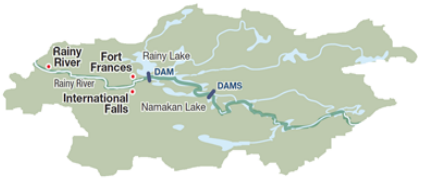


Factsheet # 6

Title: Forecasts Used by the Water Levels Committee

Background

The Water Levels Committee is responsible for monitoring hydrologic conditions in the Rainy River watershed and the actions of the dam operators in managing the levels of Rainy Lake and the Namakan Reservoir. This factsheet describes what forecasting tools and approaches the Water Levels Committee uses to fulfill this duty.

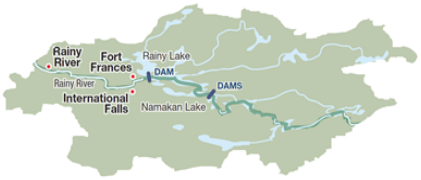
Meteorological Forecasting

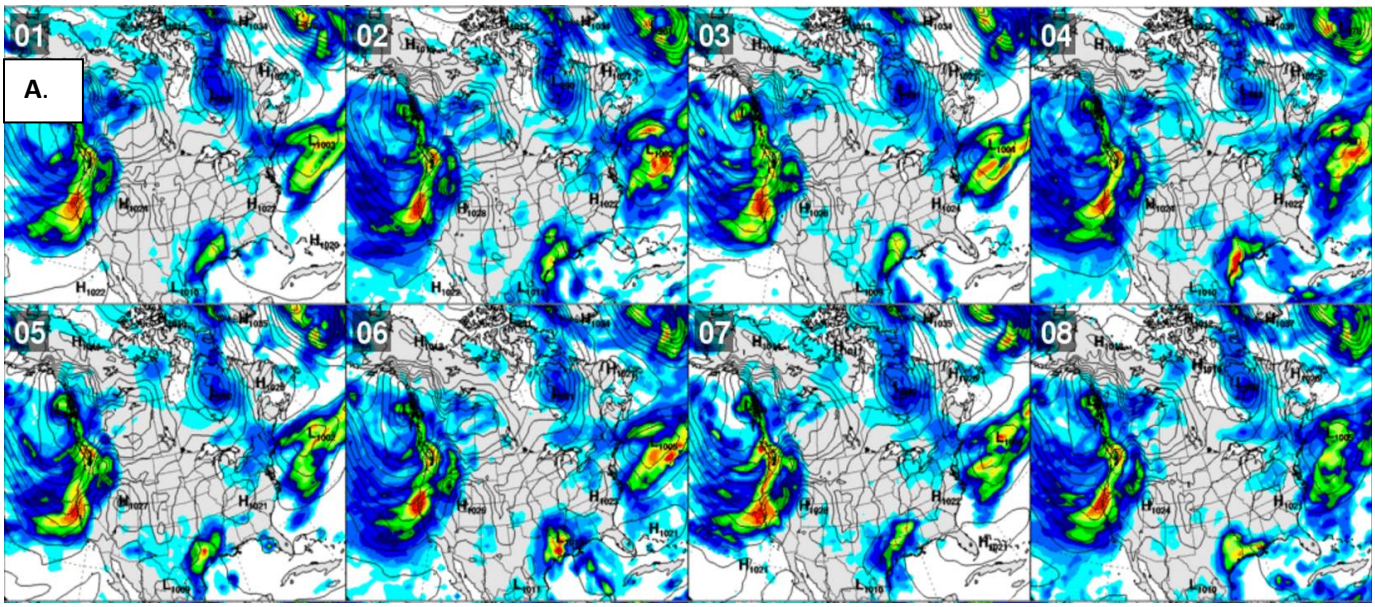
Managing the levels of Namakan Reservoir and Rainy Lake is a matter principally of balancing the flow out of the lakes with the flows entering, or inflows. Anticipating changes in inflow to the lakes, or inflow forecasting, relies on an accounting of all the water in the system. A key component in this accounting is precipitation across the watershed, as it is precipitation that ultimately results in inflows.

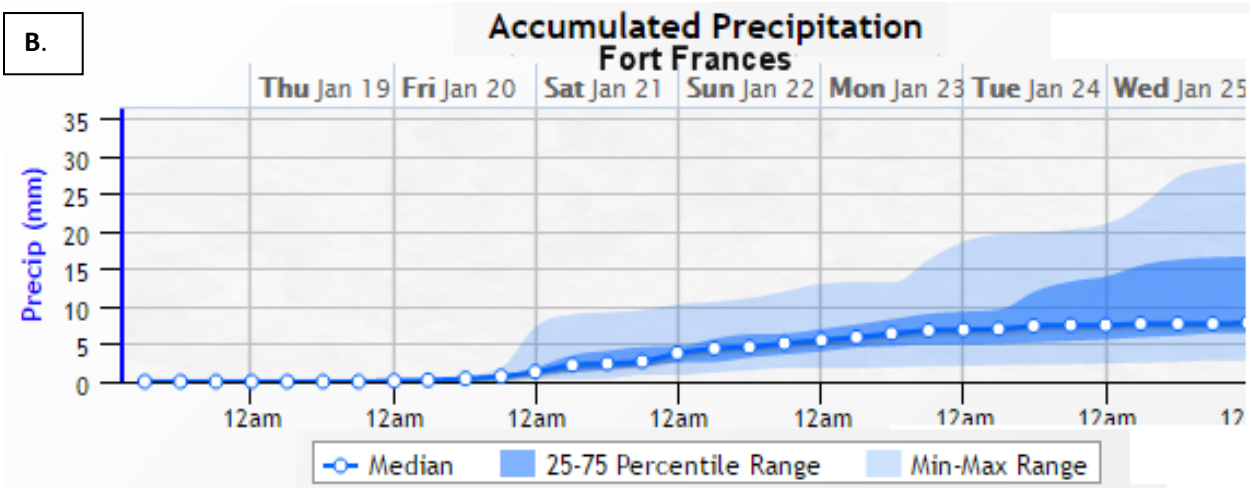
As everyone knows, predicting precipitation can be a tricky business. Modern meteorology makes use of sophisticated atmospheric monitoring and computer modelling, but still can be far off the mark. The basic reason for this is that atmospheric processes that produce precipitation are complex and involve many factors. For example, if a forecast model is slightly off in the way it estimates tomorrow's temperature in a certain region, the result could be poor estimates of rainfall in another region. To account for the sensitivity of forecast models to slight changes, forecasting agencies make use of ensemble forecast models. In basic terms, many different model simulations are made, each with slightly different estimates of important data. The results of the various simulations are then compared, and statistics are computed that relate the probability of certain weather conditions developing.

The Water Levels Committee makes use of two ensemble forecast products from the North American Ensemble Forecast System, a project collaboratively managed by the federal meteorological agencies of Canada, the United States, and Mexico. The first is the Global Ensemble Prediction System (GEPS) model, developed by the Meteorological Service of Canada. The second is the Global Ensemble Forecast System from the National Operational Model Archive and Distribution System (NOMADS) in the United States. Every six hours, both systems produce twenty-one different forecasts in their ensembles. The Water Levels Committee uses these forecasts looking ahead ten days. Figure 1 provides an example of precipitation output from an ensemble model.

In addition to these forecasts, the Water Levels Committee reviews Quantitative Precipitation Forecasts (QPF) produced by Ontario and the National Weather Service. These are maps produced every few hours showing the total rainfall over a specific period that is expected (from five to seven days out). These are based upon the forecast simulations, but are first reviewed and manually adjusted by meteorologists with expertise in these models. Examples of QPFs output are provided in Figure 2.

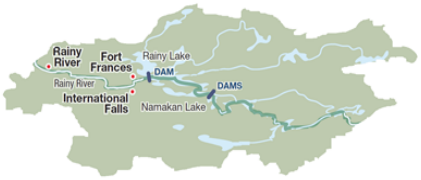


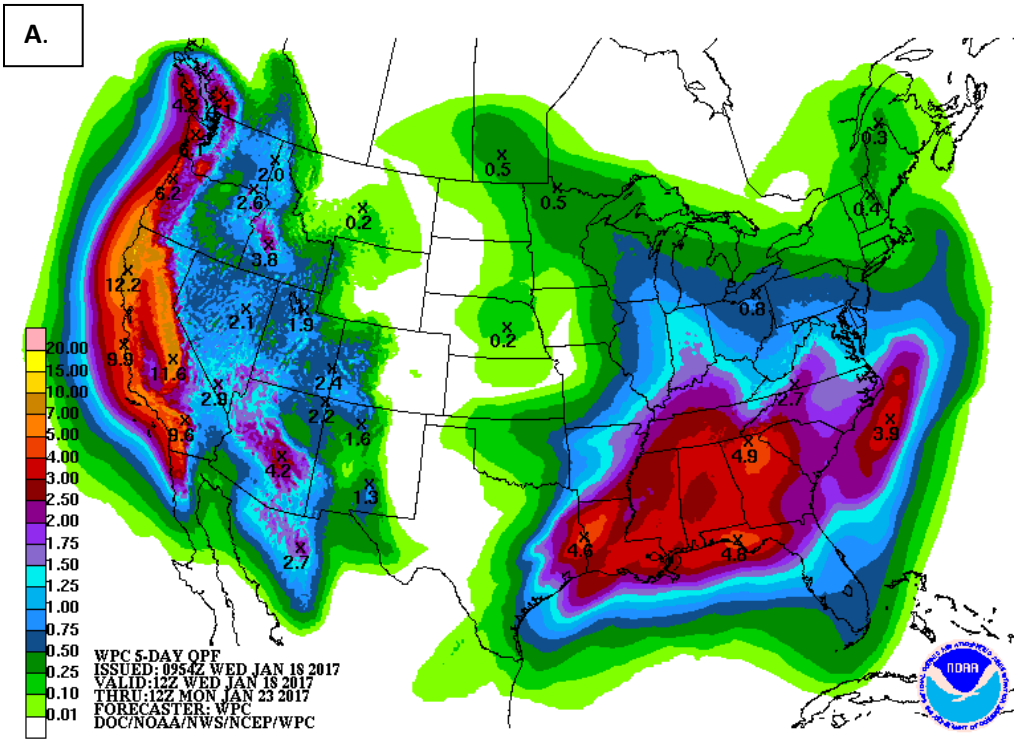




a. Eight individual precipitation forecasts for North America that go into the twenty-one member ensemble

b. Probabilities of accumulated precipitation based on all twenty-one ensemble forecasts (modified from Spot.wx website)





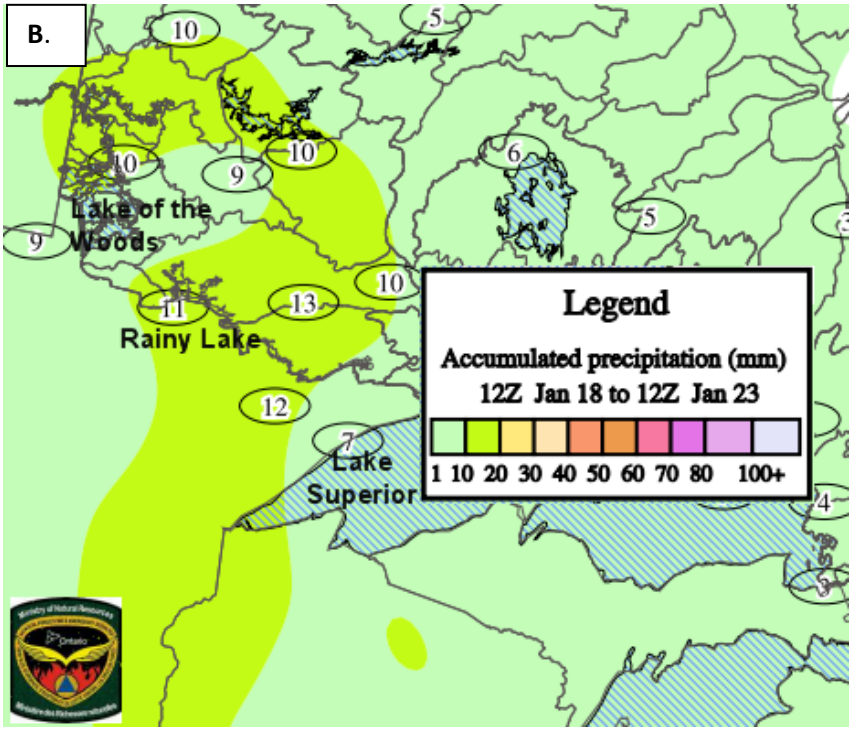


Figure 2. Examples of a 5-day Quantitative Total Precipitation Forecast

A. NOAA

B. Modified from Ontario Ministry of Natural Resources and Forestry

Inflow Forecasting

Outputs from models such as these, and also from well-known corporate weather forecasters, are reviewed each working day by the Water Levels Committee's engineering advisors (and more frequently as required during emergency conditions). Considering the outputs of various models from different agencies and companies, they get a broad picture of likely near-term precipitation across the basin.

Since 2014, the Water Levels Committee has benefited from further application of the data from ensemble forecasts, in a watershed inflow forecasting model. This model, known as WATFLOOD, automatically gathers the latest ensemble forecast data and simulates current and future water levels and flows in lakes and rivers across the watershed. In simple terms, the model does water accounting. It divides the whole watershed into a grid, and keeps track of the movement of water in and out of each individual grid cell (see Figure 3). To do so, it models processes such as precipitation, evaporation, seepage to groundwater, flow across land surfaces, along rivers and out of lakes.

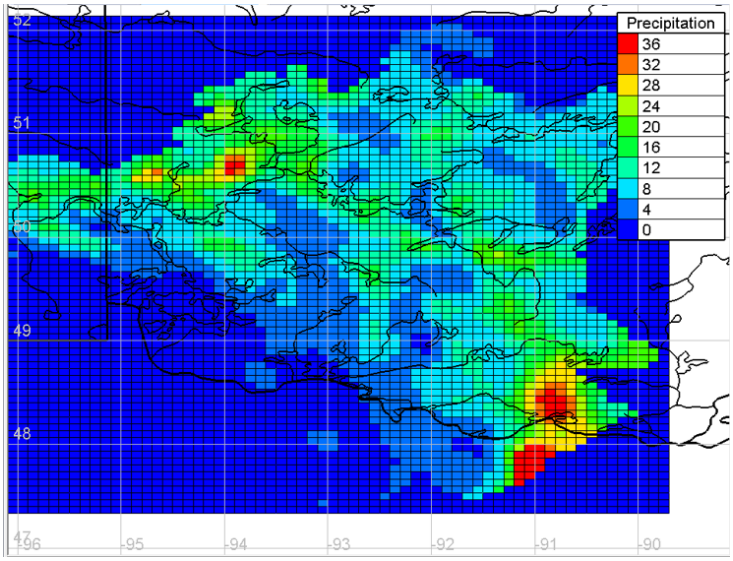


Figure 3. The WATFLOOD model grid for the Winnipeg River watershed, including Rainy-Namakan

The model relies on streamflow, temperature, and rainfall data provided at regular intervals by the Meteorological Service of Canada, including the Canadian Precipitation Analysis (CaPA, see Factsheet #5 for more information). These data are used by the model to estimate the current state of the rivers, lakes, and landscape in the watershed. Ensemble forecast data, described earlier, are then ingested by the model to simulate future water levels and flows, all the while tracking the movement of water.

The outputs from the forecast component of the model include standard water level and flow graphs for the major water bodies for the recent past as well as a near-term forecast. For each of the twenty-one ensemble weather forecasts, the inflow model simulates the water levels flows that would develop over the forecast period. It then computes the probability of certain flows and levels developing based on the results of these twenty-one separate simulations.

In practical terms, these outputs allow for a risk assessment on the likelihood of increasing or decreasing inflows to the lakes and resulting change in lake levels. Consider the example output from the WATFLOOD model from the summer of 2016 shown in Figure 4. Here, the blue line is "today", while the region to the right of the blue line is what the model forecasted for Rainy Lake inflow for the following couple of weeks. 90% of the twenty-one simulations had inflow within the grey band. The red line represents the middle of those simulations, or median.

For the first few days after "today", the grey band is very small and crowded around the red line. This is because the twenty-one inflow forecasts were similar, showing very little change in inflow. At about 4-5 days, however, there is clearly rainfall in the forecast, as all of the simulations show a sharp rise in inflow. How large will this rise be? This is less certain. Because the grey band is quite wide – some of the simulations show a small increase, but some a very large one – it is difficult to predict just what the increase will be. This may be due, for instance, to some of the meteorological forecasts showing a line of thunderstorms passing through at that time, while others have it tracking outside of the watershed. Towards the end of the forecast window at far right, about ten days out, the grey area shows that there is another increase in inflow in some of the simulations. However, the red median line doesn't change much. This indicates that most of the forecasts are not predicting another inflow rise, but a few are. The Water Levels Committee must interpret these outputs and judge the risks in the context of all other available basin information.

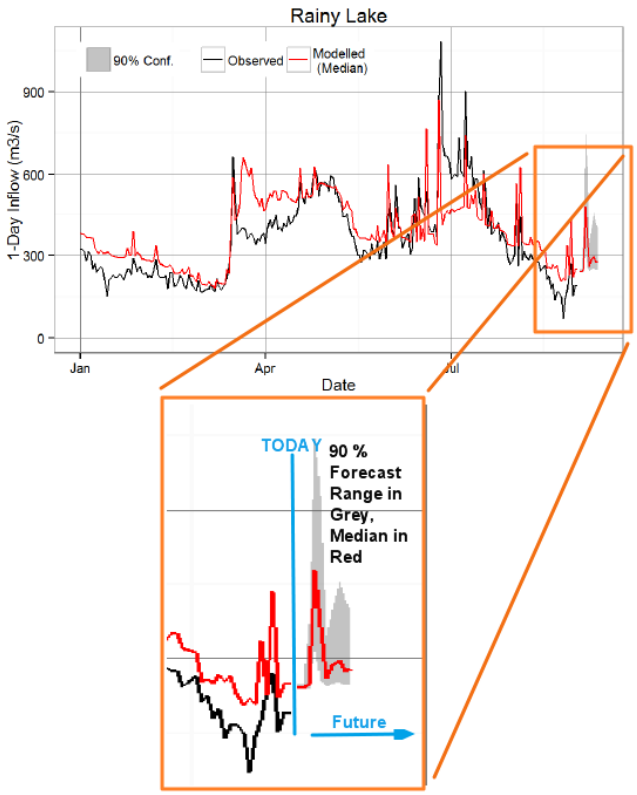


Figure 4. Example Output from Inflow Forecast Model for Rainy Lake

Use of Forecasts, Future Work

The Water Levels Committee makes use of the forecasts described above to anticipate potential near-term issues with Rule Curve compliance, and communicates these with the dam operators. During emergency conditions, the inflow model can help to estimate near-term changes in the water levels for Rainy Lake and Namakan Lake.

Work to improve weather observations and forecasts is ongoing by federal meteorological agencies. As these improve, so should inflow forecasts that use them. Research, including field work and collaboration with university researchers, is also underway to improve the inflow modelling in the watershed. Uncertainty with respect to future inflows will always be a reality, however, and the short range of these forecasts will not enable the Water Levels Committee to avoid future high water events entirely. Improvements may, however, provide a small reduction in high water peaks and improve the reliability of water level forecasts under emergency conditions.

Other Resources

In addition to the resources described above, the Water Levels Committee relies on information and perspectives provided by others. For example, reports of ground conditions from local residents or local members of the Water Levels Committee can help put data into perspective. In cases where the engineering advisors need advice or further information on forecasts, for example if a large system is tracking towards the basin in the spring, they speak with meteorologists at Environment and Climate Change Canada's Storm Centre to get a better picture of forecast uncertainty and risk.

Links to Forecasts
Some links to ensemble weather forecasts and QPFs described above are provided below:

Ensemble Forecasts
Canada:
https://weather.gc.ca/ensemble/index_e.html
http://meteocentre.com/models/get_ensemble.php?lang=en&map=na&run=00&mod=cmc_geps&stn=PNMPR&stn_type=postagestamp&display=img&hh=024
United States:
http://ssd.wrh.noaa.gov/naefs/
Other:
www.spotwx.com (select location of interest, then choose GEPS from Canada or SREF from USA)

Quantitative Precipitation Forecasts
Ontario:
http://www.affes.mnr.gov.on.ca/extranet/Bulletin_Boards/WxProducts/Flood_NAM_sum.pdf

http://www.affes.mnr.gov.on.ca/extranet/Bulletin_Boards/WxProducts/Flood_NpM_sum.pdf
United States:
http://www.wpc.ncep.noaa.gov/qpf/day1-7.shtml