Raise Sandy Lake Spillway, p. 8 of 96, $612,000

Q. Please provide a copy of the 2008 study undertaken by NP into alternative ways to improve the efficiency and energy production of existing hydro plants.

A. Attachment A includes a copy of the 2008 study undertaken by Newfoundland Power identifying potential projects to increase energy production of existing hydro plants.

Potential Projects to Increase Energy Production

Potential Projects to Increase Energy Production

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January 2009

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1.0 Introduction

Newfoundland Power ("the Company") operates 23 hydroelectric plants in 19 developments across the province. The annual normal production of these developments is 425.8 GWh which is less than 10% of Newfoundland Power customers' electricity requirements. The remainder of the required electricity is purchased from Newfoundland and Labrador Hydro ("Hydro"). A significant portion of the electricity purchased from Hydro is generated at the oil fired Holyrood thermal generating plant. At present, oil is a more costly source of electricity than that generated at hydroelectric plants on the Island interconnected electrical system.

Prior to the construction of the Island interconnected electrical system, the majority of the Company's 23 hydroelectric plants were operated as small isolated systems across the province. When constructed, these plants were the only source of generation for local systems. The plants were designed for year round operation with maximum utilization of available water resources. Today, the hydroelectric plants are connected to the Island interconnected electrical system and are operated to their maximum efficiency, providing low cost electricity to the entire electrical system.

Newfoundland Power is looking at alternative ways to improve the efficiency and energy production of its existing hydroelectric plants. There is potential to increase the annual production of existing hydroelectric plants by modifying existing dams, penstocks, turbines, and constructing new developments within existing watershed areas.

Increasing energy production at Newfoundland Power's existing hydroelectric plants would replace energy produced at Hydro's Holyrood thermal generating plant.

The purpose of this study is to (1) identify projects with the potential to increase energy production at Newfoundland Power's plants, and (2) provide budgetary cost estimates and economic analysis using current cost of energy for each potential project.

It should be noted that prior to implementing any of these projects, in particular the new developments, a detailed engineering study would be required to determine the environmental impacts and regulatory requirements associated with the potential development.

2.0 Methodology

In December 2000, Hatch Limited ("Hatch") completed a report, *Water Management Study,* to provide an estimate of the normal annual production of Newfoundland Power's hydroelectric systems. As a follow up to this study Hatch also completed a review of Newfoundland Power's hydroelectric developments to identify opportunities for increasing energy generation though operational or physical changes to the systems. Potential projects identified by Hatch for increasing energy generation for Newfoundland Power's hydroelectric developments are outlined in the report *"Hydroelectric Systems Strategic Planning Study"*. The review was undertaken using the computer simulation models developed for the Water Management Study. Changes to the system were tested using these models and the energy results were compared to the long term production as estimated in the Water Management Study.

This study reviews the Hatch *"Hydroelectric Systems Strategic Planning Study"* including a list of projects identified in the Hatch study that appeared to be practical and feasible. In addition, a review of each system was conducted by Newfoundland Power in 2008 to determine other potential projects that Hatch had not identified that could also result in an increase in energy production. For example, Hatch did not investigate reinstating dams that have been previously decommissioned nor did they investigate possible new developments that could be constructed within existing watersheds.

For each potential project, the feasibility was established along with a description of the work required. A budgetary capital cost was estimated and was used to determine a levelized unit cost of the energy for the potential project.

Based on the review of the study completed by Hatch, and this review completed by Newfoundland Power, a final list of potential projects to increase energy production was compiled. A budgetary cost estimate and feasibility analysis was completed for each project and the results are presented in Section 3.0 of this report.

3.0 Potential Projects to Increase Energy Production

3.1 Rocky Pond/Tors Cove Development

Newfoundland Power's Rocky Pond/Tors Cove development is comprised of two generating plants, Rocky Pond and Tors Cove, and is located on the southern shore of the Avalon Peninsula, approximately 40 km south of the City of St. John's.

Rocky Pond hydroelectric generating plant is located upstream of Tors Cove Pond. The plant was placed into service in 1942 and has one generating unit with a capacity of 3.25 MW under a net head of 32.6 m. The normal annual production at Rocky Pond is approximately 14.1 GWh or 3.3 % of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Rocky Pond plant is approximately 152 km^2.

Tors Cove hydroelectric generation plant is located downstream of Tors Cove Pond. The plant was placed into service in 1940 and has three generating units with a total capacity of 6.9 MW under a net head of 52.7 m. The normal annual production at Tors Cove is approximately 25.5 GWh or 6.0 % of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Tors Cove plant is approximately 183 km^2.

Storage is provided by structures at Franks Pond, Cape Pond, Rocky Pond Forebay and Tors Cove Forebay. All major storage reservoirs are in series, with Franks Pond being the most upstream reservoir in the system. There are seven dams that impound water on Franks Pond reservoir. Two of these dams contain overflow spillways, which when overtopped, lead to spill out of the system. Water flows from Franks Pond to Cape Pond through Franks Pond canal. Water is conveyed from Cape Pond to Rocky Pond Forebay through Cluneys and La Manche canals. Several spillways are located along the canals, which when overtopped would lead to spill out of the system. There is also considerable leakage through the canal embankments which spills out of the system. Power flow and spill from Rocky Pond Forebay enters Tors Cove Pond Forebay where the water is stored, spilled out of the system or used for generation.

There is a fish plant located in the community of Tors Cove which draws water from the Tors Cove station penstock for its water supply.

To increase energy production within the Rocky Pond /Tors Cove system the following potential projects were assessed:

- Increase height of Cape Pond structures and La Manche canal capacity;
- Increase sill elevation of Franks Pond spillways;
- New Hydroelectric Development at Yellow Marsh.

3.1.1 Increase Height at Cape Pond Structures and La Manche Canal Capacity

Structures within Cape Pond reservoir include Cape Pond dam, spillway and outlet structure. The dam is an earthfill structure with a maximum height of approximately 6 m and a crest length of 150 m. The spillway is a concrete overflow spillway approximately 40 m long. Also incorporated into the earthfill section is a concrete outlet complete with a 2.4 m x 1.8 m steel gate and screw stem lift.

La Manche canal conveys water from Cape Pond reservoir to Rocky Pond forebay. The canal is a side hill excavation and earthfill dyke structure approximately 5600 m long and incorporates a total of seven spillways along its length.

To determine the effect on energy production, Cape Pond dam and spillway were raised by 2.0 m and La Manche canal capacity was increased by 3.0 m^3/s. Increasing the height of Cape Pond structures and La Manche canal capacity would increase the amount of storage in the system and reduce the amount of spilled water at Cape Pond and Cluneys canal.

The total estimated cost for this project is $1,380,000. The incremental energy increase related to implementing these upgrades is estimated to be 2.88 GWh/yr.

The estimated levelized cost of raising the structures at Cape Pond and increasing the capacity of La Manche canal is 3.756 cents per kWh.

3.1.2 Increase Sill Elevation of Franks Pond Overflow Spillway

Structures within Franks Pond reservoir include Franks Pond main storage dam, overflow spillway and outlet. In addition there are six other smaller dams that were constructed around the reservoir where low spots were identified.

The spillway consists of an earthfill/rockfill embankment with a vertical galvanized steel core and is approximately 120 m long.

To determine the effect on increased energy production, all structures at Franks Pond was raised 1.5 m. Increasing the height of the structures will reduce the spill at Franks Pond and increase storage within the system.

The total estimated cost for increasing the height of the structures at Franks Pond is $2,157,000. The incremental increase in energy output related to implementing these upgrades is estimated to be 0.19 GWh.

Implementing these upgrades is not economical at this time due to the size and quantity of structures on Franks Pond.

3.1.3 New Hydroelectric Development at Yellow Marsh Pond

Based on data collected from 1:50 000 maps it was determined that there is approximately a 10.7 m elevation difference between the end of La Manche Canal and Yellow Marsh Pond that could be utilized to develop a small hydroelectric plant within the existing water shed area of Rocky Pond/Tors Cove.

Figure 1 shows a conceptual layout for a proposed development at Yellow Marsh Pond.

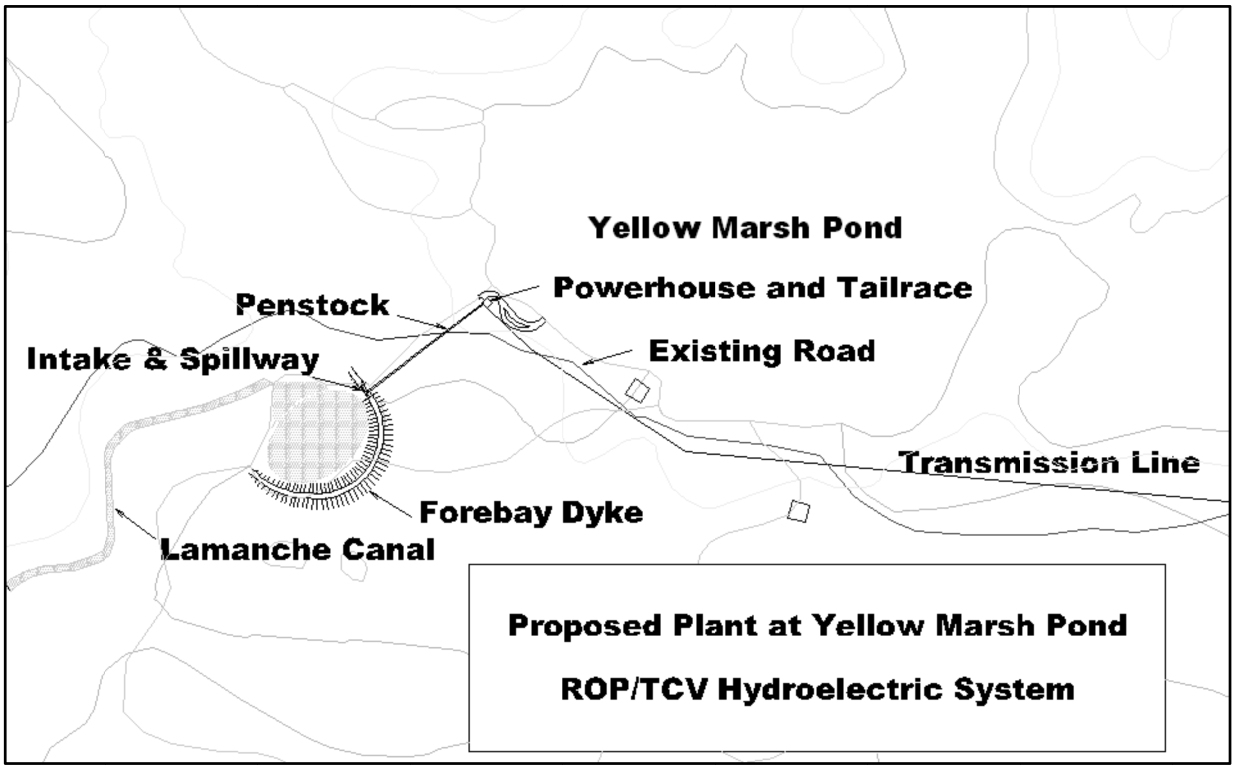

Figure 1 – Conceptual Layout of a Proposed Development at Yellow Marsh Pond.

The Yellow Marsh Pond Hydroelectric Plant would consist of one generating unit with a capacity of 650 kW and a gross head of 10.7 m. It is estimated that the average annual output of the plant would be 4.0 GWh/yr.

Yellow Marsh Pond Plant would include an earthfill dam, a concrete overflow spillway and intake. These structures would be located at the end of La Manche Canal.

A 170 m long, 2.3 m diameter penstock would convey water from the forebay to the new powerhouse. The powerhouse would consist of a reinforced concrete foundation with a pre-engineered steel building, housing a turbine, generator, governor and controls. The building would contain an overhead crane for installation and maintenance purposes as well as space for disassembling and working on the unit.

Outflow from the plant would be directed into a spawning canal similar in construction to the Morris Development arrangement to compensate for reduced spawning habitat in the natural river.

A 66 kV substation and a 3 kilometre transmission line would tie into transmission line 20L at a location near the start of Cape Pond Access Road.

The total estimated cost for the construction of a new power plant at Yellow Marsh Pond is $ 6,100,000.

The estimated levelized cost of construction of this plant and associated transmission facilities is 12.84 cents per kWh.

3.2 Horsechops/Cape Broyle Development

Newfoundland Power's Horsechops/Cape Broyle development is composed of two generating plants, Horsechops and Cape Broyle, both located on the southern shore of the Avalon Peninsula.

Horsechops hydroelectric generating plant is located upstream of Cape Broyle forebay. The plant was placed into service in 1953 and has one generating unit with a capacity of 8.3 MW under a net head of 84.1 m. The normal annual production at Horsechops is approximately 41.80 GWh or 9.8% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Horsechops plant is approximately 155 km^2.

Cape Broyle plant was also placed into service in 1953 and has one generating unit with a capacity of 6.3 MW under a net head of 54.8 m. The normal annual production at Cape Broyle is approximately 32.80 GWh or 7.7 % of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Cape Broyle plant is approximately 191 km^2.

Storage is provided by structures at Blackwoods Ponds (Northwest Blackwoods Pond, East Blackwoods Pond and Fourth Blackwoods Pond), Mount Carmel Pond, Horsechops Forebay and Cape Broyle Forebay. The upper part of the basin is a plateau with numerous small streams, ponds and bogs. Inflows in this area are diverted by structures located at Ragged Hills Pond, Rock Pond and the Blackwoods Ponds. Inflows are either stored or spilled out of the system. Water stored in the Blackwoods Ponds is conveyed through the Fourth Blackwoods Pond canal and a series of small lakes to Mount Carmel Pond. Mount Carmel Pond is the main storage reservoir for the Horsechops/Cape Broyle system. Controlled releases and spill from Mount Carmel Pond are both discharged into Horsechops Forebay, and are used for generation or spilled. Power flows and spill from Horsechops Forebay enter Cape Broyle Forebay and are used for generation or spilled out of the system.

To increase energy production within the Horse Chops/ Cape Broyle system the following potential projects were assessed:

- Raise Blackwoods Ponds spillway elevations; and
- Replace Cape Broyle runner.

3.2.1 Raise Blackwoods Ponds Spillway Elevation

Structures within Blackwoods Pond include Fourth Blackwoods dam/spillway, two freeboard dams at Fourth Blackwoods, East Blackwoods Pond dam/spillway, nine freeboards dams at East Blackwoods, Northwest Blackwoods Pond diversion dam, freeboard dam and spillway and Pond K diversion dam.

Fourth Blackwoods dam/spillway, East Blackwoods dam/spillway and Northwest Blackwoods spillway are a rockfill/earthfill overflow construction with a central steel core. Fourth Blackwoods structure is approximately 55.0 m long and 4.6 m high, East Blackwoods pond dam/spillway is approximately 90.0 m long and 1.2 m high while Northwest Blackwoods Pond spillway is 75.0 m long and 2.4 m high.

Based on the simulation model, created by Hatch, for the Horsechops/Cape Broyle system it was determined that the main physical limitation of the system is the elevation of the spillways at Blackwoods Pond. Blackwoods Pond does not have adequate storage capacity to store normal inflows without spilling. In addition the spill elevation limits the discharge through Fourth Blackwoods Pond canal by preventing full utilization of the canal depth and flow area. The canal itself is deep and fully excavated and is therefore not limited by freeboard on the side berms. If the spill elevation were raised, more of the canal’s physical flow capacity could be utilized.

To determine the increased energy production, the spillway elevation of Fourth Blackwoods, East Blackwoods and Northwest Blackwoods spillways were raised by 1.0 m. The simulation achieved almost complete recovery of Blackwoods Pond spill.

The total estimated cost for increasing the height of the spillways at Fourth Blackwoods, East Blackwoods and Northwest Blackwoods is $553,000. The incremental increase in energy output related to implementing these upgrades is estimated to be 1.9 GWh/yr.

The estimated levelized cost of raising the structures at Blackwoods Pond is 2.286 cents per kWh.

3.2.2 Runner Replacement at Cape Broyle

The runner at Cape Broyle is 29 years old. Efficiency testing was completed on this unit in 1997 by Hatch. Efficiency testing concluded that the turbine efficiency was acceptable considering the age of the unit. Best efficiency was estimated to be 88% and efficiency at maximum load was 86%. A new runner design is estimated to increase these values to approximately 91% and 89% respectively. The resulting increase in energy production due to the runner replacement is estimated to be 0.96 GWh/yr.

The total estimated cost to replace the runner at Cape Broyle is $842,000.

The estimated levelized cost of the replacement of the runner at Cape Broyle is 6.896 cents per kWh.

3.3 Sandy Brook Development

The Sandy Brook development is located in central Newfoundland near the Town of Grand Falls-Windsor. The plant was placed into service in 1963 and has one generating unit with a capacity of 5.5 MW under a net head of 33.5 m. The normal annual production at Sandy Brook is approximately 27.7 GWh or 6.5% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Sandy Brook plant is approximately 529 km^2.

Storage is provided by structures at Island Pond, West Lake, Sandy Lake and Sandy Brook Forebay. On the west side of the drainage basin, Island Pond drains into a series of small lakes along West Brook, and into West Lake. On the east side of the basin, Sandy Lake plus other small lakes drain into Sandy Brook. West Lake flows into Sandy Brook forebay. West Lake and Sandy Lake are the main storage reservoirs for the system. Island Pond provides some storage but is essentially uncontrolled. The Sandy Brook Forebay spillway discharges out of the system while the other spillways discharge within the system.

To increase energy production within the Sandy Brook system the following potential projects were assessed:

- Increase Storage at Sandy Lake;
- Reinstate Leonards Lake Dam; and
- Reinstate Three Angle Lake Dam.

3.3.1 Increase Storage at Sandy Lake

Structures on Sandy Lake reservoir include Sandy Lake dam/spillway and outlet. The dam/spillway is an earthfill/rockfill overflow type constructed with a galvanized metal core. The structure is approximately 130 m long with a maximum height of 2.7 m. A reinforced concrete outlet structure with a 2.4 m x 2.4 m timber gate and a mechanically operated gate lift is located in the spillway section near the left abutment.

To determine the increased energy production, Sandy Lake dam/spillway structures were assumed to be raised to allow an increase of full supply level by 1.0, 1.5 and 2.0 m. Increasing the height of Sandy Lake structures will increase the amount of storage in the system and reduce the amount of spilled water at Sandy Lake.

The total estimated cost for increasing Sandy Lake structures by 1.0 m, 1.5 m and 2.0 m is $612,000, $764,000 and $934,000 respectively. The incremental increase in energy output related to implementing these upgrades is estimated to be 0.86 GWh for a 1.0 m raise, 1.24 GWh for a 1.5 m raise and 1.7 GWh for a 2.0 m raise.

The estimated levelized cost of raising the Sandy Lake structure is 5.282 cents per kWh, 4.584 cents per kWh and 4.219 cents per kWh respectively for a 1.0 m, 1.5m, and 2.0 m increase in elevation.

There are several cabin owners on the perimeter of Sandy Lake. Further investigation would be required prior to proceeding with this project to determine if the upgrades to Sandy Lake structures would impact the property of these cabin owners.

3.3.2 Reinstate Leonards Lake Dam

Leonards Lake dam and outlet were decommissioned in 1992. To determine the effect that additional storage would have on the system it was assumed that the dam and outlet structure were reinstated. The storage capacity of Leonards Lake reservoir, prior to decommissioning the dam and outlet, was 0.24 GWh. This value was used in completing the economic analysis to determine if reinstating the structures at Leonards Lake is feasible. The total estimated cost for the construction of a new dam and outlet structure at Leonards Lake is $405,000.

The estimated levelized cost of constructing a new dam and outlet at Leonards Lake is 13.98 cents per kWh.

3.3.3 Reinstate Three Angle Dam

Three Angle dam and outlet were decommissioned in 1992. To determine the effect that additional storage would have on the system it was assumed that the dam and outlet structure were reinstated. The storage capacity of Three Angle Lake reservoir, prior to decommissioning the dam and outlet, was 0.30 GWh. This value was used in completing the economic analysis to determine if reinstating the structures at Three Angle Lake is feasible. The total estimated cost for the construction of a new dam and outlet structure at Three Angle Lake is $470,000.

The estimated levelized cost of constructing a new dam and outlet at Three Angle Lake is 13.92 cents per kWh.

3.4 Lookout Brook Development

The Lookout Brook development is located on the west coast of Newfoundland near the community of St. Georges. The plant was placed into service in 1945 and currently has two generating units with a total capacity of 6.2 MW under a net head of 154.5 m. The normal annual production at Lookout Brook is approximately 30.10 GWh or 7.1% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Lookout Brook plant is approximately 82 km^2.

Storage is provided by structures at Cross Pond, Joe Dennis Pond and Lookout Brook Forebay. The major storage reservoirs are in series, with Cross Pond being the most upstream reservoir in the system. There is an overflow spillway located on Cross Pond, which spills out of the system when overtopped. Water is released from Cross Pond to Joe Dennis Pond using the control structure located at its outlet. Water entering Joe Dennis Pond is stored, spilled within the system or released downstream to Lookout Brook Forebay using the control structure located at its outlet. Water from the upstream reservoirs entering Lookout Brook Forebay is either spilled out of the system or used for generation. The Cross Pond and Lookout Brook Forebay overflow spillways discharge out of the system while the remaining spillways discharge within the system.

To increase energy production within the Lookout Brook system the following potential projects were assessed:

- Increase Storage Capacity at Joe Dennis Pond; and
- New Hydroelectric Plant on Lookout Pond.

3.4.1 Increase Storage Capacity at Joe Dennis Pond Dam

Structures on Joe Dennis Pond reservoir include the main storage dam, spillway, outlet structure, side dam and side dyke. The main dam is of earthfill construction with an overall length of approximately 135 m and a maximum height of about 6.0 m. Incorporated into the centre section of the main dam is a 30 m long earthfill/rockfill spillway with a galvanized steel core. The outlet is a timber culvert and a CSP liner with a concrete well which houses a 2.2 m x 1.5 m high timber gate and a screw stem gate lift. The outlet is incorporated into the left side of the main dam. The earthfill side dam extends from the right side of the main dam. The side dam is approximately 240 m long and is low with a maximum height of only 2.0 m. The side dyke is a separate earthfill freeboard structure located to the left of the main dam. This structure is approximately 92 m long with a maximum height of 3.0 m.

To determine the increased energy production, all structures at Joe Dennis Pond were increased by 2.0 m. Increasing the height of Joe Dennis structures will increase the amount of storage in the system and reduce the amount of spilled water at Joe Dennis Pond.

The total estimated cost for increasing the height of the structures at Joe Dennis Pond by 2.0 m is $1,388,000. The incremental increase in energy output related to implementing these upgrades is estimated to be 1.6 GWh.

The estimated levelized cost of raising the structures at Joe Dennis Pond is 6.817 cents per kWh.

3.4.2 New Hydroelectric Plant on Lookout Pond

The Lookout Pond Hydroelectric Plant would be located at the upstream end of the Lookout Brook forebay with one generating unit with a capacity of 925 kW and gross head of 37.2 m. It is estimated that the average annual output of the plant would be 7.25 GWh/yr.

Figure 2 shows a conceptual layout for the new plant at Lookout Pond.

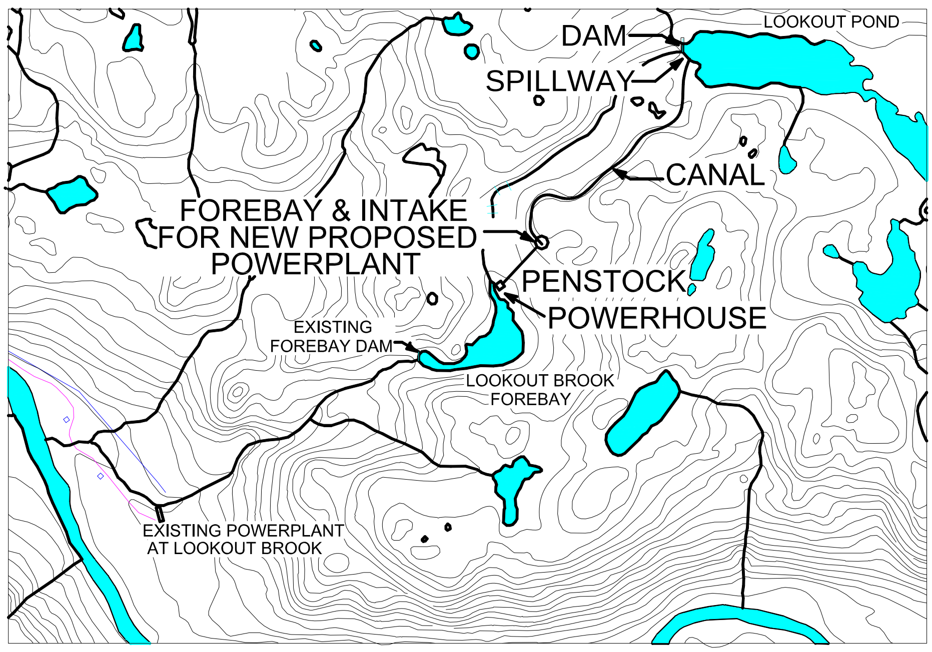

Figure 2 – Conceptual Layout of Proposed Plant on Lookout Pond

Lookout Pond plant would include an earthfill dam and concrete overflow spillway at the left bank. The dam would be founded directly on the bedrock immediately downstream of the existing dam. It would be approximately 6.5 m high and about 90 m long. A concrete overflow spillway would be on the left bank of the dam. The canal intake would start from the spillway approach channel area to the left of the spillway and would continue to the intake. The total length of canal would be approximately 1205 m. A 225 m long, 1.37 m diameter steel penstock would deliver the water from the forebay to the new powerhouse. The water from the new powerhouse would be discharged into the existing forebay of Lookout Brook development.

A feasibility review of installing a new hydroelectric power facility at Lookout Pond was assessed in January 1982 by Montreal Engineering Company Ltd (*"MEC"*). The assessment completed by MEC included a conceptual design related to the layout of the new hydroelectric development, estimates related to the average annual output and detailed cost estimates for the construction of the new plant. This report was reviewed by Newfoundland Power, capital costs were updated and an economic analysis was completed to determine if the construction of the new development is feasible. For the purposes of the economic analysis it was assumed that the average annual energy would be 7.25 GWH/yr, the same as that determined by MEC in 1982.

The total estimated cost for construction a new power plant at Lookout Pond is $10,500,000.

The estimated levelized cost of constructing the new plant is 12.265 cents per kWh.

3.5 Pierre's Brook Development

The Pierre's Brook development is on the southern shore of the Avalon Peninsula. The plant was placed into service in 1931 and has one generating unit with a capacity of 4.3 MW under a net head of 76.0 m. The normal annual production at Pierre's Brook is approximately 23.40 GWh or 5.5% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Pierre's Brook Plant is approximately 116 km^2.

Storage is provided by structures at Gull Pond, Big Country Pond and Witless Bay Country Pond.

Controlled releases and spills from Big Country Pond, and controlled releases from Witless Bay Country Pond, are discharged into Gull Pond. Spill from Witless Bay Country Pond and Gull Pond is discharged out of the system while spills from Big Country Pond spills within the system.

To increase energy production within the Pierre's Brook system the following potential projects were assessed:

- Increase Storage at Big Country Pond;
- Increase Storage at Gull Pond; and
- New Development located at Big Country Pond.

3.5.1 Increase Storage at Big Country Pond

Structures on Big Country Pond reservoir include the main storage dam, spillway, outlet structure and Rocky Pond freeboard dams. The main dam is an earthfill structure with an overall length of approximately 90 m and a maximum height of about 6.0 m. The dam includes a reinforced concrete gate section with concrete guide walls. The timber gate is 1.5 m x 1.6 m and is operated by a manual screw stem lift. The spillway is a rockfill overflow spillway with a galvanized steel core. The spillway is approximately 52 m long and 2.0 m high. The two freeboard dams impound water when the level in Big Country Pond is high. One dam is approximately 1.8 m high and 36 m long and the other is 2.5 m high and 50 m long.

To determine the increased energy production, all structures at Big Country Pond were increased by 1.0 m. Increasing the height of Big Country Pond structures will increase the amount of storage in the system and reduce the amount of spilled water at Big Country Pond.

The total estimated cost for increasing the height of the structures at Big Country Pond by 1.0 m is $275,000. The incremental increase in energy output related to implementing these upgrades is estimated to be 0.3 GWh/yr.

The estimated levelized cost of raising the structures at Big Country Pond is 7.195 cents per kWh.

3.5.2 Increase Storage at Gull Pond (Forebay)

Structures on Gull Pond reservoir include the main dam/intake structure, spillway and freeboard dam. The main dam is an earthfill dam with an impervious concrete core. The dam is approximately 120 m long and 7.6 m high. The intake consists of a concrete box culvert through the dam, a 1.2 m x 1.5 m gate, a gate hoist, steel trashracks, a concrete gate shaft, control equipment and a wooden gatehouse. The spillway is a concrete overflow structure with a length of approximately 30 m and a height of 2.0 m. The spillway is topped by steel flashboard guides and a walkway. The freeboard dam is an earthfill structure with a length of approximately 380 m and a height of about 6.0m.

To determine the increased energy production, all structures at Gull Pond were increased by 1.0 m. Increasing the height of Gull Pond structures will increase energy output by 0.50 GWh.

The total estimated cost for increasing the height of the structures at Gull Pond by 1.0 m is $887,000.

The estimated levelized cost of raising the structures at Gull Pond is 13.938 cents per kWh.

3.5.3 New Development at Big Country Pond

Based on data collected from 1:50 000 maps it was determined that there is approximately a 41.4 m elevation difference between Big Country Pond and Gull Pond that could be utilized to develop a small hydroelectric plant within the existing water shed area of the Pierre’s Brook development.

Figure 3 shows a conceptual layout for the Big Country Pond Plant.

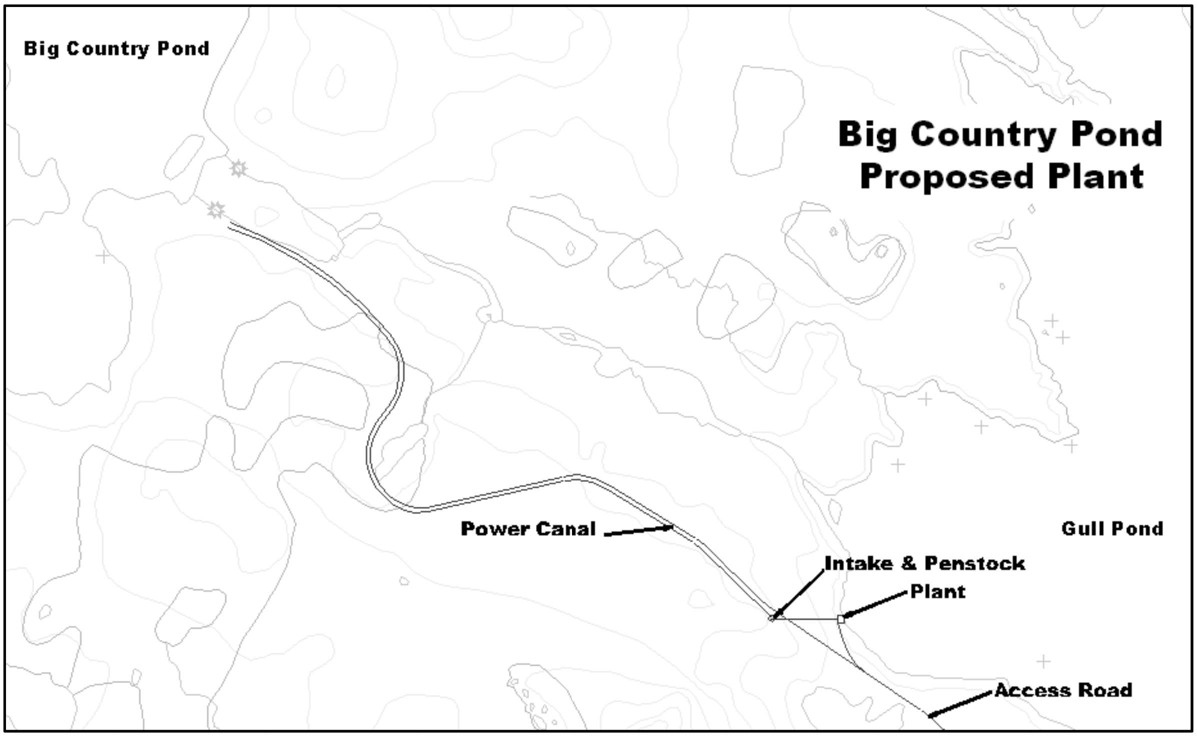

Figure 3 – Conceptual Layout of Proposed Plant at Big Country Pond

The Big Country Pond Hydroelectric Plant would be located on the west side of Gull Pond with one generating unit with a capacity of 1,500 kW. It is estimated that the average annual output of the new plant would be approximately 8.0 GWh/yr.

Big Country Pond Plant would involve diverting the flow from Big Country Pond through a canal parallel to Pierre's Brook. The canal would be approximately 3,500 m long. A small forebay dam, spillway and intake would be constructed at the end of the canal. A 250 m long, 2.3 m diameter penstock would convey the water from the forebay to the new powerhouse.

The powerhouse would consist of a reinforced concrete foundation with a pre-engineered steel building, housing a turbine, generator, governor and controls. The building would contain an overhead crane for installation and maintenance purposes as well as space for disassembling and working on the unit.

Outflow from the plant would be directed into a spawning canal similar in construction to the Morris Development arrangement to compensate for reduced spawning habitat in the natural river.

A 66 kV substation and a 3.5 kilometre transmission line would tie in to Transmission Line 24L at a location in close proximity to the existing Pierre's Brook forebay.

A 1.5 kilometre access road would be constructed from an existing road, as well a road would be constructed along the power canal embankment, providing vehicular access to Big Country Pond Dam.

The total estimated cost for the construction of a new power plant at Big Country Pond is $ 12,283,000.

The estimated levelized cost of construction of this plant is 12.957 cents per kWh.

3.6 Topsail Development

The Topsail development is located on the southeast coast of Conception Bay near the community of Topsail. The plant was placed into service in 1932 and has one generating unit with a capacity of 2.6 MW under a net head of 85.5 m. The normal annual production at Topsail is approximately 13.50 GWh/yr or 3.2% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Topsail plant is approximately 61 km^2.

Storage is provided by structures at Thomas Pond, Paddy's Pond, Three Arm Pond and Three Island Pond. All major reservoirs are in series, with Thomas Pond being the most upstream reservoir in the system. There is an overflow spillway located on Thomas Pond, which when overtopped, would lead to spill out of the system. Water is released from Thomas Pond to Paddy's Pond using the control structure located at its outlet. Water entering Paddy's Pond is stored, spilled out of the system or released downstream to Three Arm Pond. Additional inflow occurs at Paddy's Pond due to spill from Cochrane Pond located in the Petty Harbour system. The Thomas Pond, Paddy's Pond and Topsail Pond overflow spillways discharge out of the system while the other spillways discharge within the system.

To increase energy production within the Topsail system the following potential projects were assessed:

- Increase Storage in Thomas Pond; and
- Divert Cochrane Pond into Topsail system.

3.6.1 Increase Storage in Thomas Pond

Structures on Thomas Pond reservoir include the main dam, spillway and outlet. The main dam is an earthfill dam, incorporating a reinforced concrete spillway at the left abutment and a reinforced concrete outlet at the right abutment. The main earthfill section is approximately 520 m long and 10.7 m high. The concrete overflow spillway is approximately 50 m long and 2.1 m high. It includes timber stoplogs along the crest, a concrete retaining wall on the right abutment and a gabion retaining wall on the left abutment. The outlet structure consists of two concrete buttress abutments separated by a 1.8 m wide x 2.0 m high timber gate controlled by a screw stem lift. The structure is about 20 m long with a maximum height of about 5.0 m.

To determine the increased energy production, the dam and spillway at Thomas Pond were increased by 1.0 m. Increasing the height of these structures will increase the amount of storage in the system and reduce the amount of spilled water at Thomas Pond.

The total estimated cost for increasing the height of the structures at Thomas Pond by 1.0 m is $970,000.The incremental increase in energy output related to implementing these upgrades is estimated to be 0.3 GWh/yr.

The feasibility analysis results indicate that this project is not economical at this time.

3.6.2 Divert Cochrane Pond into Topsail System

The Cochrane Pond watershed was diverted from Manuals River (now the Topsail system) as part of the Petty Harbour hydroelectric development in 1917. Subsequent to this diversion, the Topsail development was constructed. As the Topsail unit operated under a greater net head than the Petty Harbour units, a simulation considering the re-routing of Cochrane Pond flows to Topsail was modelled for both systems. The resulting incremental increase in annual production at Topsail was 1.4 GWh. The reduction in annual generation at Petty Harbour was also 1.4 GWh indicating there would be no benefit to re-routing the flow from Petty Harbour to Topsail. As a result a cost estimate and feasibility analysis for this change was not completed.

3.7 Petty Harbour Development

The Petty Harbour development is located on the east coast of the Avalon Peninsula. The plant was placed into service in 1900 and has three generating units with a combined capacity of 5.3 MW under a net head of 57.9 m. The normal annual production at Petty Harbour is approximately 16.0 GWh or 3.8% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Petty Harbour plant is approximately 136 km^2.

Storage is provided by structures at Bay Bulls Big Pond, Cochrane Pond and Petty Harbour Forebay.

Bay Bulls Big Pond is the largest reservoir and is also used as a municipal water supply for the Regional Water System, serving the City of St. John’s, the City of Mount Pearl, the Town of Conception Bay South, and the Town of Paradise. Spill and controlled released from Bay Bulls Big Pond are discharged into Raymond Brook, which in turn flows into the forebay. Controlled released from Cochrane Pond are discharged into Cochrane Pond Brook, which also flows into the forebay. Spill at Cochrane Pond is discharged into Paddy’s Pond, part of the adjacent Topsail development. Spill from the forebay is discharged around the plant and out of the system.

To increase energy production within the Petty Harbour system the following potential projects were assessed:

- Increase Spill Elevation at the Forebay; and
- Rehabilitate Unit No.1.

3.6.1 Increase Spill Elevation at the Forebay

Structures at Petty Harbour Forebay include the forebay dam, spillway and intake. The forebay dam is a concrete gravity structure with an approximate length of 75 m and height of 9 m . The overflow spillway is approximately 40 m in length and is incorporated into the dam. The intake is also part of the dam and includes steel trashracks, gate, screw stem lift, control equipment, and a wooden gatehouse.

To determine the increased energy production, the dam and spillway at Petty Harbour Forebay were increased by 1.0 m. Increasing the height of these structures would allow for some additional storage at the forebay during heavy flows. The incremental increase in energy output related to implementing these upgrades is estimated to be 0.5 GWh.

However since these structures are located in the community of Petty Harbour, and are adjacent to the road, it was determined that implementing these upgrades would not be practical as the road and bridge elevations in the area would have to be increased as well.

3.7.2 Rehabilitate Unit No. 1

Generating Unit 2 and 3 at Petty Harbour are relatively efficient and equipped with modern control equipment. Head losses have been improved by the replacement of the lower section of Petty Harbour penstock. Unit 1 is the oldest and least efficient of the three units. To investigate the option of rehabilitating the unit, two changes were implemented to the base model for Petty Harbour plant. It was assumed that the estimated unit efficiency was increased by 20%, which would make it comparable to the estimated efficiencies of Unit 2 and 3, and the unit dispatch order was also revised so that all units would be loaded to best efficiency before any were loaded to maximum.

The total estimated cost for rehabilitating Unit No. 1 at Petty Harbour is $575,000. The incremental increase in energy output related to implementing these upgrades is estimated to be 0.4 GWh/yr.

The estimated levelized cost of implementing these upgrades at Petty Harbour is 11.302 cents per kWh.

3.8 Seal Cove Development

The Seal Cove development is located on the southern coast of Conception Bay near the community of Seal Cove. The plant was placed into service in 1924 and has two generating units with a capacity of 1.1 MW and 2.4 MW under a net head of 55.5 m. The normal annual production at Seal Cove is approximately 8.5 GWh or 2.0% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Seal Cove plant is approximately 78 km^2.

Storage is provided by structures at Fenelons Pond, Soldiers Pond and White Hills Pond Forebay. The two main reservoirs in the Seal Cove system are Fenelons Pond and Soldiers Pond. Spill flow and flow released through the gated outlet at Fenelons Pond travels to Big Otter Pond and then to Gull Pond East. Spilled water at Soldiers Pond flows out of the system while the flow released through the gated outlet travels to Round Pond and then to Gull Pond East. The flows at Big Otter Pond, Round Pond and Gull Pond East are not controlled. The combined flows from Fenelons Pond, Soldiers Pond and local inflows to Big Otter Pond, Round Pond and Gull Pond East discharge into White Hill Pond Forebay. Flow into White Hill Pond Forebay is stored, spilled out of the system or used for generation.

To increase energy production within the Seal Cove system the following potential projects were assessed:

- G1 Runner Replacement;
- New Development at Gull Pond; and
- Reinstatement of Gull Pond Dam and Spillway.

3.8.1 G1 Runner Replacement at Seal Cove

The G1 runner at Seal Cove is 44 years old. Since commissioning of the unit in 1924, this runner was replaced in 1964. Previous studies performed by American Hydro and GE Hydro, suggest that a replacement runner will result in a peak capacity of 1,300 kW, with a peak efficiency of 91% at 1,200 kW. The resulting increase in energy production due to the runner replacement is estimated to be 0.30 GWh/yr.

The total estimated cost to replace the runner on Seal Cove G1 is $508,000

The estimated levelized cost of the replacement of Seal Cove runner is 3.631 cents per kWh.

3.8.2 New Development at Gull Pond East Plant

Based on data collected from 1:50 000 maps it was determined that there is a 41.4 m elevation difference between Gull Pond East and White Hills Pond (Seal Cove Forebay) that could be utilized to develop a small hydroelectric plant within the existing water shed area of Seal Cove development.

Figure 4 shows a conceptual layout for Gull Pond East development.

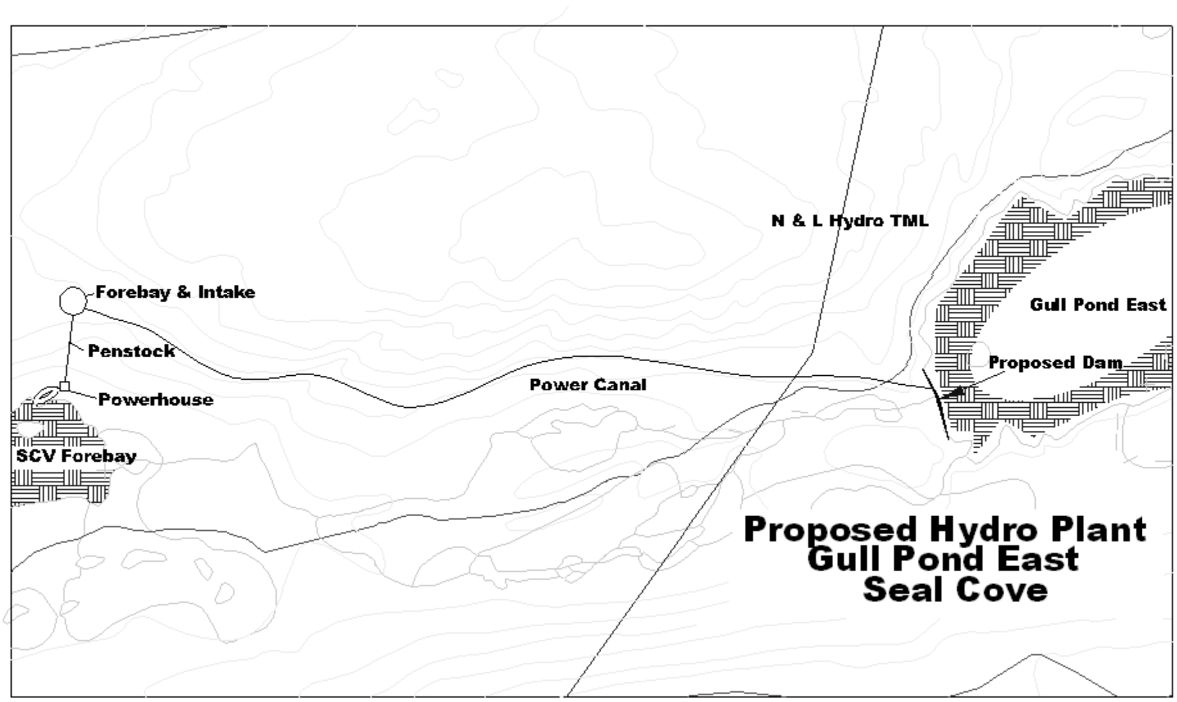

Figure 4 – Conceptual Layout for Proposed Plant at Gull Pond East

The Gull Pond East Hydroelectric Plant would be located just upstream of Seal Cove Forebay with one generating unit with a capacity of 1,250 kW and a gross head of 41.4 m. It is estimated that the average annual output of the plant would be 8.0 GWh/yr.

Gull Pond East Plant would involve the reinstatement of a 130 m long, 4.0 m high storage pond on East Gull Pond. This dam originally formed part of the Seal Cove development and was decommissioned in the 1980's.

The powerhouse would consist of a reinforced concrete foundation with a pre-engineered steel building, housing a turbine, generator, governor and controls. The building would contain an overhead crane for installation and maintenance purposes as well as space for disassembling and working on the unit.

Outflow from the plant would be directed into a spawning canal similar in construction to the Morris Development arrangement to compensate for reduced spawning habitat in the natural river.

Electricity would be transmitted through a 66 kV substation and a 2.5 km transmission line, which would tie in to transmission line 52L at a location immediately downstream of Seal Cove forebay.

An abandoned access road would be re-constructed together with two river crossings to provide access to the plant and Gull Pond East Dam.

The total estimated cost for the plant is $ 12,533,000.

The estimated levelized cost of construction of this plant is 12.957 cents per kWh.

3.8.3 Reinstatement of Gull Pond Dam and Spillway

Gull Pond dam, spillway and outlet were decommissioned in the 1980's. To determine the effect that additional storage would have on the system it was assumed that the dam, spillway and outlet structures were reinstated. Reservoir and discharge characteristics were based on the previous structures that were at Gull Pond east. The resulting incremental increase in generation to the system was 0.40 GWh/yr. The total estimated cost for the construction of a new dam, spillway and outlet structure at Gull Pond dam is $1,112,000.

The results of the feasibility analysis show that reconstructing Gull Pond dam spillway and outlet is not economical at this time.

3.9 Rattling Brook Development

The Rattling Brook development is located in central Newfoundland near the community of Norris Arm South. The plant was placed into service in 1958 and has two generating units, both with a capacity of 7.5 MW under a net head of 87.8 m. The normal annual production at Rattling Brook is approximately 76.2 GWh or 17.9% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Rattling Brook plant is approximately 383 km^2.

Storage is provided by structures at Frozen Ocean Lake, Rattling/Amy's Lake and the Forebay.

On the west side of the basin, a series of small lakes along Rattling Brook, including Frozen Ocean Lake, Gull Lake and Beaton's Lake, flow into Rattling Lake. To the east, a second series of ponds including Dowd Pond, Lewis Pond, and Upper and Lower Christmas Ponds also flow into Rattling Lake. The impoundment for the system joined Rattling Lake and Amy's Lake. Rattling/Amy's Lake flows into Rattling Brook Forebay.

Only Frozen Ocean Lake, Rattling/Amy's Lake and Rattling Brook Forebay are controlled. Frozen Ocean Lake spillway discharges within the system while Rattling/Amy's Lake spillway and Rattling Brook forebay spillway discharge out of the system.

To increase energy production within the Rattling Brook system the following potential projects were assessed:

- Reinstatement of Little Christmas Lake Structures; and
- Installation of a Micro Hydro Plant at Amy's Lake Dam.

3.9.1 Reinstatement of Little Christmas Lake Structures

Little Christmas Lake dam, spillway and outlet were decommissioned in the 1980's. To determine the effect that additional storage would have on Rattling Brook system it was assumed that the dam, spillway and outlet structure were reinstated. It was determined that reinstating Little Christmas Lake structures would not reduce spill at Rattling Lake/Amy's Lake and therefore would not result in an increase in energy generation for the Rattling Brook system.

3.9.2 Micro Hydro Plant at Amy's Lake Dam

A feasibility review of installing a new hydroelectric facility at Amy's Lake dam was assessed in 1983 by Newfoundland Power. The assessment completed by Newfoundland Power included a conceptual design of the layout, an estimate of the average annual output and a detailed cost estimate for the construction of the new micro hydroelectric plant. This report was reviewed, capital costs were updated and an economic analysis was completed to determine if the construction of the new micro hydro plant is feasible.

The Micro Hydro Plant at Amy's Lake would be located at the downstream side of Amy's dam with two generating units with a capacity of 800 kW. It was estimated that the average annual output would be 3.31 GWh/yr.

Amy's Lake Micro Hydro plant would include a 2.5 m diameter penstock that would be installed through the top section of the dam. The penstock would be bifurcated into two 1.5 m diameter penstocks on the downstream side of the dam to feed the two units.

Siphoning equipment would start the water flowing to the plant. To stop the machine, a valve would be released allowing the penstock to dewater. The canal on the downstream side of the dam would act as the tail race for the plant.

The powerhouse would consist of a reinforced concrete foundation with a pre-engineered steel building, housing a turbine, generator and controls. Electricity would be transmitted through the existing 3 phase forebay line to Rattling Brook plant substation.

The total estimated cost for the plant is $ 4,000,000. The energy output of the plant is expected to be 3.31 GWh/yr.

The estimated levelized cost of construction of Micro Hydro Plant at Amy's lake dam is 10.26 cents per kWh.

3.10 Lockston Development

The Lockston development is located on the Trinity Bay side of the Bonavista Peninsula near the community of Port Rexton. The plant was placed into service in 1956 and has two generating units, each with a capacity of 1.5 MW under a net head of 82.2m. The normal annual production at Lockston is approximately 8.4 GWh or 2.0% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Lockston plant is approximately 46 km^2.

Storage is provided by a structure at Trinity Pond with Rattling Pond Forebay acting as the headpond for the plant. Water is released from Trinity Pond to Rattling Pond using the control structure located at the outlet of Trinity Pond. Controlled releases and spill from Trinity Pond enter Rattling Pond Forebay, and are stored, spilled out of the system or used for generation.

To increase energy production within the Lockston system the following potential projects were assessed:

- New Development on Trinity Pond; and
- Runner Replacement.

3.10.1 New Development at Trinity Pond

A pre-feasibility review of installing a new hydroelectric power facility just upstream of Lockston development was assessed in October 1982 by Newfoundland Power. The assessment included a conceptual design related to the layout of the new hydroelectric development, estimates related to the average annual output and detailed cost estimates for the construction of the new plant. Capital costs were updated and an economic analysis was completed.

The Trinity Pond Hydroelectric Plant would be located at the upstream end of the Rattling Pond, the forebay for Lockston Plant. The new plant would contain one generating unit with a capacity of 670 kW and gross head of 25.8 m. It was estimated that the average annual output of the plant would be 2.6 GWh/yr. Trinity Pond would be the forebay for the new plant. The drainage area of the new development would be approximately 44 km^2.

The new development would consist of a small concrete dam downstream of the existing dam, a 430 m long penstock, and a powerhouse on the shores of Rattling Pond. Trinity Pond will form the forebay of the new plant. A new intake structure will be required and will be constructed approximately 90 m downstream of the existing concrete outlet structure on Trinity Pond. No canals will be constructed. A 430 m long penstock will run from the intake to the powerhouse on the shores of Rattling Pond. The penstock will run in the riverbed to avoid large excavations because of the high river banks. Since no spillway is located on Trinity Pond, to provide flow to Lockston Plant Forebay when the Trinity Pond plant is down, the penstock will be bifurcated. A valve would allow flow through the penstock to Rattling Pond.

The total estimated cost for constructing the new plant is $6,928,000. The estimated levelized cost of constructing the new plant is 22.84 cents per kWh.

3.10.2 G2 Runner Replacement at Lockston

The G2 runner at Lockston is 46 years old. The G1 runner was replaced in 1989 and is 19 years old. Efficiency testing was completed on both units in 2003 by Hatch. Efficiency testing conducted on the units indicated that the turbine efficiency of G2 was significantly less than G1. Best efficiency was estimated to be 80 % for G2 and 89 % for G1. A new runner design for G2 is estimated to increase the best efficiency value to approximately 91 %. The resulting increase in energy production due to the runner replacement is estimated to be 0.46 GWh/yr.

The total estimated cost to replace the G2 runner at Lockston is $525,000.

The estimated levelized cost of the replacement of the Lockston G2 runner is 2.752 cents per kWh.

3.11 Hearts Content Development

The Hearts Content development is located on the Avalon Peninsula near the community of Hearts Content. The plant was placed into service in 1918 and has one generating unit with a capacity of 2.7 MW under a net head of 46.9 m. The normal annual production at Hearts Content is approximately 8.3 GWh or 2.0% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Hearts Content plant is approximately 89 km^2.

Storage is provided by structures at Packs Pond, Long Pond and Hearts Content Forebay. Water is released from Packs Pond to Long Pond through a diversion canal located at its outlet. Water entering Long Pond is stored, spilled out of the system or released downstream to Hearts Content Forebay. Water from upstream reservoirs entering the forebay is used to satisfy the water supply demand from the community of Hearts Content, or is stored, spilled out of the system or used for generation.

To increase energy production within the Hearts Content system the following potential projects were assessed:

- Increase Storage at Gull Pond; and
- New Hydroelectric Plant at Gull Pond

3.11.1 Increase Storage at Gull Pond

Structures on Gull Pond include the main dam, spillway and outlet. The dam is a rockfill dam with timber crib construction. The main section is approximately 121m long and 4.7 m high. The spillway is 16m long with a 1.8 m wide x 5.5 m high gate section.

To determine the increased energy production, the dam and spillway at Gull Pond were increased by 1.0 m. Increasing the height of these structures will increase the amount of storage in the system and reduce the amount of spilled water at Gull Pond.

The total estimated cost for increasing the height of the structures at Gull Pond by 1.0 m is $800,000. The incremental increase in energy output related to implementing these upgrades is estimated to be 0.47 GWh/yr.

The estimated levelized cost of raising the structures at Gull Pond is 13.374 cents per kWh.

3.11.2 Hearts Content Gull Pond Plant

Based on data collected from 1:50 000 maps it was determined that there is approximately 91.5 m of elevation difference between Gull Pond and Hearts Content Forebay that could be utilized to develop a small hydroelectric plant within the existing water shed area of the Hearts Content development.

Figure 5 shows a conceptual layout for the proposed plant at Gull Pond.

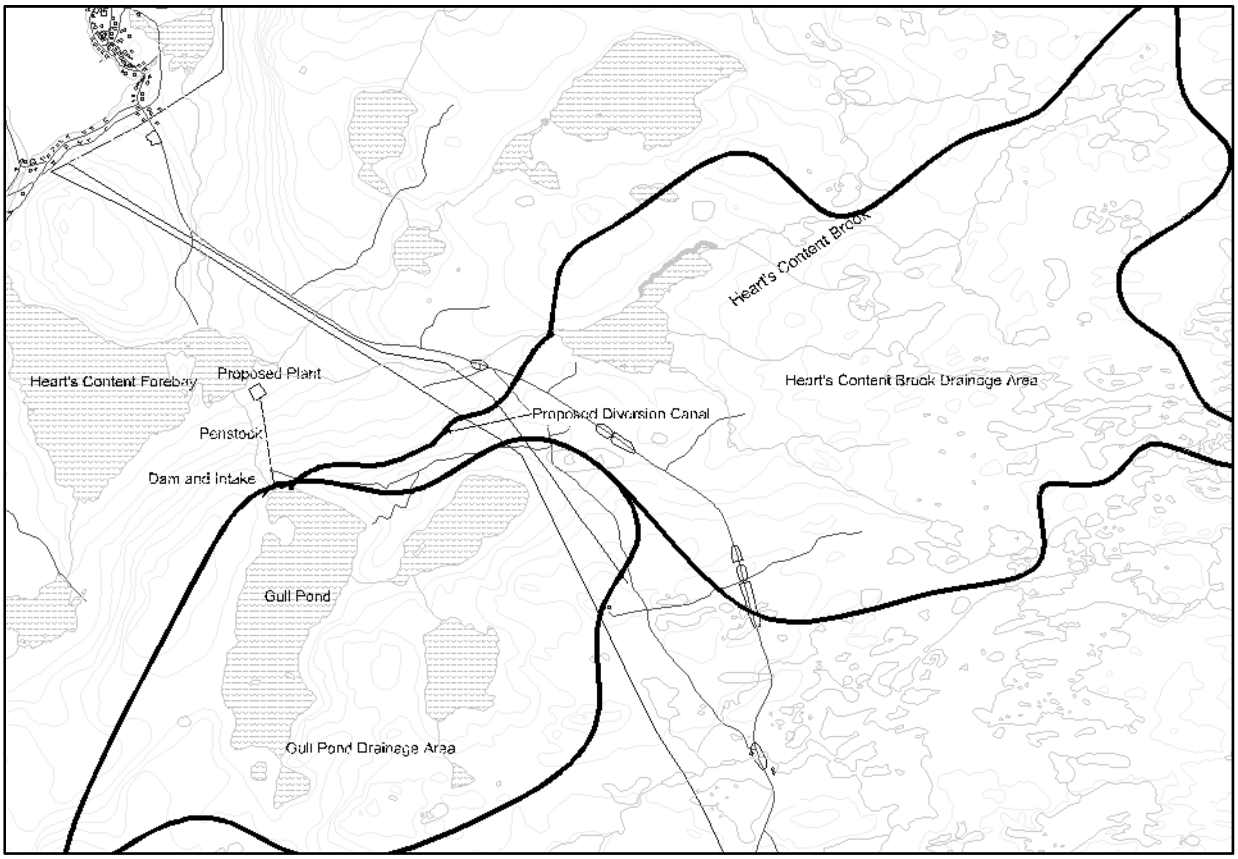

Figure 5 – Conceptual Layout of Proposed Plant at Gull Pond

Gull Pond sub basin is only 12 km^2 therefore the amount of generation is limited. However the drainage area could be increased to 32 km^2 with the expansion of the upper reaches of Hearts Content Brook into the Gull Pond basin. Two options were assessed for this:

- Option 1: Gull Pond Plant (without diversion)
- Option 2: Gull Pond Plant (with diversion)

Option 1: Gull Pond Plant (without diversion)

Gull Pond Plant would be located on the southeast shore of Southern Cove Pond (Hearts Content Forebay). The plant would contain one 450 kW generating unit with a gross head of 91.5 m. It is estimated that the average annual output would be 3.0 GWh/yr.

Gull Pond Plant would include an earthfill forebay dam with a concrete spillway and intake structure. These structures would be located at Gull Pond. A 900 m long, 0.914 m diameter penstock would convey water from the forebay to the new powerhouse.

The powerhouse would consist of a reinforced concrete foundation with a pre-engineered steel building, housing a Francis turbine, generator, governor and controls. The building would contain an overhead crane for installation and maintenance purposes as well as space for disassembling and working on the unit.

Outflow from the plant would be directed into a spawning canal similar in construction to the Morris Development arrangement to compensate for reduced spawning habitat in the natural river.

Electricity would be transmitted through a 66 kV substation and a 1.0 kilometre transmission line, which would tie in to transmission line 41L adjacent to the highway.

Access to the site would require the construction of a two kilometre access road.

The total estimated cost for to construct a new plant at Gull Pond (without the diversion) is $ 6,541,500. The estimated levelized cost to construct this new plant with this arrangement is 19.302 cents per kWh.

Option 2 – Gull Pond Plant (with diversion)

Gull Pond Plant would still be located on the southern shore or Southern Cove Pond. The plant would contain one generating unit with a generating capacity of 1,150 kW. The estimated average annual output of this option would be 7.5 GWh/yr.

This option would still require the same infrastructure as described in Option1 – Gull Pond Plant (without diversion). Additional infrastructure required would include a diversion dam and a 3 km long canal.

The total estimated cost for Option 2 – Gull Pond Plant (with diversion) is $11,995,000. The estimated levelized cost to construct this new plant is 13.41 cents per kWh.

It should be noted that the entire Hearts Content reservoir is a Protected Public Water Supply which may restrict or prohibit any development at this location. Further investigation into the environmental requirements would be required before proceeding with this project.

3.12 New Chelsea/Pittman's Pond Development

Newfoundland Power's New Chelsea/Pittman's development is composed of two generating plants, New Chelsea and Pittman's Pond. Both systems are located on the east side of Trinity Bay, near the community of New Chelsea.

New Chelsea is located upstream of Seal Cove Pond. The plant was placed into service in 1956 and has one generating unit with a capacity of 3.7 MW under a net head of 83.8 m. The normal annual production at New Chelsea is approximately 15.40 GWh or 3.6% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to New Chelsea plant is approximately 8 km^2.

Pittman's Pond hydroelectric generating plant was placed into service in 1959 and has one generating unit with a capacity of 0.6 MW under a net head of 21.3 m. The normal annual production at Pittman's Pond is approximately 2.9 GWh or 0.7% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Pittman's Pond plant is approximately 66 km^2.

Pittman's Pond is the forebay of Pittman's development and Seal Cove Pond is the forebay for New Chelsea development. Each reservoir contains a dam, spillway and outlet. Spill from Pittman's Pond flows into Seal Cove Pond while spill from Seal Cove Pond flows out of the system.

To increase energy production within the New Chelsea/Pittman's Pond system the following potential projects were assessed:

- Runner Replacement at New Chelsea;
- Runner Replacement at Pittman's; and
- Increase height of Pitman's Pond dam.

3.12.1 Runner Replacement at New Chelsea

The runner at New Chelsea is 52 years old. Efficiency testing was completed on this unit in 1997 by Hatch as part of the Water Management Study. Efficiency testing indicated that the turbine efficiency was acceptable considering the age of the unit. Best efficiency was estimated to be just over 83% and efficiency at maximum load was over 82%. A new runner design is estimated to increase these values to approximately 89% and 85% respectively. The resulting increase in energy production due to the runner replacement is estimated to be 1.0 GWh/yr.

The total estimated cost to replace the runner at New Chelsea is $640,000.

The estimated levelized cost of the replacement of New Chelsea runner is 5.032 cents per kWh.

3.12.2 Runner Replacement at Pittman's

The runner at Pittman's is 49 years old. Efficiency testing has not been completed on the unit. However, based on the analysis of SCADA data, the efficiency of this unit is thought to be substantially lower than that of New Chelsea. It is estimated that best efficiency is approximately 71% and the efficiency at maximum load is 66%. A new runner design is estimated to increase these values to 88% and 84% respectively and the estimated incremental increase in energy production is 0.7 GWh/yr.

The total estimated cost to replace the runner at Pittman's is $395,000

The estimated levelized cost of the replacement of New Pittman's runner is 4.436 cents per kWh.

3.12.3 Increase Height of Pittman's Pond Dam

Structures on Pittman's Pond reservoir include the main dam, spillway, intake and dyke. The main dam is an earthfill structure about 300 m long with a maximum height of 11.6 m. It incorporates a concrete spillway at its right abutment that is 44 m long and 1.2 m high. A 2.4 m high concrete wing wall separates the dam and spillway. The intake is a concrete structure incorporated into the center of the dam. It includes a 2.1 m x 1.9 m concrete box culvert through the dam, a 1.5 m X 1.5 m steel gate and handwheel, steel trashracks, upstream removable stoplogs and control equipment. The dyke is an earthfill freeboard structure and is located to the west of the main dam. The dyke is approximately 366 m long with a maximum height of 3.0 m.

To determine the effect on increased energy production, the dam, spillway and dyke at Pittman's Pond were increased by 1.0 m. Increasing the height of these structures will increase the amount of storage in the system and reduce the amount of spilled water at Pittman's Pond.

The total estimated cost for increasing the height of the structures at Pittman's Pond by 1.0 m is $1,272,000. The incremental increase in energy output related to implementing these upgrades is estimated to be 0.2 GWh.

3.13 Rose Blanche Development

The Rose Blanche development is located on the southwest coast of Newfoundland, near the community of Rose Blanche. The plant was placed into service in 1998 and has two generating units, each with a capacity of 3.0 MW under a net head of 114.2m. The normal annual production at Rose Blanche is approximately 20.7 GWh or 4.9% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake to Rose Blanche plant is approximately 53km^2.

Rose Blanche is essentially a run-of-river hydroelectric plant. There is one overflow spillway on Rose Blanche Brook Forebay. The spill re-enters Rose Blanche Brook downstream of the plant.

To increase energy production within the Rose Blanche system the following potential project was assessed:

- Increase Height of Rose Blanche Spillway.

3.13.1 Increase Height of Rose Blanche Spillway

Structures within the Rose Blanche development include the forebay dam, intake and one overflow spillway. The dam is located in a narrow gorge with a maximum height of approximately 30 m and a crest length of 53 m. The intake, located through the left abutment, consists of a reinforced concrete box culvert, steel gate with mechanical lift and a wood frame gatehouse. The spillway is a concrete overflow spillway, located approximately 500 m east of the forebay and is 40 m long.

Since the construction of the development in 1998, average spill at the Rose Blanche development has been estimated at approximately 6.3 GWh annually. A detailed assessment to identify options to reduce spill and increase energy production at Rose Blanche hydroelectric development was carried out by Hatch in September 2003. This report was reviewed and updated by Hatch in May 2008 to reassess the energy benefits and to update the cost estimates for the alternatives to increase energy production.

Increasing the amount of storage in the development will reduce the amount of spilled water and result in increased energy production.

The total estimated cost for increasing the height of the existing spillway is $464,800. The incremental increase in energy output related to raising the spillway is estimated to be 0.9 GWh. The estimated levelized cost of raising the spillway at Rose Blanche is 4.060 cents per kWh.

This project was approved in Newfoundland Power's 2009 Capital Budget Application and will be completed in 2009.

3.14 Mobile/Morris Development

The Mobile/Morris Main Development is comprised of two generating plants, Mobile and Morris. Both systems are located on the east coast of the Avalon Peninsula near the community of Morris.

Mobile was placed into service in 1951 and has one generating unit with a capacity of 12.0 MW with a new head of 114.6 m. The normal annual production at Mobile is approximately 41.8 GWh or 9.8% of the total hydroelectric production of Newfoundland Power. The drainage area above the intake of Mobile is approximately 113 km^2.

Morris was placed into service in 1983 and has one generating unit with a capacity of 1.1 MW with a rated net head of 30.0 m. The normal annual production at Morris is approximately 7.4 GWh or 1.7% of the total hydroelectric production of Newfoundland Power. The drainage area above Morris is approximately 96 km^2.

The upper part of the basin drains into Mobile Big Pond, which is the main storage reservoir for the system. Morris Canal extends 2.5 km from Mobile Big Pond to Morris Forebay. Both the canal and Mobile Big Pond are equipped with overflow spillways, which discharge around the Morris plant into Mobile First Pond. Power flows from the Morris plant are discharges through a fish spawning canal, about 100 m in length, into Mobile First Pond. Mobile Canal extends 2.1 km from Mobile First Pond to Mobile Forebay. Spill from Mobile First Pond is discharged out of the system.

To increase energy production within the Mobile/Morris system the following potential project was assessed:

- Micro Hydro Plant at Mobile Big Pond Dam

3.14.1 Micro Hydro Plant at Mobile Big Pond Dam

A feasibility review of installing a new Micro Hydro Plant at Mobile Big Pond dam was assessed in the 1980's by Newfoundland Power. The assessment included a conceptual design, an estimate of the average annual output and a detailed cost estimate for the construction of the new Micro Hydro Plant. This report was reviewed, capital costs were updated and an economic analysis was completed.

The Micro Hydro Plant at Mobile Big Pond would be located at the downstream side of Mobile Big Pond dam and contain one generation unit with a capacity of 300 kW and an estimated average annual output of 1.07 GWh. Mobile Big Pond Micro Hydro Plant would include a 60 m long, 2 m diameter penstock that would be installed through the top section of the dam.

Siphoning equipment would start the water flowing to the plant. To stop the machine, a valve would be released allowing the penstock to dewater. The canal on the downstream side of the dam would act as the tail race for the plant.

The powerhouse would consist of a reinforced concrete foundation with a pre-engineered steel building, housing a turbine, generator and controls.

The total estimated cost for to construct a Micro Hydro Plant at Mobile Big Pond is $ 3,222,000.

The estimated levelized cost of construction of this plant is 23.673 cents per kWh.

4.0 Conclusion

Attachment A provides a summary of the projects identified in this report. The economic feasibility of the projects will be determined by the cost of energy on the Island interconnected system, and the detailed engineering estimates prepared for projects under consideration.

Prior to implementing any of these projects the following additional engineering work must be completed:

- Confirm that the physical modifications that will be made to existing structures does not compromise dam safety;
- Further investigate environmental requirements related to the construction of new hydroelectric plants in existing water shed areas;
- Confirm the accuracy of the assumed characteristics utilized by Hatch to determine increases in energy related to physical modifications to existing structures;

- Confirm the accuracy of the estimated annual energy output, through hydrology modelling, related to new proposed hydroelectric developments in existing water shed areas; and
- Confirm the accuracy of the estimated increase in efficiency, through efficiency testing, for the runner replacement projects.

In some locations the watershed areas are shared with other stakeholders. The stakeholders would need to be included in any decision to proceed with individual projects. The inclusion of stakeholders, and working with regulatory authorities on some projects, will increase the level of diligence required in planning for the execution of these projects.

Attachment A

Summary of Projects to Increase Energy Production

Proposed Project	Estimated Cost	Levelized Cost (¢ / kWh)	Energy (GWh/yr)	Regulatory Approvals[1]	Consult Stakeholders[2]
Rocky Pond /Tors Cove Development:					
1) Increase Height of Cape Pond and La Manche Canal.	$1,380,000	3.76	2.88	Yes	Yes
2) New Hydroelectric Plant at Yellow Marsh Pond	$6,100,000	12.90	4.00	Yes	No
3) Franks Pond Overflow Spillway	$2,157,000	-	0.19	-	-
Cape Broyle/Horse Chops Development:					
1) Cape Broyle Runner Replacement	$842,000	6.90	0.96	No	No
2) Raise Blackwoods Pond Spillway Elevation	$553,000	2.29	1.90	Yes	Yes
Sandy Lake Development:					
1) Increase Storage at Sandy Lake	$934,000	4.22	1.70	Yes	Yes
2) Reinstate Leonards Lake Dam	$405,000	13.98	0.24	Yes	Yes
3) Reinstate Three Angle Lake Dam	$470,000	13.92	0.30	Yes	Yes
Lookout Brook Development:					
1) Increase Storage at Joe Dennis Pond	$1,388,000	6.82	1.60	Yes	No
2) New Hydroelectric Plant on Lookout Pond	$10,500,000	12.27	7.25	Yes	No
Pierre's Brook Development:					
1) Increase Storage at Big Country Pond	$275,000	7.2	0.30	Yes	Yes
2) Increase Storage at Gull Pond	$887,000	13.94	0.50	Yes	Yes
3) New Hydroelectric Plant on Big Country Pond	$12,283,000	12.96	8.00	Yes	No
Topsail Development:					
1) Increase Storage Thomas Pond	$970,000	-	0.30	Yes	Yes
Petty Harbour Development:					
1) Rehabilitate G1	$575,000	11.30	0.40	No	No
2) Increase Forebay Spill Elevation	-	-	0.50	Yes	Yes
Seal Cove Development:					
1) Runner Replacement	$508,000	3.63	0.30	No	No
2) New Hydroelectric Plant at Gull Pond East	$12,533,000	12.96	8.00	Yes	Yes
3) Reinstate Gull Pond Dam and Spillway	$1,112,000	-	0.40	Yes	No
Rattling Brook Development:					
1) Reinstate Little Christmas Lake Structures	-	-	-	-	-
2) Micro Hydro Plant at Amy's Lake Dam	$4,000,000	10.26	3.31	Yes	No
Lockston Development:					
1) New Hydroelectric Plant on Trinity Pond	$6,928,000	22.84	2.60	Yes	Yes
2) Runner Replacement	$525,000	2.75	0.46	No	No

Proposed Project	Estimated Cost	Levelized Cost (¢ / kWh)	Energy (GWh/yr)	Regulatory Approvals[1]	Consult Stakeholders[2]
Heart's Content Development:					
1) Increase Storage at Gull Pond	$800,000	13.40	0.47	Yes	Yes
2) New Hydroelectric Plant at Gull Pond Option 1	$6,541,000	19.30	3.00	Yes	Yes
3) New Hydroelectric Plant at Gull Pond Option 2	$11,995,000	13.41	7.50	Yes	Yes
New Chelsea/Pittman's Pond Development:					
1) Runner Replacement at New Chelsea	$640,000	5.03	1.00	No	No
2) Runner Replacement at Pittman's	$395,000	4.44	0.70	No	No
3) Increase Height Pittman's Pond Dam	$1,272,000	-	0.20		
Rose Blanche Development:					
1) Increase Height of Rose Blanche Spillway	$464,800	4.06	0.9	Yes	No
Mobile/Morris Development					
1) Micro Hydro Plant at Mobile Big Pond Dam	$3,222,000	23.67	1.07	Yes	Yes

Notes 1 Regulatory approvals include Environmental, Department of Fisheries and any other appropriate government agency

2 Stakeholders could include cabin owners and municipal governments who share water sheds with Newfoundland Power