

Issues about Hydropower Generation



Type of Hydro-Power

Reservoir Storage Systems

Pump Storage Systems

Run of the River Hydro



Key for Low Carbon Economy

Hydro = 6 gr CO₂ /kWh

Coal = 1024 gr CO₂ /kWh

Solar = 45 gr CO₂ /kWh

Wind = 16 gr CO₂ /kWh

Most of the Hydro-Systems are in Mountains

Some are Glacial Fed

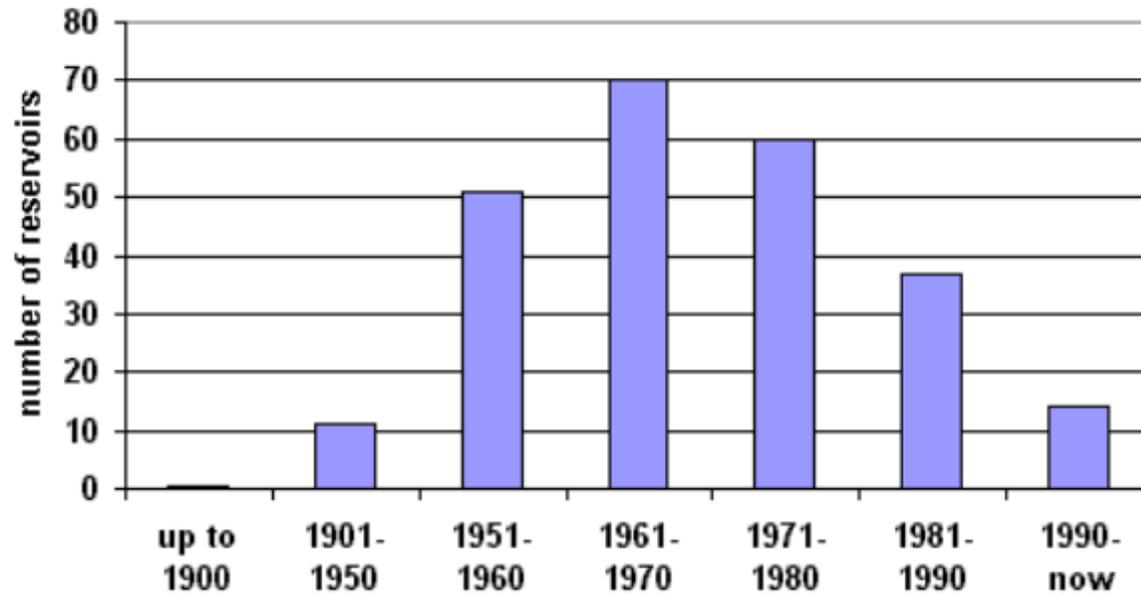
Some are dominated by Snow or Rain

Or a Combination of all Types



Hydropower Development

Average Number of Large Reservoirs Built per Year, by Time Period



Number of Large Dams: > 40000 (>150m tall, > 15m³/sec discharge)

Number of Small Dams: > 80000 (All kinds of storage)

500000 km² of Land Inundated, Storing 6000km³ of Water

Current trends: Re-emergence of need to build reservoirs because:
Increased water shortages, increased demand for green energy and increased climatic variability

Hydro-Power = 16% of World Electricity Capacity

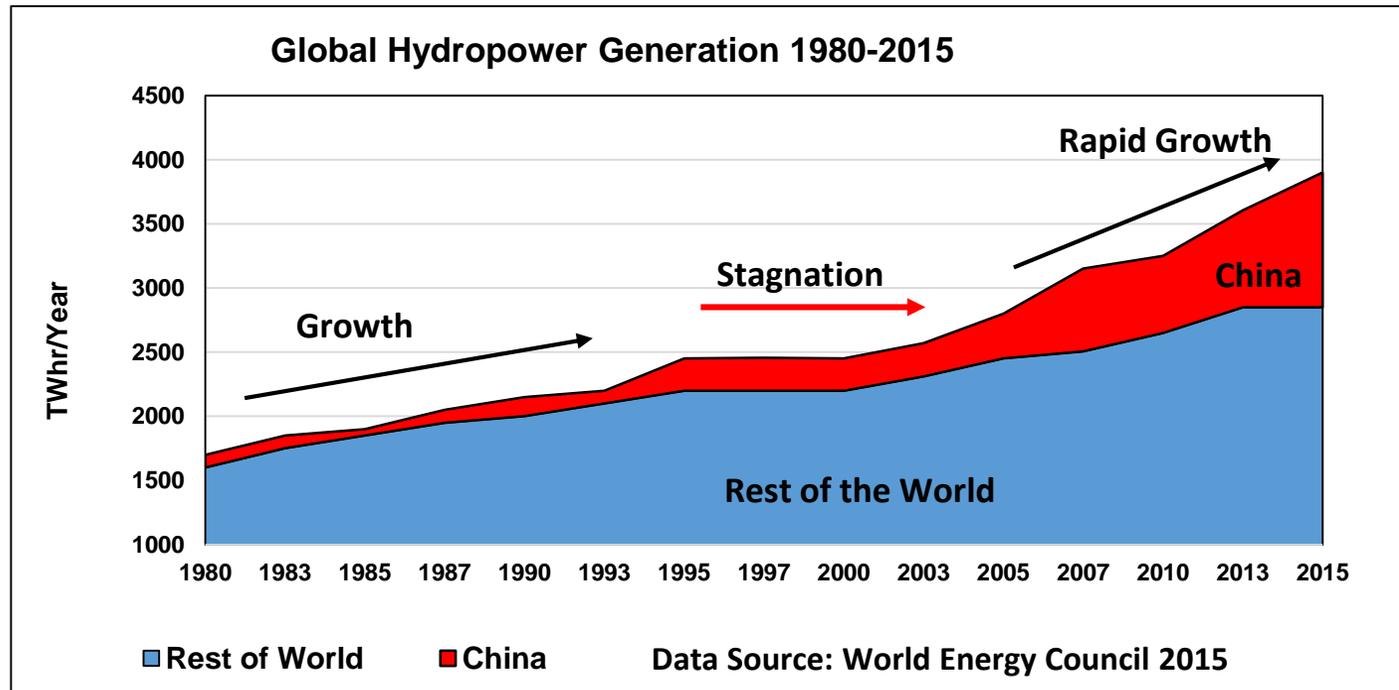
71% of Global Renewable Energy (Flexible Capacity)

Increases in Installed Capacity Between 1905-2015 = 39%

Projected Hydropower Demand = 1-4% / Year

By 2020 Winter Electricity Demand Will Decrease

Summer Demand is Expected to Increase by 9-11% (Air-Conditioning)



By 2040-2060: Expect a 60% Decrease in Capacity of Glacier Fed Reservoirs

Estimated No. of Air-Conditioning Units in the World
2018 = 1.6 Billion Units (Current Electricity Use 20%)
2050 = 5.6 Billion Units (Estimated Use in 2015 > 50%)

Data Source: International Energy Agency (IEA) 2018

Examples of Record Temperatures

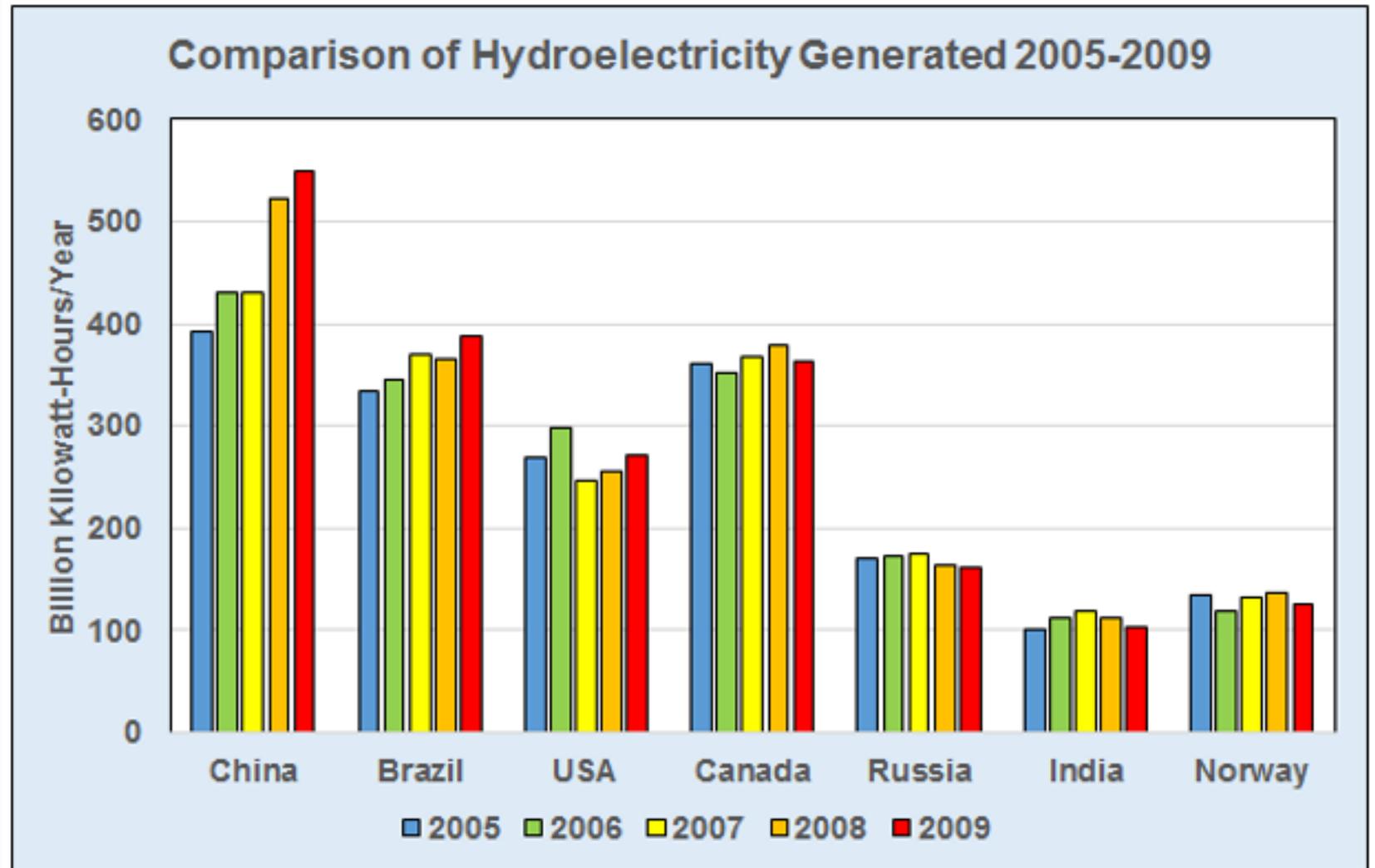
	Temp.	Population
2016 Phalodi, India	51°C	0.4 Million
Basra, Iraq	53.9	2.2 Million
Kuwait	54.0	4.0 Million
2017 Ahvas, Iran	53.7	1.1 Million
Turpan, China	50.5	0.6 Million
Oman	50.8	4.4 Million
2018 Nawabshah Pakistan	50.0	1.1 Million
Sydney, Australia	47.0	5.0 Million
Rajasthan, India	46.0	70 Million

Blood Temperature = 36-37 °C
Sauna Temperatures = 40 + Degrees

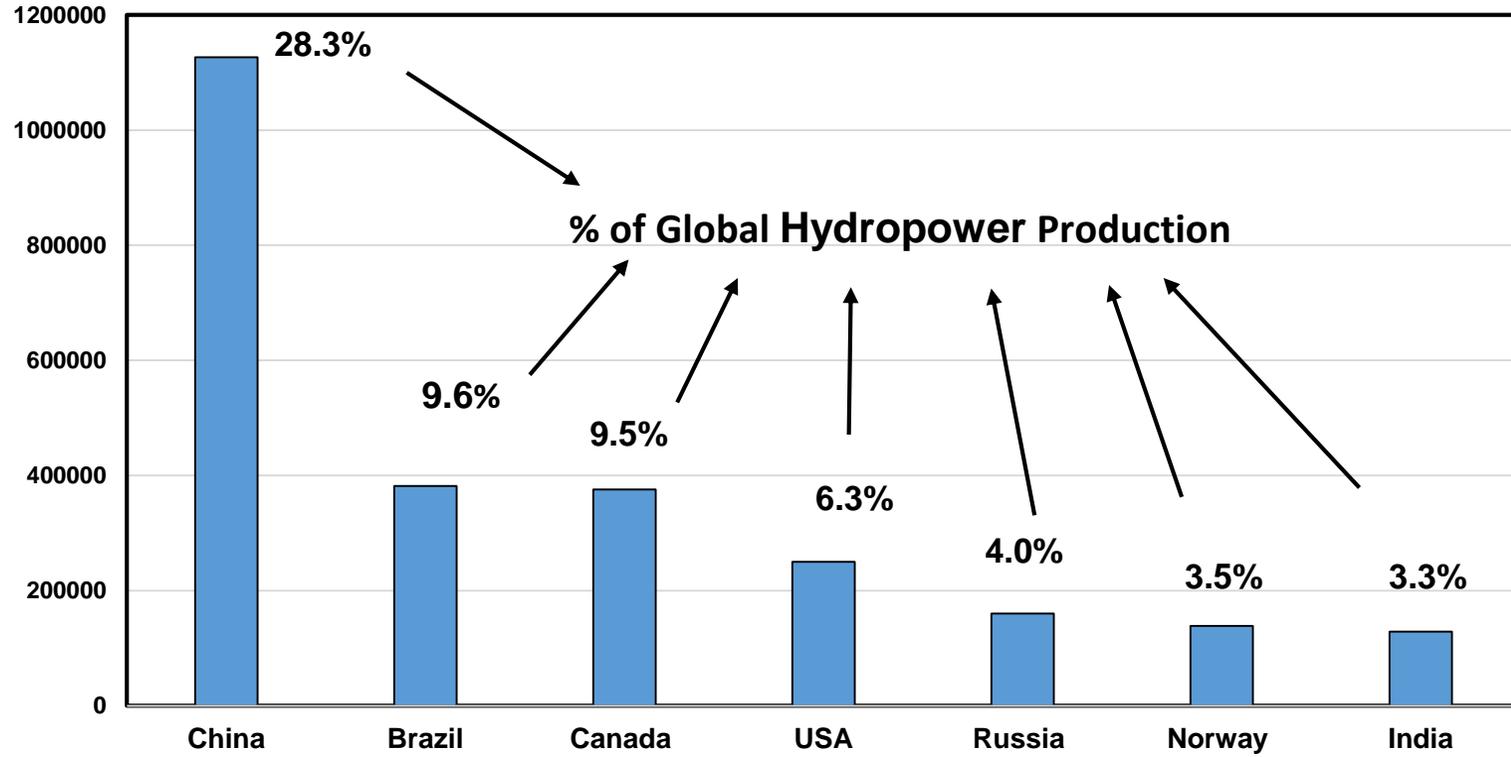
Air Conditioning is Critical Above 45°C



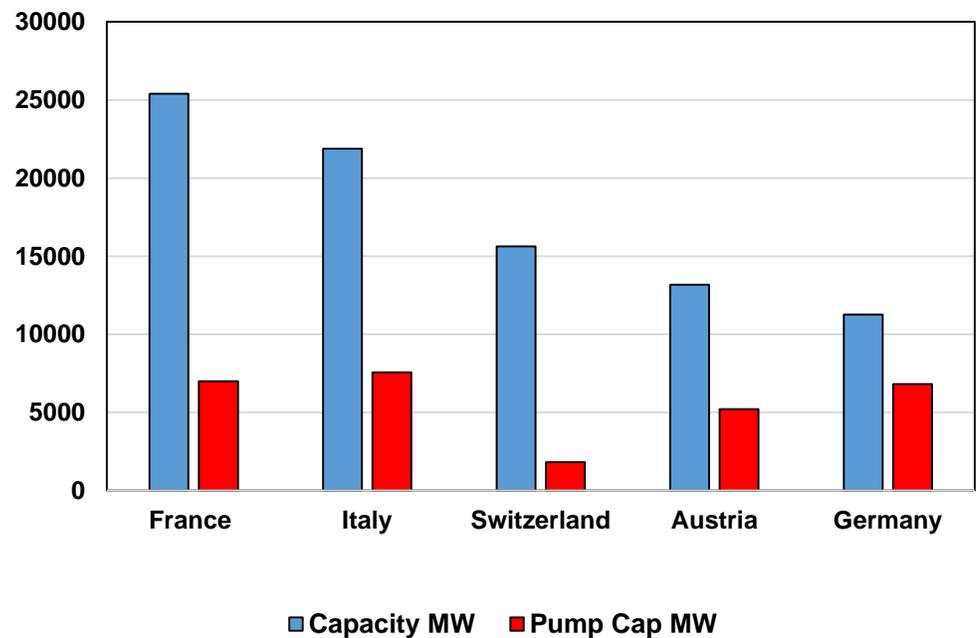
Changes in Hydropower Electricity Generated 2005-2009



Estimated Generation of Hydropower in 2015 in GWh



Hydropower Capacity in Central Europe and Pump Storage Capacity in 2015 in MW

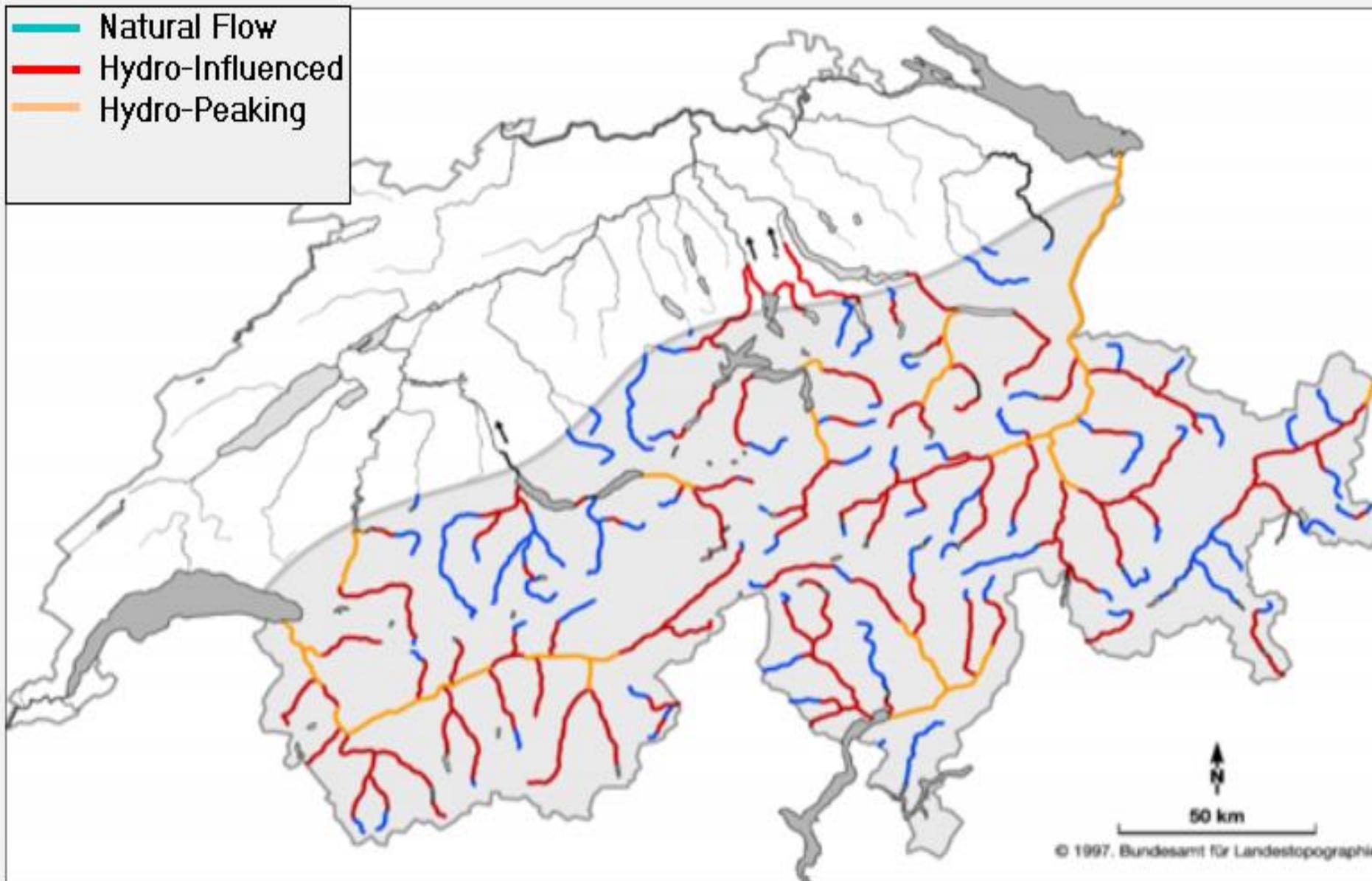


What does this traffic sign indicate ???



Discharge Regime in Swiss Rivers

- Natural Flow
- Hydro-Influenced
- Hydro-Peaking



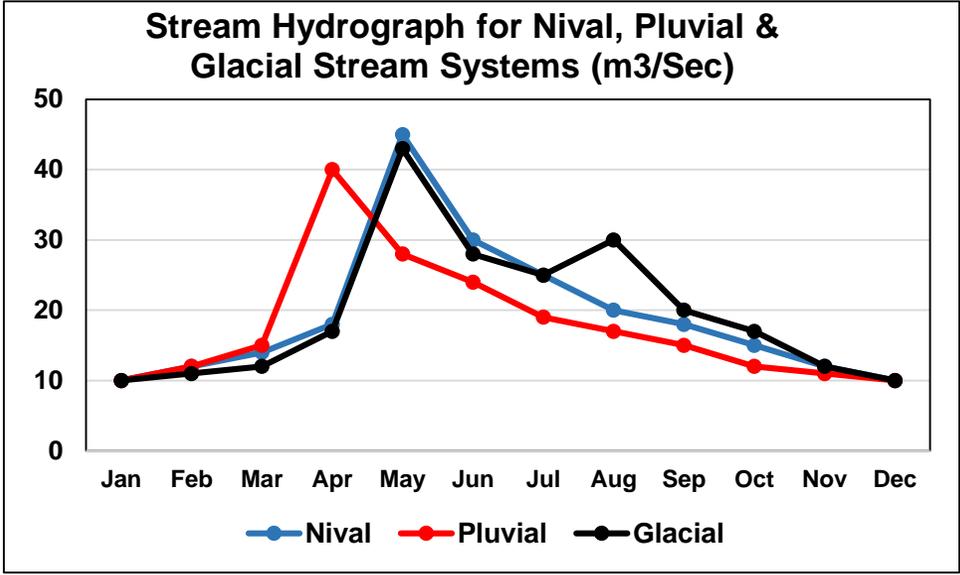
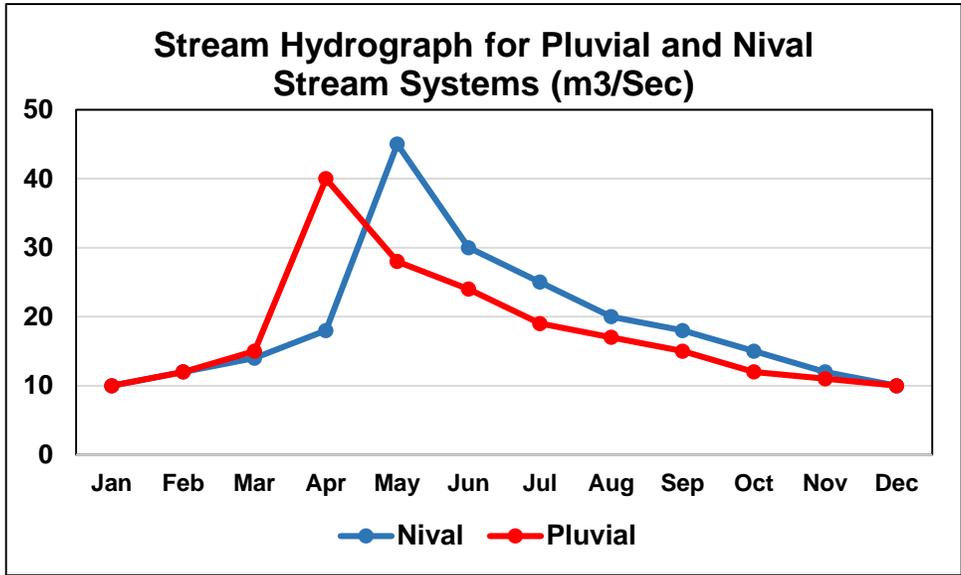


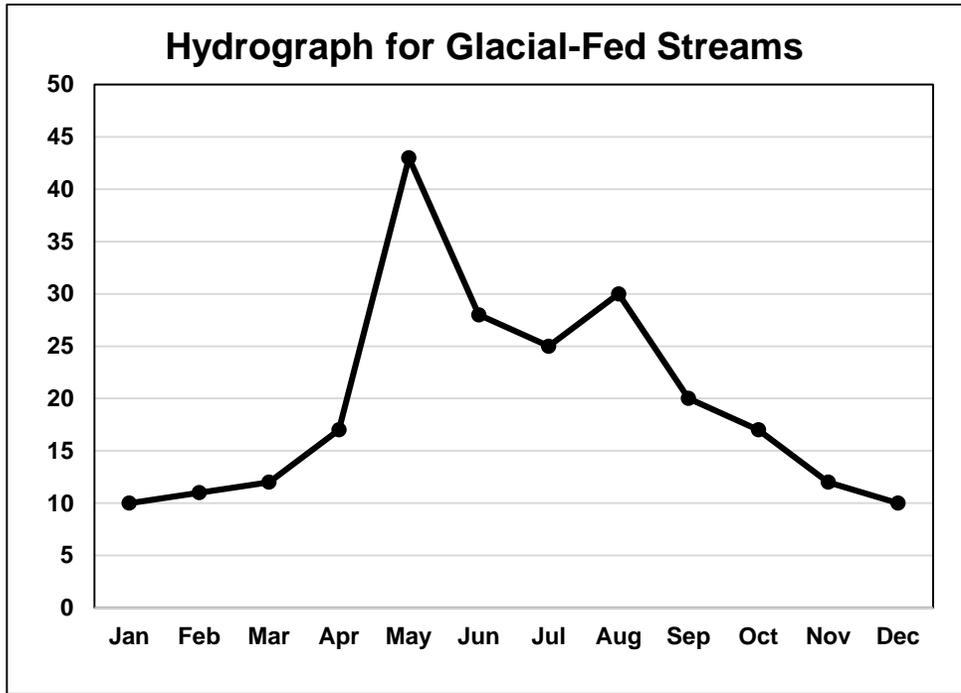
4th Largest River in North America
900 m Vertical Gradient
Average Discharge = 7500 m³/sec

Has 450 Dams for Hydropower Generation
Canadian Portion 15% of River Basin
Provides 40% of Annual Discharge

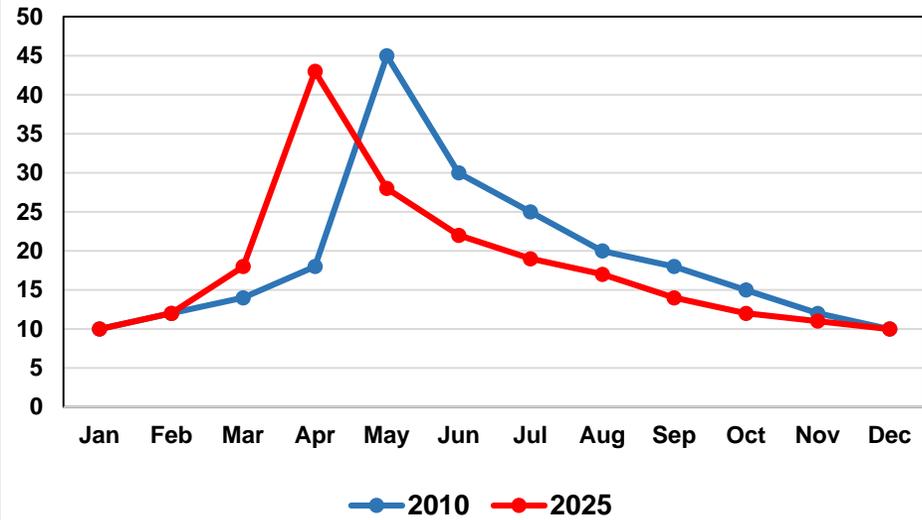
% of Large Free Flowing Rivers Remaining in the World	
Asia	37%
South America	54%
North America	18%
Africa	35%
Europe	28%
S-Pacific	43%

Data Source: WWF 2017

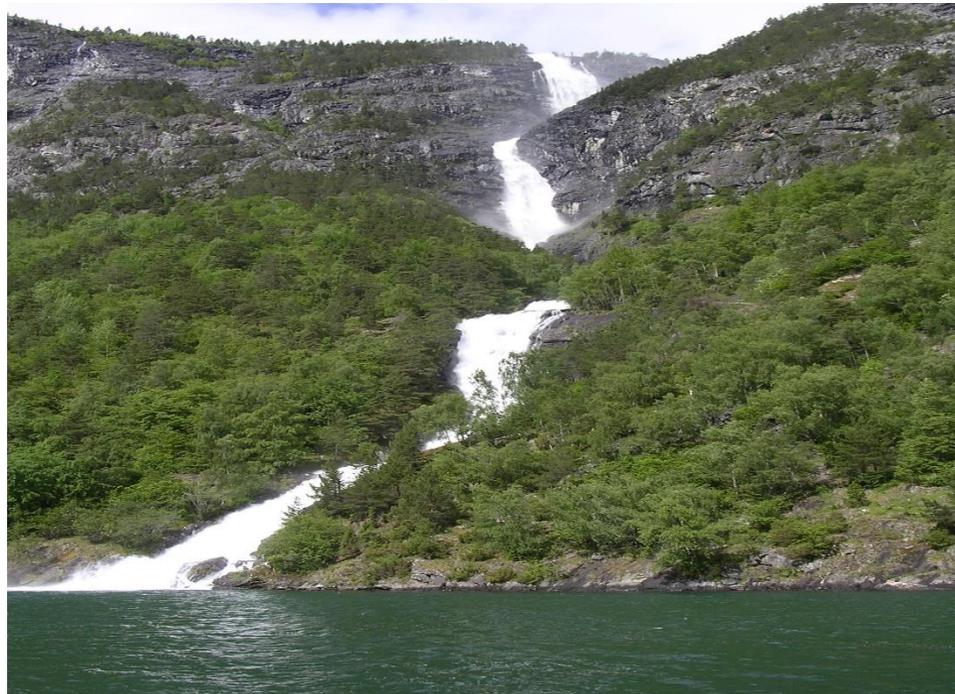
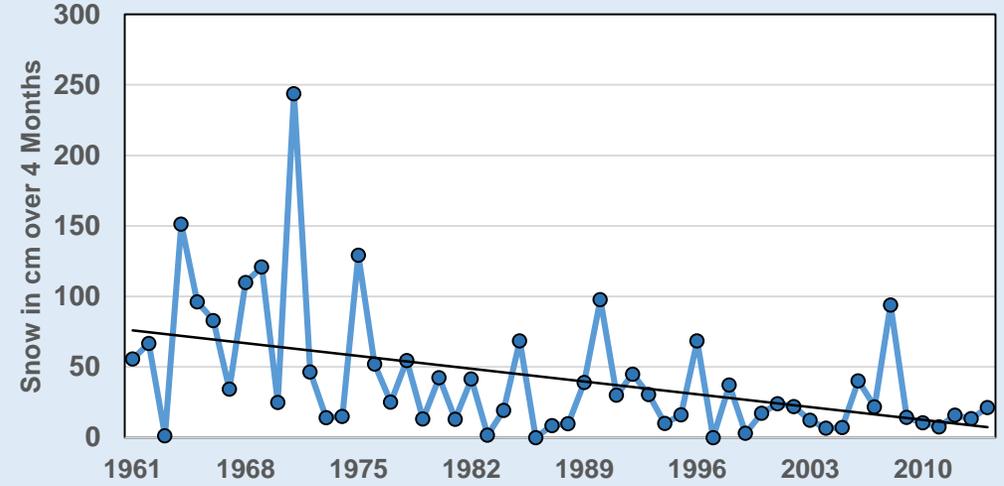




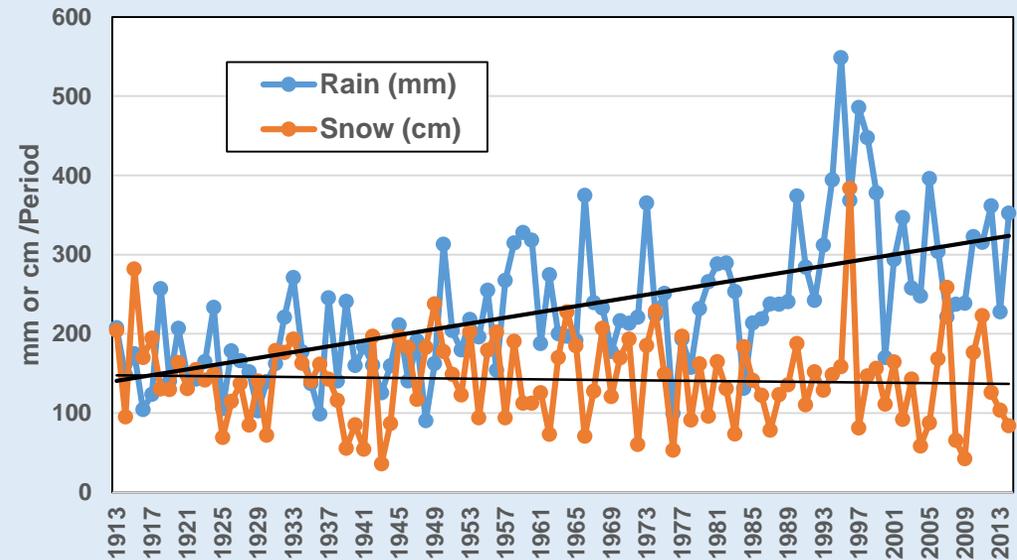
Shift in Pluvial and Nival Stream Hydrographs 2010-2025



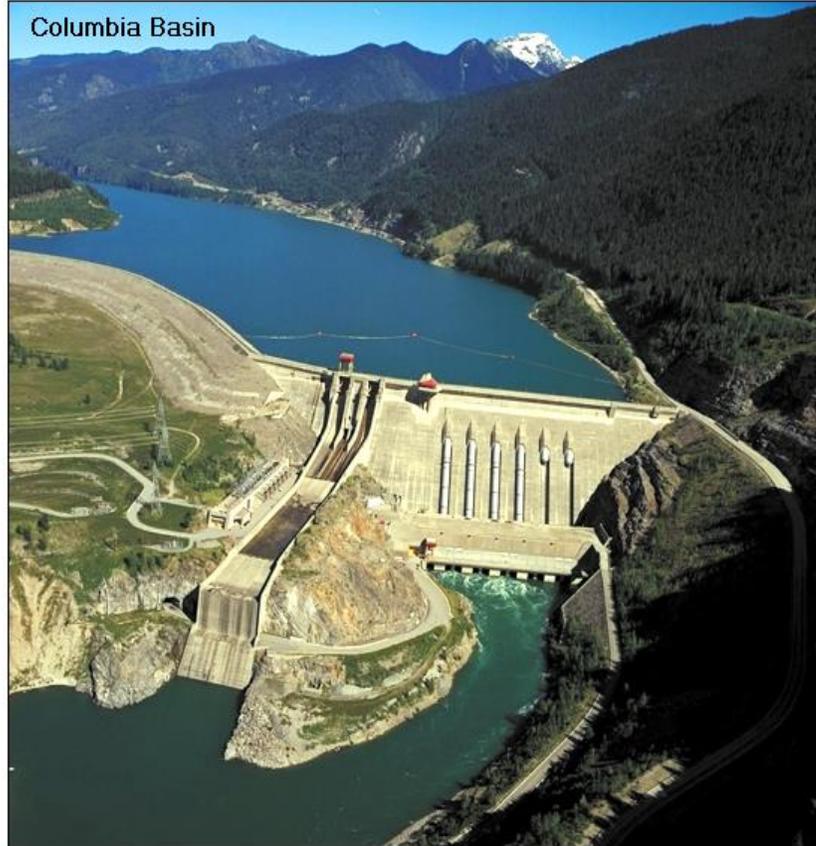
Changes in Winter Snow Accumulation (Nov-Feb) in Gibsons, B.C. 1961-2015

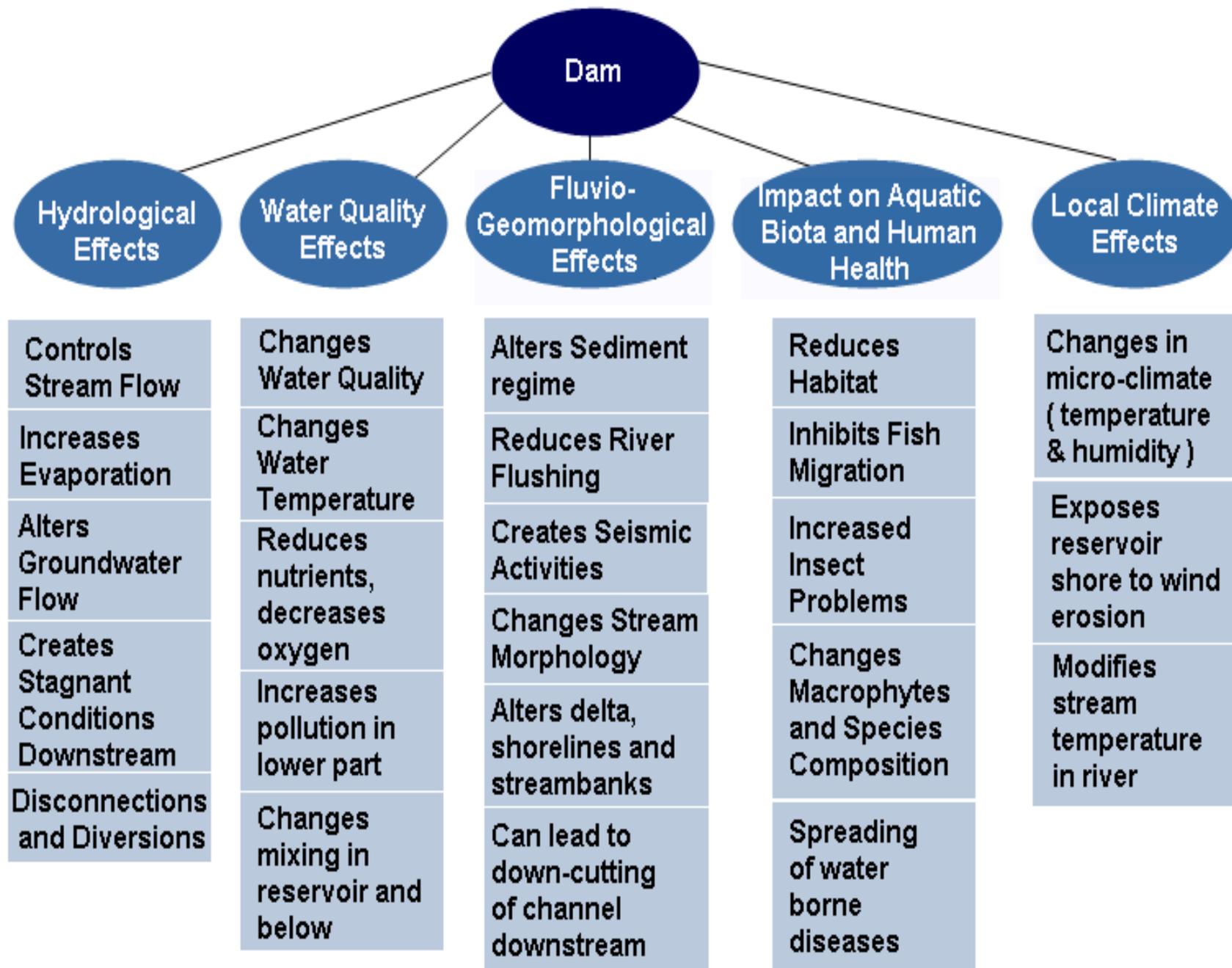


Long Term Trends in Winter Rain & Snow Accumulation in Creston, B.C. (Oct-April) 1913-2015



Impact of Hydropower







Kulekhani Hydropower Project, Nepal

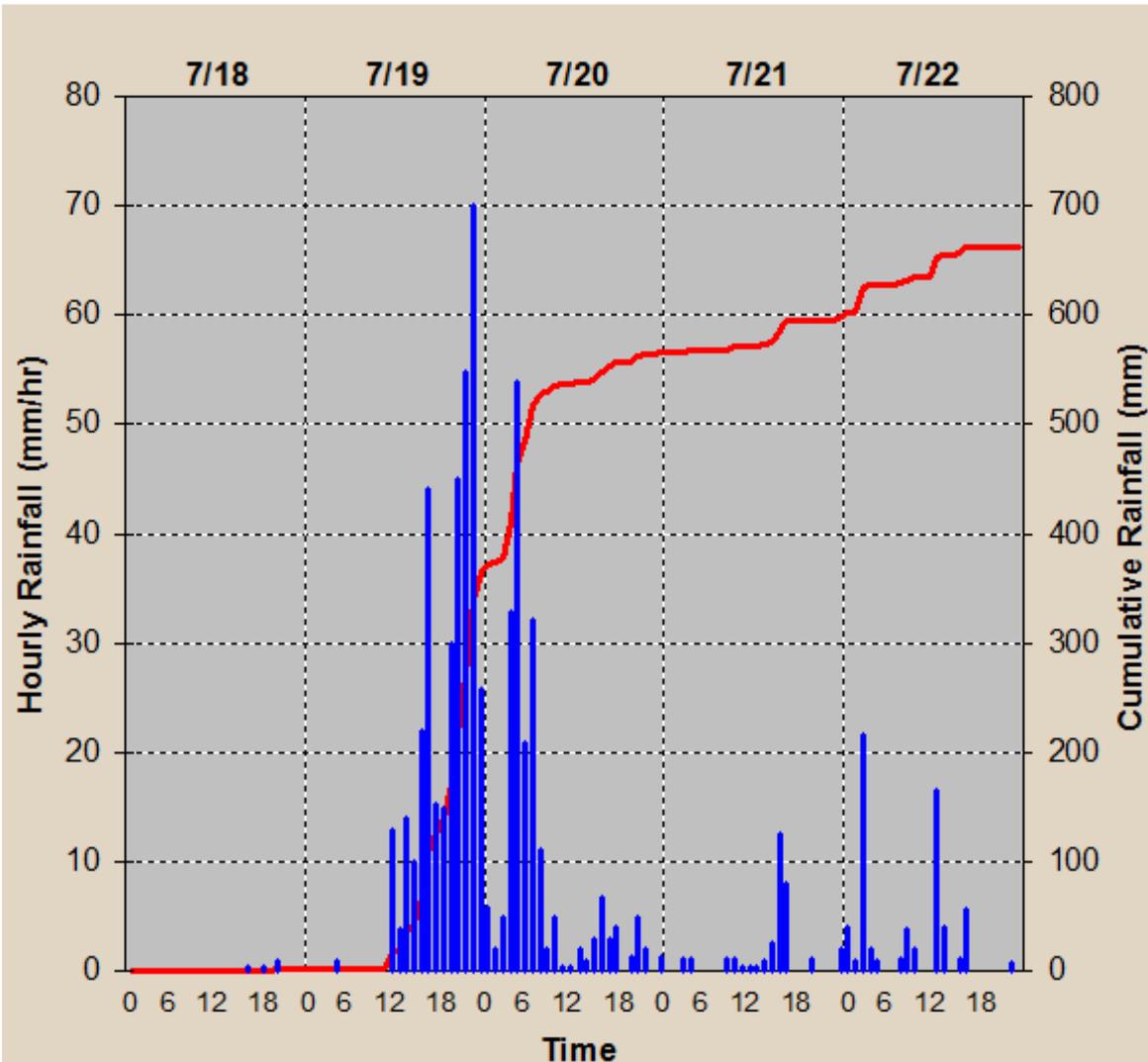
Height	150m	Estimated Sediment Production: a) At Construction Time 1982 : 11.2 t / ha / Year b) Averages Rate 1982-1992 : 20-45 t / ha/ Year (based on reservoir sonar surveys, Galay et al. 1995.)
Reservoir storage	85 million m ³	
Reservoir length	approx. 8000m	
Power production	92 MW	
Completed	1982	
Watershed Area	125 km ²	



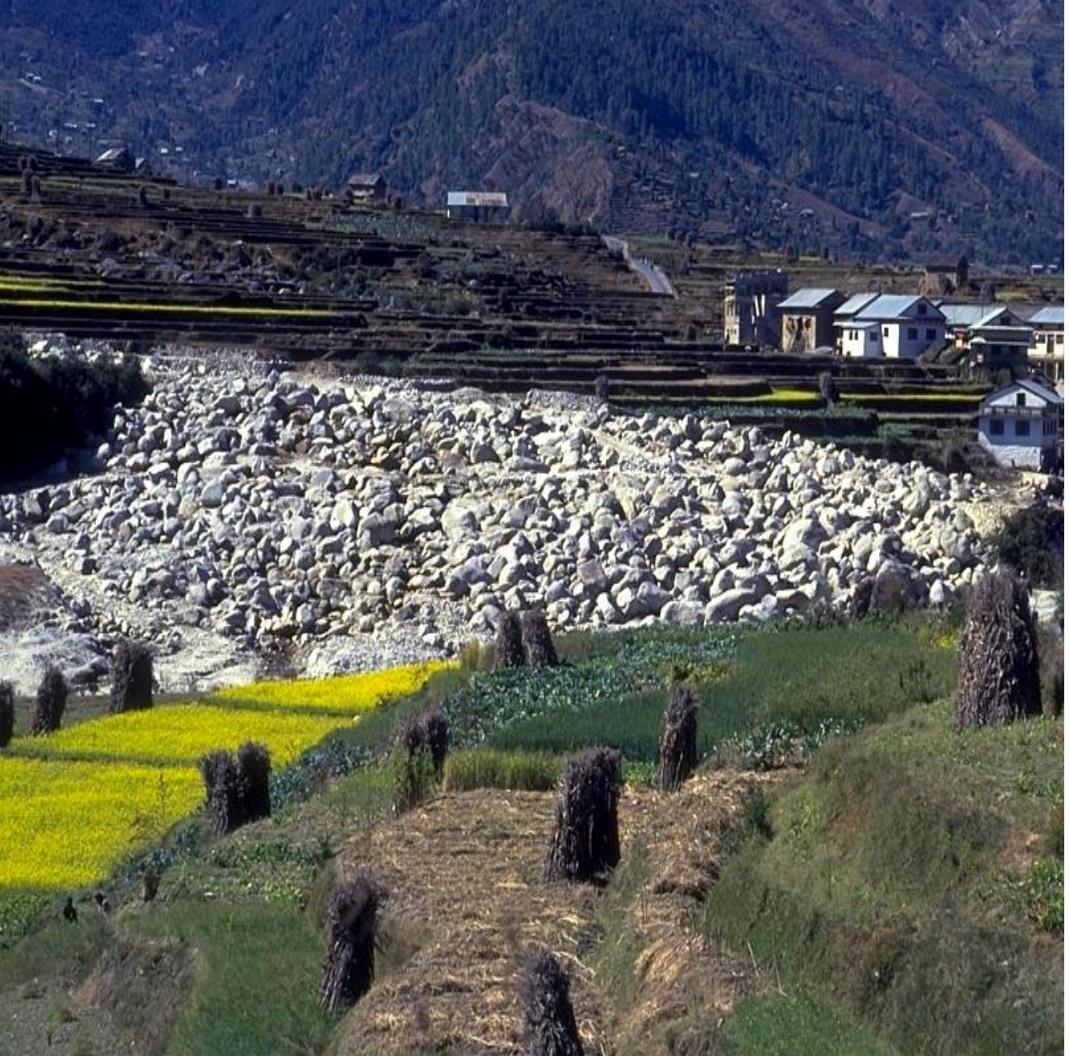
1993 Rainstorm Event

Total Rainfall in 24 hours : 540 mm

Max Rainfall / hour: 70 mm





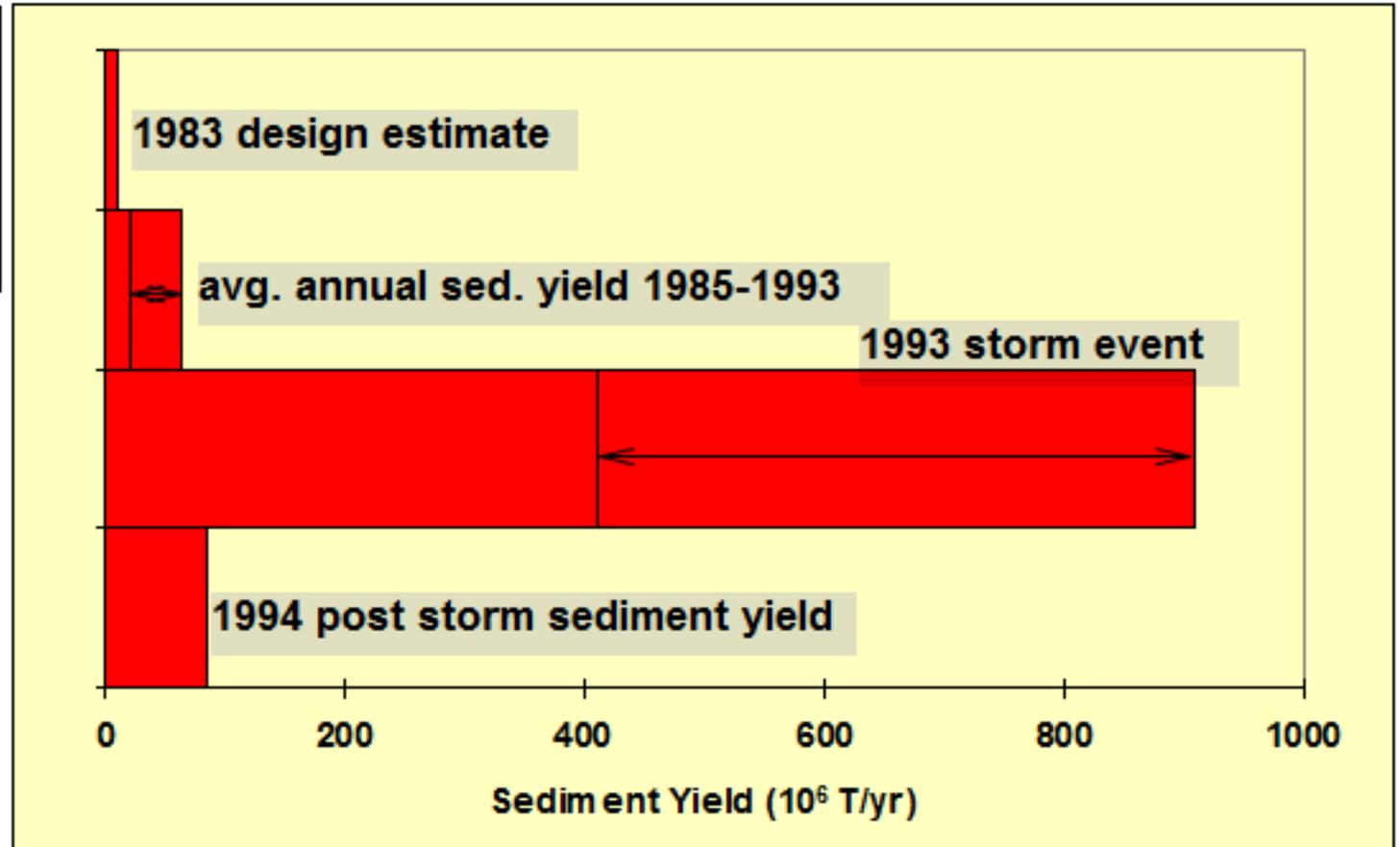


Sediment Accumulation History

Sediments accumulate in the reservoir were measured regularly with sonar profiling

1993 storm characteristics:

- 540 mm total rainfall in 24 hrs
- up to 70 mm/hr rainfall intensity
- more than 1000 landslides
- up to 47 slides/km² in some areas
- return frequency of storm <100 years, maybe < 50 years



Life-Time Reduction of Reservoir = 20-25 Years

Benefits

Provides Flexible Electricity

Reliable Supply of Water for Irrigation and Domestic Use

Can Enhance Water Based Recreation (Fishing, Boating, Swimming)

Can Mitigate Summer Water Temperatures by Releasing Water from Depth of Reservoir

Can Mitigate Flooding Risks

Minimizes CO₂ Emissions

Impacts

Loss of Agricultural Land & Displaces People

Reduces Sediment and Nutrient Supply Downstream

Obstruction of Fish Migration Changes Aquatic Organisms, Habitat and Biodiversity

Water Pollution Impacts

Changes Streamflow Pattern

Safety Issues & Effects of Increased Climatic Variability