



KETTLE RIVER TECHNICAL ASSESSMENT – PHASE 1

SAC Meeting

June 18, 2012



OUTLINE

- Project background
- Scope and methods
- Surface water quantity
- Groundwater quantity
- Water quality
- Fisheries and riparian habitat
- Information gaps and water planning





SUMMARY

- Surface water: Aug-Sept flows much less than average; difference more pronounced in drought years & exacerbated by withdrawals. Actual surface use less than licensed.
- Groundwater: Major suppliers use it instead of surface water; connected to surface water; data gaps outside Grand Forks
- Water Quality: SW good except for temperature; GW has nitrate issues in GF; little data in northern 70% of basin
- Aquatic Life: Natural conditions limit fish; exacerbated by withdrawals in below-average years; work needed on potential to improve habitat





BACKGROUND

- **Watershed Management Plan** Terms of Reference published October 2010
- Phase 1 is Technical Assessment – started in April 2011. TAC Meetings April, July & October 2011
- Phase 1 leads to Phase 2 – Watershed Management Plan (there will likely be a Phase 1b – “gap filling”)
- Scope:
 - Watershed physical description
 - Water quantity (surface water & groundwater)
 - Water quality (surface water & groundwater)
 - Aquatic Habitat & Riparian Areas





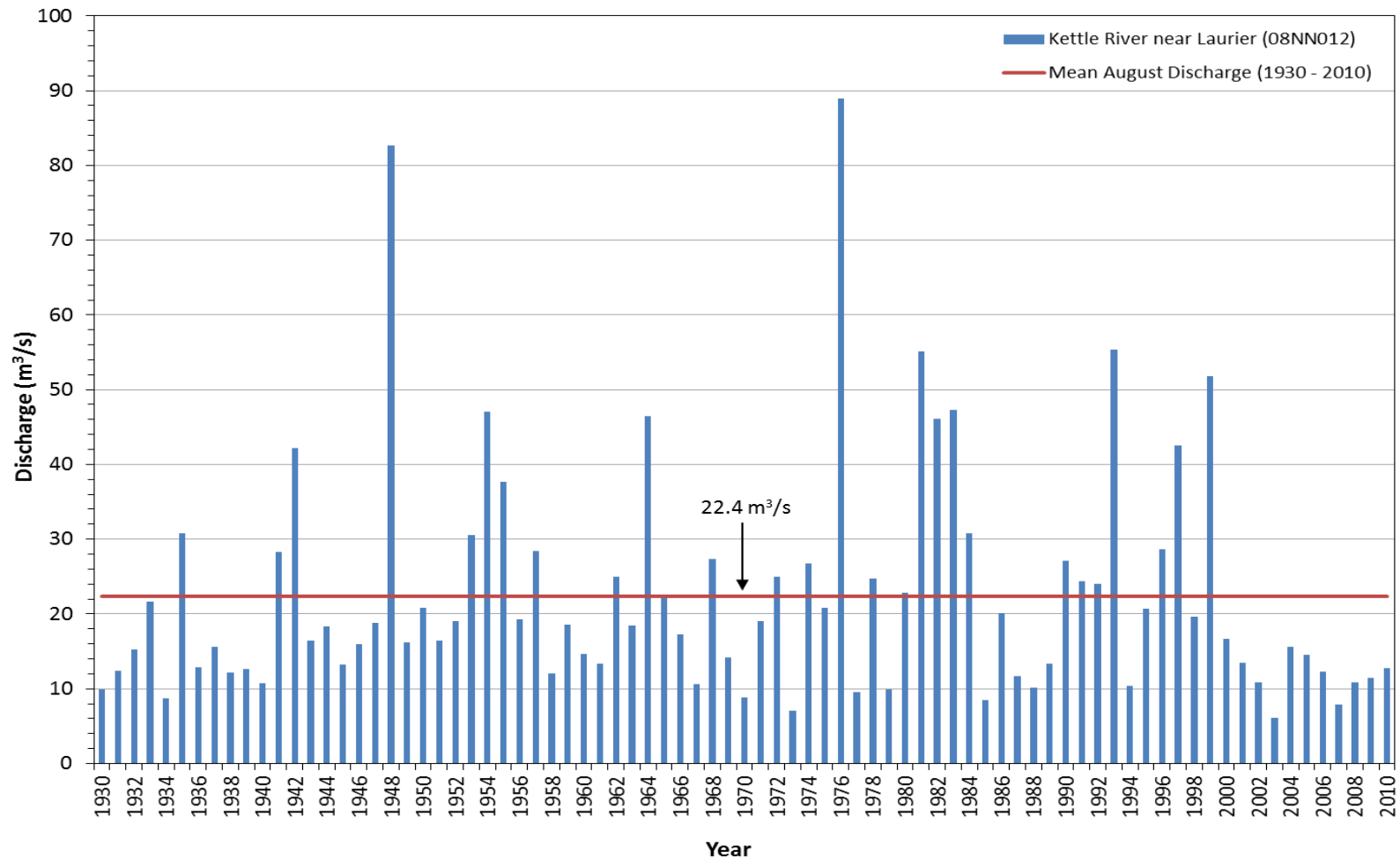
KEY ISSUES & QUESTIONS

- Water demand during low flows & potential for conflict (near future & medium term)
- Climate change effects & drought frequency
- Surface water quality & effects (mining, land development, municipal, agriculture, forestry, ...)
- Groundwater quality trends (e.g. nitrate)
- Low flow & warmer temperature effects on fish
- Groundwater – surface water interaction



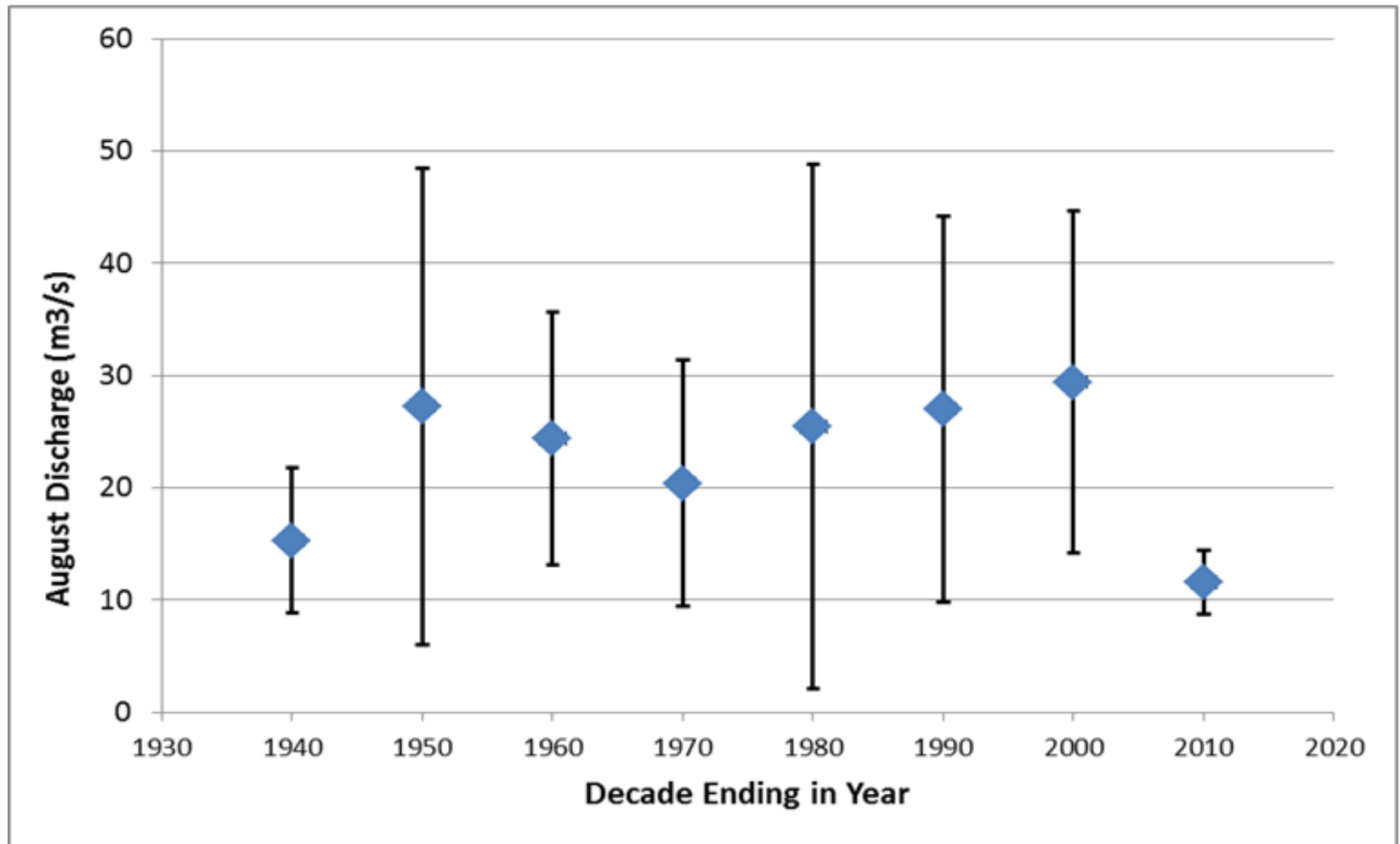


Kettle River Near Laurier – August (1930-2010)





Kettle River Flow (Laurier) – Decade Averages \pm 1 Standard Deviation





KEY ISSUES & QUESTIONS (cont.)

- Riparian function
- Riparian & fish habitat restoration
- Flood hazards
- Potential for constraints on economic development due to water
- Goal: A clearly written report that summarizes the “state of the watershed” for a broad range of stakeholders & informed citizens





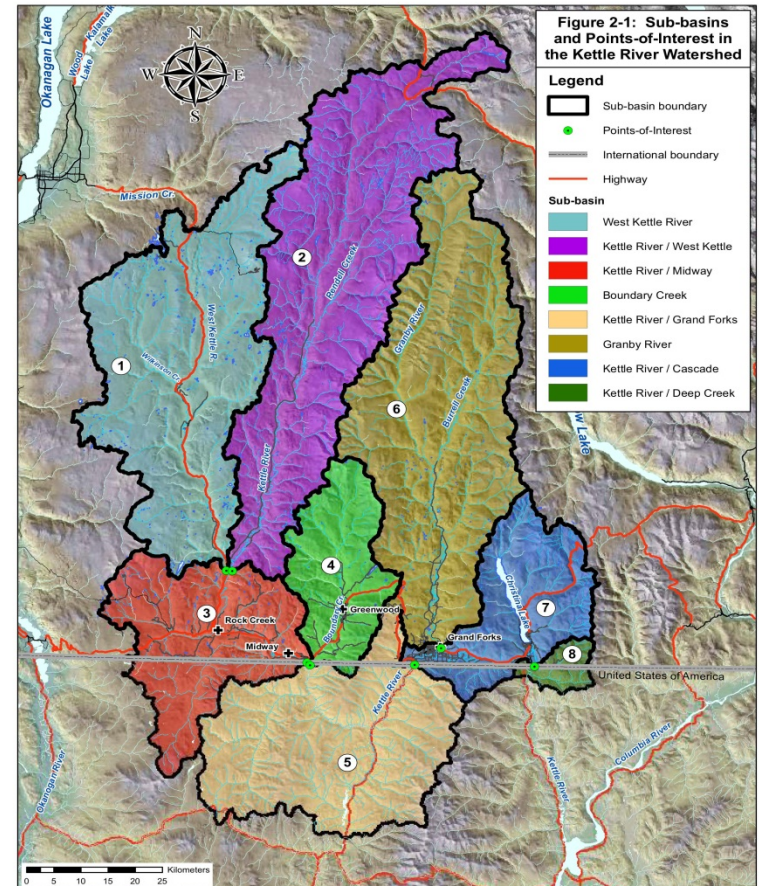
Kettle River Technical Assessment Part 1

SURFACE WATER QUANTITY



Sub-Basin Delineation

- Considered locations of existing WSC and USGS hydrometric stations
- Selected sub-basins:
 - #1 – West Kettle River
 - #2 – Kettle River / Westbridge
 - #3 – Kettle River / Midway
 - #4 – Boundary Creek
 - #5 – Kettle River / Grand Forks
 - #6 – Granby River
 - #7 – Kettle River / Cascade
 - #8 – Kettle River / Deep Creek



Water Licences

- A total of 994 current licences (at 827 points of diversion) are issued on streams, springs, and lakes (in Canada)
 - Issued for:
 - Waterworks
 - Irrigation
 - Domestic
 - Stockwatering
 - Enterprise
 - Mining
 - Snow making
 - Mining
 - Processing
 - Storage
 - Conservation
- The totals include 54,199 ML (Offstream), 7,351 ML (Storage), and 1,352 ML (Conservation)
 - Note 1 ML equals one million litres or 1,000 m³ (220,000 imperial gallons)





Water Licences by Sub-basin

- Kettle River / Midway (#3) includes the largest portion of offstream licences
 - Irrigation purposes
- West Kettle River (#1) includes the largest portion of storage licences
 - SEKID diversion into the Okanagan Basin

Sub-basin	No. Water Licences	No. of Points of Diversion	Licensed Offstream Volume (ML)	Licensed Storage Volume (ML)	Licensed Conservation Volume (ML)
1	89	71	8,106	5,997 ^a	580
2	96	84	6,193	265 ^b	31
3	278	270	18,560	896 ^b	n/a ^c
4	136	113	4,365	125	697
5	18	17	440	n/a ^c	n/a ^c
6	87	67	4,978	3.7	n/a ^c
7	279	192	11,523	64 ^b	44
8	11	13	34	n/a ^c	n/a ^c
Total	994	827	54,199	7,351	1,352

Notes:

- Licensed storage supports irrigation and waterworks licences;
- Includes the water use purpose "ponds"; and
- n/a = not applicable; no licences have been issued for conservation or storage purposes.



Water Purveyors

- Conducted meetings with water purveyors and obtained pertinent information:
 - City of Grand Forks
 - Grand Forks Irrigation District
 - SION Improvement District
 - Village of Midway
 - City of Greenwood
 - Sutherland Waterworks District
 - Covert Irrigation District
 - Christina Waterworks District
 - Bridesville Waterworks District
 - Big White Water Utility Ltd.
 - South East Kelowna Irrigation District



Photo Courtesy of
Murray Knox (GFID)





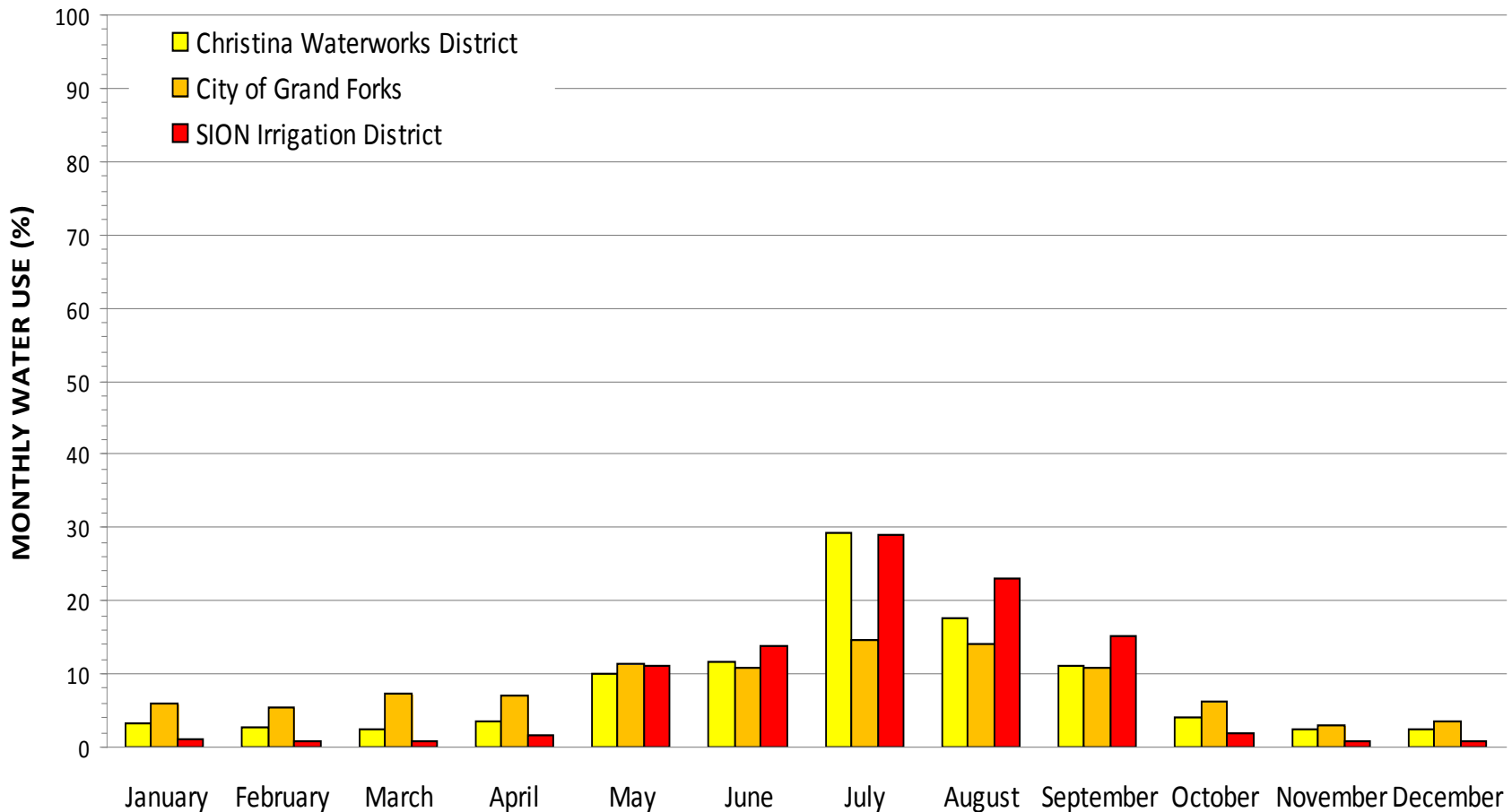
Water Purveyors - Summary

- The majority of purveyors are using groundwater as their main supply source
 - Christina WWD & Big White are currently the only purveyors utilizing a surface water source
 - SEKID diverts 1,700-3,400 ML/yr of surface water from the West Kettle watershed into the Okanagan Basin
- Largest water use is generally in the summer months to meet irrigation demand requirements.
- Available water use records from purveyors range from 1995-2010 with either monthly or annual information



Example - Monthly Water Use Comparison

Monthly Water Use Distribution From Selected Water Suppliers (2007)





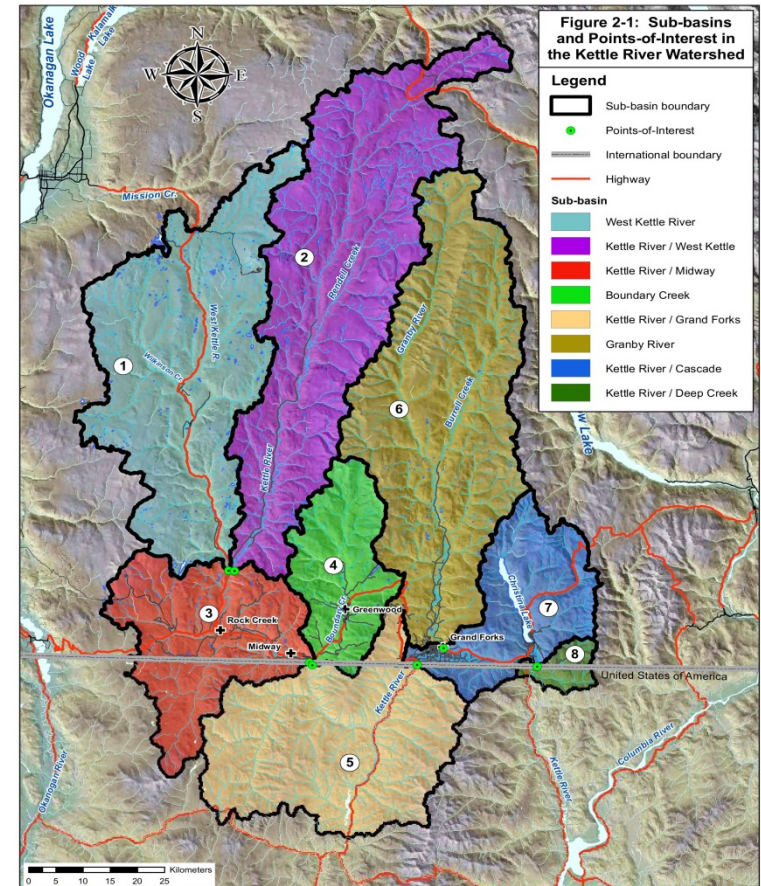
Water Use - Agriculture

- Agricultural Census of Canada
 - Provides a statistical picture of Canada's Farm Sector based on questionnaires filled out by farm operators
 - Estimates suggest that 40%-50% of total agricultural lands in the Kettle River are being irrigated
- Agricultural Water Demand Model
 - Ministry of Agriculture and Agri-Foods Canada developed the model
 - Estimates total water use based on crop type, irrigation system type, soil texture and climate data
 - For 2003, estimates suggest that 51% of the total volume of irrigation licences was used



Surface Water Quantity

- Seven (7) points-of-interest (POI) (based on selected sub-basins)
 - West Kettle River
 - Kettle River above West Kettle
 - Kettle River at Midway International Border
 - Boundary Creek
 - Kettle River at Grand Forks International Border
 - Granby River
 - Kettle River at Cascade International Border
- Adopted a standardized period of record (1981-2010)
 - Current water use statistics, current climate “normal” period





Surface Water Quantity

- Utilized existing WSC and USGS hydrometric stations to develop monthly estimates of net and naturalized flows at each POI for the standard period
 - Net Flows – streamflows that include water extractions and storage effects occurring upstream
 - Naturalized Flows – estimates of natural flows adjusting net flows for the effects of water withdrawals and storage
- Estimated the 1-in-10 year and 1-in-50 year return period mean monthly net low flows at each POI
 - These return period low flows have a 10% and 2% chance of happening in any given year, respectively
 - The lowest flows generally occur in August and September





Why do we “naturalize” flows?

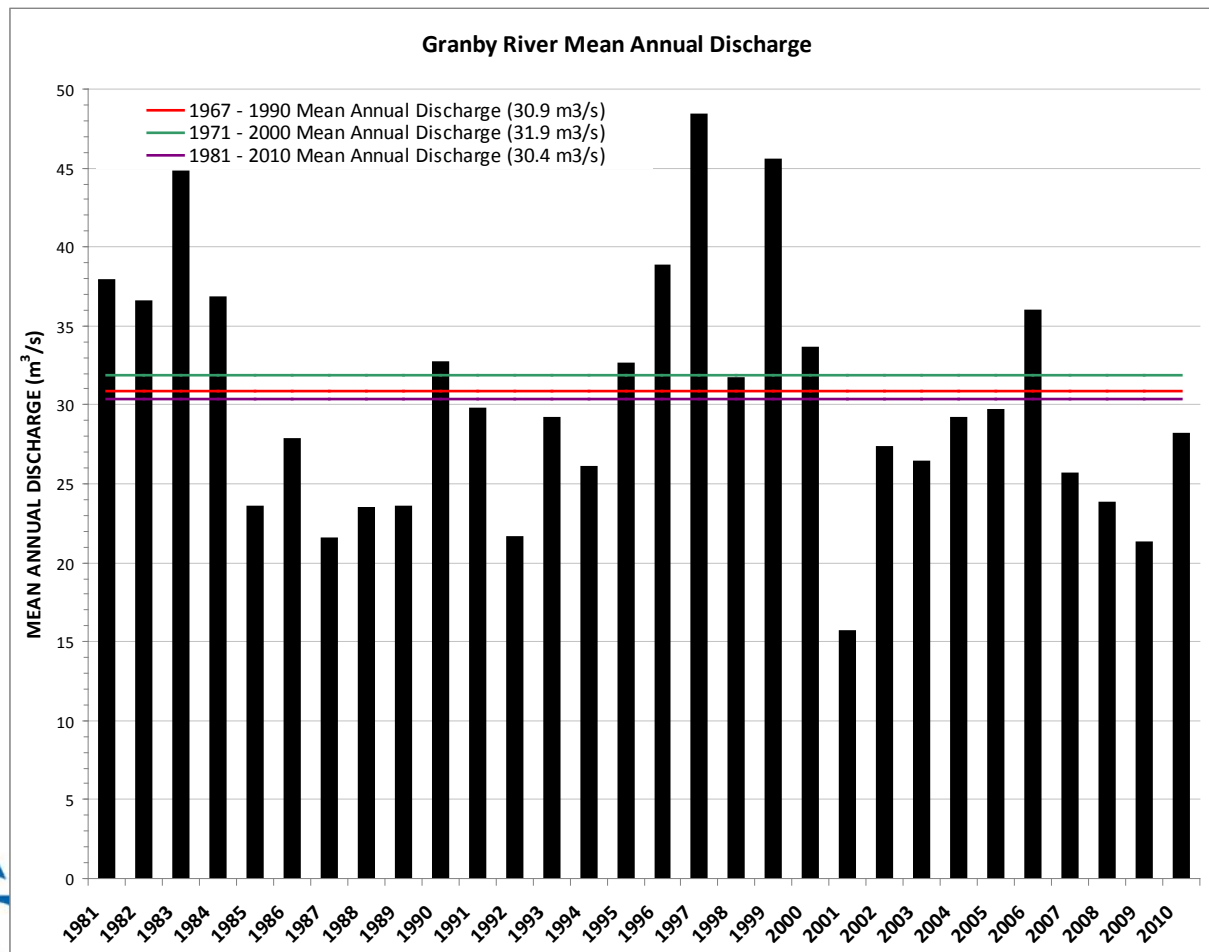
- To determine effect of withdrawals on flow – average, high & low flow periods
- Characterize natural temporal patterns of flow – especially how low flows compare to licensed volumes
- Naturalized flow is the starting point for determining in-stream flow needs (IFN) for aquatic life (more on this later)



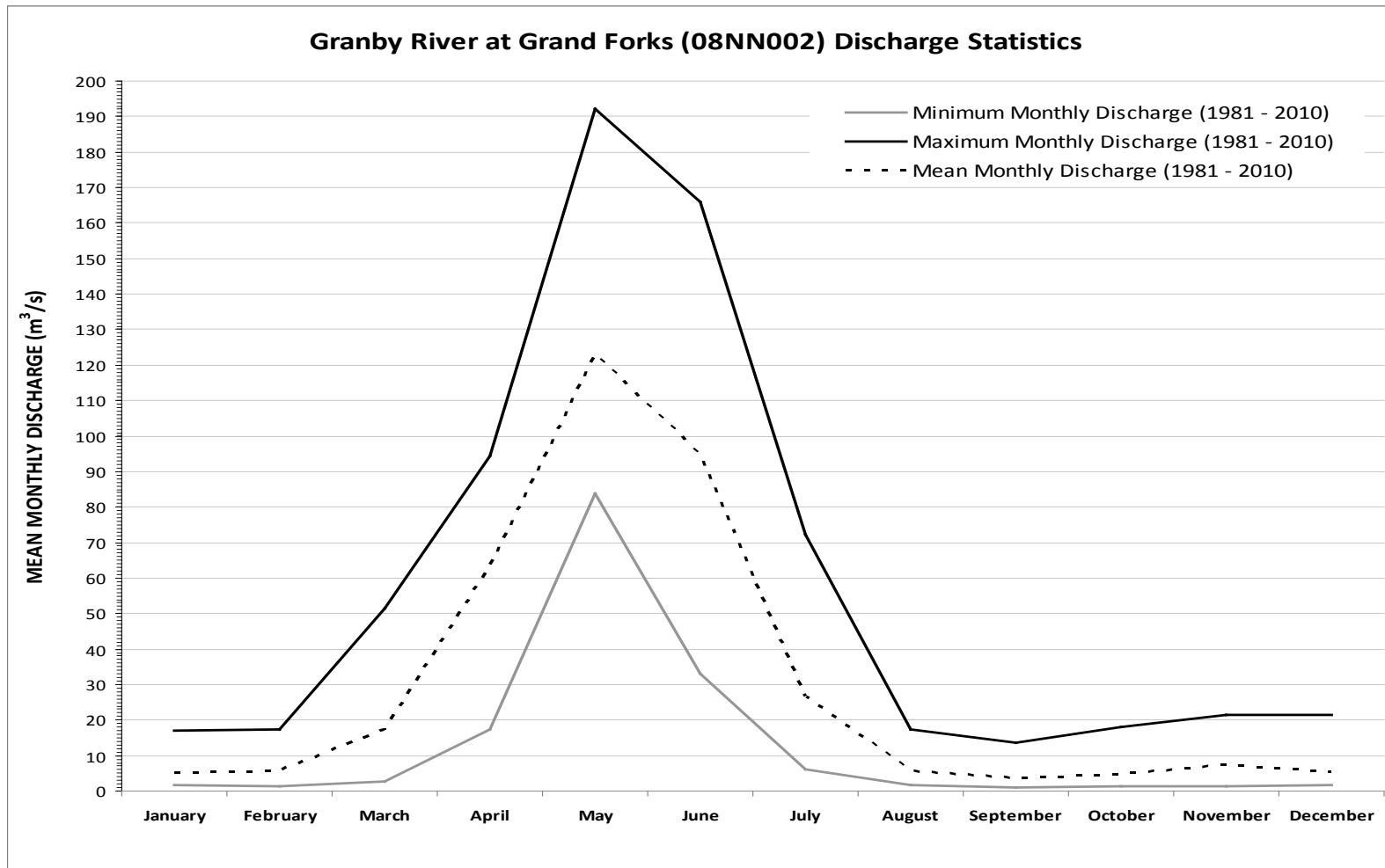


Granby River Net Flows

(Standard Period 1981-2010)



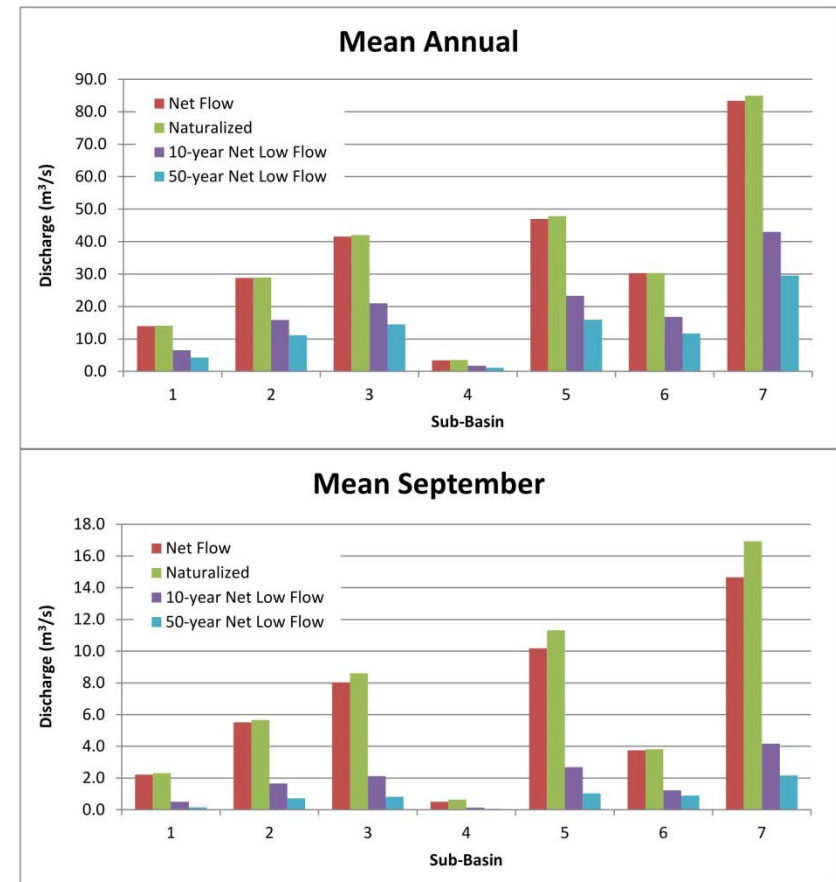
Granby River Naturalized Flow (1981-2010)





Flows in “dry” years drop off significantly from average flows

- Water use is higher, but most of lows explained by natural processes
- Indicates that the Kettle River is sensitive to climatic variation, like most semi-arid region rivers





Is there a trend in River Flow?

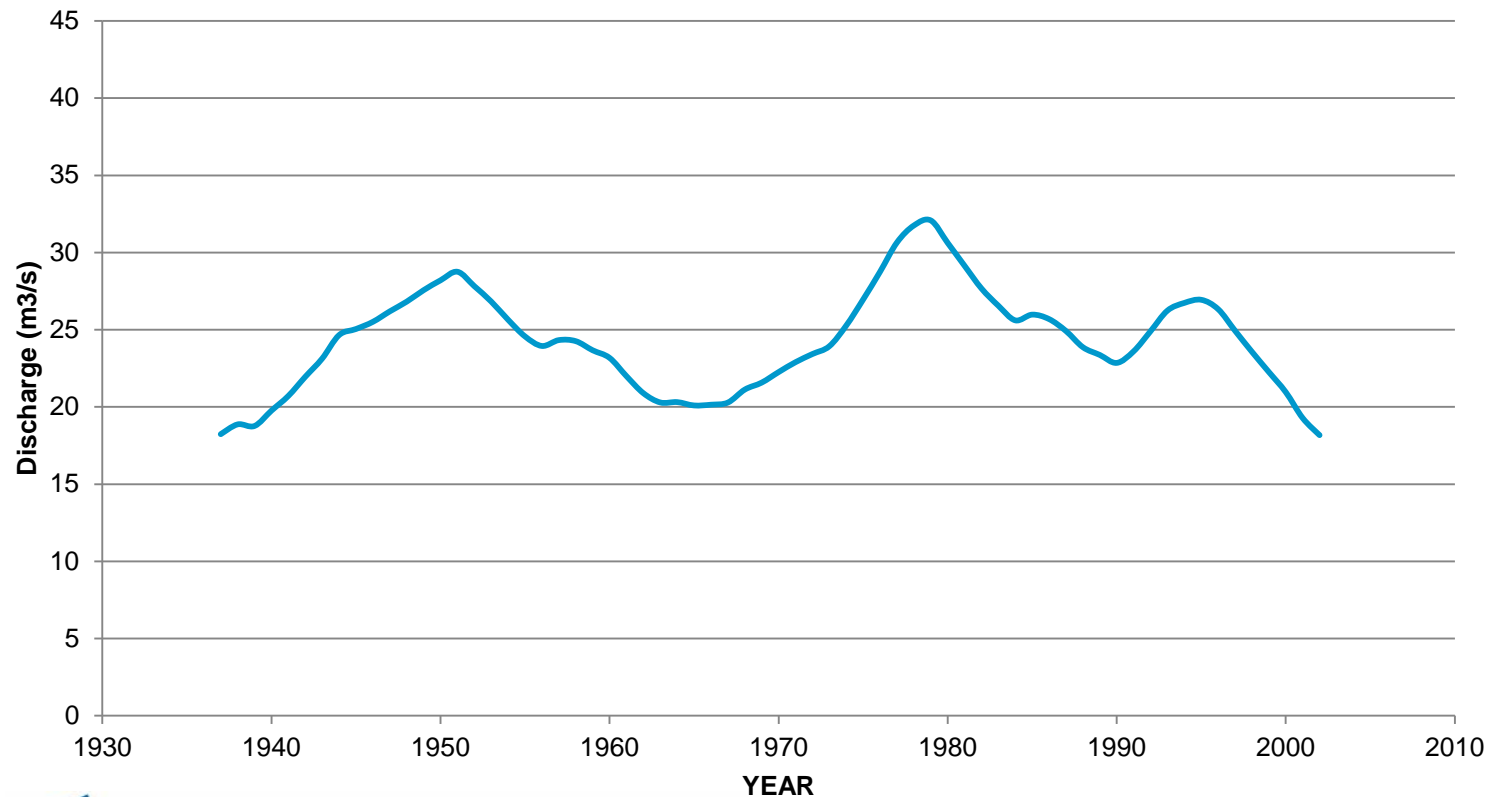
- Trend – a statistically significant change over time
- Suitable data for Kettle Laurier (1929-2010) and Granby (1967-2010); looked at all months and just August
- Trend is not significant ($p \leq 0.05$) when full data sets are used (flow is not decreasing or increasing)
- There is a statistically significant downward trend when just 1981-2010 is assessed for:
 - Kettle all months (Sen's slope -0.034)
 - Kettle August (Sen's slope -0.750)
 - Granby all months (Sen's slope -0.007)





Flow Moving Average - Kettle at Laurier

12 Point Moving Average





Climate Change Implications - Streamflow

- Climate change work completed by the University of Washington's Climate Impacts Group has predicted the following for the Kettle River watershed:
 - Streamflow
 - A general shift to an earlier spring melt period
 - Total water yield for the year increase slightly
 - High Flows in Freshet
 - Higher total flows earlier, but lower peaks on average
 - Low Flows
 - Late summer/early fall low flows decrease, while winter low flows increase
 - Snow Water Equivalent (SWE)
 - A general shift to a transition watershed (between a rain and snow dominant behavior)
 - A decrease in SWE

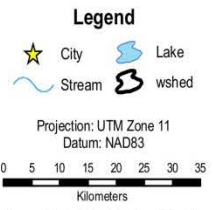




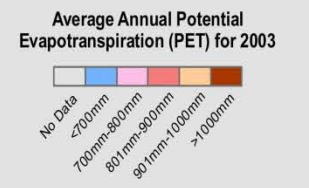
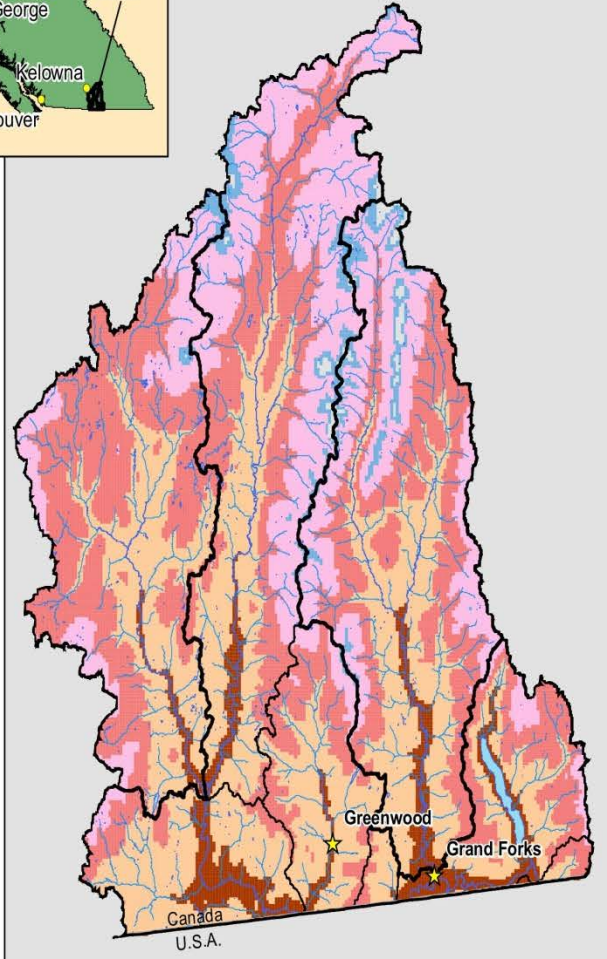
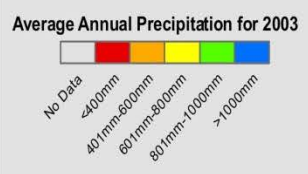
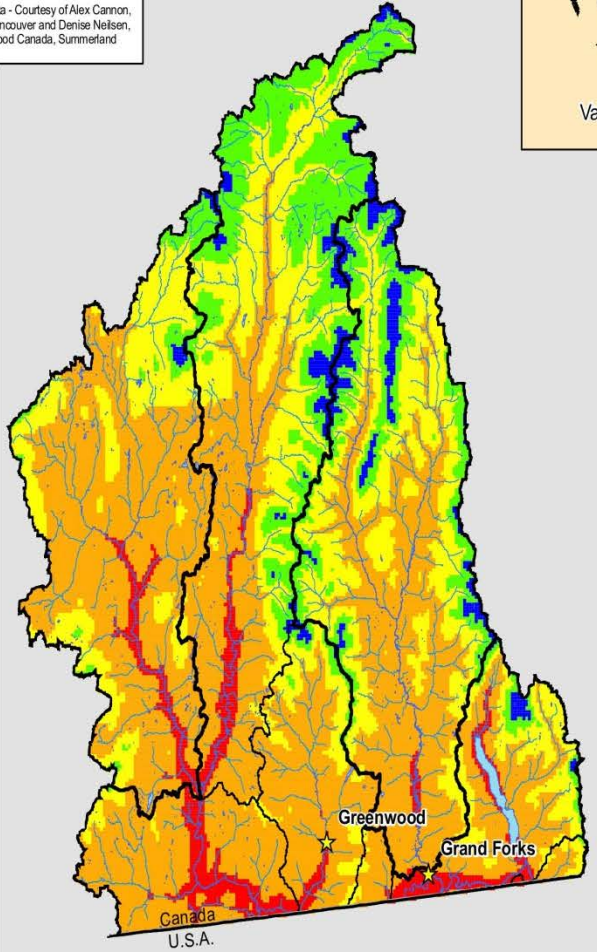
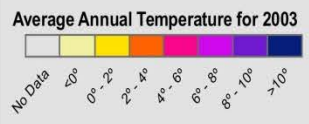
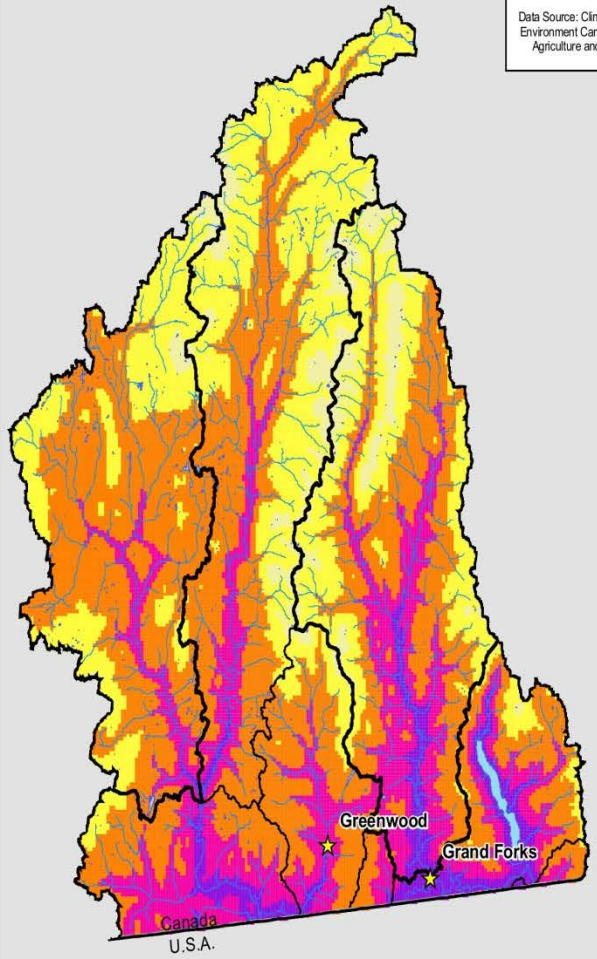
Agriculture Canada – Environment Canada Climate Model

- Recently developed for Kettle basin
– 1,000 m grid (only run for 2003)
- Tool to project changes in climate at this scale by “downscaling” Global Circulation Models (in progress)
- Will allow development of hydrologic models to assess climate change





Data Source: Climate Data - Courtesy of Alex Cannon, Environment Canada, Vancouver and Denise Nielsen, Agriculture and Agri-Food Canada, Summerland





Kettle River Technical Assessment Part 1

GROUNDWATER QUANTITY



ISO 9001 & 14001 Certified



GROUNDWATER

- Mapped and summarized wells and aquifers in the MOE well database
- Summarized well and aquifer information in tables
- Obtained and analyzed monitoring well data
- Obtained & reviewed extraction rates from water purveyors
- Gathered groundwater quality data from MOE and assessed nitrate trends over time
- First estimate of water balance to compare extraction rates against aquifer recharge





AQUIFER MAPPING

- BC has mapped 15 aquifers – only 1% of watershed area but covers >90% of population
- **Demand – Productivity – Vulnerability** (e.g. IA, IIIC)
- Two high demand aquifers – Grand Forks & Midway (42.4 km²)
- Four moderate demand - 2 at Rock Creek (6.2 km²) and 2 at Grand Forks (0.5 km²)
- Mod. & High demand aquifers tend to be vulnerable – unconfined sand and gravel



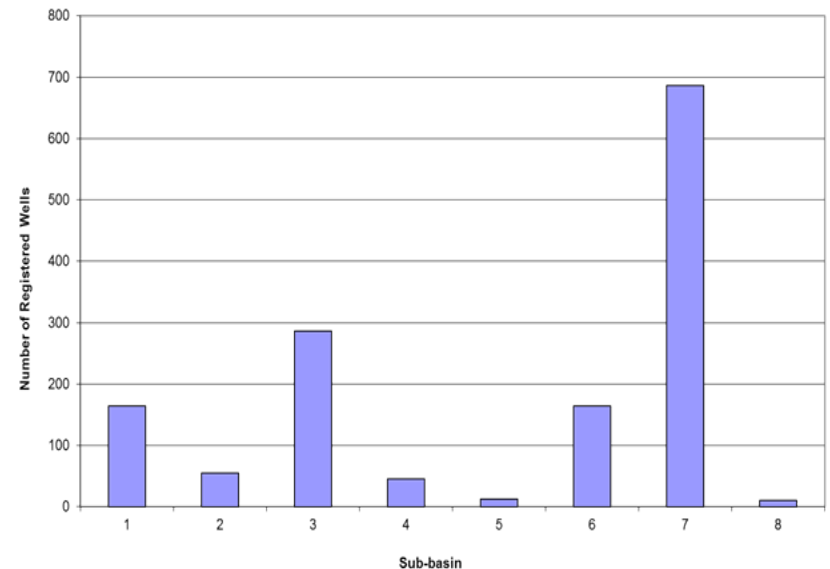
Note: Demand ratings reflect early 2000s



WELLS – BC Database

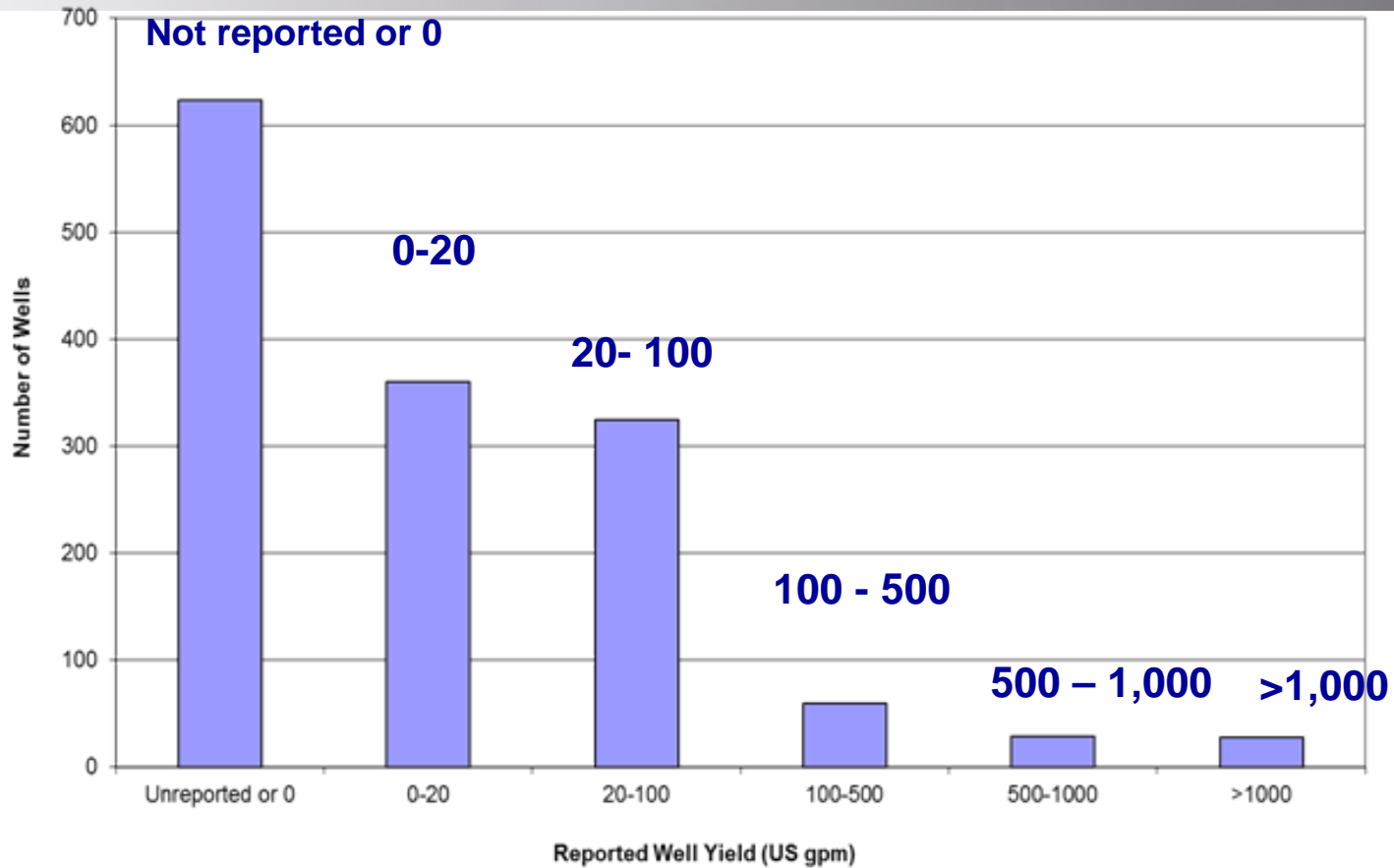
- 1,425 wells on file
- Half in Grand Forks area (sub-basin 7)
- About 20% in sub-basin 3 – Midway, Rock Creek
- Reporting of new wells & well closure not required before 2005
- Reported yields – 85% have 100 USgpm or less

- No. by Sub-Basin





WELL YIELDS – US gpm



Groundwater Level

- Two active observation wells -
- Strong evidence of hydraulic connectivity

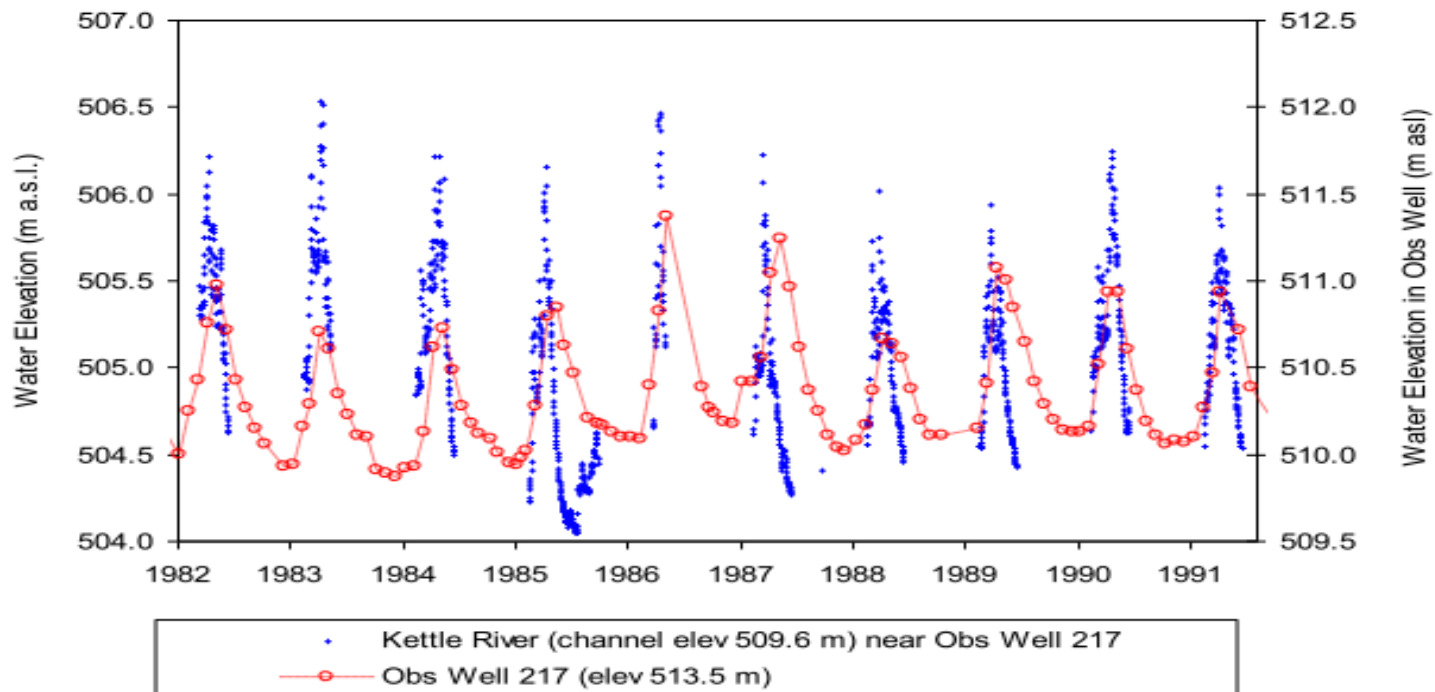


Figure 24

Water elevations at Observation Well 217 and on the Kettle River (08NN024), for the selected period of record from 1982 to 1991.



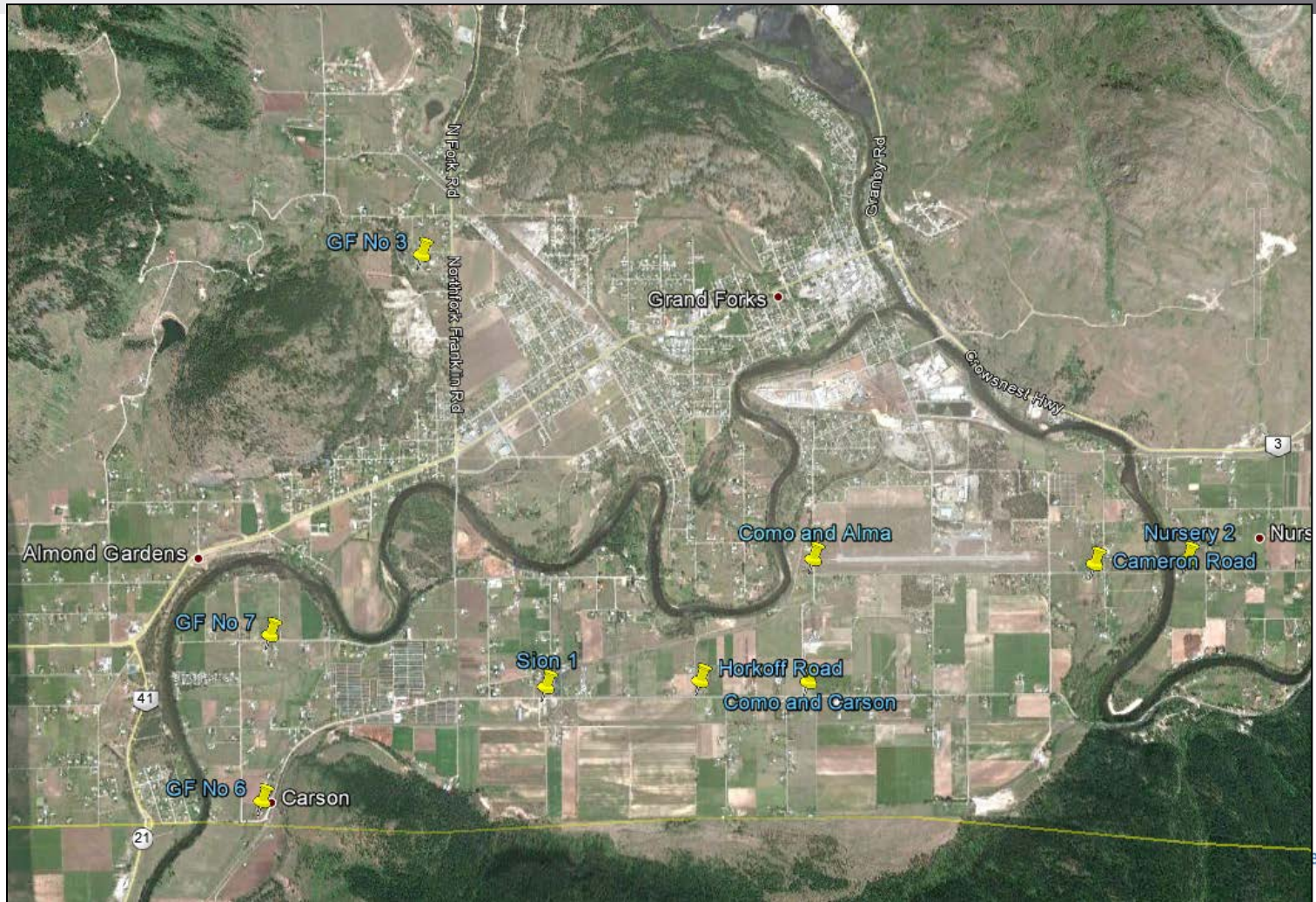
Groundwater – What else do we know?

- Fortunate that Grand Forks aquifer has been studied in detail - BC MOE and Simon Fraser University 2010
- Included a numerical computer model that assesses impact of groundwater pumping
- Could be used for further assessment (e.g. actual pumping rates, increased PET)
- Much less known about other areas, but GF provides a solid conceptual model for aquifer behavior in the valley bottom

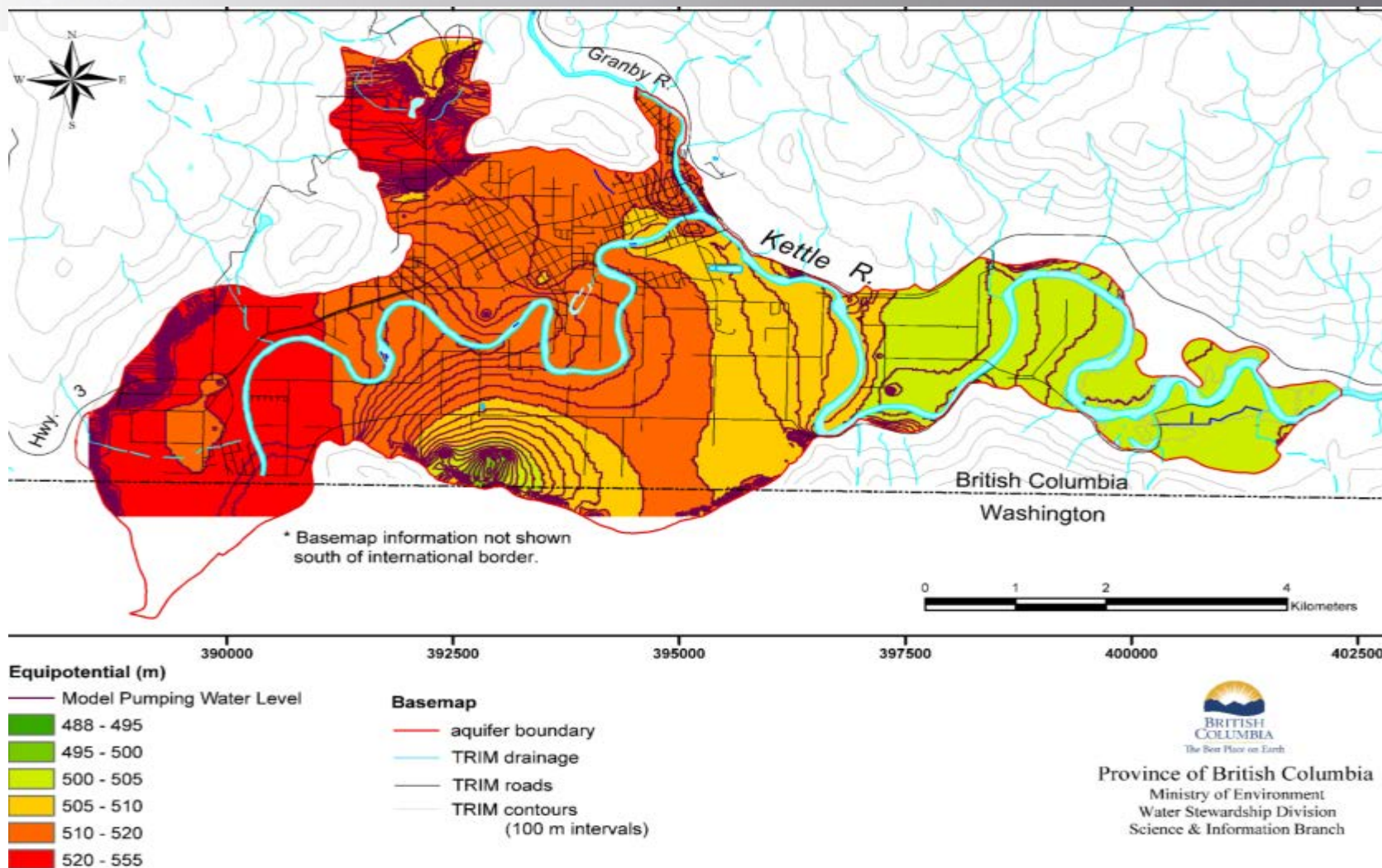




Map of Production Wells, Grand Forks Area



Hydraulic Head during Pumping



Gaining & Losing (Wei et al. 2010)

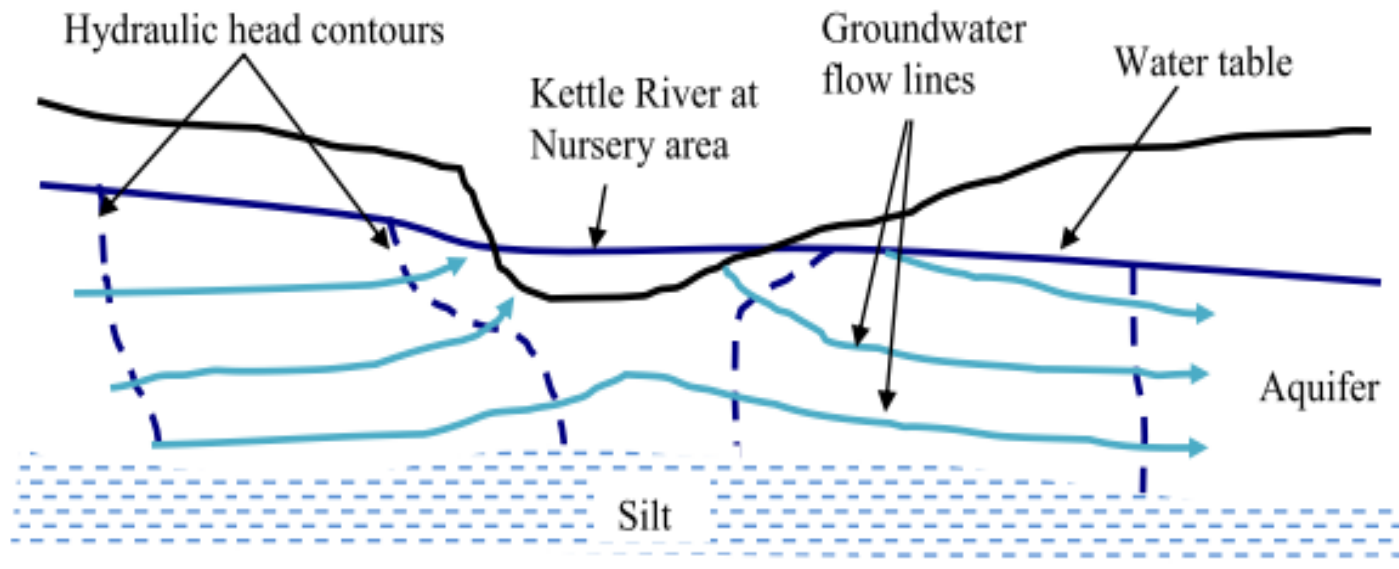


Figure 16 Schematic cross-section (looking north) at the Nursery area, showing the Kettle River gaining water from the aquifer along the west bank and losing water to the aquifer along the east bank.



Kettle River Technical Assessment Part 1

WATER QUALITY





WATER QUALITY DATA

- Completed systematic search of databases (EMS and federal)
- Canada-BC Program: Kettle has 2 of the 44 sites in the province
- Kettle River at US border monitored bi-weekly since 1980 (Carson & Midway; regular reports)
- Most data are from sites in the southern third of the watershed - large sections of river without data
- Parameters – suspended sediment, pH, temperature, dissolved solids, nutrients, organic matter, coliform bacteria, and total metals





STREAMS WITH SOME DATA

- Kettle
- West Kettle
- Boundary
- Granby
- Christina Lake
- July
- Moody
- Skeff
- Sutherland
- Rock
- Goosmus
- Burrell
- Snowshow
- Fisherman
- Gibbs
- May
- Myers





Canada – BC Stations

- Carson & Midway on-going - about 30 years (former stations at Gilpin & Myers Creek)
- 2001-2004 Canadian Water Quality Index - Carson rated “Good to Fair”; Midway rated “Fair” (Gilpin was “Excellent” over 1980 - 94)
- water temperature, fluoride, phosphorus, and cadmium - parameters with guideline exceedances
- In 2009 the Canada-B.C. program published an assessment of water quality trends (i.e. changes over time) at the two active sites based on 18 years (1990-2007) of data





Canada – BC Trend Report (2009)

- Water quality at the 2 sites was very similar and “generally good”
- Increasing trends - turbidity, hardness, total P, total molybdenum, dissolved chloride, dissolved fluoride, & fecal coliforms
- Decreasing trends - total colour, conductivity, & several metals (Al, Cr, Cu, Fe, Pb, Mn, Ni, Z); also Midway flow
- Concentrations of several total metals exceeded water quality guidelines
- But these were strongly correlated with turbidity; bound to suspended sediments & organic matter - not available for uptake by biota





“Upstream – Downstream” Monitoring

- Permit requirement at only some sites
- Boundary Creek at Greenwood’s wastewater treatment facility (WWTF) – differences in water quality not statistically significant (N, P, bacteria, dissolved oxygen, TSS); all parameters met guidelines
- Midway & Grand Forks WWTFs near Canada BC sites
- Midway – slight increase 1990-2007 in fecal coliforms, total P (but not dissolved P), and dissolved chloride
- Grand Forks – only total P trending up, but Sen’s slope very slight (0.002)
- No “upstream” sites at Grand Forks & Midway





Christina Lake

- Basin-wide WQ study in 1977 identified concerns & recommended more work on Christina Lake - Monitored yearly since then
- 1994 assessment completed and **Water Quality Objectives** (WQO) were set
- 1994 report indicated that Christina Lake was in an oligotrophic state and the overall water quality was considered “very good”
- 2006 - most recent WQO attainment report
- WQO met 97% of time: minor excursions noted for dissolved oxygen and Secchi depth.
- Water quality rating score 85% - quality “good”
- However, recent study indicates shift in abundance of algae and in composition species of phytoplankton between 1992 and 2006 (McGregor 2010)



Groundwater Quality

- Compared to surface water, there are few data in public domain except for Grand Forks aquifer
- Domestic wells may be sampled once, but results usually private. No requirement to continue sampling or to report
- In general, groundwater can be high in iron, manganese & other minerals; and may exceed aesthetic guidelines





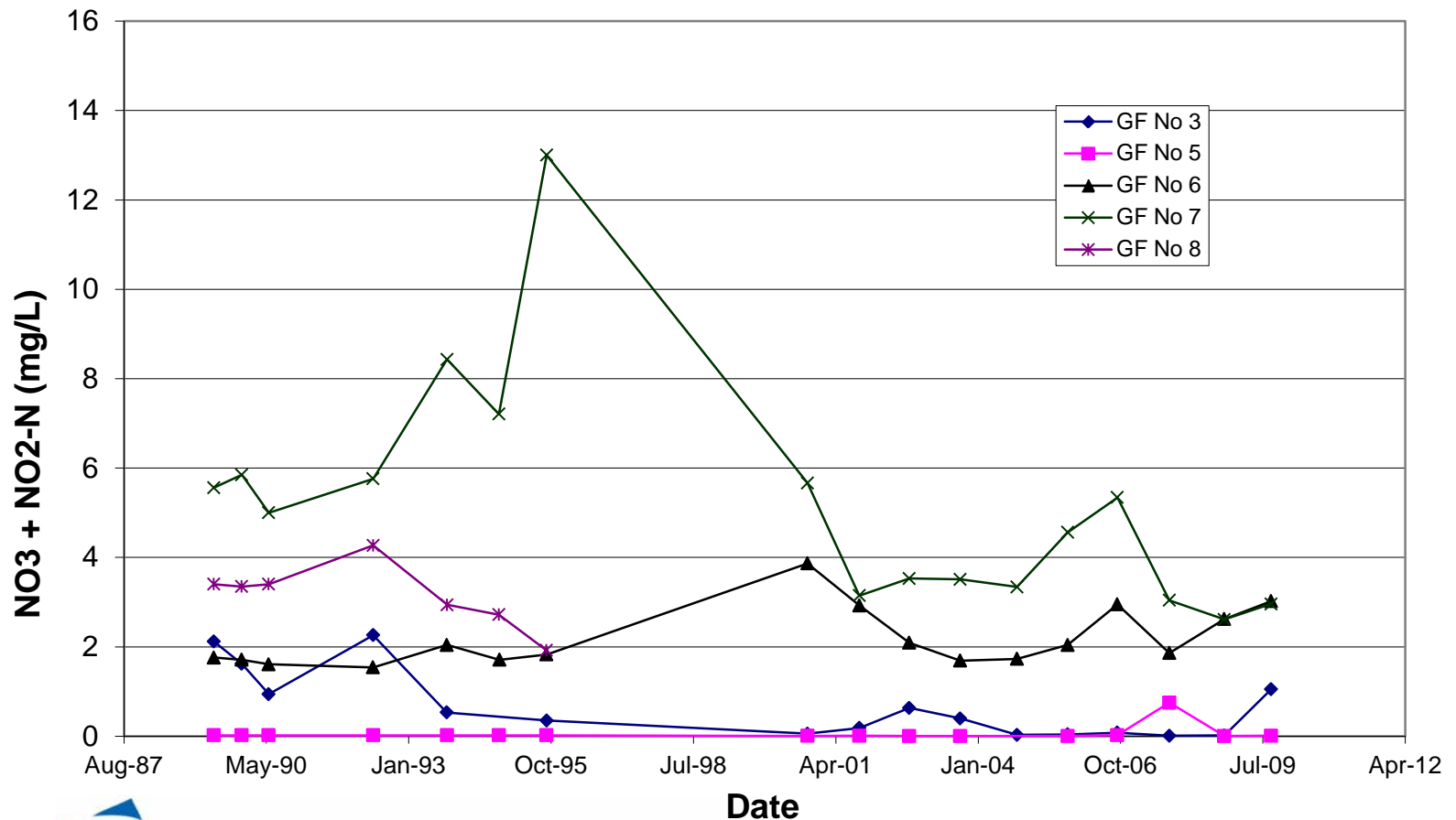
Grand Forks Aquifer (MOE & SFU 2010)

- Nitrate-nitrogen has been the groundwater contaminant of greatest concern
- Nitrate-N in groundwater ranges from <0.01 mg/L to >30 mg/L; median 3.4 mg/L (Canadian Drinking Water Guideline 10 mg/L nitrate-N)
- Nitrate-N was generally highest in shallower wells, and that concentration decreases with well depth
- Sources include fertilizers (largest source), septic systems, and sites with concentrated livestock wastes
- **Action** has been taken since late 1990s. OCPs limit septic fields; education; adoption of BMPs





Nitrate Trends, Grand Forks

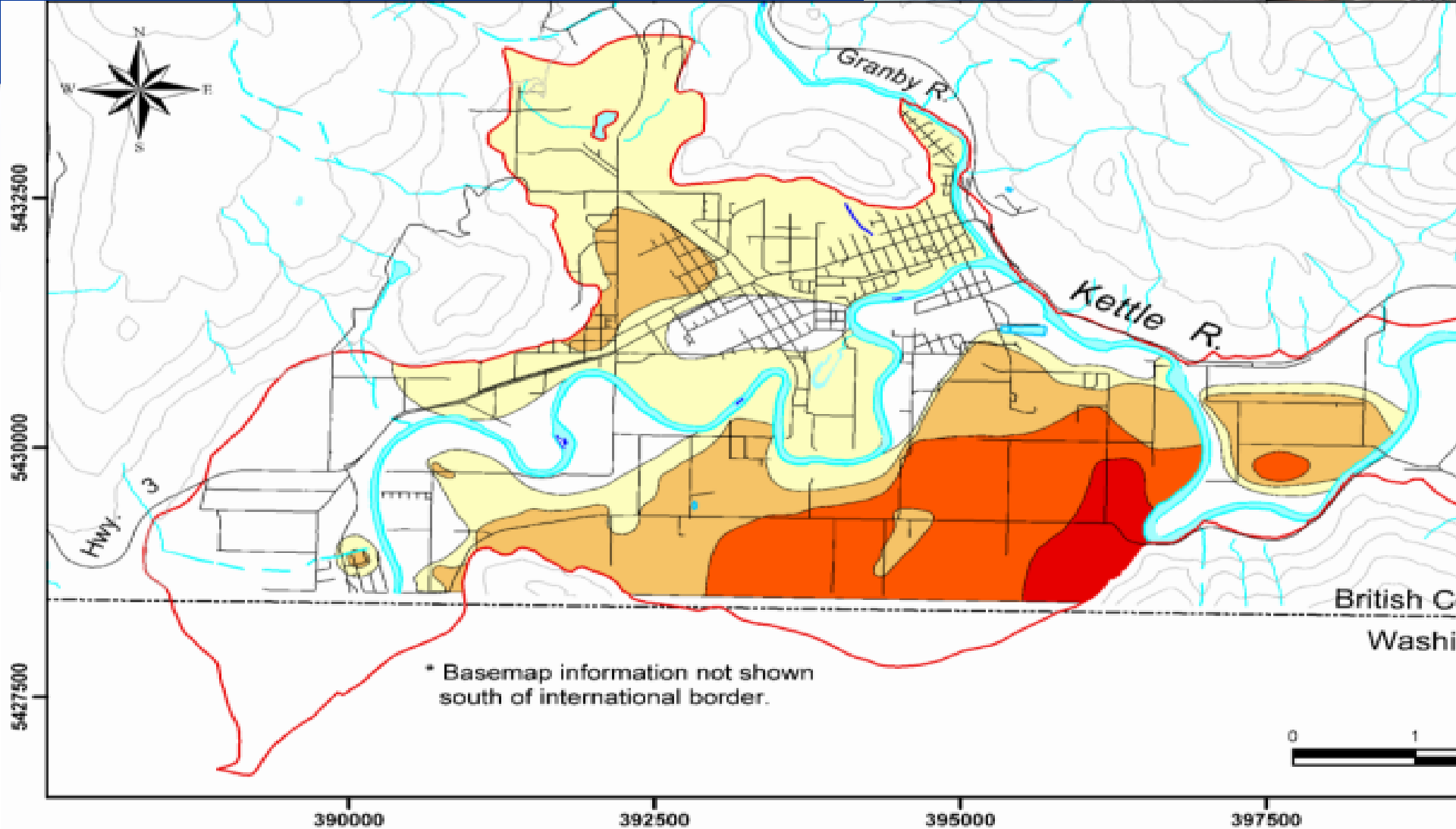




Grand Forks Aquifer Quality (cont.)

- Groundwater hardness values range from “soft” to “very hard”. On average rated “very hard” (about 300 mg/L average), indicating relatively high concentrations of calcium, magnesium, and iron.
- Total dissolved solids (TDS) also relatively high but with a wide observed range. Possibly indicative of land use effects.
- Dissolved chloride high in some areas, generally the same areas where nitrate-N and TDS are elevated
- The highest concentrations of nitrate, TDS, chloride and nitrate are found in the southeast corner of the aquifer near the US border

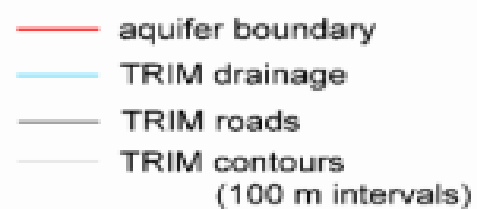




Nitrate-Nitrogen (mg/L)



Basemap





Kettle River Technical Assessment Part 1

FISHERIES & RIPARIAN HABITAT





AQUATIC & RIPARIAN HABITAT

- **Fisheries Management Objectives:**
 - Conserve and restore wild fish stocks and their habitat; and
 - Improve the quality of angling and ensure a recreational fishery for future generations.





30 native species in the Kettle Watershed

- Key sportfish – rainbow trout, mountain whitefish;
- Provincially Red-listed – speckled dace, Umatilla dace;
- Provincially Blue-listed – westslope cutthroat trout, bull trout, chiselmouth, shorthead and Columbia sculpin;
- Federally “Special Concern” – westslope cutthroat trout, shorthead and Columbia sculpin
- Federally “Endangered” – speckled dace





Fisheries Issues

Kettle River sport fishery has been deteriorating due to natural and anthropogenic factors;

- Seasonal low flow;
- High water temperatures;
- Habitat availability, especially a lack of deep water habitats for adult and sub-adult rainbow trout; and,
- Over-fishing





Instream Flow Needs (IFN) Study

Habitat Conservation Trust Fund (HCTF) funding a 3-year study looking at IFN for fish. Preliminary results at study sites indicate that rainbow trout parr rearing habitat is:

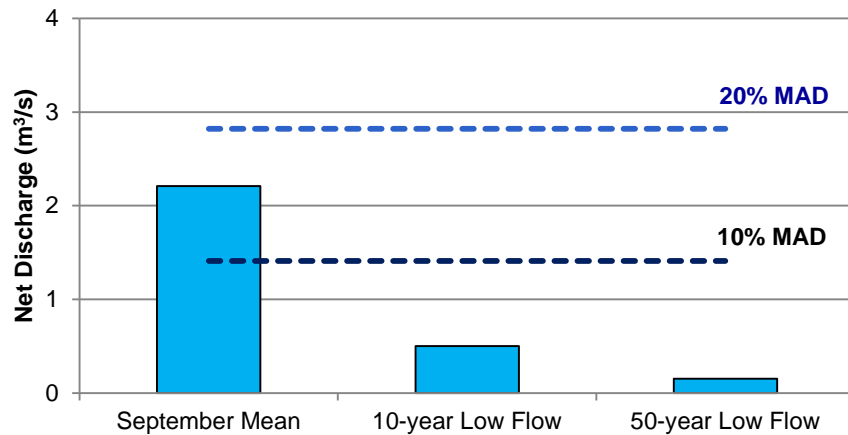
- Good at flow higher than 20% long term mean annual discharge (% MAD);
- Still “Reasonable” at 10% MAD;
- Declines rapidly below 10% MAD
- Under average summer flow conditions habitat availability and quality is “Reasonable to Good”, but under dry year conditions there is a substantial reduction in habitat



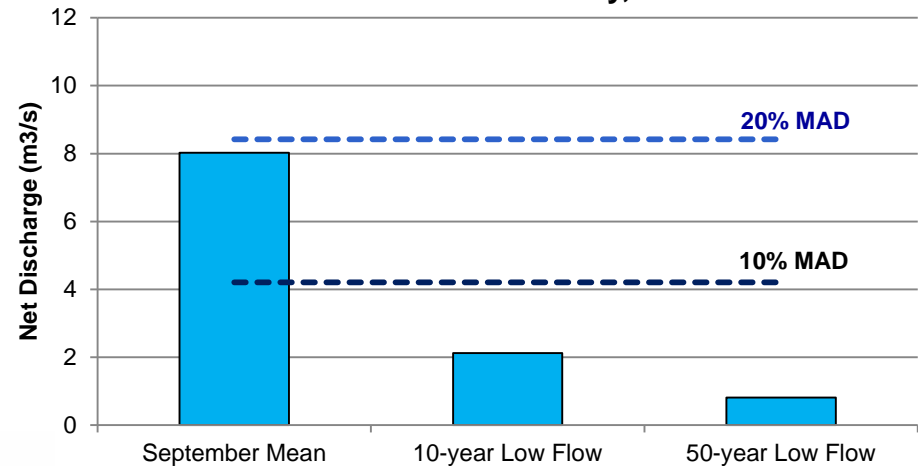


Instream Flow Needs

West Kettle River



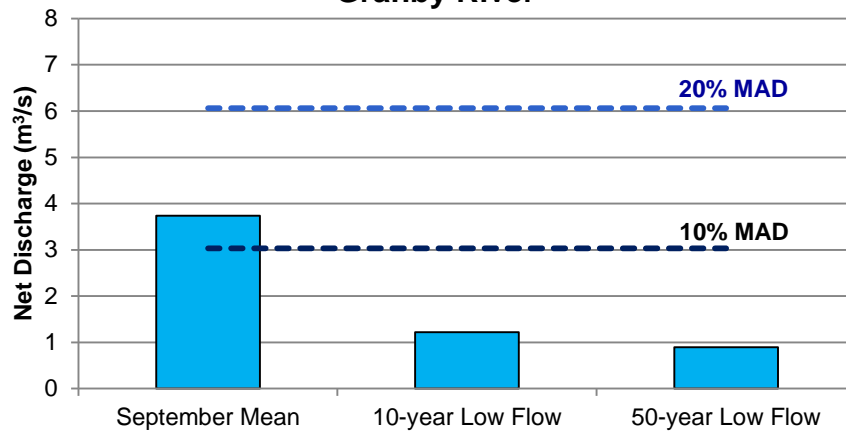
Kettle River near Midway, BC



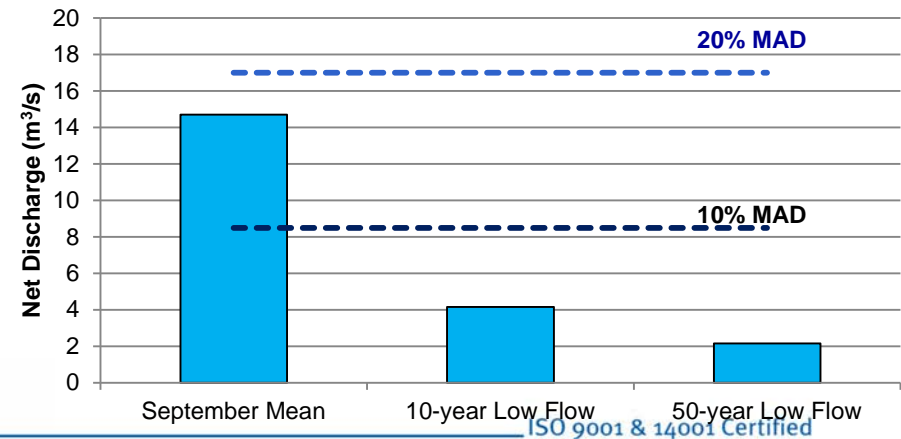


Instream Flow Needs

Granby River



Kettle River near Cascade





Riparian Habitat & Stream Restoration

- Riparian degradation remains a concern – agriculture, range, & land development
- Riparian and channel habitat restoration has been occurring since 1990s, but not currently coordinated or well documented
- Overview aerial photo inventory of agricultural areas: 0-35% of stream length has negligible cover or cover on just one bank; suggests 65% is “functioning”
- Needs some follow-up to confirm
- EFP Program has invested \$126,500 in riparian projects; individuals have cost-shared





Kettle River Technical Assessment Part 1

SUMMARY, INFORMATION GAPS & RECOMMENDATIONS FOR WATER PLANNING





KEY FINDINGS

- Surface water: Aug-Sept flows much less than average; difference more pronounced in drought years & exacerbated by withdrawals. Actual surface use less than licensed.
- Groundwater: Major suppliers use it instead of surface water; connected to surface water; data gaps outside Grand Forks
- Water Quality: SW good except for temperature; GW has nitrate issues in GF; little data in northern 70% of basin
- Aquatic Life: Natural conditions limit fish; exacerbated by withdrawals in below-average years; work needed on potential to improve habitat





MAJOR INFORMATION GAPS

- Groundwater outside Grand Forks, especially GW – SW interaction
- Irrigation water return
- High elevation climate data
- Water quality in sub-basins with potential for mining
- Riparian function
- What is potential to improve habitat conditions for target fish species? (flow, temperature, riparian function, channel morphology)





RECOMMENDATIONS – Part 1b

- Develop watershed population and economic development future scenarios
- Review groundwater demand, considering potential switches from SW; set priorities for detailed study
- Desktop assessment of GW-SW interaction for higher priority aquifers
- Additional runs of Climate & Agricultural Demand Models (present & future)
- Water quality survey





Recommendations 1b (cont.)

- Creel surveys – update angler use
- Radio-telemetry to identify critical habitats and confirm fate of adults fish in the summer (do they depart or die?)
- Organize “riparian working group” to collate existing knowledge and set priorities for assessment and/or restoration





MONITORING NETWORK UPGRADES

- High elevation climate station & one or more Farmwest stations
- Boundary Creek hydrometric station
- Observation wells (e.g. Midway & Grand Forks)
- Fisheries monitoring in support of management strategies
- Regular assessments of riparian function





Questions

