CAC/MSOS Exhibit #_____

Manitoba Hydro Risks: An Independent Review

Submitted to

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4.7 Conclusions

We wish to emphasize our view that for MH's forecasting challenges, as in many others involving complex systems, it is not possible to show conclusively that any one prediction method is better than any other. Our goal in this chapter has been to describe some alternative approaches to the ones that MH has used, and apply them to MH's aggregate water flow data. These approaches involve different statistical models, varying the number of lags in AR models, suggesting the use of other variables in AR models, and using variable transformations.

Our main focus, in keeping with the risk management element in our terms of reference, was on predicting the frequency and severity of low water flow events. We use simulations based on estimated AR models, and an entirely different method that uses results from extreme value theory (EVT) in which the observed low water flow events are used to fit the tail shape of that extreme end of the distribution.

We are then able to simulate the distribution of the minimum annual water flow that would be observed over a 94-year period. This is more informative than simple historical simulation. We find that the actual minimum lies roughly in the middle of our 95% intervals, and the means and medians of our simulated minima are greater than the actual minimum. On the one hand, this reassures us that the use of the actual minimum as a kind of benchmark worst-possible-case scenario is not unduly optimistic or pessimistic. On the other hand, because we find that the 95% intervals are fairly wide, we wish to caution that an over-reliance on the actual minimum could result in a mind-set in which it is not necessary tot consider the possibility of even worse outcomes, or indeed more beneficial water flow conditions.

The totally-different AR and EVT approaches provided very similar 95% intervals, which we consider to be an important check on the sensitivity of the results to the choice of model.

The same AR simulation method produces simulated five-year water flow minima within the same 94-year periods. Again, we find that the actual minimum is very close to the mean of the simulated minima, which is again reassuring, but we note that the 95% intervals are still fairly wide. The lowest five-year event in the next 94-year period may

ICF International considers MH's quantification of risk exposure to drought to be reasonable (ICF, 108). They assert that the scenario examined by MH is sufficiently stressful. They consider it equivalent to adopting a 95% confidence interval. This is based on the assumption that in any given year there is only a 3.1% chance (3 droughts in 97 years) of the onset of a drought equal or worse than the five year drought examined. A 95% confidence interval would have a 2.5% chance of occurring or being worse. They base this assertion on the assumption that conditions in any future year are unknown to MH and each year can independently be assumed to have an equal chance of being the first year of this severe drought.

ICF observed that other financial stress tests involved multiple risk factors changing simultaneously, and recommended that MH begin running tests of this nature. ICF also recommended the use of Monte Carlo simulations of cash flow or net revenue at risk. This, in their opinion, would serve to track risks and to facilitate communication across the organization and with stakeholders regarding progress of the drought and the likely financial impacts of the Drought Preparedness Plan. ICF believes this would build upon ongoing work and facilitate the additional examination of short term (1-2 years forward) hedging tools.

MH simulates the recurrence of water flows of the historic five year drought between April 1987 and March 1992 beginning the forecast year 2010/11 and extending through 2014/15. Then MH assesses the financial consequences of this drought relative to IFF 2008. More specifically, MH compares the net revenues in 2008 relative to those that would emerge under the drought.

Based on this methodology, MH has estimated that over a 5-year drought period, net export revenue would be reduced by $2.2 billion (excluding financing costs). Such a drought would have the potential of depleting MH's baseline retained earnings by 20% in the first year. If this drought continues to persist for 5 years, it has the potential to deplete 90% of baseline retained earnings. Including the cost of financing, the losses could exceed $2.7 billion. If other risk factors were to be included—higher import prices, appreciation in the exchange rate of the Canadian dollar, etc. the drought losses would increase.

According to ICF, MH is sensitive to the fact that while records have only been kept for the last 97 years, it is possible to face the risk of droughts of potentially longer durations

(ICF, 111). The treatment of joint events would reduce the probability of occurrence of the joint event. ICF calculates that the probability of occurrence of a drought of five years is 3.1% and if high electricity prices have a 50% chance of occurring during a drought this would reduce the probability of occurrence of both events to 1.5%; there would be only a probability of 1.5% for drought with high electricity prices to occur (ICF, 113).

There are a few problems with these calculations. First, the probability of occurrence of a 5 year drought is not 3.1% unless one assumes that the historical series is made of events having equal chances of occurrence. Considering this value to fall within the 2.5% tail of the distribution is based on considering the historical series to define a normal distribution. Furthermore, the assumption that higher electricity prices are a totally independent event and are not correlated with a drought is perhaps unrealistic.

The Consultant raises many questions about MH's exposure to drought risk and suggests that MH is exaggerating its risk estimates to conceal other operational inefficiencies.

"Manitoba Hydro has inadequately categorized and quantified its true 5-year Risk Capital exposure. The methodology being used to arrive at that $2 billion dollar number, that is in place to date, including the statistics is flawed in arriving at a true 95% exposure." (Public Document, 203).

The Consultant goes on to claim ... "This stress test is an unrealistic and impractical measure of risk that provides Hydro with no secure basis for quantifying or expanding its risk capital or hedging its true exposure for financial planning. An overstatement of projected risk capital would also envelope millions of dollars of operating risks and errors in internal hydraulic systems" (Public Document, 206).

The Consultant produced its own estimates of the risk exposure of a 5 year drought. The Consultant states that over a 5 year drought period the order of magnitude of risk capital is between $760 million and $1,250 million. To this one can add operational risk capital exposure of $550 million to $860 million and Credit Risk Capital of less than $100 million. The Consultant suggests that all of these were derived by using a variation on a variance/covariance method at the 95% confidence level (Public Document, 198).

The estimates of the Consultant are based on assuming each year in the 97 water flow years to be independent of the other years. Her estimate of the probability of a drought of the magnitude used by MH to estimate its exposure to a drought risk is infinitesimally small; this probability is estimated as (1/93)^5 which is equivalent to a chance of one in 6.9 billion years.

This estimate is contingent on a number of seriously flawed assumptions (KPMG, 95). First, it assumes that the probability of a future year being a drought year is drawn as one observation from the 93 observations. Second, each flow year is totally independent of the prior years. Third, there are many low flow years other than the one drawn. Fourth, drought years appear in the very series the Consultant is drawing observations from to include successive (correlated) years.

KPMG examined the 94 years (1912 to 2005) of water flow data and found that many years are correlated and the Consultant did not take into account the statistical information embedded in the series. A simple examination of the data reveals that low flow years do not happen independently, rather they appear in clusters (KPMG, 97). Testing for autocorrelation, KPMG confirmed that indeed auto correlations among two, three and four years are positive.

In Chapter 4 we tested higher order autocorrelations and found that the AR(3) (three year dependence) is high and significant. We also examined extreme value distributions and concluded that repeated drawings from this series (100 drawings of 94 values) confirmed the AR (3) process, and allowed us to estimate the probabilities of observing the actual minimum and even lower minima. What emerged from this analysis is that the minimum used by MH to determine its dependable energy corresponds closely to the mean of all minima (the actual minimum lies roughly in the middle of the 95% intervals), and that the chance of getting a smaller minimum is less than 2.5%.

In Chapter 6 we quantify the drought risk under both MH conditions and more stringent ones. Our numbers are close to MH or even higher. We also include multiple risk factors working in combination and assess the probability of their occurrence.