 ahead of schedule, is currently delivering Green Energy to BC Hydro under a long-term Energy Purchase Agreement.

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FULL PROJECT DESCRIPTION

1. PROJECT OBJECTIVES, SOLUTIONS AND ACHIEVEMENTS

Knight Piésold Ltd. was hired as the lead EPC design firm by Kiewit to design the East Toba and Montrose Hydroelectric Project. Working closely with the Contractor and several sub-consultants in a design-build atmosphere to develop innovative and cost effective design solutions, two state of the art run-of-river hydroelectric facilities, along with associated infrastructure including roads and power lines, were designed and constructed on time and on budget. The design team worked closely with the Contractor and Owner under an EPC Contract that guaranteed performance, schedule and price. In order to meet these guarantees several challenges were overcome, including the remoteness of the sites, diverse and complex environmental timing and overall coordination required for such a large project.

Salient details for the major project components are as follows:

East Toba River Hydroelectric Facility

Rated Capacity of Plant:	147 MW
Design Flow:	30.7 m^3/s
Penstock Length:	5.3 km (Diameter: 2.54 m to 3.35 m)
Gross Head:	581.1 m
Turbine(s):	2 x Pelton Units, 6-Jet Vertical Axis

Montrose Creek Hydroelectric Facility

Rated Capacity of Plant:	88 MW
Design Flow:	22.8 m^3/s
Penstock Length:	4.2 km (Diameter: 2.13 m to 3.35 m)
Gross Head:	465.8 m
Turbine(s):	2 x Pelton Units, 6-Jet Vertical Axis

Power Line

Line Voltage:	230 kV
Length:	150 km (East Toba Powerhouse to BC Hydro Grid at Saltery Bay)
Pole Type:	H-Frame wooden structures and steel towers where required.

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EAST TOBA AND MONTROSE HYDROELECTRIC PROJECT

Access Roads

Road Length:	60+ km of Access Road
No. Bridges:	11 - Large (20 to 120 m spans); 45 - Small (5 to 15 m spans)
No. Culverts:	357 (0.4 to 2.0 m diameter)

Main Intakes:

The East Toba and Montrose intake structures have been designed to provide the following functions:

1. Divert a portion of the natural stream flow to the water conveyance system for energy production,
2. Provide the In-stream Flow Release downstream of the intake to maintain natural aquatic ecology,
3. Exclude large sediments from entering the water conveyance system that could cause damage to the pipe and turbine equipment, and
4. Allow passage of flood flows without damage to the structures.

Stream flow required for energy production is diverted into the Montrose intake structure through Coanda (shear effect) screens. The East Toba facility makes use of an inflatable rubber weir to divert flow through submerged portals. Flow through the Montrose Coanda screen collects in a channel below that delivers the water to the intake reservoir box. Flow entering the East Toba intake portals passes through a trash rack and a vortex de-sander before entering the intake reservoir box. In-stream flow release (IFR) is delivered downstream of the intakes through submerged outlets in each intake reservoir box. Flow enters the water conveyance downstream of the IFR bypass through a roller gate that can be used to isolate the intake reservoir box from the water conveyance system (penstocks).

Water Conveyance System:

The water conveyance systems are designed with a combination of HDPE (Weholite) pipe in the lower pressure sections and continuously welded steel penstock in the high pressure sections. Where possible pipe sections are designed to be direct buried into the natural ground making use of engineered fills to restrain pipe movement eliminating the need for concrete anchor blocks. The Montrose water conveyance system utilises surface mounted steel penstock for the steeper sections leading down to the powerhouse. In general, the penstocks were constructed adjacent to access roads, backfilled and re-

vegetated in order to minimise the project footprint, improve aesthetic appeal and maintain wildlife habitat and migration routes.

Powerhouses:

The powerhouses are design with concrete substructures and structural steel superstructures to house the turbine/generator units and all associated mechanical, electrical, protection and control equipment. Tailraces comprised of rip-rap lined channels return flow to the natural creek unaltered in terms of temperature and water quality.

Switchyards:

Switchyards comprising of a step-up transformer, and other protection, control and isolation equipment were constructed alongside the powerhouses, to step up the voltage from generation voltage of 13.8 kV to transmission voltage of 230 kV.

Transmission Line:

A new 150 km 230 kV transmission line runs from the East Toba switchyard to the Saltery Bay substation where energy that is generated from the facilities is delivered to the BC Hydro Grid. The power line is comprised of H-frame wooden structures and single steel towers. Maintaining a narrow corridor for the power line was essential in reducing loss of harvestable land base, minimising aesthetic impacts to the surrounding area and reducing loss of habitat for resident fauna.

Access:

Access to the project site required transportation to Toba Inlet by boat, barge, float plane or helicopter. Weather played a significant role in accessing Toba Inlet throughout the 3-year construction period. Existing forestry roads and new roads were designed with more than 400 stream crossings to gain access to the East Toba and Montrose powerhouse and intake sites. In order to keep within the strict fisheries construction windows, designs had to be finalised just prior to construction to ensure fisheries resources were not impacted while maintaining a cost effective solution for the contractor.

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EAST TOBA AND MONTROSE HYDROELECTRIC PROJECT

2. TECHNICAL EXCELLENCE AND INNOVATIONS

Customized project management tools, innovative design concepts, project optimization studies and great teamwork all played significant roles in the project's success. Some of these aspects included:

- Coanda ("shear-effect") intake screens, which are self-cleaning and prevent sediment inclusion into the penstock.
- Intake model testing for hydraulic design and optimisation.
- Sighting of projects upstream of known fish barriers and project layout optimisation.
- Geotechnical designs to deal with varied and complex site conditions.
- Snow avalanche protection design at the Montrose intake, and along the transmission line.

Coanda – Shear Effect Screen

The Montrose intake structure uses Coanda shear effect screens to divert stream flow into the intake reservoir. The Coanda screens were chosen due to the high sediment loading of Montrose Creek. Coanda screens prevent debris and sediment greater than 1.0 mm from entering the penstock by allowing them to pass over the screens and into the creek downstream. The Montrose Creek installation, having an overall length of 60 m, is the largest of its kind in the world. The team completed extensive research into the use of these screens before recommending them for the Montrose hydroelectric project, including a full prototype test for a 1 metre wide section of screen. Testing was completed at the hydraulic testing laboratory at Colorado State University. Issues such as ice formation on the screens during colder winter months, clogging of the screens with leaves in the fall season, the ability to deal with large bed load and long-term maintenance requirements were addressed in the intake structure design.

Intake Model Testing

A 1:25 scale model was constructed for the East Toba intake facility and tested extensively by Northwest Hydraulic Consultants. Several optimisation tasks were performed during model testing such as scouring capacity upstream of the intake, vortex suppression within the reservoir box, sediment exclusion within the vortex de-sander and overall flow efficiency (headloss reduction) through the structure at all flows. Several design changes were made due to model results.

Project Sighting and Optimisation

Optimising the project layouts required several iterations throughout the construction phase. In this design-build atmosphere an "optimisation on the fly" cycle had to be well coordinated between the design team, the Owner and the Contractor to ensure a final product that was operationally sound, cost effective and minimised impacts to the environment. Due to the absence of fish within the East Toba and Montrose diversion reaches it was possible to design the largest run-of-river hydroelectric project in B.C. history while having a low direct impact to fish and fish habitat.

Geotechnical Assessments

Knight Piésold provided technical expertise in the geotechnical discipline including terrain hazard assessments, seismic analysis, foundation design, seepage cut-off design, structural fill design, pile design, liquefaction assessments and geomorphological assessments. Complex seepage cut-off designs at each intake involved the use of in-situ material, man-made liners and engineered fill to achieve an effective, low cost solution that minimised the footprint of works and disturbance to the surrounding environment.

Snow Avalanche Protection at Montrose Intake

Montrose Intake is situated in the run-out zone of a large snow avalanche path as is most of the upper Montrose catchment. Design of a 90 m long by 16 m high rock fill deflection berm was required to divert potential snow avalanches away from the intake and headpond. Avalanche specialists were required to map avalanche paths and determine loading such that the riprap protection and size of berm could be designed.

3. ENVIRONMENTAL, ECONOMIC AND SOCIAL SUSTAINIBILITY AND AESTHETIC ASPECTS

The Knight Piésold team has been involved with the East Toba and Montrose project throughout project development and were responsible for project identification, environmental studies, project permitting and preliminary engineering prior to completing the detailed design. Every step during the development process has taken into consideration the effects to the environment, economic and social sustainability and aesthetic aspects.

During the permitting process project concepts were continually changed to provide a project that resulted in the least impact and highest benefit to British Columbians.

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EAST TOBA AND MONTROSE HYDROELECTRIC PROJECT

Working closely with environmental consultants, the three First Nations groups and the public, GIS models were developed to assist in facility sighting to reduce impacts. Most notably a ranking system, integrated into GIS software was used for transmission line tower placement such that every tower was sighted in its optimum location.

In addition to reducing environmental impacts, efforts were also made to minimise aesthetic impacts. Routing of a 150 km long power line through a vast area known for its recreational value and active logging required careful consideration. Optimum power line routing was assessed from key vantage points in the field where the viewscape was determined to be most critical. 3-D modelling of the power line on the current landscape was performed to assess the impacts to the viewscape from these vantage points upon construction completion. Time step modelling was also performed to show re-growth within the impacted area over time.

A project of this size required significant resources for labour, equipment and materials. All efforts were made to use local resources. A resulting impact to this was a boost to the economy of the surrounding communities and First Nations, recently plagued with mill shut downs as a result of a downturn in the softwood lumber industry.

Local First Nations groups were engaged throughout the project development. During early stages several individuals were hired to assist with engineering studies on site. These individuals were also provided training and employment opportunities by the Contractor during construction. The Klahoose First Nation, one of the poorest communities in B.C. prior to the development of the East Toba and Montrose project, has seen a significant economic and social turnaround. Having contributed to the success of the project by providing a labour force, logging specialists etc. the Klahoose have continued their economic expansion and are now actively logging in the Toba Valley and looking for other economic opportunities in the renewable energy sector.

As a result of specific design considerations and permitting requirements the East Toba and Montrose Hydroelectric has received EcoLogo Certification, the highest standard in North America for “Green” renewable energy projects. This aspect in conjunction with achievements realised by the East Toba and Montrose project proves that the energy we all need, can be obtained locally through sustainable methods for the benefit of the environment and for the world we live in.

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EAST TOBA AND MONTROSE HYDROELECTRIC PROJECT

PROJECT PHOTOS

PHOTO 1 – Transportation to Toba Inlet by Float Plane.

PHOTO 2 – Toba River Bridge.

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PHOTO 3 – Montrose Powerhouse, Switchyard and Surface Penstock.

PHOTO 4 – Montrose Intake, Headpond and Avalanche Deflection Berm.

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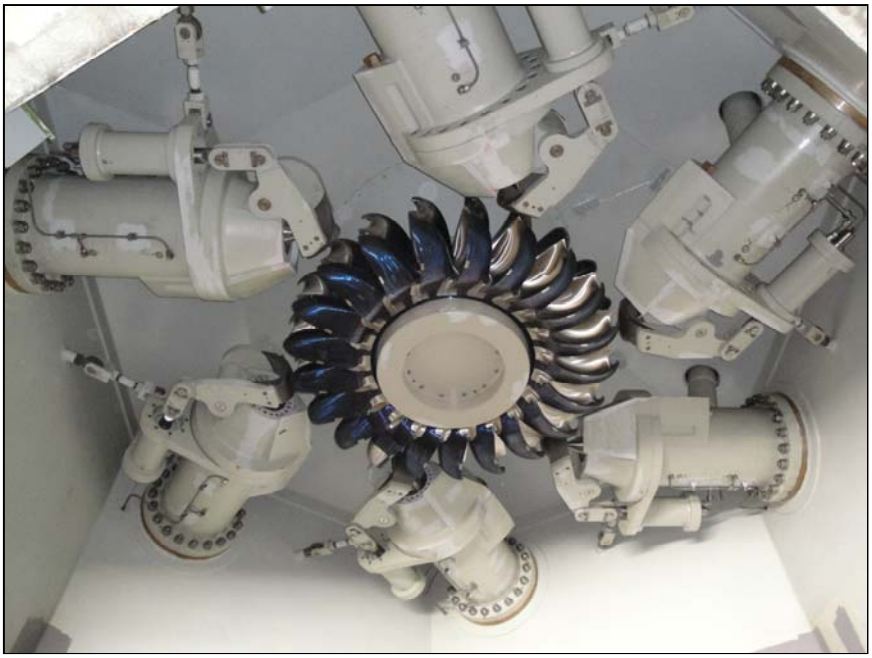

PHOTO 5 – 6-Jet Pelton Turbine

PHOTO 6 – East Toba Intake – Rubber Weir Spillway.

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PHOTO 7 – East Toba Powerhouse and Tailrace.

PHOTO 8 – 230 kV Transmission Line.

East Toba and Montrose Hydroelectric Project

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Innovation and team work were key aspects to overcoming the numerous challenges encountered in developing these remote hydroelectric facilities in some of the country's most challenging terrain. Challenges such as snow and debris avalanches, numerous river and stream crossings, slope instabilities, limited instream construction windows, remote location and extreme weather were overcome in order to deliver 60 km of new access road, 11 major bridge crossings, 150 km of 230kV transmission line and two run-of-river hydroelectric facilities on budget and ahead of schedule. The project was developed under an EPC (Design-Build) contract that guaranteed performance, schedule and price. The EPC team was successful in meeting or exceeding all requirements.

Throughout the development, long-term working relationships were established and maintained with the local and three First Nations communities. Economic development opportunities within these communities expanded during construction and continue to expand beyond project completion.

Innovation in design, project optimization, great teamwork and community involvement all played a vital role in the project's success. Some of these major achievements include:

- The largest Coanda screen intake in the World (Montrose Intake)
- The largest run-of-river hydroelectric project in BC (East Toba Facility)

Prior to the completion of the detailed design, Knight Piésold was also responsible for the project identification, environmental studies, project permitting and preliminary engineering.

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Owner

Toba Montrose General Partnership

EPC Contractor

Kiewit

First Nations Partners

Sechelt Indian Band

Klahoose First Nation

Sliammon First Nation

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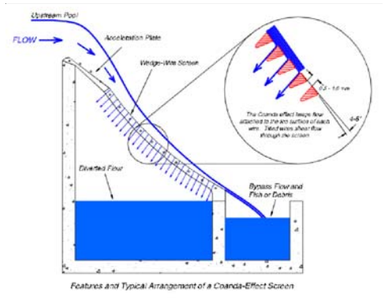
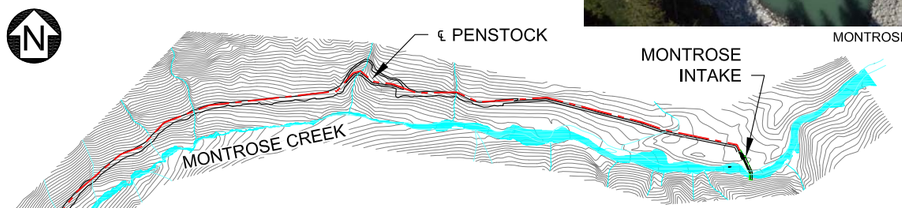
COANDA SCREEN PROFILES



COANDA SCREEN SCHEMATIC

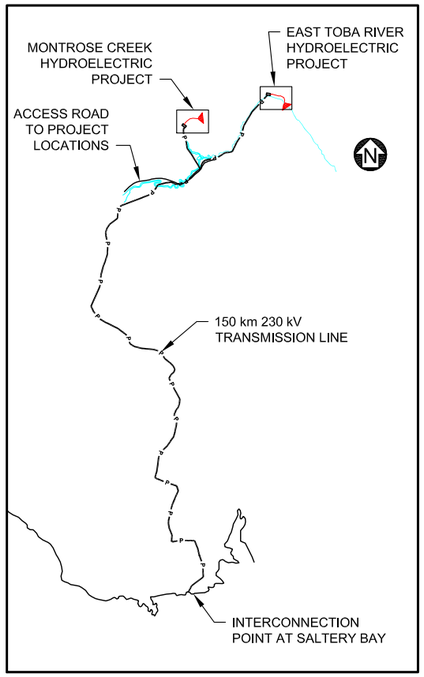
MONTROSE INTAKE



MONTROSE SWITCHYARD AND POWERHOUSE

EAST TOBA POWERHOUSE AND TAILRACE

REVEGETATED PENSTOCK RIGHT-OF-WAY



PENSTOCK INSTALLATION

WEHOLITE PIPE WELDING

EAST TOBA INTAKE

OWNER: Toba Montrose GENERAL PARTNERSHIP

EPC CONTRACTOR: Kiewit

PETER KIEWIT INFRASTRUCTURE CO.