

Advice From a River:

Go with the flow.

Immerse yourself in nature.

Slow down and meander.

Go around the obstacles.

Be thoughtful of those downstream.

Stay current.

The beauty is in the journey!

–lian Shamir

EXPERIENCE
JOURNEYS

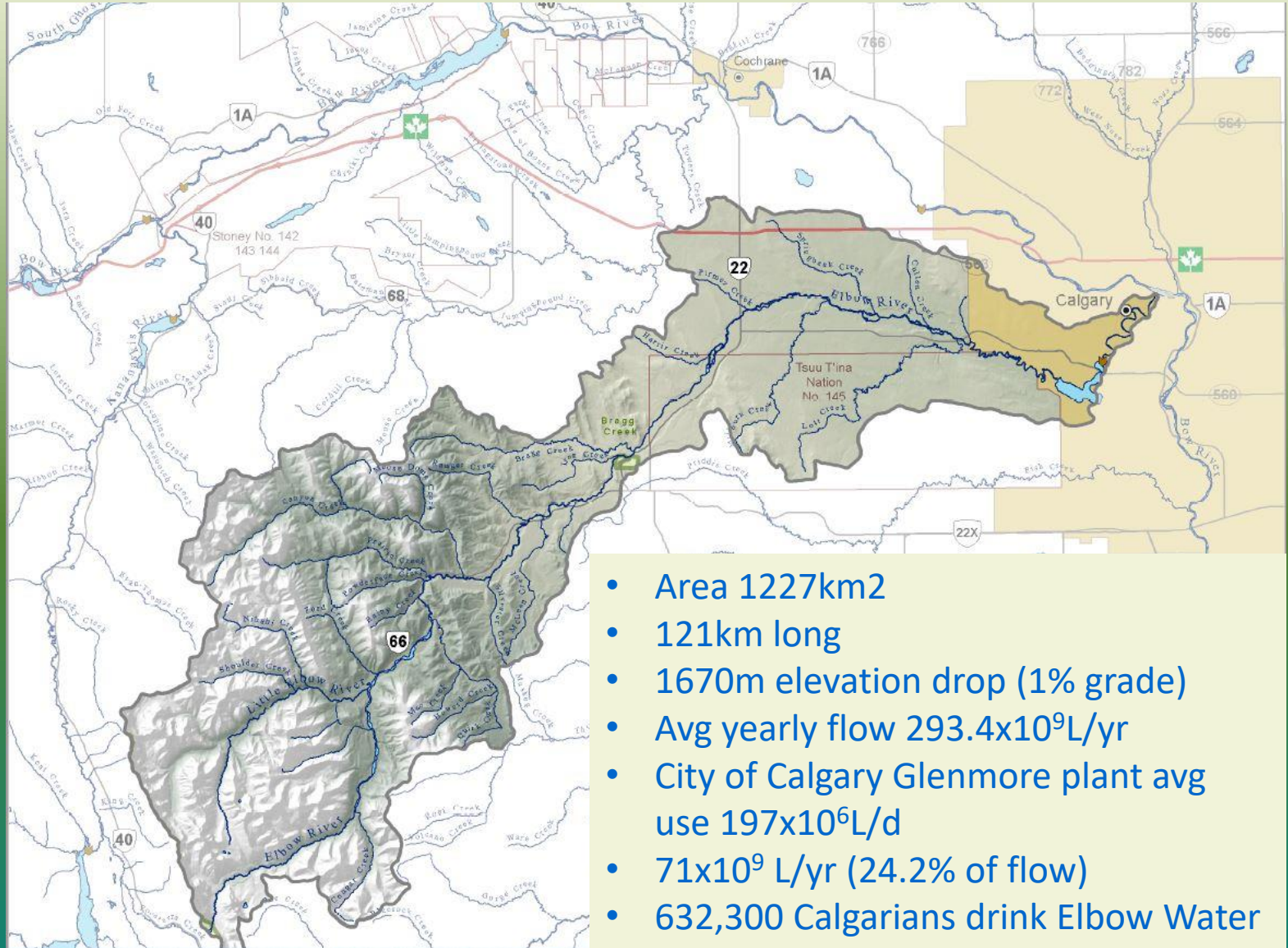
March 18, 2021

Dave Klepacki PhD, Experience Journeys Ltd., Bragg Creek, AB
dna@experiencejourneys.ca, www.experiencejourneys.ca



Our relationship with the Elbow River: Time for Therapy

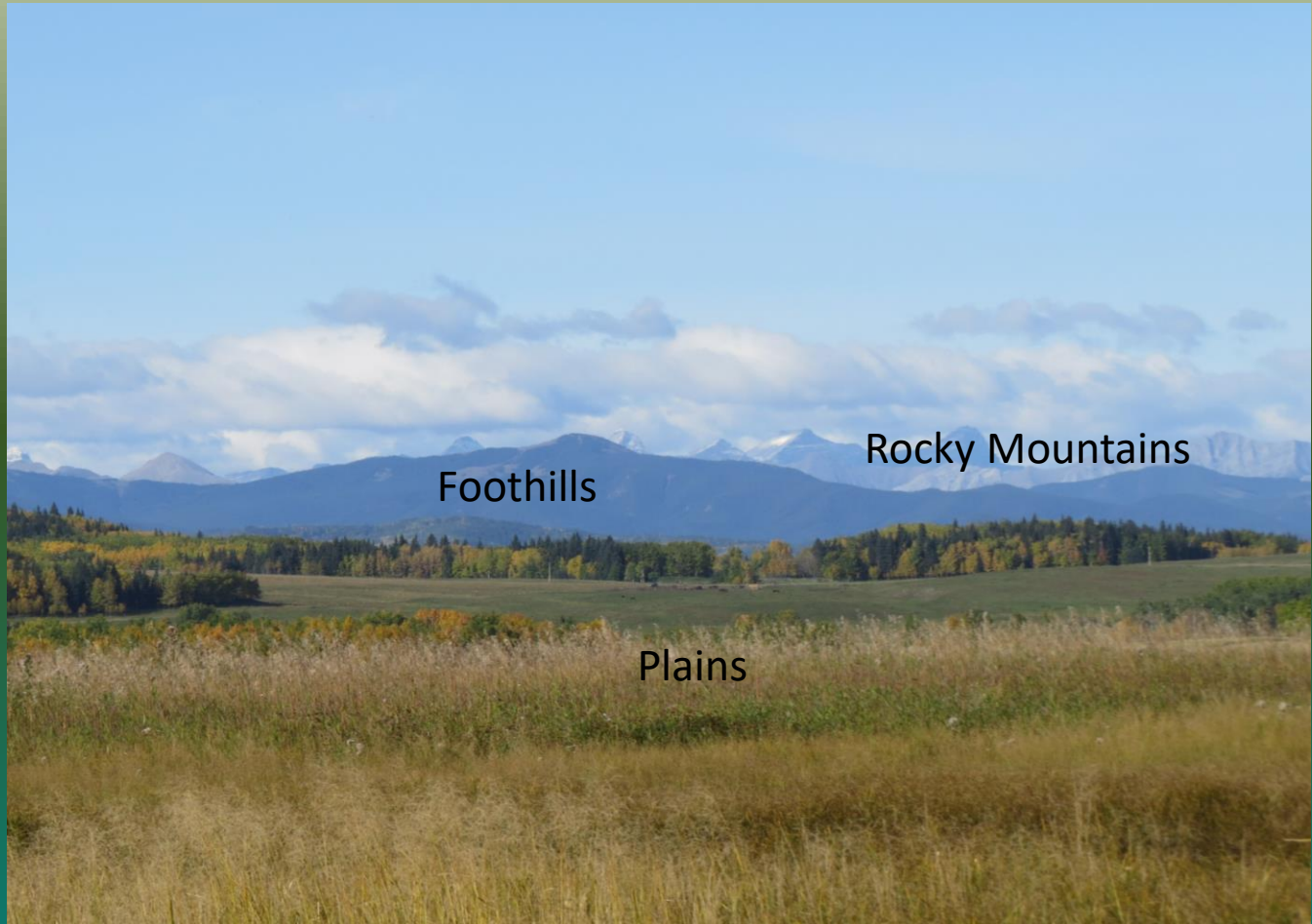
- Elbow River geography and dynamics: Headwaters, water quantity and quality, sediment movement, the aquifer, climate drivers for flood, drought and wildfire.
- The watershed wild inhabitants, trout, invertebrates, wildlife.
- Land Use: Recreational visits, McLean Ck OHV FLUZ, Logging, Grazing, Hwy 8 Development
- Therapy for the Elbow River: Provide for it so it can provide for us: Action steps.



- Area 1227km²
- 121km long
- 1670m elevation drop (1% grade)
- Avg yearly flow 293.4x10⁹L/yr
- City of Calgary Glenmore plant avg use 197x10⁶L/d
- 71x10⁹ L/yr (24.2% of flow)
- 632,300 Calgarians drink Elbow Water

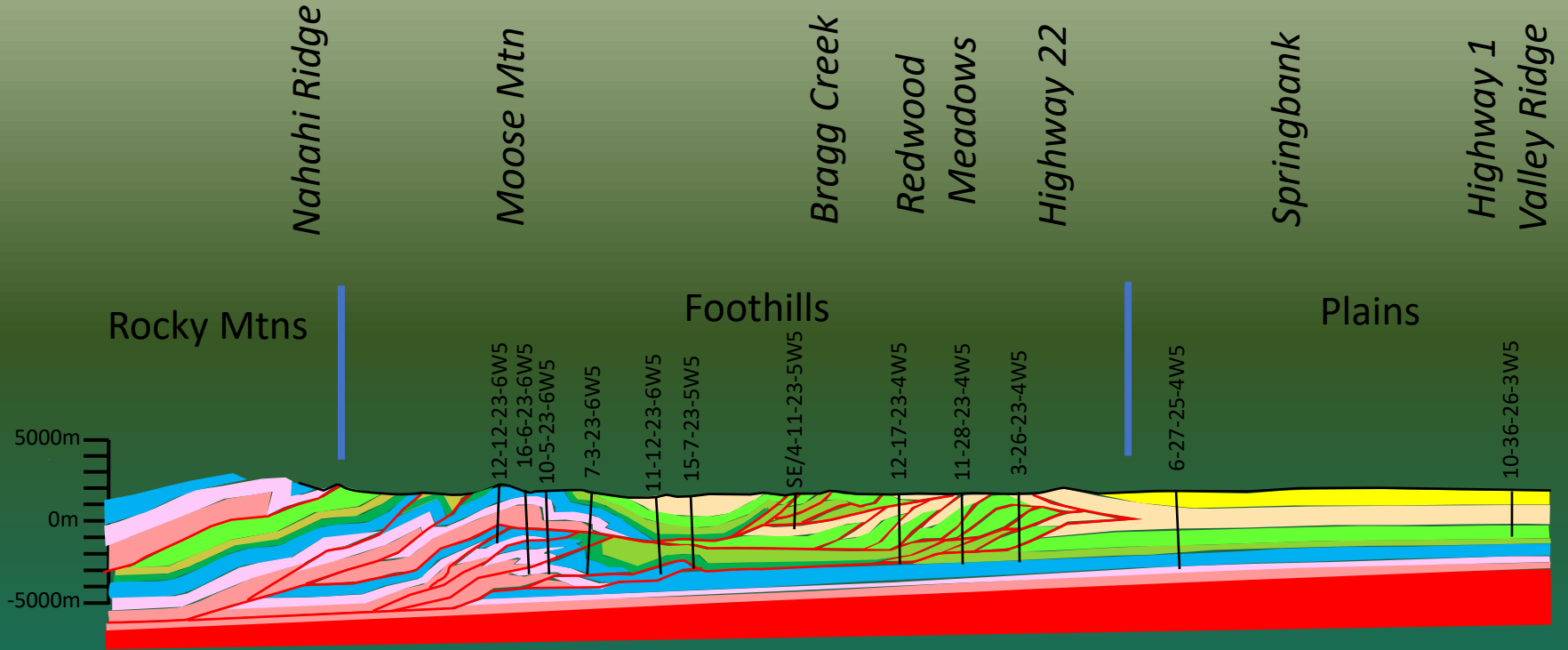


The three geomorphic regions along the Elbow River Watershed (view from south Springbank).



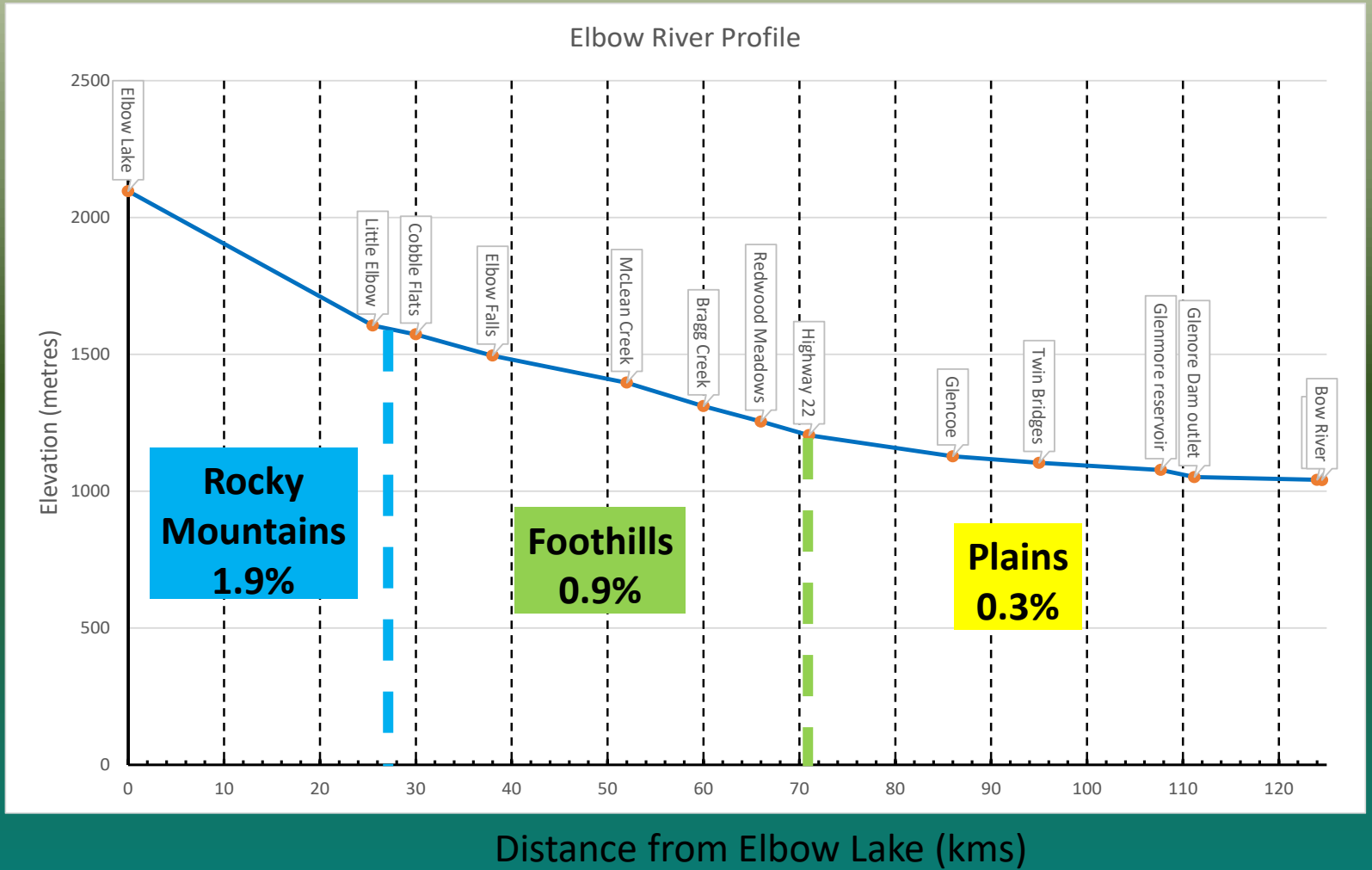


Geological Structure section along the Elbow River



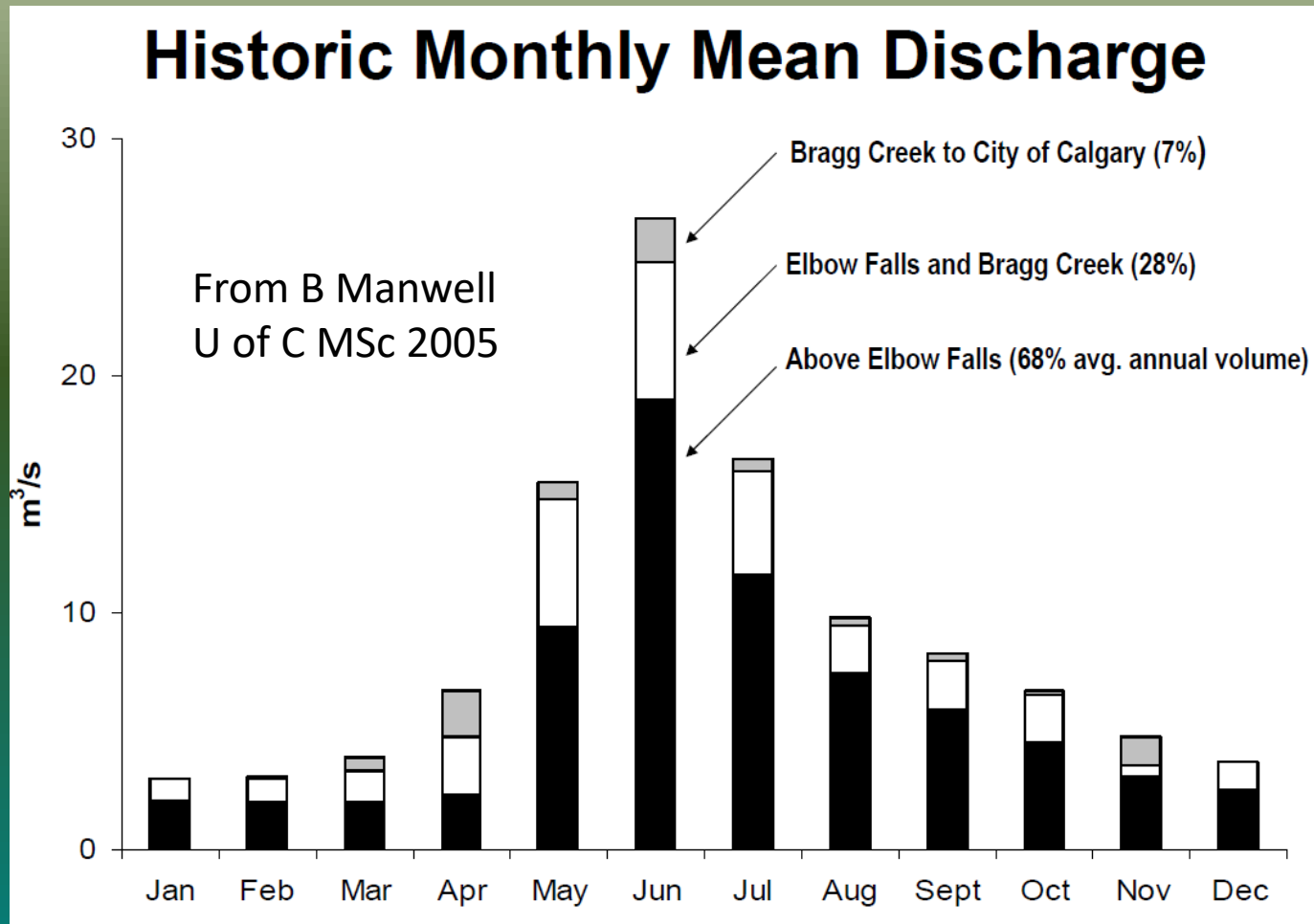


Topographic Profile (25x vert exg) and gradient along the Elbow River





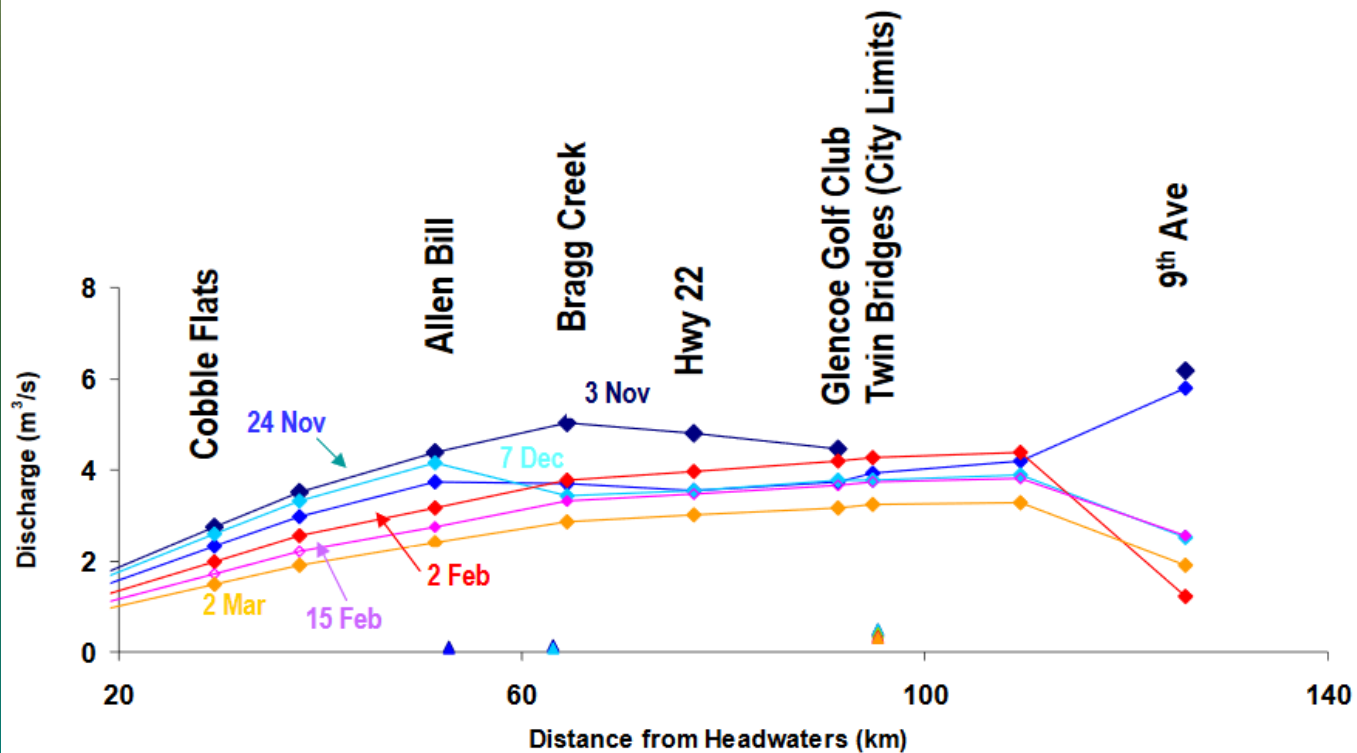
Hydrograph showing most of water in the Elbow River comes from mountains and foothills. Only 10-30% of moving water manifests as surface flow.



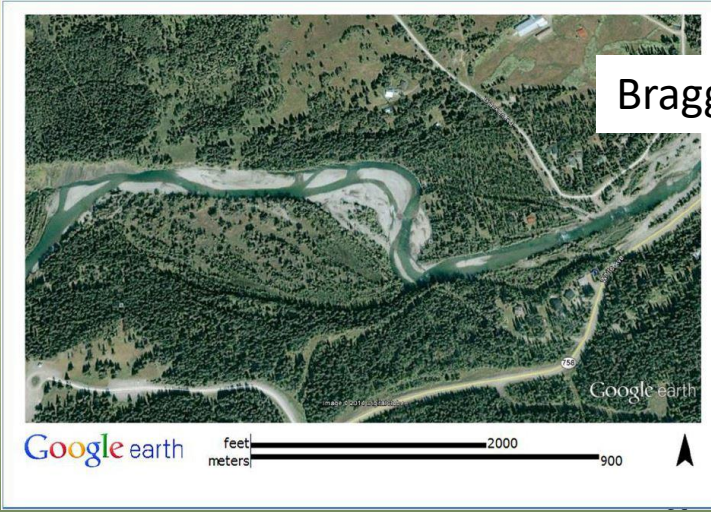


Most of Elbow River water is sourced in upper watershed.

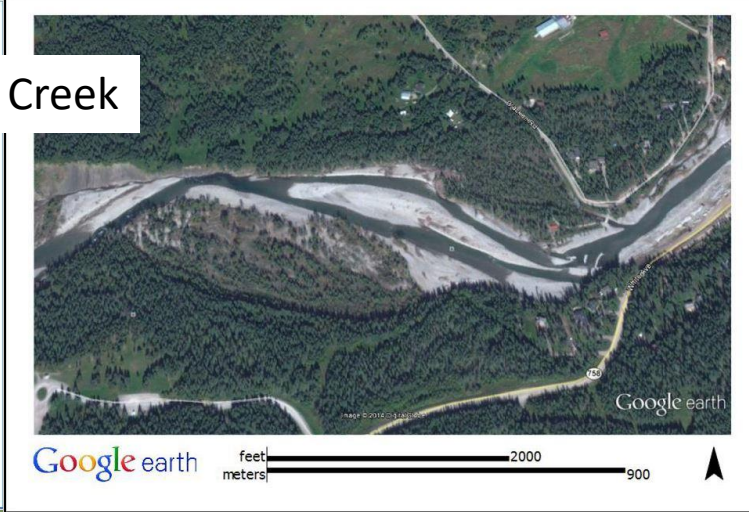
Estimated Discharge



Source: Elbow River Watershed Assessment: What has changed in the past 14 years: Univ of Calgary Env. Sci. 502 Sept 2015.



Bragg Creek



Downstream Sediment movement and channel changes from 2013 flood event

Redwood Meadows

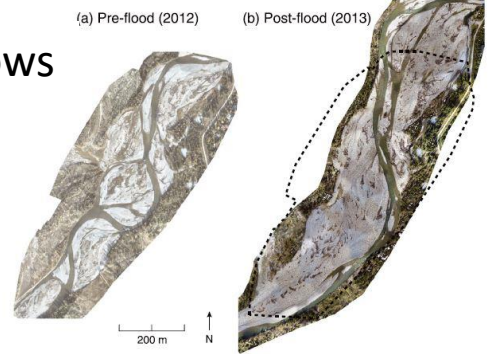
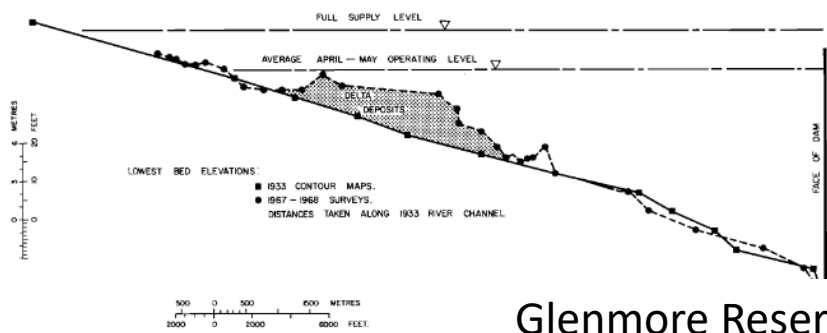


Figure 6. Orthomosaics for (a) pre- and (b) post-flood UAS surveys. The black dashed outline on the post-flood image corresponds to the extent of the 2012 survey, for reference. This figure is available in colour online at wileyonlinelibrary.com/journal/espl



Glenmore Reservoir

FIG. 3. Longitudinal profile through reservoir along alignment of original river channel

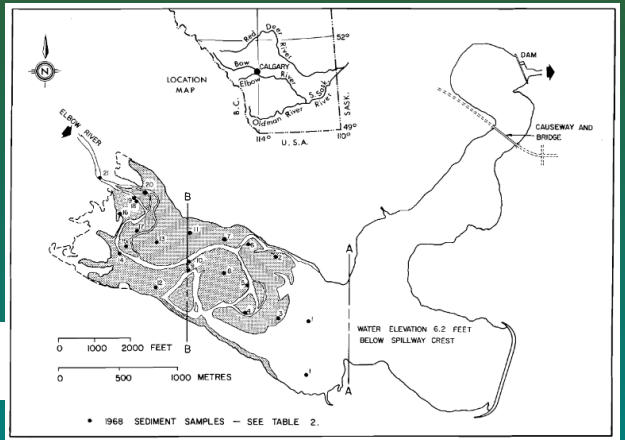
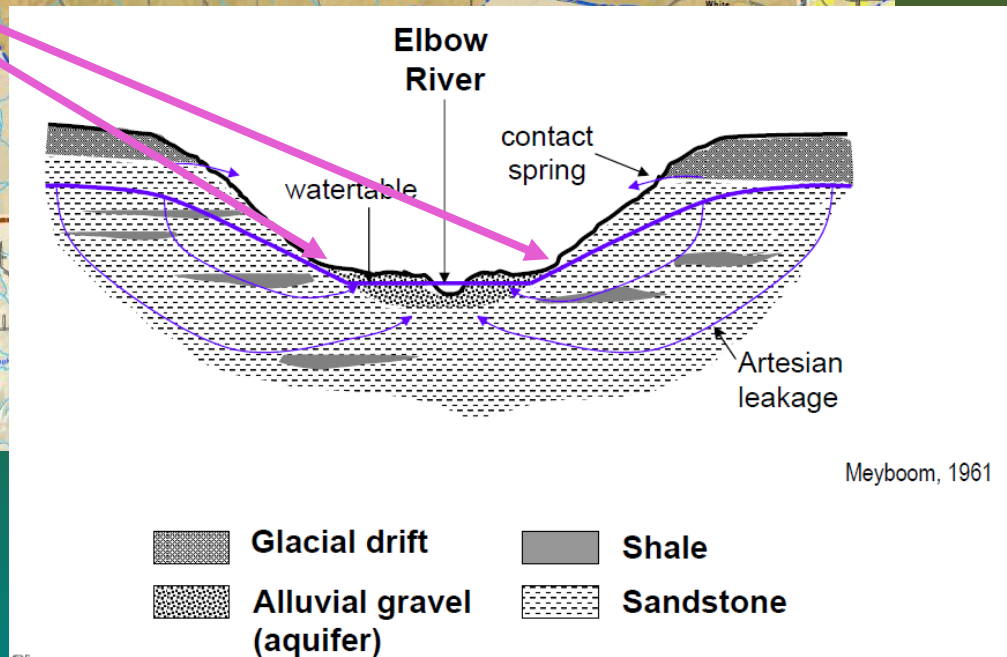
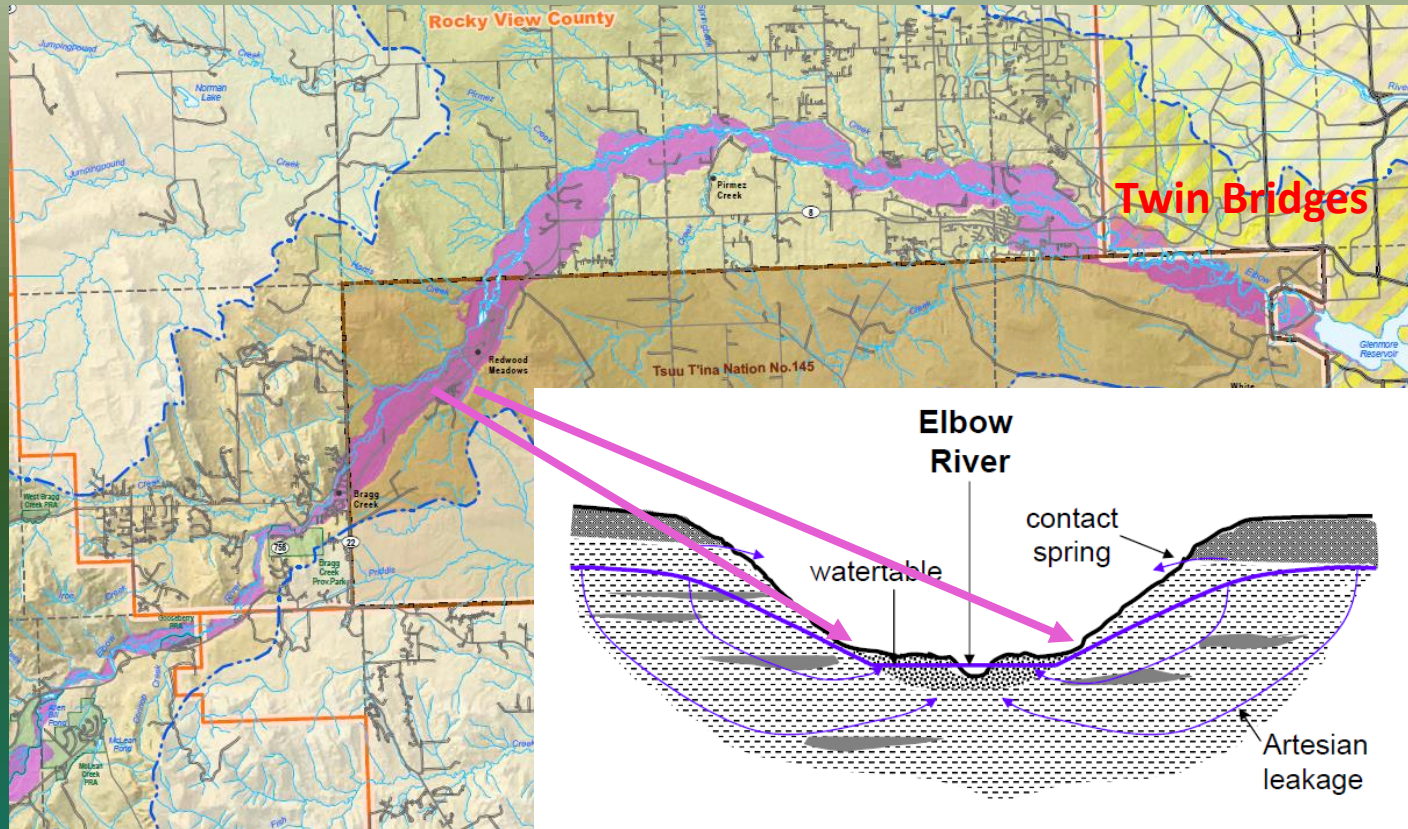


FIG. 1. Plan of Glenmore Reservoir showing extent of visible sedimentation (1968).

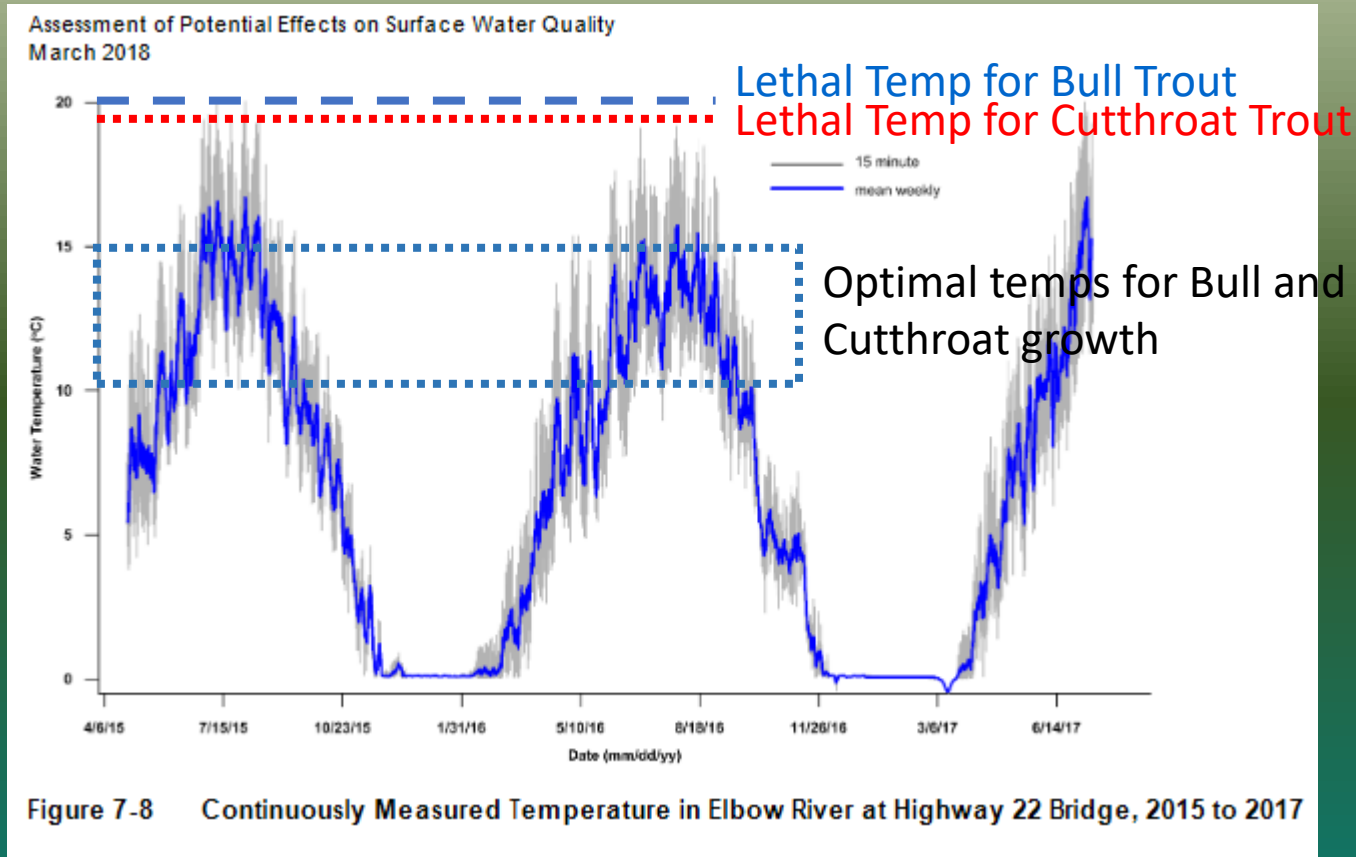


Alluvial (boulder and gravel) aquifer along the Elbow River. Holds 80-90% of the water in the Elbow Watershe.





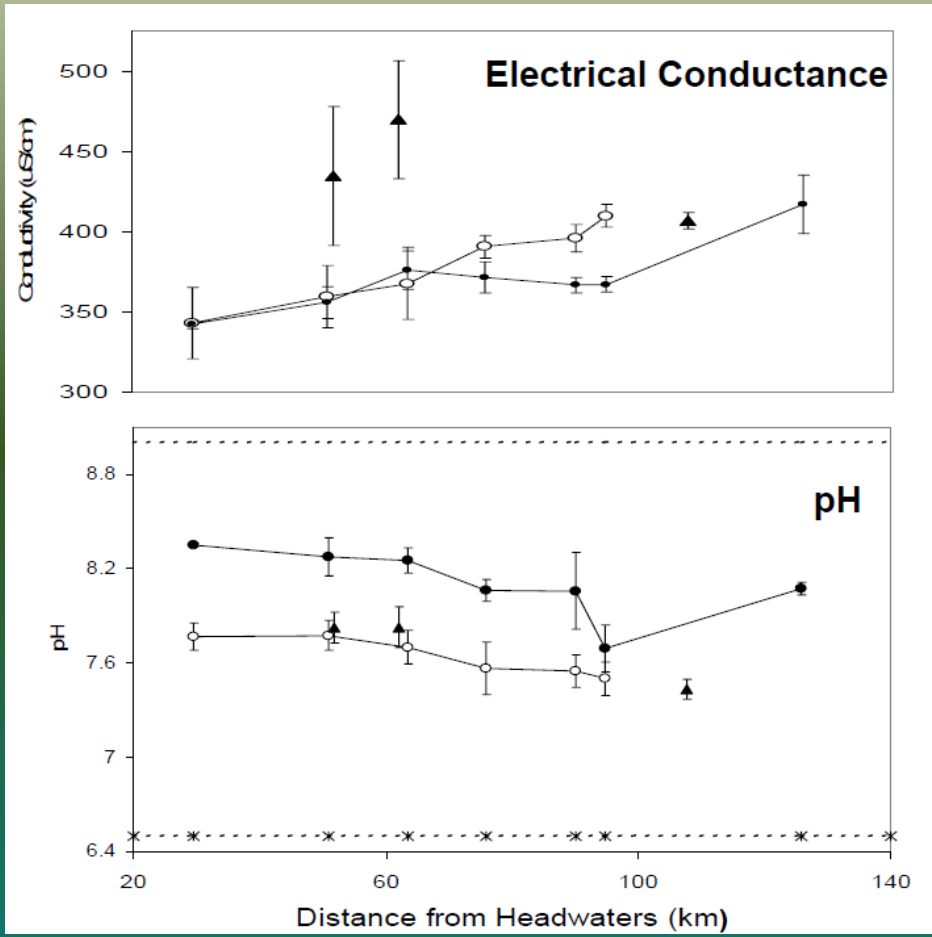
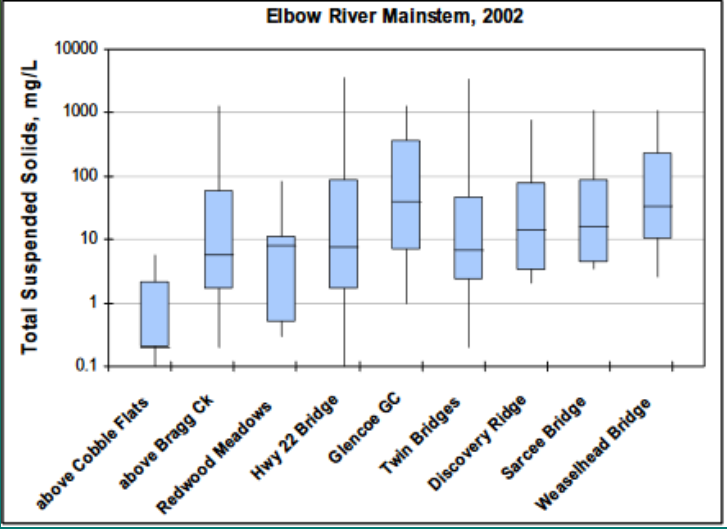
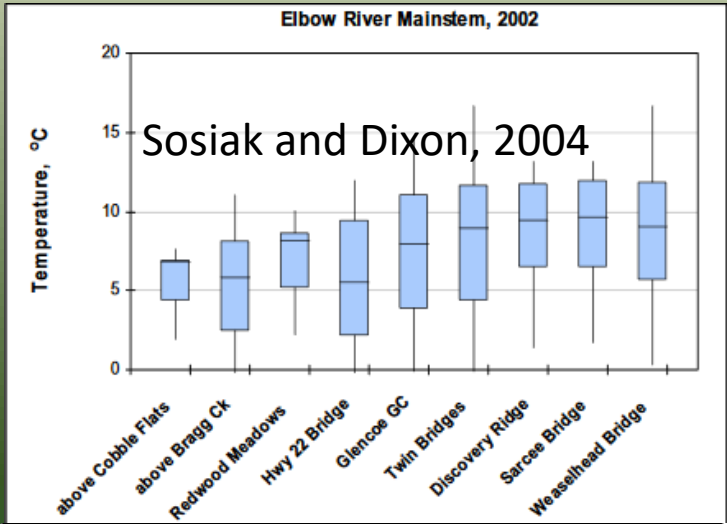
Yearly water temperature variation at Hwy 22 bridge.



Elbow River water temperatures from Springbank Off-Stream Reservoir Project EIA V3B: Effects Assessment (Flood and Post-Flood Operations. March 2018



Physical properties of the Elbow River water showing increasing temps, dissolved salts and lower pH downstream

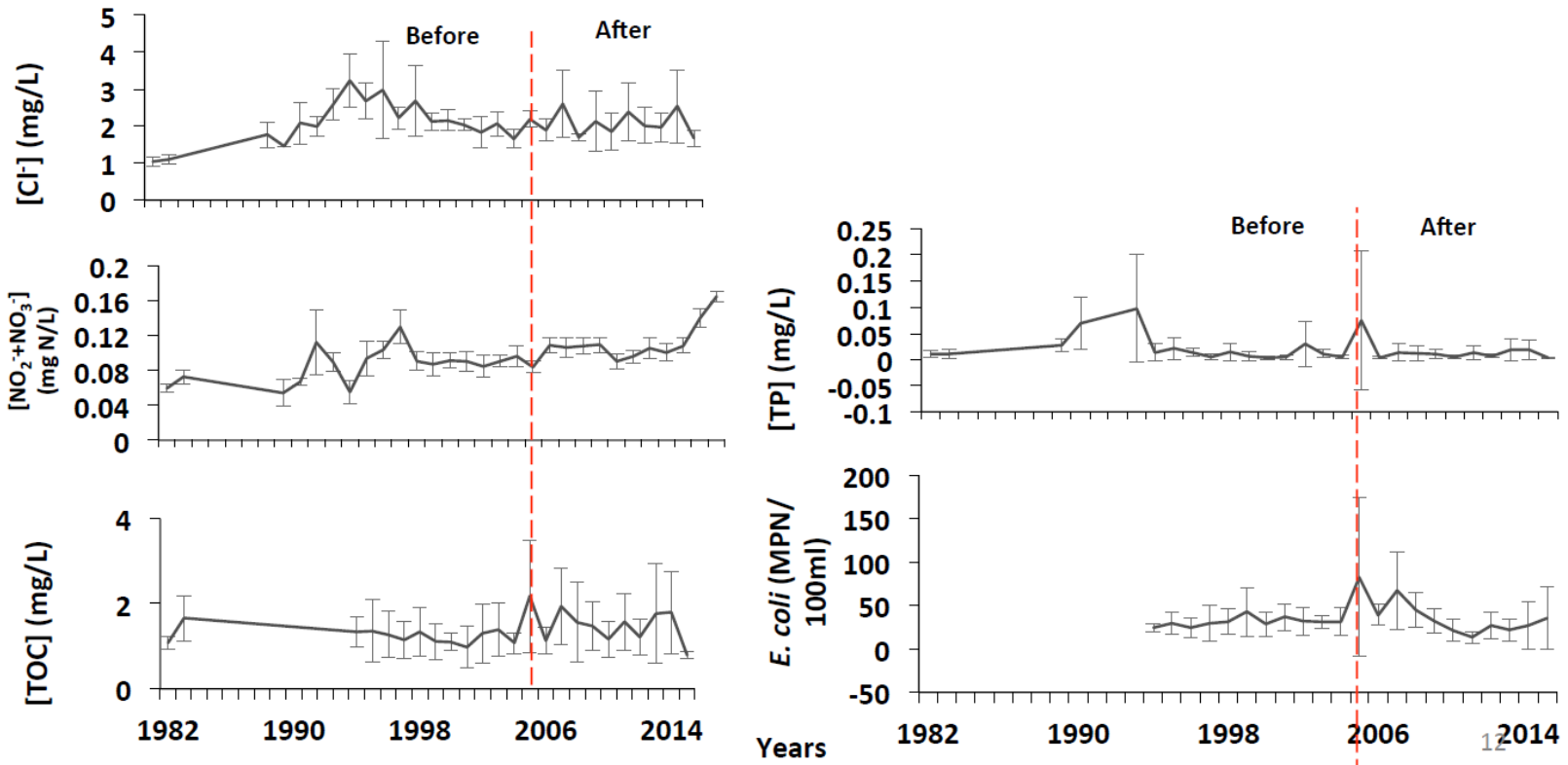




Decreasing water quality upstream of Glenmore Reservoir

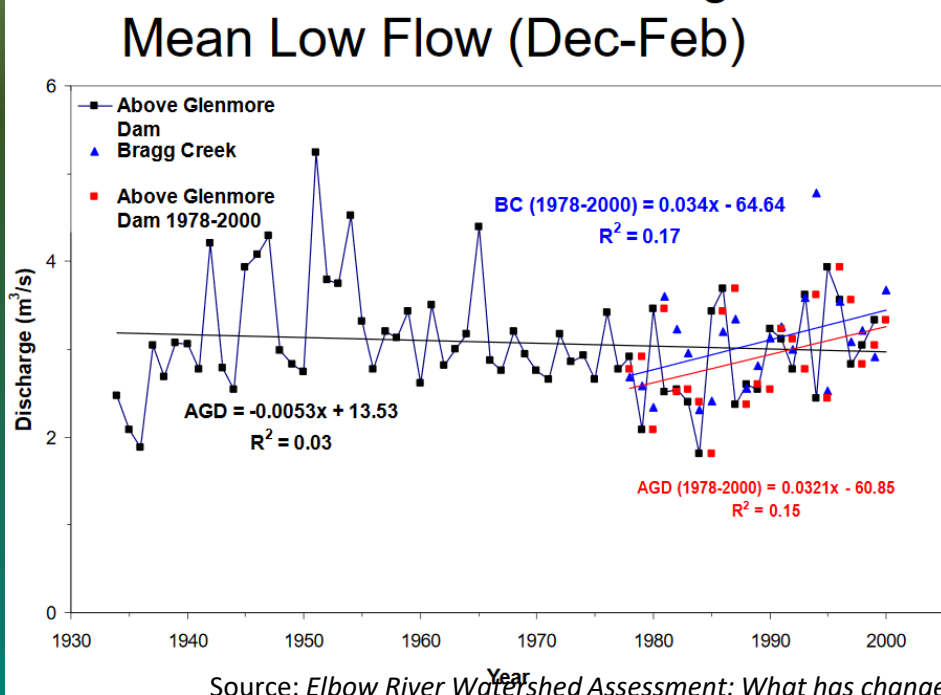
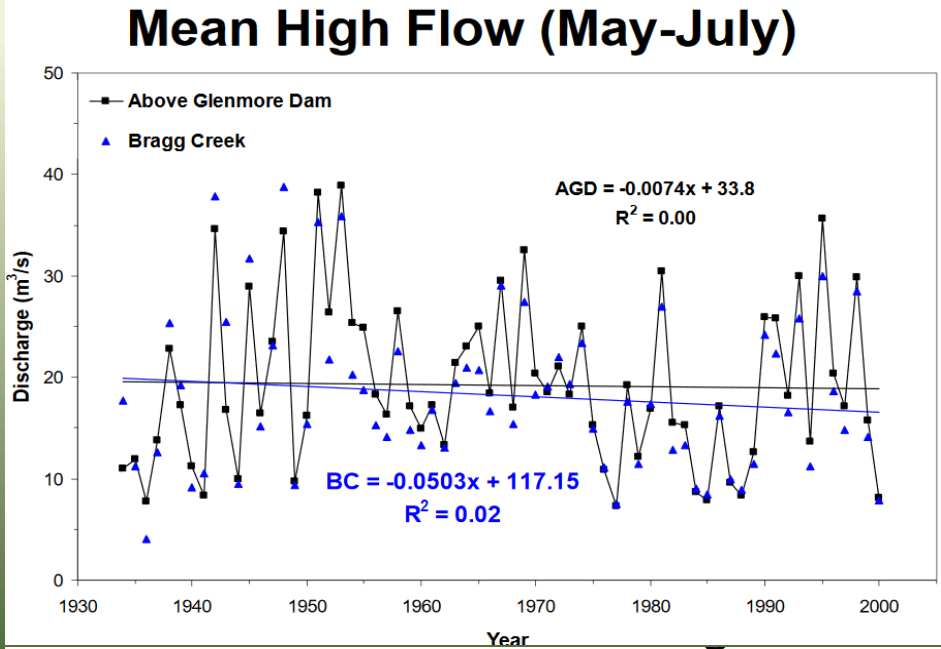


Twin Bridges 1982-2015





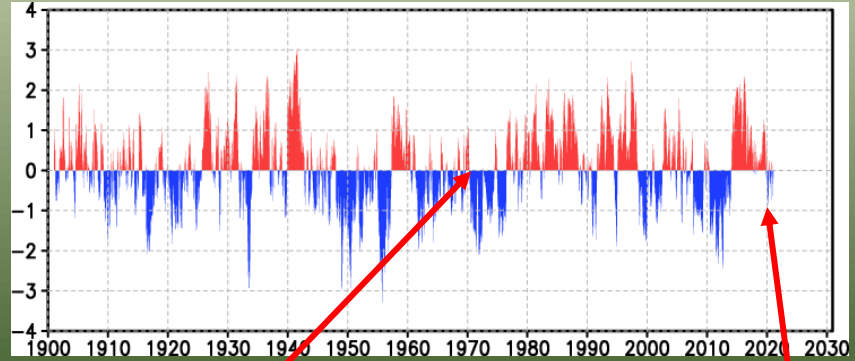
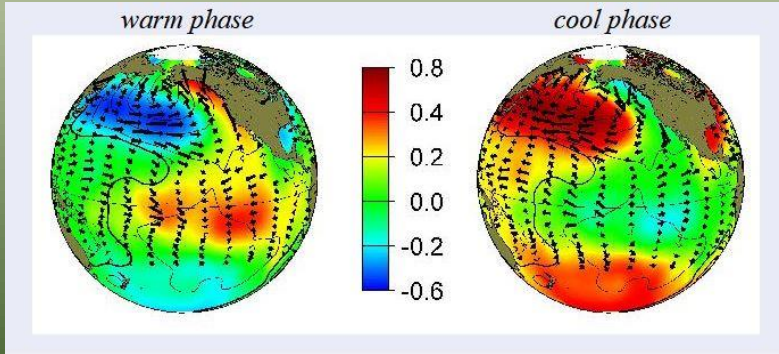
Decreasing
Flows in the
Elbow River:
about
-20%/100yrs



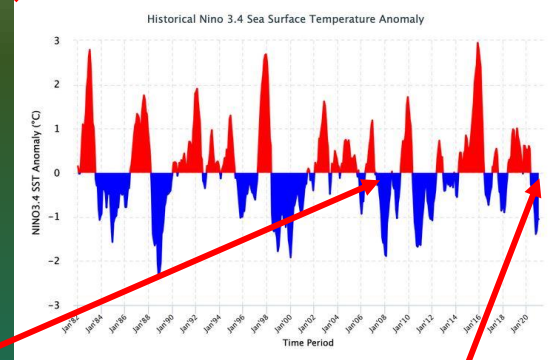
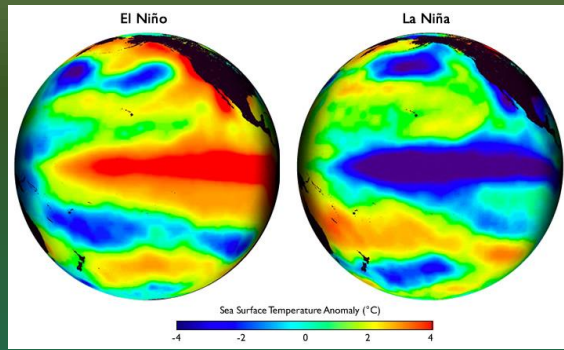
Source: *Elbow River Watershed Assessment: What has changed in the past 14 years: Univ of Calgary Env. Sci. 502 Sept 2012.*

Climate Drivers for flood and fire

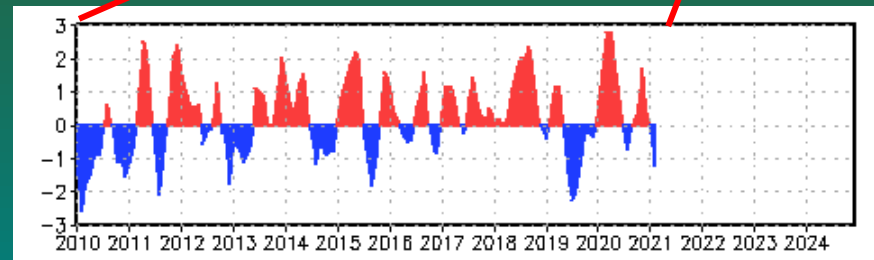
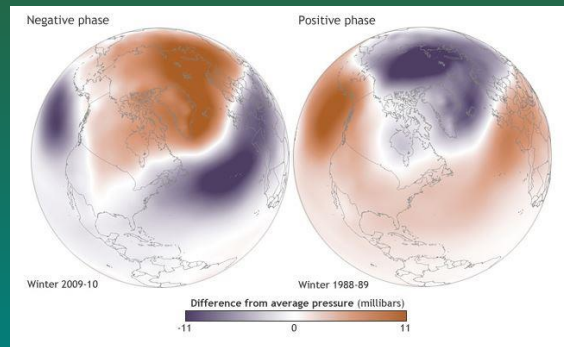
Pacific Decadal Oscillation



El Niño Southern Oscillation



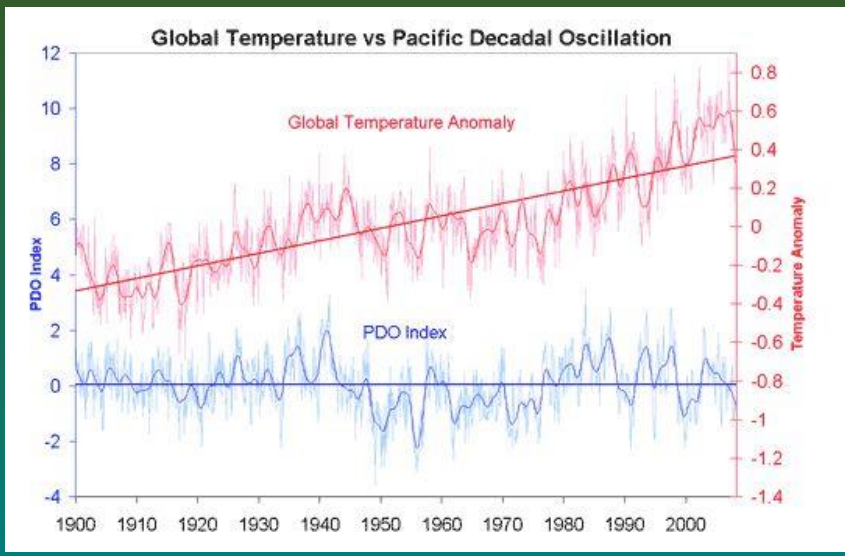
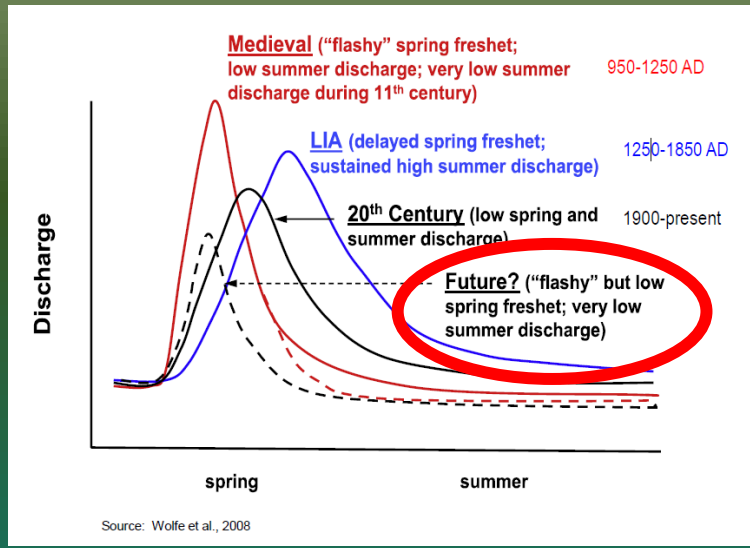
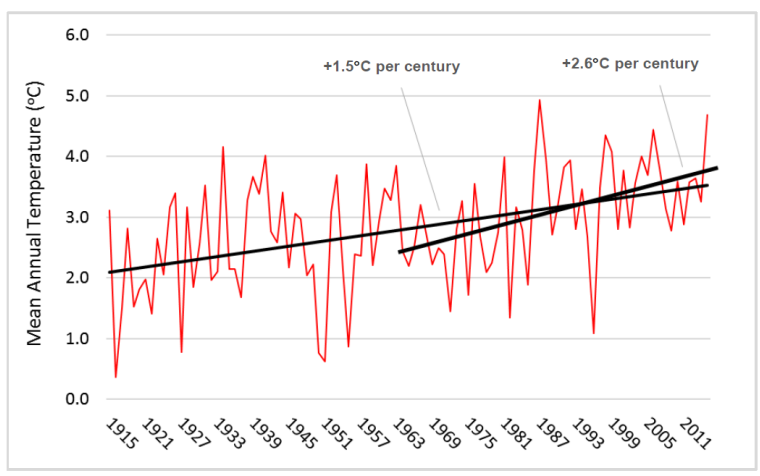
Arctic Oscillation





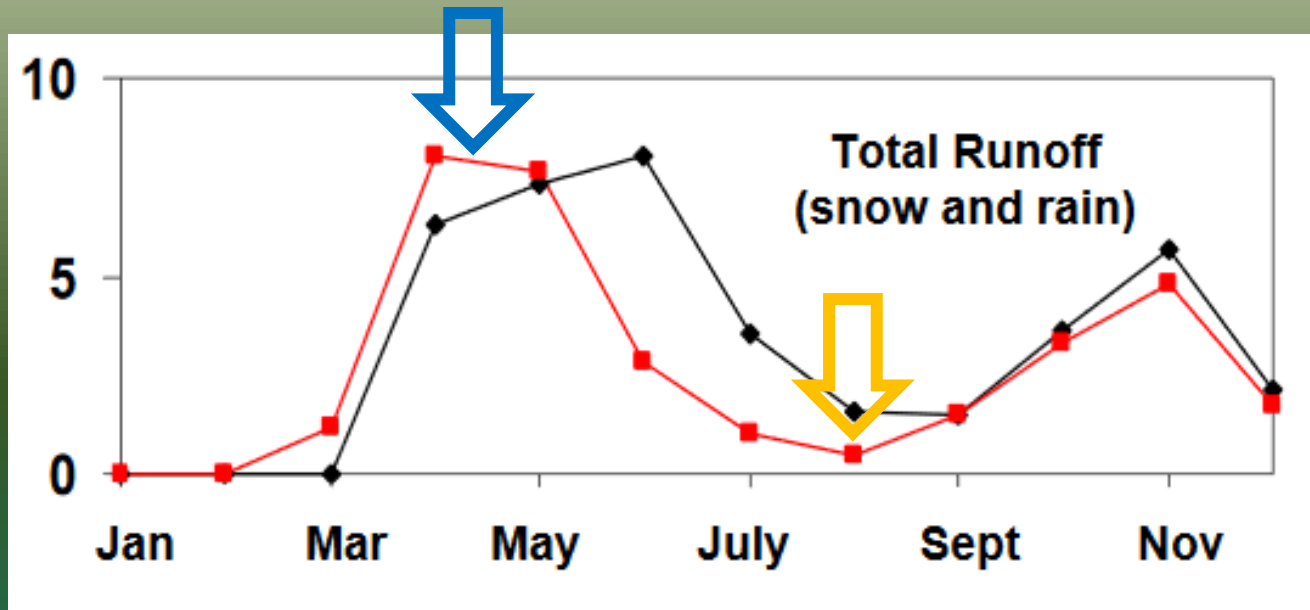
Current climate variations are the addition and subtraction of oceanic circulation cycles superposed on rising temperatures.

Figure 2: Mean Annual Temperature in the Bow Valley Corridor (1915-2015)





Calculated changes in future snowmelt runoff for the Elbow River. Earlier spring runoff, lower summer flows.

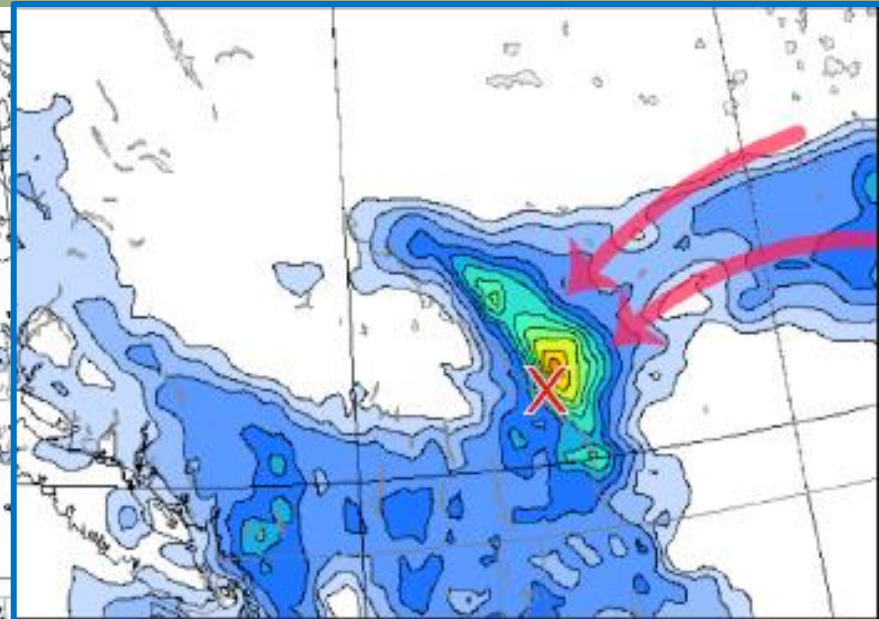
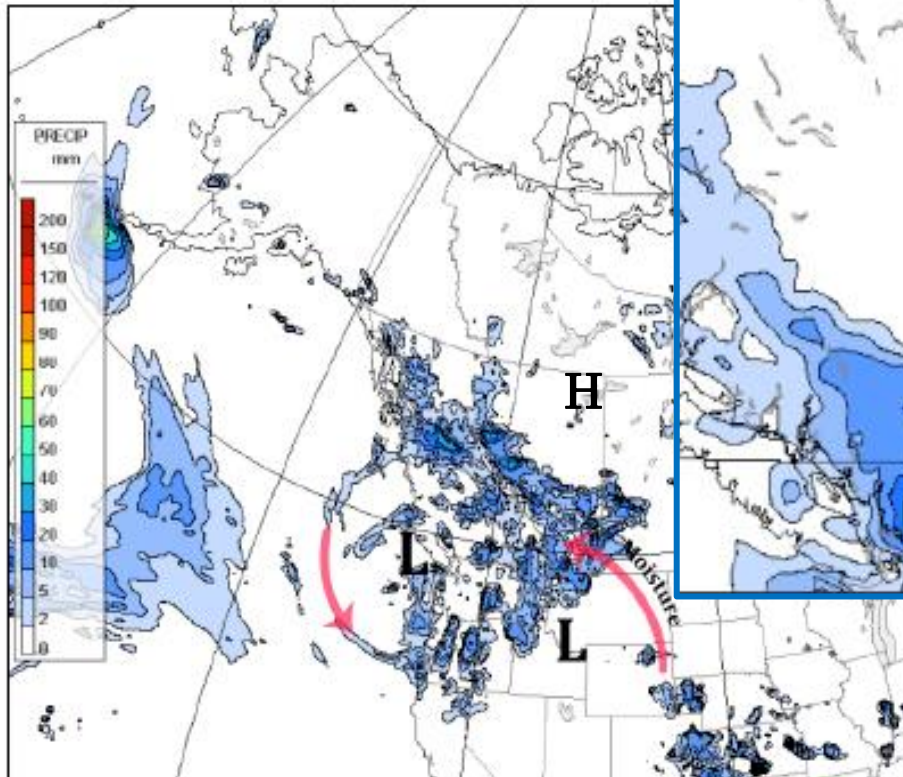


Predicted hydrologic changes (in cm) for Elbow River region
(calculated for 1975-84 (black) and 2040-49 (red) for 32,400 km² CRCM block)

Elbow River Watershed Assessment 2012, U of C

Source: *Elbow River Watershed Assessment: What has changed in the past 14 years: Univ of Calgary Env. Sci. 502 Sept 2015.*

Blocking high and colliding lows draw moisture up from Gulf of Mexico creating upslope precipitation event.

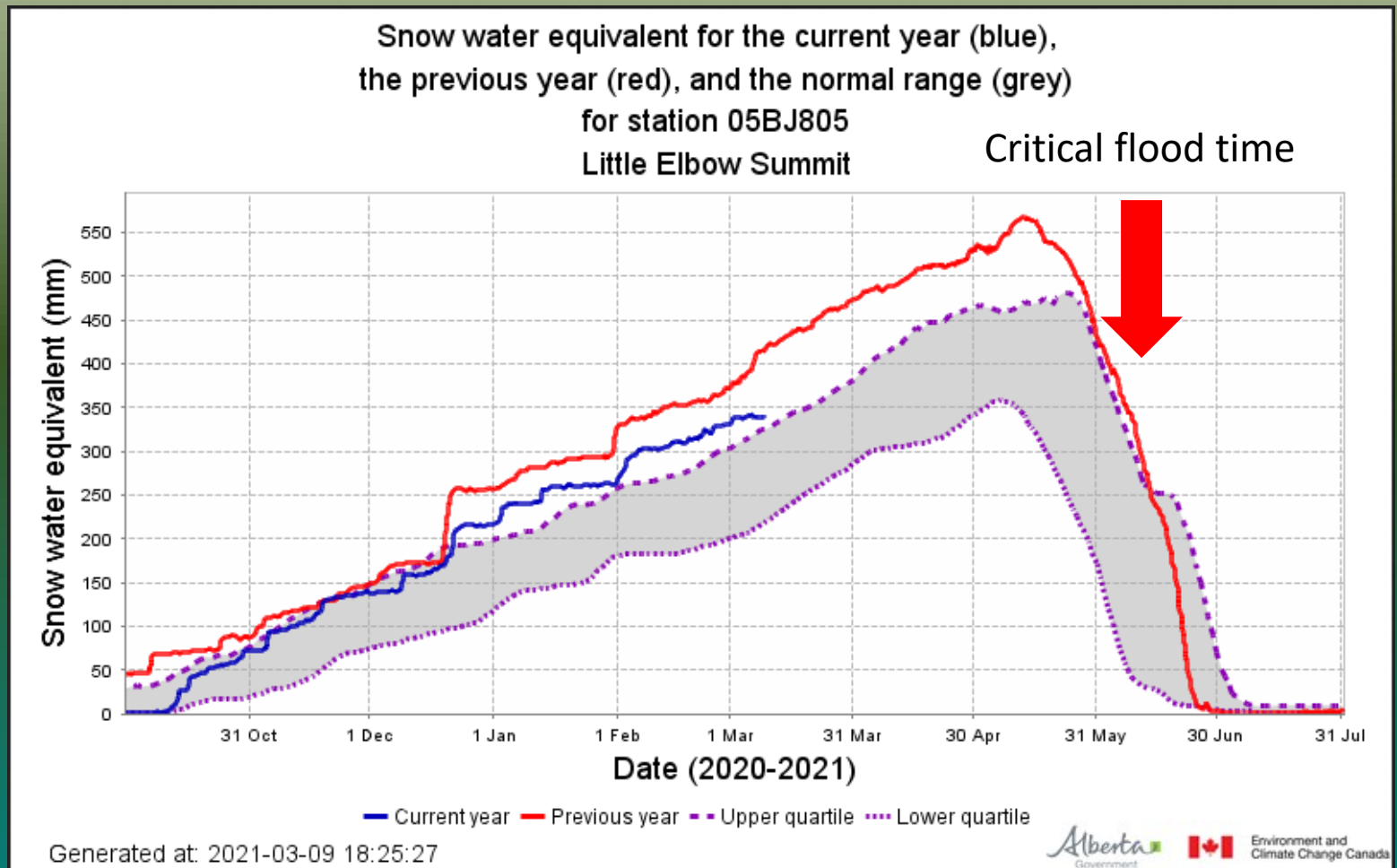


From: Hydroclimatic analysis of the June 2013 Storm. BGC Engineering Inc. Aug 1, 2014

Figure 2. As for Fig. 1, except valid at 5am on 19 June 2013.
(Source of background map: <http://lokl.qc.ec.gc.ca/DAI/CaPA/Index.html>).



Snow pillow for Elbow Lake station (this year) showing critical flooding time



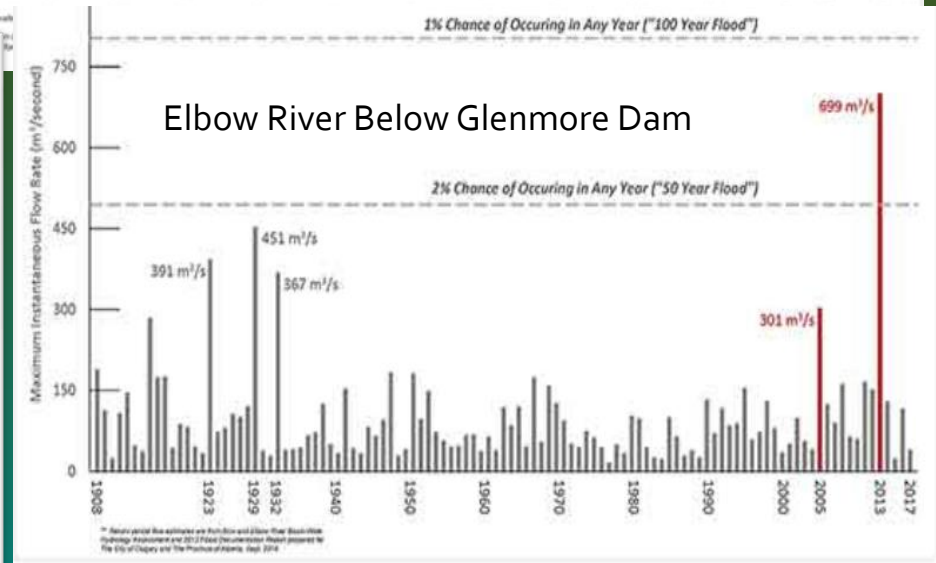
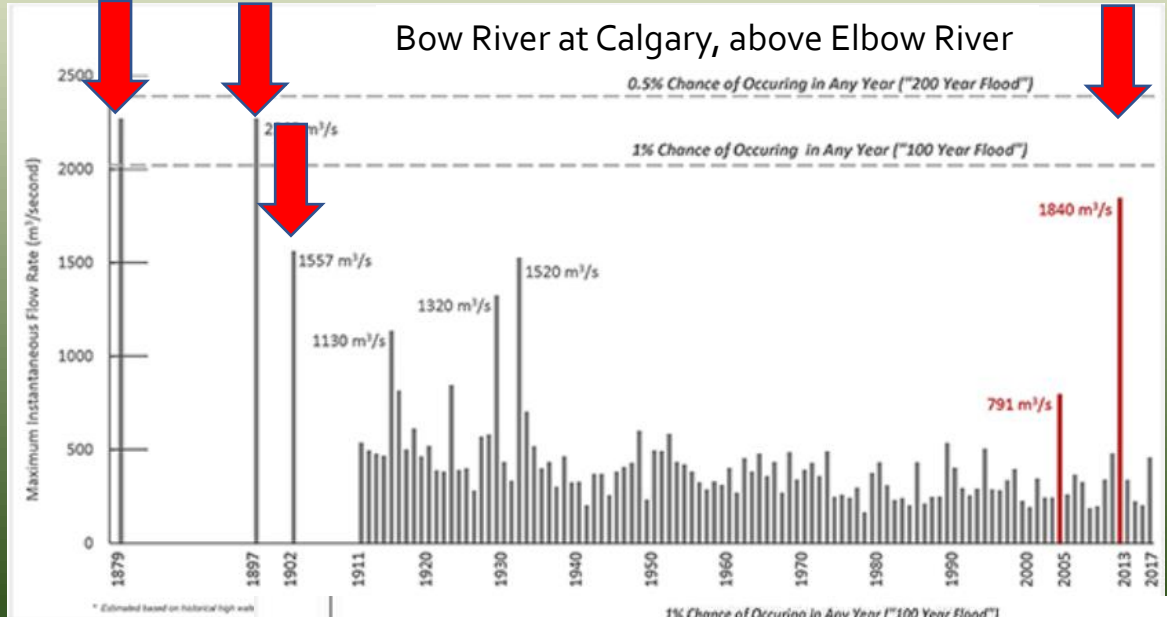


Elbow River Flooding





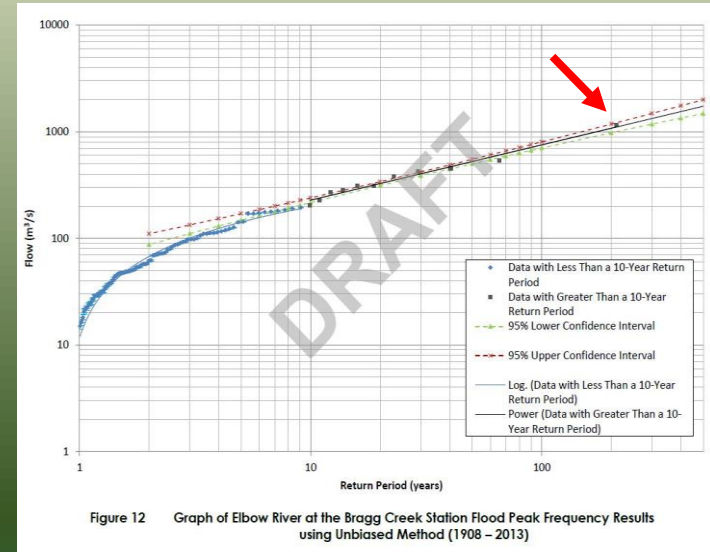
4 Largest flood events in 1879, 1897, 1902 and 2013.



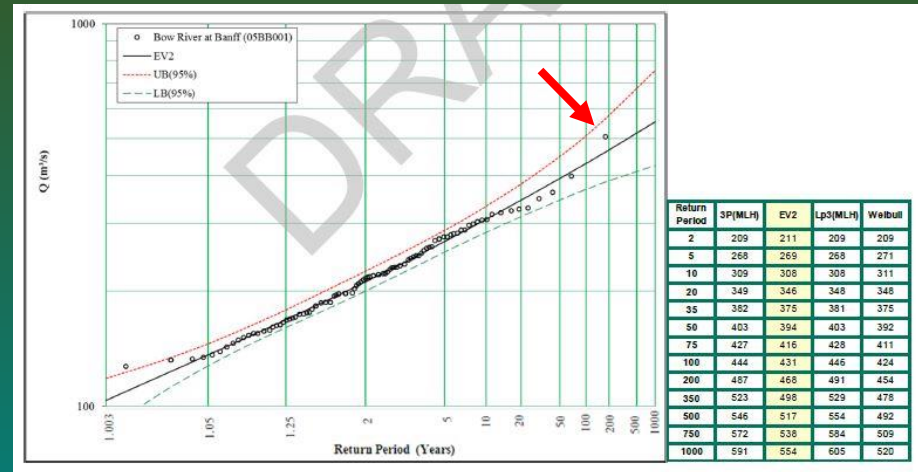


Calculations of flood frequency on Bow and Elbow Rivers using 1908-2015 data

Elbow R at Bragg Creek peak instantaneous discharge of 1085 m³/s is 1:200 based on 1908-2013 data. Stantec, 2018



Bow R at Banff 2013 flow is 1:200 based on 1910-2015 data. Golder, 2020





2013 Flood frequency using 1879-2013 data 1:40

Alberta Tree Ring Data show 1875-1902 Wet Years Razavi et al. 2019

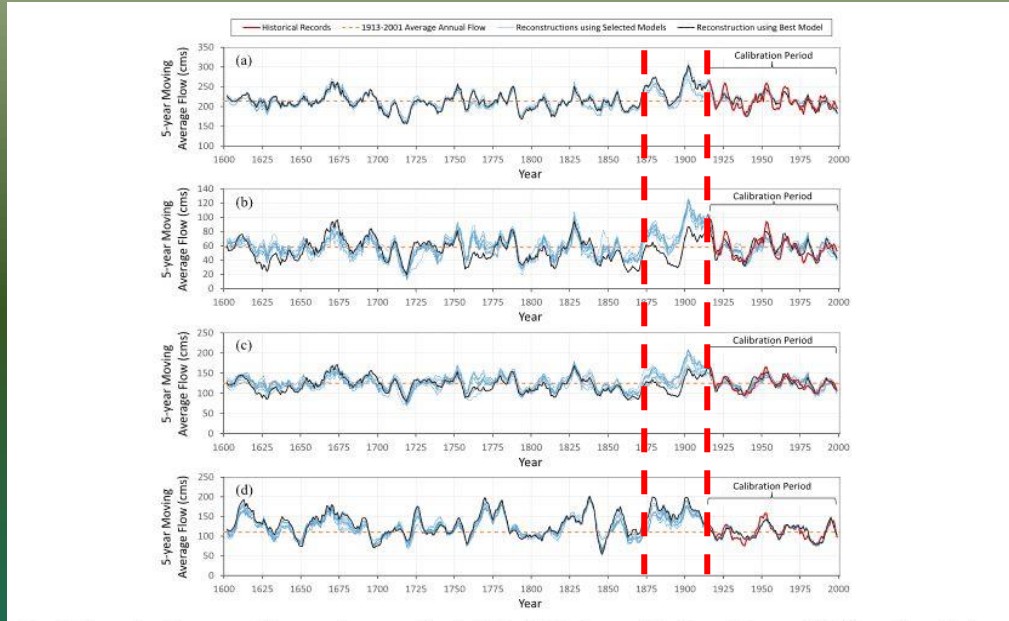
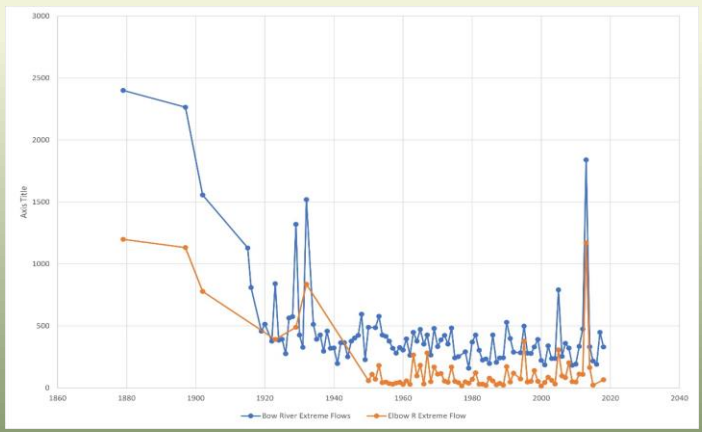


Figure 8. Time series of reconstructed 5-year moving average flows in (a) North Saskatchewan, (b) Red Deer, (c) Bow, and (d) Oldman Rivers. The best model is the model with minimum Akaike information criterion. The shown reconstructed flows for the calibration period are the results of cross-validation

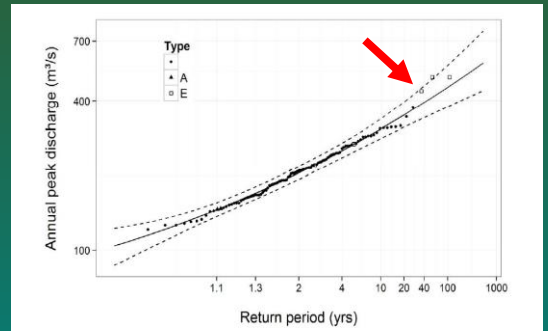
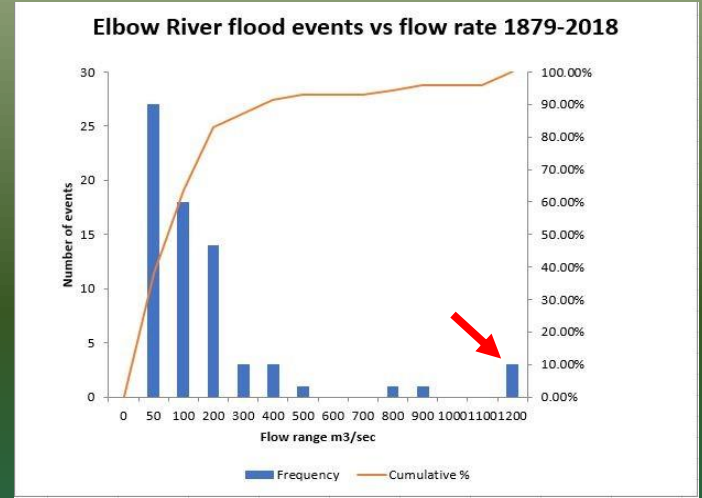


Figure 8. Estimated return periods for the Bow River at Banff from 1884 to 2013 by rank and fitted using the log Pearson type III distribution (solid line) with 95% confidence intervals plotted as dashed lines. Circle is measured peak flow, triangle (A) is annual maximum of a partial year, hollow square (E) is estimated as noted by the Water Survey of Canada. The 2013 event is third from the right (439 m³/s).

Pomeroy, Stewart and Whitfield, 2015, 2013 flood at Banff 1884-2013



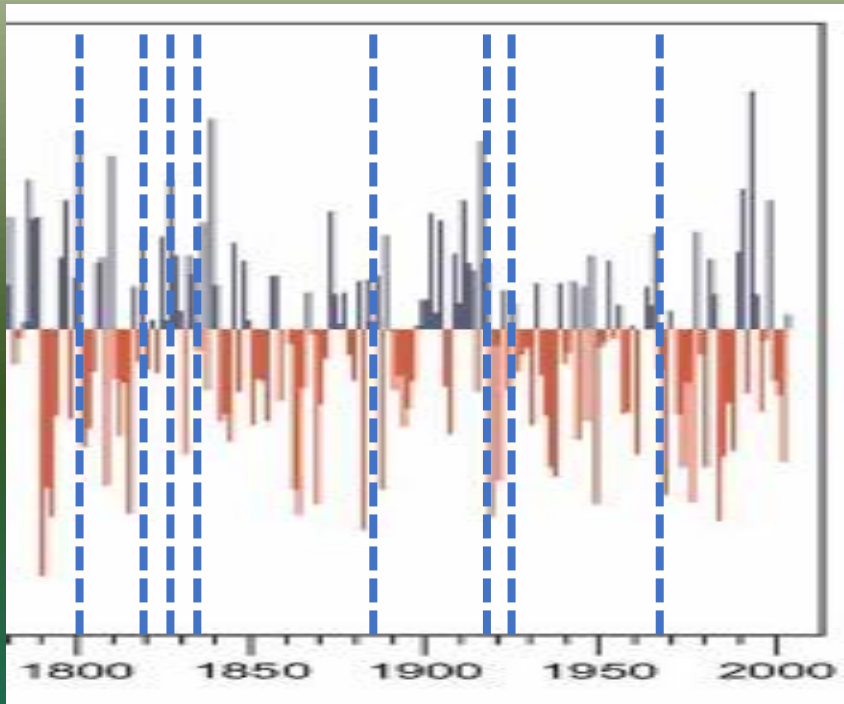
Drought



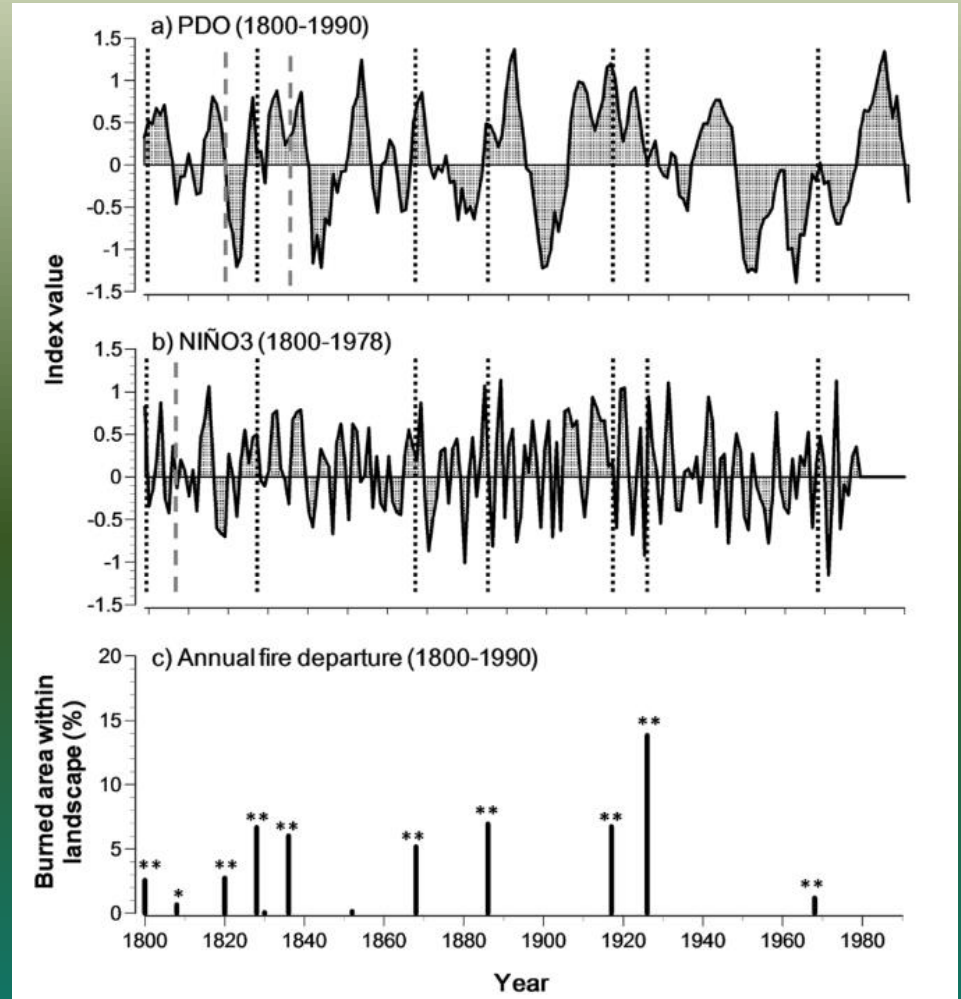
Big Elbow River at Forget-me-not pond, August 2017



Climate drivers and Wildfire occurrence in Kootenay National Park.



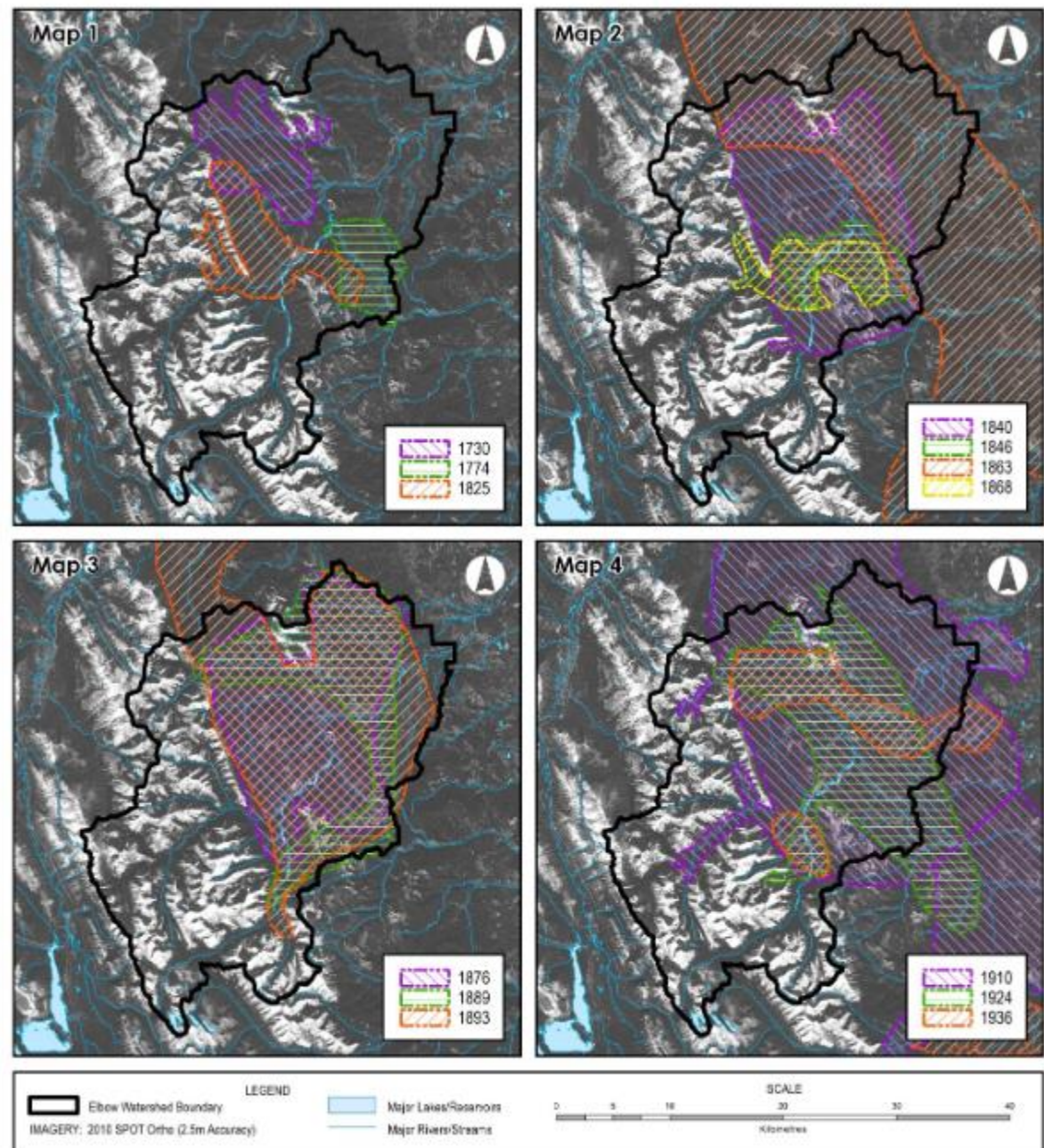
Palmer Drought Severity Index for Calgary from Bonsal et al. 2010



Wildfire related to PDO and ENSO for Kootenay National Park, Mori, 2011

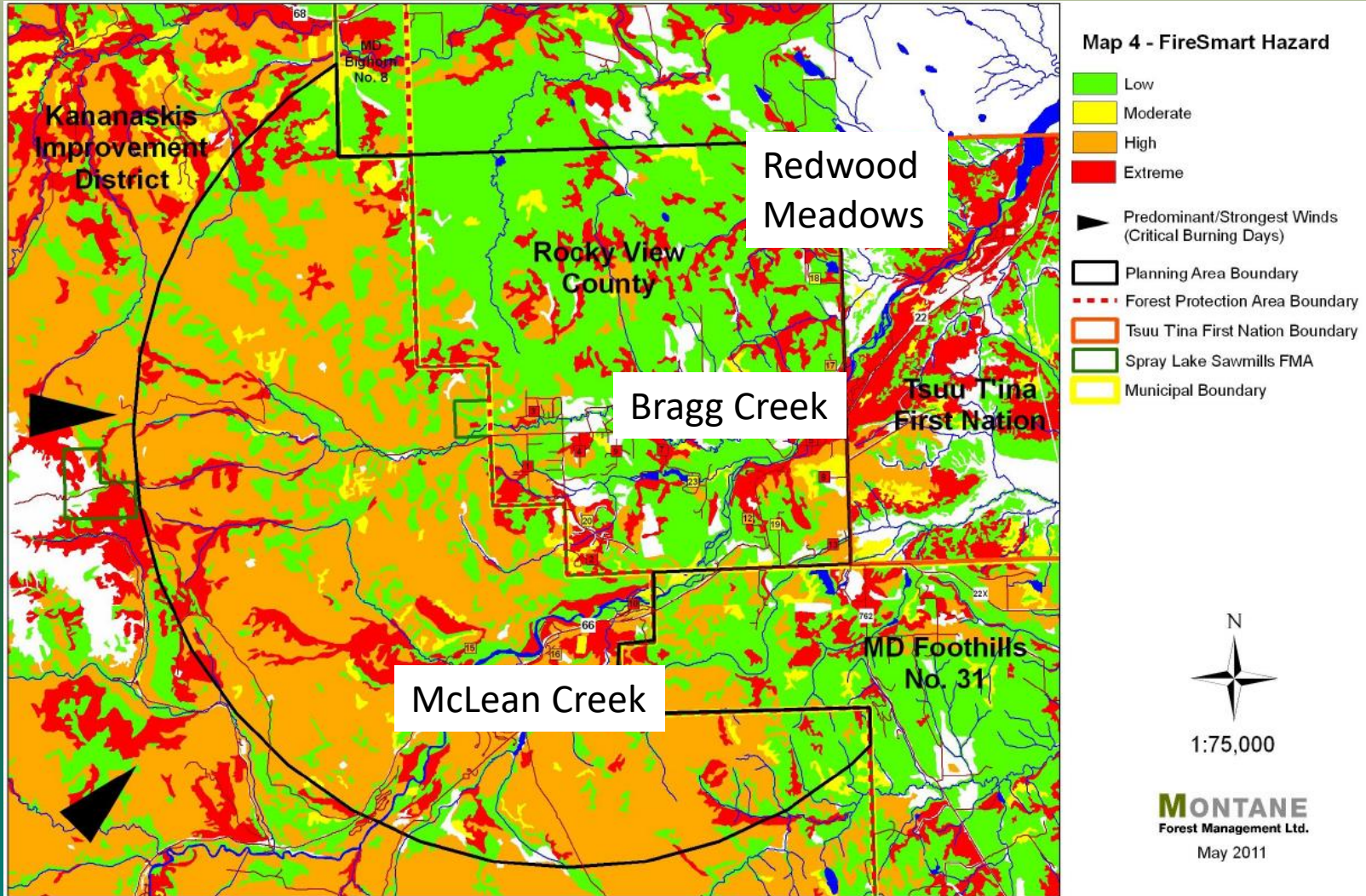


Wildfires in the Elbow River headwaters from Rogeau, 2016.





Firesmart Hazard Elbow River Valley. Bragg Creek and Whitecourt are Alberta's highest risk communities for wildfire.





Kananaskis Wildfire

Champion Lakes/McLean Creek
Wildfire May 27-31 2018

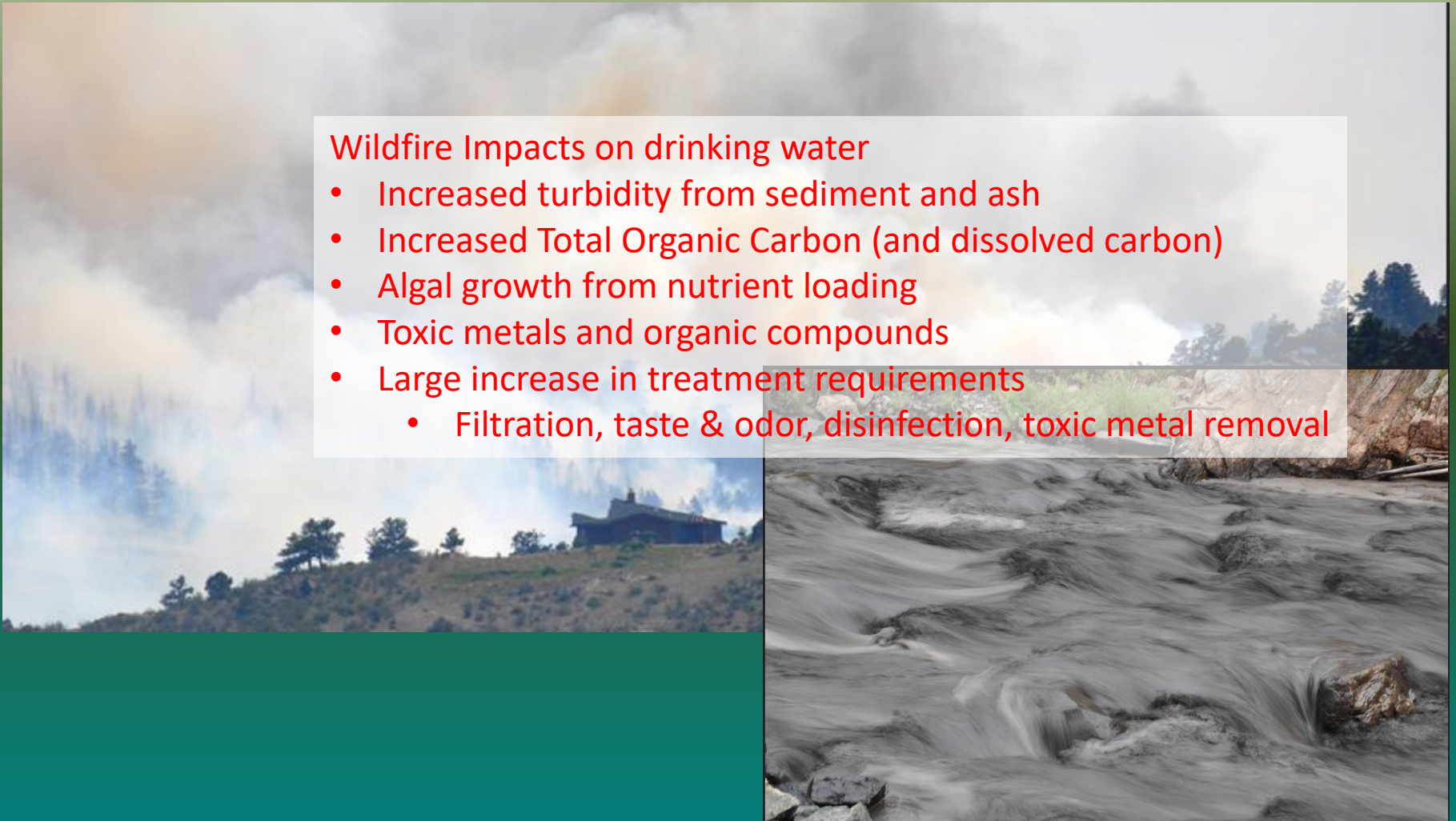




Effects of wildfires on surface drinking water treatment

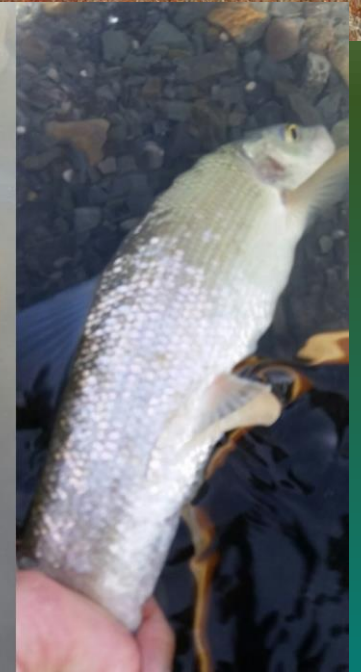
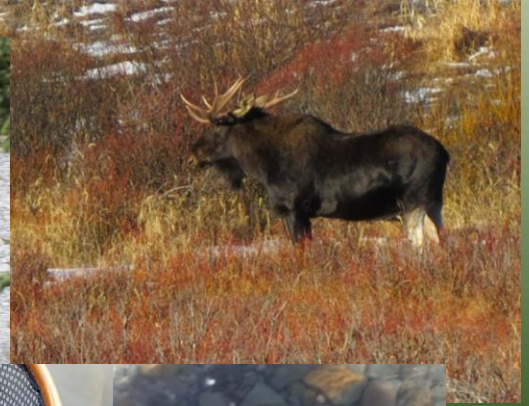
Wildfire Impacts on drinking water

- Increased turbidity from sediment and ash
- Increased Total Organic Carbon (and dissolved carbon)
- Algal growth from nutrient loading
- Toxic metals and organic compounds
- Large increase in treatment requirements
 - Filtration, taste & odor, disinfection, toxic metal removal





Watershed inhabitants: wildlife, trout, people



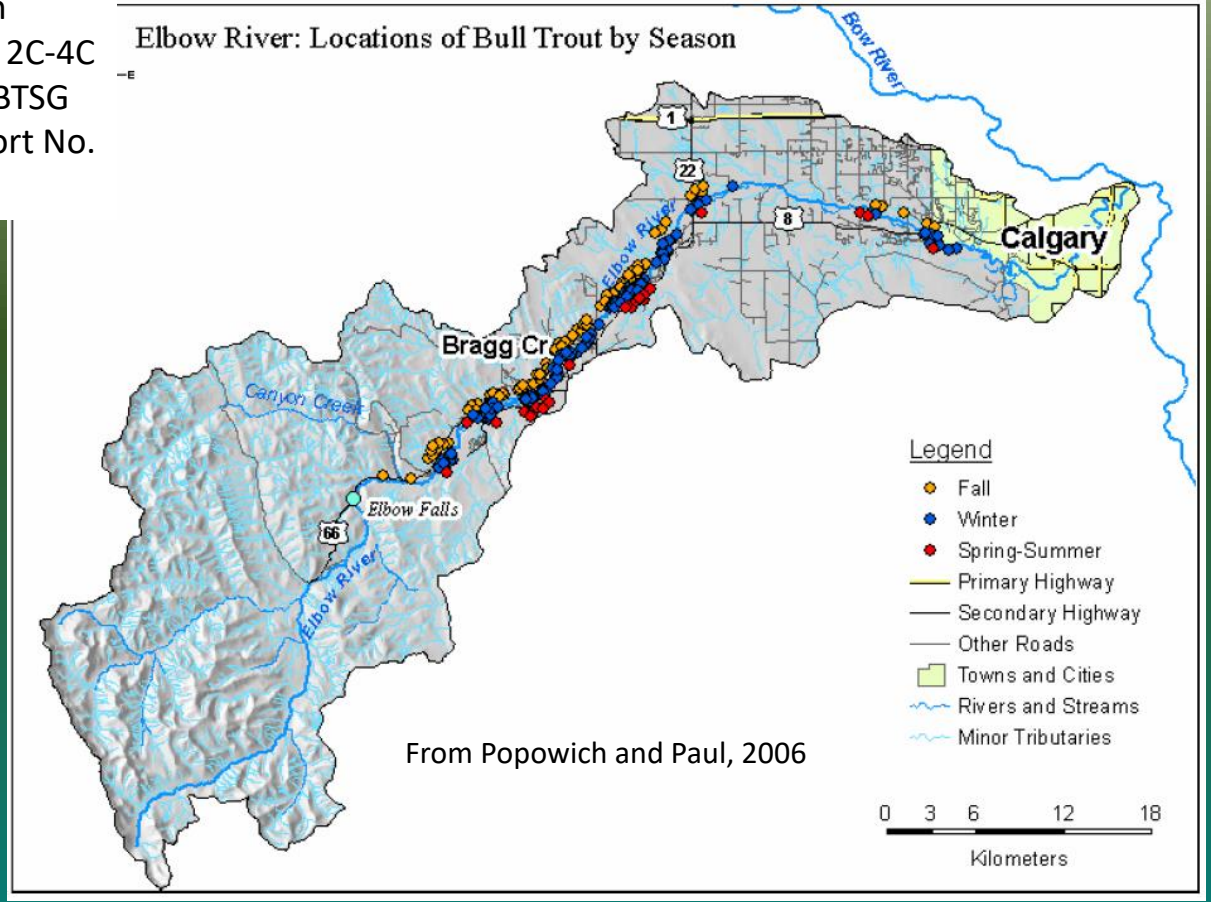


Bull Trout, Threatened species Alberta wildlife act.

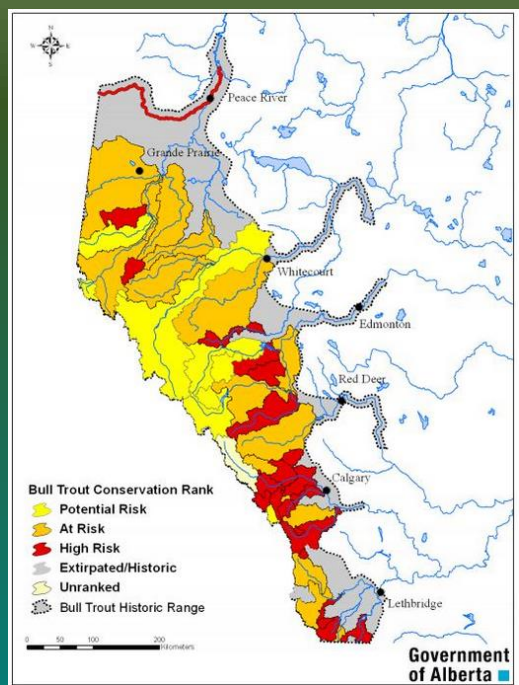


[Bull Trout] "Eggs require temperatures less than 8C to survive, and have an inter-gravel incubation optimum of 2C-4C (Berry 1994, Fairless et al. 1994, MBTSG 1998)." Alberta Wildlife Status Report No. 39 (2009) M. Rodtka

Elbow River: Locations of Bull Trout by Season



From Popowich and Paul, 2006



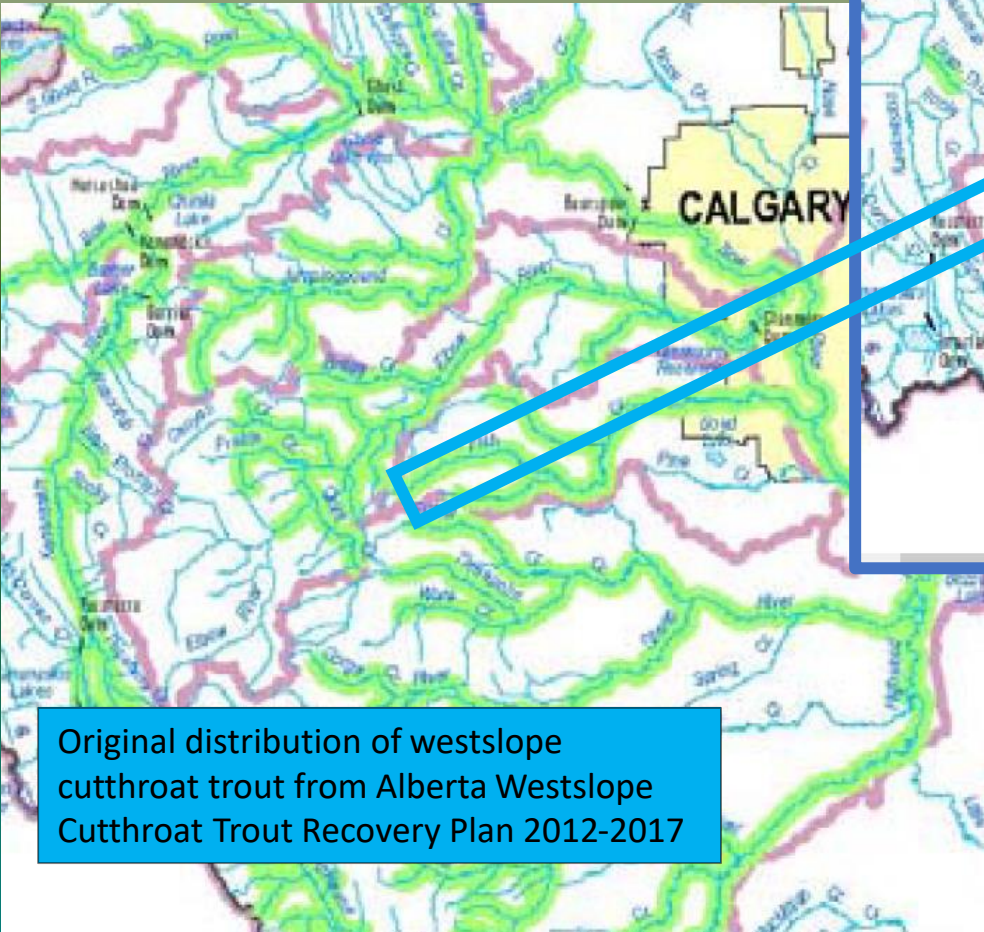
Bull Trout Conservation Rank
 Potential Risk
 At Risk
 High Risk
 Extirpated/Historic
 Unranked
 Bull Trout Historic Range

Government of Alberta

West Slope Cutthroat trout: Threatened species



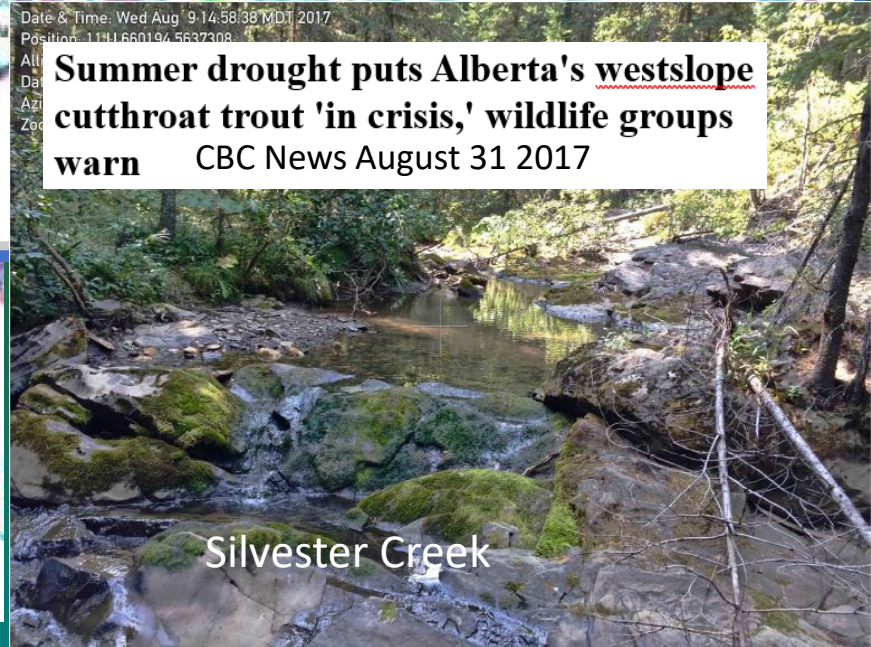
“genetically pure populations currently occupy less than five percent of their original distribution.” Alberta Wilderness Association



Original distribution of westslope cutthroat trout from Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017

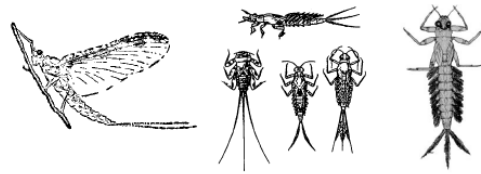
Date & Time: Wed Aug 9 14:58:38 MDT 2017
Position: 113.1660194, 56.37308

Summer drought puts Alberta's westslope cutthroat trout 'in crisis,' wildlife groups warn CBC News August 31 2017

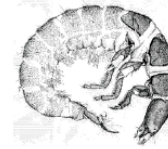


Silvester Creek

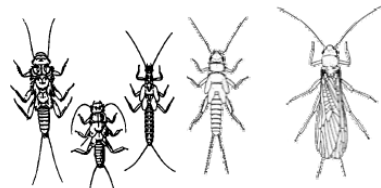
Aquatic Macroinvertebrates



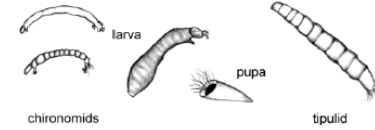
Ephemeroptera-Mayflies



Trichoptera-Caddis Flies



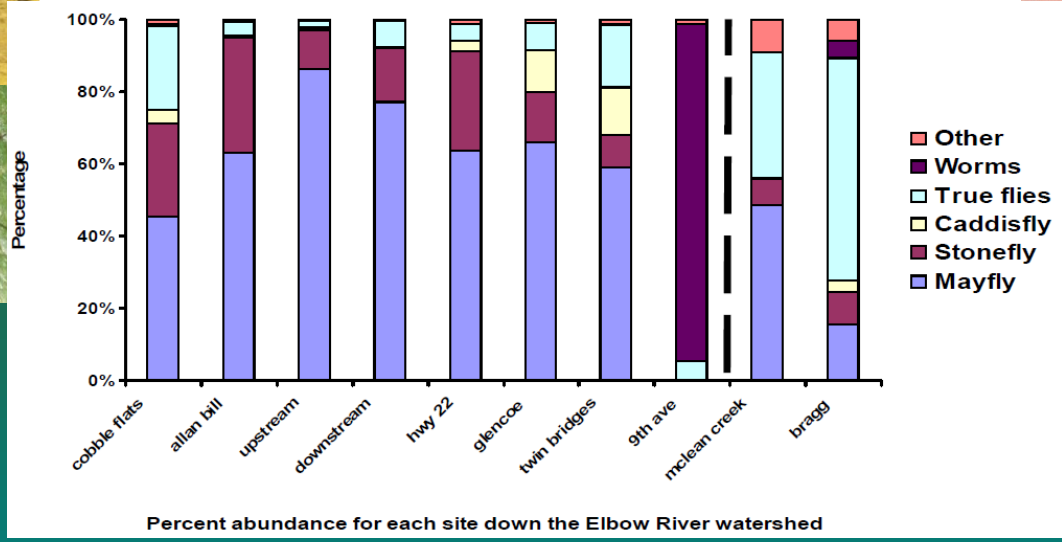
Plecoptera-Stone Flies



Diptera-True Flies



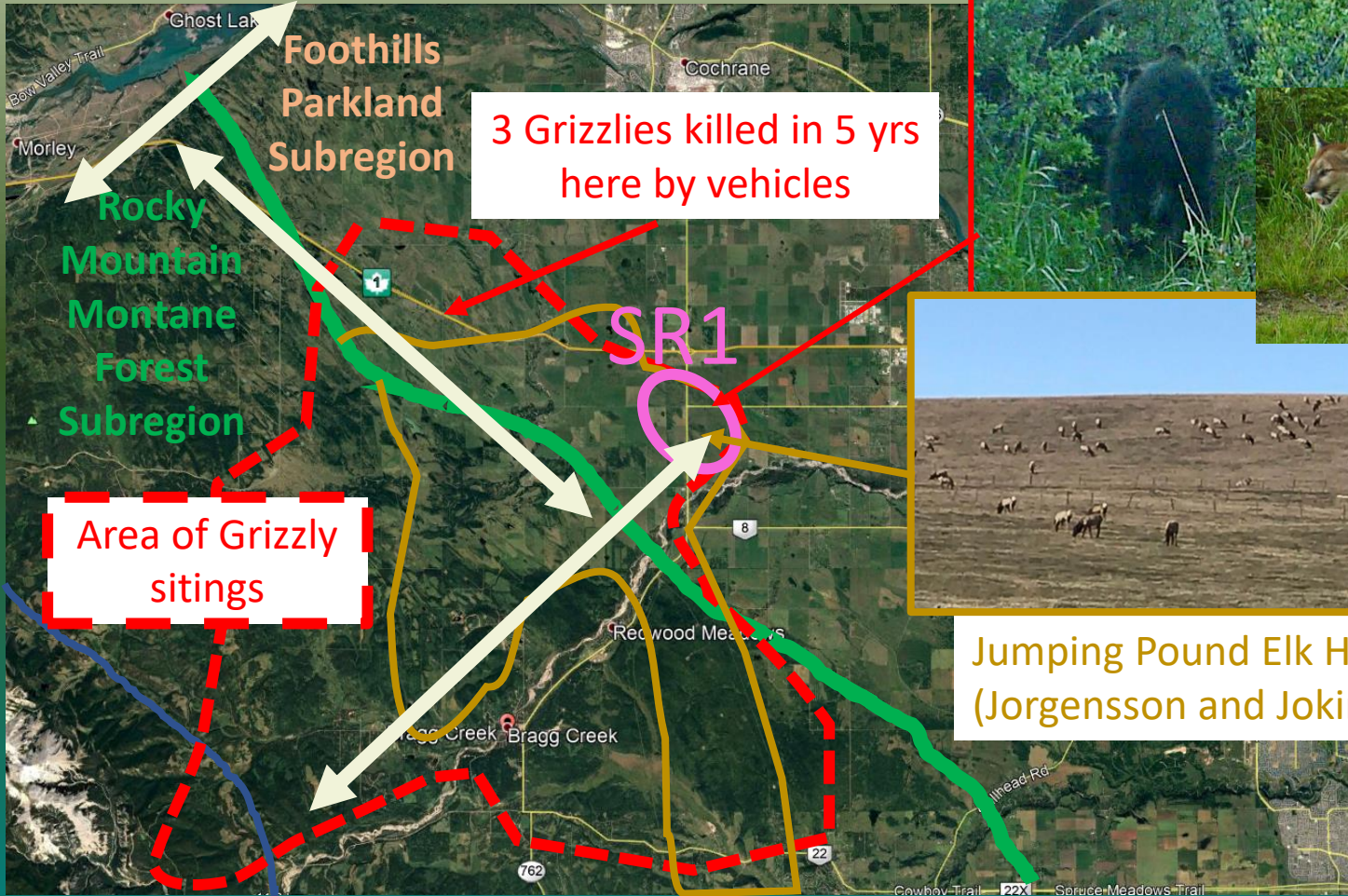
Environmental Science 502



Percent abundance for each site down the Elbow River watershed



Important wildlife corridor along **Foothills Montane** and **Parkland** natural regions.



3 Grizzlies killed in 5 yrs here by vehicles



Jumping Pound Elk Herd area (Jorgensson and Jokinen 2008)



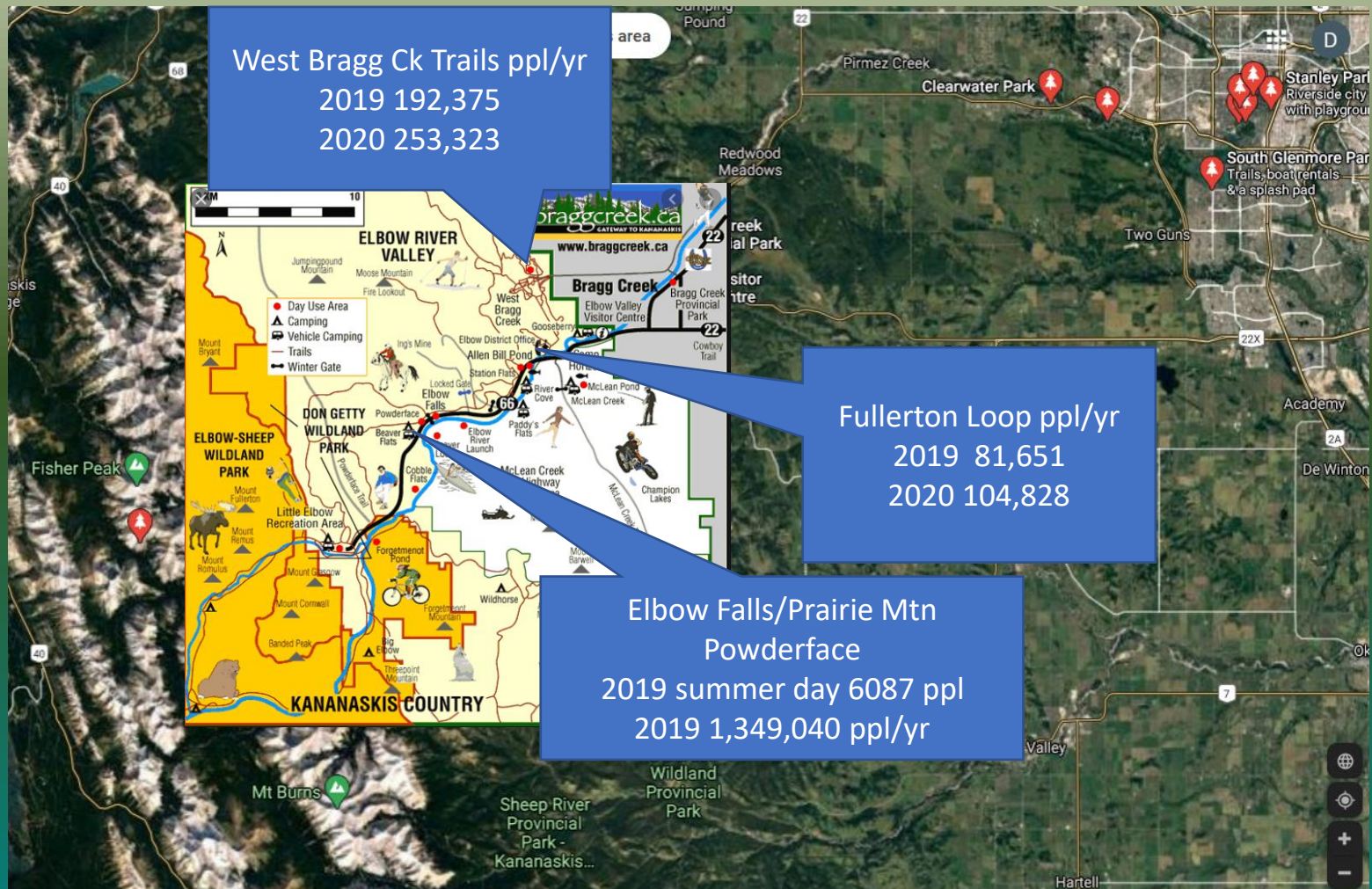
Land Use in the Elbow Watershed: Recreation, Logging, Wildfire, Grazing, Hwy 8 development





Approximately 2.01MM visitors to the Elbow Valley in Kananaskis in 2020 as determined from traffic counters.

About a 35% increase from 2019.





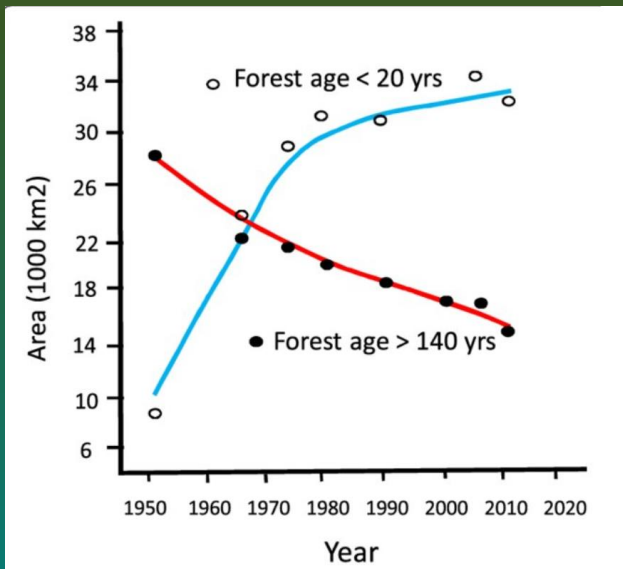
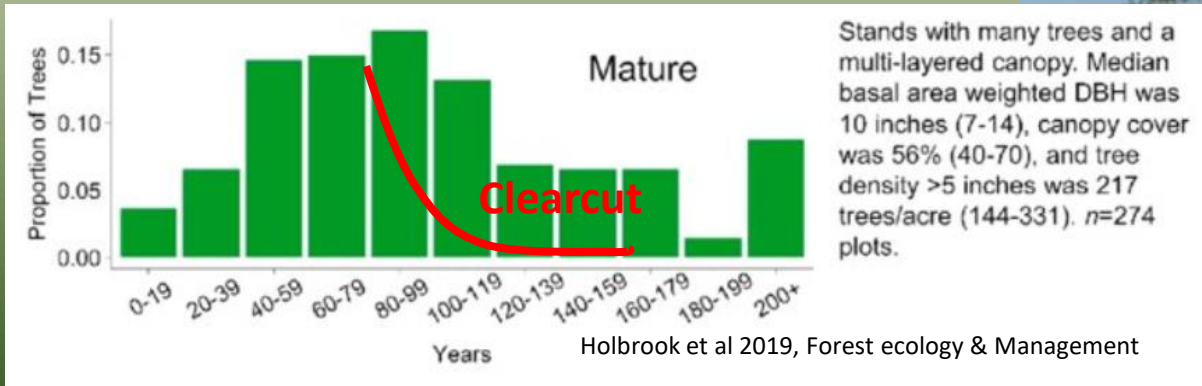
Elbow River Watershed logging footprint: 1984/2016



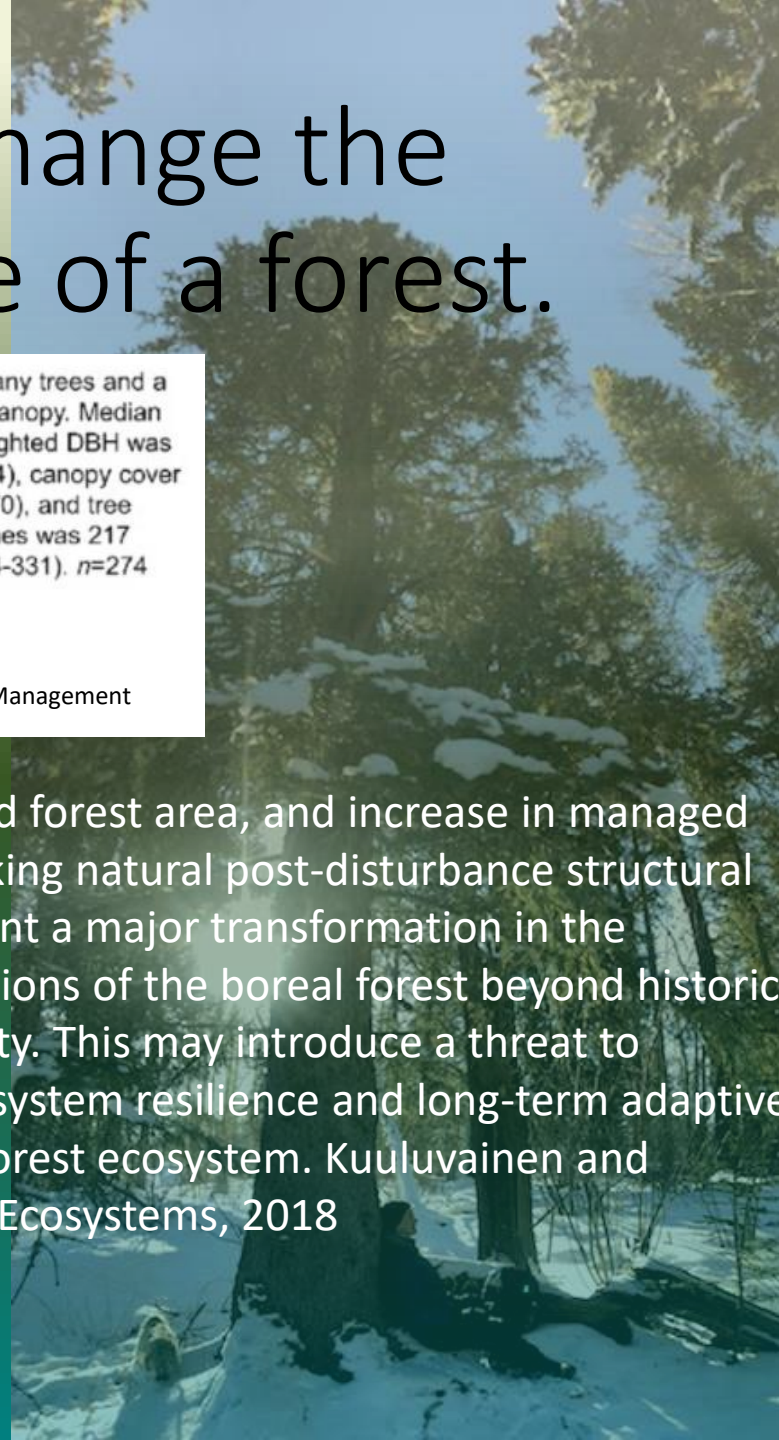
24% of harvestable forest logged in 31 years, for a 0.8%/yr deforestation rate
2001-2019 Deforestation rates: World 6%, Canada 10%, Elbow River 14%



How clearcuts change the natural structure of a forest.



The decline in old forest area, and increase in managed young forest lacking natural post-disturbance structural legacies, represent a major transformation in the ecological conditions of the boreal forest beyond historical limits of variability. This may introduce a threat to biodiversity, ecosystem resilience and long-term adaptive capacity of the forest ecosystem. Kuuluvainen and Gauthier, Forest Ecosystems, 2018





Soil moisture and forest harvest

Forest harvest strategies and seasonal soil moisture in Alberta's Mountain headwaters (Coleman AB). D. Greenacre MSc U of A, 2019

Spatial patterns of soil temperature and moisture..S BC. Redding et al. 2003 Can J Soil Sci 83:121-130

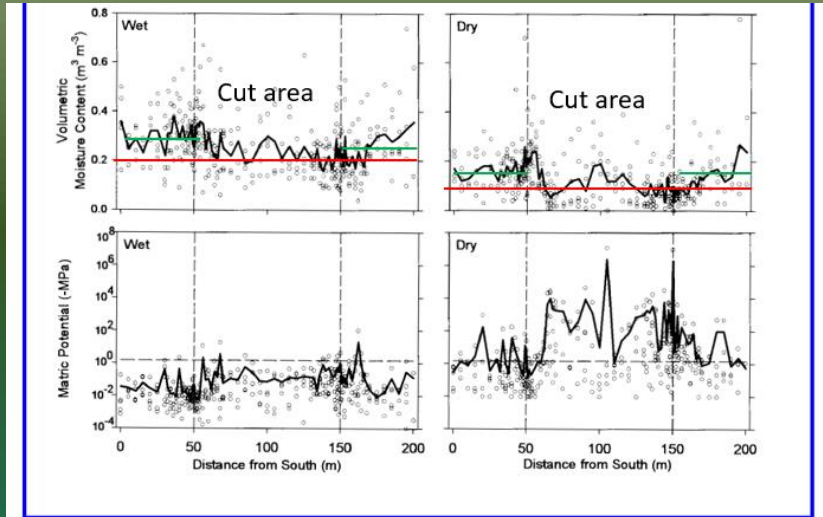
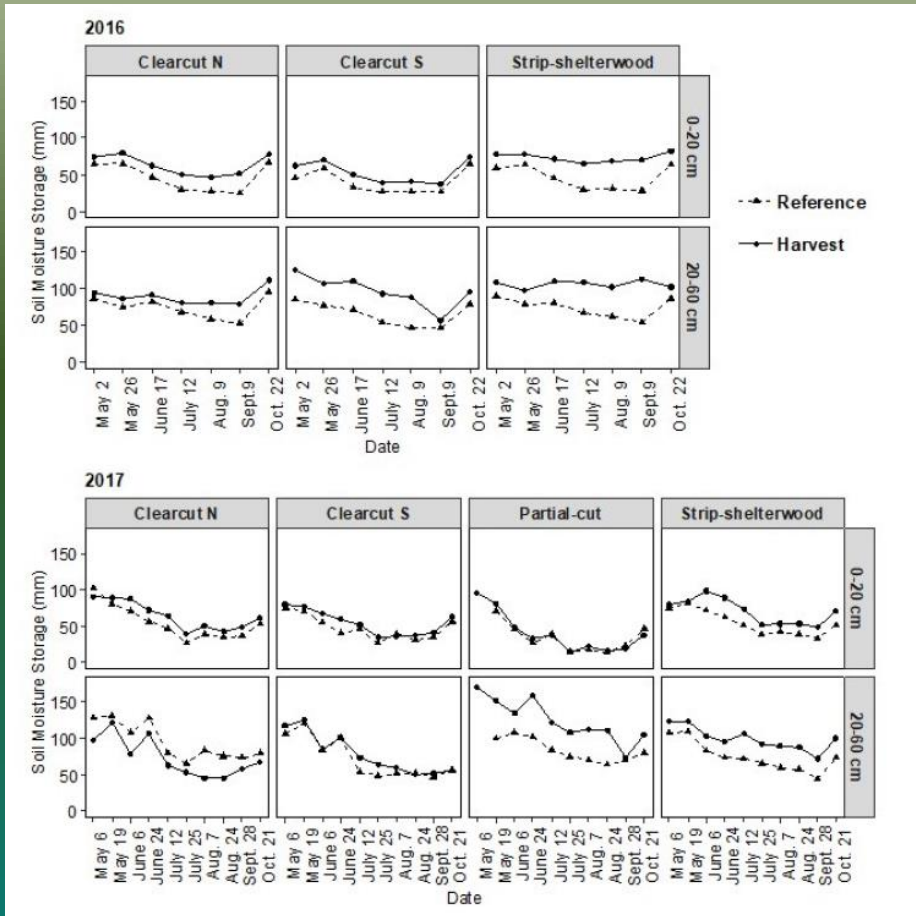


Fig. 1. The trend of forest floor temperature and moisture along N-S transects across a 1-ha opening. Vertical dashed lines denote the south (50 m) and north (150 m) edges. Open circles are individual measurements, solid black lines are the means of all individual measurements at each location along the distance axis. Soil temperature was measured under clear-sky (30 July) and overcast conditions (24 August). Moisture content was measured under wet (6 July) and dry (8 August) conditions. The horizontal dashed lines on the matric potential graphs are the estimated permanent wilting point (-1.5 MPa).





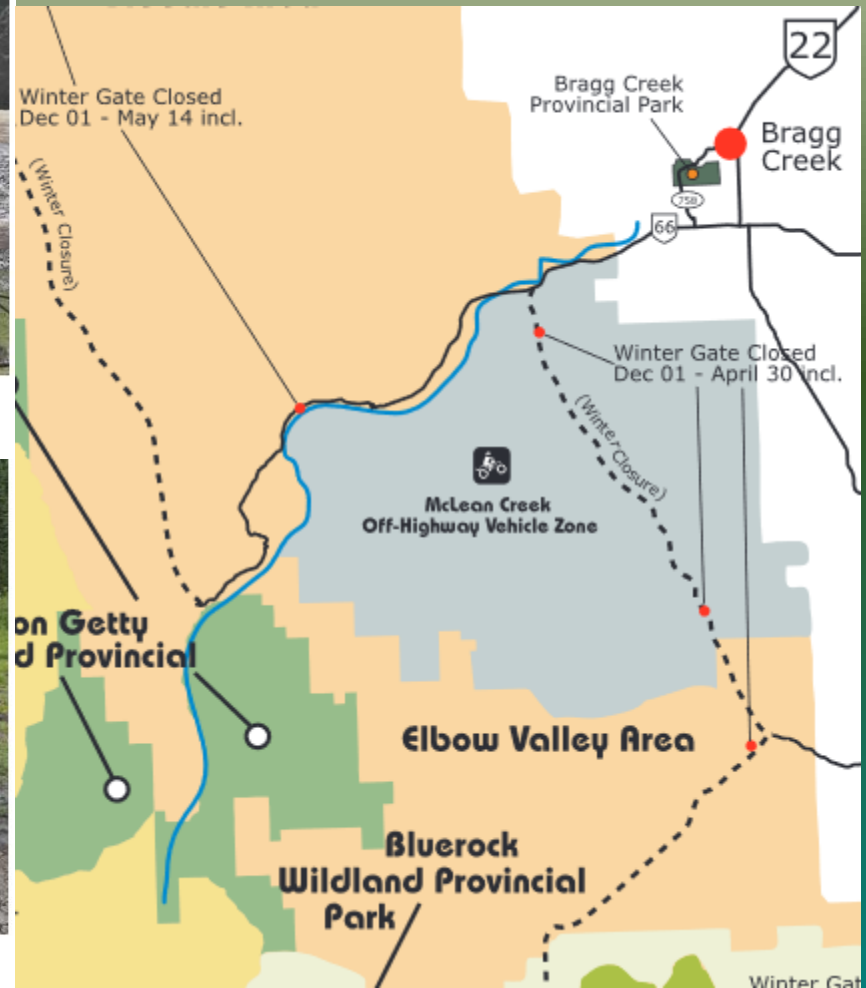
McLean Creek Off-Highway Vehicle Land Use Zone



Off roaders hit the trails on their ATVs at McLean Creek, a popular camping and off-road use area west of Calgary on Sunday May 21, 2017. Jim Wells/Postmedia PHOTO BY JIM WELLS / Jim Wells/Postmedia



Trucks and OHV's frequent McLean headwaters for mudding PHOTO: © L. BOYER





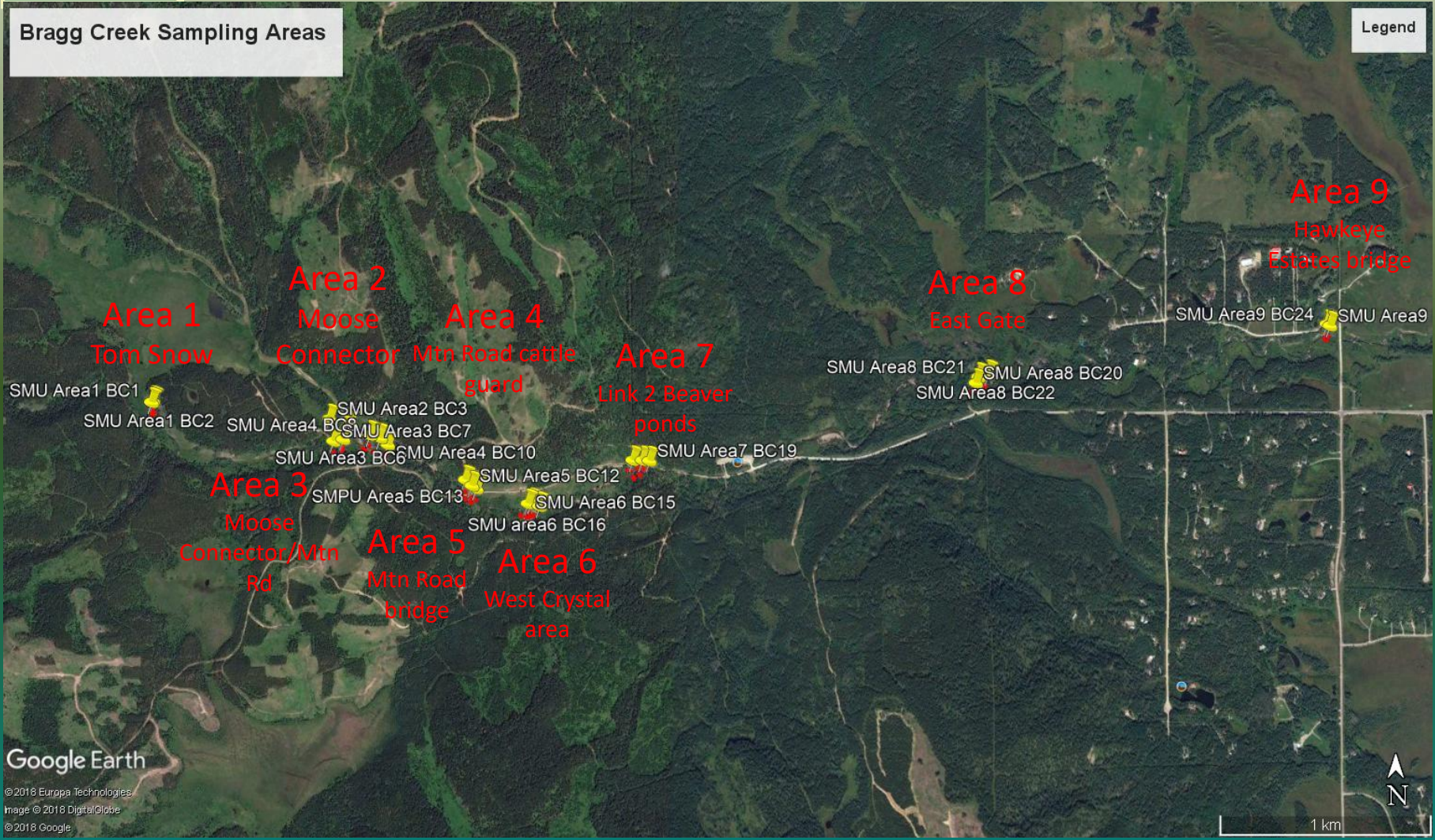
“Total loading of TSS to the Elbow River over the 4 May-10 July study period, estimated by an indirect and a direct method, was 11.9 tonnes to 14.0 tonnes, respectively.” L. Boyer Study of McLean Creek, 2017





Cattle grazing and water quality in the Greater Bragg Creek Trails area

Dave Klepacki, Prof. Ralph Cartar (U of C), St Mary's University Fall 2018

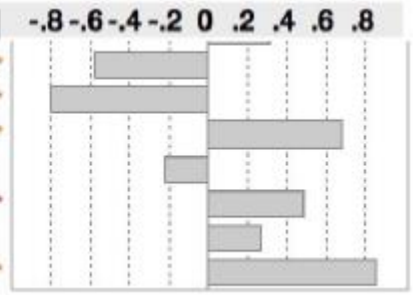




What chemical traits relate to density of cow use?

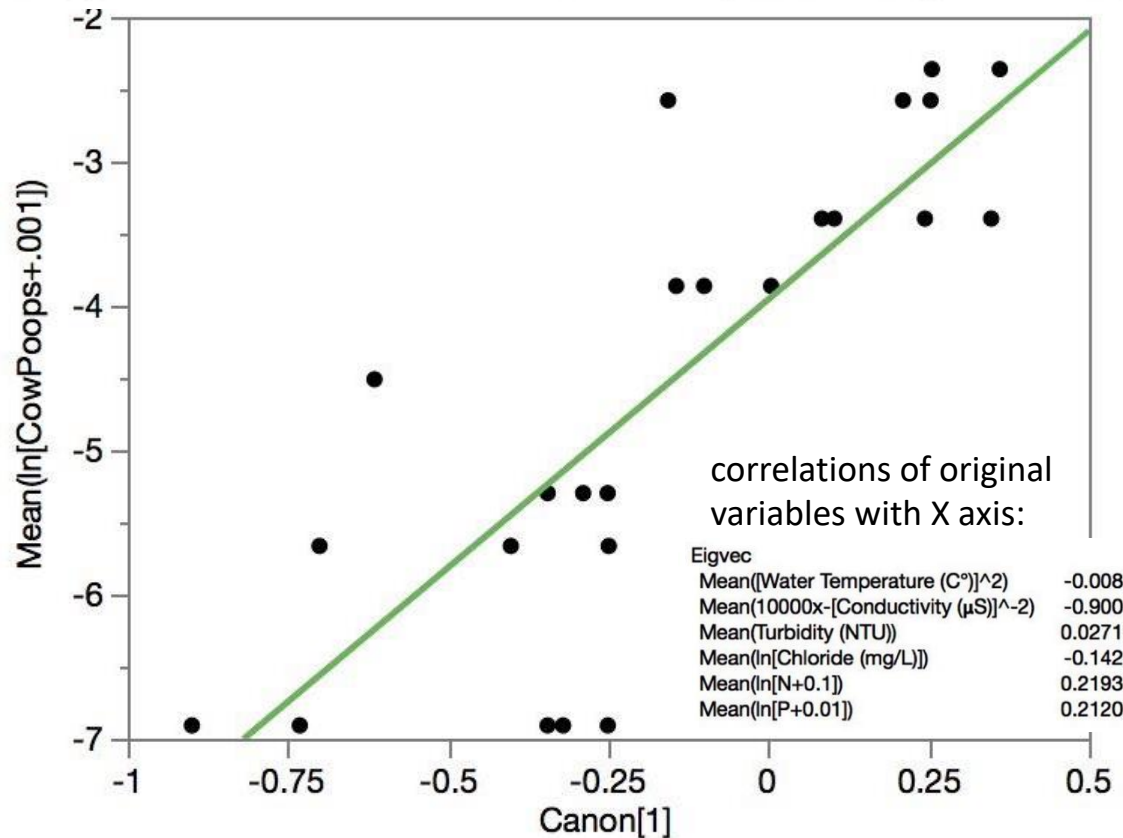
analysis by Ralph Cartar Dec. 2018

Variable	by Variable	Spearman ρ	Prob> ρ
Mean(ln[CowPoops+.001])	Mean([Water Temperature (C°)]^2)	-0.5701	0.0036*
Mean(ln[CowPoops+.001])	Mean(10000x-[Conductivity (μS)]^-2)	-0.7956	<.0001*
Mean(ln[CowPoops+.001])	Mean(Turbidity (NTU))	0.6827	0.0002*
Mean(ln[CowPoops+.001])	Mean(ln[Chloride (mg/L)])	-0.2182	0.3057
Mean(ln[CowPoops+.001])	Mean(ln[N+0.1])	0.4856	0.0161*
Mean(ln[CowPoops+.001])	Mean(ln[P+0.01])	0.2711	0.2001
Mean(ln[CowPoops+.001])	Canon[1]	0.8531	<.0001*



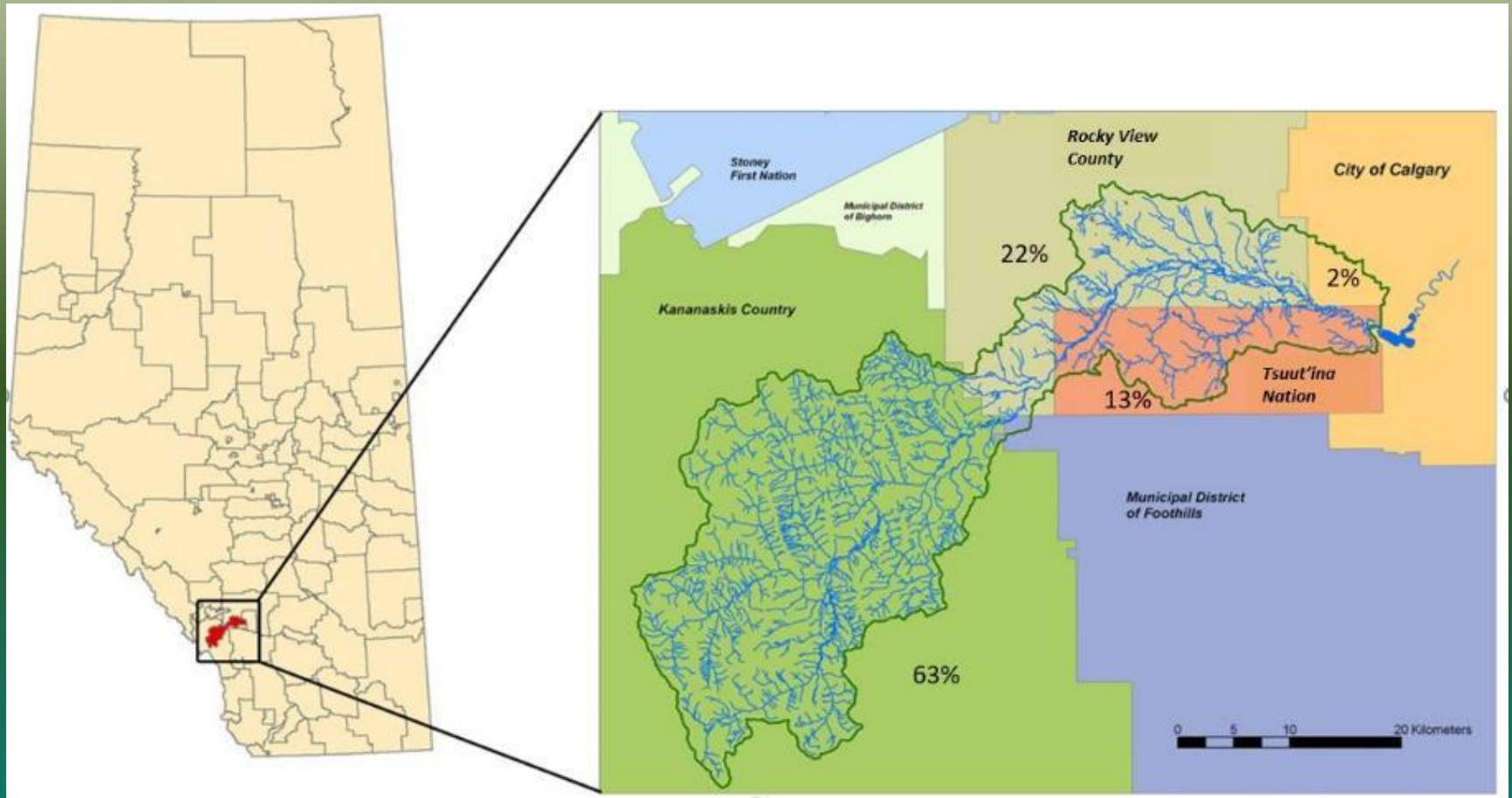
Cow poo is negatively associated with Temperature and Conductivity, and is positively associated with Turbidity, Nitrates, and Phosphate....**Overall, there is a strong association of cow poo and water traits.**

Ralph Cartar, Dec 18 2018.





Land Management in the Lower Elbow River Watershed



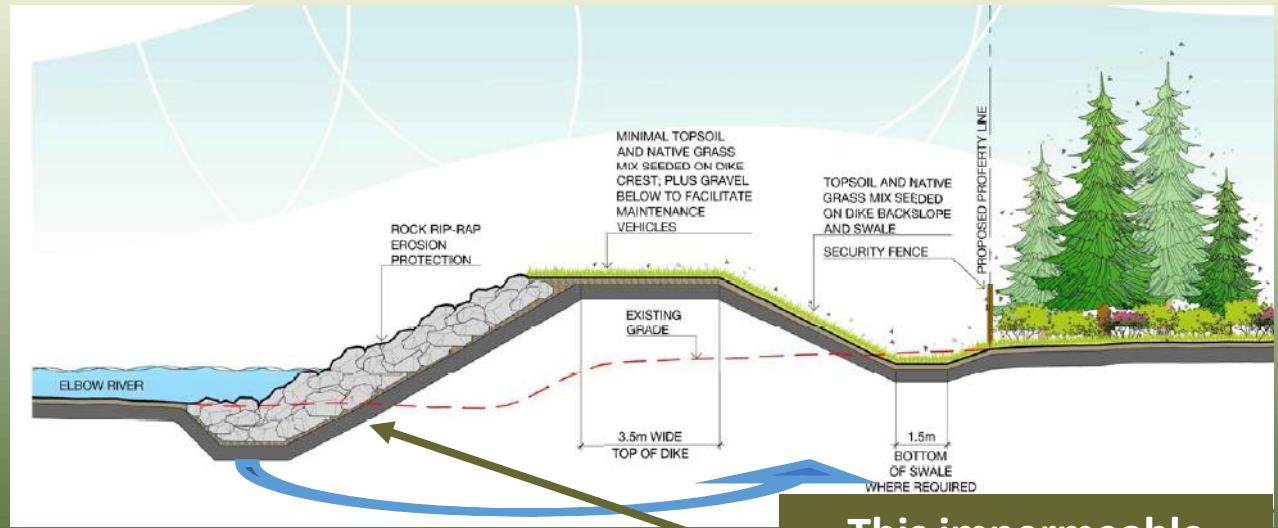


Berms...making
a river into a
culvert.

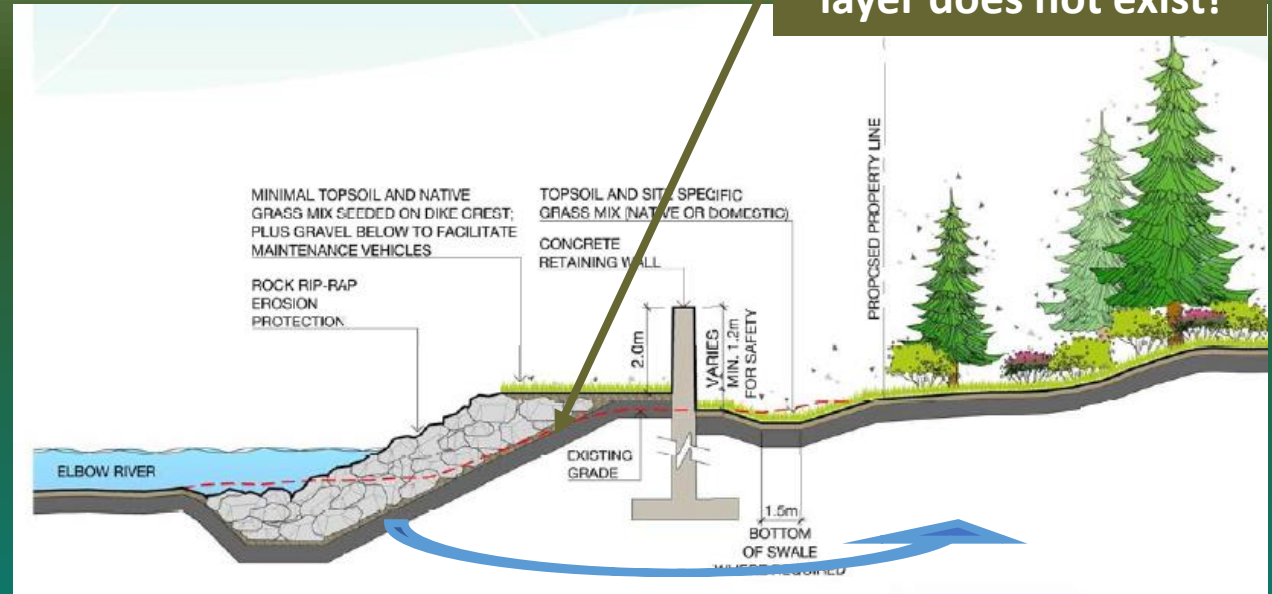




Berm protection proposed for Bragg Creek will only be effective if berms have a wall to bedrock isolating alluvial deposits from the river flow.



This impermeable layer does not exist!





Basement flooding in Redwood Meadows, June 2013.
Note 60-80cm basement flooding 200-300m from the river...behind the berms!! The alluvial aquifer delivered the water despite berms.

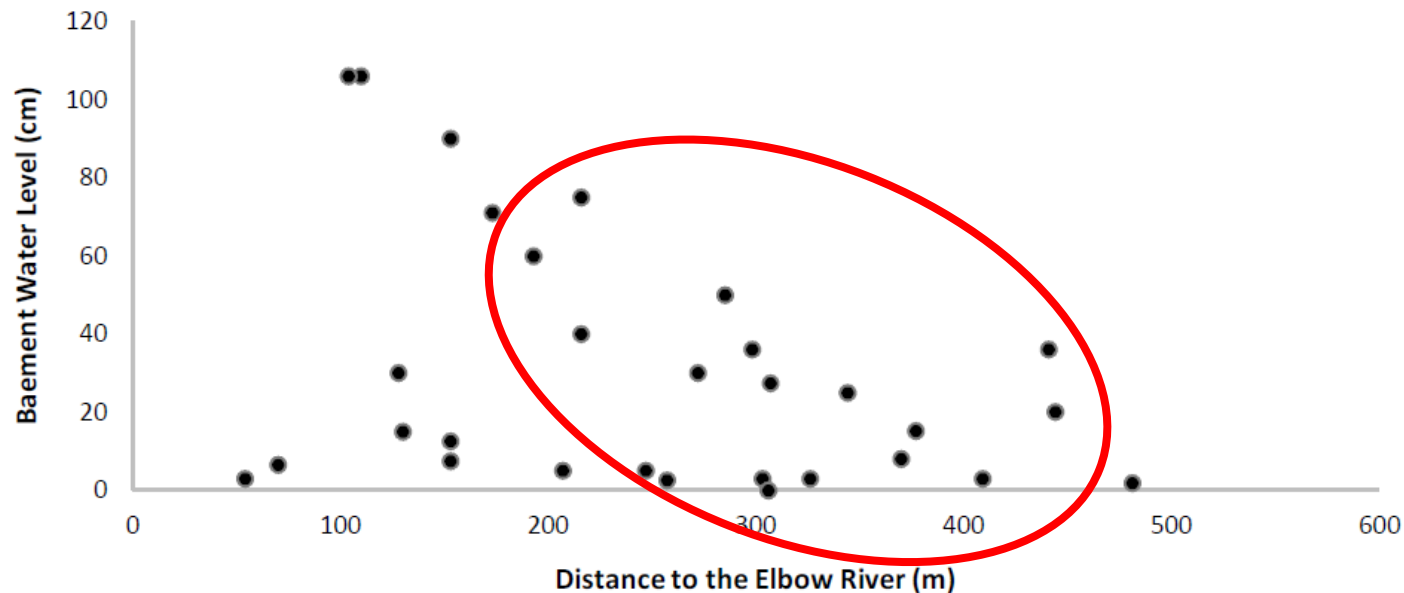
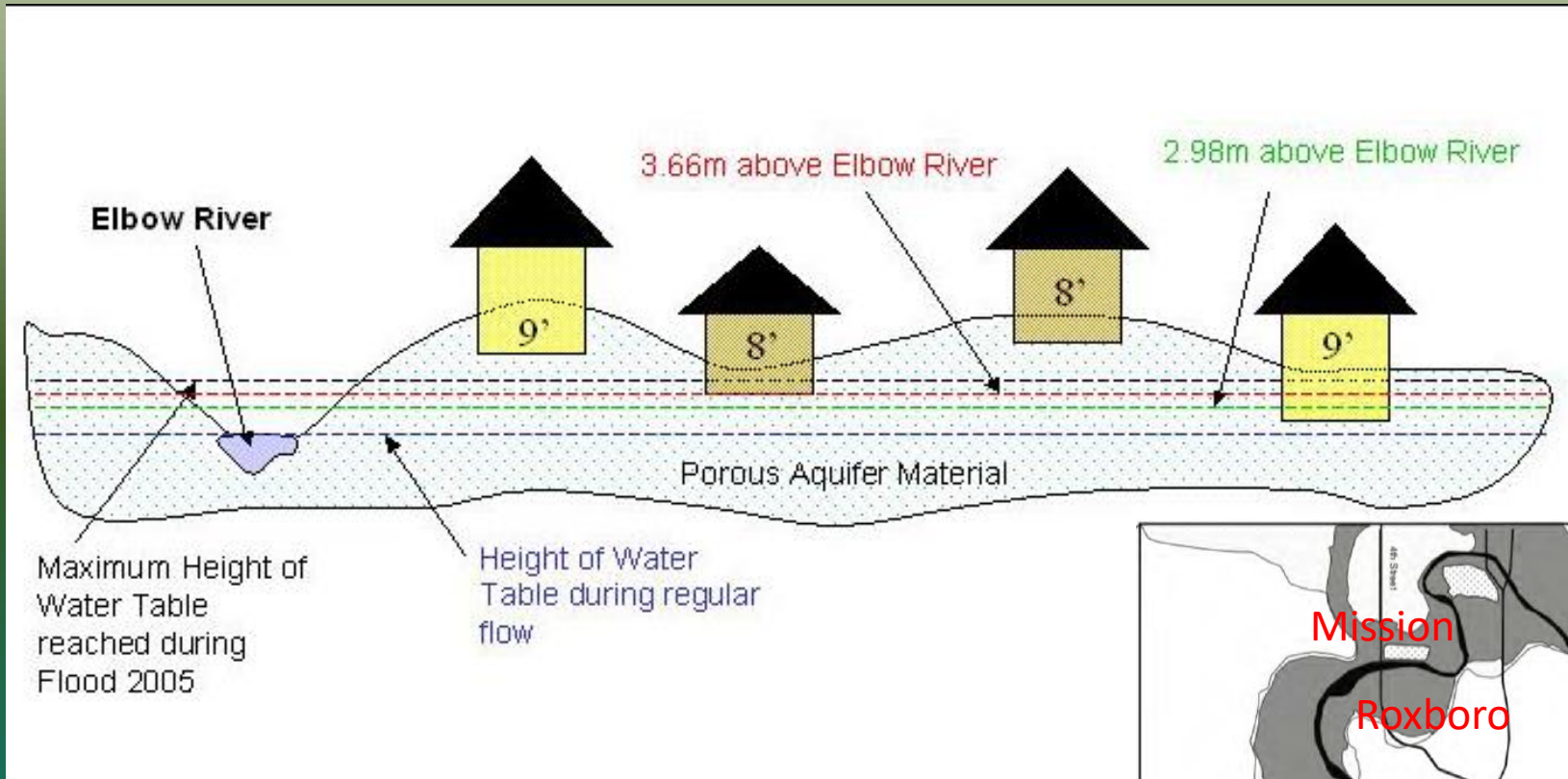


Figure 1. Flood water height above basement floor (cm) with distance of the home to the Elbow River (m).



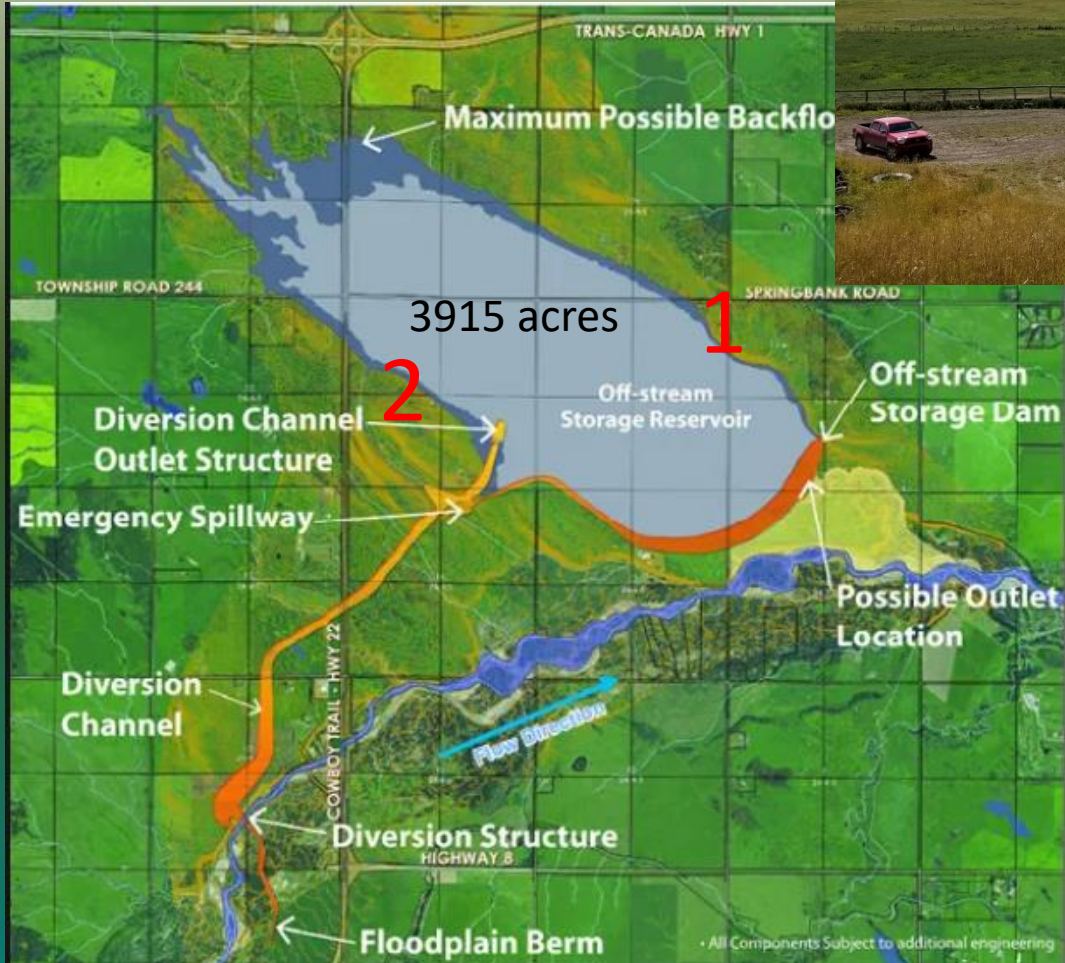
Comparison of basement depth to river height during 2005 in Rideau and Roxboro.

ENSC502 2006





Springbank Off Stream Reservoir Flood Control Project



View across proposed reservoir from east shore to west shore



Major flaws of the SR1 Project.

- Flood mitigation limited by 600 m³/s diversion canal. 2013 flood of 1150m³/s will pass 550m³/s into Glenmore.
- Flood mitigation only. Drought mitigation must come from Bow, requires Stoney Nakoda dam.
- Lost of critical ecozone boundary habitat likely remove Jumping Pound elk herd, grizzlies and wetland willows.
- Release of warmed 70mm m³ water at 10-26m³/s in July and August will severely degrade downstream ecosystem and infiltrate aquifer.
- Each flood event will deposit up to 4m of silt, potentially pathogenic from upstream (Redwood, BC, campground) sewage. Dust problem.
- Costs are now estimated at \$650MM by SCLG.



Release of $\sim 70 \times 10^6$ m³ of warmed waters downstream from SR1 will drastically disrupt ecosystem and Glenmore reservoir.

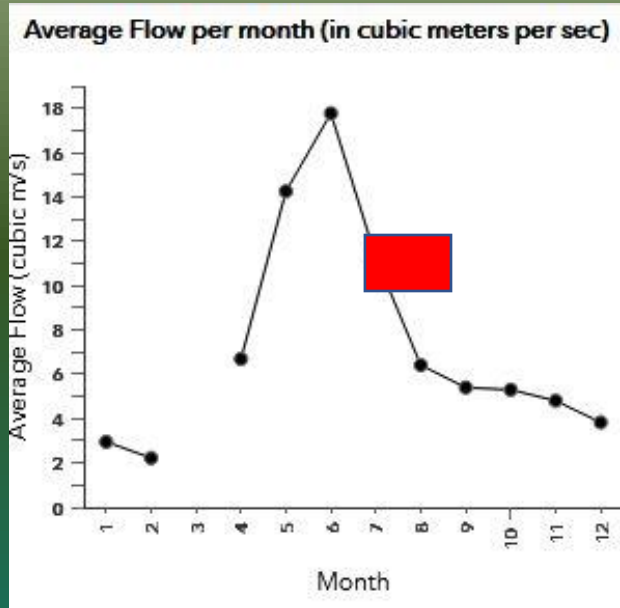


Figure 7-10 Dilution in Elbow River During Water Release from the Reservoir (Discharge) for the Design Flood

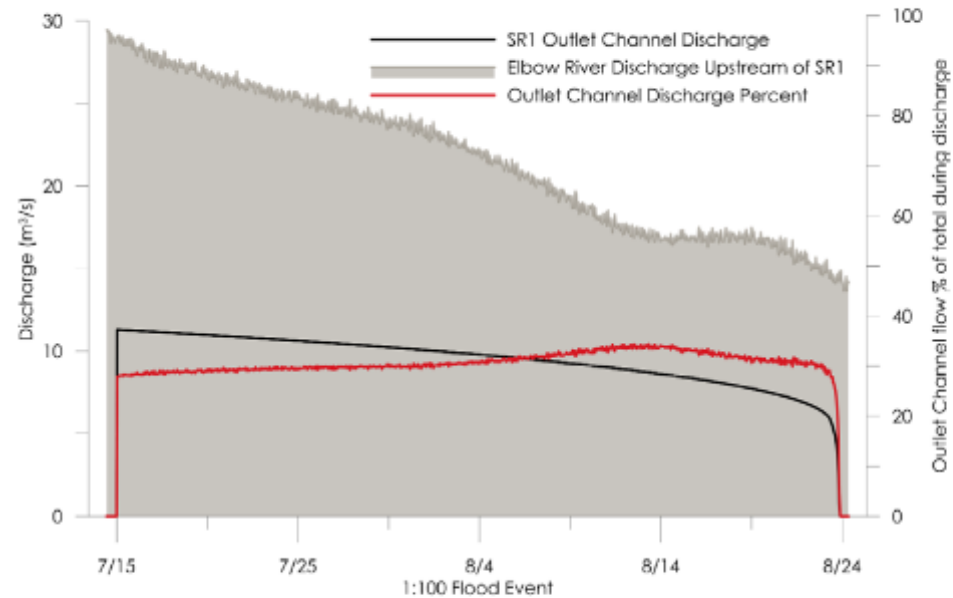
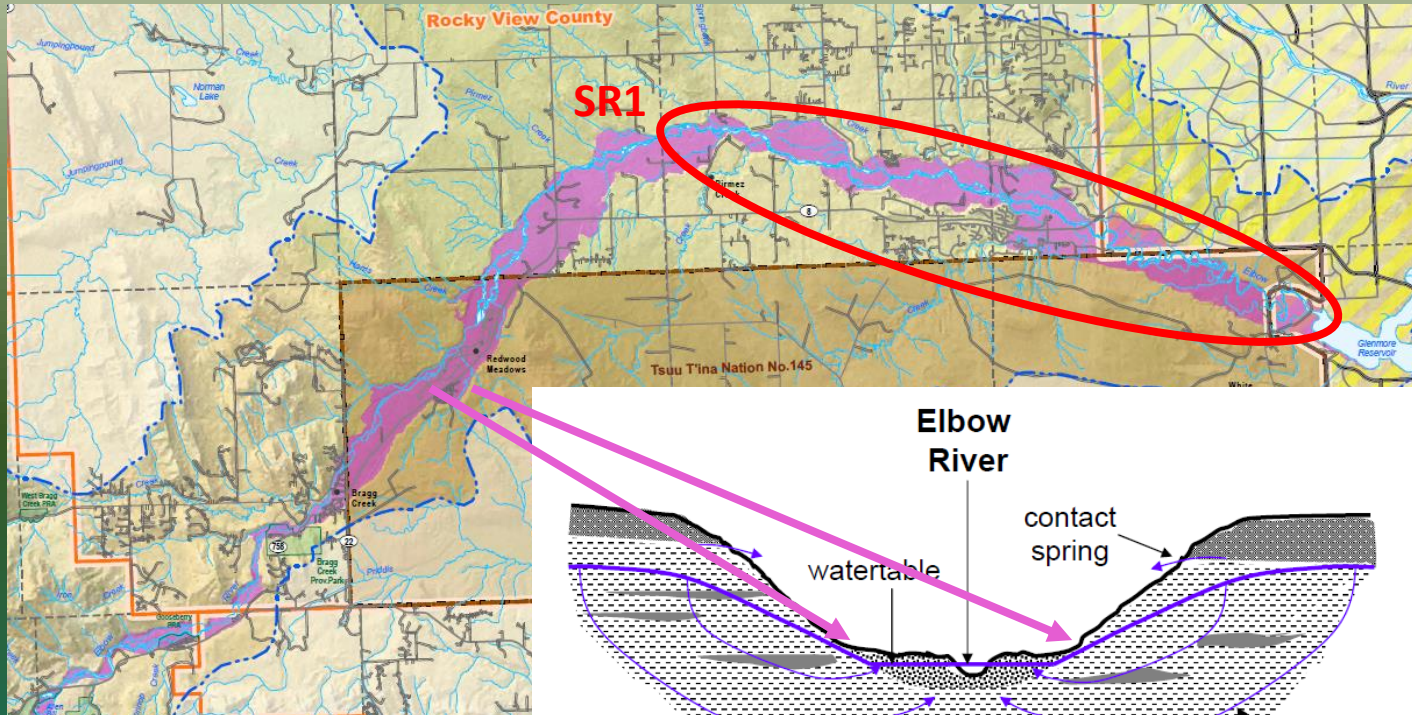


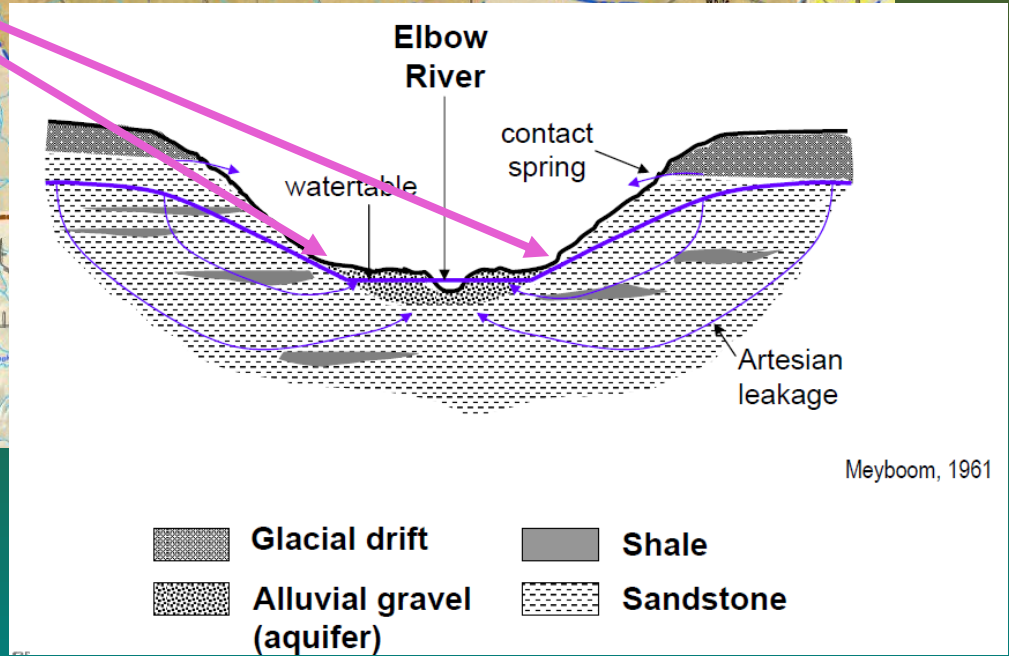
Figure 7-11 Dilution in Elbow River During Water Release from the Reservoir (Discharge) for the 1:100 Year Flood



What is the impact of development on the Elbow River aquifer, holding some 80-90% of water in the watershed, for the 600,000+ people and wildlife that depend on clean water?



Setbacks: 500m from flowing water, 100m from aquifer edge. Blanche et al., 2016 enteric virus survival



Meyboom, 1961



Highway 8 development along the Elbow River Aquifer

Elbow River in the Springbank area
Development footprints along the Elbow River

Legend

- City of Calgary Boundary
- Discovery Pond
- Discovery Ridge
- Elbow River Aquifer
- Elbow Valley Community
- Elbow View Double Creek
- Gardner Land Western Securities
- SR-1 Footprint

Springbank Off-Stream Reservoir Flood Mitigation

Elbow River Aquifer

Gardner Plan
2000 units,
6000 ppl

Elbow View
7000 units/20 yr
19,000 ppl

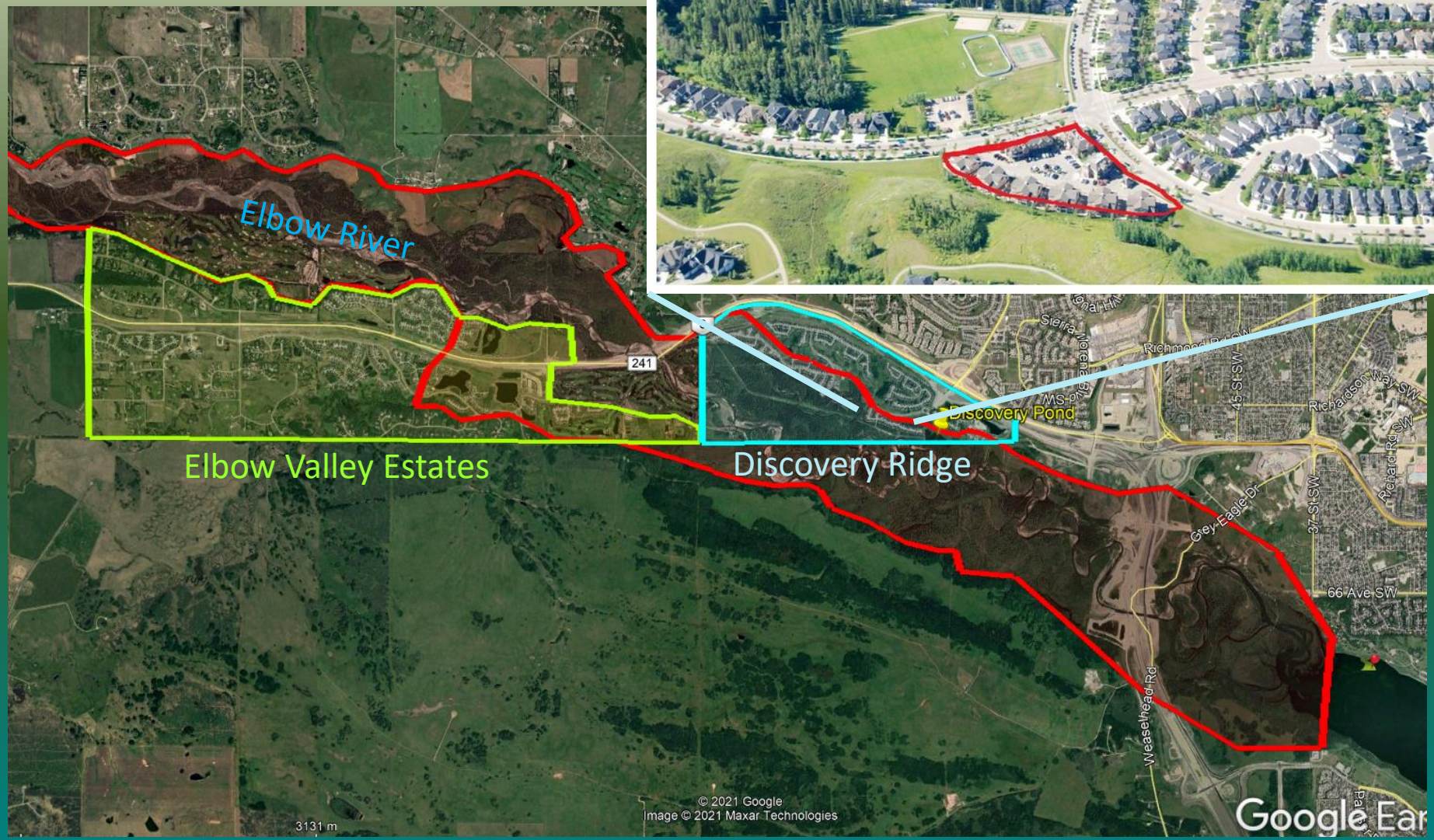
Elbow Valley
1000 units, 3000 ppl

Discovery Ridge
1625 units
4475 ppl





Suburban sprawl along the Elbow River aquifer.





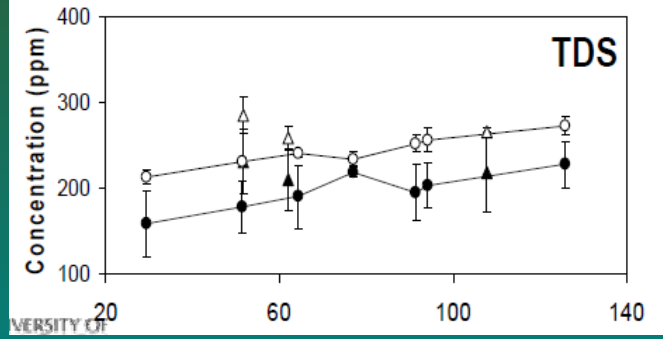
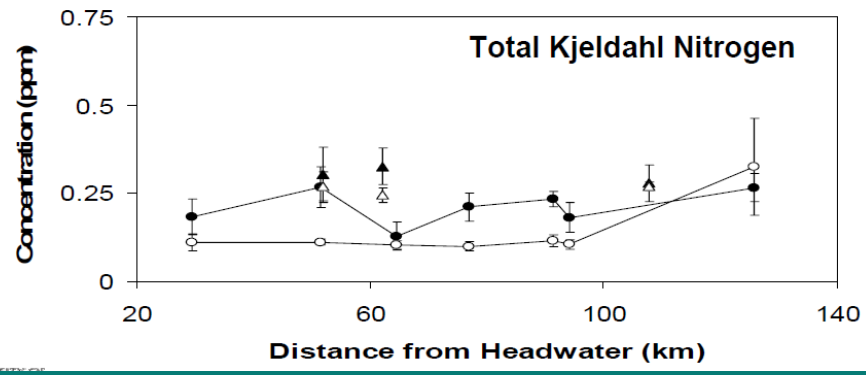
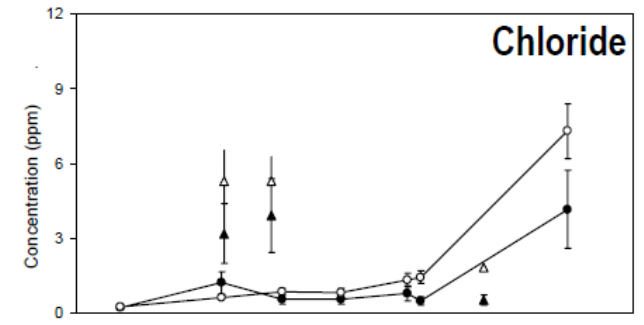
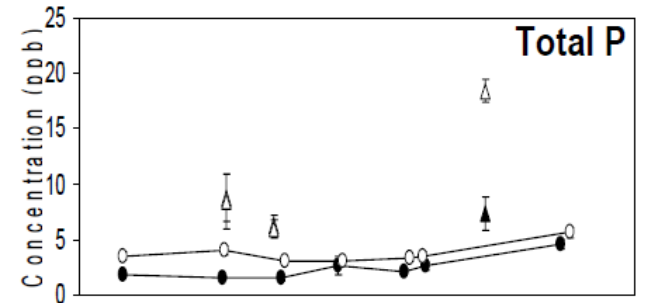
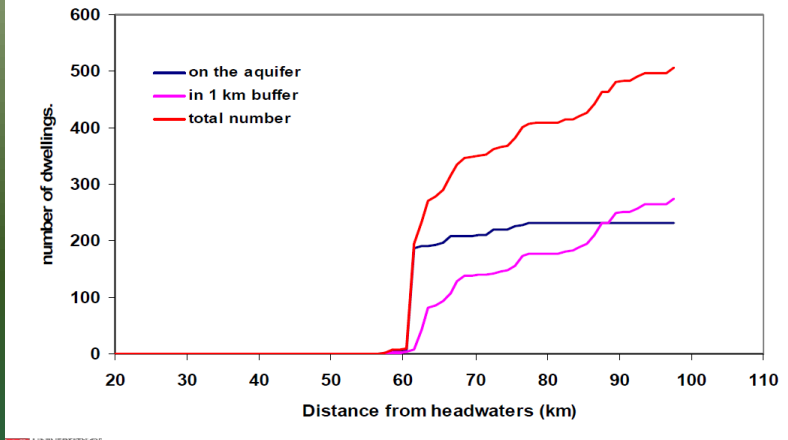
Discovery Pond: What does close development do to a river-connected aquifer?





Decreasing water quality and increasing nutrient levels in the lower Elbow River (From ENSC 502 2012). What about unmeasured metals and toxins?

Number of Dwellings Served by Septic Systems Along Elbow River





Degradation of the Weaselhead.



About 50 or so protesters turned out for a walk Saturday to a popular beaver pond in the Weaselhead area. The group says construction of the southwest ring road will cause irreparable harm. (Julien Lecacheur/CBC)

Consequences
of vehicle
emissions?



Courtesy Yves Dansereau,
Weaselhead Preservation Society



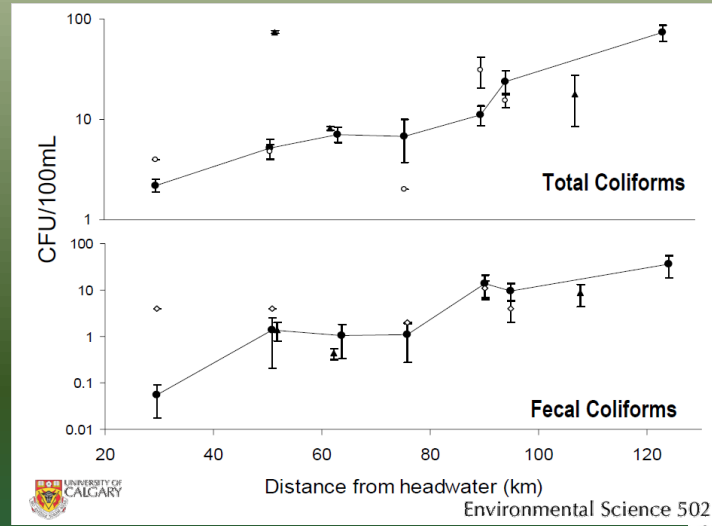
Pollution in the lower Elbow





There's been too much human poop in the Elbow River for 3 years now and Calgary can't figure out why | CBC News

Drew Anderson · CBC News · Posted: Jun 26, 2019 5:30 AM MT | Last Updated: 2 hours ago



UNIVERSITY OF CALGARY Environmental Science 502

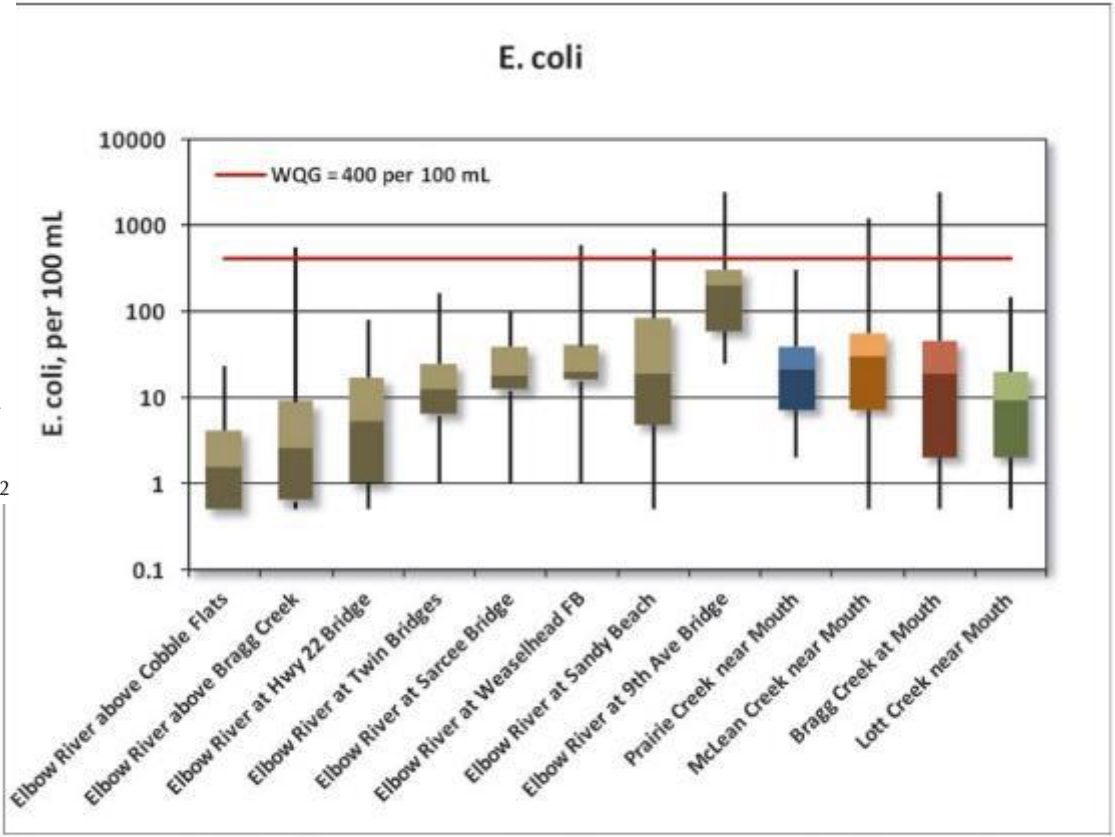


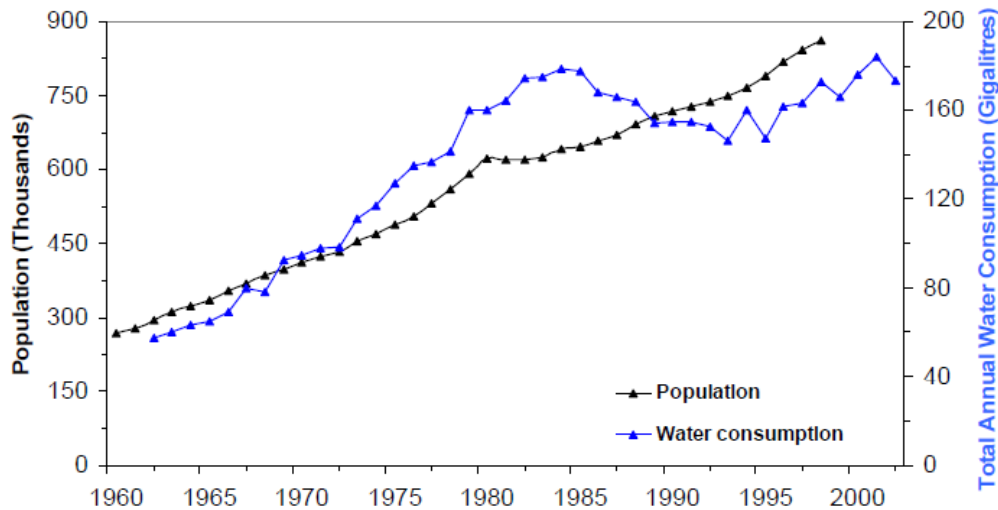
Figure 43. Box and whisker plots of *E. coli*, summarized from 2010-2012 for Elbow River mainstem stations and tributary stations: Prairie Creek, McLean Creek, Bragg Creek, and Lott Creek with the Health Canada Recreational Water Quality Guideline (WQG) for *E. coli* of 400 per 100mL.

Note increasing coliform content downstream.



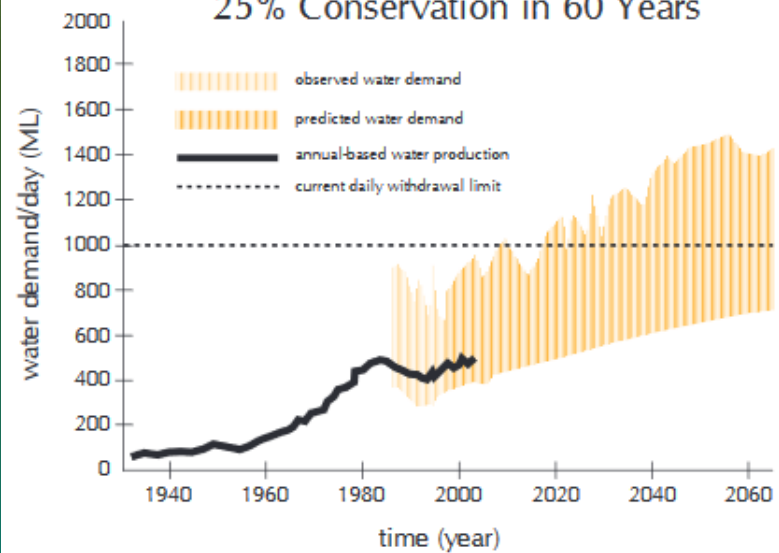
Increasing water demands on the Elbow River (40% of Calgary's supply). May 14 2019 Calgary City Special Meeting on water security predicts water licenses exceeded 2036.

Calgary's Population Growth and Calgary Regional Water Consumption



Sources: The City of Calgary & Asibey 1990

25% Conservation in 60 Years



From U of C Env 501 and Nat Res Canada Municipal Case Studies: Climate Change and the Planning Process, Calgary. 2007.



This is not the end of the Elbow!



For years we have depended on the Elbow River. Now the River
depending on us.

