DALHOUSIE UNIVERSITY
Department of Civil and Resource Engineering

Design of a mini Hydro-plant at Mary's Harbour

ATLANTIC HYDRO
Joshua Takenaka
Ahammed Latif
Rishab Verma
Allan Beaton

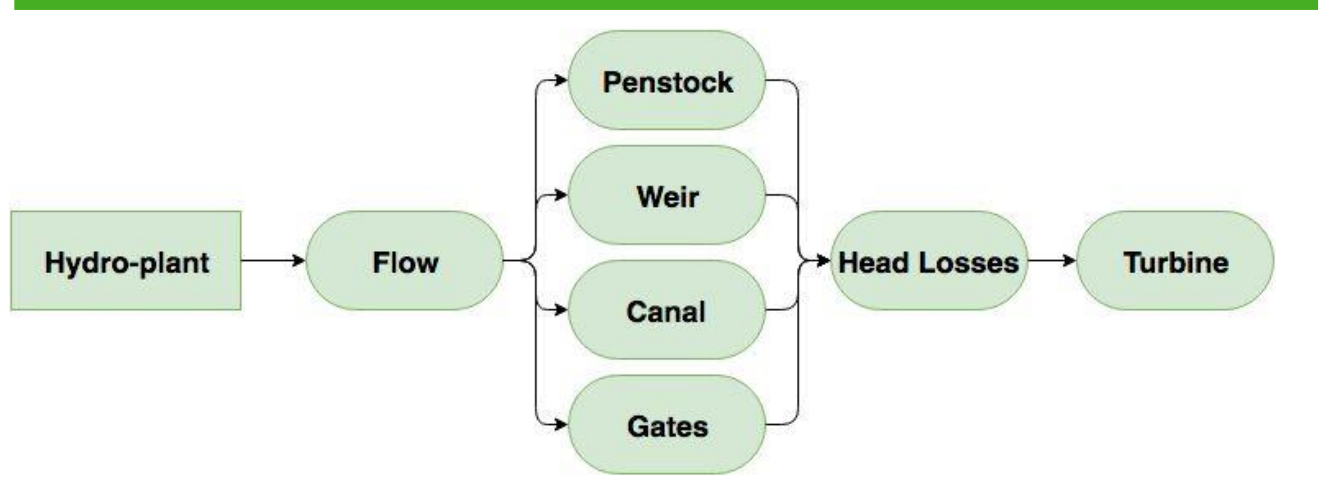
Faculty Professor: Dr. Mysore Satish Client: Dr. Ian Hill

PROJECT SCOPE

Atlantic Hydro was assigned the task of re-designing and replacing a non-operational mini hydro-plant to generate power from the St. Mary's River. The project scope includes designing a weir to increase head at the upstream reservoir and re-designing the canal, penstock and intake structure. Additionally the project requires selection of the most efficient turbine for the system and designing a draft tube safe against cavitation.

Figure 1: Proposed hydro-plant location near Mary's Harbour Airport (YMH) in coastal Labrador.

DESIGN PROCESS



FLOW

The figure below shows the FDC produced for St. Mary's River using a series of equations provided in the report *"Feasibility of Hydraulic Potential of Coastal Labrador"* by HATCH. Several physical parameters were used to produce the FDC which were obtained using ArcGIS and interpolation of physical parameters of similar sized watersheds. A design flow of 9.25 m^3/s was selected and the 1/100 year flood was found to be 127.14 m^3/s

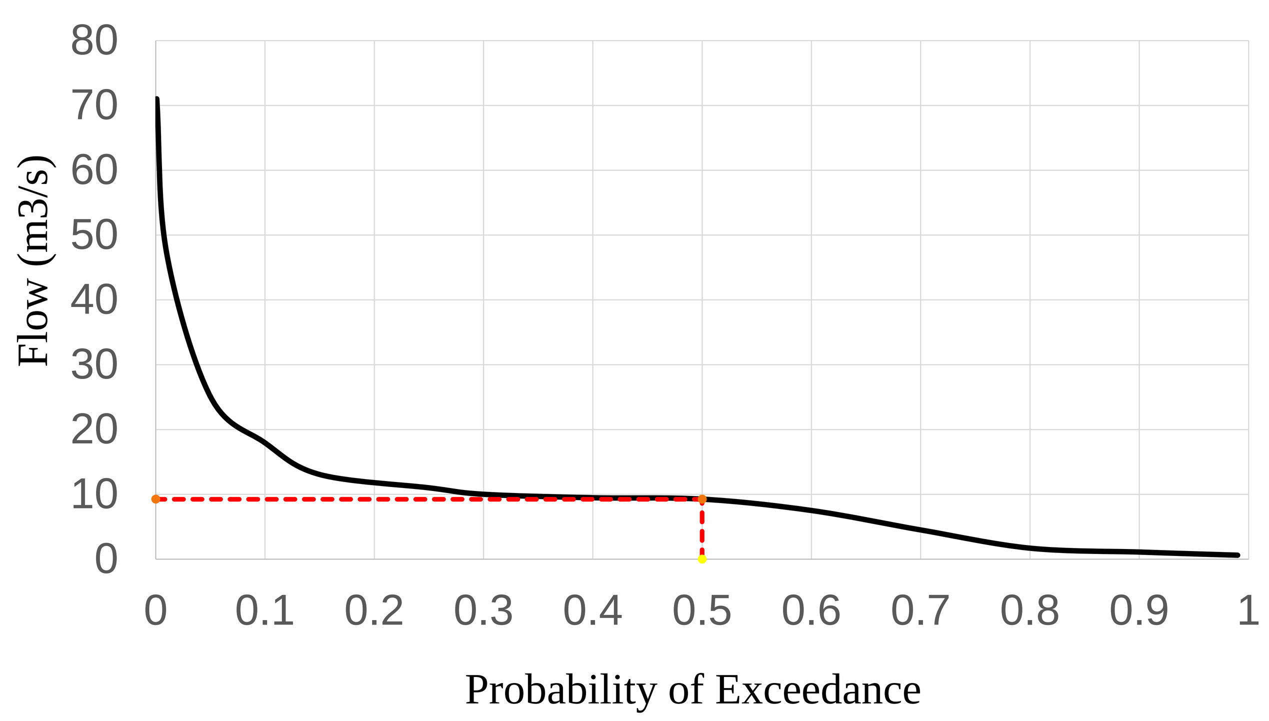


Figure 2: Flow Duration Curve for St. Mary's river

DETAILS OF DESIGN

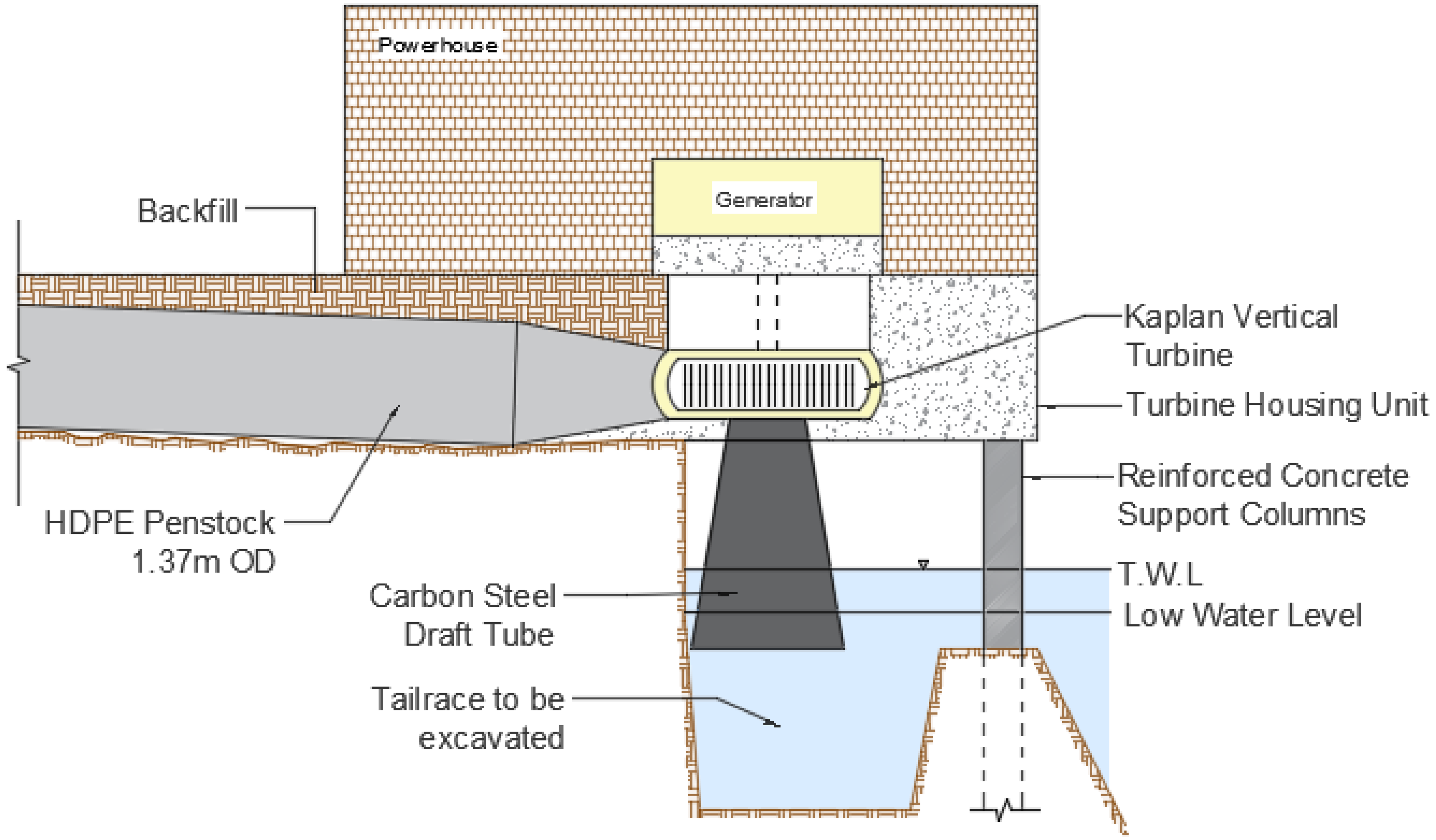


Figure 3: Final design setup for hydro-plant at Mary's Harbour

WEIR

A broad crested weir was selected in the design to increase the available storage in the head pond. The weir increased the upstream head by 0.28m which would provide an additional $30,000/yr in power produced by the turbine. Steel ties will be used to anchor the weir to the bedrock and prevent against sliding failure.

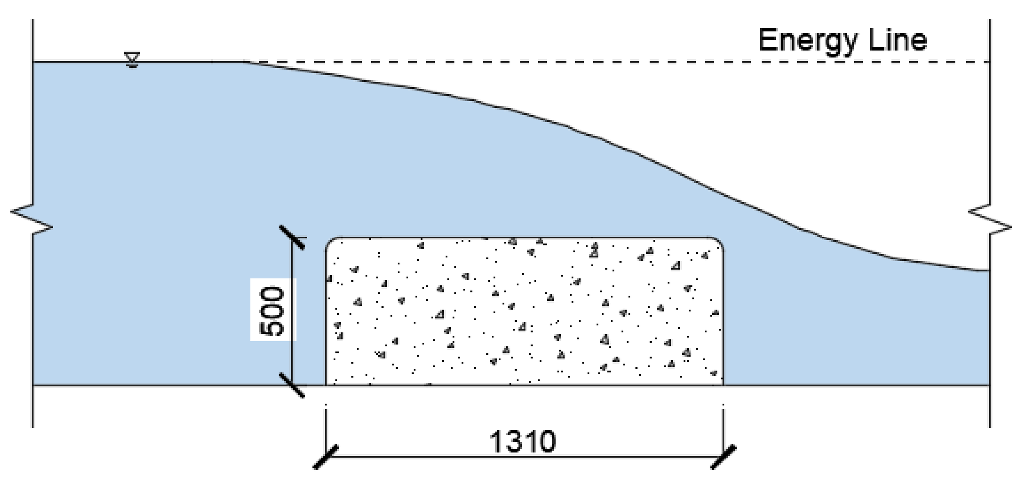


Figure 4: Broad crested weir cross section.

PENSTOCK

The penstock was designed to minimize head loss with consideration to capital costs. The 75 metre penstock is 54" IPS (1.23m) inner diameter and constructed with High Density Polyethylene (HDPE), with a pressure rating of 100 psi.

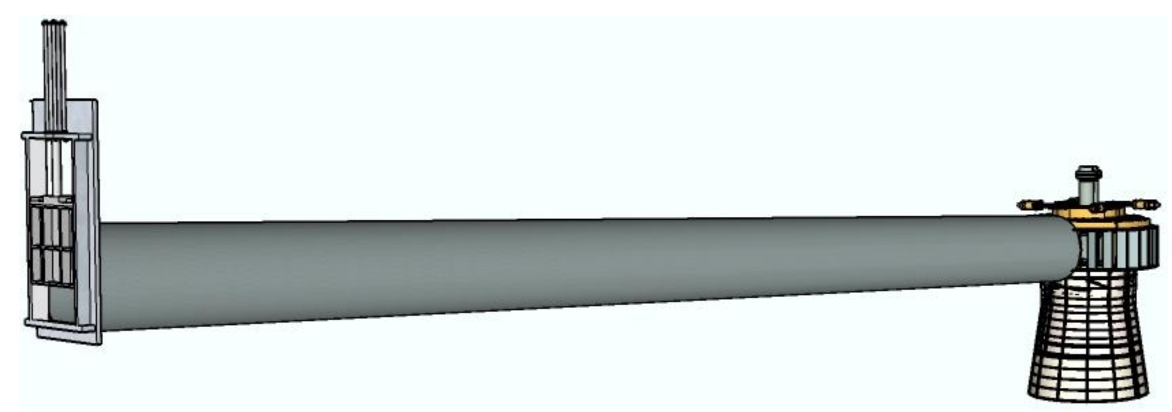


Figure 6: Penstock and intake.

CANAL

The current cross sectional area is not adequate in meeting flow requirements. In order to improve the capacity, the canal will be blasted increasing the minimum cross sectional area to 5 meters.

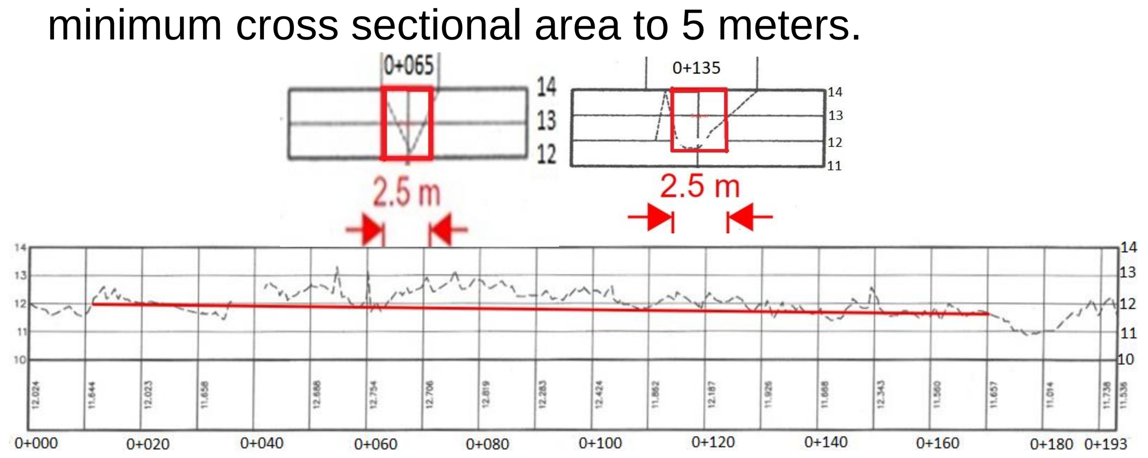


Figure 5: Canal cross section and Alignment.

CANAL GATE

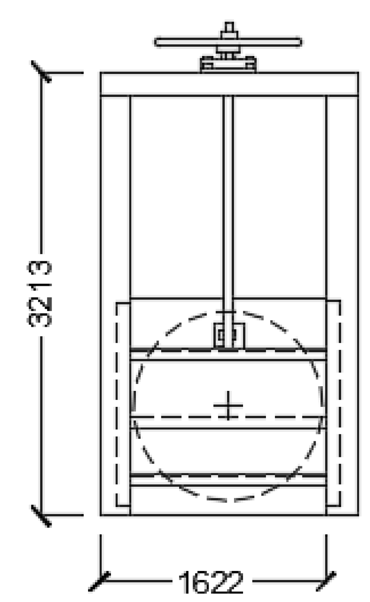


Figure 7: AC-31 Type 6 canal gate.

An AC-31-6 canal gate will be installed at the entrance of the penstock from the canal. The only required function of the gate is to stop the flow of water through the penstock when maintenance is required or when the flow is outside the turbine's capacity. A trash rack will also be installed at the entrance to stop debris in the canal from entering the system.

TURBINE

	Detail
Type	Vertical Kaplan
Specific Speed	450
Efficiency	88% (T+G)
Runner	4 Blade, 0.9 m
Rotative Speed	450 rpm
Scroll Casing	3.0 m
Cavitation	2.75 m *< 3.05 m*
Generator	16 poles, 60Hz
Power	180 kWh
Revenue	$0.5m/year

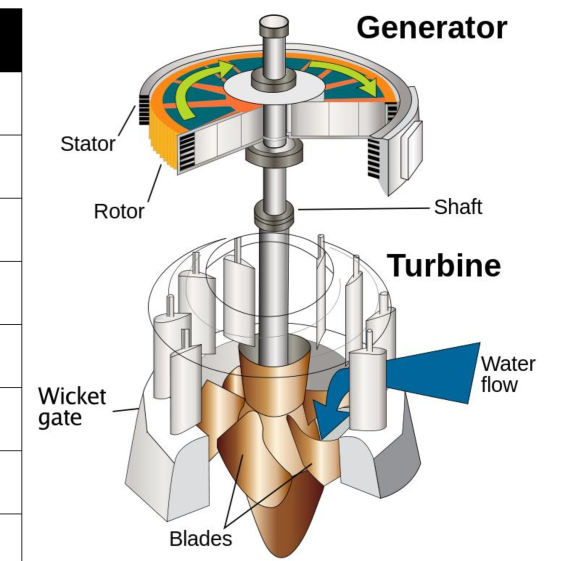


Figure 8: Exploded Turbine View

A Vertical Kaplan System was chosen through the turbine selection process. Water enters the scroll case from the penstock, and is led into the runner through a series of guide vanes. Hydraulic energy is converted to mechanical energy to produce power from the generator.

A vertical draft tube was designed to allow water to exit after it has been used. The entrance and exit diameters were selected to reduce exit velocity, decreasing energy lost.

Draft Tube	Detail
Sizing	1.0m, 2.0m @8° *< 10°*
Length	3.5m
Material	Carbon Steel
% Losses	6.46% *< 10%*
Immersion	0.5m
Head Loss	0.231m (E+V+F)

CONCLUSION & RECOMMENDATIONS

The newly designed hydro-plant will provide 180 kWh of power for commercial and residential purposes to Mary's Harbour. Constraints such as providing adequate flow for the fish passage and to the town have been considered during the design phase. The total project cost, using a Class D Cost Estimate is approximately $2.8 million with a payback period of 6 years.

A few recommendations which would improve the design are:

- Use a stream gauge to obtain accurate and reliable flow data for St. Mary's river.
- Perform geotechnical testing to gather information regarding subsurface conditions.
- Acquire more Kaplan turbine options from manufacturers.
- Look at other viable options for renewable energy in that region such as solar or wind.

REFERENCES

- HATCH. (2013). *Feasibility Study of Hydraulic Potential of Coastal Labrador.*
- Linsley, R. K., & Franzini, J. B. (1972). *Water Resources and Environmental Engineering* (2nd ed.). New York: McGraw-Hill.
- Peschka, M. P. (2016). *Hydroelectric power, a guide for developors and investors.* Stuttgart, Germany: International Finance Corporation.