Flow and Water Level Forecasting for the Lower Fraser River (from Hope to the Ocean)

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One of the principal tasks of the Ministry of Forests' River Forecast Centre (RFC) and Flood Safety Section is to provide long-term and short-term forecasts of discharge and water level for the Fraser River. This document summarizes the flood forecasting procedures and the timing of forecasts for the lower Fraser River, through the Lower Mainland.

A. What Produces High Flows on the Fraser River

High flows and floods on the Fraser River during spring freshet result from two factors: snow and weather:

- Snow accumulates during the winter in the mountains of the Fraser River watershed. In years of heavy snowpacks (such as this year), the large volume of water contained in the snowpack results in high (well above average) streamflow in the Fraser River, when that snow melts. Whether or not those heavy snowpacks and large runoff volumes result in flooding depends on the weather during the snowmelt period from mid-May to late-June.
- The critical weather factors that result in increased risk of flooding are extended periods of hot weather, or a significant frontal rainstorm near the time of peak snowmelt.
- In general, the snow factor produces about 20-40% of the flood risk, while the weather factors produce about 60-80%.

Hot Weather Scenario:

- In years of heavy snowpacks, an extended period of hot weather between mid-May and mid-June in the Upper Fraser (McBride, Prince George, Blue River, etc.) can produce very high flows on the Fraser River in the Lower Mainland, by producing rapid snowmelt and rapid streamflow runoff.
    - In general, 5-6 days of hot weather will produce very high flows (but not flood flows), and 8-9+ days of hot weather may produce flows that approach those of 1948 (when flooding occurred).
    - By "hot weather", we mean daily high temperatures at Prince George (for example) of greater than 25° (with seasonal normal high temperature being near 18°).
- It is temperatures in the central interior of B.C. that are the most important, since it is the mountains in those areas that contain most of the snow that becomes the flow of the Fraser River through the Lower Mainland.
- Once the snowmelt water is in the major tributaries of the Fraser River (Nechako River, Upper Fraser, McGregor, Quesnel, North Thompson, South Thompson), a significant period of time is required for the water to move to the lower mainland. Time of travel for a peak flow in the Fraser River from Prince George to Hope is approximately 3 days. The time of

travel from the North Thompson at McLure to Hope is about the same. From Hope, it is approximately another 12 hrs to Mission.

- With respect to forecasting these high flows, hot weather is produced by strong high pressure ridging across the south and central interior. Weather forecast models generally show the potential for strong ridging 24-48 hrs before it begins. The weather forecast model information provides the RFC with our first qualitative "heads-up". Should the weather forecast models show strong ridging forming with the potential for sustained heat, the RFC will provide an advisory to this effect. This will be approximately 7-8 days before high flows will begin on the Fraser River in the Lower Mainland.

Frontal Rainstorm Scenario

- In years of above-normal snowpacks, a widespread frontal system that produces significant rainfall amounts over a 24-48 hour period, during the period of high flows from snowmelt (usually in June), can produce very high stream flows.
  - Rainfall of 30-50 mm over 48 hours, occurring widespread in the water source areas in the Fraser River watershed (Upper Fraser, Nechako, North and South Thompson), can produce very high flows through the lower mainland.
  - Rainfall of 70+ mm over 48 hours, occurring widespread near the time of snowmelt peak, can produce extremely high flows on the Fraser River.
- Rainfall forecasts are fraught with uncertainty, and rainfall is highly spatially variable (because of the complex mountainous terrain of B.C.). As a result, flow forecasts for the rainfall scenario have significant uncertainty beyond about 3-4 days.
- An example year for the frontal rainstorm scenario is 1972.

B. Flow Forecasting

- The B.C. River Forecast Centre currently operates several different flow forecast models for the Fraser, producing up to 10-day flow forecasts, to provide as early warning of high flows and floods as possible, to help ensure public safety. The models are:
  - **CLEVER (Channel Links Evolution Efficient Routing) Flow Forecast Model**: This is a numeric watershed model which forecasts flows 10 days into the future utilizing 10-day weather forecasts. The model is set up for the major gauged locations within the Fraser River watershed, including forecasts for flows on the Fraser River at Hope. Technical details on the CLEVER model area available on the River Forecast Centre website.
  - **Fraser Routing Model**: We have a routing model which takes measured flows from the major basins in the headwaters and routes the water down to Hope and Mission (refer to Figure 2). It is akin to an accounting model, based on measured flows at a number of locations, such as: the Fraser at Hansard (approximately 3 days travel to Hope); McGregor River (3 days to Hope); Nechako at Vanderhoof (3 days to Hope); Fraser River at Shelley (2½ days to Hope); Fraser River at South Fort George (2¼ days to Hope); Fraser River at Marguerite (2 days to Hope); Fraser River at Texas Creek (½+ day to Hope); North Thompson River at McLure & South Thompson River at Chase (3 days to Hope); and the Thompson River at Spences Bridge (½ day to Hope). A further ½ day

is required for the water to move from Hope to Mission. The routing model provides accurate and precise forecasts of flows at Hope and Mission, for the 12-48 hour forecast period. The forecasts become less precise for 2-4 days ahead.

- **WARNS (Water and Routing Numeric System) Flow Forecast Model**: This is a numeric watershed model which forecasts flows 10 days into the future, based on 10-day weather forecasts. The model is applied to all the major sub-basins of the Fraser, and provides forecasts down to Hope. We also use the forecast flows for the tributaries as input to the routing model. Precision is on the order of plus or minus 5-8%. The quality of the results is very dependent on the weather forecasts. Weather forecasts for days 4 and 5 can be quite unreliable. One of the applications of the WARNS model is that we can test or evaluate weather scenarios. As examples, we ask: "what will the flows be if the weather is 3 degrees warmer for 2 days?", or "what will the flows be if we get 20 mm of rainfall?", etc. The other useful component of the WARNS model is that we can apply previous years' weather record, to see what flows will be produced. For example, we can model flows on the Fraser up to today, using observed weather up to yesterday. We can then simulate the hydrograph from today until the end of the freshet season using 1948 weather, or 1972 weather, or any other year.

- Flow forecast modelling has many uncertainties:
  - Forecast models are simplified versions of reality, and may not be fully representative of watershed conditions.
  - Flow forecasts are based on weather forecasts, and weather forecasts can be notoriously inaccurate, particularly for 3-5 days into the future. The weather that occurs can be significantly different from the weather that is forecast to occur.
- Some of the uncertainty of the forecast modelling is addressed by RFC staff reviewing and interpreting the different model outputs as a group, and by applying professional hydrology experience to the information.
- In any event, flow forecast modelling provides the basic information used to provide early warning of high flow and floods, to protect public safety.
- The 10-day flow forecasts have the following general level of accuracy (for flows measured on the Fraser River at Hope):
  - 12-24 Hour Forecasts: ±200 cubic metres per second (cms).
  - 24-48 Hour Forecasts: ±300-400 cms.
  - 48-96 Hour Forecasts: ±5-7% (for flows greater than 10,000 cms).
  - 4-5 Day Forecasts: Approximately ±7%.
  - 6-7 Day Forecasts: These are semi-quantitative forecasts of rising flows, given with a potential range of peak magnitude.
  - 8+ Day Forecasts: This is qualitative "heads-up" of potential high flows developing, based of the confidence in the weather forecasts.

C. River Level Forecasting

- The Ministry of Forests Flood Safety Section produces 10-day water level forecasts, for the Fraser River from Hope to the ocean. These forecasts are produced for a number of locations along the Fraser River.
- The modelling platform is “Mike 11”, a hydrodynamic model produced by the Danish Hydrology Institute.
- The Mike 11 hydrodynamic modelling uses the flow forecasts provided by the River Forecast Centre’s CLEVER model as input variables, and then forecasts the daily peak water levels on the Fraser River incorporating tidal effects.

D. Information Sources

- CLEVER Model Forecasts
- WARNS Model Forecasts
- Fraser River Water Level Forecasts

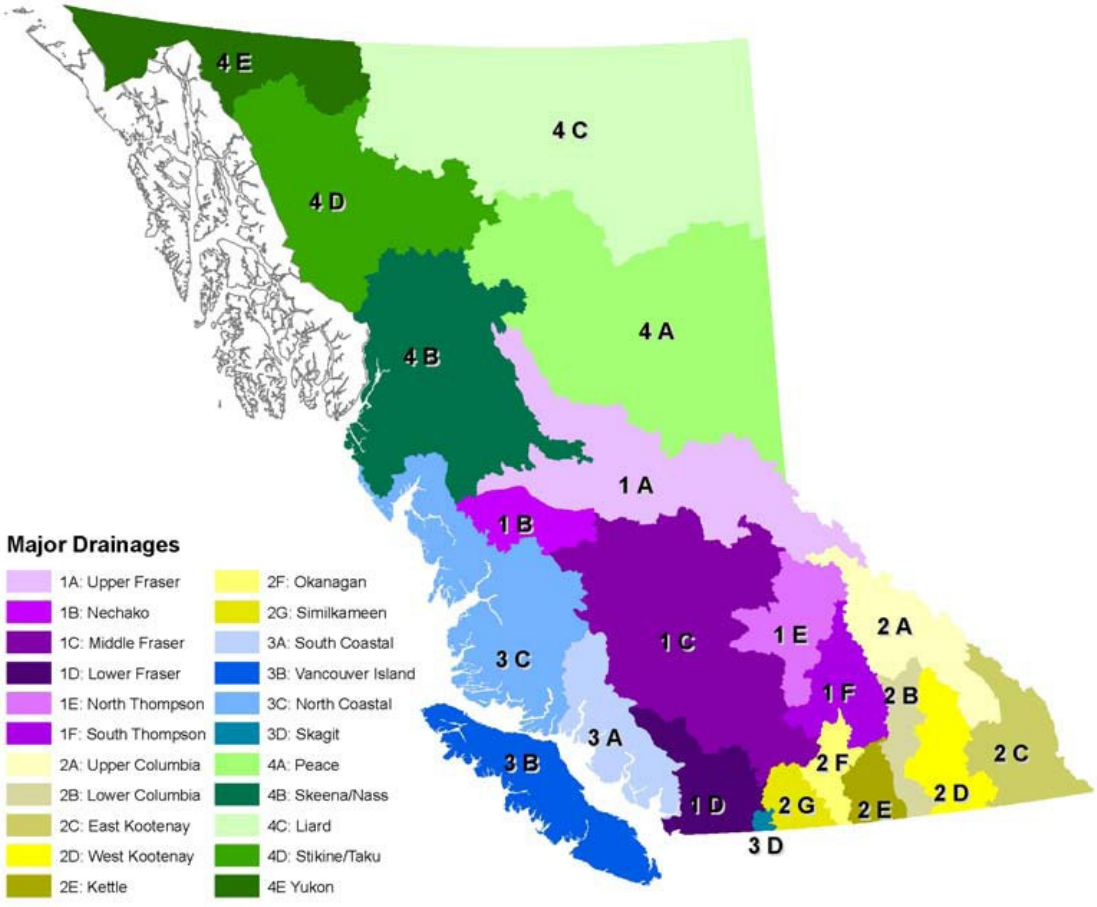

Figure 1. Major River Basins in British Columbia

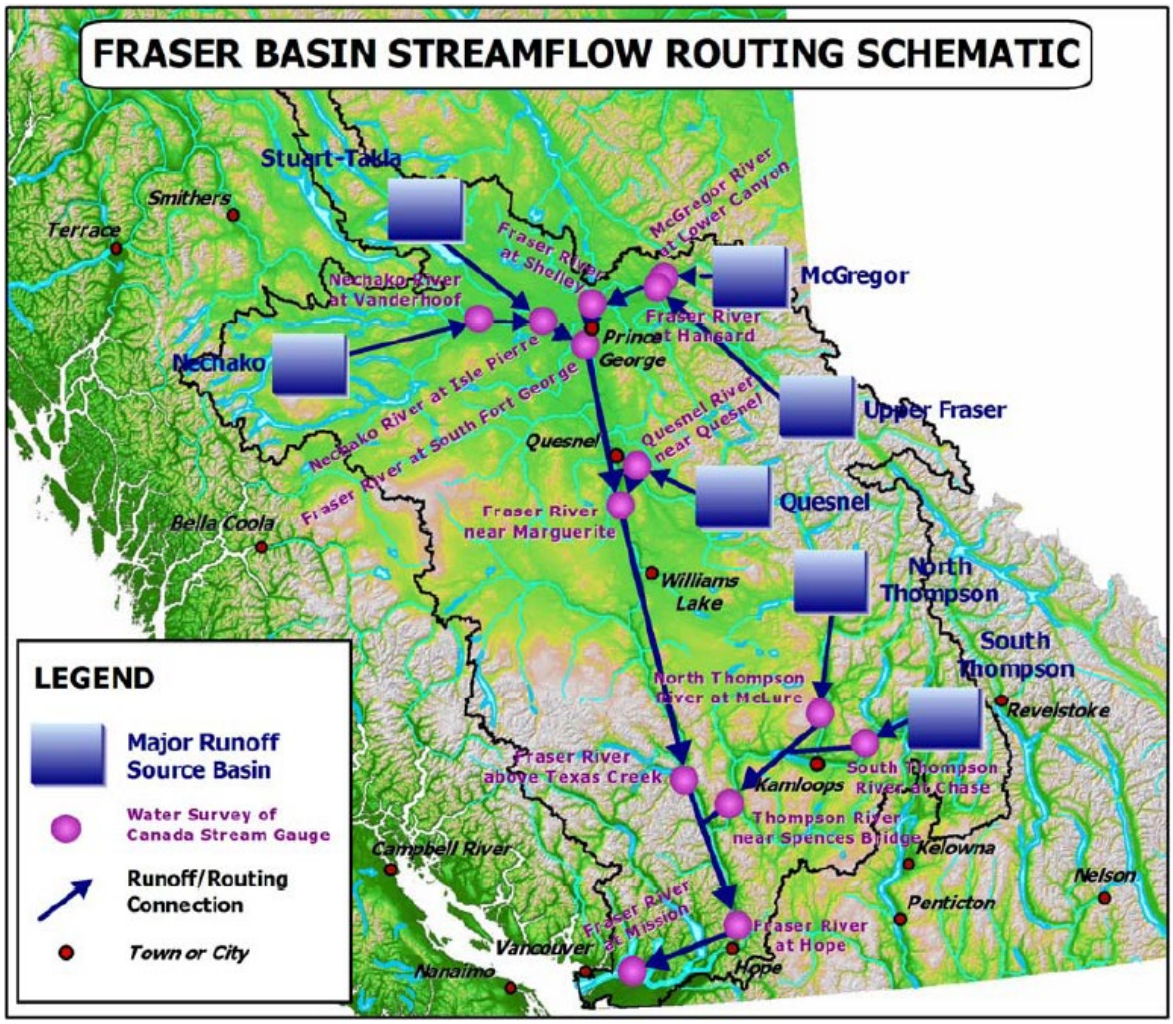

Figure 2. Streamflow Routing Schematic for the Fraser River