Ministry of Forests, Lands, Natural Resource Operations and Rural Development

BRITISH COLUMBIA

RIVER FORECAST CENTRE

BC Flood Forecasting System



Darryl Dyck/The Canadian Press

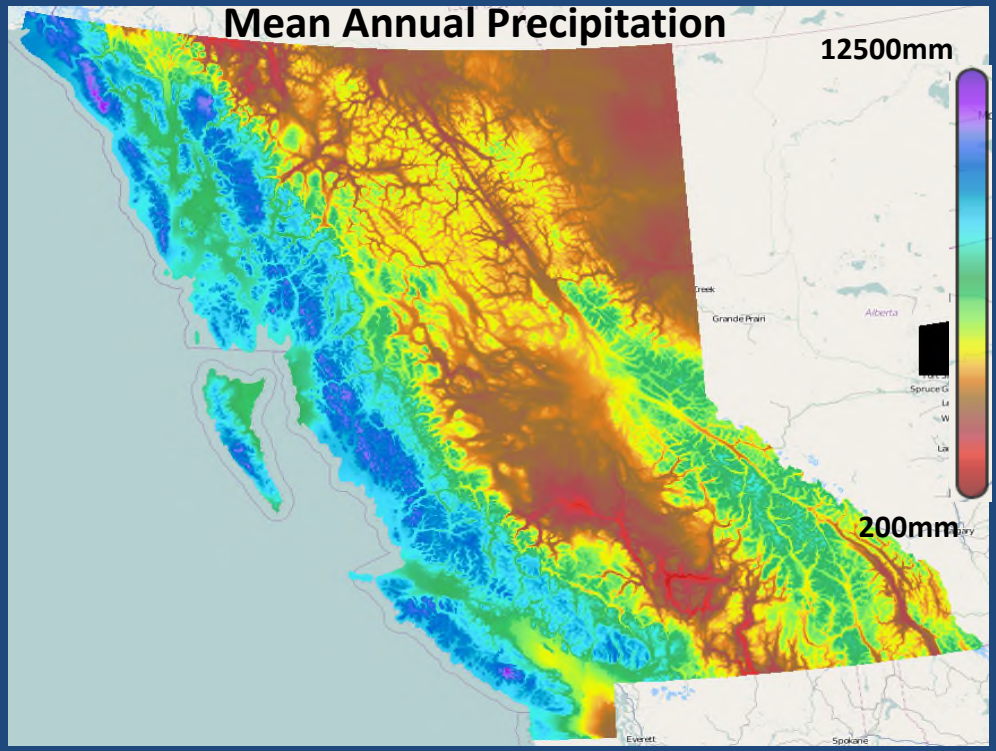
National Workshop on Flood Forecasting

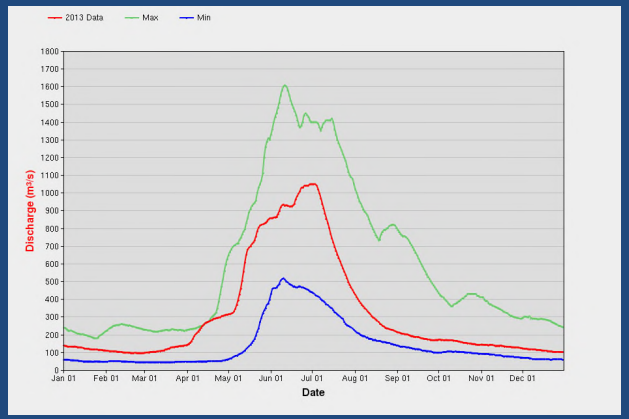
David Campbell, Head – BC River Forecast Centre

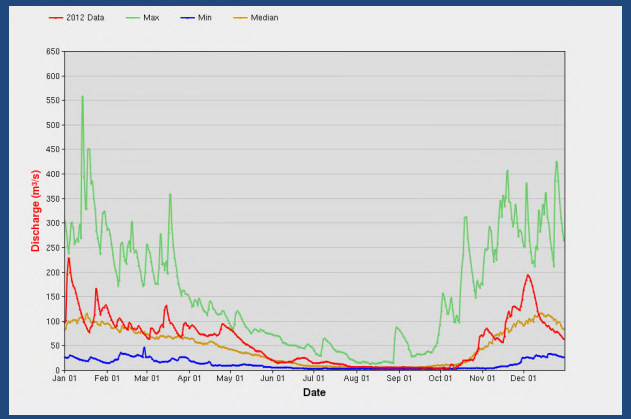
February 20th, 2019

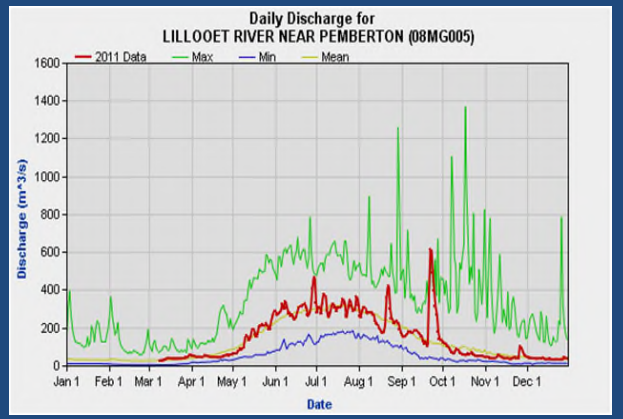
BC Hydrology

- Mountainous, high degree of spatial variability
- Snow-dominated spring freshet (Interior)
- Rain-dominated fall-winter (Coast)









BC RFC Operations

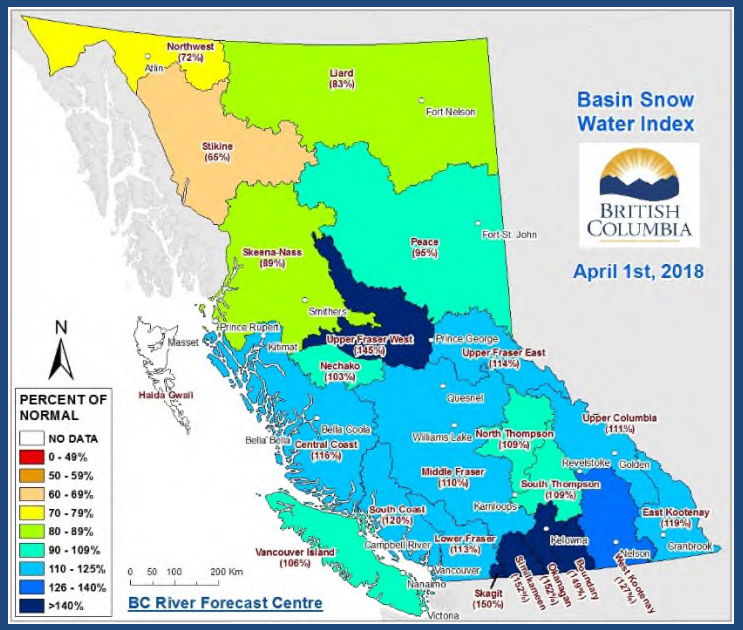
- Act as subject matter experts to support provincial response to flood emergencies (BC Flood Plan)
- Seasonal Risk and Snow pack analysis
- Real-time hydrologic modelling and Flood Forecasting
- Issuing Flood Advisories and Warnings
- Briefings
  - Feed into all levels of emergency response, from planning, regional emergency operation centres (local governments, critical infrastructure), Provincial EOC, senior government, inter-governmental

Data Management

- No database or platform
- Data managed through 2 data servers
  - Primary data acquisition through scripts and ftp source (web, eg DataMart)
  - Back-up ingest via GOES
  - Transitioned away from data service contracts with providers
  - All data stored in csv file format and automated hourly update
- Data Used
  - Hydrometric (WSC, some 3rd party), Weather Observations (EC, Fire Weather, Provincial Snow), Weather Forecasts (GEM-Regional, GEM-Global)
- Data Processing
  - Extraction of GRIB forecast data, bias corrections applied, data gaps filled, quality control
  - Model files created using MS Excel scripts to create spreadsheet files
- Provincial Snow Data
  - Transitioned to Aquarius Database and managed by provincial environmental and climate monitoring program
- Data Analysis
  - Increased use of R software for scheduled tasks and analysis

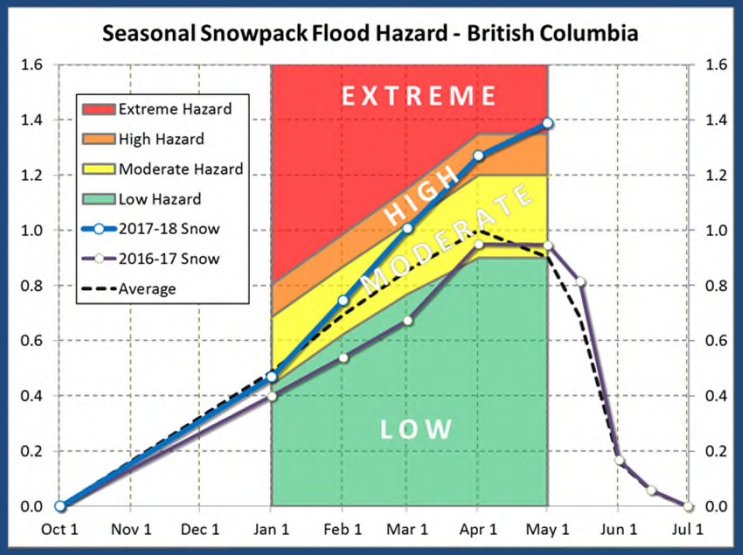
Data Management - Challenges

- Corporate-level IT policies and procedures
  - Web-publishing, server management, software, IT contracts and procurement
  - Limited IT support to assist with meeting government requirements
  - Extremely limited funding resources for IT
- In-house solutions are effective, but vulnerable (eg staffing, policy changes)
- Fragmentation with snow program data management
- Limitations associated with a lack of database/platform for forecast operations



Snowpack and Seasonal Risk

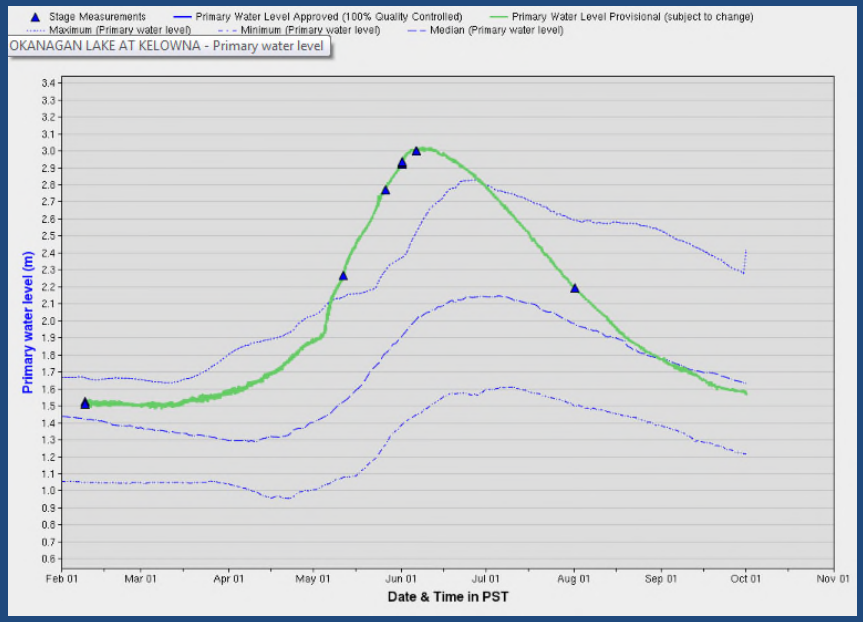
- Summarize basin snowpack conditions and seasonal risks into monthly report
- legacy analysis techniques but undergoing modernization project

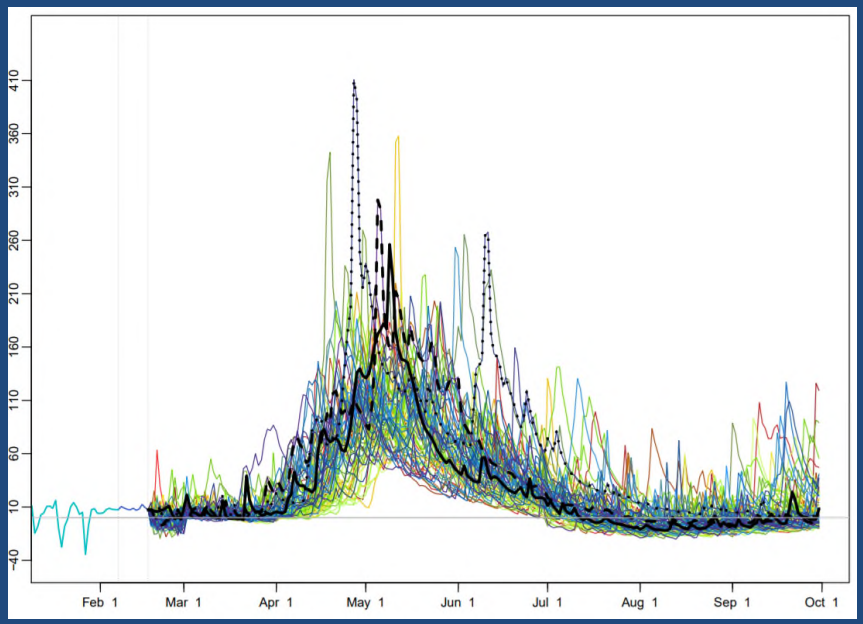


- <u>Challenges</u>
  - High degree of spatial variability in snowpack
  - Limited snow monitoring in areas and at certain elevations
  - Fragmentation of snow program from RFC and data management

Seasonal Forecasting

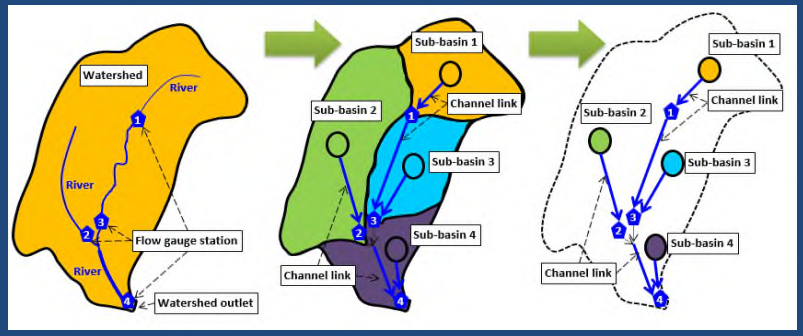
- Statistical approach (PCA) for volume runoff and peak-flow
- Emerging use of ensemble forecasting
- Challenges
  - Statistical approaches are less robust under changing climate
  - Forecasts tend to be “most-likely” scenario, but generally are concerned with extreme conditions (should we be adopting a better way to describe risk)
  - Seasonal weather (particularly precipitation) a key driver, but have limited forecast skill
  - RFC under scrutiny after 2017 flooding in the Okanagan

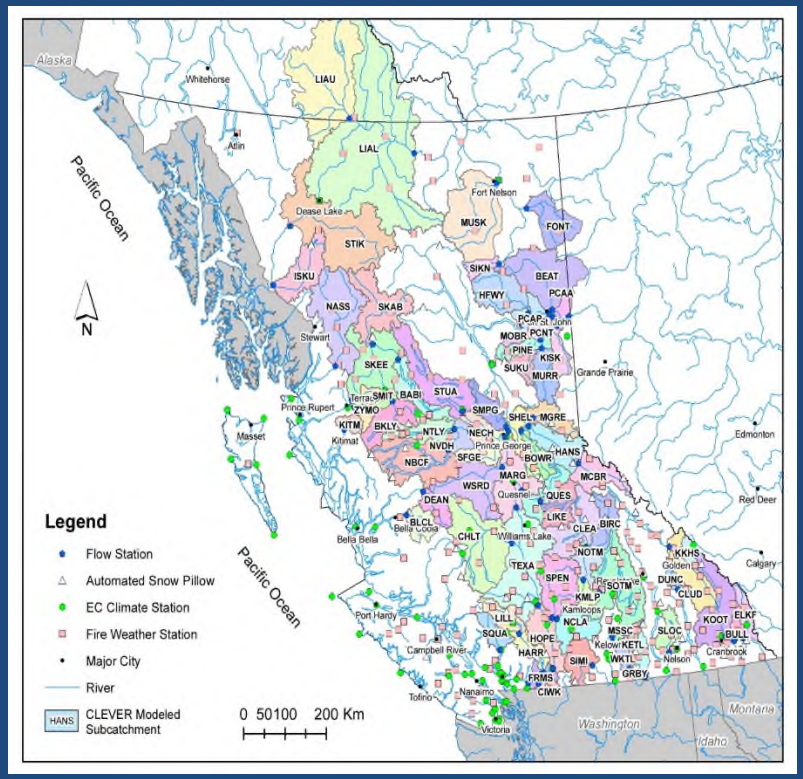




Hydrologic Modelling

- WARNS (Water and Routing Numeric System)
  - Lumped model, legacy system (implemented 1974)
  - variation on UBC Watershed Model with revised snowmelt component
  - Snowpack as initial condition
  - Fraser River with 10 sub-basins
- CLEVER (Channel Links Evolution Explicit Routing)
  - Lumped model, modified UH approach with routing, snowmelt/freshet
  - In-house development 2013 (Dr. Charles Luo)
  - 73 watersheds (600,00 km^2 total, 800-250,000 km^2 sub-basins)
- COFFEE (Coastal Fall Flood Ensemble Estimation)
  - Lumped, modified UH approach, in-house dev't
  - Used for rain and rain-on-snow fall-winter flooding in Coastal BC
  - Ensemble calibration approach
  - 94 watersheds (225,000 km^2 total, 20-40,000 km^2) sub-basins
- MIKE-11 Hydraulic Model (Lower Fraser River)
- RAVEN Model
  - seasonal and real-time ensemble inflow forecasting for Okanagan Lake Management
- FRouT Model
  - Routing/Mass balance model for Fraser River



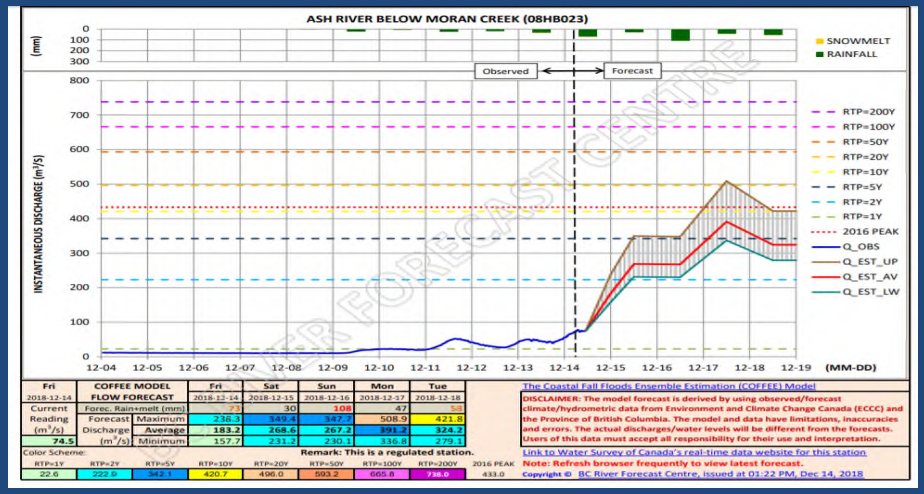


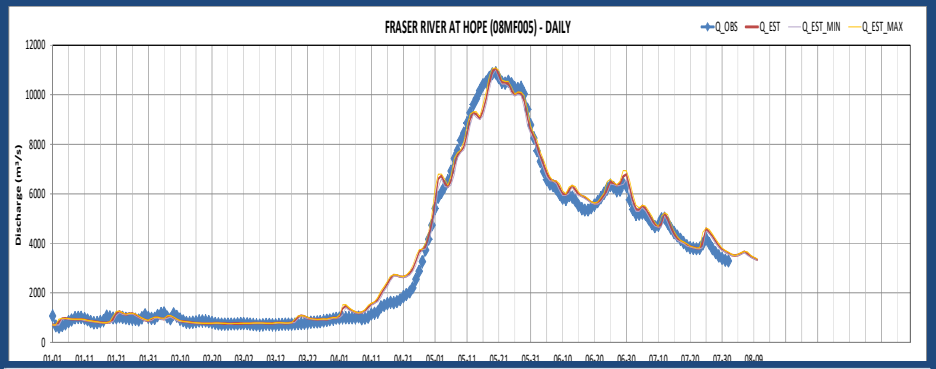
Hydrologic Modelling

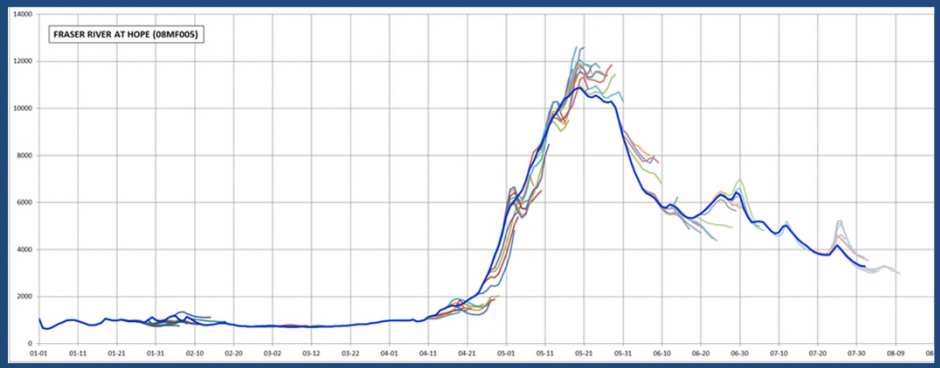
- Successes
  - In-house development
    - significant increase in modelling capacity (from 10 to 150 forecast points over past 6 years)
    - Adaptable to new data acquisition sources (WSC, ECCC DataMart)
  - Simple but computationally efficient
    - 5-10 minutes computation time
    - Aim for 3 hours start to publish
- Challenges
  - Modelling ability exceeds human resource capacity (7 day coverage, calibration and QC of individual locations)
  - Vulnerable to staffing changes
  - Adoption of new platforms difficult (eg transferrable code, integrating new tools)

Uncertainty

- Model (<5-10%) vs. forecast error (<20-30%)
- Ensemble Calibration (COFFEE)
- Initial conditions (snow)
- Weather (primary source of uncertainty)
- How to communicate uncertainty to lay audiences?
  - Scenarios
  - Develop more standardized criteria eg likely (50% chance) or likely “worst” case (10% chance)

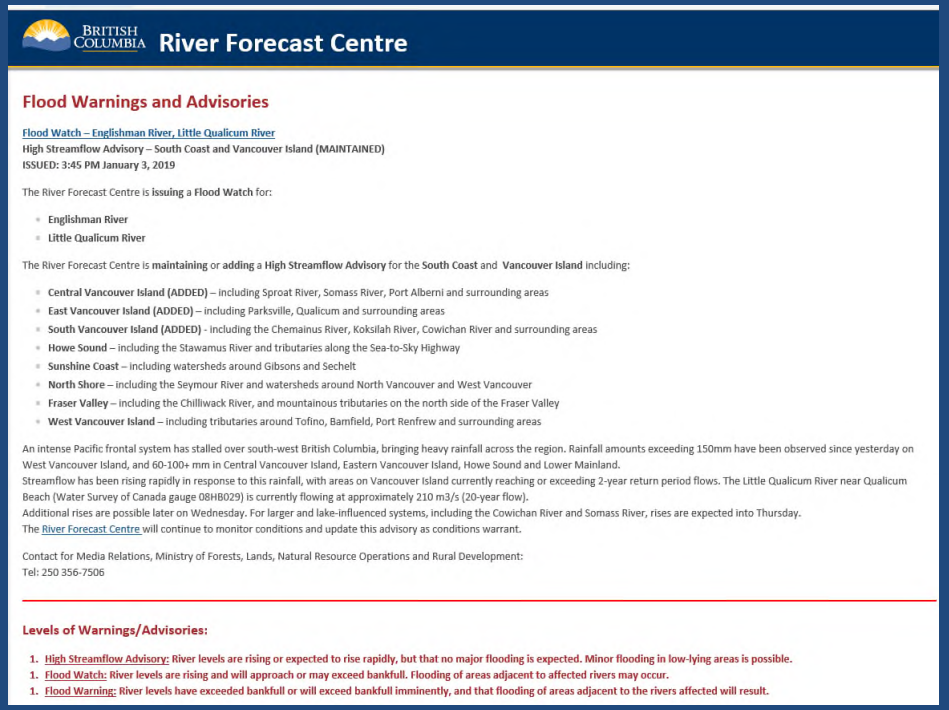






Flood Advisories and Warnings

- No explicit criteria
  - In many areas flood level not known, or flooding occurring on ungauged rivers
  - Incomplete floodplain mapping, limited database of flood infrastructure
  - Use flood frequency analysis to estimate (2-5yr=high streamflow advisory, 5-10yr flood watch, >10-20yr flood warning)
  - No automated threshold warnings (even for internal purposes)
- Decision to issue warning is held with the forecaster
  - Interpretation of conditions and risk
  - Determination of geographic extent
- Manually written description
  - Emailed to distribution (further disseminated through EMBC)
- Map-based Advisories (in development)



BRITISH COLUMBIA River Forecast Centre

Flood Warnings and Advisories

Flood Watch – Englishman River, Little Qualicum River
High Streamflow Advisory – South Coast and Vancouver Island (MAINTAINED)
ISSUED: 3:45 PM January 3, 2019

The River Forecast Centre is **issuing** a **Flood Watch** for:

- **Englishman River**
- **Little Qualicum River**

The River Forecast Centre is **maintaining** or **adding** a **High Streamflow Advisory** for the **South Coast** and **Vancouver Island** including:

- **Central Vancouver Island (ADDED)** – including Sproat River, Somass River, Port Alberni and surrounding areas
- **East Vancouver Island (ADDED)** – including Parksville, Qualicum and surrounding areas
- **South Vancouver Island (ADDED)** - including the Chemainus River, Koksilah River, Cowichan River and surrounding areas
- **Howe Sound** – including the Stawamus River and tributaries along the Sea-to-Sky Highway
- **Sunshine Coast** – including watersheds around Gibsons and Sechelt
- **North Shore** – including the Seymour River and watersheds around North Vancouver and West Vancouver
- **Fraser Valley** – including the Chilliwack River, and mountainous tributaries on the north side of the Fraser Valley
- **West Vancouver Island** – including tributaries around Tofino, Bamfield, Port Renfrew and surrounding areas

An intense Pacific frontal system has stalled over south-west British Columbia, bringing heavy rainfall across the region. Rainfall amounts exceeding 150mm have been observed since yesterday on West Vancouver Island, and 60-100+ mm in Central Vancouver Island, Eastern Vancouver Island, Howe Sound and Lower Mainland.
Streamflow has been rising rapidly in response to this rainfall, with areas on Vancouver Island currently reaching or exceeding 2-year return period flows. The Little Qualicum River near Qualicum Beach (Water Survey of Canada gauge 08HB029) is currently flowing at approximately 210 m3/s (20-year flow).
Additional rises are possible later on Wednesday. For larger and lake-influenced systems, including the Cowichan River and Somass River, rises are expected into Thursday.
The River Forecast Centre will continue to monitor conditions and update this advisory as conditions warrant.

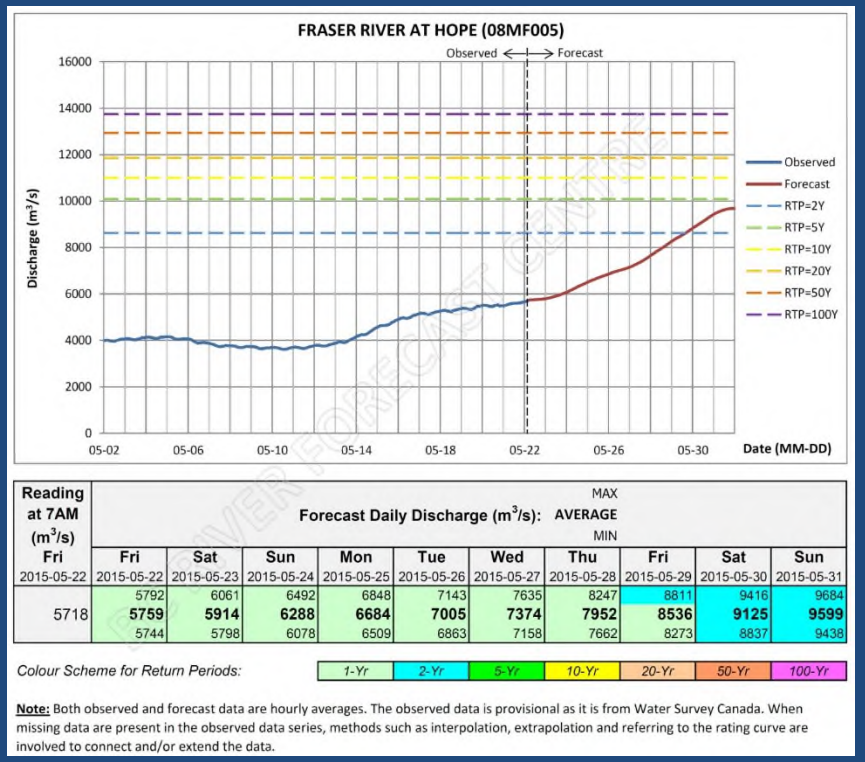
Contact for Media Relations, Ministry of Forests, Lands, Natural Resource Operations and Rural Development:
Tel: 250 356-7506

Levels of Warnings/Advisories:

1. **High Streamflow Advisory: River levels are rising or expected to rise rapidly, but that no major flooding is expected. Minor flooding in low-lying areas is possible.**
1. **Flood Watch: River levels are rising and will approach or may exceed bankfull. Flooding of areas adjacent to affected rivers may occur.**
1. **Flood Warning: River levels have exceeded bankfull or will exceed bankfull imminently, and that flooding of areas adjacent to the rivers affected will result.**

Communication

- Website
  - Model output
  - Hydrometric data summaries/mapping
  - Warnings
- Conference Calls and Briefings
- Media

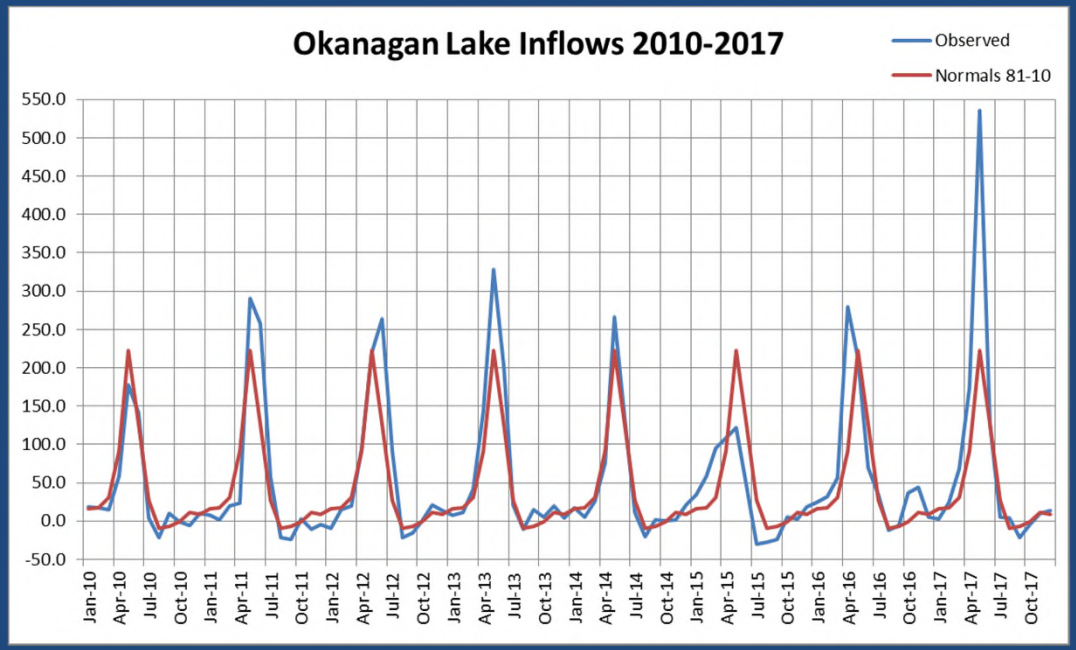


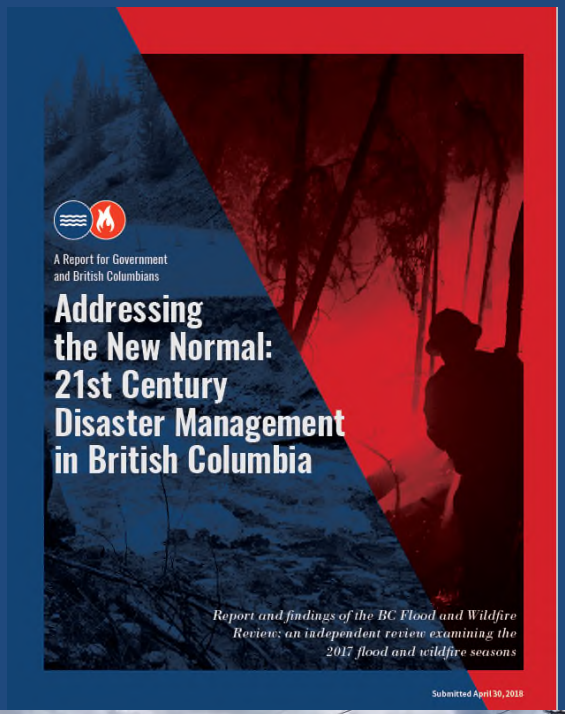
Reading at 7AM (m^3/s)	Forecast Daily Discharge (m^3/s): MAX / AVERAGE / MIN									
Fri	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
2015-05-22	2015-05-22	2015-05-23	2015-05-24	2015-05-25	2015-05-26	2015-05-27	2015-05-28	2015-05-29	2015-05-30	2015-05-31
5718	5792	6061	6492	6848	7143	7635	8247	8811	9416	9684
	5759	**5914**	**6288**	**6684**	**7005**	**7374**	**7952**	**8536**	**9125**	**9599**
	5744	5798	6078	6509	6863	7158	7662	8273	8837	9438

Colour Scheme for Return Periods: 1-Yr | 2-Yr | 5-Yr | 10-Yr | 20-Yr | 50-Yr | 100-Yr

Note: Both observed and forecast data are hourly averages. The observed data is provisional as it is from Water Survey Canada. When missing data are present in the observed data series, methods such as interpolation, extrapolation and referring to the rating curve are involved to connect and/or extend the data.

2017 Flooding on Okanagan Lake

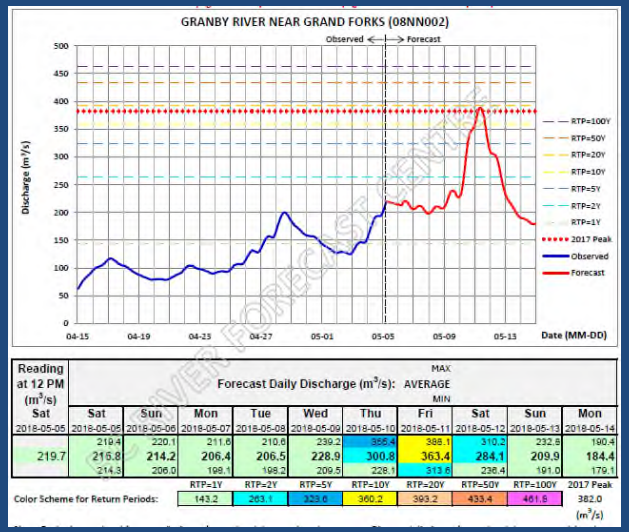




- Seasonal inflow forecast Mar-Jul= 485 kdam3
- Actual inflow= 910 kdam3
- Predominantly the result of extremely wet seasonal weather
- What is the utility of a statistical seasonal forecast once it has been exceeded?
- Flood and forecast subject of internal and external reviews



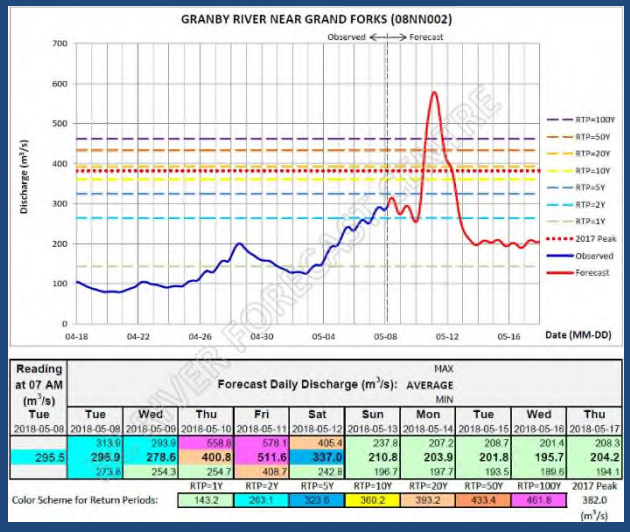
2018 Flooding in Grand Forks



Reading at 12 PM (m³/s)	Forecast Daily Discharge (m³/s): AVERAGE									
Sat	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
2018-05-05	2018-05-05	2018-05-06	2018-05-07	2018-05-08	2018-05-09	2018-05-10	2018-05-11	2018-05-12	2018-05-13	2018-05-14
	219.4	220.1	211.6	210.6	239.2	356.4	388.1	310.2	232.8	190.4
219.7	215.8	214.2	206.4	206.5	228.9	300.8	363.4	284.1	209.9	184.4
	214.3	206.0	198.1	198.2	209.5	228.1	313.8	236.4	191.0	179.1

MAX / MIN

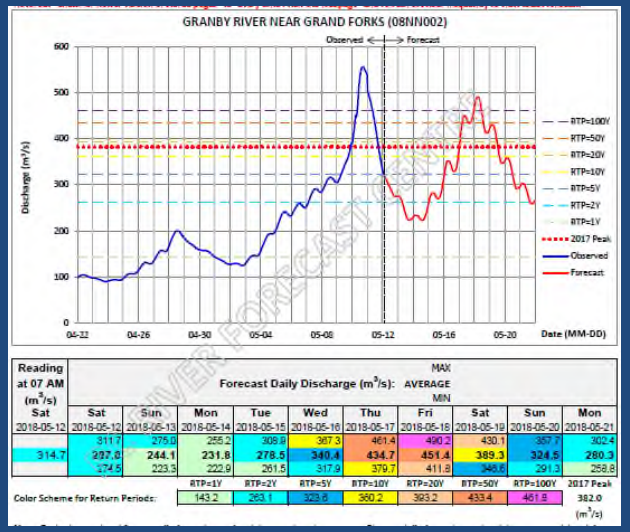
Color Scheme for Return Periods:	RTP=1Y	RTP=2Y	RTP=5Y	RTP=10Y	RTP=20Y	RTP=50Y	RTP=100Y	2017 Peak
	143.2	263.1	323.6	360.2	393.2	433.4	461.8	382.0 (m³/s)



Reading at 07 AM (m³/s)	Forecast Daily Discharge (m³/s): AVERAGE									
Tue	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu
2018-05-08	2018-05-08	2018-05-09	2018-05-10	2018-05-11	2018-05-12	2018-05-13	2018-05-14	2018-05-15	2018-05-16	2018-05-17
	313.0	293.9	558.8	578.1	405.4	237.8	207.2	208.7	201.4	208.3
295.5	298.9	278.6	400.8	511.6	337.0	210.8	203.9	201.8	195.7	204.2
	273.8	254.3	254.7	408.7	242.8	196.7	197.7	193.5	189.6	194.1

MAX / MIN

Color Scheme for Return Periods:	RTP=1Y	RTP=2Y	RTP=5Y	RTP=10Y	RTP=20Y	RTP=50Y	RTP=100Y	2017 Peak
	143.2	263.1	323.6	360.2	393.2	433.4	461.8	382.0 (m³/s)



Reading at 07 AM (m³/s)	Forecast Daily Discharge (m³/s): AVERAGE									
Sat	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
2018-05-12	2018-05-12	2018-05-13	2018-05-14	2018-05-15	2018-05-16	2018-05-17	2018-05-18	2018-05-19	2018-05-20	2018-05-21
	311.7	275.0	255.2	309.9	367.3	461.4	490.2	430.1	357.7	302.4
314.7	297.8	244.1	231.8	278.5	340.4	434.7	451.4	389.3	324.5	280.3
	274.5	223.3	222.9	261.5	317.9	379.7	411.8	345.8	291.3	258.8

MAX / MIN

Color Scheme for Return Periods:	RTP=1Y	RTP=2Y	RTP=5Y	RTP=10Y	RTP=20Y	RTP=50Y	RTP=100Y	2017 Peak
	143.2	263.1	323.6	360.2	393.2	433.4	461.8	382.0 (m³/s)

- History of “over-prediction”
- Model identified extreme flood potential 7+ days in advance
- Very accurate forecast (<5%) 3 days out
- Flood of record with significant community impacts





2018 - Fraser River

- Prolonged extreme early season heat
- Flows outside of historic range for nearly 3 weeks and peak 3 weeks ahead of normal (>100 year record)
- No historic analogues, only other year with similar weather was 1948
- Scenarios developed within uncertainty bounds (particularly snow)
- Exhausted snowpack and extreme flows failed to materialize

