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CONSULTING ENGINEERS & PROJECT MANAGERS

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Government of Manitoba
Manitoba Water Stewardship
Water Branch
200 Saulteaux Crescent, Box 11
Winnipeg, Manitoba
R3J 3W3

ATTENTION: Mr. Steven D. Topping, P.Eng.
Director

Re: Peer Review of Manitoba Hydro's Simulation Program
For Long Term Analysis of SPLASH

Dear Mr. Topping:

This report summarizes my peer review of Manitoba Hydro's Simulation Program for Long Term Analysis of System Hydraulics (SPLASH), as requested in the terms of reference for my contract with Manitoba Water Stewardship (MWS).

My peer review has been based on the following information:

- Review of the document entitled "Utilization of the SPLASH Computer Model to Represent Water Regime in the Manitoba Hydro System".
- Attendance at a presentation by Manitoba Hydro on May 3 at the office of MWS, and information obtained in the discussions with Manitoba Hydro pursuant to that presentation

For readers of this document other than the staff of MWS, I have summarized my background in Appendix A so that the perspective that I have brought to this peer review can be understood.

My opinions are summarized below.

1.0 MODEL CAPABILITY

The SPLASH is an impressive product of almost 15 years of intensive development and application by skilled practitioners at Manitoba Hydro. It has been developed specifically for the Manitoba Hydro system and addresses all the major characteristics of their system, the hydro stations and the river/reservoir system that would be needed and expected for the

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comprehensive assessment of additions to the Manitoba Hydro system. I believe that it is comparable to, and in many areas, superior to, the leading software that is currently commercially available for studying hydroelectric reservoirs, plants, and rivers and their effects in the long term. Examples are the Vista DSS software available from Acres International Ltd, the HYDROPS software available from Powel Group Inc. (previously C. Howard and Associates), and the RIVERWARE software available from the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado.

My personal experience with ***development*** of major hydroelectric system analysis programs occurred primarily in the 1970's and 1980's and I can confidently say that SPLASH is superior to any model that was available in that era. Manitoba Hydro has clearly taken advantage of the evolution of the computer capabilities and the development of the technology in reservoir system simulation.

In my opinion, there are no better tools of which I am aware that could be used for a more detailed assessment of the effects of the addition of the Wuskwatim plant on the future water levels at Cross Lake. That is not to say that SPLASH is perfect, as it is not (nor does Manitoba Hydro suggest that it is). However, models used to assess incremental changes to a hydraulic system need not be perfect to enable them to accurately and adequately indicate the potential ***incremental*** effects due to that change to the system. That fact has been long recognized by authorities in the field.

2.0 CAVEATS

In spite of the strong endorsement of SPLASH expressed in 1 above, I do have a few points that should be kept in perspective in considering the effects of a project many decades in the future.

- The best indications today are still based on historical datasets of river flows and lake levels. Changes to the river flows in future decades as climate change evolves are not clearly understood at this time, and conceivably could affect reservoir operations in some way that is not fully appreciated at this time. The estimates of SPLASH must be considered as best estimates at this time, and should be used as the best basis for making decisions today on future works.

- Manitoba Hydro plans its system and operates it using the criterion of conserving stored water to allow the system to operate without power shortages if even the worst sequence of stream flows that have been recorded to date (1940 to 1941) in approximately the last 90 years were to reoccur. As the decades progress in the future, I suspect that this now accepted policy will come under scrutiny and may change. This could be driven by a variety of factors such as a conscious effort to either increase system security or reduce it to accept more risk of shortages of power to achieve other benefits. The current policies could also be modified to reflect an as-yet-unseen sequence of drought years worse than 1940-41. If such changes in policy occur, at some future time, today's predictions by SPLASH may be affected. Having said this, my intuition suggests that the ***incremental*** changes now predicted by SPLASH would still be reasonably valid. The only difference is that these increments could be masked by more dramatic changes in water regime brought on by the changes in risk tolerance and reservoir use by Manitoba Hydro.

3.0 POTENTIAL MODEL IMPROVEMENTS

In spite of my positive view of SPLASH, I do see areas where potential improvements could be made:

- Manitoba Hydro observes that operations strategy on a month by month basis under conditions of severe drought differs in the real world from the assumptions made by SPLASH for those same conditions. This results in quite different predictions by SPLASH, as compared to reality, for years that are much below normal in flow availability. I believe that there are ways and means to improve this representation of the real world and I recommend that Manitoba Hydro explore this with a view to improving the capability of SPLASH even further.

- I am skeptical of the use of perfect foreknowledge of river flows to simulate the release of water from reservoirs, in spite of the fact that Manitoba Hydro has determined that it does not adversely affect the accuracy of the model. I would recommend that a less optimistic approach be incorporated in future versions of the model that reflect the real world in which river flows cannot be predicted perfectly.

- The effects of attenuation of flow releases and travel time should be included in the simulations, if even indirectly and with rough approximations.

- Manitoba Hydro has suggested means to avoid random differences in simulations that result from the optimization techniques used by SPLASH. I support that and suggest that they be incorporated to avoid unfair criticism of the model results.

The suggestions listed above are recommended for future studies of the type carried out for the Wuskwatim development, as I do not believe that they will materially affect the predictions of the ***incremental*** effects of the impacts due to the addition of the development. I believe this because the robustness of the techniques already applied by Manitoba Hydro that permit the identification of the effects in a relative sense.

4.0 OTHER POSSIBLE REVIEWS

The observations and recommendations that I have stated above are based on my knowledge of simulation techniques for reservoir systems. Had the time available for my review been more substantial, my opinions could have been supported by a thorough literature review and interviews with utilities comparable to Manitoba Hydro in other jurisdictions, such as B.C. Hydro, Quebec Hydro, Tennessee Valley Authority, Bonneville Power Authority, etc. I doubt that the methods that they use for such assessments are superior to SPLASH, but that could be confirmed to provide even further credibility to the peer review team.

5.0 CONCLUSIONS

In conclusion, I wish to summarize my opinion that SPLASH is the best available scientific means of assessing the range of potential impacts on Cross Lake levels and flows that could be expected due to the addition of the Wuskwatim plant to the power system.

I wish to commend Manitoba Hydro for their diligent efforts and unbiased and professional assessment of the effects of their future system additions.

6.0 RECOMMENDATIONS

I recommend that the predictions provided by SPLASH regarding the potential future effects on Cross Lake levels be accepted as the best indication available at this time.

I also recommend that the SPLASH model continue to be refined by Manitoba Hydro, with focus on the points that I listed in Item 3. Furthermore, I would encourage Manitoba Hydro to explore the state of the art in simulation techniques at other comparable utilities periodically to ensure that SPLASH continues in the future to be at the leading edge in capability to assess future changes to the power system.

Yours truly,

Rick W. Carson, P.Eng.
Manager, Water Resources

RWC/mlb
Enclosure

APPENDICES

APPENDIX A

QUALIFICATIONS

EXPERIENCE OF R.W. CARSON, P.ENG. SPECIFICALLY RELATED TO THE FIELD OF RIVER AND RESERVOIR SIMULATION

- 35 years of experience in hydraulic engineering, hydrology, and project management for water resource projects

- Involved in development of and application of numerical models to assess river flows, reservoir use for hydroelectric systems and multi-purpose developments. Key areas are:

  - Numerical modelling of the system of rivers/lakes at outlet of Lake Winnipeg

  - Development of a multi-reservoir simulation package for planning of the expansion and operation of the hydroelectric system of Centrais Eletricas de Sao Paulo in south central Brazil

  - Participation in adjustment and application of the simulation model used by the Pacific Northwest Power Pool of the U.S. to plan operations of its plants and reservoirs, for use to analyze the power system of south central Brazil, specifically for prediction of the effects of addition of the largest existing hydro project in the world (Itaipu)

  - Preparation of and application of numerical models to examine the effects of changes to the operating rule curves overseen by the International Joint Commission for Rainy and Namakan Lakes in north-western Ontario

  - Direction of the development of an optimization model for assisting the day-to day operation of 3 reservoirs, and three hydro plants on the Seine River in north-western Ontario

  - Direction of development of various hydrological models for assessment of flood potential in the Nelson River and Lake Winnipeg catchments, including Cross Lake

  - Participation in the planning, design, environmental assessment, and/or construction of hydroelectric projects totalling over 20,000 MW in Canada, the U.S., South America, India, and Africa

  - Master of Science in Civil Engineering, with emphasis on hydroelectric development. Thesis topic was “Power System Simulation in South Central Brazil”