



ADAPTING WATER MANAGEMENT PRACTICES TO CHANGING YUKON HYDROLOGIC REGIMES

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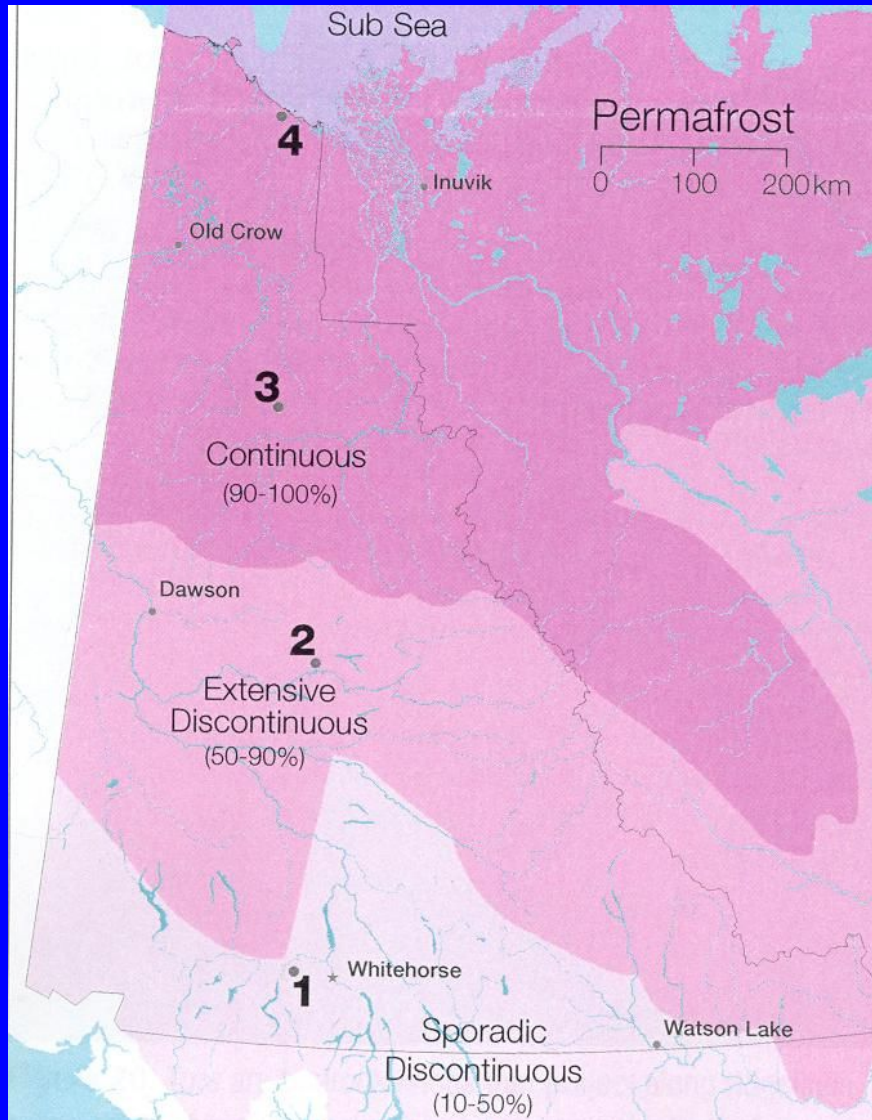
IP3 3rd Science Workshop – Whitehorse, YT – November 13 – 15, 2008

Yukon

OBJECTIVES

- DESCRIBE YUKON HYDROLOGIC RESPONSE
- DISCUSS RECENT CHANGES IN CLIMATE
- DEMONSTRATE HOW HYDROLOGIC RESPONSE HAS CHANGED OVER THE LAST 3 DECADES
- PRESENT RECENT ADAPTATIONS TO WATER MANAGEMENT PRACTICES

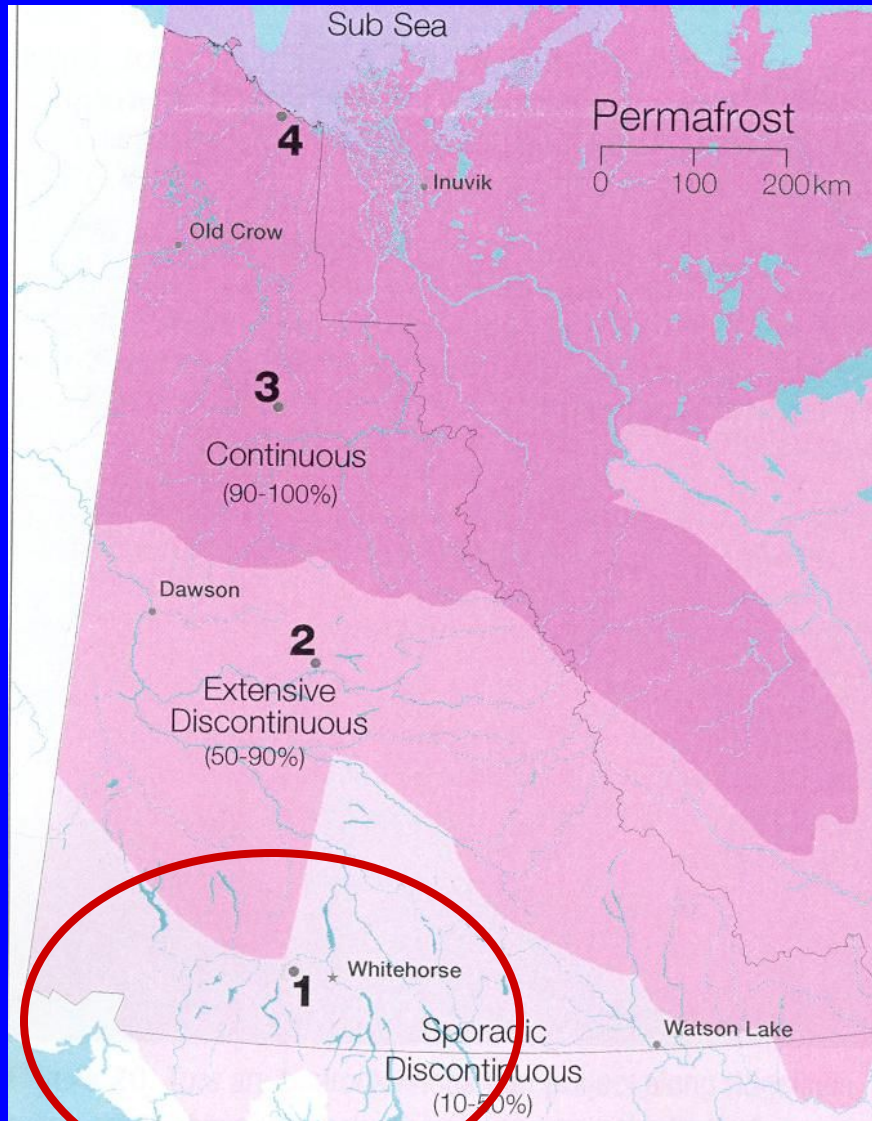
YUKON PERMAFROST DISTRIBUTION



• Yukon Hydrologic Response Controlled by Permafrost (or lack of)

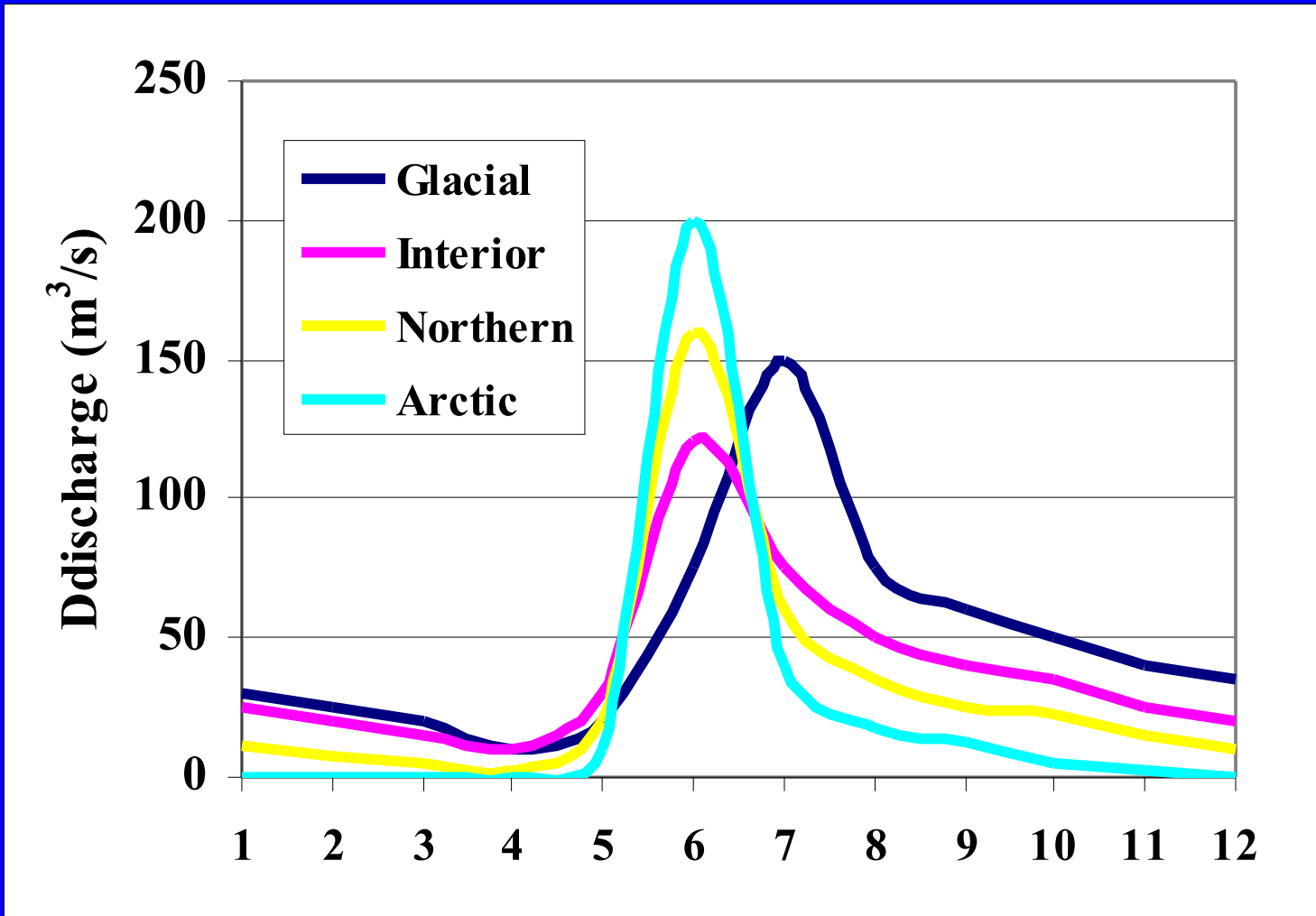
- Sporadic
- Discontinuous
- Continuous

YUKON PERMAFROST DISTRIBUTION

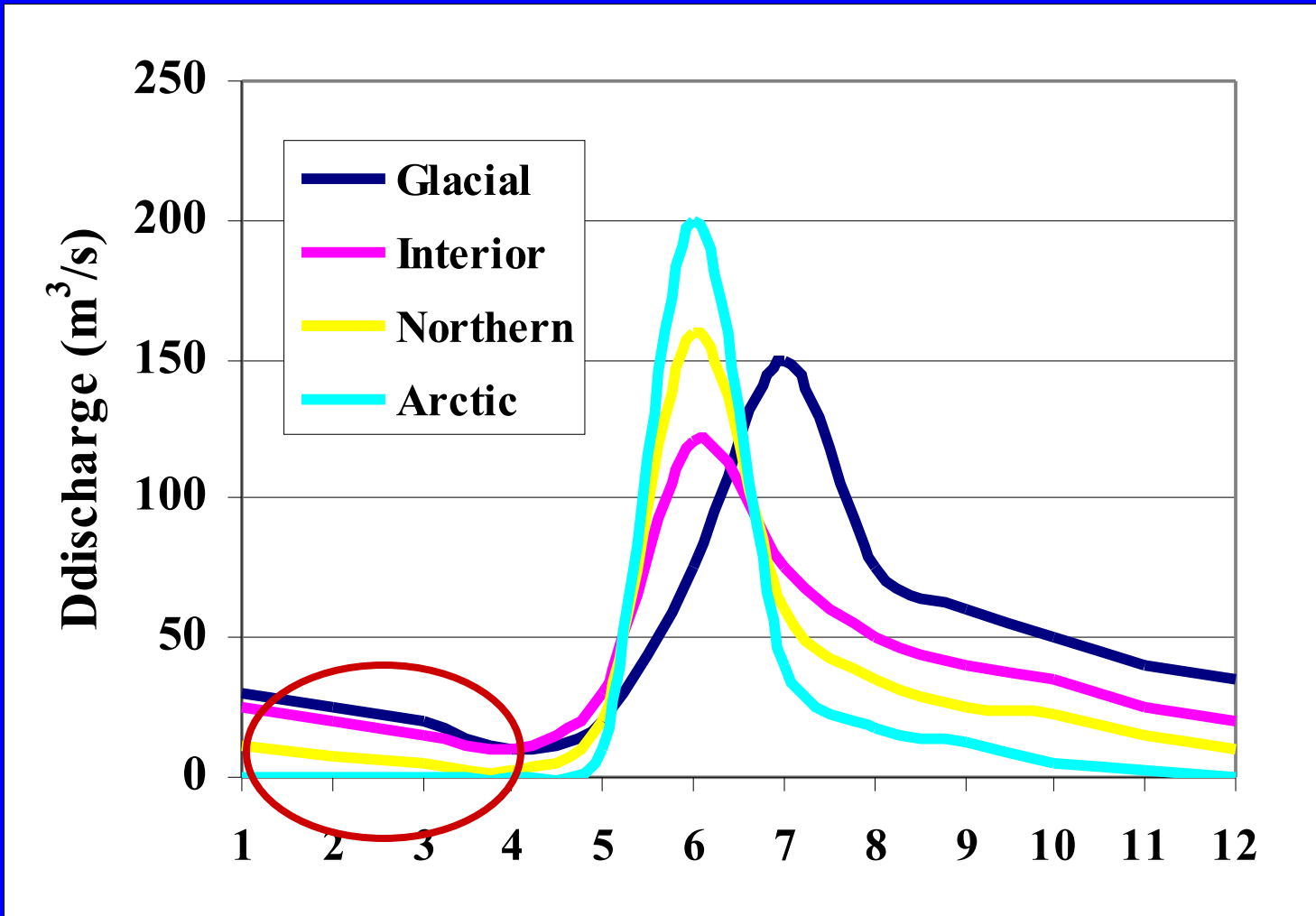


- Sporadic Permafrost Zone Co-located with Glacerized Systems
- Glaciers Provide Significant Control

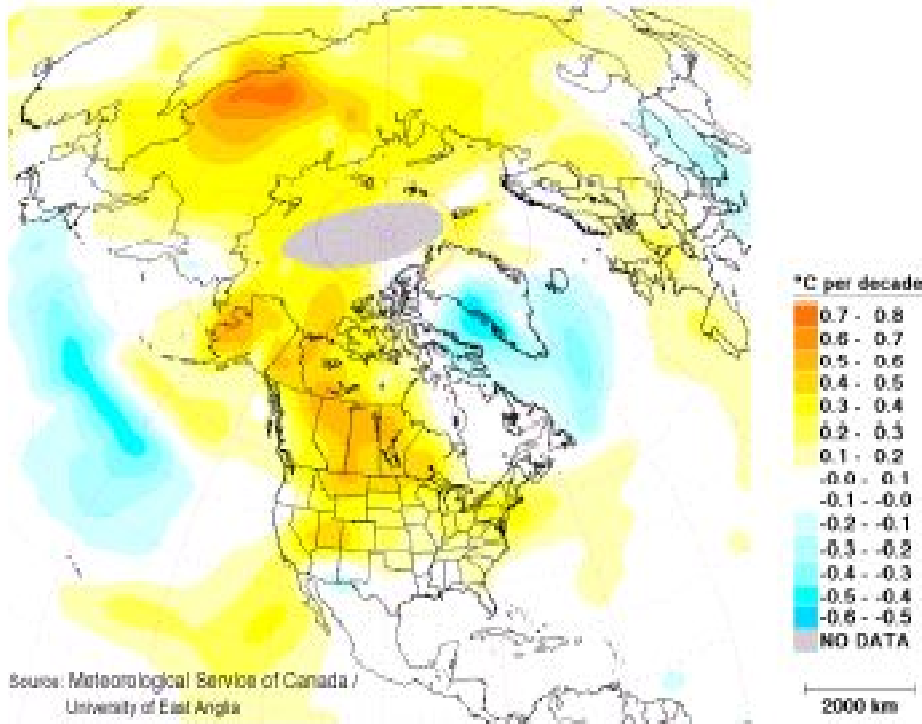
YUKON HYDROLOGIC RESPONSE



YUKON HYDROLOGIC RESPONSE

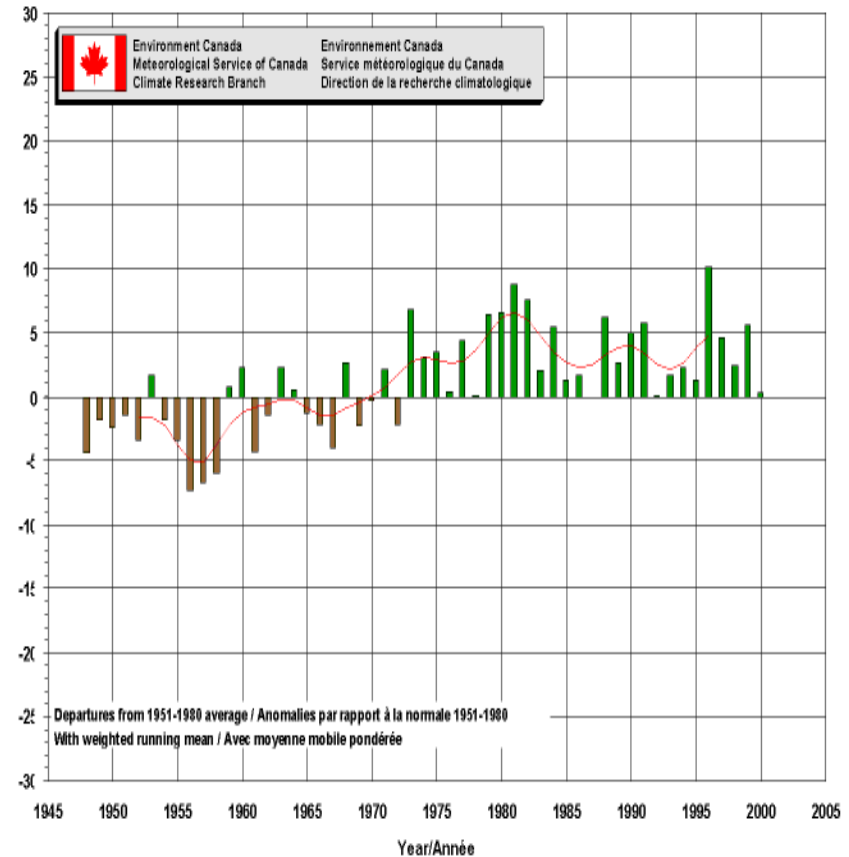


Annual Surface Air Temperature Trends 1961-1990



HISTORICAL TEMPERATURE AND PRECIPITATION

Annual national precipitation departures with weighted running mean, 1948-2000
Anomalies des précipitations annuelles nationales et moyenne mobile pondérée, 1948-2000



- Summer Temp + 2 - 6 ° C
- Winter Temp + 4 - 6 ° C
- Summer Precip + 5 - 10 %
- Winter Precip -10 - + 20 %

CLIMATE CHANGE IMPACTS

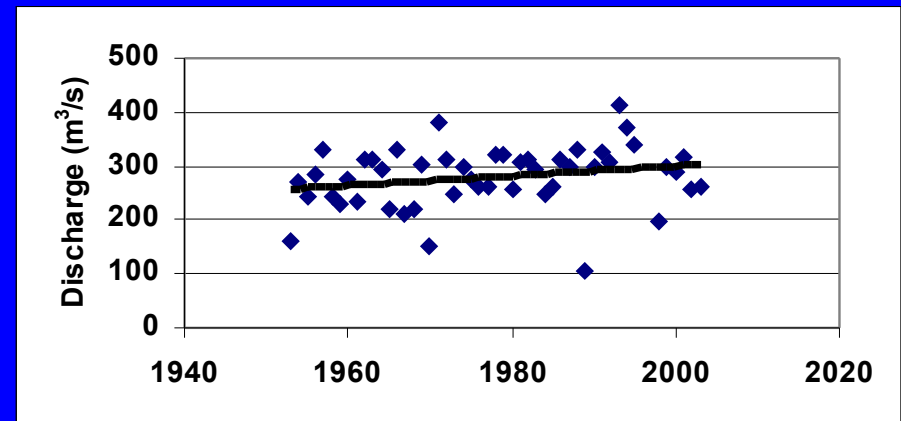
- Yukon Climate Change Political Reality
- Yukon Government in Process of Finalizing a Climate Change Action Plan Which Includes:
 - Monitoring impacts
 - Actions for reducing greenhouse gas emissions
 - Adaptation strategies

CLIMATE CHANGE IMPACTS

Increasing Peak Flows Due to Melting Glaciers



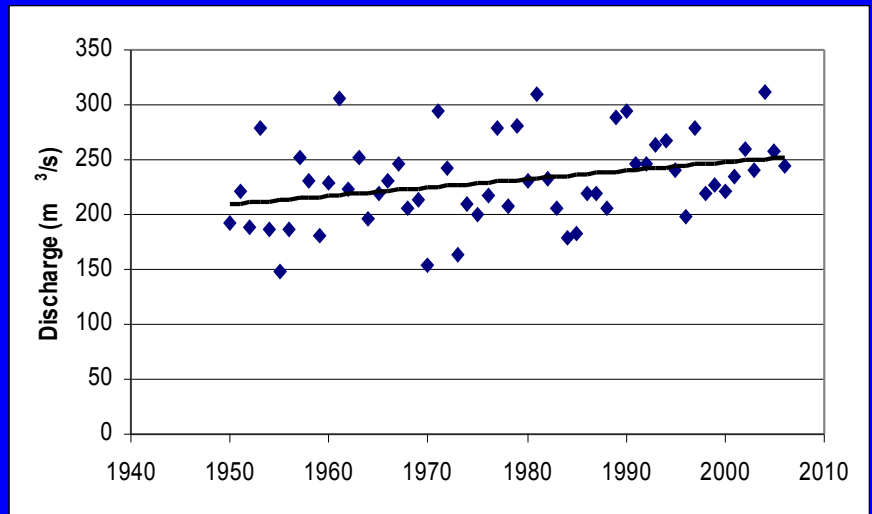
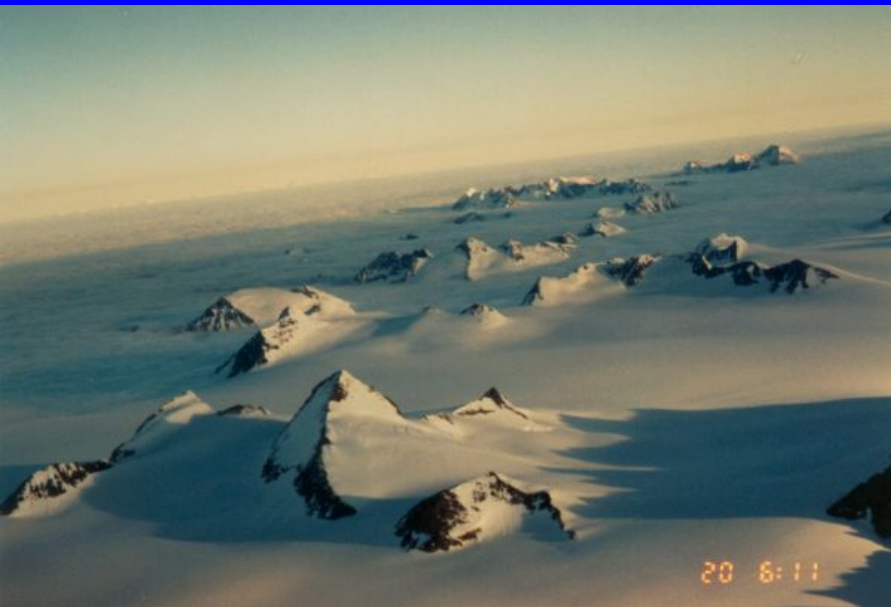
Kluane River at Kluane Lake



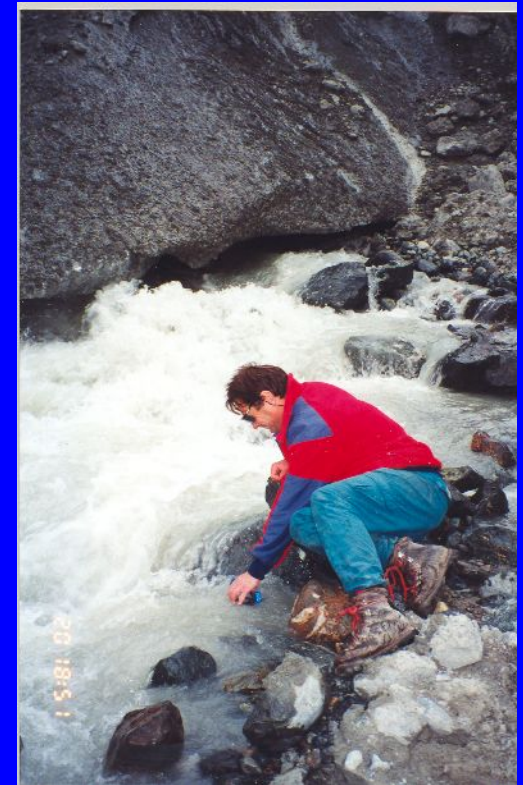
CLIMATE CHANGE IMPACTS

Increasing Peak Flows Due to Melting Glaciers

Atlin River nr Atlin



YUKON RIVER HEADWATERS



CLIMATE CHANGE IMPACTS

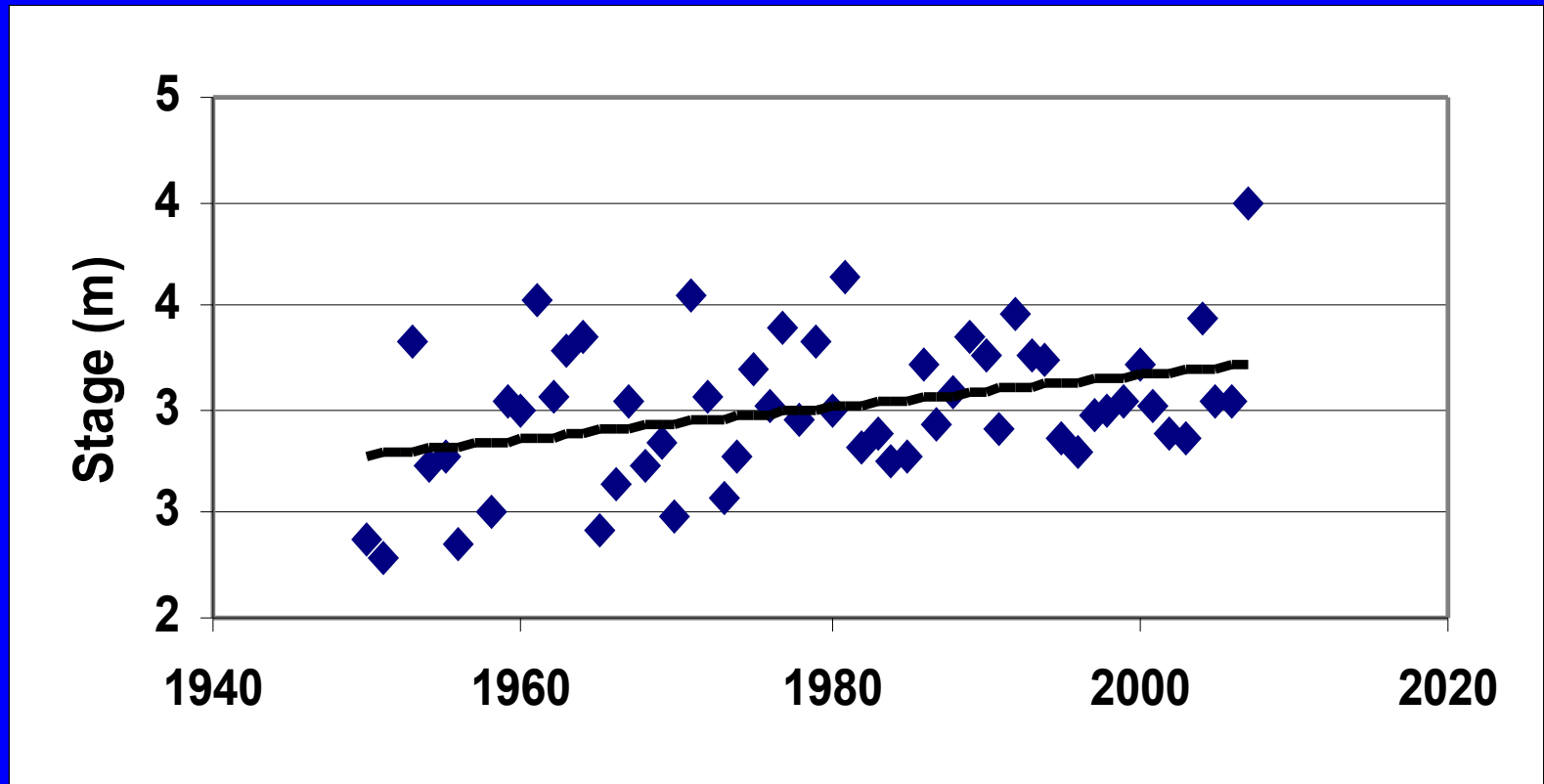
MARSH LAKE – 2007



CLIMATE CHANGE IMPACTS

MARSH LAKE MAXIMUM STAGE

1950 – 2007



CLIMATE CHANGE IMPACTS

2008 KLONDIKE HIGHWAY FLOODING (Cole Creek)



- Very Wet Summer
- August 300 % Normal Rainfall
- Hillslope Slump Produced by Melting Permafrost
- Triggered Debris Flow

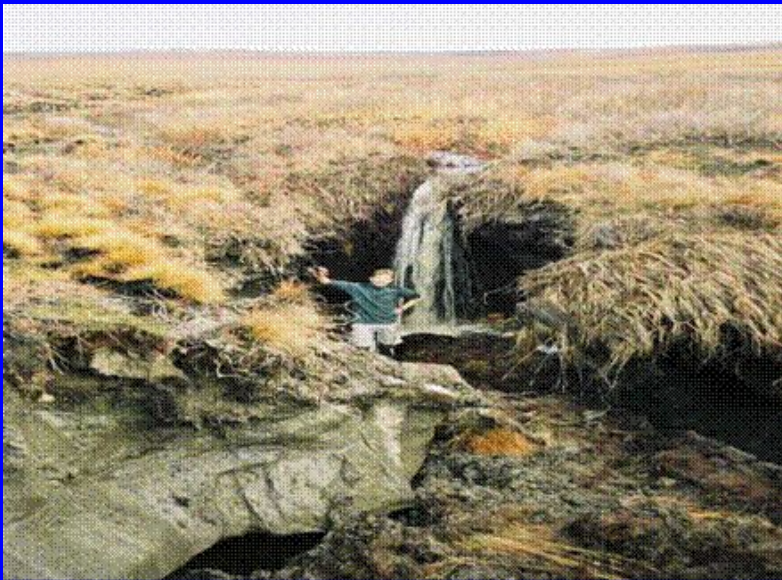
CLIMATE CHANGE IMPACTS



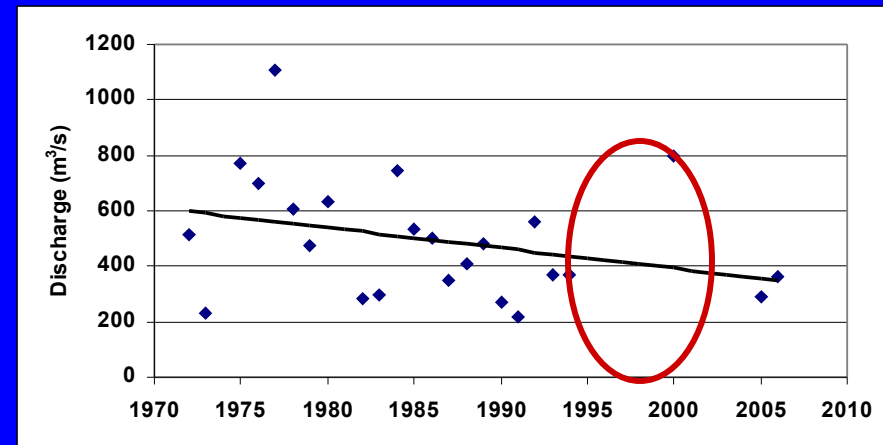
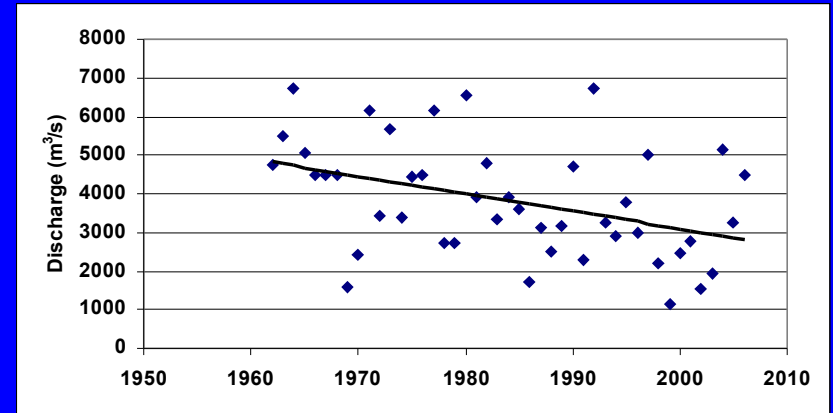
CLIMATE CHANGE IMPACTS

Decreasing Peak Flows

Porcupine River bl Old Crow



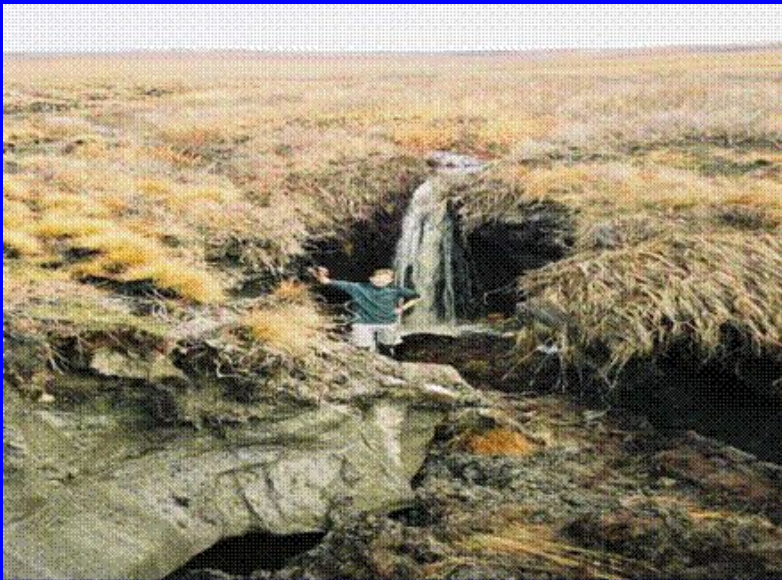
Firth River near Mouth



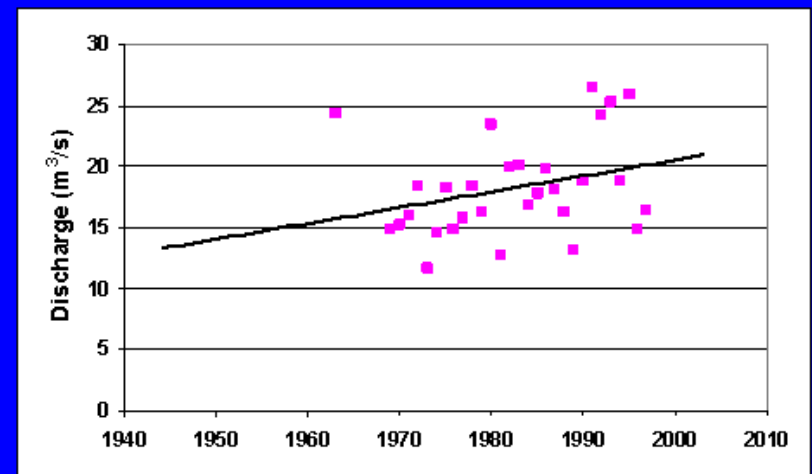
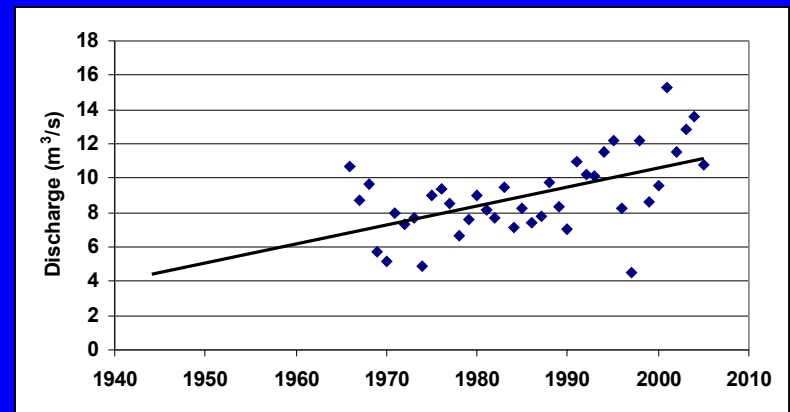
CLIMATE CHANGE IMPACTS

Increasing Winter Flows

Klondike River ab Bonanza Creek

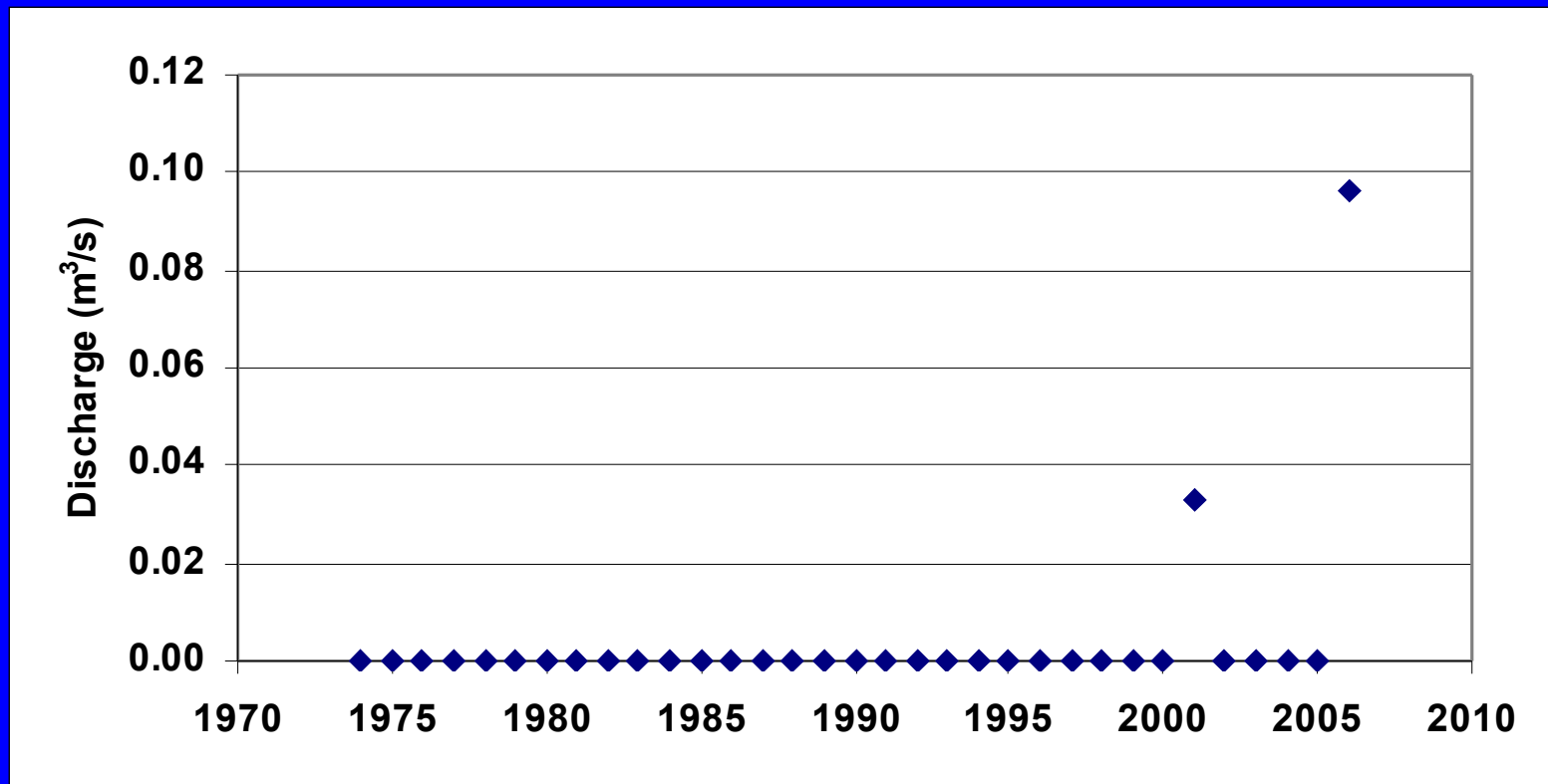


Peel River bl Canyon Creek



CLIMATE CHANGE IMPACTS

Increasing Winter Flows



Continuous Permafrost – 10LC003 – Rengleng R at Dempster Hwy

MANN-KENDALL TREND TEST – DISCONTINUOUS PERMAFROST ZONE

Station #	Drainage Area (km ²)	Record Period	n	Annual Q	M-S Q	JI-S Q	MAF	Mx JI-S Q	Min JI-S Q	7-Day Min	J Day Mx	J Day Min
09AH003	1750	1975-2006	30	-0.39 / -	-0.73 / -	-0.81 / -	-0.39 / -	-1.52 / -	0.47 / -	1.52 / -	-1.79 / *	1.02 / -
09AH004	6370	1983-2006	24	-1.39 / -	-1.31 / -	-1.69 / *	-1.34 / -	-0.92 / -	-1.49 / -	-1.19 / -	-1.07 / -	1.34 / -
09BA001	7250	1961-2006	45	-0.33 / -	-1.01 / -	-0.60 / -	-2.41 / **	-1.77 / *	0.07 / -	1.70 / *	-2.34 / **	0.35 / -
09BC001	49000	1953-2006	53	0.30 / -	-0.36 / -	-0.63 / -	-1.27 / -	-2.66 / ***	0.70 / -	2.21 / **	-1.17 / -	0.28 / -
09BC004	22100	1973-2006	34	0.12 / -	-0.20 / -	-0.53 / -	-0.12 / -	-0.83 / -	-0.67 / -	2.82 / ***	-0.71 / -	1.32 / -
09DD003	51000	1964-2006	43	0.82 / -	0.52 / -	0.16 / -	0.17 / -	-1.72 / *	0.73 / -	0.95 / -	0.60 / -	1.04 / -
09EA003	7800	1966-2006	41	1.79 / *	1.13 / -	0.71 / -	0.55 / -	0.93 / -	2.40 / **	3.27 / ***	-0.70 / -	0.25 / -
09EA004	1100	1975-2006	31	0.48 / -	0.15 / -	-0.05 / -	0.25 / -	-0.51 / -	0.90 / -	1.68 / *	-0.41 / -	1.65 / *
09EB003	2220	1982-2006	23	0.95 / -	0.77 / -	0.29 / -	0.82 / -	1.27 / -	1.14 / -	1.98 / **	-0.40 / -	2.01 / **
10EA003	8560	1961-2006	39	0.39 / -	-0.08 / -	-0.61 / -	-0.47 / -	-2.09 / **	1.75 / *	0.94 / -	-1.56 / -	3.72 / ****
10EB001	14600	1964-2006	42	0.96 / -	0.09 / -	0.72 / -	1.32 / -	-0.98 / -	1.81 / *	2.30 / **	-1.62 / -	0.59 / -
10GB001	20200	1975-2006	23	1.11 / -	1.57 / -	1.44 / -	0.89 / -	0.99 / -	1.28 / -	1.03 / -	1.35 / -	2.58 / ***
10KB001	7400	1978-2006	21	-1.40 / -	-1.44 / -	-0.99 / -	-2.00 / **	-1.30 / -	-0.63 / -	1.00 / -	-1.21 / -	0.53 / -

CLIMATE CHANGE IMPACTS

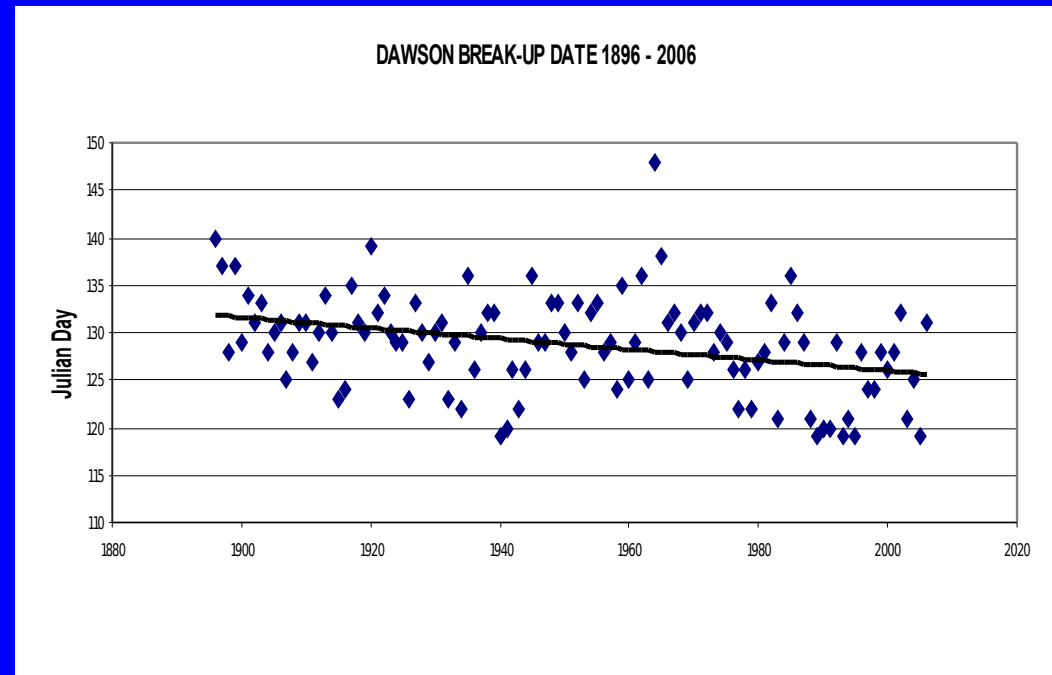
Results Summary

- Winter Low Flows Increasing All Zones
 - 50 / 55 / 45 % Con / Discon / Sporadic
- Maximum Annual Flows
 - Decreasing Continuous / Discontinuous
 - Increasing Sporadic
- Max / Min Summer Flows Decreasing / Increasing Continuous & Discontinuous
 - Mixed Sporadic

CLIMATE CHANGE IMPACTS

Yukon River at Dawson

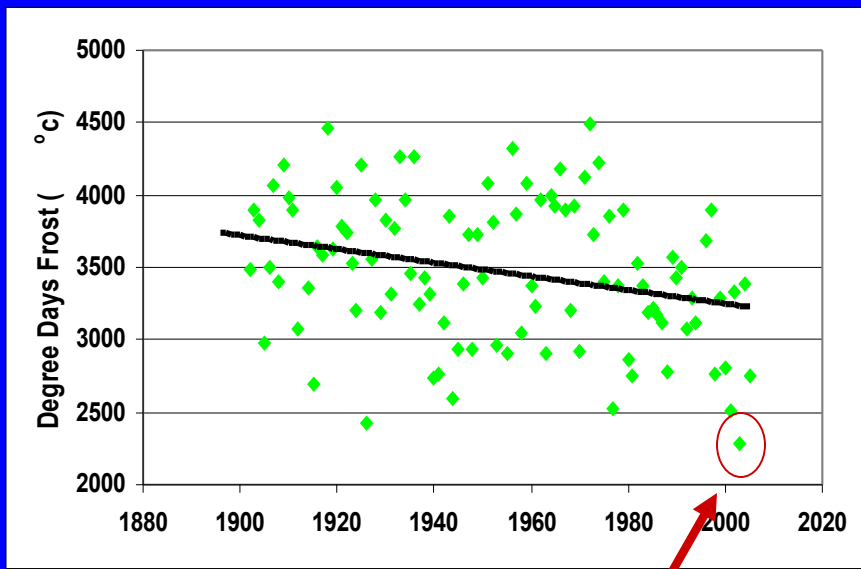
Significantly earlier break-ups in last 3 decades



CLIMATE CHANGE IMPACTS

2002/03 Mid-Winter Klondike River Ice Jam and Flooding

Dawson City Winter Temperatures 1902 - 2005



Klondike River Ice Jam - 2003



2002/03 warmest winter

CLIMATE CHANGE IMPACTS

Greater Frequency Ice Jams Because of Warmer Winters

Old Crow Ice Jam - 1991

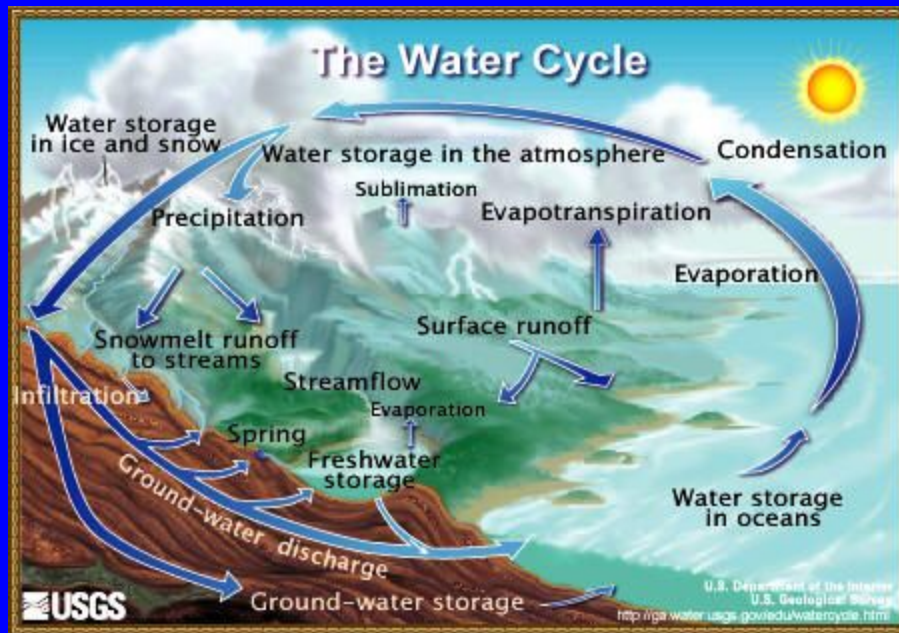


Dawson City Ice Jam - 1998



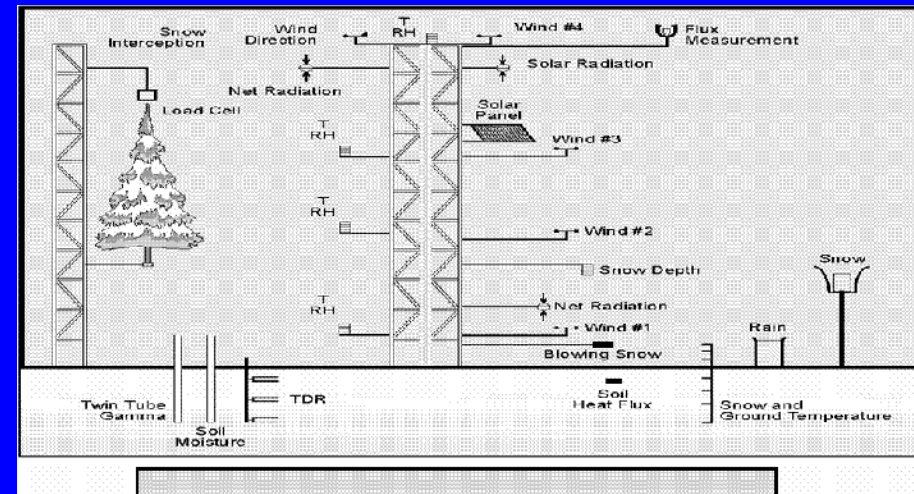
CLIMATE CHANGE ADAPTATION RESEARCH

Physical Hydrologic Processes in Cold Regions Poorly Understood



CLIMATE CHANGE ADAPTATION RESEARCH

Wolf Creek Research Watershed Established to Study Hydrologic Processes



Wolf Creek Tower Schematic

CLIMATE CHANGE RESEARCH

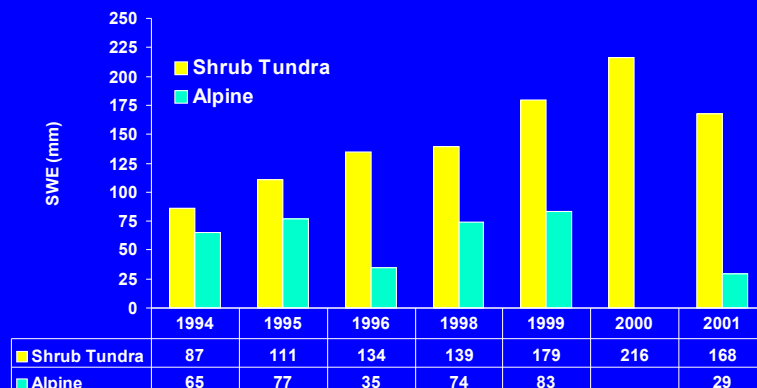
Snowpack Accumulation, Redistribution and Melt is Variable



- Blowing snow transports 80 % from alpine

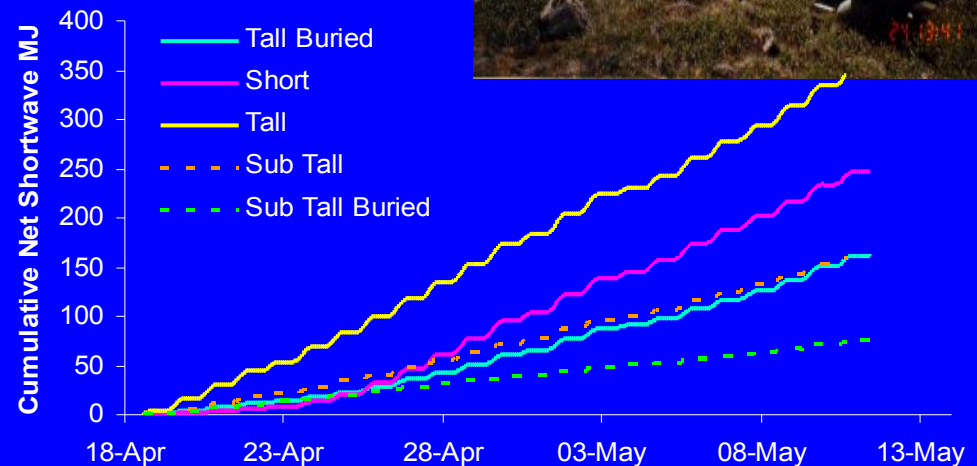
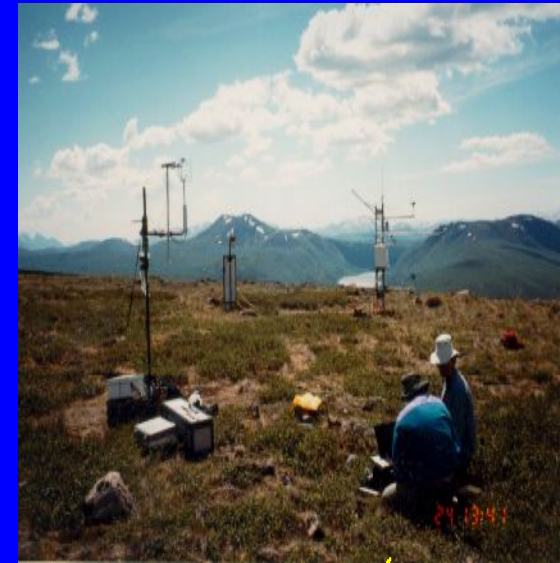
- Forest sublimation accounts for 60 % of snowfall

- Snowmelt is 300 % faster in the alpine than forest



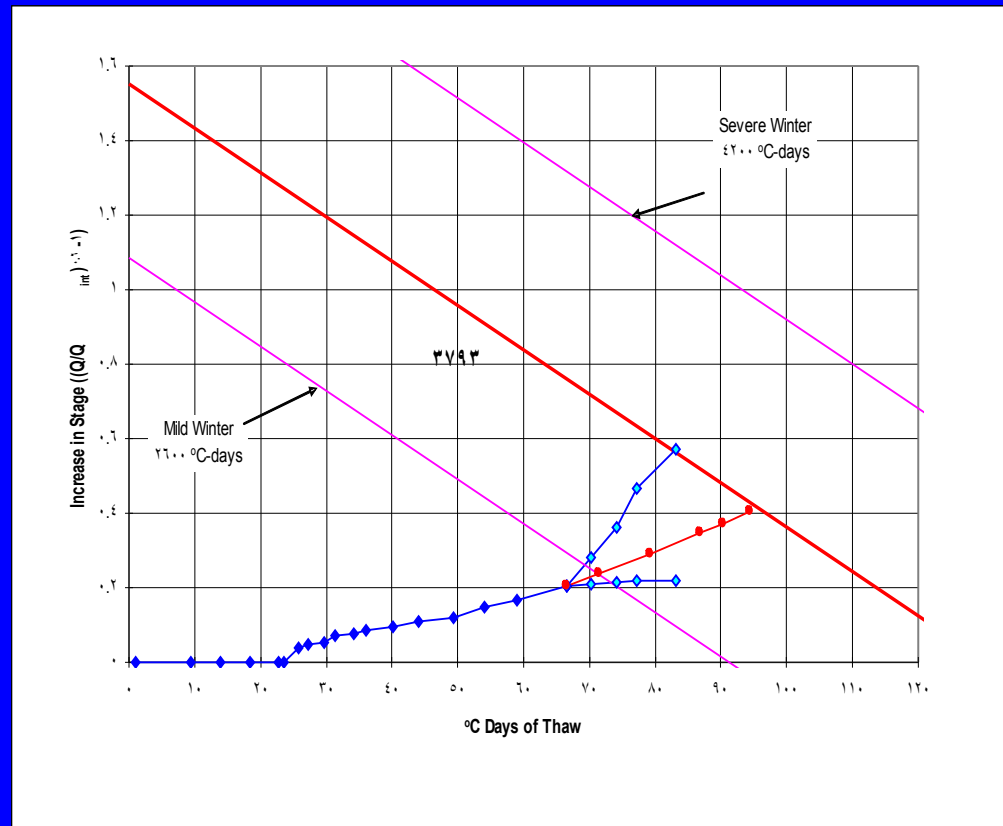
CLIMATE CHANGE RESEARCH

Studies Indicate that Evapotranspiration is 50 % Higher in Forested Areas



CLIMATE CHANGE ADAPTATION

UPDATE FLOOD FORECAST MODEL

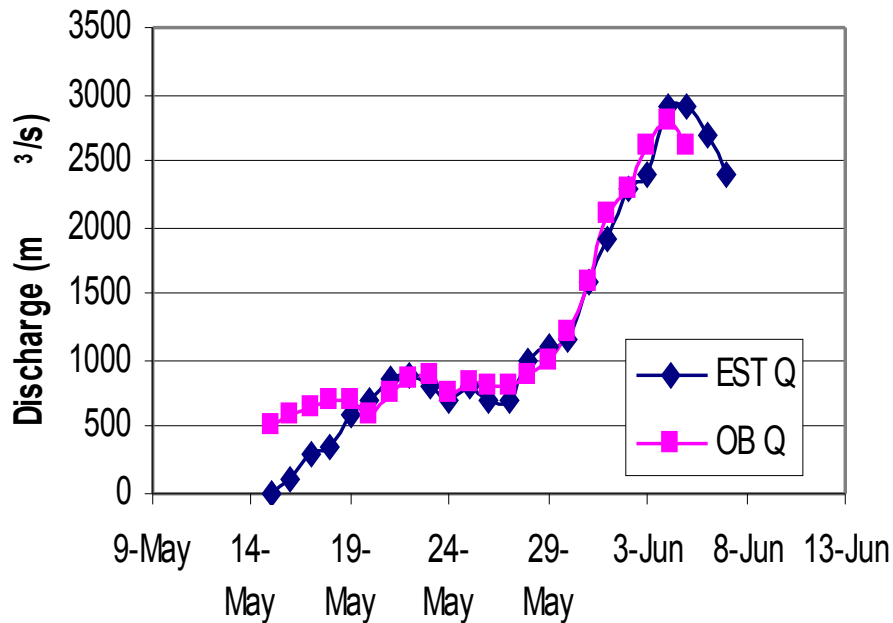


Dawson Break-up

CLIMATE CHANGE ADAPTATION

FRESHET FORECASTING

RECORDED AND ESTIMATED STREAMFLOW -
STEWART RIVER AT MAYO - 1983



- Existing model outdated
- NWSRFS
- Alaska River Forecast Center have offered to provide model and support

ALASKA RIVER FORECAST CENTER ANCHORAGE



YUKON TERRITORY FORECAST CENTRE WHITEHORSE



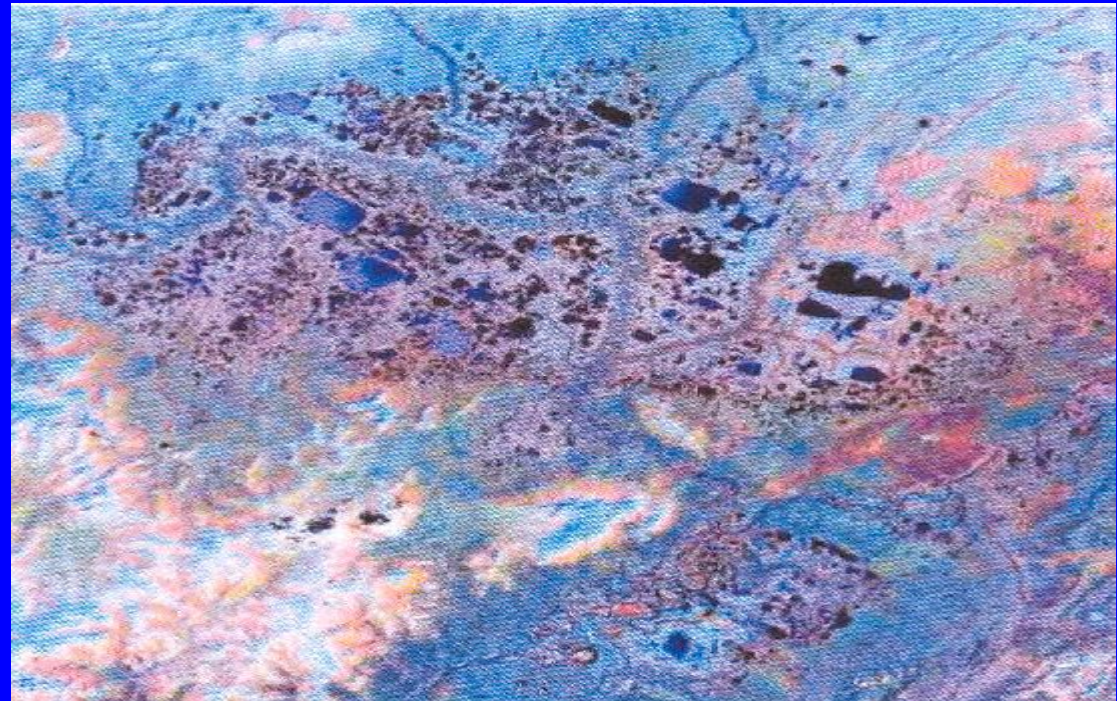
CLIMATE CHANGE ADAPTATION

Spring Break-up and Ice Jam Forecasting Studies for Old Crow and Dawson



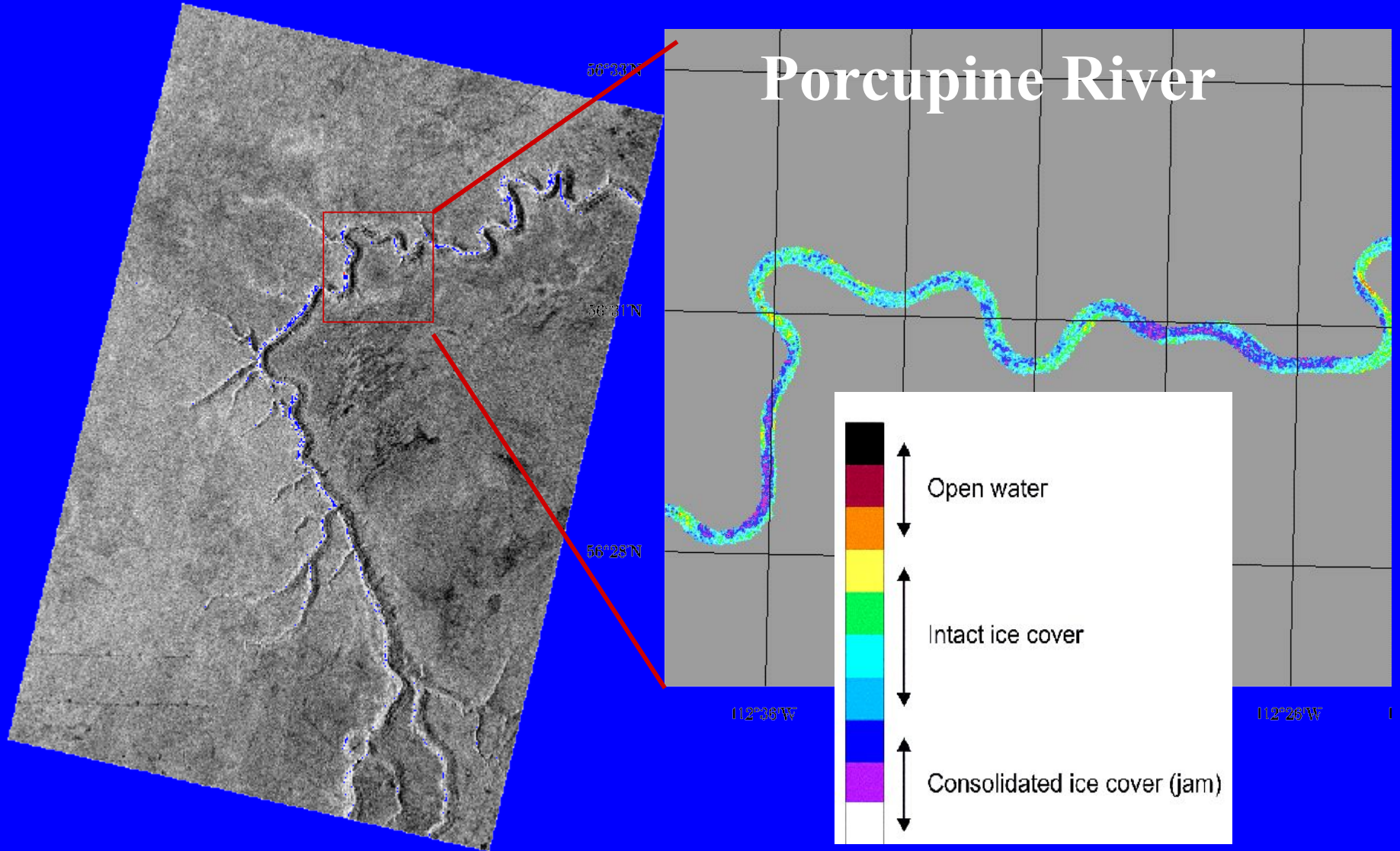
CLIMATE CHANGE RESEARCH

Old Crow and Porcupine River



**River Break-up Studies using Satellite Telemetry
Will Improve Forecasting Capability for Old Crow**

Porcupine River



BREAK-UP MONITORING / GROUND TRUTHING



ANVIL RANGE MINING CORPORATION FARO MINE COMPLEX



- Could we Transfer Wolf Creek Finding to Faro Waste Rock Dumps to Develop a Water Balance?

ANVIL RANGE MINING CORPORATION FARO MINE COMPLEX

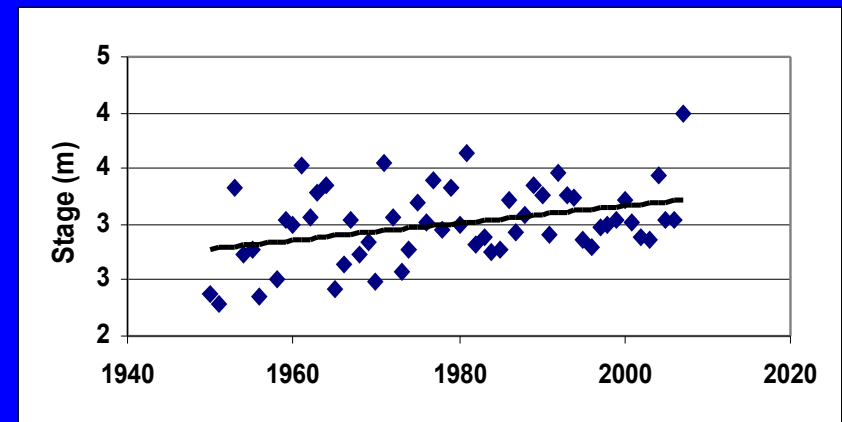
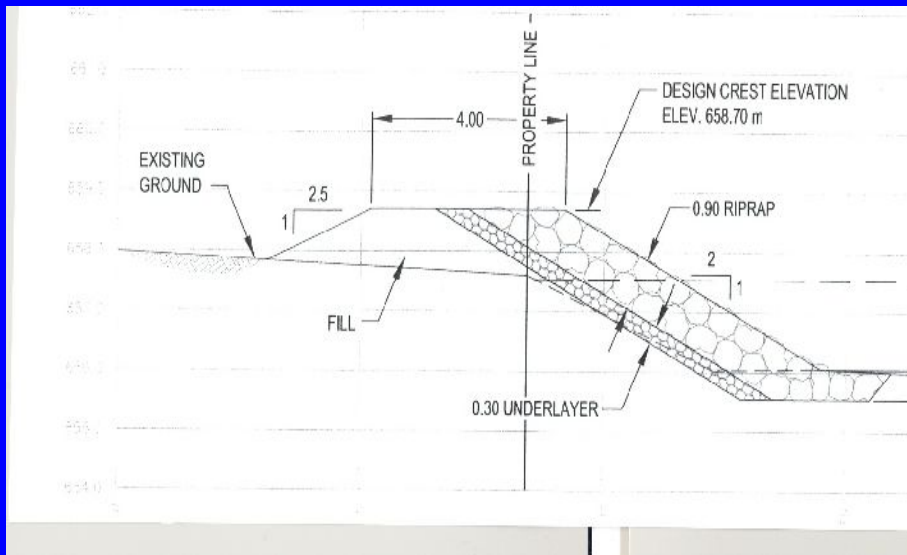


 <p>SRK Consulting Engineers and Scientists VANCOUVER</p>	 <p>Deloitte & Touche</p>	Monitor Mine Waste Rock Trial Covers 2005 Data Summary		
		Looking towards the trial covers on Vangorda Waste rock pile		
Job No.: TCD003-071 Filename: Figures 4 to 8_20090322.pdf	Anvil Range Mining Complex	Date: March 2006	Author: SMW	Figure: 2

CLIMATE CHANGE ADAPTATION

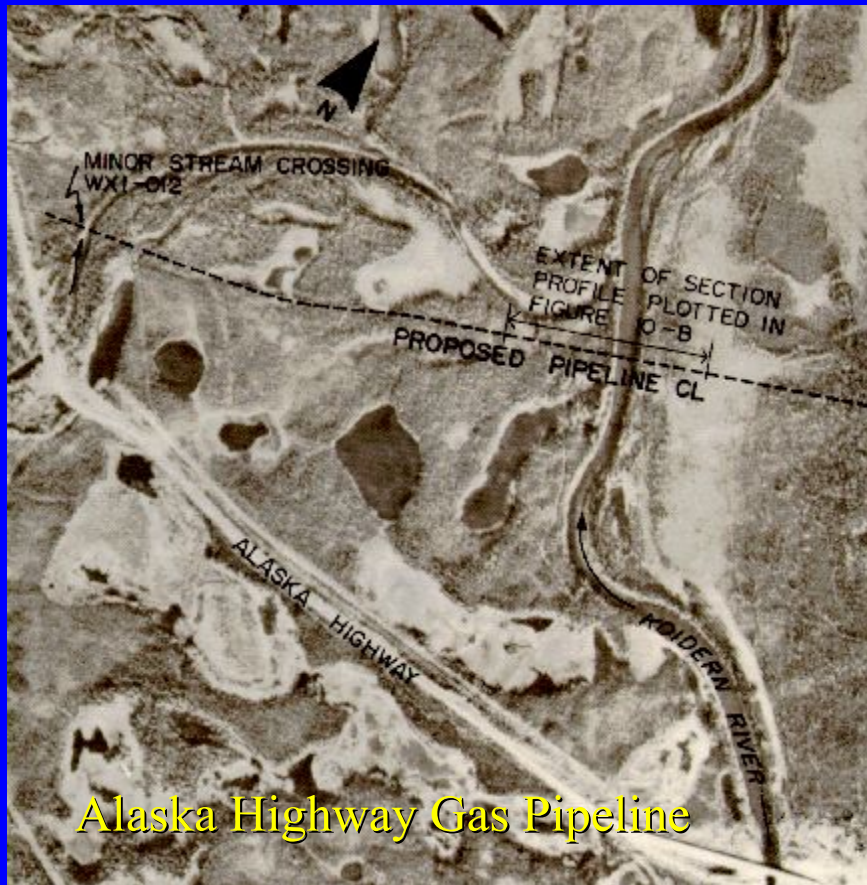
Infrastructure Design Implication Due to Rapidly Changing Hydrologic Data Series (last 30 years)

Marsh Lake Dyke Design - 2008

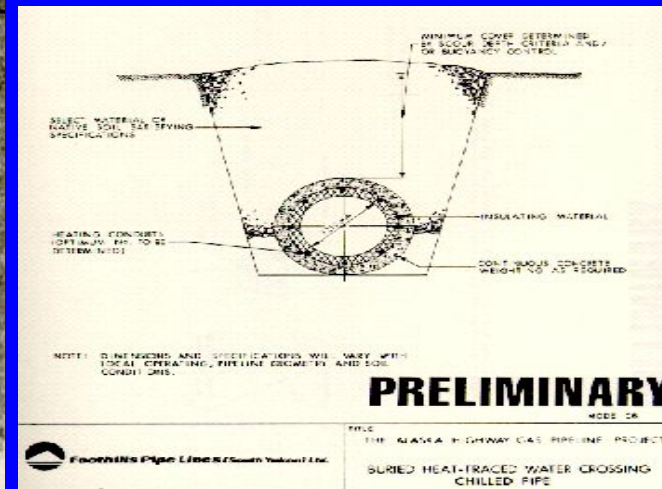


CLIMATE CHANGE ADAPTATION

Alaska Highway Gas Pipeline



Infrastructure Design
Implication Due to Rapidly
Changing Hydrologic Data
Series (last 20 years)



SUMMARY

- Climate Change Reality in Yukon
- Increased Flooding from Glacial Regions
 - Increased Frequency Ice Jam Flooding
- Wolf Creek Research Watershed
Established to Carry Out Cold Regions Research
 - Adapt Flood Forecasting Models
- Using Remote Sensing to Improve Ice Jam Forecasting Techniques
- Adapt Design Tools and Methodology

THANK YOU



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