POINTE DU BOIS GENERATING STATION

SPILLWAY REPLACEMENT PROJECT – NUMERICAL AND PHYSICAL MODELING

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ABSTRACT

The Pointe du Bois Generating Station, which is owned and operated by Manitoba Hydro, is located on the Winnipeg River, 150 km northeast of Winnipeg, Manitoba. The Pointe du Bois Generating Station was constructed between 1909 and 1926, and is the oldest hydroelectric plant operating in Manitoba. Despite extensive repairs and upgrades over the years, the spillway facilities require replacement in order to maintain public and dam safety and provide a safer working environment for staff. Accordingly, Manitoba Hydro decided to undertake the Spillway Replacement Project. With these improvements, the current Canadian Dam Safety Association Dam Safety Guidelines (2007) will be addressed.

The Spillway Replacement Project is comprised of replacing the existing 92 spillway bays and 5 sluiceways with a new 7-bay spillway located to the east of the existing facility. Numerical and physical modeling studies were conducted to evaluate the spillway design, confirm its hydraulic performance, and reduce potential risks during construction and operation of the spillway. A good understanding of the limitations and strengths of each modeling technique was key in selecting which design aspects to evaluate in each model.

Manitoba Hydro retained KGS Group as design consultant to undertake the computational fluid dynamics (CFD) analysis, and Northwest Hydraulic Consultants (NHC) as physical modeling contractor to construct and test the physical model. The CFD model was used to provide a preliminary assessment of the spillway structures, and to provide an assessment of flow conditions over a larger reach of the river throughout the design process. The physical model study was used to confirm the spillway’s hydraulic performance and optimize the arrangement of the spillway’s approach and discharge channels. Physical model demonstrations during the design development process also allowed for collaboration between the project owner, manager, design consultants and construction contractor to achieve a design that balanced a wide range of project objectives such as spillway performance, constructability, costs, timelines, risk management, and environmental considerations.
Throughout the design process, a hybrid modeling approach, which included both CFD and physical modeling, was used to understand the hydraulic design complexities, as well as, maintain the fast track design process that was demanded of the design team. This paper discusses the benefits and challenges of hybrid modeling; compares results from the two modeling methods, and describes the hybrid modeling approach adopted for the Pointe du Bois Spillway Replacement Project.

PROJECT DESCRIPTION

The Pointe du Bois Generating Station currently has a total of 16 horizontal turbines with a combined capacity of 78 MW and operates at a head of 14 m. The existing spillway consists of ninety-two gated spillways and five sluiceways, as shown in Photo 1.

Photo 1 Pointe du Bois Generating Station (photo provided by Manitoba Hydro)

The Pointe du Bois Spillway Replacement Project is comprised of replacing the existing spillways and sluiceways with a new spillway (referred to as the East Spillway) at the east shore and a new earthfill dam constructed downstream of the existing spillway facilities. The existing east and west gravity dams will be maintained and enhanced for dam safety with a new permanent earth fill dam constructed downstream of the east gravity dam and tied into the powerhouse with a new concrete gravity wall.

The overall objectives of the design included providing a spillway that safely passes floods up to the Inflow Design Flood (IDF) discharge of 5040 m³/s; that maintains adequate operation of the powerhouse; and that optimizes the spillway approach and discharge channel excavation in terms of constructability and costs.
HYBRID MODELING APPROACH

A hybrid modeling approach, which included both computational fluid dynamics (CFD) modeling and physical modeling, was used to evaluate and confirm the hydraulic performance of the proposed spillway and to reduce potential risks during its construction and operation. The hybrid modeling approach is used by Manitoba Hydro in hydraulic design work, since each modeling technique has distinct advantages for analysing and comparing design alternatives (Teklemariam et al, 2008; Sydor and Waterman, 2010). For example, evaluation of large areas or extended river reaches is generally quicker and less costly to evaluate using CFD modeling than using a physical model due to its size. In addition, evaluation of major changes such as adjusting structure locations or significant bathymetric alterations may also be less costly and time consuming to evaluate using a CFD model. However, evaluation of localized design refinements and shorter reaches of a river can, in many cases, be much more efficient and less costly using a physical model. Designers may be capable of looking at several alternatives and make observations over a range of flow conditions in a physical model in much less time than required for a single CFD model run.

If extensive data are required from a model, such as a detailed velocity grid at several water depths, then the data may be extracted more readily from a CFD model when compared to collecting and processing the same data in a physical model. Nevertheless, a physical model has the distinct advantage of being more visual, tangible and understandable to most observers, which can be more inclusive of all project stakeholders. Finally, although CFD modeling has become more sophisticated in recent years, a CFD model may still not be capable of accurately simulating some of the more complex flow phenomena, such as intermittent vortex activity or sediment scour and transport. Physical modeling is a widely accepted method for evaluating the design and operation of many types of hydraulic structures, and if the appropriate design criteria are applied to the construction of a physical model, that model can reproduce many traits of a complicated flow process. For that reason, physical models are often used to validate CFD models and confirm the final design developed for a project.

For selection of the most appropriate modeling technique, designers must consider whether the selected method is capable of producing an accurate simulation of the key performance criteria and whether the option will provide a practical, efficient and cost-effective analysis.

DESIGN APPROACH FOR THE POINTE DU BOIS SPILLWAY

The design approach used for the Pointe du Bois Spillway Replacement Project included initially using CFD modeling to evaluate alternative spillway arrangements and configurations, provide preliminary hydraulic assessment of the spillway structures, and establish the initial design of the project. The selected spillway alternative, referred to as the East Spillway (Figure 1) was developed collaboratively with other design aspects and requirements, to provide an arrangement that met the various design objectives as well as preserve an important sturgeon habitat area immediately downstream of the spillway.
Once the initial design was evaluated using CFD, a 1:50 scale physical model was constructed to optimize the design and to understand the complex hydraulics associated with the existing conditions, the various stages of construction, and the final design configuration.

Figure 1 Rendering of the East Spillway Alternative

The design team “fast-tracked” the design process to meet strict construction schedule requirements by using the hybrid modeling approach to effectively develop and optimize the design. The final design arrangement of the approach and discharge channels was based on physical model optimization results, complementary CFD analyses, and constructability considerations.

OBJECTIVES OF INTEGRATED HYBRID MODELING

At the onset of the project, the objectives of the CFD model and physical model were intended to serve different, but complementary objectives.

The CFD model study was carried out to:

- Evaluate a number of alternate general arrangements
- Assess hydraulic performance of the spillways
- Assess and develop a cofferdam construction sequence alternative, including the definition of required erosion protection, to isolate the work area from the turbulent hydraulic conditions on the spillway rapids that result from the operation of the existing spillway and sluiceway
- Assess and develop spillway operating sequence
The physical model study was carried out to:

- Confirm and optimize the temporary construction access
- Confirm and optimize the cofferdam staging and erosion protection requirements
- Evaluate the hydraulic performance of the spillway
- Optimize the approach and discharge channel designs
- Confirm the spillway operations
- Evaluate sediment movement during spillway commissioning

To accommodate the “fast-tracked” design process, the CFD and physical model were applied simultaneously and in a more integrated manner to optimize the arrangement of the spillway’s approach and discharge channels, investigate construction cost saving alternatives, evaluate spillway operation, and confirm rockfill sizing. The integrated hybrid modeling approach took advantage of the strengths of each modeling technique to confirm and supplement the analysis for the mutual objective of developing a general arrangement that would meet the hydraulic design requirements, while at the same time providing Manitoba Hydro confidence that the new arrangement could be constructed on schedule and with reduced project costs. The main design objectives of the integrated model process included:

- **Approach Channel Optimization** to optimize the configuration of the channel to minimize rock excavation without creating unacceptable hydraulic conditions, to ensure that hydraulic control remains at the spillway, and to confirm the configuration and rock sizing for the guide berms, mattress remnant, and Stage 2 cofferdam located at the approach channel entrance.

- **Discharge Channel Optimization** - The objectives of the discharge channel optimization were to enhance the design of the discharge channel by minimizing excavation, while maintaining adequate discharge capacity and acceptable hydraulic conditions downstream of the spillway, both within the discharge channel and across the river at the powerhouse tailrace on the west bank of the river. The discharge channel optimization also included an assessment of the sensitivity of the channel roughness to address initial excavation results observed in the field.

Once the final arrangement was defined through this process, the physical model was used to document and confirm water levels and flow patterns for a range of discharges, confirm the spillway operation sequence, and assess any changes in the hydraulic conditions in the powerhouse tailrace. The physical model was also used in evaluating the potential for sediment and excavation remnants to mobilize in the spillway approach and discharge channels during spillway commissioning, and assess whether the eroded material would be deposited in a sturgeon spawning habitat area located directly downstream of the discharge channel.
DESCRIPTION OF NUMERICAL AND PHYSICAL MODELS

CFD Model
KGS Group developed a CFD model using FLOW-3D software, which solves the equations of motion for fluids to obtain three-dimensional solutions to flow problems. To complete the numerical analyses, FLOW-3D uses a rectangular grid of variably sized cells, termed a computational mesh, to define the flow region. The geometry of the region is defined within the rectangular grid by computing the volumes of each grid cell that is both blocked by a solid object or open to fluid. For each cell, fluid flow parameters such as velocity, pressure, and density are retained and finite-difference approximations to the equations of motion are then used to calculate the spatial distribution of these values. The finite-difference method is designed to solve the CFD governing equations for a fluid flow (i.e. the continuity equation and Navier-Stokes equations).

The computational domain for the Pointe du Bois spillway project extended from approximately 600 m upstream of the existing north spillways (Bays 1 to 65) to approximately 600 m downstream from the existing sluiceways (Figures 2 and 3). The computational mesh size adopted for the model was optimized between computation performance and accuracy of model results during the early model development stage. A mesh size of 4 m by 4 m in the horizontal plane by 1 m in the vertical plane was used for the upstream part of the domain encompassing the forebay, while a mesh size of 2 m by 2 m by 1 m was used for the domain downstream of the spillway. A more detailed mesh was required for some areas of the model to accurately represent the geometry of the new spillway components. For example, the mesh was refined to 1 m by 1 m by 0.5 m at the new spillway and within the excavated approach and discharge channels, using the nested mesh function of FLOW-3D.

![Figure 2 CFD Model Layout](Image)
The upstream boundary condition of the model was defined as either the full supply level (FSL) of the forebay or the IDF level. The downstream boundary condition was based on a tailwater rating curve that was developed by Manitoba Hydro and based on a combination of field measurements, downstream operations, and one dimensional model analyses of the river channel downstream. All of the model simulations were carried out under steady-state conditions.

**Figure 3** Extents of CFD and Physical Models

**Physical Model**
Northwest Hydraulic Consultants (NHC) built and tested an undistorted 1:50 scale physical model that encompassed just over 150 m of the forebay approaching the existing north spillway bays (Bays 1 to 65) and sluiceway bays, and a portion of the inner forebay approaching the existing Curved Spillway (Bays 101 to 114) and the High Spillway (Bays 121 to 133). The model extended approximately 800 m downstream from the existing sluiceways to ensure that flow conditions in the powerhouse tailrace channel and in the vicinity of the sturgeon spawning habitat were adequately simulated. The river bed and banks were simulated as fixed surfaces in the model in accordance with a digital elevation model (DEM) supplied by Manitoba Hydro. Key structures that
were incorporated in the model included the existing spillway and sluiceway facilities, the exit from the powerhouse draft tubes and various components required for construction of the new spillway. The model footprint was approximately 22 m long by 24 m wide (model units). Photo 2 shows the proposed East Spillway (viewed looking downstream) as built in the physical model.

Photo 2 Proposed Spillway in the Pointe du Bois Physical Model

INTEGRATED HYBRID MODEL ASSESSMENT

There were a number of design and modeling components that required complementary model results from both the CFD and physical models. The following sub-sections present some of the fundamental interactions that were required with the integrated CFD and the physical models, and illustrate how each model complemented the other throughout the optimization of the approach and discharge channel configurations.

Approach Channel Optimization

The initial design of the East Side Spillway that was developed with the use of the CFD model consisted of an approach channel arrangement that ranged from 130 m at its entrance to 114 m wide at the spillway. The floor of the approach channel was set horizontal at El. 287.0 m from the spillway to about 150 m upstream, where it stepped up at a slope of 1H:5V to El. 290.0 m, and then extended upstream at that elevation until it merged with the existing channel bathymetry. The ogee crest of the spillway was designed at El. 289.5 m.

The initial design also included a guide berm situated on the upstream west side (right side looking downstream) of the approach channel. This design provided a balance between minimizing the width of the channel and providing acceptable hydraulic
conditions such as smooth flow patterns, a uniform distribution of flow across the channel, and flow control set at the spillway. The initial design was then tested in the physical model to confirm the hydraulic conditions predicted by the CFD model, and to provide a feasible starting point for optimization of the approach channel design.

**Upstream Boundary Condition**

Due to the variable bathymetry within the river channel upstream of the project site, it was critical to obtain the correct flow direction and flow distribution approaching the spillway. Since the CFD model encompassed a larger area of the outer forebay upstream of the spillway than the physical model and no field data was available, the CFD model results were used to define the inflow characteristics for the physical model. A series of calibration tests were carried out to ensure approach flow patterns to the spillway closely matched those provided by the CFD model. The CFD model captured the river channel 600 m upstream of the proposed approach channel, while due to space constraints imposed when the model basin was expanded to accommodate a revised spillway location on the East shore, the physical model headbox was within 100 m (prototype) of the entrance to the approach channel. As a result, the CFD model is expected to provide a better representation of the flow distribution and flow direction approaching the proposed spillway.

![Figure 4](image)

**Figure 4** A photo showing flow entering the spillway approach channel in the physical model (string lines indicate location of velocity transects). Graphs show comparison of velocity magnitude along two transects from both the CFD and physical models.

A comparison of mid-depth velocity data at two transects in the vicinity of the approach channel entrance, as predicted in the CFD model and measured in the physical model, was performed for the IDF surcharge condition. The inflow patterns to the physical model were then adjusted at the model headbox using baffling to ensure approach flow patterns to the spillway closely matched those predicted by the CFD model. For the final configuration of the physical model head box, velocity magnitudes at all points were generally within about ± 10 % (Figure 4) and velocity vectors were within ± 6 degrees of
the CFD model direction. Furthermore, the measured flow rate in the physical model at the IDF surcharged level of El. 299.7 m was 5320 m³/s, which was only 4% lower than that predicted by the CFD model (5540 m³/s).

The integration of the CFD model to accurately define the upstream boundary condition in the physical model was important for confirming the accuracy of the physical model assessments that were subsequently used to optimize the orientation and shape of the approach channel guide berms, since their performance is directly affected by the direction of the approaching flow.

**Design Optimization**

Once the approach flow patterns in the physical model matched those predicted by the CFD model, the physical model was used to confirm the hydraulic performance and optimize the design of the approach channel as developed in the CFD model. This included evaluating narrower channel widths, alternate side wall alignments, and alternate guide berm arrangements. The objective of these tests was to reduce excavation volumes (and hence costs), while minimizing headlosses and maintaining adequate spillway capacity to safely pass the IDF. The design team was able to combine their efforts and expertise during model witness tests during the design optimization phase to investigate several alternatives with consideration for potential risks and potential cost savings. In addition, the team could make observations over a large range of flow conditions in the physical model in much less time than required for a CFD model run, which was imperative for the success of the fast-tracked project schedule.

Through the optimization testing it became apparent that the guide berm on the west side of the approach channel required reshaping to streamline the flow and eliminate flow separation (and hence headlosses) at the entrance to the approach channel. It was also determined that an additional guide berm should be constructed on the upstream east side of the approach channel to eliminate the flow separation (and headlosses) along the east side of the channel. This testing confirmed that it was not feasible to reduce the approach channel width or raise the channel invert elevation. However, changes to the shape and size of the west guide berm and the inclusion of an east guide berm resulted in a more evenly distributed flow across the approach channel and reduced the associated headlosses through the channel.

**Confirmation of Intake Channel Control Section**

Detailed velocity data at multiple water depths within the approach were used by the designers to confirm that the Froude number within the channel remained low enough to ensure that the channel hydraulics would be stable and that control would remain at the spillway structure. The governing criteria for acceptance of the optimized configuration of the approach channel was to limit the Froude number in the approach channel to less than 0.5, on average, across the channel. Local areas that exceeded 0.5, but were less than 0.6 were accepted.
Detailed velocity data was more readily extracted from the CFD model than from the physical model, since the effort to record the large quantity of data from the physical model would have been impractical. The information from the CFD model allowed for continuous mapping of the data and estimation of Froude numbers over the entire approach channel, and measured data recorded at key points in the physical model were used to confirm the results from the CFD simulation. This integrated physical model and CFD model approach provided confidence in the estimated Froude numbers, as shown in Figure 5, which confirmed that the criterion was met for the final recommended configuration of the approach channel.

![Figure 5 Froude Number within Approach Channel estimated with both CFD and Physical Models](image)

**Discharge Channel Optimization**

To meet the design requirements and the site constraints at Pointe du Bois, the configuration of the discharge channel for the proposed East Side Spillway was configured to have a notable curvature to the West and a zero gradient (i.e. horizontal
invert). The initial design of the discharge channel was developed with the use of CFD modeling and consisted of a channel width that ranged from 114 m at the spillway to 200 m at its downstream end, and an invert elevation of El. 286.0 m (spillway crest at El. 289.5 m). The CFD modeling was used to provide an initial design that would minimize the risk of a hydraulic jump developing at the base of the spillway structure, and then the physical model was used to efficiently optimize the configuration to minimize rock excavation costs, while confirming acceptable operation and spillway capacity.

**Complex Hydraulic Phenomenon**

One of the reasons that confirmation of the Pointe du Bois discharge channel design was required in the physical model was that the selected discharge channel arrangement was susceptible to super-elevation of the water surface and the formation of cross waves downstream of the spillway due to the significant curvature of the channel. The magnitude and proximity of the cross waves can be sensitive to the effective flow width and channel roughness. If the channel is too narrow or too rough, there is risk of a standing wave forming near the spillway apron, which could result in reduced discharge capacity and/or damage to the spillway gates. The CFD model, alone, was not well suited to representing the cross wave patterns that would form in the discharge channel, nor was it well suited to rapidly testing the sensitivity of the wave patterns to the channel width. The physical model was considered better at handling transitional flows and wave activity, and provided the opportunity to efficiently test and visualize design modifications (Photo 4).

**Design Optimization**

The design team was able to investigate several alternatives for the width and curvature of the discharge channel, and make observations over a large range of flow conditions in the physical model.

Ongoing collaboration and coordination with Manitoba Hydro, the design consultants (KGS Group) and the physical modeling project team (NHC) continued throughout the design optimization phase to ensure that the designs being evaluated in the model were practical, economical and accurate. This collaboration included several full-day working model demonstrations / witness tests at NHC’s laboratory to resolve concerns, determine limitations, and compare alternatives. For each of these working model demonstrations, the results of the physical model were interpreted along with model results from CFD model simulations that were prepared in the days prior to the meetings. The combination of the detailed results from the CFD model and the rapid assessment and visualization of the physical model proved to be invaluable to the design team to quickly design and optimize the project and to provide Manitoba Hydro with the confidence that the new arrangement could be constructed on schedule and with reduced project costs.
The performance criteria used in the physical model included: ensuring that the spillway capacity was not reduced, that the standing wave which formed downstream of the spillway remained at least 50 m downstream of the spillway apron, and that no pronounced or unstable cross-wave activity or water levels that exceed the channel walls were created. In addition, designs were evaluated to ensure that there were no shockwaves or high velocities at the west bank and powerhouse downstream of the discharge channel. The requirement to ensure the standing wave remained at least 50 m downstream of the spillway apron was developed by the project team and deemed to be a conservative distance downstream from the spillway to account for unknowns in discharge channel roughness that may result from excavation in the field.

Testing showed that there was significant potential for a reduction in the width of the discharge channel without adversely impacting the spillway capacity, increasing wave activity in the vicinity of the spillway, or creating water levels that exceed the channel walls. After several iterations involving adjustments to the channel width and curvature, an optimal discharge channel configuration was determined. The inside (west side) bend of the discharge channel was reshaped to eliminate an ineffective flow area and reduce excavation volumes, and the east side of the channel was realigned to further reduce excavation quantities. These revisions provided a substantial reduction in the overburden and rock excavation for the project. The optimization of the discharge channel eliminated approximately 150,000 cubic metres of excavation (a total excavation reduction of 20%). The use of the integrated CFD and physical models allowed the project team to expediently optimize the discharge channel design and
confirm its performance met the required hydraulic criteria over a range of spillway discharges.

**Figure 6** Rendering of Final Spillway Arrangement.

**SUMMARY AND CONCLUSIONS**

The design team was able to successfully “fast-track” the design process by using a hybrid modeling approach to develop and optimize the design to meet the needs of Manitoba Hydro’s spillway replacement project. The integrated use of both CFD and physical models was applied to optimize the arrangement of the spillway’s approach and discharge channels, investigate construction cost saving alternatives, and evaluate spillway operation.

The CFD model was used to develop the initial designs for the spillway approach and discharge channels. Since the CFD model encompassed a larger area of the outer forebay upstream of the spillway than the physical model and no field data was available, the CFD model results were also used to define the inflow characteristics for the physical model.

The simultaneous use of the CFD and physical models allowed the project team to expediently optimize the design and confirm the final approach channel configuration. The physical model allowed for the rapid optimization of the shape and configuration of
the guide berms, while the CFD model allowed for the confirmation of Froude numbers within the entire channel.

Although CFD modeling has become more sophisticated, a CFD model may still not be capable of accurately simulating some of the more complex flow systems and geometries such as wave patterns in a channel with transitional flow and a significant bend. As a result, the physical model was used to validate CFD model results for the spillway replacement project and confirm the final design developed for the project. In turn, CFD modeling was used to help interpret and complement results taken from the physical model.

The design team was able to combine their efforts and expertise during physical model witness tests throughout the design optimization phase. The physical model provided the opportunity to efficiently test and visualize design modifications over a range of flow conditions. This allowed efficient investigation of several alternatives with consideration for potential risks and potential cost savings. In addition, the team could make observations over a large range of flow conditions in the physical model in much less time than required for a CFD model run, which was imperative for the success of the fast-tracked project schedule. The CFD model was applied to develop a better understanding of the impacts of practical limitations of the physical model such as model scale and size, and to provide detailed velocity and depth data at any location within the model.

The combination of the detailed results from the CFD model and the rapid assessment and visualization of the physical model proved to be invaluable to the design team to quickly design and optimize the project to meet the hydraulic design objectives and to provide Manitoba Hydro with the confidence that the new arrangement could be constructed on schedule and with reduced project costs.

REFERENCES

Sydor and Waterman. “The Value of CFD Modeling in Designing a Hydro Plant”. Kevin M. Sydor and Pamela J. Waterman. HYDRO REVIEW; 29, 6; 46-54, 2010
AUTHORS

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Ms. Hurtig’s professional background involves hydraulic design, and the application of physical and numerical hydraulic models for the analysis of various hydraulic structures including dam spillways and outlets, hydroelectric developments, storage reservoirs for drinking water treatment facilities, pump intakes for power generation facilities, raw water and wastewater pump stations, flood bypass channels, and bridge crossings. Kara served as the Lead Project Engineer for the Pointe du Bois Spillway Replacement physical model study conducted by NHC.

David S. Brown, P. Eng., M.Eng., Manager of the Water Resources Department KGS Group

David Brown has gained extensive experience in a variety of projects involving hydrologic studies, river hydraulics, flood protection, fish passage, fish habitat enhancement, hydroelectric development, erosion and sediment control, as well as numerical and physical modeling. David served as the Lead Hydrotechnical Engineer for KGS Group for the Pointe du Bois Spillway Replacement project including the role of oversight of the physical model studies conducted by NHC in support of Manitoba Hydro.

Brian Hughes, P.Eng. M.Sc., Principal, Northwest Hydraulic Consultants

Mr. Hughes is the Director of NHC’s modeling operations and sits on the firm’s Board of Directors. He has acquired strong managerial and technical knowledge in the areas of hydraulic design, physical and numerical hydraulic modeling, and river hydraulics. His modeling experience includes hydroelectric developments, fish passage projects, spillway design, navigation and sediment transport investigations, and intake and pump station design studies. Brian served as the Project Manager for the Pointe du Bois Spillway Replacement physical model study.

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Mr. Sydor leads hydrotechnical studies for operational, final design and construction support for existing and planned hydropower generation stations and hydraulic systems for Manitoba Hydro. He also leads environmental water regime studies related to physical environment impact assessments for riverine and oceanographic environments related to hydroelectric developments. Mr. Sydor was Lead Hydrotechnical Engineer responsible for directing the hydraulic design aspects during planning, final design and construction of the Pointe du Bois Spillway replacement project.