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3.0 PROJECT DESCRIPTION

3.1 Project Components

3.1.1 Design Considerations and Approach

The magnitude of the effect of the Project on the environment depends on the ability of Glacier Power Ltd. (Glacier Power) to avoid significant negative impacts by examining alternatives and implementing environmentally sensitive designs, construction techniques and operational plans.

The proposed Project has evolved to a preliminary design level in consideration of alternatives from engineering, environmental and cost perspectives. Each of the project components including the powerhouse, spillway, boat lock, fishways, power transmission line and access roads, has been planned with environmental management and contingencies built into the design, construction and operations plan. Figure 3.1-1 shows the overall site layout for the Project including road access.

Run-of-river hydroelectric projects are positioned and sized to fit the environment in which they are to operate. Since the overall objective of run-of-river projects is to provide low-impact, green energy from running water, a renewable resource, they must adhere to several engineering and environmental criteria.

The project location was selected for several reasons, including the physical characteristics of the river and valley configurations, transportation and access, proximity of an existing transmission line and availability of a nearby labour force, supplies and services.

3.1.2 Components and Layout

The Project entails building a spillway and powerhouse across the Peace River approximately 2 km upstream from the Highway 2 Bridge crossing at Dunvegan. The Project is designed to increase the water level in the river at the headworks by 6.6 m on average (ranges from 5.4 to 7.6 m depending on river flow) to create adequate differential for the operation of a 100 megawatt (MW) low-head hydroelectric facility. The facility is a run-of-river hydroelectric plant that produces power from the flow of the river without storing water and, therefore, does not regulate or change the flow regime downstream from the facility. Figure 3.1-2 shows the headworks plan.

The powerhouse will consist of 30 turbine units arranged side by side extending from the south bank of the main channel and 10 turbine units arranged side by side extending from the north bank of the main channel for a total of 40 turbines contained in the powerhouse extending a total length of 285 m. A crest gated spillway will extend between the north and south sets of powerhouse units across the remaining 110 m of channel width to maintain sufficient water level differential across the structure. Based on mapping of the local study area at 2 m contour intervals using orthographic aerial photographs, the headpond created by the headworks structure will extend up to approximately 26 km upstream from the powerhouse and spillway. The increase in water level will result in a new water-bank interface zone that will inundate between 106 ha and 215 ha when comparing the pre- and post-project 5 percent and 95 percent exceedance conditions, respectively. The total extent of inundation is approximately equal to the current 1:100 year flood level.
The facility incorporates a boat lock for upstream and downstream passage of river traffic and a boat ramp upstream from the headworks to provide direct access to the headpond. The ramp fishways will be placed on each bank to provide for upstream fish migration and ten fish sluices will be placed between groups of five powerhouse units for downstream fish migration.

The Project powerhouse, fish sluices and spillway are located within the present wetted portion of the river channel, whereas the headworks abutments at each end of the headworks structure, the boat lock, boat ramp and the two ramp fishways are outside the present wetted channel on Crown Land.

Power will be transmitted along a new 144-kV line for approximately 4.3 km to the southeast of the Project to interconnect at the existing ATCO 144-kV line (7L73-1).

Access to the project site will be available along both sides of the river through a combination of private and Crown Land.

### 3.2 Project Design Elements

#### 3.2.1 Design Concept

Successful hydroelectric plant development is accomplished through selecting the critical balance between the capitalization of the river regime, facility costs, construction risks and proven technical solutions. Hydrologic and hydraulic modeling was carried out by Mack Slack & Associates Inc. (2005 and 2006). The hydroelectric power capacity and configuration of the Project was determined based on a number of key factors:

- The gross head (water differential from upstream to downstream from the powerhouse), which ranges between 5.5 and 7.6 m, was selected based on attempting to maintain the headpond level increase within the river’s natural banks below pre-Bennett Dam flood levels. The gross head varies in relation to the incoming flows in the river. For example, during low flow conditions the headpond water levels are held constant and the downstream water levels fluctuate based on inflows at the upstream end of the headpond resulting in a higher gross head and increased energy production. When inflows are high, the headpond levels are maintained but there is reduced gross head because tailwater levels will be higher to match inflows to the headpond. This was determined to be the optimum operating regime for energy production and minimal environmental effects. Lower head levels would have required a significantly wider powerhouse and decreased spillway width, which would result in substantially more frequent overtopping of the powerhouse and shutdown of operations and, therefore, was not suitable. As well, submergence requirements of ultra low-head units would require significant riverbed excavation and costly instream channel work. Higher heads would have required a larger structure which would make design and construction considerably more difficult and costly with the existing foundation conditions and would have resulted in an increased inundation area in the headpond.

- The capacity of the plant was determined based on the available gross head and river flow. The plant capacity at the design flow of 1800 m$^3$/s is 100 MW. The 100 percent available flow is 400 m$^3$/s, which corresponds to a minimum output capacity of 19 MW. The operable turbine flow for each unit is between 42.5 m$^3$/s and 46.3 m$^3$/s. The units will typically operate at full capacity at a flow of 45 m$^3$/s each.
Turbine unit size was selected on the basis of submergence requirements: the larger the unit, the deeper the required setting due to higher unit flow. Turbine setting is the depth of the horizontal turbine shaft axis below the downstream tailwater level. A 2.5 MW unit capacity at the design head requires a setting of about 3 m. Normal tailwater depth at the site is about 4 m at full operational flow; therefore, the unit centreline is set about 1 m above bed level.

The turbine units selected are based on a modular concept using 40 identical units. The turbines are simple bulb propeller turbines (i.e., similar to Kaplan turbines without regulated blades) based on the idea that if low river flow occurs, instead of throttling down all of the turbines, some turbines will be shut down entirely. This will allow the remaining turbines to operate at their full capacity and peak efficiency. By having 40 identical units, economies of scale come into play and less spare parts inventories are required. The units will be manufactured as complete packages including turbine, generator, turbine housing and draft tube. This will enable rapid assembly on a flat concrete slab foundation ready for concrete encasement without significant time-consuming alignment requirements.

The spillway will be a concrete overflow structure with an adjustable gate installed on the spillway crest. The gates will be lowered during flood events so that they do not impede flow. This is ideal for this application, given the size of the river, the trees and other large debris it carries and the ice regime at this site.

The key hydraulic design parameters for the facility are shown in Table 3-1.

<table>
<thead>
<tr>
<th>Table 3-1: Key Design Parameters</th>
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<tbody>
<tr>
<td><strong>River</strong></td>
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<tr>
<td>River valley width</td>
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<tr>
<td><strong>Powerhouse</strong></td>
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<tr>
<td>Combined powerhouse width (40 units) including fish sluices</td>
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<tr>
<td>Top of powerhouse elevation</td>
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<tr>
<td><strong>Spillway, Boat Lock and Fishways</strong></td>
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<tr>
<td>Total spillway length</td>
</tr>
<tr>
<td>Fixed spillway crest elevation</td>
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<tr>
<td>Maximum movable spillway crest elevation</td>
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<tr>
<td>Boat lock width</td>
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<td>Boat lock length</td>
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<tr>
<td>Boat lock depth (minimum)</td>
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<tr>
<td>Ramp fishway (upstream fish passage)</td>
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<td>Width</td>
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<td>Length</td>
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<tr>
<td>Fish sluices (downstream fish passage)</td>
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<tr>
<td>Width</td>
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<tr>
<td>Length</td>
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<tr>
<td><strong>Turbine Flow</strong></td>
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<tr>
<td>Turbine flow per unit</td>
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<tr>
<td>Total turbine flow</td>
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3.2.2 Powerhouse

The powerhouse will contain the modular turbine units. Figure 3.2-1 illustrates the general arrangement elevation of the headworks and shows forty units (each 6.2 m wide) with each unit comprising 2500 kW (2.5 MW) propeller type turbines. Figures 3.2-2 and 3.2-3 illustrate the powerhouse features in plan and section views, respectively.

The powerhouse will be built on the riverbed at elevation 337 m and a top elevation of 348.4 m giving the structure a total height of 11.4 m. The powerhouse will be designed to overtop if flows exceed about the 1 in 2 year flood. On average powerhouse overtopping will occur 1.3 days/year varying between zero and nine days under normal historic Bennett Dam operating and tributary inflow conditions between Bennett Dam and Dunvegan. It is anticipated that the turbines may need to be shutdown once significant overtopping occurs and the differential head results in conditions where the head is outside of the operating range for the units.

The facility is designed to pass extreme flood events up to and including the estimated Probable Maximum Flood (PMF) of 28,300 m³/s. A concrete and rip-rap apron extends 38 m downstream from the structure to prevent riverbed scour in the turbulent tailrace flow regime zone.

Figure 3.2-3 shows the powerhouse with the key upstream and downstream water levels.

The selected turbines, which have four fixed-pitch blades and a runner diameter of 2.6 m, will rotate at about 170 rpm. The turbines and housing will pass suspended sediment and bed material up to 25 mm in size. Flow regulation by Bennett Dam has substantially reduced the frequency of mobilization and size of bed material being transported by the Peace River. Sediment transport studies indicate that formation of the project headpond will result in approximately 700,000 m³/annum of sediment deposition. Bed material larger than 2 mm in size will be deposited in the upper portion of the headpond and the Peace River is predicted to become generally sand bedded downstream from km 18 after 10 years of project operations. This pattern of sediment deposition will minimize the potential for coarse sediment accumulation in the vicinity of the turbine intakes.

The headworks structure containing the powerhouse and spillway will be built using a barge and caisson construction method. Figures 3.2-3 and 3.2-4 show the barges in their final positions upstream and downstream from the main concrete structures. The barge and caisson construction concept involves the construction of precast concrete barges, which will be floated and sunk in place to form the permanent upstream and downstream sections of the structure. Construction will be done in flowing water conditions without any other form of cofferdam; however, dredging will be required in order to achieve the proper bottom elevations for the barges. It is estimated that approximately 53,000 m³ of river gravels will need to be dredged. Dredging will be done during periods when high levels of suspended sediment transport occur and outside of critical fisheries periods in order to minimize the incremental increase in sediment levels over background levels. In addition, appropriate dredging equipment will be selected to minimize the amount of suspended sediment introduced into the river during dredging operations. It is anticipated that a suction dredge with mechanized means for loosening the material would be used. The cutting/suction head would have a cover on it and would operate much the same as a vacuum cleaner.
The barges will also be used as working platforms in order to drive sheet piles to create working cells to allow for the construction of the main sections of the powerhouse and spillway structures. Once the sheet pile cells are complete, the water level within the cell will be lowered slightly to create a positive head differential between the river water levels and the water levels in the cells. This will prevent dredged material from entering the river.

Construction within the cells will involve excavation of river bed material to the depths required for the construction of the substructure for the powerhouse and spillway. The excavation must be carried out in wet conditions in order to maintain the stability of the cells. Controlled removal of the excavated material using a conveyor system will be used to transport material to a storage facility on shore and prevent material from entering the river.

Similarly, the foundation concrete will need to be poured in the cell in wet conditions. This will be done using tremie concrete. Tremie concrete is a special mix that allows the concrete to be pumped through a pipe and can be used to place concrete underwater. The tremie concrete is placed in the water to provide structure cutoff and anchorage and to maintain the stability of the sheet pile walls. Once the foundation tremie slab is in place the cell will be dewatered and the structural portion of the powerhouse built in the dry with no standing water present in the works. Seepage water entering the construction site will be pumped to settling infiltration ponds near the works and tested for acceptable water quality before being released back to the river. Settling ponds will likely be located in the existing inactive gravel pits located nearby on each bank. The ponds will be lined as required and include appropriate settling, skimming, decanting and treatment features.

Construction activities in the river will be initiated in mid-summer and extend into the late fall, into initial freeze-up depending upon weather conditions and BC Hydro releases from the Bennett Dam.

### 3.2.3 Spillway

The 110-m long spillway has a fixed crest elevation of 344.4 m (Figure 3.2-4). The spillway crest will be separated into seven sections by piers extending from the upstream face to the start of the energy dissipater. Adjustable gates will be installed between the piers on the ogee crest in order to achieve a headpond elevation of 347.9 m. The gates will be lowered during flood events so that they do not impede flow. This is ideal for this application, given the size of the river, the trees and other large debris it transports and the significant ice floe at this site.

### 3.2.4 Boat Lock and Boat Ramp

Provisions for maintaining navigability of the river in both upstream and downstream directions are required under the *Navigable Waters Protection Act (NWPA)*. Boaters wishing to pass upstream or downstream from the facility will use the proposed boat lock incorporated into the headworks structure. Boaters wishing to initiate travel upstream from the facility will be able to use the proposed boat ramp located approximately 100 m upstream from the powerhouse. Parking facilities will be provided for boat trailers and vehicles near the boat ramp. Final design of the boat ramp and boat lock will consider input from local boaters and boating clubs.

An 8.5-m wide by 18.0-m long boat lock will be installed adjacent to the fishway ramp structure to retain navigability along the river. The style of lock will be such that frequent users could operate the facility...
unassisted if desired. A common goal for low-lift lock designs such as the Project is fill or empty the lock in an 8 minute time frame. Therefore, for the worst case scenario where a boat arrives just as another boat has just started to move through the lock, it is estimated that there would be less than a half hour wait (i.e., 8 minutes to fill, 8 minutes to empty, enter the lock and 8 minutes to lift/lower the boat). The number of boats that can pass through the lock at any one time depends on the size of the boats. Assuming the boats are 5-m long by 2.5-m wide (roughly the size of an average jet boat), it would be possible to load at least six boats at any one time.

Dual safety booms, signs and navigational aids will be in place upstream and downstream from the headworks to guide boaters to the boat lock and boat ramp. As an added safety feature, guide walls will be provided in the immediate vicinity of the powerhouse to isolate boats from the powerhouse. Boat safety, rescue and education programs will be implemented in local communities and in conjunction with local boating clubs.

Boat lock operation during flood events will be dependent on the conditions in the river at the time with respect to debris and hazardous conditions. It is anticipated that during flood events equivalent to the 1 in 2-year flood event or higher when overtopping of the powerhouse section commences that conditions at the entrance to the boat lock will likely be too turbulent to allow for safe access to the area.

A boat ramp providing access for upstream or downstream river travel is currently 2.5 km downstream from the Project on the south river bank immediately below the Dunvegan Bridge. The proposed project boat ramp will be in the headpond upstream from the headworks structure and will be about 6-m wide and 40-m long with about 20 m submerged to ensure operation even with the headpond drawn down to the fixed crest level (Figure 3.2-5).

3.2.5 Ramp Fishways and Fish Sluices

Fishways will be required to provide safe passage of fish migrating upstream and downstream from the Project. Fish passage facilities consisting of two ramp fishways (one on each bank) for upstream passage have been designed and incorporated into the headworks.

Each ramp fishway is comprised of two structural components; the ramp portion and the submerged vertical slot headworks portion. The ramp section of the fishway is 10 m wide by 132 m long and consists of a series of riffle/pool sequences with rock riprap along the edges. Riffles are created by a double row of v-baffles, offset to provide the hydraulic conditions suitable for fish more than 150 mm in length. The pool sections provide resting areas for fish between the riffle sections. The riprap along the fishway margins provides a combination of cover and hydraulic conditions for fish smaller than 150 mm. The ramp section design flow of 1.8 m³/s is controlled by gated openings in the submerged vertical slot headworks and operates at the full range of headpond elevations, except flood conditions. The submerged vertical slot headworks is also designed to allow fish to exit the fishway regardless of headpond level. Hydraulic conditions in the lower section of the ramp can be adjusted by an auxiliary water supply system in combination with the adjacent fish sluice flows to provide a range of attraction flows best suited to guiding fish to the fishway entrance. Figure 3.2-5 illustrates the general arrangement plan and additional details on fishway design and operation.

Fish sluices will be required to provide safe passage of fish migrating downstream from the facility. There are ten fish sluices located across the width of the structure. One at either abutment adjacent to the fishway ramps, two between the spillway and the powerhouse and the remainder between every set of five powerhouse units. Each of the fish sluices consist of an upper (400 mm) and lower (600 mm)
gated conduit for conveying fish from the headpond to the downstream tailrace except for the fish sluice at the south abutment, which does not have an upper gated conduit. The design flows for the upper and lower gated conduits are 0.75 m$^3$/s and 20 m$^3$/s, respectively. The lower conduit is incorporated into a vertical lift gate. Therefore, if additional capacity is required the discharge from the lower gated conduit can be increased from 20 m$^3$/s to approximately 50 m$^3$/s depending on the flow conditions. Guidewalls extend out from the downstream end of the fish sluice for about 20 m to guide fish towards the ramp fishway entrance and away from the turbulent tailrace zone.

### 3.2.6 Headpond

#### 3.2.6.1 Flooding and Alteration of Flow Regime

The Project will not affect the flow regime of Peace River downstream from the structure and flooding effects in the headpond will be minimal. All water entering the headpond will flow directly through the powerhouse and or over the spillway with no regulation of downstream flows. Flows within the headpond will be deeper and therefore slower than present flow velocities. At present, the mean annual flow of approximately 1540 m$^3$/s has a flow velocity of between 1.05 and 1.59 m/s at the proposed project location. Under these conditions, flow takes approximately five hours to pass through the proposed headpond section of the river. During operation of the headpond, this time will increase to approximately eight hours. Once the development is in place, the velocity through the headpond for the mean annual flow will range from 1.27 m/s at the upstream end to 0.37 m/s at the headworks.

Figures 3.2-6 to 3.2-10 show the extent of the inundated area of the headpond. Only the rare shallow sloped bank sections, some islands and side channel areas are affected. The increase in water level will result in a new water-bank interface zone that will inundate between 106 ha and 215 ha when comparing the pre- and post-project 5 percent and 95 percent exceedance conditions, respectively. The total extent of inundation is approximately equal to the current 1:100 year flood level. This represents an average of less than 20 m on either side of the river valley bottom along the headpond. The effects of flooding will diminish towards the top of the headpond. At approximately 26 km upstream from the headworks structure, headpond levels are within 0.5 m of the present daily water level fluctuations. Within the headpond area, inundation will occur along the channel margins and will not overtop the existing riverbanks except in some low lying areas; however, the normal operating levels will be below the 1 in 100 year pre-Bennett Dam flood inundation levels.

The headpond will require a minimum of site preparation since the majority of its newly wetted area is contained in the natural river channel. Minor clearing of some trees may be required along shoreline areas closest to the facility and potentially in some low lying areas.

#### 3.2.6.2 Tributary Streams

The main tributaries in the project area include the Hamelin, Dunvegan, Hines and Boucher creeks and the Ksituan, Saddle (Burnt) and Leith rivers. Several unnamed tributaries are also present. The only named tributaries with their confluence located within the proposed headpond are the Ksituan River and Hamelin Creek. A large sand and gravel bar is located in the mainstem, immediately downstream from the mouth of the Ksituan River and extends towards the headworks structures. The headpond will inundate 1000 m into the lower Ksituan River. Hamelin Creek is near the upstream limit of the headpond and has a steep gradient at the confluence with Peace River; therefore, only the fan at its mouth will be inundated by the headpond.
3.2.7 Design Water Balance

The Project is a run-of-river hydroelectric facility with the powerhouse an integral part of the headworks structure. Consequently, the natural flow of the river remains relatively unaltered with flows entering the Project headpond and passing directly through the headworks structure. The design rules and guidelines adopted for the proposed Project account for the fact that the river discharges vary considerably from day to day and even hour to hour depending on the releases from Bennett Dam. In addition to the operational rules and guidelines for power generation, operational rules are required to accommodate upstream and downstream fish passage and boat navigation through the Project.

The guiding principles to accommodate the following project premises:

- The powerhouse discharge capacity is approximately 1800 m$^3$/s; 40 turbine units at a capacity of between 42 m$^3$/s and 46.5 m$^3$/s for differential heads of 5.7 m and 7.6 m, respectively. The width of the powerhouse is 285.7 m.

- Two submerged vertical slot headwork/ramp fishways, one per riverbank, are provided for upstream fish passage. The design discharge for each fishway is 1.8 m$^3$/s. An auxiliary water system (AWS) will also be provided within the fishways to introduce attraction flows into the ramp at different locations depending on tailwater levels. The AWS will have a capacity of 100 m$^3$/s per fishway and operates during the upstream fish migration period only. At low river flows (i.e., 95 percent exceedance), the AWS design discharge is 3 to 5 m$^3$/s per fishway. At the 50 percent exceedance flow, the AWS discharge is 10 m$^3$/s per fishway and 25 to 30 m$^3$/s per fishway at the 5 percent exceedance flow.

- The upstream fish migration season is primarily from April to June; however, the submerged vertical slot headworks are operated during the open water season (April 1 to October 31). Fishway attraction flow is provided by the adjacent turbine units with guidance flow being provided via a guidewall at the downstream end of the powerhouse to direct a portion of the tailwater flow towards the fishway entrance.

- Fish sluices consisting of ten lower and nine upper gated conduits are located within the powerhouse to provide for downstream fish passage. The lower gated conduits are sized to convey approximately 20 m$^3$/s. The upper gated conduits consist of a 400 mm diameter conduit capable of discharging 0.75 m$^3$/s.

- The spillway consists of seven 14.3 m wide bays with a fixed ogee crest and overshot gates. The fixed crest elevation is 344.4 m and the gates are 3.5 m high. The total spillway length is 110.3 m.

- In combination with the AWS system, the fish sluice adjacent to the ramp fishway is required to pass 5 to 10 m$^3$/s per sluice at the 95 percent exceedance flow, 14 m$^3$/s at the 50 percent exceedance flow and 40 to 45 m$^3$/s at the 5 percent exceedance flow.

- The downstream fish migration season is from August to October during which time flows of up to 60 m$^3$/s will be provided to the fish sluices. At peak sluice capacity this results in three sluices being operated at any given time. The distribution of flows between the fish sluices will vary depending on the presence of fish and the river flow volumes and it may be possible that all the fish sluices are operated at the same time with a flow of 6 m$^3$/s per sluice. Unit operation adjacent to the operating sluices will be selected to provide optimum entrainment flows. Hydraulic modeling was carried out.
to develop operational criteria and adaptive measures that will be field verified and based on operations monitoring of fish passage.

Table 3.2 summarizes the discharge capacity of the various elements of the Project.

**Table 3-2: Summary of Flow Design**

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Capacity (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>River</strong></td>
<td>Flow range (95% to 5% exceedance)</td>
<td>753 to 2500</td>
</tr>
<tr>
<td><strong>Powerhouse</strong></td>
<td>Turbine flow (one unit)</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Total turbine flow (40 units operating)</td>
<td>1800</td>
</tr>
<tr>
<td><strong>Spillway</strong></td>
<td>Gate flow (one gate) at El. 348.4 m</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>Total spillway flow (all 5 gates) at El. 348.4 m</td>
<td>1540</td>
</tr>
<tr>
<td><strong>Boat Lock (Volume/Passage)</strong></td>
<td></td>
<td>775</td>
</tr>
<tr>
<td><strong>Fishways</strong></td>
<td>Fishway ramp (each ramp)</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Auxiliary water supply (AWS) system (each ramp)</td>
<td>5 to 45</td>
</tr>
<tr>
<td></td>
<td>Fish sluices</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower gated conduit (each sluice)¹</td>
<td>20 to 50</td>
</tr>
<tr>
<td></td>
<td>Upper gated conduit (each sluice)¹</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Notes:
1 Fish sluices are not operating at design capacity at all times, sluice operation will be on a rotational basis to optimize fish passage location preference based on monitoring program.

### 3.2.8 Access Roads and Bridges

Permanent roads are required on the north and south banks of the river to provide access to the powerhouse and boat lock for construction, operations and boat access to the headpond. Access roads will cross a combination of Crown and private land, according to landowner and leaseholder agreements. As much as possible, access will be routed along existing roads to minimize new road construction.

Access roads, as shown in Figure 3.1-1, include 2.6 km of new gravel road, one bridge across Hines Creek, one bridge across Dunvegan Creek and 0.4 km of road upgrades. Roads will be built according to municipal standards and will include a 20 m wide right-of-way.

The results of slope stability studies in the facility area have been incorporated into the design of the access roads. Detailed final design of access roads will occur in coordination with landowners and AIT.

### 3.2.9 Transmission Line

The energy produced by the Project will be carried along a 4.3 km long 144-kV transmission line from the powerhouse to the interconnection point with the existing grid. A Right-of-Way will be provided along the transmission line route. Figure 3.1-1 illustrates the proposed transmission line route, which interconnects with the ATCO 144-kV line (7L73) at NE- 31-79-4-W6. The Project's 144-kV transmission line will use single wooden pole construction similar to existing ATCO lines in the area. Figure 3.2-11 illustrates the single wooden pole design concept of the transmission line. For the most part, the transmission line follows existing road allowances or cultivated land, the exception being where the line follows the new south access road from the plant substation to the crossing of Dunvegan Creek.
3.2.10 Facilities Visibility

The Project has a low profile that will minimize visual and aesthetic concerns as a result of:

- the headworks structure being relatively small compared to the size of the river and valley depth
- only portions of the Project being visible by the public for short durations while travelling on the highway and from a limited number of vantage points
- access to the facilities using existing roads and trails as much as possible
- the transmission line following the access roads and existing and former trails

3.3 Construction Plan

3.3.1 General

Construction of the Project will require four years – one to prepare and complete access roads and shore-based (outside of the wetted channel) components followed by two years of instream work and then the final year for completing the structures and commissioning.

In order to achieve this objective it will be necessary to mobilize construction, complete site preparation work, construct access roads and prepare the entire site in the year prior to undertaking instream work on the powerhouse and spillway. Major consideration will be given to pre-assembly and precasting of various components in order to minimize the amount of instream work required. This will involve pre-assembly of the turbines and turbine housing and the precasting and pre-fabrication of the barges that will not only provide access for construction but will form an integral part of the spillway and powerhouse structural components.

Construction of the major instream works - the powerhouse and spillway – will be substantially completed during two summer construction seasons (April to October). This key timing is necessary in order to minimize ice forces being imposed on the uncompleted structure.

3.3.2 Construction Schedule

The project schedule has been developed to accomplish a number of project objectives as follows:

- undertake engineering field investigations and survey in 2007
- complete preliminary engineering in 2007
- procure turbine and long delivery items in 2007 upon final project approval
- complete detailed engineering by early 2009
- mobilize site, undertake site preparation work and build access roads, boat lock and fishways in spring and summer, 2008
- tender and award major construction work in 2007 upon final project approval
- construct major instream work (powerhouse and spillway) from spring to fall, 2009 and 2010
- complete and commission plant in 2011
The approach adopted for the Project allows sufficient contingency to accommodate weather and other external factors preventing unnecessary winter construction. Table 3-3 is a summary of schedule milestones.

Table 3-3: Project Design and Construction Milestones

<table>
<thead>
<tr>
<th>Item</th>
<th>Start</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIA and EUB and NRCB application review and approval</td>
<td>October 2006</td>
<td>October 2007</td>
</tr>
<tr>
<td>Detailed engineering</td>
<td>October 2007</td>
<td>December 2008</td>
</tr>
<tr>
<td>Tender, award and engineer turbine and major equipment</td>
<td>September 2007</td>
<td>April 2009</td>
</tr>
<tr>
<td>Manufacture turbine and major equipment</td>
<td>February 2008</td>
<td>January 2009</td>
</tr>
<tr>
<td>Pre-assembly of turbine</td>
<td>April 2009</td>
<td>August 2010</td>
</tr>
<tr>
<td>Site preparation, abutments, boat lock and fishways construction</td>
<td>April 2008</td>
<td>July 2009</td>
</tr>
<tr>
<td>Construct powerhouse and spillway</td>
<td>April 2009</td>
<td>September 2011</td>
</tr>
<tr>
<td>Complete mechanical and electrical construction</td>
<td>September 2009</td>
<td>November 2010</td>
</tr>
<tr>
<td>Transmission line construction</td>
<td>May 2008</td>
<td>August 2008</td>
</tr>
<tr>
<td>Commission plant</td>
<td>August 2011</td>
<td>September 2011</td>
</tr>
<tr>
<td>Commercial operation</td>
<td>September 2011</td>
<td></td>
</tr>
</tbody>
</table>

Construction sequencing drawings outlining the proposed construction program and the sequencing of instream construction work are included as Figures 3.3-1 to 3.3-7. Details of the construction program are provided in the following sections.
NOTE:
1. MAXIMUM UPSTREAM 10% EXCEEDENCE FLOW - JULY ±2400 cfs
3.3.3 Construction Contracting

The major construction contract packages envisaged at this time are:

1) Site Works
   • site preparation work including construction of access roads, laydown areas and gravel stockpiling

2) Instream Works
   • sheet piling and concrete work for boat lock and fishway
   • turbine pre-assembly
   • barge construction and installation, sheet piling and dewatering
   • concrete works - powerhouse and spillway (may include boat lock and fishway)

3) Equipment Installation
   • mechanical installation and commissioning
   • electrical installation and commissioning
   • interconnection
   • transmission line
   • substation

Instream works associated with the installation of the barges and driving of the sheet piles will be restricted to open water periods only. This is the only construction constraint in terms of construction scheduling associated with climatic conditions.

Other miscellaneous contracts will be required for small components of the work.

Construction contracting packages will vary depending on the scheduling and design issues, contractor availability, site-specific conditions and weather factors.

3.3.4 General Construction

A construction program will be designed to minimize potential adverse environmental effects and enhance project benefits. Best practices and procedures will be implemented to further reduce potential environmental effects associated with construction. A program will be in place during the construction phase to monitor the implementation of these practices.

Construction activities are not expected to affect the operation of the Shaftesbury Ferry downstream from the Project until year three of the construction phase, when the flow in the river is expected to be sufficiently constricted that ice lodgement will occur in the headpond. At this point in time the ice front scenario that will prevail post-project would occur and delay of the arrival of the ice front at the Shaftesbury Crossing is possible. Ice effects at the Shaftesbury crossing are discussed further in
Sections 4.7 and 4.11. By the end of year four, construction will be complete and plant commissioning and operations will commence.

Before lodgement of ice at the structure in year three, it is expected that only local effects on ice formation due to the impingement of the structures on the river width will be experienced, and hydraulic conditions should return to normal within 1000 m downstream from the Project. The Project will have no effect on ice conditions any locations or ice bridges downstream from Notikewan River during either construction or operations.

3.3.4.1 Construction Yard and Staging Area

Several construction laydown and staging areas will be required for the Project. It is currently envisaged that four areas are required: one on each side of the river adjacent to the proposed works, one area for the pre-assembly of the turbine units and barge construction and one for contractor plant and offices. Size and location of the turbine pre-assembly and barge construction area has not been estimated at this time (Figures 3.3-1 to 3.3-8). The contractor plant and office area may be combined with one of the laydown areas adjacent to the proposed works.

3.3.4.2 Construction Camp

The workforce required will average about 125 workers on site with a peak of 300 workers in years two and three of construction. The project site is approximately 10 km from the towns of Rycroft and Spirit River, 20 km from the Town of Fairview, 100 km from the Town of Peace River and 60 km from Grande Prairie. It is anticipated that bussing of construction workers from these locations is likely but contractors may also consider construction camps for part of the workforce depending on shifts, costs and logistical details. The construction camps, if used, will likely be on nearby private land and will undergo appropriate review and approvals from regulatory agencies. Interest in hosting a construction camp has been expressed by some nearby landowners.

3.3.4.3 Traffic Control and Access

Construction of the Project will occur over a four-year period; primarily spring to fall. Although traffic on secondary highways will increase slightly, it is anticipated that disruption to the general public will be minimal.

Estimates of the volume of truck traffic involving delivery of concrete and gravel materials are provided in Table 3-4. Procedures will be implemented for the protection of the general public (e.g., flag persons, signage and lights). Road maintenance and dust control will also be implemented and discussed further with AIT prior to the commencement of construction.

Site access will be built to both sides of the river (Figure 3.1-1). The south access road will be built from Highway 2 using the existing access to an abandoned gravel pit (deeded land). The intersection and road through the gravel pit will be upgraded and new road construction will be required across Dunvegan Creek and to the project site. The north access road will use the existing intersection at the entrance to Dunvegan Historic Park and extend from the west end of Dunvegan Historic Park along an existing road on the Peace River floodplain (formerly used to access an abandoned borrow pit on the Hines Creek fan) that will require upgrading. Although the north access road does not pass through the Maples Day Use area of the park, construction traffic will be controlled to minimize interference with
recreational use of the Maples area and a residence located at the west end of the Maples area. Dust-control measures will be employed as necessary to further minimize disruption to these areas.

### 3.3.4.4 Construction Traffic Volumes

Table 3-4 outlines the flow of construction related traffic currently anticipated during construction of the Project. These traffic volumes are for vehicles arriving at the project site. At this time it is not possible to determine from which direction (Grande Prairie or Town of Peace River) the majority of traffic may originate. The direction that the traffic originates from will impact the amount of increased bridge use. All traffic will use Highway 2 and access the project site by both the north and south access roads.

**Table 3-4: Estimated Dunvegan Construction Traffic**

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Passenger Vehicles &amp; Pickups</th>
<th>Buses</th>
<th>Single Unit Trucks</th>
<th>Tractor /Trailer Combinations</th>
<th>TOTAL Daily Two-Way Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concrete Trucks</td>
<td>Dump Trucks</td>
<td>Misc.</td>
</tr>
<tr>
<td>April/2008</td>
<td>20</td>
<td>2</td>
<td>-</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>May/2008</td>
<td>20</td>
<td>4</td>
<td>-</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>June/2008</td>
<td>20</td>
<td>4</td>
<td>6</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>July/2008</td>
<td>20</td>
<td>4</td>
<td>10</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Aug/2008</td>
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<td>9</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Sept/2008</td>
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<tr>
<td>Oct/2008</td>
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<td>20</td>
<td>10</td>
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</tr>
<tr>
<td>Nov/2008</td>
<td>20</td>
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<td>4</td>
<td>4</td>
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</tr>
<tr>
<td>Dec/2008</td>
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<td>4</td>
<td>-</td>
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</tr>
<tr>
<td>Jan/2009</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Feb/2009</td>
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<td>Mar/2009</td>
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<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>April/2009</td>
<td>20</td>
<td>4</td>
<td>-</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>May/2009</td>
<td>40</td>
<td>8</td>
<td>40</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>June/2009</td>
<td>40</td>
<td>8</td>
<td>60</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>July/2009</td>
<td>60</td>
<td>12</td>
<td>100</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>Aug/2009</td>
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<td>18</td>
<td>100</td>
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</tr>
<tr>
<td>Sept/2009</td>
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<td>16</td>
<td>100</td>
<td>60</td>
<td>10</td>
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<tr>
<td>Oct/2009</td>
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<td>12</td>
<td>60</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>Nov/2009</td>
<td>40</td>
<td>8</td>
<td>10</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>Dec/2009</td>
<td>20</td>
<td>4</td>
<td>-</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Jan/2010</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Feb/2010</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mar/2010</td>
<td>10</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>April/2010</td>
<td>20</td>
<td>4</td>
<td>10</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>May/2010</td>
<td>40</td>
<td>8</td>
<td>10</td>
<td>40</td>
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</tr>
</tbody>
</table>
## Table 3-4: Estimated Dunvegan Construction Traffic

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Passenger Vehicles &amp; Pickups</th>
<th>Buses</th>
<th>Single Unit Trucks</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concrete Trucks</td>
<td>Dump Trucks</td>
<td>Misc.</td>
</tr>
<tr>
<td>June/2010</td>
<td>40</td>
<td>8</td>
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<td>60</td>
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<tr>
<td>July/2010</td>
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<td>12</td>
<td>100</td>
<td>100</td>
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<td>Aug/2010</td>
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<td>12</td>
<td>100</td>
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<tr>
<td>Sept/2010</td>
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<td>Dec/2010</td>
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<td>Jan/2011</td>
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<td>Feb/2011</td>
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<tr>
<td>TOTAL</td>
<td>1410</td>
<td>294</td>
<td>1434</td>
<td>1190</td>
<td>402</td>
</tr>
</tbody>
</table>

### 3.3.4.5 Hazardous Goods

All hazardous goods will be transported and stored as required by current government regulations. This will be the responsibility of the individual contractors.

Explosives, if required for excavation, will be transported to the site by a contractor and stored in approved, locked magazine(s). Transport, storage and handling of all explosives will be in compliance with regulations (Transportation of Dangerous Goods Act and Regulations) and by qualified persons. Safety requirements for the transportation, storage and handling of dangerous goods will be adhered to as required.

Temporary diesel fuel storage will be necessary at the construction site. Portable steel tanks will be placed onto an impermeable base (concrete pad or compacted gravel-sand pad with plastic liner), which will be bermed and designed to hold at least 110 percent of the capacity of the tank within the...
berm. Fuel storage will be a minimum of 100 m from any stream and will not be located within a floodplain. Construction personnel will be instructed on safe fuelling methods.

Maintenance of heavy equipment will be done so that petroleum products (oil, grease, fuel) do not wash towards any watercourse. Any waste oil or grease will be collected and removed from the sites and sent for recycling or disposal at an approved facility.

Spill contingency plans will be compiled to address any accidental fuel or oil spills. Absorbent and collection materials will be on hand at any fuel tank location or where equipment maintenance is carried out. This will include absorbent pads, sand or straw bales; impermeable PVC liners for temporary holding; and portable tanks, hoses and pumps for transferring spilled hydrocarbons.

All handling of concrete will follow Health and Safety precautions as provided on Material Safety Data Sheets. Handling concrete will require watertight forms, spill contingencies and designated truck clean-out pits. CO₂ canisters and diffusers will be on hand in the event of a concrete spill.

Construction crews will receive orientation in spill containment and handling. The spill contingency plan will be posted at the work sites and available for inspection by agencies. Spill response is discussed further in Section 5, Environmental Management.

### 3.3.4.6 Sewage, Domestic and Solid Waste

Contractors may establish a camp on private land near the project site (camps are mentioned at Section 3.3.4.2) and offices at the project site during construction. Disposal of sewage at the project site during the construction period will be handled by portable toilets serviced by a contractor. Permits for establishing a camp, should one be required, along with related permits for management of camp sewage and waste, will be the responsibility of the contractors.

Domestic waste and wastewater generated at the site will be deposited in containers and removed from the site on a daily or weekly basis as necessary.

Solid waste disposal during the construction period will be handled by a waste disposal contractor. Bins will be set at the site and hauled to the authorized landfill for disposal. Material will be recycled as much as possible.

### 3.3.4.7 Borrow and Waste Material Sites

Numerous existing borrow areas for gravel and backfill, all within 30 km of the project site, have been identified for the Project. Final selection of the appropriate borrow areas will depend on the material requirements identified in the detailed design and material testing and suitability.

Materials excavated for the Project will be reused or disposed of according to current government regulations. It is anticipated that some unused fill material will be disposed of in existing borrow pits near the project site. All waste disposal areas will be restored (*i.e.*, topsoil placement and seeding).
3.3.5 Site Preparation and Reclamation Work

Site preparation work will commence in the spring of 2007. Work will involve clearing and earthwork, and the construction of access roads and laydown and construction yard areas. Access road locations are as shown on the site layout plan (Figure 3.1-1).

Vegetation cover will be removed for the new and portions of the upgraded access roads, laydown areas and transmission line. Removal of mature forest may be required. The areas involved are relatively small. Merchantable timber will be salvaged while non-merchantable timber and slash will be burned according to government regulations. The determination of timber to be removed will be finalized during final design.

Vegetation, particularly trees, shrubs and grasses, stabilizes slopes and protects soils from erosion. During construction, unnecessary disturbance and erosion of disturbed areas will be reduced by:

- delaying the removal of vegetation to minimize the length of time that soils are exposed prior to excavation and earthworks (i.e., clear immediately prior to excavation rather than weeks or months ahead of time)
- limiting the areal extent of disturbance by restricting vehicles and equipment to the work site, Right-of-Way boundaries and designated access roads
- protecting vegetation in adjoining areas or environmentally sensitive sites by restricting access and managing drainage courses
- installing temporary control measures such as settling basins
- covering slopes prone to erosion with geotextiles or coco mats

Where possible, vegetation, particularly mature or potential wildlife trees, will be left intact and root systems undisturbed. Debris and slash will be disposed of in a manner that minimizes fire hazard, preserves site aesthetics, promotes re-vegetation and restoration and does not compromise future use of the site. The volume of smoke generated during burning will be reduced by minimizing the amount of soil that is mixed into the slash during clearing operations. The use of fire accelerators will also be avoided, particularly in the vicinity of the headworks due to its proximity to the river.

Stripping of topsoil will be carried out where practical. Any piles of soil formed due to construction will be placed well back from any watercourse and will not impede drainage. The release of large quantities of accumulated surface water from the construction site into adjacent watercourses during high rainfall or runoff events is a potential source of sediment loss during stripping. Excavations will be stopped during intense rainfall events or when the ground becomes saturated with water.

Before construction begins, mitigation works such as sediment traps and pumping systems will be installed at key locations, as determined during detailed design.

Reclamation of disturbed sites will be on-going throughout the construction phase. Disturbed areas will be re-vegetated to establish plant cover and assist in controlling erosion and stabilizing slopes. Due to the paucity of top soil at the site, soil may have to be brought in or special techniques such as coco
matting and or hydroseeding used for reclamation. At this point of conceptual planning, it is too early to identify exactly what will be needed in the way of reclamation. A complete reclamation plan will be developed following approvals but prior to commencement of any site preparation or construction activities.

3.3.6 Headworks Construction

3.3.6.1 General

Construction of the powerhouse will start simultaneously from each shore as shown on Figure 3.3-1. It is anticipated that no more than 30 percent of the river flow will be restricted at any one time. Water depths at the project site will be approximately 3 m before the start of construction and are expected to rise 1 m with 30 percent river blockage. Sheet piling will be designed and installed to allow for 1 m of freeboard above 1:20 year flood levels. Given the thickness of sediment over bedrock in the river bed, no blasting is expected except possibly at the abutment terminations outside of the instream regime.

The headworks components including the abutments, boat lock and fishways are currently planned to be built in the first year. Fish movement and boating traffic will be unaffected in year one, may be restricted in year two and will be restricted in year three. Fish passage and the boat lock facilities will be working in year four of construction.

3.3.6.2 Powerhouse Construction

The powerhouse, which is 285 m long, will be constructed in four stages. Each stage will be about 70 m long and involve ten turbine units. Construction will commence from the north and south shores starting in April 2008.

The turbines will be pre-assembled on or near the jobsite. The access gallery containing switchgear, control cabling, transformers, compressed air, water, etc. will be pre-assembled in compartments and cast in place. Once the concrete structure has been completed each 2.5 MW turbine will be installed.

Initial instream work involves dredging and the placement of the precast concrete barges. The barges will form part of the permanent works and will also provide a temporary work platform for the installation of sheet piling. The barges will be placed completely across the river immediately upstream and downstream from the powerhouse and spillway structure.

Once four barges have been placed to form a working cell, sheet piling work will commence. One row of sheet piles will be installed upstream from the powerhouse. Sheet piling will be driven to a depth of about 7 m and will protrude 1 m above the 1:20 year construction flood water level including an allowance for backwater effects. A second row of sheet piling will be driven immediately downstream. Once the sheet piling has been extended out from shore sufficiently to contain a ten-unit powerhouse section, a third row of sheet piles will be installed at right angles to the first two rows, connecting both and creating a containment area (cell) in the river. The material in this cell will be excavated and replaced with tremie concrete in the wet cell in order to maintain the stability of the sheet piles. The excavated material will be integrated into the works as ballast or abutment backfill or placed in designated waste areas nearby. Upon completion of the excavation and tremie concrete work, the cell will be dewatered and construction of the concrete superstructure will commence. Once the concrete
has set, the sheet piling immediately adjacent to the turbine water passages (inlets and draft tubes) will be removed to allow flow through the structure.

While work is proceeding in the first cell, sheet piling will be driven outwards into the river for a second cell and so on for the third, fourth and subsequent cells. The same sequence of work will occur in each cell until the entire powerhouse and spillway are built. It is anticipated that five separate cells will be required and that no more than two will block the river flow at any one time.

Excavation, turbine installation and concrete encasement of the second and subsequent cells will be undertaken either by barge or by access over the previously built powerhouse structure. Upon completion of the structure, work will then proceed with completion of mechanical and electrical work on each of the turbine units.

3.3.6.3 Spillway Construction

The spillway structure, which is approximately 110 m in length, will be built in a similar fashion and sequence to the procedure previously outlined for the powerhouse, using a barge and caisson approach. The spillway will be built in a single large cell requiring 14 barges to be set in place prior to commencing sheet pile installation. Following the excavation and tremie concrete work, the cell will be dewatered and the base slab and spillway piers will be built. Once the concrete piers have set, the sheet piles will be removed and water will be allowed to flow through the spillway between the piers. The spillway will be left like this until the entire powerhouse has been completed.

Upon completion of the powerhouse, flow between the piers will be cut off with the installation of bulkhead gates between the piers. The area will then be dewatered and the concrete ogee sections cast in place. This process will continue across the bays until the spillway has been completed.

3.3.6.4 Boat Lock Construction

The boat lock located on the south bank will be a concrete structure poured between sheet piling. The sheet piling will form the inside and outside faces of the lock walls. These sections will then be dewatered and filled with reinforced concrete.

It is currently envisaged that the boat lock structure will be built during year one (i.e., in 2007). This will allow water passage through the structure while construction of the powerhouse and spillway takes place. A bridge will be designed and installed over the boat lock to provide access to the powerhouse structure for both construction and operations.

While construction of the boat lock will be completed during the summer of 2007, the boat lock will not be operational until final closure of the river is achieved. Boat traffic past the Project will be regulated during construction primarily while barges are being set in place. Once the barges are in place and sheet pile driving is underway, boat traffic can pass through the unobstructed portion of the river. When final closure of the river is being carried out, boat traffic on the river past the Project will not be available. It is anticipated that boat traffic will need to be transported past the Project for approximately one year while final closure and commissioning are completed.
3.3.6.5 Fishway Construction

The ramp fishways, located on both the north and south banks, will be concrete structures poured between sheet piling. The sheet piling will be driven forming the inside and outside faces of the fishway walls. These sections will then be dewatered and filled with reinforced concrete. Construction of the fish sluices will be incorporated into the adjacent turbine unit cells.

It is currently envisaged that the fishways will be built over a two year period with the North Fishway being completed in 2007 and the South Fishway in 2008. A bridge will be designed and installed over the fishways to provide access to the powerhouse and spillway for both construction and operations.

Final commissioning of the fishways will be completed in year four (i.e., 2011).

3.3.7 Access Road Construction

Permanent access roads are required on both the north and south sides of Peace River to provide access to the powerhouse and other project facilities. Both north and south access roads cross Crown and private land according to landowner agreements.

The proposed alignments of both access roads will not impinge on any existing areas of instability along Highway 2 and hence it will not have any effects on the stability of the main highway.

The access road design will endeavour to minimize disturbance to the existing soil and groundwater regime. This will include minimizing the removal of any existing trees and vegetation and avoidance of any deep cuts or fills. It is anticipated that culverts will be used extensively to avoid disruption to existing surface water drainage paths. It is anticipated that the detailed road design will include extensive use of geogrids and geotextile fabrics to achieve a stable subgrade without extensive subexcavating and importing of granular material. If significant fill is required in some areas, consideration will be given to the use of lightweight fill or to retaining structures.

Special measures will be implemented to control erosion both in the short term during construction and in the long term, particularly near any creek crossings. These will include rip rap armouring at the bridge structures (e.g., Dunvegan and Hines creeks). Other erosion control measures could include hydroseeding of any cut or fill slopes, as well as the use of hay bales, wattle fencing, or other synthetic erosion control products, as required. The specific measures will be determined during final design and will be incorporated into the Environmental Protection Plan for the Project.

Upgrades are proposed to the existing intersections on Highway 2 to facilitate construction traffic including semi-truck traffic. Final design will incorporate the results of consultation with Alberta Infrastructure and Transportation.

Proposed upgrades to the existing north access road intersection include the following:

- a northbound pullout right-turning lane will be built to safely accommodate traffic coming from the south over the Dunvegan Bridge turning right onto the north access road
- northbound traffic from the north access road will require a widened right turn and merge lane
Highway 2 would be widened, in the vicinity of the existing intersection, to facilitate a left-turn lane for southbound traffic on Highway 2

a temporary flashing overhead light would be installed at the intersection. Temporary construction signs, including construction zone, trucks turning and possible speed reduction signs would be provided

temporary street lighting at the intersection could be installed if required

Proposed upgrades to the existing south access road intersection include the following:

a southbound pullout right-turning lane will be built from Highway 2 to the south access road to safely accommodate construction and permanent traffic

the access road would be upgraded to provide sufficient turning radii for a right turn onto Highway 2

Highway 2 would be widened, in the vicinity of the existing intersection, to facilitate a left-turn lane for northbound traffic on Highway 2 onto the south access road

a temporary flashing overhead light would be installed at the intersection. Temporary construction signs, including construction zone, trucks turning and possible speed reduction signs would be provided

temporary street lighting at the intersection could be installed if required

Dust-control measures will be implemented during construction, particularly in the vicinity of the highway, near residences and project facilities.

Road upgrades to Highway 2 and the north and south access roads would be completed in year one. Temporary construction signage would be installed in prior to construction. Construction signage and possible speed reductions would remain in place until project completion in 2010.

3.3.8 Transmission Line and Substation Construction

The transmission line will be built during the summer of 2007 and, once appropriate approvals have been applied for and received, will be used to provide construction power. The transmission line will be built according to government and utility regulations and in an environmentally sensitive manner. The transmission line right-of-way will be adjacent to the proposed access road and existing roads and trails.

The substation will be built in the fall of 2009 and will include all necessary protection and switching equipment required to tie into the provincial grid. The substation will also be completely fenced in for public safety.
3.4 Start-up

Once the powerhouse and spillway closure segment has been built, the river will continue to flow through the turbine water passages. The turbine gates will be closed sequentially in each turbine water passage to slowly fill the headpond. The flow will eventually begin overtopping the spillway crest with the adjustable spillway gates in the fully lowered position. The time to fill the headpond is estimated to be in the order of a few hours; however, environmental ramping procedures may extend this time. The final mechanical installations and dry commissioning will be done for each turbine runner by sequentially bulkheading off each unit upstream and downstream. Once the final mechanical installations have been completed, the spillway gates will be raised in order to raise the headpond level to its normal operating level. Wet commissioning activities will then be done sequentially for each turbine unit. In the event that start-up problems are experienced during commissioning, flows would be redirected from the units to the spillway which would be lowered or allowed to overtop to maintain flows in the river. Therefore, no loss or alteration of flows downstream are expected during start-up.

Once the headpond level increases to the spillway crest level, the fishways and boat lock will be commissioned and made fully operational. The permanent safety boom and associated navigational warning systems will be put in place and the temporary construction safety boom systems will be removed.

3.5 Project Operations

3.5.1 Powerhouse Operations

The Project will operate to meet all or part of a sustained and constant portion of the electrical load (base-load plant). As it is a run-of-river project, operations of the plant will be continuous throughout all seasons based on the flow available in the river. An important point to remember regarding the operations of the Project is that water is not diverted. All water in the river remains in the original river channel and flows through the turbines or over the spillway structure. As a result, flows downstream from the headworks will remain the same as flows entering the headpond as per the present regulated regime. Flows are not regulated by the Project.

The powerhouse will contain full control systems including Supervisory Control and Data Acquisition (SCADA) systems. During transmission grid outages, the turbines will be shut down and flow will continue over the spillway section. The hydroelectric plant will be manned 24 hours a day (likely with three operator-shift rotations per day). Maintenance will be undertaken daily and turbines will be shut down for maintenance on a routine rotational basis.

The turbine inlets will be protected by removable trash racks. A 25 mm bar rack spacing will be provided during the period of downstream migration to physically exclude adult fish. The predominant migratory period for downstream passage of goldeye and walleye is late August to the end of October. This period also coincides with the Peace River containing the least amount of debris and suspended sediment and makes the operation of the fine bar rack possible with increased maintenance and cleaning. After the migration period, the overlay fine bar rack (exclusion rack with 25 mm spacing) will be removed leaving a coarse debris rack with an open spacing of 100 mm. Due to potential frazil ice
problems, the 100 mm trash rack will be removed prior to freeze up (end of November), leaving the rack supports in place and then replaced after ice breakup (end of March).

A trash rack cleaner operating on an integrated rail system will be able to travel along the powerhouse to remove debris from each turbine inlet. Debris will be collected and placed on shore for disposal. If desirable for biological reasons, at certain times of the year debris can be cast back in the river immediately downstream from the powerhouse. The cleaner will be parked above the high-water mark during high flow events and will be used for other maintenance duties such as installing dewatering bulkheads for major turbine repairs.

3.5.2 Spillway Operations

The spillway will be designed to maintain a gross head differential (headwater minus tailwater) of between 5.5 and 7.6 m at the powerhouse under the majority of flow conditions. During low flow conditions, which occur about 10 percent of the time, such as late summer and fall, the net head will be maximized to 7.6 m. When flows exceed the lowest recorded river flow of 386 m$^3$/s, the headpond level will be raised to maintain the maximum possible net head up to 7.6 m without overtopping the spillway. When flows exceed approximately 1850 m$^3$/s, water would be flowing through all of the powerhouse units and the crest gates on the spillway would be lowered as required to maintain steady headpond levels.

During freeze-up, a portion of frazil ice moving downstream will continue through the turbines, while border ice will begin to build up along the edge of the river or in the headpond. Eventually, the headpond will freeze over and the plant will continue to operate using under-ice flow. Table 3-5 presents operating rule curve data for the facility.

<table>
<thead>
<tr>
<th>% Exceedance and Flood Events</th>
<th>River Discharge (m$^3$/s)</th>
<th>Turbine Status</th>
<th>Normal Operating Headwater (m)</th>
<th>Tailwater (m)</th>
<th>Normal Operating Conditions Gross Head (m)</th>
<th>Spillway Open/Units Shutdown Headwater (m)</th>
<th>Spillway Open/Units Shutdown Gross Head (m)</th>
</tr>
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<tbody>
<tr>
<td>100</td>
<td>425</td>
<td>Operating</td>
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<td>339.5</td>
<td>7.6</td>
<td>346.1</td>
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<tr>
<td>95</td>
<td>753</td>
<td>Operating</td>
<td>347.7</td>
<td>340.1</td>
<td>7.6</td>
<td>346.8</td>
<td>6.7</td>
</tr>
<tr>
<td>90</td>
<td>905</td>
<td>Operating</td>
<td>347.9</td>
<td>340.4</td>
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</tr>
<tr>
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<td>1120</td>
<td>Operating</td>
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<td>340.7</td>
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<tr>
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<td>340.9</td>
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<td>347.9</td>
<td>7.0</td>
</tr>
<tr>
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<td>341.1</td>
<td>6.8</td>
<td>348.1</td>
<td>7.0</td>
</tr>
<tr>
<td>50</td>
<td>1540</td>
<td>Operating</td>
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<td>341.2</td>
<td>6.7</td>
<td>348.3</td>
<td>7.1</td>
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<td>341.4</td>
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<td>7.1</td>
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<tr>
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<tr>
<td>20</td>
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<td>6.3</td>
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<td>7.1</td>
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<td>341.9</td>
<td>6.5</td>
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<tr>
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<td>2500</td>
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<td>342.2</td>
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<td>349.2</td>
<td>7.0</td>
</tr>
<tr>
<td>At Overtopping *</td>
<td>3380</td>
<td>Operating</td>
<td>348.4</td>
<td>343.0</td>
<td>5.4</td>
<td>349.8</td>
<td>6.8</td>
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<tr>
<td>Overtopping *</td>
<td>3380</td>
<td>Shut Down</td>
<td>343.0</td>
<td>343.0</td>
<td>5.4</td>
<td>349.8</td>
<td>6.8</td>
</tr>
</tbody>
</table>
Table 3-5: Operating Rule Curve Data

<table>
<thead>
<tr>
<th>% Exceedance and Flood Events</th>
<th>River Discharge (m³/s)</th>
<th>Turbine Status</th>
<th>Normal Operating Headwater (m)</th>
<th>Tailwater (m)</th>
<th>Normal Operating Conditions Gross Head (m)</th>
<th>Spillway Open/Units Shutdown Headwater (m)</th>
<th>Spillway Open/Units Shutdown Gross Head (m)</th>
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<td>343.2</td>
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<tr>
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<td>Shut Down</td>
<td>344.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:10 Year</td>
<td>5750</td>
<td>Shut Down</td>
<td>344.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:20 Year</td>
<td>6540</td>
<td>Shut Down</td>
<td>345.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:50 Year</td>
<td>7570</td>
<td>Shut Down</td>
<td>345.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
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<td>Shut Down</td>
<td>345.7</td>
<td></td>
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<td></td>
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<tr>
<td>1:100 Year</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:200 Year</td>
<td>9100</td>
<td>Shut Down</td>
<td>346.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:500 Year</td>
<td>10100</td>
<td>Shut Down</td>
<td>346.9</td>
<td></td>
<td></td>
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<tr>
<td>1:1000 Year</td>
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<td>Shut Down</td>
<td>347.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
* At 3380 m³/s the Plant is on verge of overtopping. For greater flows the turbines are shut down.

3.5.3 Headpond Operations

The operation of the powerhouse will be continuous throughout all seasons. As a run-of-river facility, no water is diverted during operations - all water in the river remains in the river and flows through the turbines and or over the spillway structure. The headpond formed behind the headworks will be 6 m deeper just upstream from the structures under mean annual flow conditions. This is equivalent to roughly 6 m above present river water levels and 0.6 m above the normal (pre-Bennett Dam) 1 in 100 year flood level. Total water depth at the powerhouse will be in the range of 10 to 12 m. The water depth eventually reduces to the original water level approximately 14 km upstream from the headworks. Under flood conditions, water levels increase and the effect will extend approximately 26 km upstream. The headpond will not operate as a storage reservoir, nor will flows be regulated. River flows entering the headpond will equal river flows below the structure.

The gate on top of the fixed crest spillway will be raised or lowered depending upon flow conditions in the river (dependent upon releases from the Bennett Dam and contributions from tributary streams). At high flow or flood conditions, the spillway gate will be in its lowered position. During normal and low flow conditions, such as late summer and fall, the spillway gates will be fully raised in order to maximize the net head available for power generation. In this case, water will be flowing through the powerhouse units with none going over the spillway.

3.5.4 Boat Lock Operations

The exact dimensions of the boat lock will be confirmed at a later stage of development; however, initial consultations with the boating community (paddlers, power boaters, etc.) indicate that a boat lock 6 m wide by 18 m long would be reasonable. This size could accommodate up to six average size jet boats at 2.5 m (8 ft) wide by 5 m (16 ft) long. As the Project progresses, the design and operation of the boat lock will be determined based on further consultation with the boating community to determine the needs of river users (i.e., volume of traffic, type of vessels using the river and safety considerations).
and discussions with Transport Canada with respect to meeting the requirements of the *Navigable Waters Protection Act*. Glacier Power expects the boat lock will be operational throughout the open water season (less than 20 percent ice concentration in the river) and during periods of darkness or reduced visibility so as not to limit navigation on the river. The basic concept is shown in Figure 3.2-5. The lock will have hydraulically operated main gates and electrically activated watering and dewatering valves. Pumping of water is not required since a head differential at the headworks allows for gravity flow of water into the lock to raise and lower the water levels. This type of lock has been used extensively and successfully in Ontario, the United States and elsewhere around the world.

Boat lock operation will be dependent on flow conditions in the river (*i.e.*, debris and flood conditions). As discussed in Section 3.2.4, it is anticipated that during flood events of 1 in 2 year magnitude or greater when river flows are discharging over the powerhouse the boat lock would not be operational. Similarly if there is a substantial amount of debris in the river then boat lock operation would not be available. Boat operation on the river during periods of high debris flow is generally difficult and unsafe and, therefore, boat traffic is usually low during debris events. Debris management will be in place for normal river flows however after a flood event when debris is mobilized it may take some time to clear the entrance to the boat lock.

The boat lock will have all the necessary lighting and signage to meet navigational and safety requirements and to assist boaters in locating the entrances even during the night.

### 3.5.5 Fishway Operation

The rationale behind fishway facilities operation is based on a combination of fish passage modeling and adaptive management strategies incorporated into the modeling program discussed in the Fish Passage Rationale prepared by Northwest Hydraulic Consultants (2006b). Detailed discussion of the hydraulic modeling is presented in a series of reports issued by Northwest Hydraulic Consultants between 2003 and 2006 (Northwest Hydraulic Consultants, 2003 a-d; 2004 a-c; 2006b). A total of 60 m$^3$/s has been dedicated to manage fish passage. This flow is distributed according to need at each of the fish passage structures.

The ramp fishways, because they have designated design flows of 1.8 m$^3$/s, will operate independently from the powerhouse or spillway during the open water season from about the first of April to the end of November annually. The fishways will not be used during the winter ice cover period. De-watering the ramps from late fall to early spring and then re-opening the ramps immediately after ice is clear of the headpond will allow the ramps to work more effectively in early spring during the upstream migration period. The ramps will not function properly beyond a 1:10 year flood because the headworks structure will be overtopped and there will be no way to control flows in the ramps. The auxiliary water supply system in combination with the adjacent fish sluices will be operated to provide optimum guidance flows at the fishway entrance.

Fish sluices will be operated to convey fish downstream from the headworks structure. Although the lower gated conduits in the fish sluices are operated within a design range of 20 to 50 m$^3$/s and will operate throughout the open water period, particular attention will be paid to operating the fish sluices to accommodate downstream fish migration from the beginning of August to end of October annually. During this time frame, the plant is not operating at full capacity. This means turbines adjacent to the sluices can be selectively shut down, which will enhance the influence of the guidance flows towards
the sluices making the sluice entrance easier to locate. The intent is to cycle sluice operations across the face of the headworks structure. This cycling process will be fine tuned based on results of the monitoring program. For example, if the monitoring program confirms fish moving downstream congregate in front of a particular sluice, that sluice will become the default for downstream passage and will be operated to provide optimum attraction and passage conditions for fish.

### 3.6 Adaptive Management for Fish Passage

The fish passage hydraulic modeling studies demonstrated the flexibility of the plant and fish passage facilities to adjust to variable conditions while continuing to provide optimum fish passage opportunities, all while maintaining the economic viability of the Project.

Rigorous modeling and collaboration from many experts on the fish passage strategy has produced a thoroughly researched and well understood fish passage strategy that includes significant operational flexibility to allow for adaptive management of fish passage in conjunction with a detailed monitoring program. Adaptive management strategies were implemented and assessed during the fishway modeling program and subsequently included in overall operational planning, ensuring the capacity to provide a wide range of choices and conditions for upstream and downstream fish passage. This range of passage and hydraulic conditions is possible as a result of the ability to selectively turn turbines on or off to change the influence of fish guidance flows, to vary upstream fishway attraction flows and to selectively turn on or off or vary the flows through fish sluices. The proposed monitoring program will provide essential information to measure passage success and identify preferred and default operational settings.

#### 3.6.1 Plant Operation

The powerhouse contains 40 turbine units that can be turned on or off depending on the availability of river flows. The 40 turbine units are simple propeller turbines (i.e., Kaplan turbines without regulated blades or wicket gates) and do not have the capability of fine discharge control. Each turbine either operates at full output, or is shut completely off. Consequently, depending on flows available in the river, turbine operation alone will likely not be able to exactly convey all of the river flow without resulting in minor changes in headpond level. To allow fine discharge control, while maintaining a more constant headpond level, the operational plan assumes that one or several of the fish sluices are operated to match the river inflow. The fish sluice adjacent to the ramp fishways are operated preferentially for fine discharge control while providing guidance/attraction flow to each ramp fishway.

Secondly, the preferential operation of the turbines is dependant on the following guidelines:

- During the upstream fish migration period (April through July), the turbine units and fish sluice adjacent to the fishway ramp and the auxiliary water system will be operated to provide optimum guidance/attraction flow. During the downstream fish migration period (August through October), the turbine units and the fish sluices will be operated to obtain optimum attraction and entrainment flow into the fish sluices (Northwest Hydraulic Consultants 2006b).

- Whenever possible, turbine units will be shutdown for a practical minimum period. That is, the operational plan for the turbines attempts to limit the degree of operation required by minimizing the number of start and stops for all of the units. The current assumption is that, as much as practicable, the turbine units will be shutdown for a minimum consecutive two week period.
• The sequencing of selective turbine operation will be determined to run all of the turbines for approximately the same length of time (i.e., the percentage of time each turbine is operating is relatively the same on an annual basis) to equalize wear on the equipment.

When the inflows exceed powerhouse and fish sluice capacity, the spillway is then used to maintain headpond levels.

In the event of a load rejection (i.e., all turbines shut down), the sequence of operation will be dependant on the inflow at the time of the event. If the inflows are greater than the total fish sluice capacity, the spillway will be the primary release facility.

The turbine units, upper gated conduits in the fish sluices and the submerged vertical slot headwork/ramp fishways auxiliary water system are shutdown when river flows overtop the powerhouse at the 1:10 year flood.

3.6.2 Upstream Fish Passage

Upstream fish passage is accommodated in the current project configuration via the submerged vertical slot headwork/ramp fishway structures located on each riverbank. The submerged vertical slot headworks design discharge is 1.8 m$^3$/s. The flows into the submerged vertical slot headworks are dependant on the headpond level; therefore, a trimming gate is proposed adjacent to the submerged vertical slot headworks intake to maintain the 1.8 m$^3$/s design flow and or to augment flows in the fishway ramp if required (see Figure 3.2-5). In this way, flows in the ramp fishway can be adjusted to optimize hydraulics for fish passage and improve attraction flows at the fishway entrance. During the modelling studies, ramp fishway flows were increased to 6 m$^3$/s without changing the fishway hydraulics.

Fishway attraction/guidance flows are provided via the ramp fishway, the adjacent fish sluice located between the ramp fishway and the powerhouse, the auxiliary water system within the ramp fishway the guidewall consisting of submerged vertical slot headwork conduits designed to direct tailrace flows towards the fishway entrance. The operational rule for the critical upstream fish passage season of April to June is to run selected turbine units, adjacent to the ramp fishways the auxiliary water system and fish sluice closest to the fishway throughout the upstream fish passage season. In instances when the river discharge is less than full powerhouse discharge, turbine units located away from the fishways (i.e., in the middle of the powerhouse) would be selectively shutdown.

Based on the modeling studies, each of these hydraulic conditions and adaptive measures were optimized for the 95, 50 and 5 percent exceedance flows. These are described in detail in the Fish Passage Rationale (NHC 2006b).

3.6.3 Downstream Fish Passage

Similar to upstream fish passage, the key to providing safe and efficient downstream fish passage is a combination of attraction flow to guide fish to the fish sluices and hydraulics that capture and ensure fish are not able to return to the headpond once inside the sluice.
Downstream fish passage is accommodated in the current project configuration via:

- fish sluices consisting of ten lower and nine upper gated conduits distributed across the headworks
- the submerged vertical slot headwork/ramp fishways
- for larger river flows that exceed powerhouse capacity, via the overflow spillway
- for small fish, via fish-friendly turbines

Three of the ten fish sluices will be operated during the critical downstream fish passage season (August 1 to October 31 annually) in a cyclical manner across the headworks. The selection of which fish sluices are used will be dependant upon fish monitoring and the location of fish in front of the structure. When possible, the turbine units adjacent to the operating fish sluice will be selected and operated to improve guidance/attraction flow to the fish sluice. Hydraulic and adaptive measures were optimized during the modeling studies and are described in detail in the Fish Passage Rationale (NHC 2006b) and summarized below in Table 3-6.

3.6.4 Summary of Adaptive Management Strategies

A range of operating conditions and scenarios were evaluated during the modeling program. As a result a detailed understanding of the effects of various operational adjustments was achieved and documented. These adjustments form the basis of an adaptive management strategy that will see operational changes invoked depending on the observations of the fish monitoring program developed by Mainstream Aquatics (Mainstream Aquatics Ltd., 2006). The objectives, potential fish passage concerns or observations during operations and adjustments that can be made to alter hydraulic conditions and improve success of fish passage are summarized in Table 3-6.
<table>
<thead>
<tr>
<th>Objective</th>
<th>Fish Passage Concerns and/or Observed Conditions</th>
<th>Hydraulic Adjustment Available</th>
</tr>
</thead>
</table>
| **Guide fish to ramp fishway ramp entrance** | Fish are unable to locate the fishway entrance | • Adjust flow in ramp fishway optimum: 1.8 m³/s range: 1.8 to 6 m³/s  
• Adjust flow in auxiliary water supply system optimum: 5 to 20 m³/s range: 0 to 45 m³/s  
• Adjust fish sluice flow adjacent to ramp fishways optimum: 20 to 50 m³/s range: 0 to 60 m³/s  
• Operate turbines adjacent to fishways to provide flow via guidewall (range 0 to 45 m³/s) | |
| **Cyclical flow or eddies occur downstream from ramp fishway entrance (causes confused attraction pattern and unclear entrance location)** | | • Adjust flow in ramp fishway  
• Adjust flow in auxiliary water supply system  
• Adjust fish sluice adjacent to ramp fishways | |
| **Fish are congregating at ramp fishway entrance but not entering the fishway** | | • Adjust flow in ramp  
• Adjust auxiliary water supply system | |
| **Fish are moving upstream towards the adjacent guidewall and fish sluice entrance** | | • Increase barrier flow in fish sluice adjacent to the ramp fishway (range 20 to 50 m³/s)  
• Reduce flow in sluiceway to remove attraction | |
| **Move fish through the ramp fishway and into the headpond** | Fish are stalling in the ramp fishway or are not moving through the entire ramp fishway length and return downstream to the river | • Adjust flows in the ramp fishway up or down by opening or closing the low level gate in the submerged vertical slot headworks section of the fishway | |
| **Downstream passage through fish sluices** | Fish are congregating along the upstream face of the powerhouse and appear to be having difficulty finding the entrance to the fish sluices | • Cycle sluice operation across the headworks  
• Adjust fish sluices fully (optimum 20 to 50 m³/s) and turn off turbines adjacent to the fish sluices to improve the signal or attraction flows into the fish sluices  
• Selectively open or close some sluices to concentrate attraction flow | |
| | Fish enter the fish sluices but turn around and move back out into the headpond | • Open fish sluice fully to ensure fish are captured and entrained by the sluice flow | |
3.7 Plant Closure and Abandonment

The Project has a minimum life span of 100 years. A significant feature of this design concept is that each of the components can be replaced as necessary. However, in the event that closure becomes necessary, a closure plan will be prepared for regulatory agency approval. The plan will describe methods to remove all components from the river channel as well as timing considerations for removal. Many of the machine components such as the turbines, hydraulic lifts for the lock and the adjustable spillway gate will be removed. The protruding concrete structures will be demolished and hauled to an approved landfill site.

3.8 Malfunctions, Accidents, Prevention, Safety, Features

The powerhouse, spillway, boat lock and fishways are designed to withstand the anticipated water, ice and debris loading and extreme flood and seismic events, so the potential for failure is extremely low. An initial safety hazard consequence evaluation, prepared according to the Canadian Dam Association Guidelines, indicates the hazard potential is low; however, it is intended to design this facility to a high hazard potential standard. Given the intrinsic design of the overtopping powerhouse and spillway, even extreme floods such as the probable maximum flood (PMF) of 28,300 m$^3$/s can be passed. In the unlikely event that structural failure did occur, a preliminary estimate is that the resulting flood wave would have a maximum 3.3 m high crest. The structures themselves would likely not be carried downstream, although channel bed and bank scour could occur. Recreational boaters could be affected depending upon the time of year and proximity to the structure. Markers, buoys and safety lines will be located around the structure to warn boaters of the potential dangers and to direct boat traffic to the boat lock. During flood events there is a potential for debris in the river and it is unlikely that there would be any boat traffic in the river due to the naturally occurring unsafe conditions. Debris during these flood events would be passed over the spillway and or powerhouse therefore conditions upstream and downstream from the Project will be similar to what would occur naturally.

Failure of the adjustable spillway gate could release the upper 2.5 m of the headpond causing a minor flood wave of about 1 m at the structure dissipating to less than 0.3 m at the Town of Peace River. This flow would be within the normal daily flow fluctuations in the river.

The potential for fluid spills is minimal because the turbines and associated equipment use very small quantities of hydraulic fluids. The hydraulic fluids used in the powerhouse will be vegetable-based (biodegradable) or environmentally sensitive oil. These plants will be well maintained and designed with drains and sumps capable of retaining more than the full volume of 200 L contained in each unit. Drums of hydraulic fluids will be stored in a secure, properly designed building on shore, well back from the 1:500 year flood level.

3.9 Waste Management

Wastes generated during construction will include packaging (wood, metal and plastic) of the facility components; rock and soil associated with road construction and upgrading and transmission line construction; solids and fluids associated with equipment operation; and domestic waste and sewage from the construction workers. All solid wastes will be collected on site and recycled or reused where possible. Solid waste that cannot be recycled or reused will be disposed of in an approved landfill.
A contractor will be hired to remove the waste. Portable toilets will be used during construction and a contractor will be responsible for the removal and disposal of sewage. Other liquid wastes such as lubricants for the equipment will be collected and disposed of at an approved facility.

Waste material generated at hydroelectric facilities during operations are typically limited to office supplies, low quantities of hydraulic and lubrication fluids and minor quantities of solid waste material (i.e., metals, wood etc.).

3.10 Environmental Management and Design Features

The Project has been located and will be designed to provide a clean sustainable source of electrical energy using a renewable resource with minimal effects to the environment. The following list outlines the elements that have been or will be incorporated into the Project to minimize potential environmental effects:

- The Project has been sited in the most stable geology found along the length of Peace River between the Alberta–British Columbia border and the confluence with the Slave River.
- The Project is a run-of-river plant that does not change or regulate flows downstream.
- The Project fits into the active floodplain in the bottom of the valley. Headpond inundation range from 95 percent to 5 percent exceedance is within the active floodplain and does not extensively flood the surrounding areas.
- The Project powerhouse machinery will use small quantities of environmentally sensitive oils which can be easily changed and handled inside the plant.
- The Project turbines are designed to be fish friendly to the extent possible while being able to use the low-head differential to generate electricity.
- The Project trash racks are designed to minimize entrainment of fish and provide guidance to downstream passage routes. Physical hydraulic modeling has been used to evaluate guidance flows for safe downstream passage.
- The Project spillway is designed to prevent or minimize the formation of supersaturated water downstream from the spillway to the extent possible. Fish can usually tolerate supersaturated water of less than 110 per cent near the surface of the water.
- The Project incorporates fishways and fish sluices to provide for upstream and downstream fish passage.
- The Project access roads and transmission line use existing trail and road corridors as much as possible.
- The Project incorporates a boat lock to pass boaters past the headworks structure.
- The Project incorporates a boat ramp on the upstream side of the headworks structure to allow direct access to the headpond and upstream areas.
The Project transmission line is designed as a single wood pole, similar to other transmission lines in the area.

The Project headworks construction will integrate sheet piles into the structure rather than cofferdams, which cause extensive disturbance to the channel bottom and tend to generate high sediment into the water column during installation and decommissioning.

The Project incorporates safety booms on both the upstream and downstream side of the structure to minimize the risk to boaters of being carried over the spillway or into the powerhouse.

The Project components blend into the river valley causing minimal visual impact.

The majority of construction access will be via each bank abutment, thereby minimizing instream equipment.

The Project scale will not pose a strain on surrounding infrastructure or the environment

Best practices will be incorporated into the design, construction, operations and decommissioning of the Project. A set of environmental protection procedures will be developed outlining the types of standard practices that would be implemented to minimize project effects. These standard practices will be revised to fit the context of the Project during final design and the development of environmental management programs.

3.10.1 Environmental Management Program

An Environmental Management Program (EMP) will be developed for the Project. As part of the EMP, an Environmental Protection Plan (EPP) will outline the protection measures developed by the proponent in consultation with the regulatory agencies to address environmental considerations associated with the design, construction and operations of the Project. The EPP is a dynamic document that will be updated as required to address new protection and reporting procedures, throughout the life of the Project and according to the principles of adaptive management.

The EPP will present standard, good environmental practices and the environmental protection requirements of provincial and federal environmental departments. The information presented will be used as an internal environmental management tool to meet corporate environment, health and safety management system policies with applications for training and educating personnel involved in the Project.

More specifically, the purpose of the EPP will be to:

- design, construct and operate the Project to meet green energy standards
- present the owner’s commitment to environmental stewardship
- document environmental concerns and appropriate protection measures
• provide clear and concise instructions to relevant project personnel regarding procedures for protecting the environment and minimizing environmental effects

• provide a reference document for personnel when planning or conducting specific activities

The EMP for the Project is discussed in Section 5.

### 3.11 Effects of the Environment on the Project

Aspects of the environment that may affect the Project include slope stability, river flow, ice regimes and climate change.

#### 3.11.1 Effects Related to Slope Stability

Slope stability problems, specifically slope movements and slope failure could affect the integrity of the headworks or could result in partial infilling of the headpond, reducing the gross head of the water, necessary to generate power.

The Project is located in a portion of the Peace River valley that is cut through bedrock, rather than through unconsolidated deposits of the preglacial Peace River valley. The geologic conditions that contribute to large-scale landsliding both upstream and downstream from the project site are therefore not encountered in the project headworks and headpond area. In addition, the project area is located in one of the most seismically stable regions of Canada. Two large debris flows have occurred at km 6 and 7 in the headpond between 1951 and 1961 but they do not appear to have had a substantial effect on the river regime. Normal weathering and slope erosion is expected to continue during the project life but are not expected to affect project operations.

#### 3.11.2 Effects of Variable River Flows

The entire flow of the Peace River will pass through or over the headworks. Variations in the flow will potentially affect project operations.

The headworks have been designed to handle flood conditions and low flow conditions. Even extreme floods such as the probable maximum flood (PMF) of 28,300 m$^3$/s can be passed. The gate on top of the fixed crest spillway will be raised or lowered depending upon flow conditions in the river. At high flow or flood conditions, the spillway gate will be in its lowered position. During normal and low flow conditions, such as late summer and fall, the spillway gates will be fully raised in order to maximize the net head available for power generation. In this case, water will be flowing through the powerhouse units with none going over the spillway. During normal operations, debris in the Peace River will be captured in the trash racks that operate between the end of March and the end of November (prior to freeze up). The powerhouse will be designed to overtop if flows exceed about the 1 in 2 year flood. On average powerhouse overtopping will occur 1.3 days/year. It is anticipated that the turbines may need to be shutdown once significant overtopping occurs and the differential head results in conditions where the head is outside of the operating range for the units. Debris during these flood events would be passed over the spillway and or powerhouse therefore conditions upstream and downstream from the Project will be similar to what would occur naturally.
3.11.3 Effects of Ice on the Headworks

Ice conditions in the Peace River will interact with the headworks and could affect project operations by forcing facility shut down. The Project has been designed such that during freeze-up, a portion of frazil ice moving downstream will continue through the turbines, while border ice will begin to build up along the edge of the river or in the headpond. Eventually, the headpond will freeze over and the plant will continue to operate using under-ice flow.

3.11.4 Effects of Climatic Change

Climate change could affect the Project through effects on the amount of precipitation and, consequently, the flow of the Peace River, and through changes to the ice regime on the river. Climate change trend forecasts indicate both warmer weather and increased precipitation in northeast British Columbia. These trends are not expected to necessitate changes in Bennett Dam operations, particularly given the large amount of storage available in the Williston Lake. Thus climate change is not expected to affect the availability of water to flow through the turbines. Change to a warmer climate will affect the ice regime on the Peace River but this change is not expected to affect project operations.

3.11.5 Summary of Effects of the Environment on the Project

The powerhouse, spillway, boat lock and fishways are designed to withstand the anticipated water, ice and debris loading and extreme flood and seismic events. The effects of the environment on the Project are not expected to hamper project sustainability.