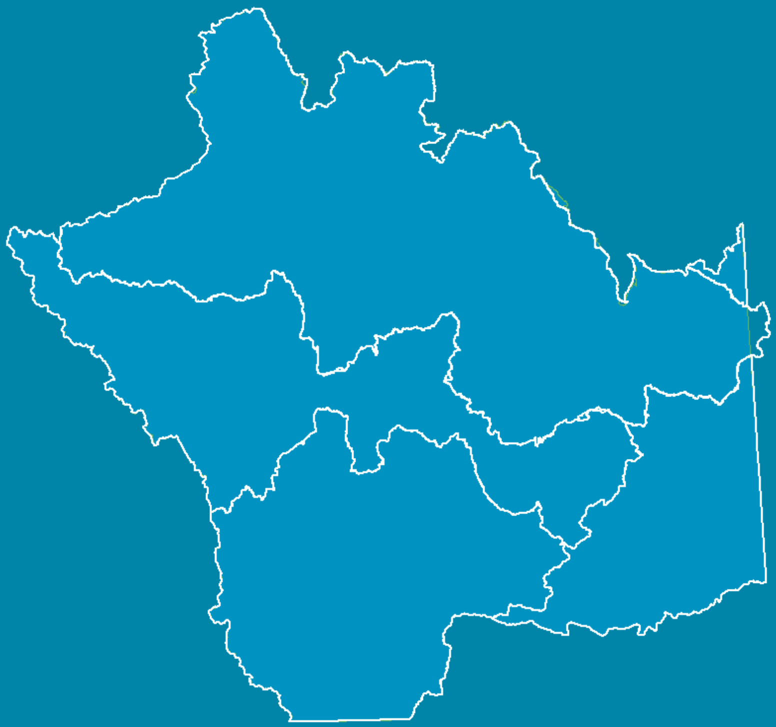
Naturalization of Flow for the South Saskatchewan River Basin in Alberta



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November 27, 2019

Presentation Overview

- What is flow naturalization
- Why we need naturalized flow
- The study area
- Previous and current studies
- Data requirement
- Methodologies/model used
- Challenges faced
- Latest update

What is Flow Naturalization

- Flow naturalization process consists primarily of removing the effects of anthropogenic influences from the recorded flows.
- Examples of anthropogenic interferences:
  - reservoir regulation (storage, release, net surface evaporation)
  - water withdrawals/diversions
  - return flows
- Project Depletion Method:

  Natural Flow = Recorded Flow + Net Depletion

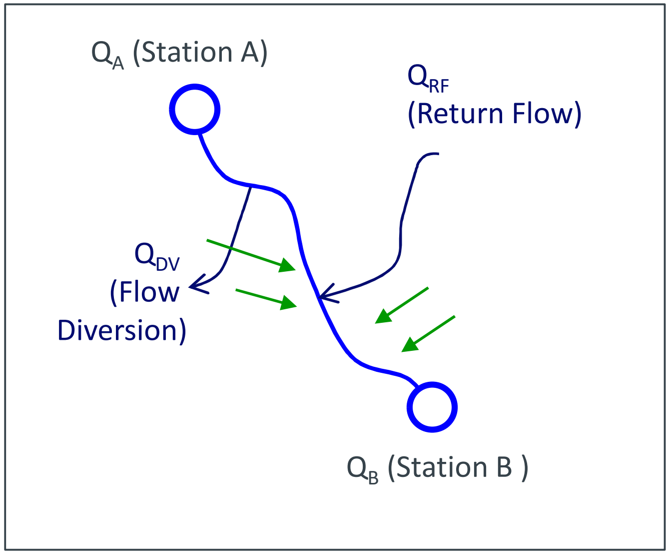
Flow Naturalization

$$Q_{B(N)} = \underbrace{\underbrace{Q_{B(R)} + \sum (Q_{DV})_i - \sum (Q_{RF})_i}_{\textit{No upstream reservoir}} + \sum EP_i + \sum \Delta S_i}_{\textit{Includes upstream reservoir}}$$

(Wurbs, R. A., 2006)

Where,

$Q_{B(N)}$	Naturalized flow
$Q_{B(R)}$	Gaged regulated flow
$(Q_{DV})_i$	Diversion upstream of gage flow
$(Q_{RF})_i$	Return flow upstream of gage flow
EP_i	Reservoir evaporation less precipitation
ΔS_i	Change in storage in reservoir

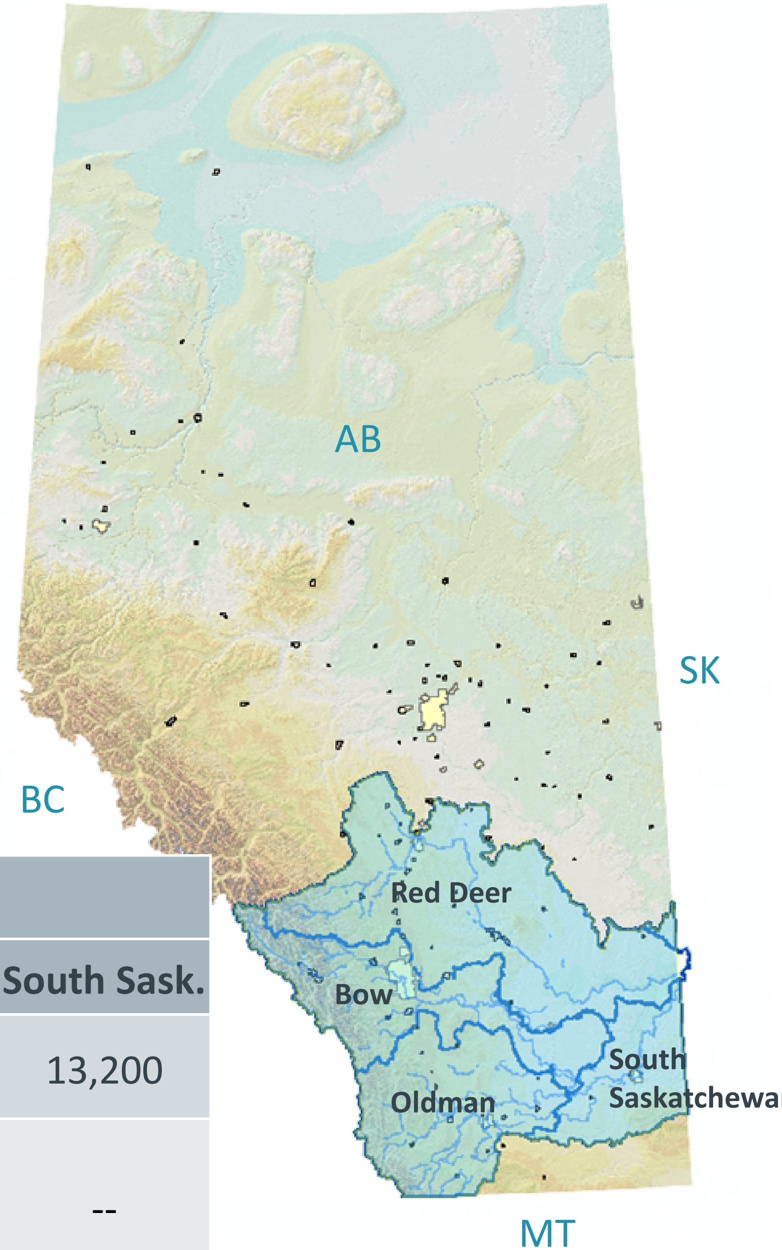


Why We Need Naturalized Flow

- South Saskatchewan River Basin (SSRB) is a highly regulated river basin
- Natural flows of SSRB are heavily allocated
- Naturalized flow information is:
  - Used to understand the impact of flow regulation and water uses on the streams
  - Used to support surface water management
  - Used to understand performance of Instream Objectives and Water Conservation Objectives
  - Used by our department to simulate water management scenarios for planning purposes using Water Resources Management Model (WRMM, WRM-DSS)
  - Used by Universities, consultants, researchers for hydrological studies
- Naturalized flows are estimated along the major rivers and their major tributaries

Study Area

- SSRB includes:
  - Red Deer River sub-basin
  - Bow River sub-basin
  - Oldman River sub-basin
  - South Saskatchewan River sub-basin
- Hydrological and meteorological characteristics of the sub-basins are influenced by the elevations, topography and landscape features



	Sub-basins			
	Red Deer	Bow	Oldman	South Sask.
Gross Drainage Area (km^2)	46,800	25,300	27,500	13,200
Median Annual Natural Flow Volume (dam^3)	1,666,000	3,829,000	3,343,000	--

Source: South Saskatchewan River Basin in Alberta, Water Supply Study, 2009

Alberta

Bow River Headwater

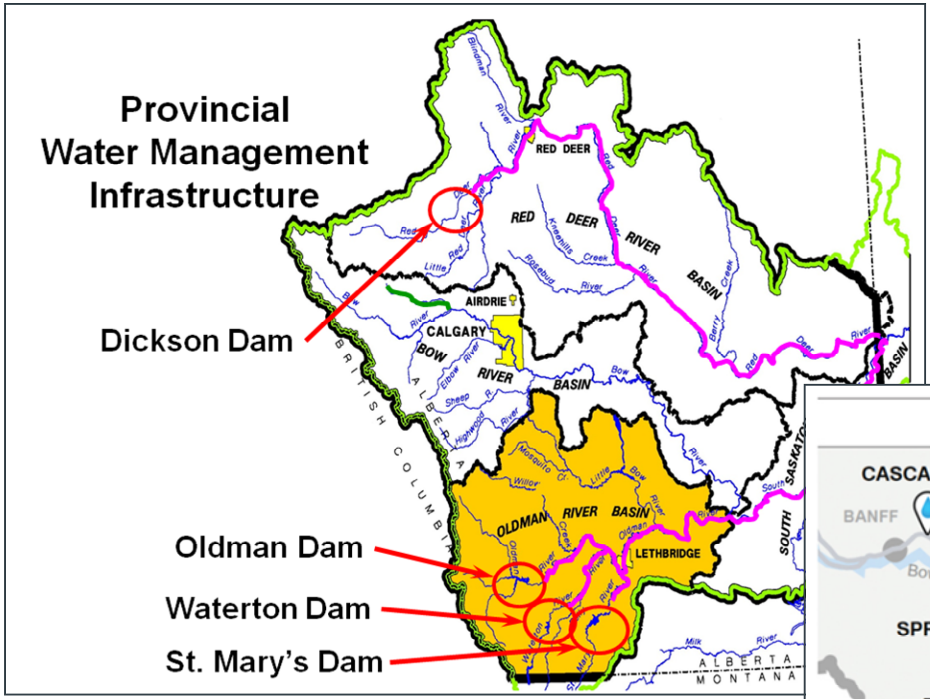
Previous and Current Studies

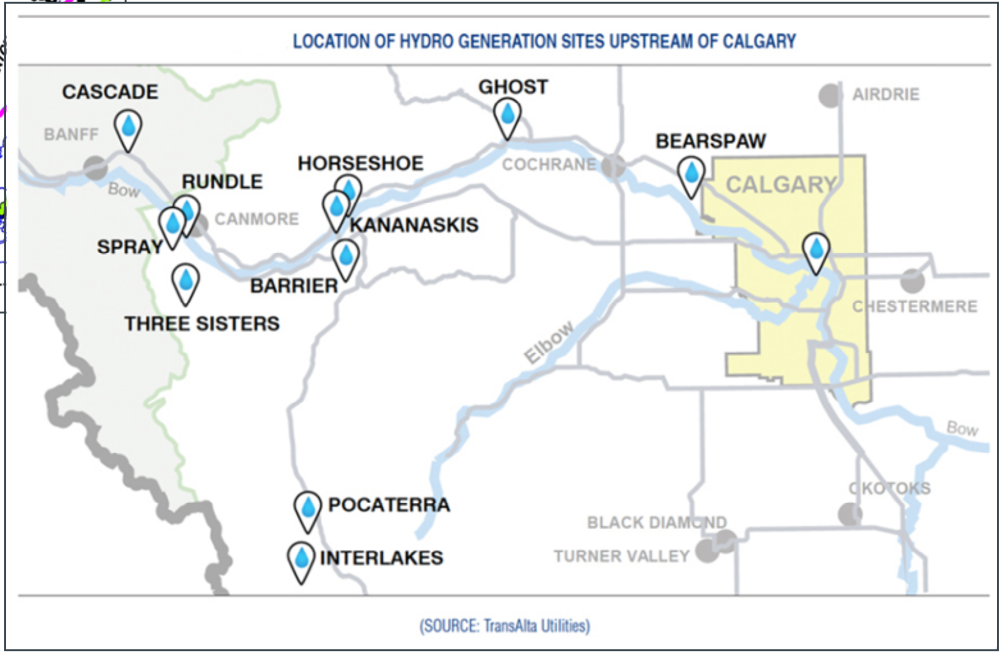
- Previous Studies:
  - 1912-1978
  - 1912-1995
  - 1995-2001
  - 2002-2009
- Tool: WISKI Model (Hydstra Model), Windows based model with GUI
- Ongoing Update: 2010-2015

Major Projects Affecting Streamflow

- Reservoir operation (15 reservoirs)
- Diversion from 13 Irrigation Districts
- Irrigation Return Flows
- Major Municipal users (diversion and return flow)
- Highwood River diversions
- Major Licences (agricultural, industrial, recreational, environmental etc.)

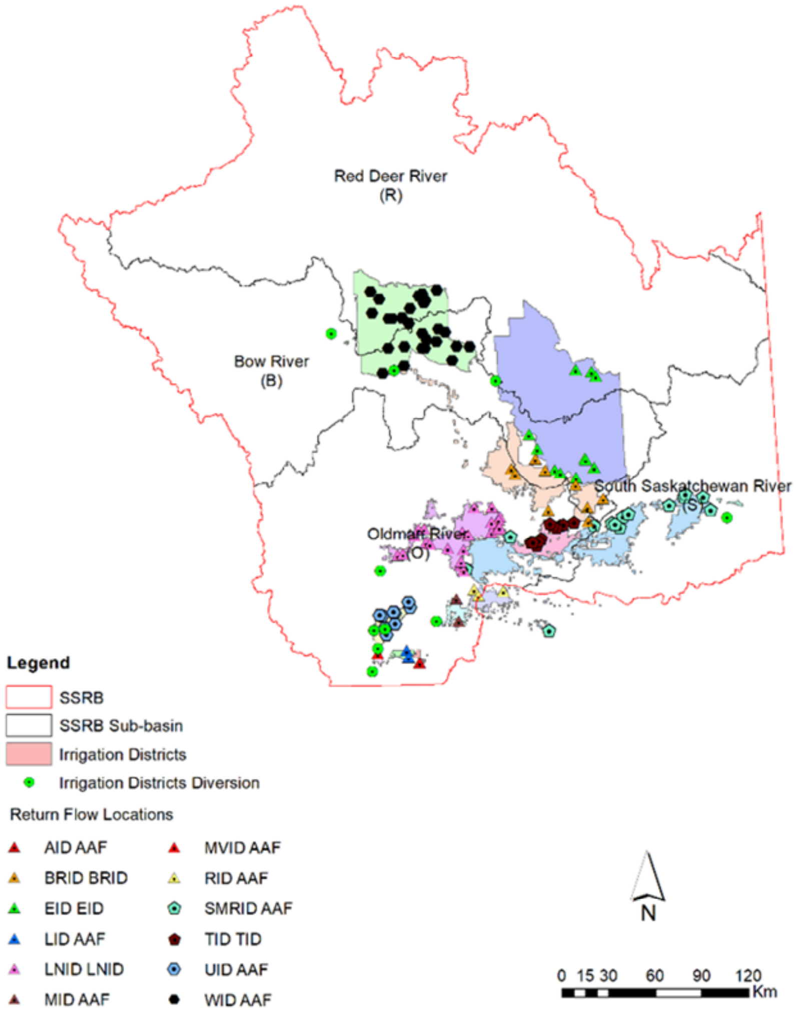
Reservoir Operation





Irrigation Districts

- Alberta represents two-thirds of irrigation developments in Canada
- 1.3 million acres (out of approx. 1.6 million acres in AB) are located in 13 Irrigation Districts within SSRB
- Water diversions are made from 22 locations by Irrigation Districts
- 80 return flow points within the basin
- Diversion from one or multiple sub-sub-basins, return to one or multiple sub-basins



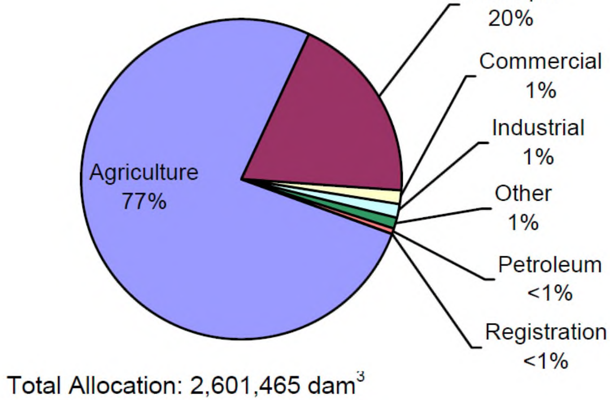
Alberta

Major Municipal users (diversion and return flow)

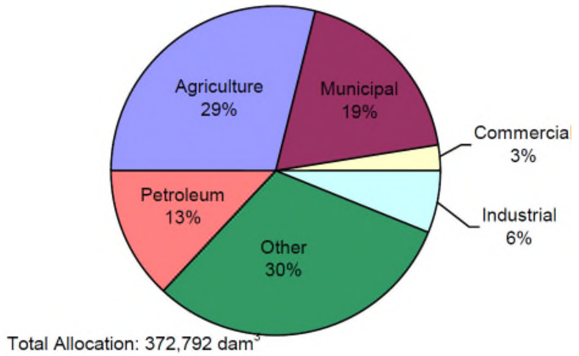
- Almost 48% of the province's population live in SSRB
- Highest population density is in Bow River sub-basin
- Major cities and Towns are:
  - Calgary, Red Deer, Lethbridge, Medicine Hat, Drumheller, Cochrane, Airdrie, Cardston, High River, Okotoks etc.

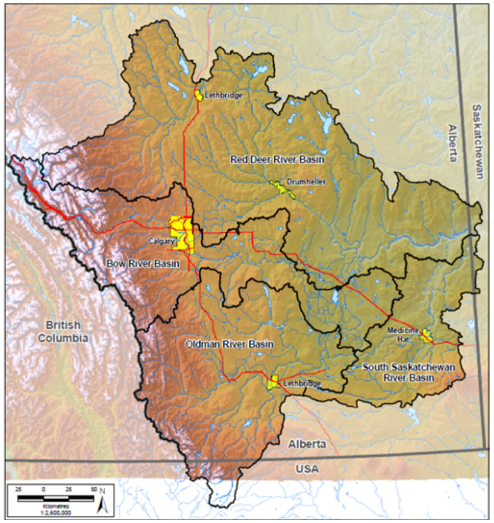
Allocation Distribution

Bow

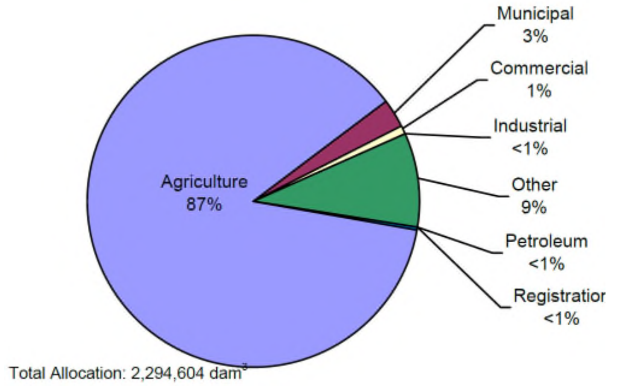


Red Deer

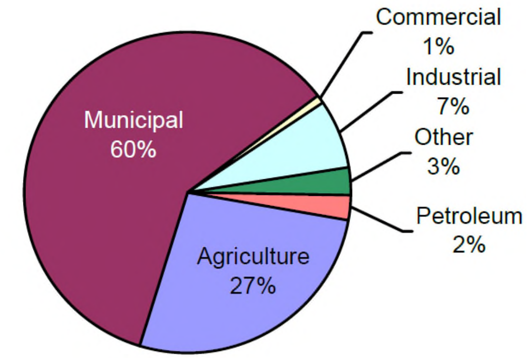




Oldman



South Saskatchewan

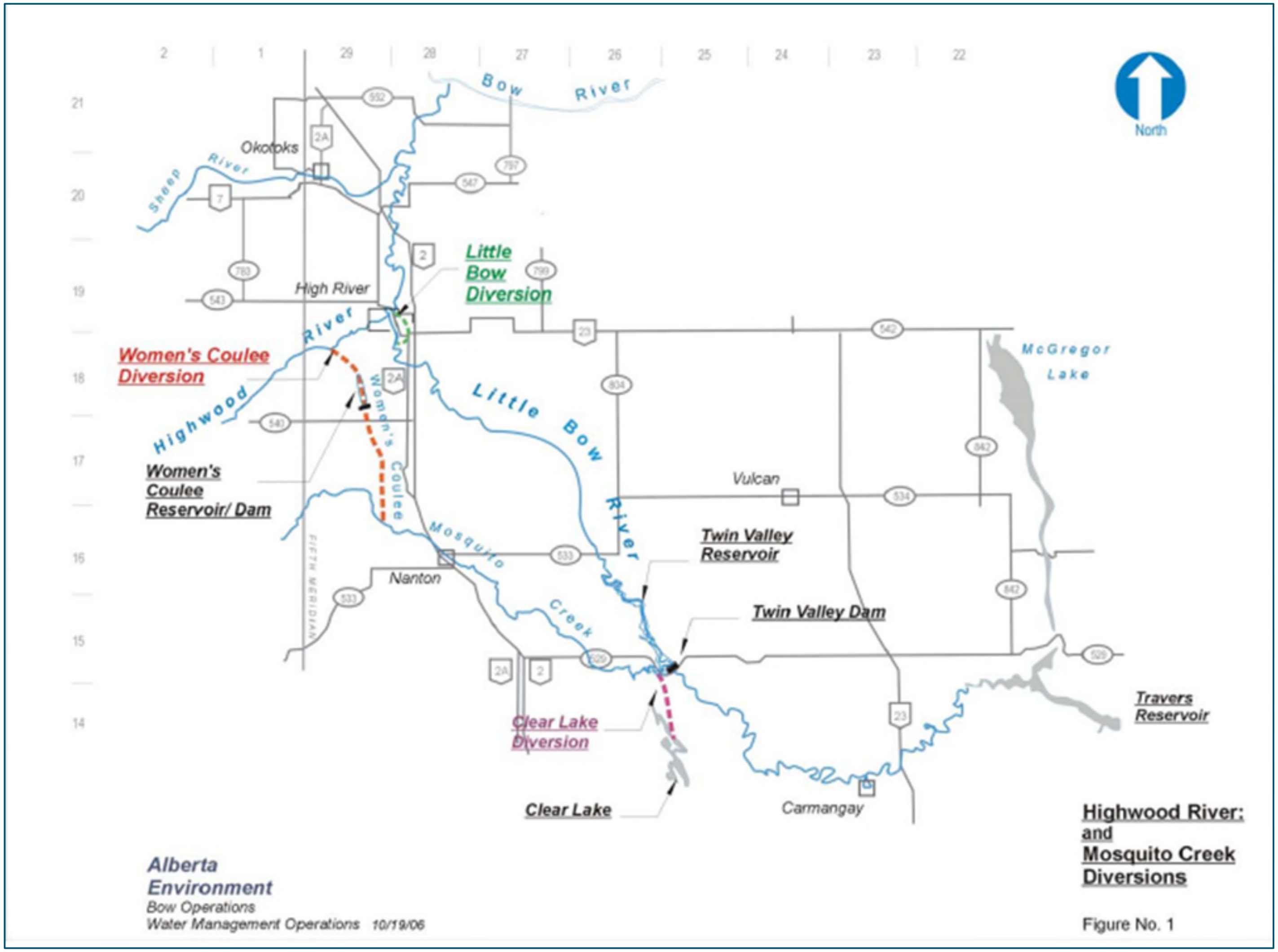


Total Allocation: 285,874 dam^3

2007 snapshot of active water allocation

Alberta

Highwood Diversion



Models

- Eight Sub-models
  1. Belly River
  2. St. Mary River
  3. Willow Creek
  4. Oldman River
  5. Upper Bow River
  6. Lower Bow River
  7. South Sask. River
  8. Red Deer River

Data Requirement

Data Type	Data Layer	Data Source	No. of Stations/ Locations	Data Frequency
Hydrometric	Recorded Stream Flow	Water Survey of Canada (WSC)/ Trans Alta Utilities (TAU)/ Alberta Environment and Parks (AEP)	127	Daily
Climate	Precipitation, Temperature (Max, and Min), Relative Humidity (%), and Estimated Solar Radiation	Alberta Agriculture and Forestry (AAF)	Townships (16)	Daily
Reservoir	Reservoir Water Elevation	WSC/ TAU	16	Daily
	Area Elevation Storage	WSC/TAU/AEP	16	Relationship
	TDS (Dissolved Solids)	Alberta Environment and Parks	16	Mean
Water Use	Irrigation District Diversion	WSC/ Irrigation Districts	22	Daily
	Irrigation District Return Flow	Alberta Agriculture and Forestry/ Irrigation District	80	Daily
	Municipal Water Use	Various Municipalities	13	Daily/ Monthly
	Other Major Diversion and Return	Specific Water Users	-	Daily/ Monthly
Topographic	DEM data	Alberta Environment and Parks		

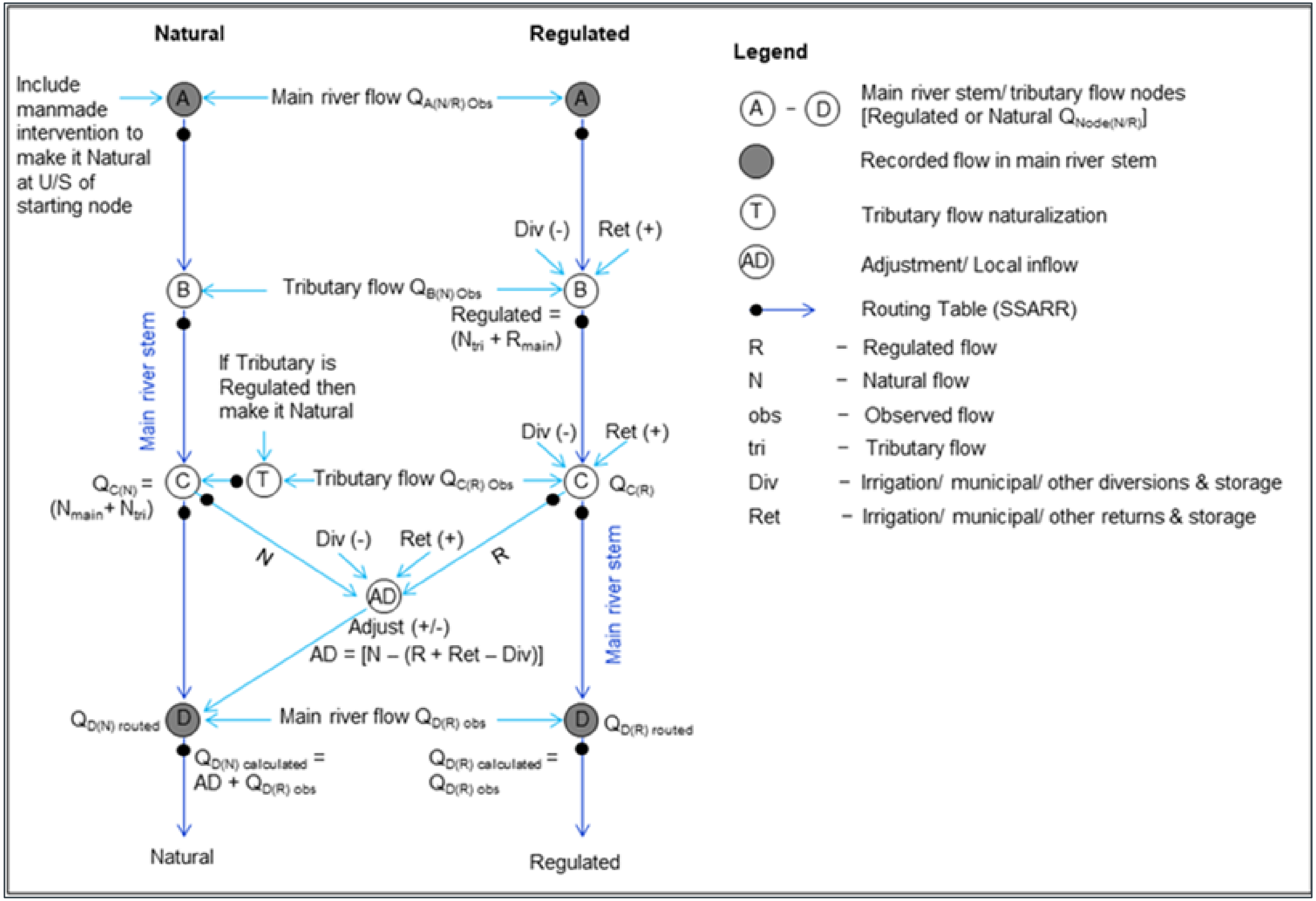
Methodology

- Methodology: Project Depletion method
- The process starts with the recorded flows monitored by Water Survey of Canada
- Data gap fillings are done for the seasonal stations (winter data gap) and stations with missing data
- Deep lake evaporation data for reservoirs are calculated using the climate data
- Input data (flow, water level, water use, evaporation) for the models are in daily time steps
- Flows are routed downstream using WISKI (Hydstra) natural flow model
- Routing is done using U.S. Army Corps of Engineers Streamflow Synthesis and Reservoirs Regulation (SSARR) model

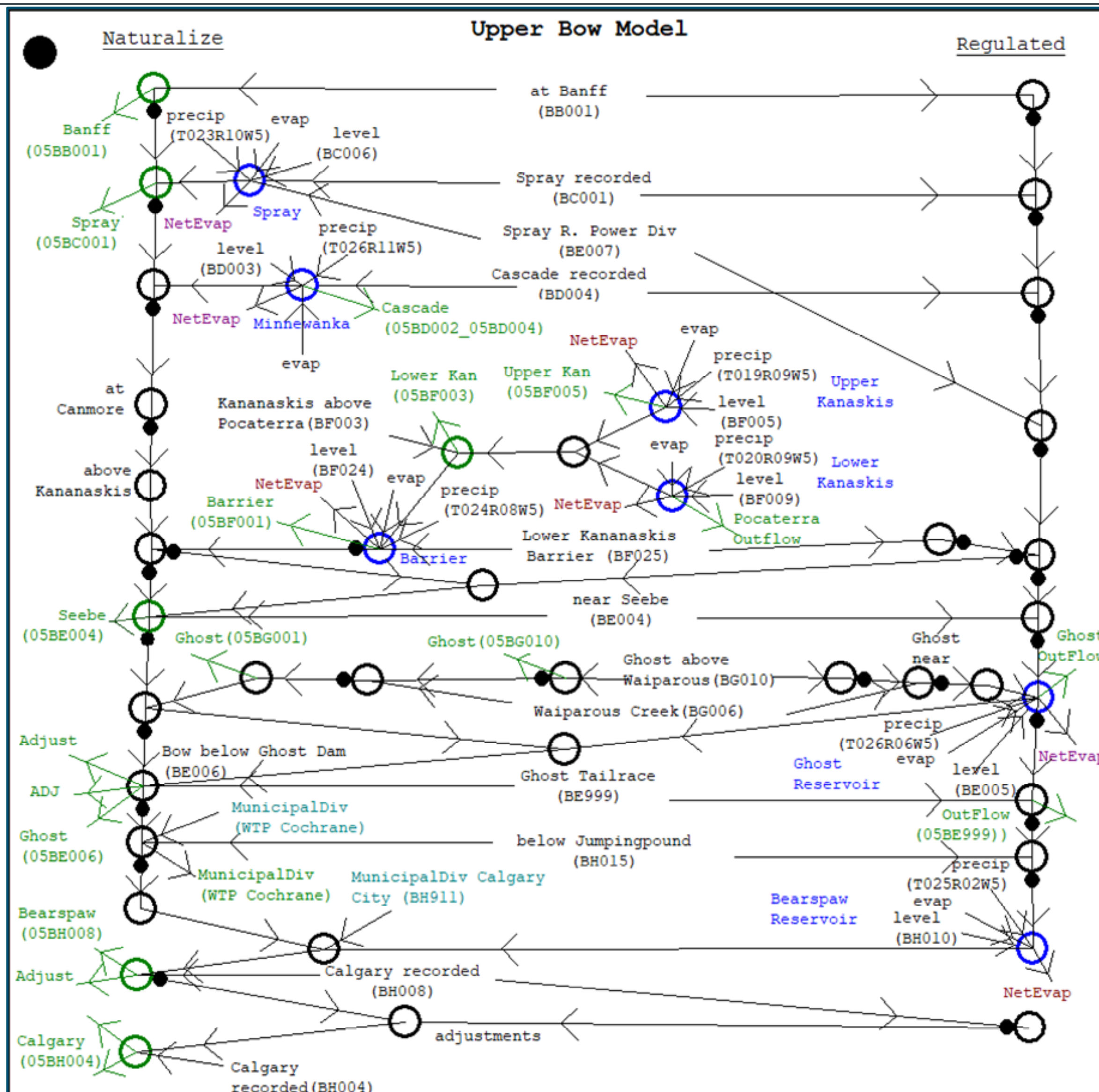
Methodology

- Adjustments are made along the stream network for anthropogenic influences such as reservoirs, municipal withdrawals and return flows, irrigation district withdrawals and return flows and other major uses
- Estimates of natural flow are done at flow gauging locations
- Estimates of natural flow are also done at additional sites of interests (ungauged locations)
- Much of the estimation is conducted using the WISKI (Hydstra) natural flow model,
- Desktop calculation is required for areas not incorporated into the model

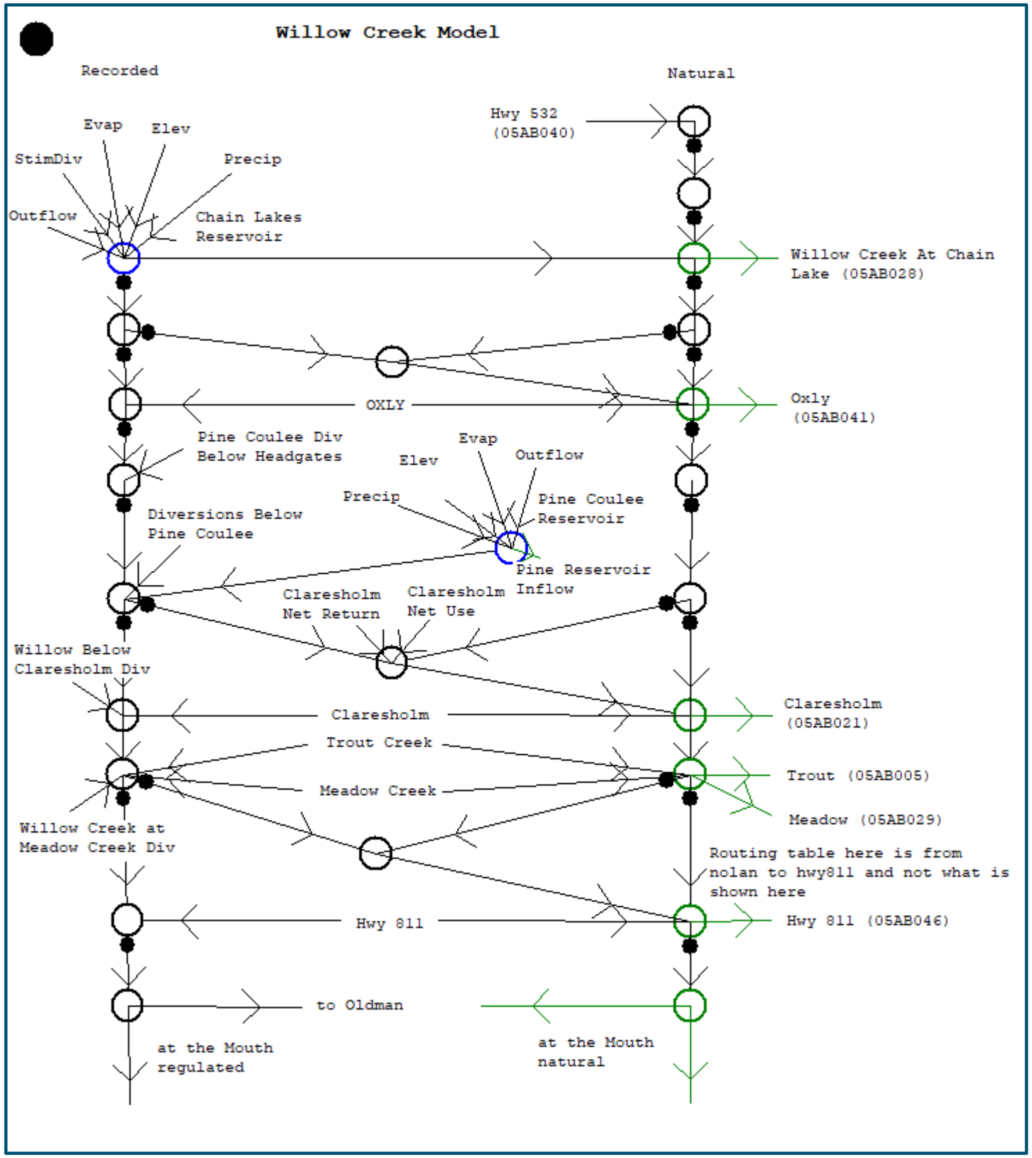
Modelling Concept



Model Example



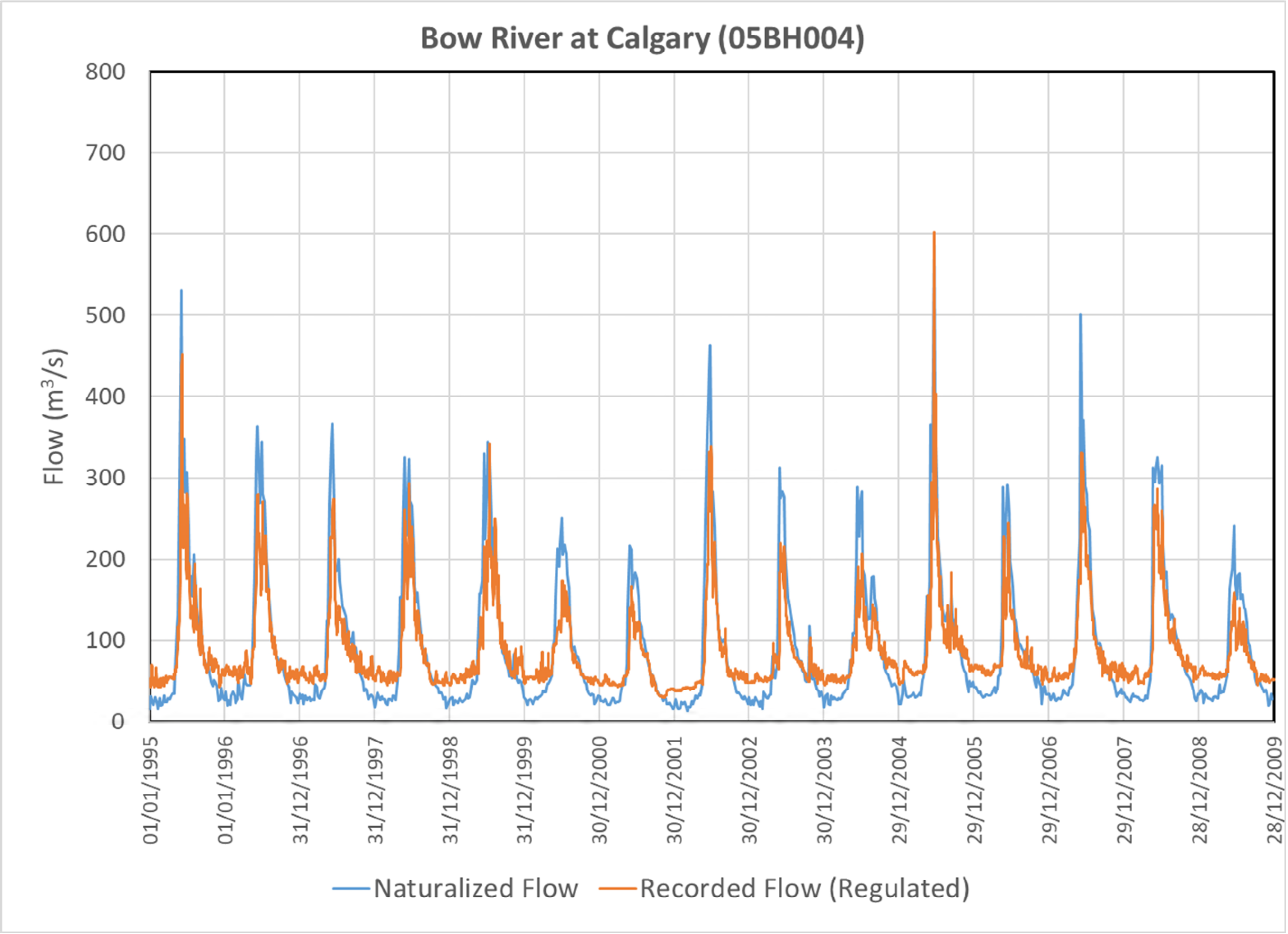
Model Example



Final product

- Weekly naturalized flow data
- Estimated at 98 sites (in last update)
  - 80 sites at active or discontinued station locations
  - 18 sites are the sites of interest that do not coincide with existing hydrometric station locations.

Output Hydrograph



Challenges Faced

- Ideally, naturalized flow data is required up to as recent years as possible
- However, availability of complete dataset for the modeling on a timely manner is a major challenge
  - Availability of official flow and water level data from Water Survey Canada
    - Data contributors are WSC, TransAlta, AEP
    - Official data not available for the latest years for all the stations
    - Official data not available for all the stations for the entire modelling time period (example missing 2014, 2015, 2016).
  - Availability of Water Use data
    - Not all of the required data are available through AEP's Water Use Reporting System;
    - Sometimes data available are not of required timesteps and/or of quality
    - In many cases need to contact individual municipalities and major licence holders.
  - Availability of Irrigation Return Flow Data
    - Need to obtain permission for data collection from all irrigation districts
    - Collect data from Alberta Agriculture and Forestry/Irrigation Districts.

Challenges Faced

- Need to send formal requests to individual data contributors which adds wait time
- Needs significant time commitment and resources
- In many cases, continuous observed data are not available, so data gap filling is necessary based on appropriate methodologies
- The required input data need to be of good quality to get a good estimation of naturalized flow
- The estimated naturalized flow can not be directly validated

Latest Update

- Currently working on to estimate naturalized flow for the 2010 – 2015 period
- Estimated timeline: 2020

Questions?