2.0 DESCRIPTION OF THE PROJECT OPTIONS

This section describes each of the end-of-life Options for the Mactaquac Project, based on conceptual design information currently available at the time of finalizing the CER Report. Further detailed engineering design will be completed for the Preferred Option once it has been selected, and therefore this information is subject to change as other aspects of Project planning proceeds. This section describes each Project Option (components, phases and activities), the anticipated Project schedule, and various mitigation measures that will be employed to minimize interactions with the surrounding environment.

Note that a fourth option, "Life Achievement", is described in Appendix A.

2.1 MACTAQUAC GENERATING STATION

The Station is a hydroelectric generating station with a capacity of approximately 670 megawatts (MW). It is located at Mactaquac, on the Saint John River, approximately 19 km west of Fredericton, New Brunswick (Figure 1.1).

Did you know?

Hydroelectric power stations are often described in terms of their generating capacity. Generating capacity is a measure of maximum power output (typically measured in megawatts [MW]) that could be created at the power station at any given time. This capacity is based on the output capacity of the installed turbines and generators. The actual electrical output of a power station depends on the amount of water flowing through these turbines, and the time where they are operating at the maximum output. The current largest hydroelectric station in Canada is the Robert-Bourassa Generating Facility in northern Quebec. It has a generating capacity of 5,616 MW (Power Technology 2013).

The Station was commissioned in 1968. It has six turbine-generator units, and provides renewable electrical energy and power reliability services to New Brunswick (Figure 2.1). The Station produces about 1.6 terawatt hours (TWh) of electricity annually (NB Power 2014a), supplying approximately 12 percent of the New Brunswick power requirements (NB Power 2015).

Construction of the Station created a 97-km long reservoir (headpond) on the Saint John River that extends from the Station to approximately 15 km upstream of the town of Woodstock. Water levels upstream of the Station increased up to 35 m. The headpond covers approximately 83 km^2. The surface water area of the Saint John River prior to creation of the headpond was about 32.6 km^2 in the current headpond area (Figure 2.2).

How was the surface water area of the headpond calculated?

The surface water area of the headpond was determined using digital information about the size and location of waterbodies provided by the New Brunswick Hydrographic Network, and was calculated using a Geographic Information System (GIS). Because water levels in the headpond fluctuate, this surface water area may be slightly different than other reported values calculated for a different water elevation. Similarly, the surface water area of the Saint John River prior to the creation of the headpond was calculated using topographic maps from 1953 that were digitized. These areas should be considered approximate.

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Sources: Basemap Aerial imagery from GeoNB. Detailed imagery from Leading Edge (2014).

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

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121811151l - Mactaquac Project - NB Power

Mactaquac Generating Station and Components

Figure 2.1

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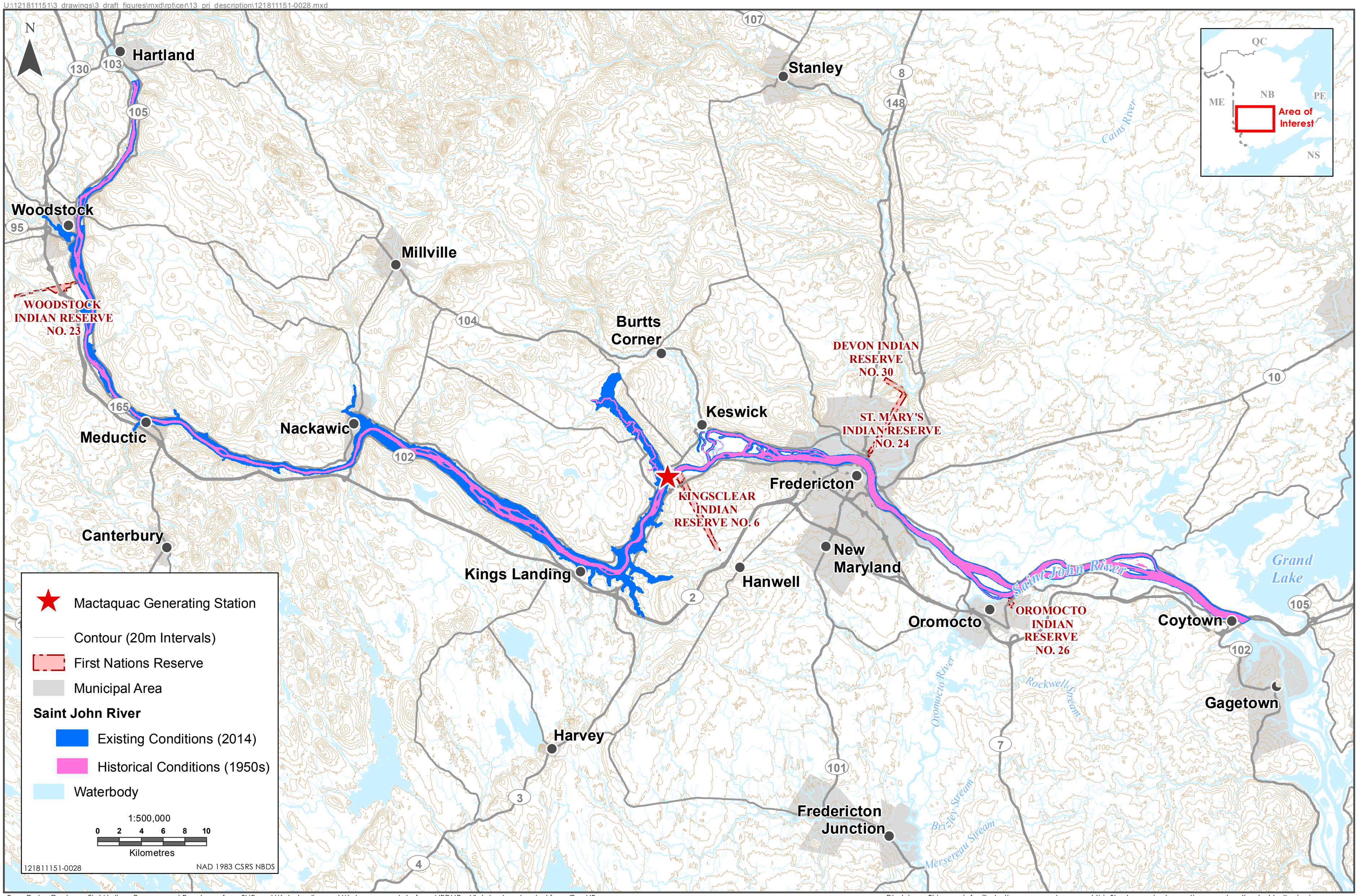

Base Data: Contours, First Nations Reserve and Roads are from SNB and Waterbodies and Watercourses data from NBDNR. All data downloaded from GeoNB.
Project Data: Historical Conditions shoreline was digitized by Stantec from several NTS topo-maps spanning the 1950s.

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Comparison of the Saint John River Before and After Construction of the Mactaquac Generating Station

Figure 2.2

The Station consists of the following major components (Figure 2.1):

- a 518-m long earthen dam constructed of rock fill and sealed by clay; it has a crest elevation of 42.37 m above mean sea level (amsl);
- an 83-m long concrete spillway, known as the main spillway, that contains water to a maximum level of 40.5 m amsl; which consists of five spill bays and is equipped with mechanically driven metal gates;
- a second spillway, known as the diversion sluiceway, that is of very similar construction to the main spillway, and used only during periods of high flow;
- an intake structure with six hydraulic passages (one per turbine), equipped with mechanical gates;
- a powerhouse that houses six Kaplan-style hydroelectric turbines, and associated equipment;
- an electrical switchyard, and associated transmission infrastructure; and
- associated equipment and instrumentation.

A schematic of how a hydroelectric generating station generates electricity is provided in Figure 2.3.

Metric vs. Imperial Units

Numerical values in the CER Report are presented in metric units. Because some of these values may be more commonly presented in imperial units, the following conversion factors are provided for reference:

1 metre (m) = 3.28 feet (ft)

1 cubic metre (m^3) = 35.3 cubic feet (ft^3)

1 cubic metre per second (m^3/s) = 35.3 cubic feet per second (cfs)

1 square kilometre (km^2)= 0.39 square miles (mi^2)

1 hectare (ha) = 2.47 acres (ac)

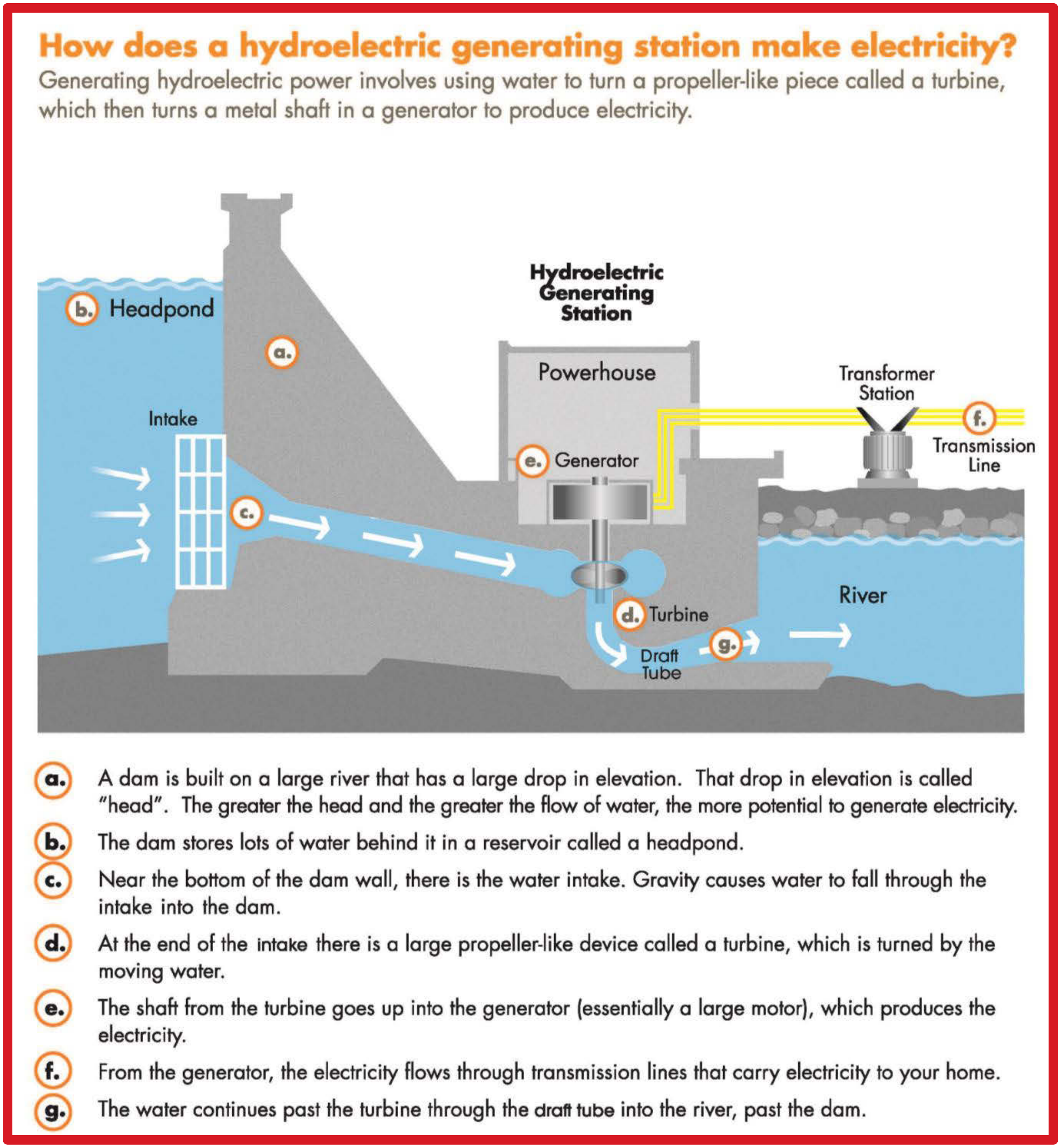

Figure 2.3 Hydroelectric Generating Station Schematic

The dam also provides a bridge and highway link across the Saint John River. It links Routes 102 and 105 of the provincial highway system.

The Station is operated much like a run-of-the-river dam during periods of high flow (*e.g.*, spring and fall), where river flows into the headpond primarily determine the flows through the powerhouse that are used for power generation. During high flow periods, the Station provides a stable base power load to the electrical system. During low flow periods (*e.g.*, the summer and winter), the Station is used to provide power during peak loading periods. The water level fluctuates within the operational water level limits to optimize power output when it is needed. Water levels are maintained between a minimum drawdown level of 39 m amsl and a maximum operating level of 40.5 m amsl, which allows for approximately 1.5 m of water level fluctuation. The Station provides approximately 33.9 m of hydraulic head in the headpond above the natural water level of the Saint John River, which ranges between 3.0 and 6.6 m amsl immediately downstream of the Station. The amount of hydraulic head and downstream water levels vary depending on environmental conditions (*e.g.*, river flows, precipitation) and the operation of the Station.

What is a run-of-the-river dam?

A run-of-the-river dam is one that does not alter water flows in the river from pre-dam conditions. Water levels may change, but these dams are operated without storing and holding back water. This means that the flows into the headpond are equal to the flows through the dam. In the case of the Mactaquac Generating Station, although the flows into the headpond are often the same as flows through the Station, there is some daily and seasonal storage of water in the headpond. This storage allows NB Power to fluctuate power generation based on available water to respond to variations in energy markets and operational requirements.

What is Hydraulic Head?

Did you ever swim to the bottom of a swimming pool and notice a feeling of intense pressure in your ears? This is a result of hydraulic head. Hydraulic head is a term used to describe the amount of pressure at the bottom of a fluid reservoir. Because fluids are subject to gravity, there is more pressure at the bottom of a reservoir than nearer to the surface due to the weight of the fluid above. This is the reason why you feel pressure in your ears when swimming in deep water. Hydraulic head in a water reservoir is generally described in terms of the height (in metres) of the water column above. Hydroelectric generating stations, like the one at Mactaquac, use the pressure created by hydraulic head to turn the blades of turbines and generate electricity.

As discussed in Section 1.3, current modelling indicates that the Station is experiencing a premature end of service life as a result of an alkali-aggregate reaction (AAR) within the existing concrete structures at the Station. To address the AAR issue, NB Power is currently considering the three end-of-life Options that are described in more detail in the following sections.

2.2 END-OF-LIFE OPTIONS FOR THE MACTAQUAC PROJECT

NB Power has identified three potential end-of-life Options. This section describes the facilities, equipment and activities associated with each of those Options, based on available conceptual design information prepared by NB Power and its engineering team. A fourth option, the Life Achievement Option, is not discussed in the main body of the CER Report but is rather described, and evaluated, in Appendix A.

2.2.1 Option 1—Repowering

Option 1 consists of repowering the Station by constructing new power generating infrastructure. This Option will allow for continued power generation and river control. Under this Option, only concrete structures will be replaced; the existing earthen dam will be maintained. New facilities will be constructed on the right (south) bank of the Saint John River and within the existing power channel on the left (north) bank. The following components will be constructed:

- approach and discharge channel;
- spilling structures (*i.e.*, main spillway and auxiliary sluiceway);
- powerhouse and associated infrastructure;
- switchyard; and
- fish passage.

Left Bank vs. Right Bank

These terms are used to allow the reader to quickly and easily understand which bank is being referred to, regardless of the orientation of the river at that location. In the CER, left bank and right bank are always from the perspective of looking downstream.

The proposed layout and configuration of these components and existing components to be decommissioned is shown in Figure 2.4. It is expected that an approach channel and discharge channel will be excavated along the right bank of the Saint John River (*i.e.*, on the south side of the river, directly opposite the location of the existing powerhouse). Once the channel is excavated, the new powerhouse, main spillway and associated infrastructure will be constructed.

A fish passage system will also be constructed. The design of fish passage will incorporate the findings of the Mactaquac Aquatic Ecosystem Study (MAES), consultation with regulatory agencies, and Aboriginal engagement with consideration of operational constraints. Several concepts for upstream and downstream fish passage are being considered and some have been included as part of the current conceptual design of the new spillway and powerhouse.

NB Power intends to have the flood carrying capacity of Option 1 meet the Canadian Dam Association's (CDA) Dam Safety Guidelines. The initial application of these guidelines to historical flood records using modern tools indicates that the required spilling capacity of the Station cannot be accommodated on the south bank alone due to geological constraints, which is the reason for the planned auxiliary sluiceway in the existing power channel upstream of the existing powerhouse location.

The existing facilities at the Station are intended to remain in operation and generate power while the new facilities are being constructed. Once the new facilities are commissioned, the existing powerhouse and main spillway will be taken out of service. Then construction will begin on the new auxiliary sluiceway within the existing power channel. The spilling capacity of the new main spillway will be slightly higher than that of the existing spillway facilities at the Station. This will allow the new facilities to operate while the new auxiliary sluiceway is being constructed. Following the construction of the new sluiceway, the existing concrete structures at the Station will be demolished.

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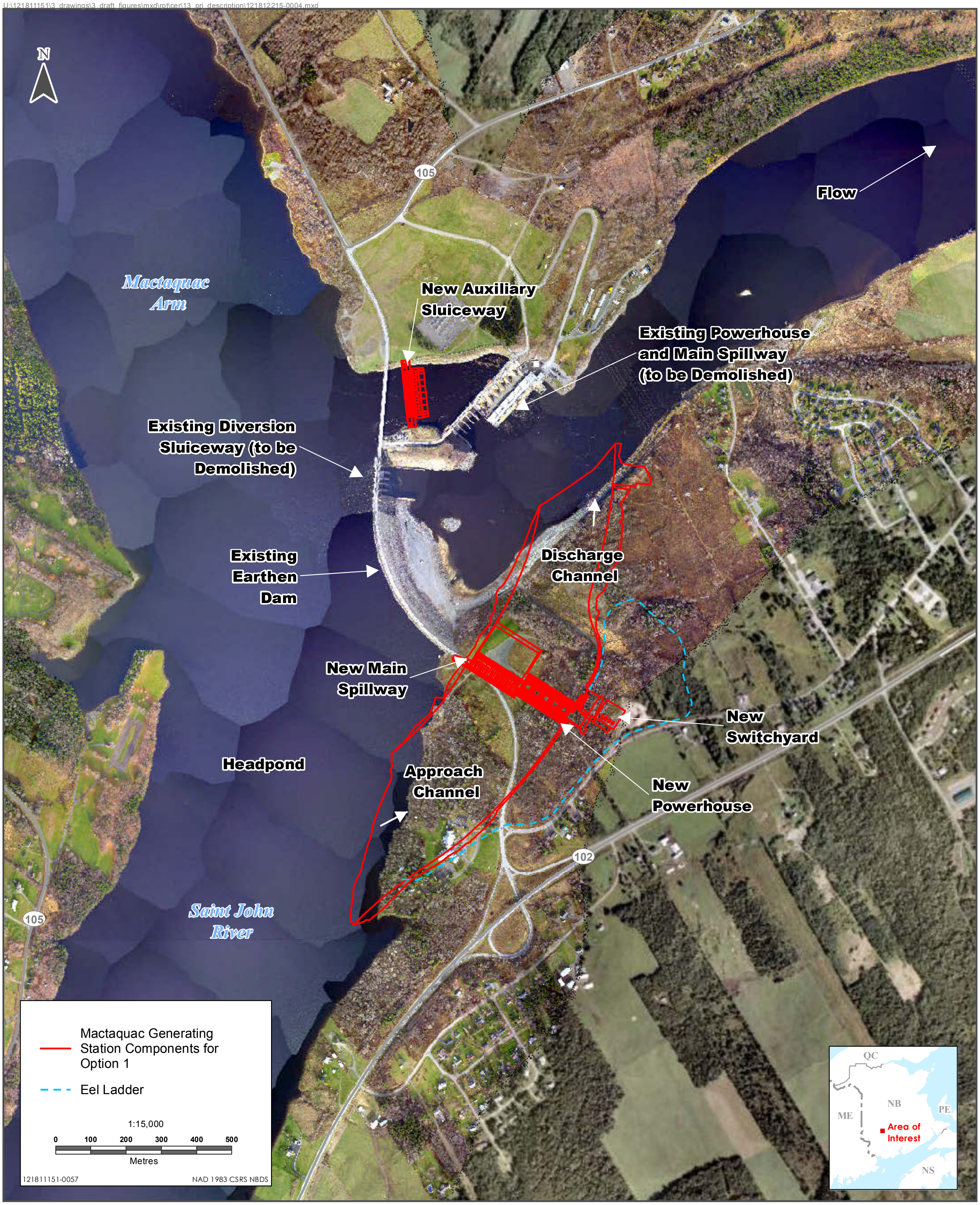

Sources: Basemap Aerial imagery from GeoNB (2004). Detailed imagery from Leading Edge Geomatics (2014).

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

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Conceptual Site Plan for Option 1 - Repowering

Figure 2.4

The new facilities will include updated technology and operating systems intended to improve operational efficiency and consider fish injury and mortality. Because the Station's power generation output is determined largely by the flow of the Saint John River, this Option will not necessarily change the Station's energy production. However, should Option 1 be selected as the Preferred Option, final design may optimize processes and increase efficiency resulting in generation capacity that is increased or more closely matched to sustainable flows.

Of the three end-of-life Options, the operation of Option 1 will be the most similar to the current operating conditions at the Station. The level of the Saint John River upstream and downstream of the dam is therefore expected to be relatively similar to existing levels with some changes in the variation of daily or seasonal discharge due to newer and more efficient equipment.

Option 1 will change the normal operation of the transportation network in the area surrounding the Station, particularly at the link between Routes 102 and 105. Transportation alternatives are being evaluated to maintain suitable transportation links for the public and for Project-related vehicles and equipment. The goal is to maintain safe access and movement of vehicles and equipment through Project construction and operation, and beyond.

2.2.2 Option 2—Retain the Headpond (No Power Generation)

Option 2 consists of replacing the existing concrete spillways at the Station to maintain the headpond level and flow control downstream of the dam. This Option does not include power generation. As with Option 1, the existing earthen dam will be maintained, and the new structures will be constructed on the right (south) bank of the Saint John River and within the existing power channel on the left (north) bank. The following components will be constructed:

- approach and discharge channel;
- spilling structures (main spillway and auxiliary sluiceway); and
- fish passage.

The proposed layout and configuration of these components is shown in Figure 2.5. Option 2 includes construction of a new approach/discharge channel, main spillway and fish passage facility on the right bank of the Saint John River. A powerhouse will not be built, and the Station will not provide electrical power generation.

An approach channel will be excavated along the right bank of the Saint John River. Its footprint will differ slightly from that under Option 1 because it will need to accommodate only the width of the new spillway (and not the powerhouse, as in Option 1).

As with Option 1, a fish passage design will be constructed to provide upstream and downstream passage of targeted fish species.

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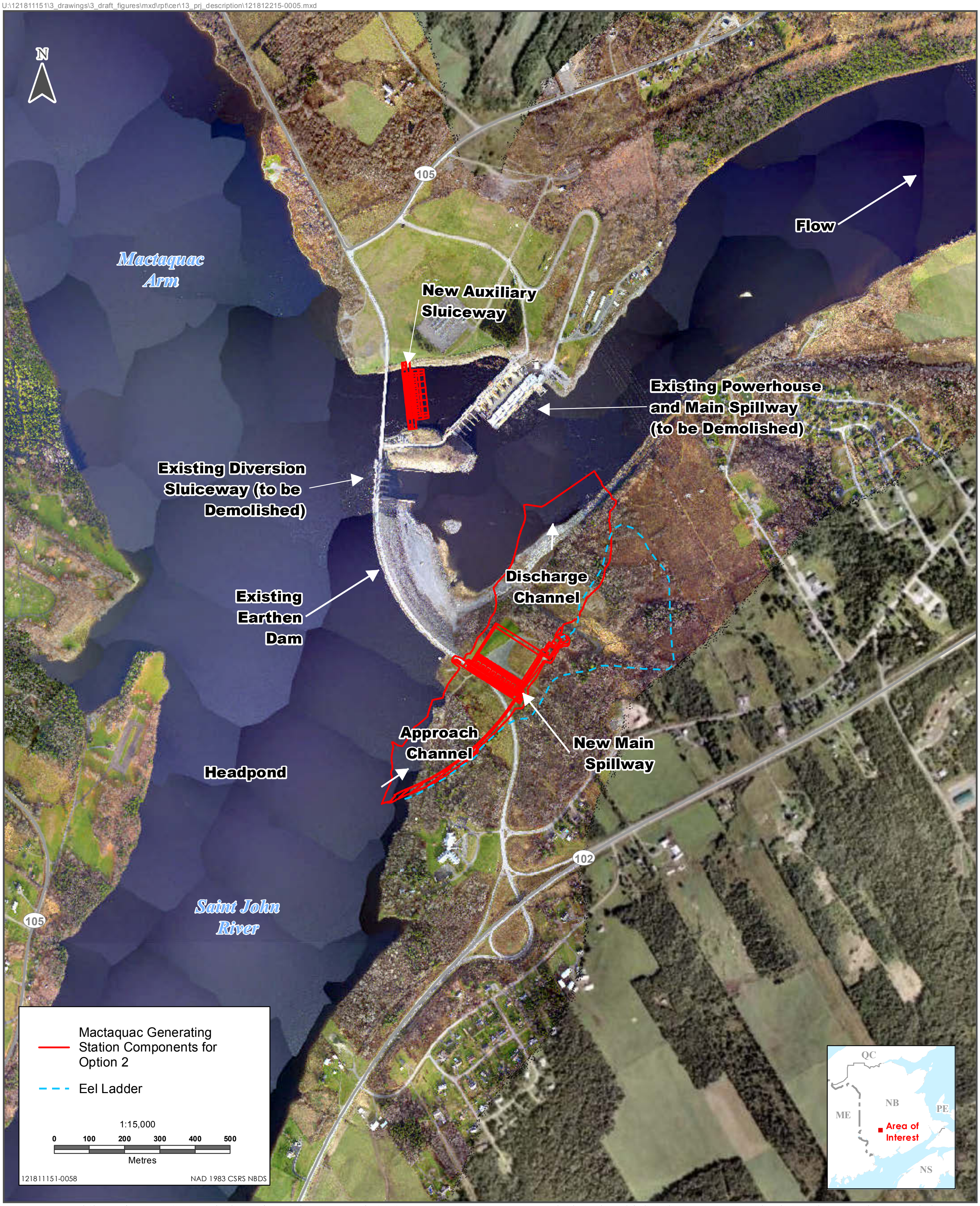

Sources: Basemap Aerial imagery from GeoNB (2004). Detailed imagery from Leading Edge Geomatics (2014).

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

Conceptual Site Plan for Option 2 - Retain the Headpond (No Power Generation)

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Figure 2.5

As with Option 1, it is anticipated that an auxiliary sluiceway will be required in the existing power channel upstream of the existing powerhouse location to meet CDA Dam Safety Guidelines for spilling capacity. Once the new spillway and associated infrastructure have been constructed, the existing powerhouse and main spillway at the Station will be taken out of service. The new auxiliary sluiceway will then be constructed, followed by the demolition of existing facilities.

Operating water levels under Option 2 are expected to be relatively similar to those associated with the existing Station, although discharge may be more consistent since changes to water levels in the headpond will be less regulated, arising from power generation no longer being required.

Option 2 will also change the normal operation of the transportation network in the area surrounding the Station, particularly at the link between Routes 102 and 105. Transportation alternatives are being evaluated to maintain suitable transportation links for the public and for Project-related vehicles and equipment.

2.2.3 Option 3—River Restoration

Option 3 consists of the decommissioning and partial or complete removal of all existing facilities and structures at the Station, including the powerhouse, main spillway, diversion sluiceway and associated infrastructure. Removal of the earthen dam structure will also occur. Option 3 will allow the Saint John River to revert to near natural flow conditions, likely similar to those that existed prior to the construction of the Station. The flow of the river will continue to be controlled in part by other generating stations upstream, but it will flow freely through the location of the Station.

Decommissioning and restoration will include dismantling and demolishing the existing structures, and rehabilitating the site and some areas upstream and downstream of the dam (*e.g.,* for erosion control). The powerhouse and main spillway will be partially removed, and the existing power channel will be infilled. The earthen dam and diversion sluiceway will be fully removed, restoring the river to near natural flow conditions. Over time, the river channel is expected to stabilize and return to a more natural flow regime.

The land that was flooded to create the headpond will be re-exposed when the Station is removed. This land formerly included farmland, residences, roadways, rail beds, and other structures that were either moved or demolished prior to flooding. The potential fate of such re-exposed land has not been determined. There are remnants of such structures (*e.g.,* portions of demolished bridges) in the headpond, which would become exposed following dewatering. Some bank stabilization and river channel and fish habitat restoration measures will likely be required to reclaim the former headpond area. Dewatering would also expose heritage resources and landmasses such as the snowshoe islands that are currently submerged beneath the headpond.

Option 3 will include removal of portions of some formerly submerged structures in the headpond, and other possible remediation or improvements to existing infrastructure (*e.g.*, shoreline protection). Option 3 will also change the normal operation of the transportation network in the area surrounding the Station, particularly at the link between Routes 102 and 105. Transportation alternatives are being evaluated to maintain suitable transportation links for the public and for Project-related vehicles and equipment (Section 2.6.3).

2.3 MAJOR COMPONENTS

The major components of the Options are summarized in Table 2.1.

Table 2.1 Major New Components of Options

	Option 1	Option 2	Option 3
Approach and discharge channel	✓	✓	
Main spillway	✓	✓	
Auxiliary sluiceway	✓	✓	
Powerhouse	✓		
Switchyard	✓		
Fish passage	✓	✓	
Permanent and temporary ancillary facilities	✓	✓	✓

The major components for Options 1 and 2 (as applicable) are described below. Since Option 3 consists of decommissioning only, no new major components will be constructed; however a description of the likely permanent and temporary ancillary facilities required for that Option is provided.

2.3.1 Approach and Discharge Channel

A new approach and discharge channel on the right bank of the Saint John River will accommodate the new powerhouse and spillway for Option 1, or the new spillway for Option 2. The term "approach" refers to the portion of the channel upstream of the main spillway and powerhouse; "discharge" refers to the portion of the channel downstream of the spillway and powerhouse. Option 1 will require a wider channel than Option 2 to accommodate both the powerhouse and spillway. The channel will be excavated mainly in rock and will be far enough away from the existing dam that it will not compromise its structural integrity during construction. The channel will be curved in such a way as to limit excavation while promoting stable and efficient water flow regimes.

Generally, the channel around the powerhouse will be approximately 10 m deeper than around the main spillway. The discharge portion of the channel will be constructed to a lower elevation than the approach portion to maximize the amount of head available for power generation. The discharge portion of the channel will include a dissipation basin (stilling basin) to reduce the energy of the water exiting the powerhouse and to protect the powerhouse and downstream portions of the river from erosion. The channel will also be curved to reduce the overall footprint of the channel and the amount of excavation required during construction.

2.3.2 Main Spillway and Auxiliary Sluiceway

Two spilling structures are planned for Options 1 and 2. The main spillway will be located in the new approach channel on the right bank, adjacent to the new powerhouse; an auxiliary sluiceway will be located in the existing power channel on the left bank, upstream of the existing powerhouse location. As noted in Section 2.2.1, the addition of the auxiliary sluiceway is to meet the CDA Dam Safety Guidelines for spilling capacity.

The main spillway will be used for routine operation of the headpond; the auxiliary sluiceway will be used very rarely (if ever), only during extreme high river flow events. The main spillway will have slightly higher spilling capacity than the existing spillways at the Station. This will allow the new structures to be commissioned prior to the construction of the auxiliary sluiceway and the demolition of the existing structures to be removed.

2.3.2.1 Main Spillway

The new main spillway will be adjacent to the earthen dam (Figure 2.6). In Option 1, it will be located between the earthen dam and the new powerhouse, and will be constructed mainly of reinforced concrete, with steel mechanical components. The spillway will contain nine waterways. Each waterway will be equipped with a vertical metal gate on rollers or wheels. Each gate will be heated during winter operation. Each waterway will also be equipped with a secondary gate (commonly referred to as stop-logs) upstream of the vertical gates to block water and allow for maintenance. A stilling basin equipped with baffles will be installed downstream of the main spillway to dissipate the energy in water exiting the spillway.

2.3.2.2 Auxiliary Sluiceway

The new auxiliary sluiceway (Figure 2.7) will be located downstream of the bridge that currently links the earthen dam to the left bank of the Saint John River but upstream of the existing powerhouse, within the existing power channel. Similar to the main spillway, the sluiceway will be constructed mainly of reinforced concrete with steel mechanical components. It will have seven identical waterways. Each waterway will be equipped with vertical metal gates and rollers, and will be heated during winter operation. Each waterway will also be equipped with stop-logs upstream of the vertical gates to block water and allow for maintenance. The elevation of the sluiceway discharge channel is the same as the base of the existing powerhouse generator floor. The powerhouse and generator floor will make up part of the discharge channel once they are demolished and all mechanical and electrical equipment is removed.

2.3.3 Powerhouse (Option 1 Only)

The new powerhouse (Figure 2.8) will be divided into two main areas: a concrete substructure, and a steel superstructure. The concrete substructure will make up the base of the powerhouse, and will contain the intakes, draft tubes, turbine and generation units, and other equipment that allows access to, and maintenance of, these components. On top of the substructure will be a steel superstructure, which will contain a large service bay with an overhead travelling crane, control rooms, offices and space for storage and additional equipment. The powerhouse will be designed so that equipment in the substructure can be accessed from the service bay above. The overhead crane will be capable of moving laterally so that it can be used to unload equipment from trucks, carry what is needed to a specific turbine-generator unit, and lower the equipment into place. Transformers will be located on the downstream side of the powerhouse near the discharge channel in an area known as the tailrace deck.

If Option 1 is selected as the Preferred Option, the powerhouse design will be refined in consideration of the minimum environmental flows required for the Saint John River and desired operational efficiencies.

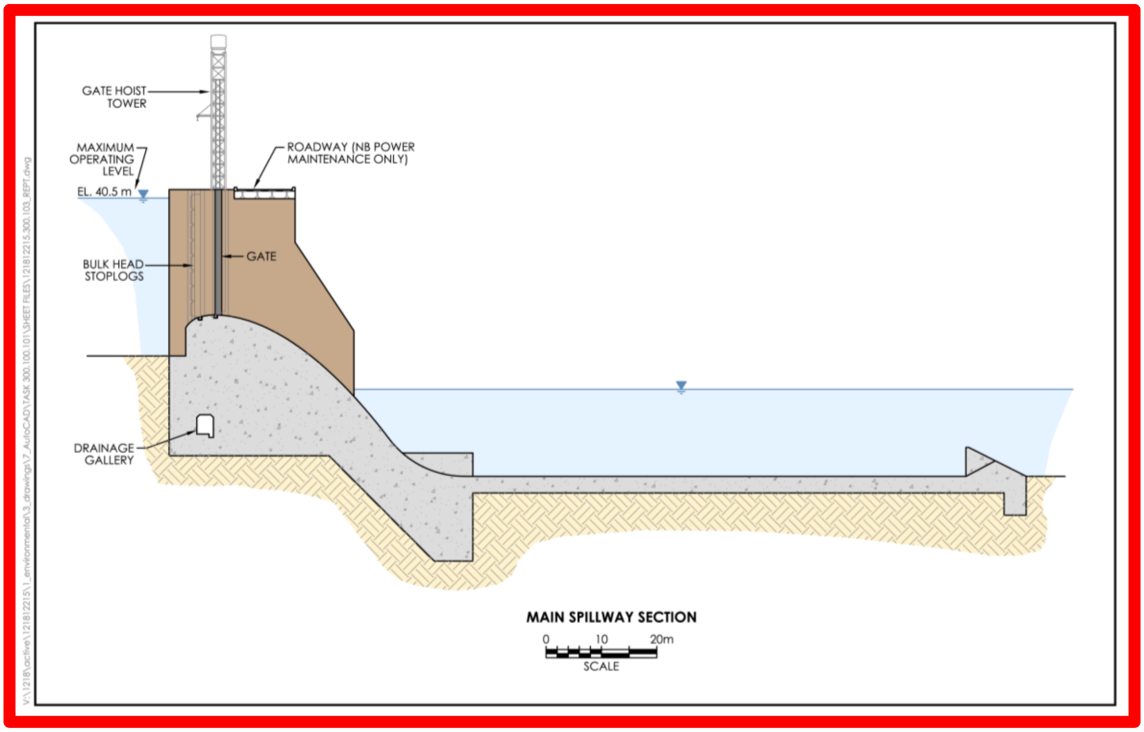

Figure 2.6 Preliminary Cross-Section of Main Spillway Based on Current Planning

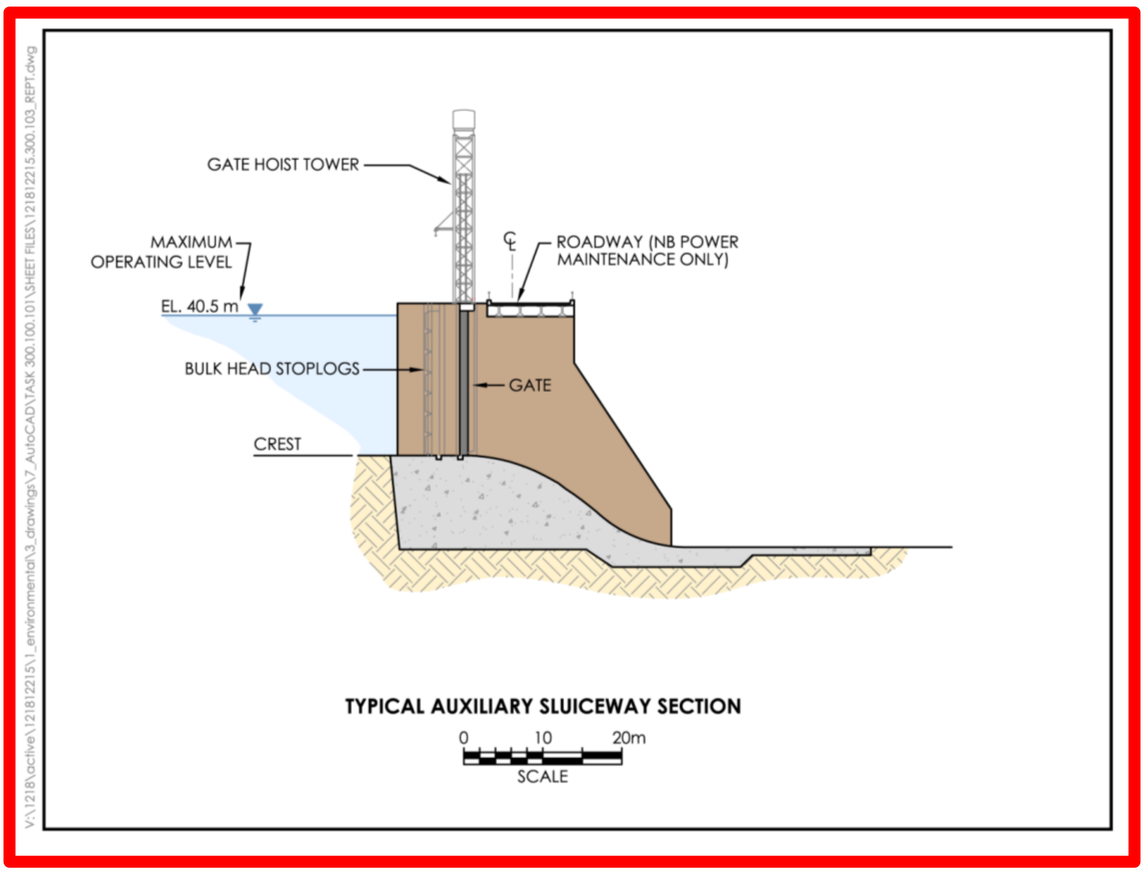

Figure 2.7 Preliminary Cross-Section of Auxiliary Sluiceway Based on Current Planning

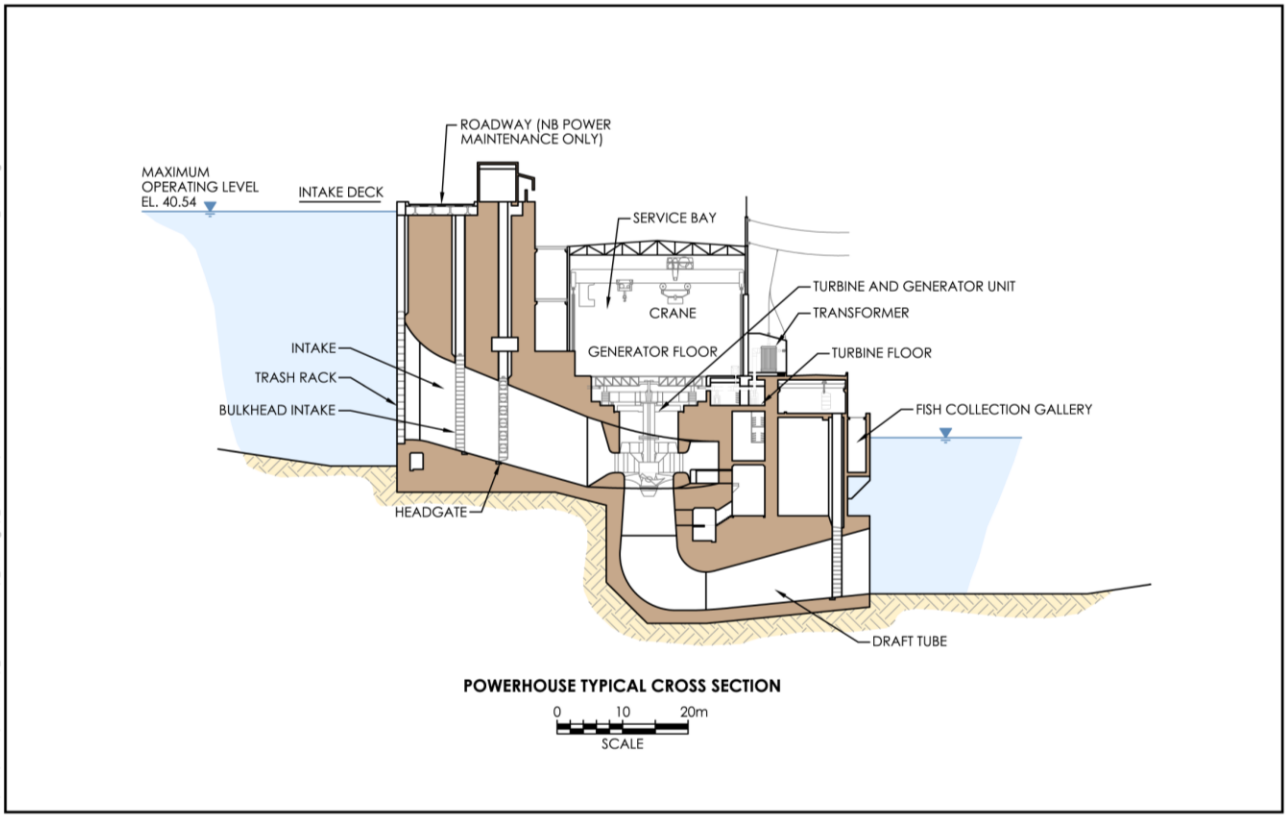

Figure 2.8 Preliminary Cross-Section of Powerhouse Based on Current Planning

2.3.3.1 Turbine-Generator Units

The current conceptual design following an optimization study for the powerhouse, is a five turbine-generator arrangement, which is anticipated to meet all forecasted functional requirements. It will include:

- three 140 MW close coupled Kaplan minimum gap generating units with articulating blades (Photo 2.1); and
- two 140 MW close coupled vertically mounted propeller units with fixed blades.

The articulating blades on the main generator units allow the units to be more efficient and produce more energy than the ancillary units during periods of low water flows.

By determining the **instream flow requirements** of the Saint John River, the Mactaquac Aquatic Environment Ecosystem Study will be determining the minimum water flows that must be sustained downstream of the Station to maintain a series of important river functions. These requirements could range from water flows required for maintaining ecological and aquatic health, to water flows needed to maintain a reliable supply of water for community, agricultural or industrial users.

Photo 2.1 Example of a Turbine Wheel (Source: Hydro Quebec, n.d.)

2.3.3.2 Intakes

The powerhouse will be equipped with five intakes, one for each turbine-generator unit. Water flow will be directed through each intake into the turbine. The powerhouse and intakes are situated in what is known as a close coupled configuration, which means that these structures are located directly adjacent to each other. This is different from the existing powerhouse, which uses a penstock to connect the intakes to the powerhouse. Each intake will be constructed of reinforced concrete.

Each intake inlet will be equipped with trash racks to prevent debris from entering the intake, and with a travelling trash rake for cleaning any debris and keeping the passage free of obstruction. Each intake will also be equipped with a vertical gate to allow for flow control through the structure, and stop-logs that can be used periodically when maintenance of the gates is required.

2.3.3.3 Draft Tubes

Each turbine-generator unit will be equipped with a reinforced concrete draft tube. The tube will be located below the turbine and will allow water to pass from the turbine to the discharge channel. The draft tubes will be designed to reduce the pressure and flow instabilities in the water exiting the turbine, and therefore increase the turbine's efficiency. The draft tubes will be equipped with stop-logs that can be put in place to allow for dewatering and maintenance.

2.3.4 Switchyard (Option 1)

A new switchyard will be required only for Option 1; it will connect the new powerhouse to the existing electrical transmission grid. The switchyard will be on the right bank, adjacent to the new powerhouse. The switchyard will consist of various electrical equipment (*i.e.*, transformers, circuit breakers, grounding), and is currently planned to be enclosed within a building

2.3.5 Fish Passage

Upstream fish passage at the Station is currently managed for the passage of Atlantic salmon and gaspereau only. The existing fish collection facilities are on the downstream side of the powerhouse, where fish are trapped and targeted species of fish trucked upstream. Existing Units 1 and 2 (*i.e.*, the two units closest to the left or north bank of the river) provide attraction flows for fish to be led to the fish collection facilities. The fish collection facility is operated by Fisheries and Oceans Canada. For downstream passage, fish must either pass through the turbines, the main spillway, or the diversion sluiceway.

There is also a hatchery downstream of the Station, which is operated by Fisheries and Oceans Canada. It was built to compensate for the losses in natural Atlantic salmon production associated with NB Power's operations on the Saint John River.

Various ways of improving the efficiency of fish passage at the Station, and general fish friendliness, are being considered for Options 1 and 2. However, it is not yet known which fish species will be a management priority. This will be informed by the ongoing MAES work and subsequently determined by the applicable government regulatory agencies (*i.e.*, Fisheries and Oceans Canada, New Brunswick Department of Natural Resources), and in consultation with Aboriginal groups and stakeholders.

The following is a preliminary list of general fish attraction/passage concepts under evaluation (Linnansaari *et al.* 2015b).

- Locate hydraulic structures near the shore and in one section of the river to concentrate river flow: This helps fish travelling upstream locate fish passage facilities. Although the auxiliary sluiceway is on the left bank away from the powerhouse and main spillway, it will only be used during improbable flood events. Therefore, it is not anticipated to be problematic for fish when river flow is periodically divided between the two structures.

- Fish lift and hopper: This is a mechanical device that captures fish in a hopper at the base of a dam and lifts them so they can be sorted and trucked upstream. The fish will be attracted into the hopper by concentrating a current of flow out of this device. This structure will be similar to the existing fish lift but will be designed to accommodate more fish species. This device will likely provide passage to most fish species.

- Fish collection facilities: For upstream passage, these facilities are located directly downstream of the turbines (or spillways in dams with no power generation) where flow is most commonly concentrated, and are used to guide fish toward the fish passage structures. They can be designed with multiple entrance locations that may appeal to different species. For downstream passage, collection facilities can be used to trap fish for manual transportation across the dam.

- Fishways (fish ladders) (Photo 2.2): These complement fish lifts and can be used for strong swimming species, such as Atlantic salmon and American shad. Fishways provide upstream passage around barriers by providing a series of low steps flooded with water that fish can swim and jump along. However, these structures require adequate flow through them so that they attract fish, but not too much flow that they impede the ability of fishes to swim through the structure. Design considerations can include species-specific passage options. Furthermore, a modular design can facilitate improvement modifications based on fish passage performance.

- Fish ramps: These complement fish lifts and fishways. They can be used for species such as American eel (including juvenile eels, or elvers) that generally are not successful at upstream passage with other conventional structures.

- Angling of the powerhouse as much as possible to the axis of flow: This allows for fish passage structures to be located so they benefit from the concentration of flow passing through powerhouse. This may result in more migrating fish finding the passage structures.

- Fish-friendly turbines: Fish travelling downstream through hydroelectric turbines can be harmed. The use of fish-friendly turbines could reduce this kind of interaction. In the current conceptual design, Kaplan-type minimum gap turbines are used for three of the five the turbine-generator units.

- Downstream bypass structures: The design and construction of bypass structures for fish passage may be considered to provide an alternative to passing through the turbines/spillways. Both surface- and bottom-oriented species must be considered in the design of such structures. Consequently, full-depth entries or separate surface and bottom openings may also be considered.

- Top opening gates in one or two main spillway gates: Consideration is being given to installing fish passage gates above the main spillway gates to allow more efficient fish passage downstream. These gates generally work by being situated above the concentration of flow passing through the spillway, especially for fish species that swim in the upper surface water layers. Full-depth entries or separate surface and bottom openings may also be considered to accommodate the passage of more fish species.

- Downstream guidance structures: Various guidance structures and diversion mechanisms for directing fish to downstream passage structures are being considered. For example, the use of a screen guide wall with flow inducers is being considered for fish that swim at shallow depths. These structures would direct fish away from the powerhouse and toward the fish passage gates. This would help avoid delays that arise when these fish need to find downstream passage through the deeper powerhouse intakes or spillway openings. The depth of the screen guide would need to be appropriate for the fish species being targeted. A breakwater could also be used to funnel fish toward downstream passage structures and prevent them from swimming laterally away from the concentration of flow (*e.g.*, along the earthen dam) when they encounter the barrier.

- Flexible tube pressure-differential fish passage (*i.e.*, Whooshh Technologies): this innovative technology may provide an economically feasible increase in passage capacity during key migration times, such as occurs during the peak gaspereau migration period.

Photo 2.2 Example Fish Ladder (Source: USDA, n.d.)

The various fish species that use the Saint John River and the associated methods for allowing their passage were studied as part of the MAES, and reports are pending. These observations will be used in regulatory discussions aimed at determining the species that are a priority for fish passage. Then the appropriate fish passage facilities can be selected and designed.

The initial conceptual designs for the purpose of developing a cost estimate for Options 1 and 2 included facilities for upstream passage of the following species:

- the Atlantic salmon (*Salmo salar*);
- the alewife (*Alosa pseudoharengus*);
- the blueback herring (*Alosa aestivalis*);
- the American shad (*Alosa sapidissima*); and
- the American eel (*Anguilla rostrata*).

Under current conceptual design, downstream passage would be achieved through the turbines or the spillways. The initial conceptual designs have not considered regulatory engagement, First Nations engagement, or the results of the MAES; these and other considerations will influence the final design and objectives of the fish passage facility. The current conceptual design includes the following fish passage features:

- the concentration of flows along the right bank;

- an upstream fish passage facility consisting of fish collection facilities, fish lift, and trucking as necessary, similar to those at the current Station installed along the right bank, that is intended to provide passage for all of the above species except American eel;
- an eel and elver ladder; and
- "fish friendly" minimal gap Kaplan turbines for downstream passage.

2.3.6 Permanent and Temporary Ancillary Facilities

Under Option 2, a maintenance and control building will be required for operation of the main spillway and auxiliary sluiceway. A step-down transformer from distribution voltages will also be required to power the equipment and facilities.

For Options 1 and 2, a permanent excavated material disposal area will be developed. Its location has not been confirmed; however a potential location for the disposal area that is being considered is shown on Figure 2.9. A good portion of the rock material excavated will be construction grade and suitable for use in other construction projects. All of the necessary permits and approvals will be obtained for this site. Temporary or permanent material stockpiles will not be located within 30 m of a watercourse or wetland without a permit and will use erosion and sedimentation control structures.

Temporary facilities that will be developed to support the construction of Option 1 or 2, include:

- concrete mixing (batch) plant(s);
- rock crushing and storage area;
- aggregate storage area;
- site buildings (*e.g.*, offices, washrooms, infirmary);
- material laydown areas (on right bank);
- demolition materials laydown area (on left bank);
- temporary roads and gravel parking areas; and
- security office and gate houses.

The planned locations of permanent and temporary ancillary facilities for Option 1 are shown in Figure 2.9. The locations of facilities for Option 2 will be very similar to Option 1 but require a smaller total footprint.

U:\121811151\3_drawings\3_draft_figures\mxd\rpt\cer\13_prj_description\121812215-0002.mxd

Sources: Basemap Aerial imagery from GeoNB (2004). Detailed imagery from Leading Edge Geomatics (2014).

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

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Permanent and Temporary Ancillary Facilities for Option 1

Figure 2.9

Option 3, will require a permanent material disposal area for the concrete and rock removed during the decommissioning of concrete structures and the earthen dam that cannot be re-used on-site. A proposed location on the right bank for this disposal area, subject to regulatory acceptance, is shown on Figure 2.10. All of the necessary permits and approvals will be obtained for this site. Permanent material stockpiles will not be located within 30 m of a watercourse or wetland without a permit and will use erosion and sedimentation control structures.

The existing powerhouse currently includes a control centre that manages other NB Power hydro facilities along the Saint John River. If decommissioned under Option 3, ancillary facilities will include a replacement control centre. The location of this control centre is currently undecided, however, conceptual design includes a new control centre located adjacent to the Station on the left bank to take advantage of existing infrastructure (*e.g.*, existing switchyard microwave tower) and avoid interference with decommissioning activities. The control centre would consist of a 230 m^3 building equipped with a control room, electrical room, server room, mechanical room, offices, kitchen and washroom.

Temporary facilities at the Station for Option 3 will include:

- material laydown areas to support shoreline interventions (left bank);
- temporary contractor facilities (*e.g.*, offices, washrooms, infirmary);
- demolition materials laydown area (on left bank);
- temporary roads and gravel parking areas;
- security office and gate houses; and
- water access point/wharf.

The planned locations of temporary ancillary facilities near the Station for Option 3 are shown in Figure 2.10.

A temporary staging area with contactor facilities and a laydown area for shoreline intervention materials will also be constructed near Nackawic. This location, once it has been confirmed, will include an access road to the water and a wharf.

2.4 MAJOR PROJECT PHASES AND ACTIVITIES

The phases and activities associated with implementing each Option are summarized in Table 2.2.

Table 2.2 Project Option Phases and Activities

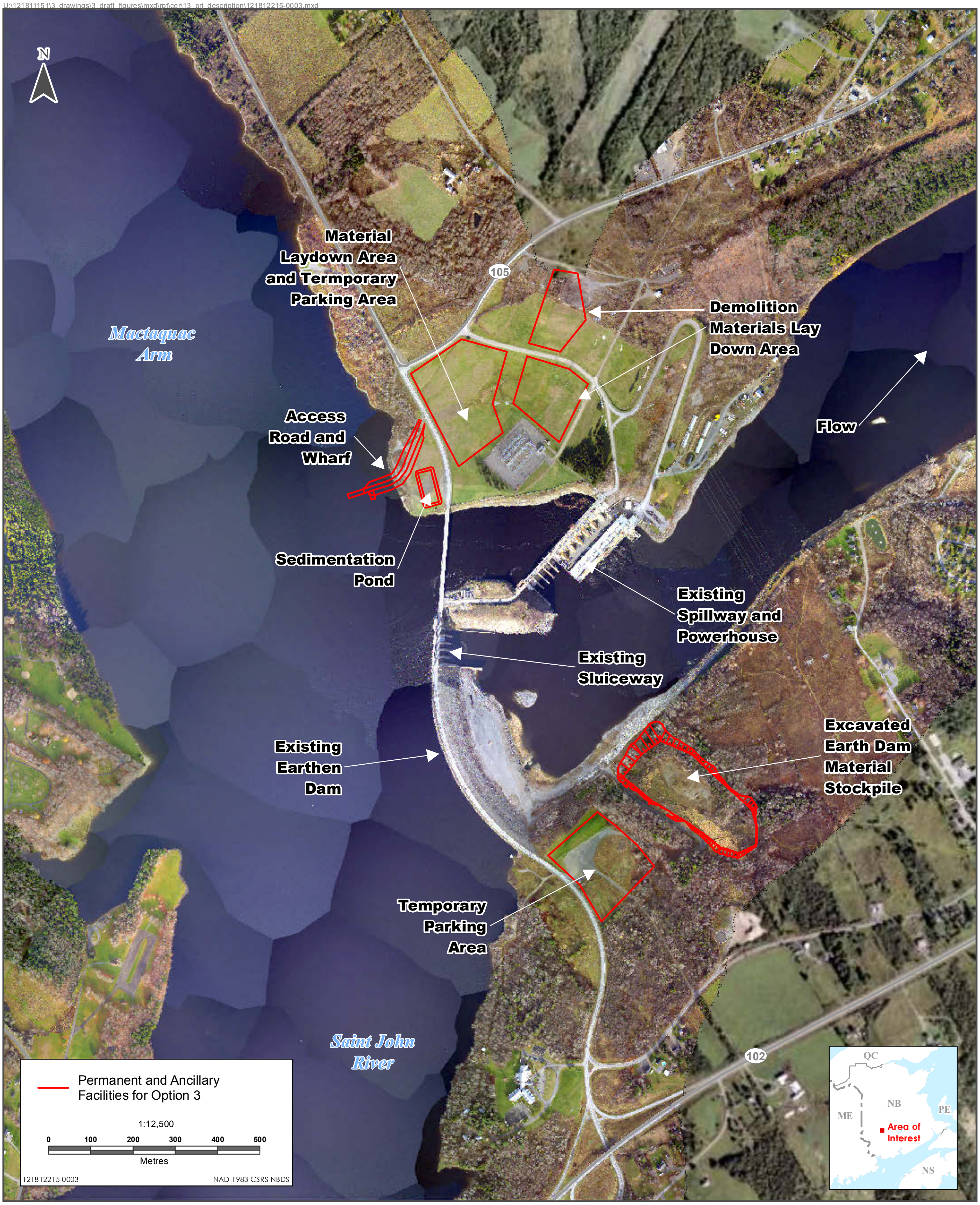
Phase/Activity	Option 1	Option 2	Option 3
Construction (New Facilities, Options 1 and 2 Only)			
Site preparation and establishment of temporary ancillary facilities	✓	✓	
Approach and discharge channel excavation	✓	✓	
Powerhouse construction	✓		
Main spillway construction	✓	✓	
Switchyard construction	✓		
Fish passage facility construction	✓	✓	
Auxiliary sluiceway construction	✓	✓	
Establishment of permanent ancillary facilities	✓	✓	
Demolition (Existing Structures, Options 1 and 2 Only)			
Preparation for demolition	✓	✓	
Demolition of existing diversion sluiceway	✓	✓	
Demolition of existing main spillway	✓	✓	
Demolition of existing powerhouse	✓	✓	
Demolition of existing switchyard	✓	✓	
Site reclamation and rehabilitation	✓	✓	
Operation (Options 1 and 2 Only)			
Power generation	✓		
Water level control	✓	✓	
Fish passage facility	✓	✓	
Decommissioning (Option 3 Only)			
Headpond dewatering			✓
Site preparation for decommissioning			✓
Establishment of temporary and permanent ancillary facilities			✓
Removal of existing concrete and steel structures			✓
Removal of earthen dam (partial or full)			✓
Site reclamation and rehabilitation			✓
Natural flow regime			✓

What is the difference between "demolition" and "decommissioning"?

Demolition and decommissioning may involve many of the same physical activities (*e.g.*, blasting, excavation, and dismantling of existing powerhouse and spillways); however, they have separate meanings in the context of the CER.

In the CER, "demolition" refers to the dismantling and partial or full removal of existing structures under Option 1 or 2; it refers to the removal of structures to support the development of new facilities.

"Decommissioning" refers to the dismantling and full removal of all existing facilities under Option 3 only; it refers to the removal of all structures (including the earthen dam) to enable the permanent decommissioning and closure of the site as a generating station.



Sources: Basemap Aerial imagery from GeoNB (2004). Detailed imagery from Leading Edge Geomatics (2014).

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

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Permanent and Temporary Ancillary Facilities for Option 3

Figure 2.10

2.4.1 Phases and Activities—Options 1 and 2

The phases and activities associated with Options 1 and 2 are described below. The sequencing and methods used for the activities will be confirmed through detailed engineering design following selection of the Preferred Option, constructability review, and site-specific conditions.

2.4.1.1 Construction

2.4.1.1.1 Site Preparation and Construction of Temporary Ancillary Facilities

Site preparation for construction of Options 1 and 2 will begin mostly on the right bank in the area of the new approach and discharge channel, along with the some smaller areas also being prepared on the left bank. Site preparation will include surveying, clearing, grubbing and grading the site. Temporary ancillary areas will be developed as required. They will be located mainly on the right bank; however, a laydown area, parking facilities, and other temporary facilities will be located on the left bank to support construction of the new auxiliary sluiceway and demolition of the existing powerhouse and spillways. Temporary construction roads will also be developed on the right bank.

As part of site preparation, a defined construction zone will be established and a fence will be installed to control access to the site. Temporary services for the site, such as power, sewer and water, will be installed to support construction. Water required during construction for activities such as concrete production and dust control will be withdrawn from the headpond, or supplied from on-site water wells. These same water sources will also be used for the supply of potable water, and water treatment will be applied as needed. If required, potable water could also be transported to the site from nearby sources (*e.g.*, the City of Fredericton).

2.4.1.1.2 Channel Excavation

Following site preparation, excavation for the new approach/discharge channel will begin. This excavation will require the removal and transport of a substantial amount of material, mostly rock, from the right bank. To maintain slope stability, the excavation of overburden material will maintain side slopes of 1 m vertical to 2.5 m horizontal, whereas the excavation of rock will maintain side slopes of 6 m vertical to1 m horizontal except adjacent to the structures where it would be 10 m vertical to 1 m horizontal to reduce concrete volume. Standard earth-moving equipment will be used during excavation, in addition to blasting when bedrock is encountered. Preliminary planning estimates the total volume of material that will be removed during excavation are approximately 13 million m^3 under Option 1, and 4.9 million m^3 under Option 2.

Material excavated from the approach/discharge channel will be designated for use in future demolition/infilling activities. The material will be stockpiled in the designated area or transported off-site to the permanent excavated material disposal area.

The approach/discharge channel will be constructed in the dry by initiating the excavation on land and maintaining a rock plug between the excavation and Saint John River. The rock plugs will be removed once the new structures are complete.

2.4.1.1.3 Construction of New Powerhouse, Main Spillway, Switchyard and Fish Passage Facility

Part way through channel excavation, construction of the new main spillway (in both Options 1 and 2) and new powerhouse (Option 1 only) will begin. These structures will be built out of concrete and steel. Due to the large volume of concrete required, it is likely that two temporary concrete batch plants plant will be installed; one on the right bank, and another on the left bank. Concrete will be mixed using local aggregate material, if possible, while avoiding AAR concerns. If local aggregate cannot be used, suitable material will be transported from off-site. Once the concrete structures for the main spillway are completed, spillway gates, hoists and other associated mechanical equipment will be installed. Once the concrete structures for the powerhouse are completed, the turbine-generator units and other mechanical equipment (*e.g.,* intake gates, trash racks, hoist) will be installed.

Construction of the powerhouse will also include the installation of electrical transmission equipment, which will connect to the switchyard. The switchyard will be near the existing transmission line that crosses the Saint John River downstream of the Station and runs through the construction site. This will allow for easy connection to the existing power grid without major upgrades being required. The switchyard will be constructed at the same time as the powerhouse and main spillway.

The powerhouse and main spillway will also include a fish passage facility and other mitigation to support fish passage. The configuration and location of fish passage facilities will be determined based on the results of MAES and in consultation with regulatory agencies Aboriginal groups and stakeholders. It is anticipated that fish passage facilities will be constructed as part of the main spillway and powerhouse construction.

Once the main spillway, powerhouse and switchyard are complete and ready for commissioning, the upstream and downstream rock plugs in the approach/discharge channel will be removed. This will allow the Saint John River to flood the channel. It is anticipated that the rock plugs can be removed from land, and will not require a cofferdam.

Power generation will then switch from the existing Station to the new facilities, and the existing Station components will be taken out of service. Water levels will not be lowered below current operational limits (*i.e.,* maximum drawdown level of 39 m amsl) at any time during construction of Options 1 and 2.

2.4.1.1.4 Construction of New Auxiliary Sluiceway

Once the new spillway and powerhouse structures are commissioned, construction of the auxiliary sluiceway will commence in the existing power channel. A cofferdam will be installed upstream of the existing bridge on Mactaquac Road and the existing powerhouse and spillway. This will allow the new auxiliary sluiceway to be constructed in the dry. Portions of the existing power channel will have to be deepened by approximately 10 m to accommodate the sluiceway. This will require the excavation of approximately 630,000 m^3 of rock. This material will be excavated using standard earth-moving equipment, in addition to blasting when required. The excavated material will be transported off-site to the permanent excavated material disposal area.

Similar to the main spillway, the auxiliary sluiceway will be constructed of concrete and steel. Spillway gates, hoists and associated equipment will be installed after the concrete structures have been constructed.

2.4.1.2 Demolition of Existing Structures

Upon completion of the construction of the new auxiliary sluiceway, the existing powerhouse and main spillway will be partially demolished to elevation 11.28 m amsl; this corresponds to the elevation of the existing powerhouse generator floor. All non-embedded mechanical and electrical equipment in the powerhouse or spillway will be removed. The concrete structures will then be demolished using mechanical equipment such as jack-hammers and excavators. Blasting will also be used to break apart large masses of concrete, such as intakes, draft tubes, foundations and footings. New mass concrete will be poured into voids in any remaining portions of the concrete structures that were not demolished (*e.g.,* portions of intakes and draft tubes).

Either during or after commissioning of the new auxiliary sluiceway, the existing diversion sluiceway will be partially demolished and converted into a permanent water-retaining structure. It will act as an extension of the existing earthen dam. This activity will begin by using rock fill material to construct a work pad downstream of the diversion sluiceway. From this work pad, grout, concrete and compacted rock fill material will be used to reinforce the existing structure. This will create a permanent, impermeable water-retaining structure around the existing gates. Rock fill material will be dumped and not compacted upstream of the structure and a layer of rip-rap will be placed along the top of this rockfill material to prevent erosion at the surface of the headpond.

2.4.1.3 Operation

Operation of both Options 1 and 2 will consist of water level control and operation of a fish passage facility. Water levels will be managed similar to those at the existing Station, and the maximum water level (40.5 m amsl) and minimum drawdown level (39 m amsl) will be the same. Operation of Option 1 will also include power generation. Water levels will be manipulated within the operational range and environmental flow restrictions to maximize power generation. In Option 2, water levels and flow through the spillways will typically be governed by upstream flows into the headpond. Maintenance will be carried out as needed throughout the life of the new facilities.

2.4.2 Phases and Activities—Option 3

2.4.2.1 Decommissioning

Option 3 will include dewatering of the headpond and decommissioning of the existing Station and associated components. At the time of writing the draft CER Report (Stantec 2015b), a slow 3-year progressive drawdown was used for planning (as opposed to a quick drawdown). Since then, the design for Option 3 has been advanced and the preferred dewatering schedule has changed to an accelerated (quick) drawdown scenario carried out in two stages during the spring and fall freshets of the same year. This change, along with other refinements to the Option 3 conceptual design, is described further below.

2.4.2.1.1 Site Preparation for Decommissioning and Establishment of Ancillary Facilities

Site preparation for decommissioning will begin simultaneously on both the left and right banks as well as at other areas along the headpond. Ancillary areas will be established to support the decommissioning of structures and completion of shoreline interventions prior to the beginning of dewatering. These areas will include material disposal areas, laydown areas, infrastructure to access the Saint John River (*e.g.,* wharves), and other temporary facilities. Temporary services such as power, sewer and water will be installed where needed, and temporary roads will be constructed. Site preparation will involve surveying, clearing, grubbing and grading the site.

Because the river crossing on Mactaquac Road that links Routes 102 and 105 will be removed, a replacement transportation link will have to be created prior to the beginning of decommissioning. Several alternatives are being considered to replace this transportation link and maintain the current level of service throughout construction and after the Project is completed (Section 2.6.3).

2.4.2.1.2 Dewatering of the Headpond

Implementation of dewatering will depend on the desired dewatering schedule. Various factors have been considered when developing this schedule, including the volume and quality of headpond sediment, the predicted fate of those sediments, downstream water elevations, downstream erosion and biological considerations. Initially, as discussed in the draft CER Report (Stantec 2015b), a slow drawdown scenario (over three years) was envisioned as this presented the most conservative scenario from a cost and timeline perspective. However, the MAES and preliminary conceptual design have since recommended that an accelerated (quick) drawdown is preferred and this scenario was used for the advancement of engineering design and planning for Option 3.

Dewatering using an accelerated drawdown will begin following the construction of ancillary facilities and be completed in two stages. The first stage of dewatering will be scheduled to coincide with the end of the spring freshet.. The first stage of dewatering would occur over approximately one month and see water levels in the headpond reduced from 40.5 m amsl to the elevation of the diversion sluiceway gates (24.4 m amsl). The powerhouse will be shut down prior to the start of dewatering.

Alterations to the existing diversion sluiceway will be required to lower water levels below elevation 24.4 m amsl. This will be accomplished by removing concrete from the base of the diversion sluiceway waterways. This work will be completed in the dry on two of the waterways, while the river is allowed to flow through the remaining three as well as the main spillway. These modifications will take approximately five to six months to complete. When partial demolition of the first two waterways is complete, the second stage of dewatering will occur by flowing water through the lowered diversion sluiceway. The remaining waterways will be removed in the dry once the first two are complete.

The second stage of dewatering would begin in the fall of the same year during the fall recharge period (a seasonal period of heavier precipitation), and last for approximately 1 month. This would see water levels in the headpond reduced from 24.4 m amsl to approximately 5 m amsl. Water elevations downstream of the Station currently range between 3.0 and 6.6 m amsl depending on environmental conditions and operation of the Station. In Option 3, water elevations downstream of the Station are expected to be similar to current conditions.

Although an accelerated drawdown scenario is currently being used for planning in Option 3, longer drawdown scenarios are also being considered so that the evaluation of different approaches is comprehensive. As was discussed in the draft CER Report, a slow drawdown scenario could involve draining the headpond over as many as three years with decommissioning beginning mid-way through dewatering. Although the accelerated drawdown scenario is being used for planning, further evaluation of these scenarios would be required if Option 3 is selected as the Preferred Option. The final CER Report assumes that the accelerated drawdown scenario will be used; however, potential environmental issues under both the slow and accelerated drawdown scenarios are discussed generally, as applicable, throughout the CER Report.

2.4.2.1.3 Removal of Existing Concrete and Steel Structures

Once the powerhouse is no longer generating electricity and the first stage of dewatering of the headpond has occurred, the removal of steel and concrete structures will begin. Work will begin at the powerhouse, first with the removal of electrical and mechanical equipment (*e.g.,* turbines, generators, transformers and hoists) followed by the removal of concrete structures.

Decommissioning of the main spillway and diversion sluiceway will not begin until after the second stage of dewatering, when the diversion sluiceway has been lowered. This will allow the main spillway to be available for spilling if a high water flow event should occur. As with the powerhouse, mechanical equipment in the diversion sluiceway and main spillway (*e.g.*, gates, rollers, hoists and trash racks) will be removed first, followed by concrete structures.

Mass concrete structures, such the intakes, footings, foundations and piers, will require blasting to break apart the material and allow it to be removed. Excavators and jackhammers will be used to break apart and remove the smaller structural concrete components.

Because the main spillway and powerhouse are located outside the original river channel, concrete portions of these structures will be decommissioned only down to the level of mass concrete. Rock from the decommissioned earthen dam will be used to infill around the remaining structures and infill the power channel to re-establish original grades in that area. A temporary crossing will be installed over the top of the diversion sluiceway to allow for material to be transported from the earthen dam to the powerhouse/main spillway.

Base concrete in the diversion sluiceway will be removed down to the base slab; however, this will not take place until after flow has returned to the original channel after the earthen dam has been removed and the cofferdams have been breached.

Steel removed from the Station will be sent to an off-site recycling facility or a licensed disposal facility. Concrete removed will be crushed on-site and have the reinforcement steel removed for recycling. The crushed concrete will either be reused on site for infilling around structures, sent off-site for recycling or disposal at a licensed facility, or sent to the permanent disposal site created for the Project. The necessary permits will be obtained for any disposal sites used by the Project.

2.4.2.1.4 Removal of Earthen Dam

Removal of the earthen dam will begin after dewatering has occurred to allow the work to be completed in the dry. The full removal of the earthen dam will be completed so to restore flow to the entire width of the original channel. Material will be excavated using standard earth-moving equipment. Excavation will begin from both sides of the dam and move progressively toward the centre. Material will be excavated in layers; the thickness of these layers will be determined by the limitations of excavation equipment. Excavation will progress below the water elevation using the existing upstream and downstream cofferdams that make up part of the earthen dam. It may be required that these cofferdam be built up using material removed from the center of the dam as this work progresses. The excavated material will then be transported along the top of the remaining dam to the right or left bank, depending on the site of the excavation. It will then be transported off-site to one of two permanent disposal areas, or dumped into the existing power channel.

Once the main portion of the dam is removed, the cofferdams will be breached returning flow to the original channel. The cofferdams will then be removed from the channel.

2.4.2.1.5 Site Reclamation and Rehabilitation

Land previously occupied by the Station and any land upstream or downstream of the Station where undesirable conditions are observed (*e.g.,* large scale slumping, instability, erosion, dust, etc.) will be reclaimed and rehabilitated.

Following the removal of the Station's main components, areas previously occupied by the power channel, powerhouse, main spillway and switchyard will be returned to near pre-dam grades and allowed to revegetate. Roads and buildings on land adjacent to the Station, and staging areas and temporary roads used in the decommissioning of facilities, will also be removed and the land will be rehabilitated.

The land that was flooded to create the headpond and areas downstream of the Station may also require reclamation for undesirable conditions. This will be determined on a case-by-case basis following dewatering; however, some assessment and preliminary conceptual design has been completed to anticipate the types of intervention that will be required and higher risk areas. Some structures that were not demolished prior to the creation of the headpond (*e.g.,* currently submerged bridges within the headpond) may also require removal. Rehabilitation and reclamation work may involve sediment removal, bank stabilization, bank revegetation, and/or river channel and fish habitat restoration.

The ultimate fate of the newly re-exposed land that was formerly submerged beneath the headpond has not been determined at this time.

2.4.2.1.6 Natural Flow Regime

Option 3 will allow the Saint John River to revert to near natural flow conditions in the area of the Station and along the length of the headpond. The flow regime will still be partly controlled by other existing generating stations upstream (*e.g.,* Beechwood Generating Station, Grand Falls Generating Station, Tobique Generating Station), but water will flow freely through the decommissioned Station site.

Because the Station operated much like a run-of-the-river dam in high flow conditions, water flows downstream of the Station under Option 3 are not expected to change dramatically during periods of high flow. However, in low flow conditions (*e.g.,* summer, winter), the Station is currently managed to supply power during peak demand periods, and therefore flow is periodically restricted through the Station. Because of this, the removal of flow control under Option 3 will result in less flow variability downstream of the Station during periods of low flow.

2.5 SCHEDULE

The anticipated duration of each end-of-life Option, and the schedule for executing each Option, is provided below:

- Option 1—Construction of the powerhouse and main spillway is anticipated to take approximately six years beginning in 2024 and the new facilities would be commissioned in the fall of 2030. The construction of the auxiliary sluiceway and demolition of the existing structures would be completed over the following five years, with major load-bearing structures being out of commission by 2034. For planning purposes, it is assumed that physical work associated with Option 1 will begin in 2024 and be completed in 2035, therefore, the total duration to complete Option 1 is eleven years.

- Option 2—Construction of the main spillway is anticipated to take approximately five years beginning in 2024. Following this, the construction of the auxiliary sluiceway and demolition of the existing structures is anticipated to take an additional five years, with the powerhouse out of operation by 2030. For planning purposes, it is assumed that the physical work associated with Option 2 will begin in 2024 and be completed in 2034, therefore, the total duration to complete Option 2 is ten years.

- Option 3—Decommissioning of the existing Station components and subsequent rehabilitation and reclamation activities are anticipated to take approximately seven years. This assumes an accelerated (quick) drawdown of the headpond that takes place in two one-month stages (one during the spring freshet and one during the fall recharge period) both within the same year. However, additional time may be required for drawdown of the headpond and for rehabilitation and reclamation upstream and downstream of the Station. For planning purposes, it is assumed that the physical work associated with Option 3 will begin in 2028 and be completed in 2035.

The anticipated schedule for implementing these options is provided in Table 2.3.

Table 2.3 Anticipated Schedule for each of the Options, Phases and Activities

Phase	Anticipated Schedule		
	Option 1	Option 2	Option 3
Planning Phase	2016-2023	2016-2022	2016-2026
Construction Phase	2024-2035	2024-2034	2028-2035
Operation Phase	Present-2130	Present-2130	Present-2030

Dates and timelines discussed above are based on preliminary engineering studies for each of the Options. The schedule for the Preferred Option is subject to change based on the progression and refinement of engineering design and the results of additional study that will be completed in support of the Project.

NB Power is planning to recommend a Preferred Option in 2016 to prepare for conducting the applicable approval processes. Since the publication of the draft CER Report, the work to be completed by 2030 was redefined as commissioning of the new generation rather than removal from service of all AAR affected concrete structures. This perspective aligns with the fact that the 2030 target date is derived from the risk of loss of generation.

2.6 MITIGATION

In this report, we distinguish between two types of mitigation:

- "standard" mitigation, which generally results from best management practices and compliance with regulatory standards to conduct a project in an environmentally responsible way (described below in Section 2.6.1); and
- "additional" mitigation, which is the result of a VC-specific need to further lessen adverse environmental interactions between a project and the surrounding environment, beyond the normal best practices that will be used as standard mitigation (described in each VC).

Mitigation measures are steps that can be taken to lessen the environmental changes caused by a project. These steps may arise from project design considerations, or be in the form of timing restrictions (*e.g.*, sensitive periods for wildlife), physical mitigation (*e.g.*, he use of hay bales to catch sand and silt) or engineered solutions (*e.g.*, changing a building design to avoid a sensitive wetland). Mitigation is an important part of adaptive management. It is considered throughout the life of a project to reduce environmental interactions.

Various environmental protection and management measures will be used to guide Project planning, design, construction and operation. They will apply regardless of the Option selected. The objective of environmental protection and management measures is to allow for the adaptive management of environmental issues as they arise during the course of the Project and provide mechanisms to identify these issues. They include:

- reducing the footprint of Project facilities and activities, where feasible, to reduce the amount of disturbed land, wetlands and water resources;
- using good planning, design and management practices to comply with:
  - regulated standards for air and water emissions, storage or disposal of solid wastes, and handling and disposal of hazardous materials;
  - regulated or industry design and management standards to satisfactorily deal with environmental risks such as seismicity, unusual weather events, flooding and erosion;
- preparing an Environmental Protection Plan for construction activities that is included in, and enforced through, construction contracts;
- preparing and implementing an Environmental Management Plan for operation to attend to the ongoing management and monitoring of land and soil resources; air and water quality; noise and vibration; hazardous materials and waste; and occupational and community health and safety;
- preparing and maintaining an Emergency Response Plan;

- planning and financing activities to compensate for unavoidable adverse effects on environmental resources such as wetlands and aquatic habitats;
- implementing a public, stakeholder and Aboriginal engagement program to identify and address concerns about the Project throughout design, construction and operation; and
- communicate employment, business, and other opportunities to First Nations and the public to promote and enhance local benefits.

2.6.1 Standard Mitigation Measures

The following summarizes standard mitigation measures by Project activities. Additional environmental mitigation measures for each Option will be identified in Sections 4.0 to16.0.

2.6.1.1 General Construction

- All buildings and ancillary facilities will be constructed according to all applicable safety codes, with reference to public health, fire protection and structural quality.
- Safety exclusion zones will be required to manage access to construction sites.
- Existing infrastructure and previously developed areas will be used where possible to reduce additional site clearing and the need for new materials.
- Clearing activities will be restricted to the area needed for site development and operation.
- Environmentally sensitive features will be identified and clearly marked where feasible (*e.g.*, watercourses, wetlands, locations of Species of Conservation Concern, protected areas, areas with elevated archaeological potential).
- Natural vegetation will be preserved where possible.
- Whenever possible, clearing activities will be scheduled outside the normal breeding season for migratory birds (generally April 1 to August 31).
- Natural vegetation buffers will be maintained, where feasible, around wetlands and riparian zones. Watercourse and wetland buffers will be at least 30 m wherever feasible.
- Soil and rock will be sourced from existing, approved pits or quarries.
- All deliveries to the site and transportation of construction and waste materials will be managed within the legal loading requirements. All loads will be properly covered during transport to avoid spillage of material.
- Roads frequently traveled will be upgraded and repaired as necessary.

2.6.1.2 Blasting and Noise Control

- To the extent feasible, blasting activity will be limited to daytime or evening hours.

- Blast design will attempt to reduce ground vibration and noise.
- Pre-blast surveys will be completed to evaluate the potential for ground vibration and identify potentially affected structures.
- Blasting will be conducted according to provincial legislation, and will be subject to terms and conditions of applicable permits.
- Landowners near the construction site will be notified of any blasting activities.
- All blasting will be conducted by certified professionals.
- Blasting near watercourses will follow the requirements of the *Fisheries Act* and the *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* (Wright and Hopky 1998).
- Mechanical excavation measures will be used in lieu of blasting where practical.
- Blasting contractors will review the design and associated mitigation measures to control noise, and to monitor the blasting program.
- All equipment will be maintained in good working order to maintain noise suppression.
- Traffic patterns will be optimized so that Project-related traffic follows efficient routes to and from the site and to reduce use of noise-producing equipment (*e.g.*, back-up beepers).
- Idling of vehicles will be limited. Vehicles and equipment will be turned off when not in use, unless required for effective or safe operation.
- Vehicles and equipment will be maintained regularly (including mufflers), following vehicle and equipment maintenance schedules.
- Nearby residents will be given a construction schedule for key noise-generating activities, and provided with contact information in case of complaints.
- Noise mitigation will be monitored and additional mitigation will be identified if needed to reduce noise to acceptable levels.

2.6.1.3 Dust and Air Emissions Control

- Idling of vehicles will be limited. Vehicles and equipment will be turned off when not in use, unless required for effective or safe operation.
- Vehicles and equipment will be maintained regularly, following vehicle and equipment maintenance schedules.
- To limit dust, clearing and grubbing will be limited to reduce the area of exposed soils.
- Where feasible, haul routes to and at the site will be shortened and revised to avoid residential areas.

- Cleared areas will be revegetated where possible.
- Natural vegetation will be preserved where possible.
- When dust is a concern, dust suppressants (*e.g.,* water) will be applied to exposed surfaces.

2.6.1.4 Traffic Management

- Project-related traffic will be managed in accordance with the NBDTI Work Area Traffic Control Manual (*e.g.,* traffic control persons, signage, temporary markings) (NBDTI 2009).
- During construction activities, advance public notice will be given for any necessary detours or road closures.
- Planning for required traffic delays will avoid peak traffic times when possible; and will consider other traffic disruptions in the area.
- Vehicles will yield to wildlife and will be operated at appropriate speeds.
- Flag persons, detours, safety barricades, fences, signs and/or flashing lights will be used as required.

2.6.1.5 Erosion and Sedimentation Control

- The area of exposed soil will be limited, and the length of time soil is exposed without mitigation (*e.g.,* mulching, seeding, rock cover) will be reduced through scheduled work progression.
- Erosion and sedimentation control structures will be used and maintained throughout construction activities.
- Erosion and sedimentation control structures will be inspected regularly, especially before and after heavy rain events. Water released from the site will be monitored so that it does not exceed total suspended sediment limits specified by regulatory approvals.
- Erosion and sedimentation control structures will remain in place until the disturbed area is stabilized or natural revegetation occurs.
- Dewatering of excavated areas will control the release of sediment-laden water (*e.g.*, filtration through vegetation or engineered erosion control devices.
- Overburden storage piles and exposed topsoil will be covered, or seeded and revegetated, as soon as possible.
- Engineered surface water drainage and diversion channels will be constructed to direct flow around the construction site and away from watercourses and wetlands.
- A water treatment facility (*e.g.*, settling ponds) will be constructed to treat surplus water from the Project before it is discharged.

- Construction material (*e.g.,* gravel) placed in or next to watercourses will be free of debris, fine silt and sand, and chemical contaminants.
- Coffer dams will be used where feasible during the demolition/decommissioning of structures located below the waterline.
- Excavations for new in-water structures will be completed "in-the-dry" to the extent practicable.

2.6.1.6 Decommissioning and Rehabilitation

- Features such as onsite borrow pits and quarries that will not be required for future dam operation will be decommissioned and rehabilitated.
- Disturbed areas will be returned to pre-construction grades, where feasible, with remaining organic material or topsoil redistributed over the disturbed areas.
- Where possible, compacted areas will be scarified or ripped after the temporary fill (rock/gravel) is removed in order to loosen the ground before new topsoil is added.
- Exposed slopes will be stabilized as early as possible to prevent erosion.

2.6.1.7 Dangerous Goods Management

- All fuels and lubricants used during construction will be stored according to containment methods in designated areas. Storage areas will be located at least 30 m from watercourses, wetlands and water supply areas (including known private wells).
- Refueling of machinery will not occur within 30 m of watercourses and water supply areas (including private wells). Where stationary equipment is situated near a wetland, special precautions will be implemented to prevent spills during refueling (*e.g.,* absorbent pads will be placed below nozzles, and spill response kits will be placed at the refueling site).
- Storage of all hazardous materials will comply with WHMIS requirements. Relevant material safety data sheets will be kept at the storage area.
- Fuel storage areas will have approved secondary containment.
- Transportation of dangerous goods will comply with Transport Canada's *Transportation of Dangerous Goods Act.*
- Emergency response plans will be in place for spill response, with spill kits and trained personnel present on-site at all times.

2.6.1.8 Waste Management

- All sites will be kept free of loose waste material and debris.
- Solid wastes, including waste construction material, will be disposed of in approved facilities.
- Temporary storage of waste materials on-site will be located at least 30 m from watercourses, wetlands and water supply areas (including known private wells).
- Temporary on-site sewage systems will be installed and operated according to relevant provincial legislation.
- All solid waste will be properly sorted for recycling, reuse, composting and landfilling.
- Before waste is sent to provincially approved waste disposal areas (*e.g.*, landfill), it will be stored in a manner that prevents decomposing, burning or burying on-site.
- Food and food waste will be stored and disposed of properly to avoid attracting wildlife.

2.6.2 Contingency Planning for Accidental Events

Best practices and safety will be the primary considerations when designing the preferred Option. Accidents, malfunctions and unplanned events may occur despite best efforts to avoid them. Therefore, mitigation measures, control mechanisms and response procedures will be used to reduce the potential for accidents and associated effects. In the unlikely event that accidents or malfunctions do occur, NB Power would have contingency and emergency response procedures in place to guide clean-up efforts, emergency reporting, and plan for further mitigation aimed at preventing a re-occurrence.

Accidents, malfunctions and unplanned events will be prevented and mitigated by taking a systematic approach to safeguarding worker health and safety. NB Power will ensure that its contractors use staff who are trained in workplace accident prevention, including handling of hazardous materials (WHMIS), first aid, and other training programs. Construction contractors will be responsible for their own health and safety practices, and contracting companies will be required to demonstrate their knowledge about these practices before they are awarded jobs.

The focus of the CER is on Project-related environmental issues. Throughout all Project phases, all necessary precautions will be taken to prevent malfunctions and accidental events and reduce any environmental effects that occur. Some of the events that could occur during construction and operation with environmental consequences include:

- spills of hydrocarbons or other hazardous materials;
- failure of erosion and sediment control measures;
- dust and other material arising from blasting activities;

- vehicular accidents; and
- wildlife encounters.

Prevention measures and response procedures for such events will be developed prior to the commencement of each Project phase.

2.6.3 Transportation Link

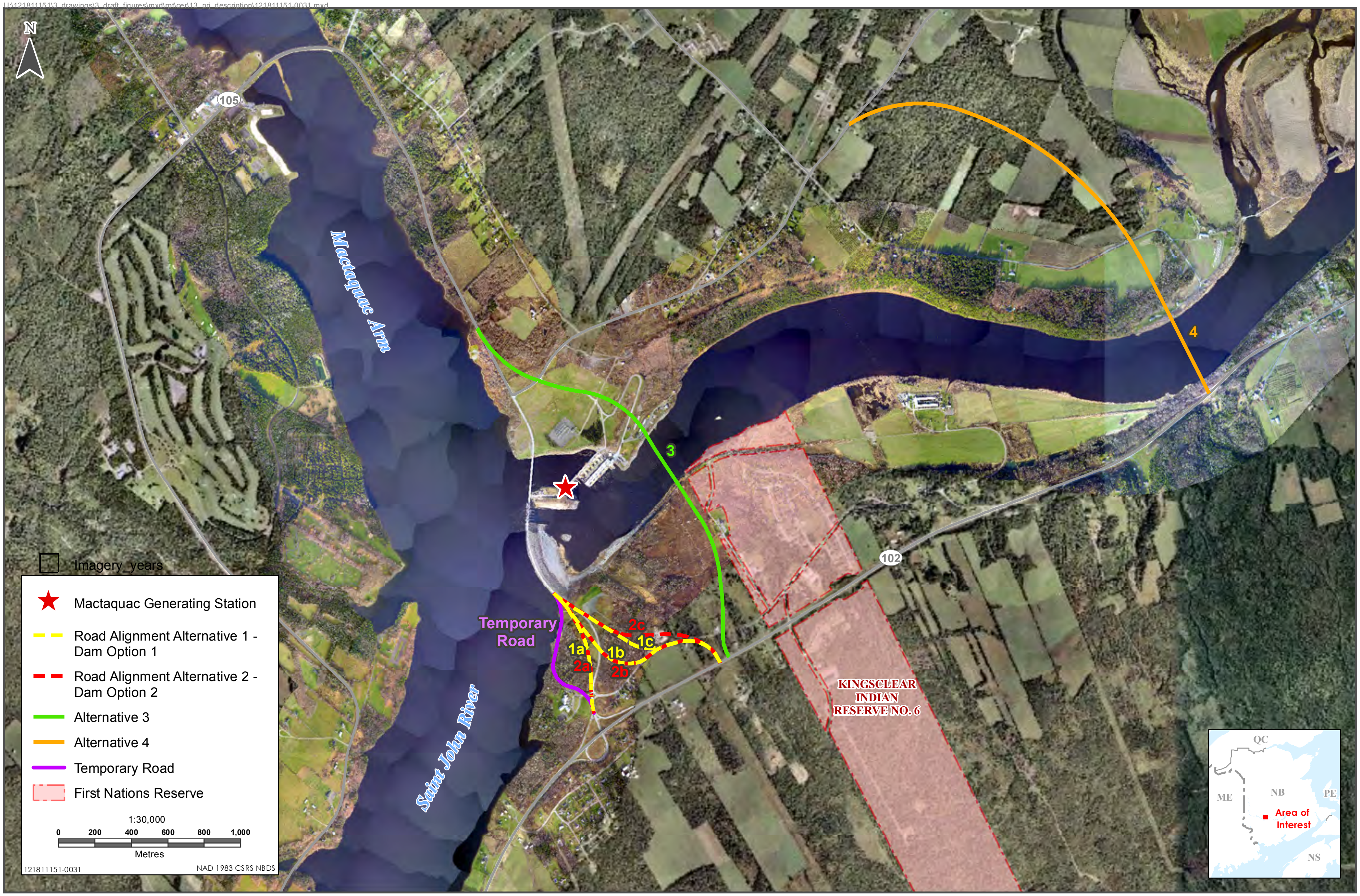
The Station provides an important thoroughfare over the Saint John River and an integral link between two collector highways between Nackawic and Fredericton (Routes 102 and 105). Mactaquac Road traverses the earthen dam, and is used by approximately 4,500 vehicles per day.

Regardless of which Option is selected, the existing transportation link between Routes 102 and 105 at Mactaquac will be affected by Project activities, either temporarily or permanently. Therefore, each Option will require mitigation to maintain a transportation link in the Project area, whether existing, modified, or new. A transportation study conducted for NB Power (exp Services Inc. 2015) identified eight potential alternatives for maintaining a transportation link in the Station area (Figure 2.11):

- Alternatives 1a, 1b and 1c —These alternatives apply only to Option 1. They provide slightly different transportation route configurations upstream of the Station, but all of them link to the existing earthen dam and left bank infrastructure. Alternatives 1a and 1b include a new river crossing over the approach channel; one of them will use the new spillway and powerhouse structures as a crossing. All three alternatives require the construction of a temporary public access road, which will be used during construction of the permanent transportation route. A permanent crossing would need to be in place for the fall of 2029 when the upstream rock plug would be removed, or sooner.
- Alternatives 2a, 2b and 2c—These alternatives are very similar to 1a, 1b and 1c, but they apply only to Option 2. They are slightly reconfigured to fit the size and location of Option 2 components. All of the other 1a, 1b and 1c descriptors apply to these routes. All three alternatives require the construction of a temporary public access road, which will be used during construction of the permanent transportation route. A permanent crossing would need to be in place for the summer of 2029 when the upstream rock plug would be removed, or sooner.
- Alternative 3—This alternative proposes a new river crossing approximately 800 m downstream of the Station. It can apply to all three Options. This alternative could be constructed independently of the construction of the Options and be in place by the time the current transportation link between Routes 102 and 105 needs to be taken out of service (*i.e.*, Option 1 – 2024, Option 2 – 2024, Option 3 – 2028).
- Alternative 4—This alternative proposes a new river crossing approximately 4.5 km downstream of the Station. It can apply to all three Options. This alternative could be constructed independently of the construction of the Options and be in place by the time the current transportation link between Routes 102 and 105 needs to be taken out of service (*i.e.*, Option 1 – 2024, Option 2 – 2024, Option 3 – 2028).

The review of the alternative transportation routes will be completed independently from the Project. The preferred alternative will likely be selected by the New Brunswick Department of Transportation and Infrastructure (NBDTI). This decision will consider the following factors:

- the preferred Option selected for the Project;
- public and stakeholder feedback collected through the CER process;
- current and planned future land use in the area of each transportation alternative and the Station;
- environmental constraints (*e.g.*, heritage and cultural resources, rare plants, wetlands); and
- engineering and economic feasibility.



Sources: Basemap Aerial imagery from GeoNB. Detailed imagery from Leading Edge (2014).
Base Data: First Nations Reserve and Roads are from SNB. All data downloaded from GeoNB.

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

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Transportation Link Alternatives

Figure 2.11