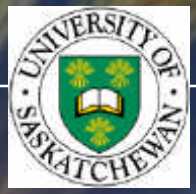
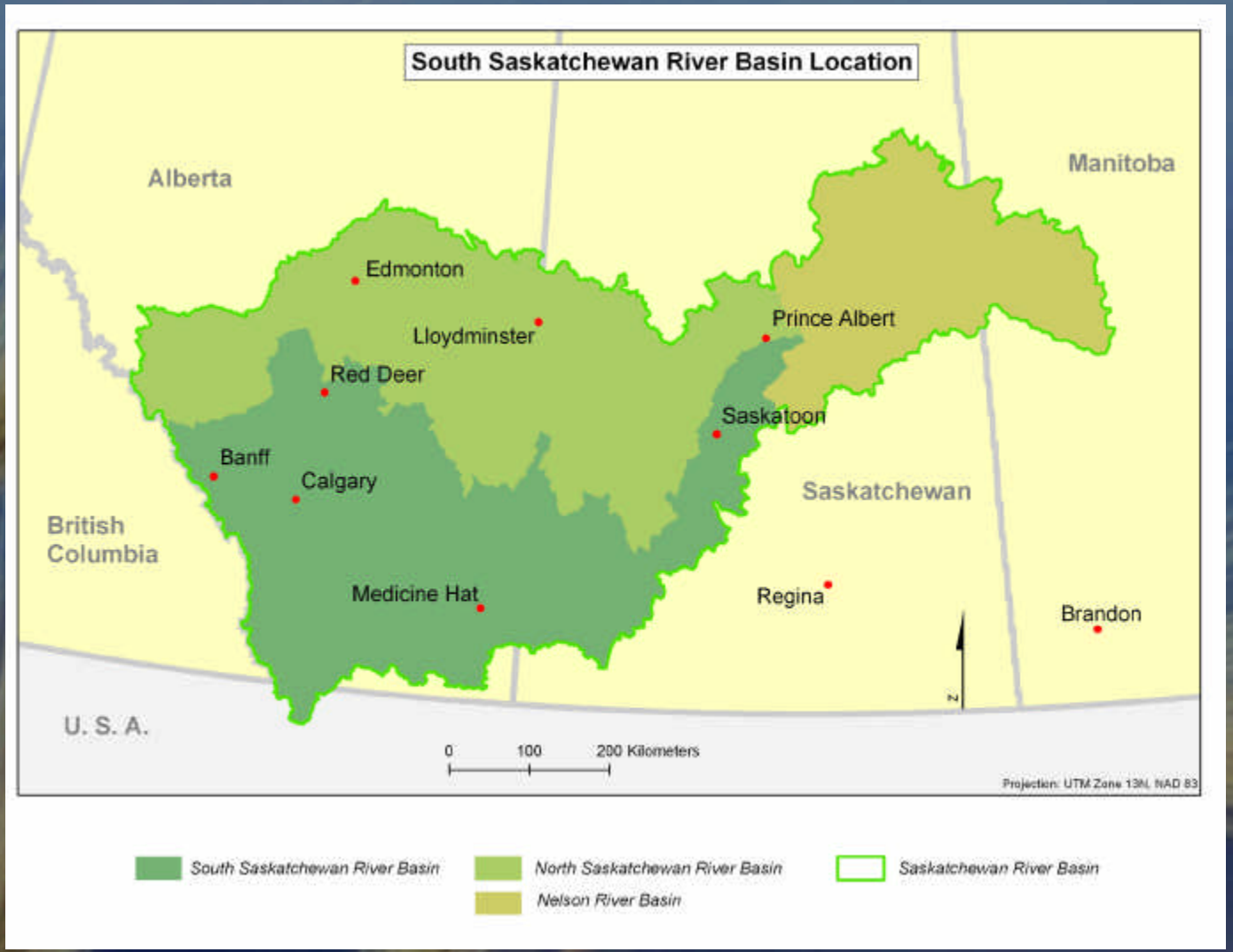
Drought Research Initiative (DRI) Workshop #1
Saskatoon, Saskatchewan
11-12 January 2006

Applying Hydroclimatological Science to the Socio-Economic Dimensions of Water

Lawrence Martz, Joel Bruneau (USask),
Brenda Toth, Al Pietroniro (EC-NWRI)



SSRB Study Area



Linked CCIAP Projects

Water Availability in the SSRB under Climate Change

- physical science study to predict future streamflow in SSRB under climate change
- hydrologic models calibrated to SSRB and forced by downscaled climate scenarios from selected GCM

Vulnerability of Key Water Use Sectors in the SSRB to Changes in Water Supply from Climate Change

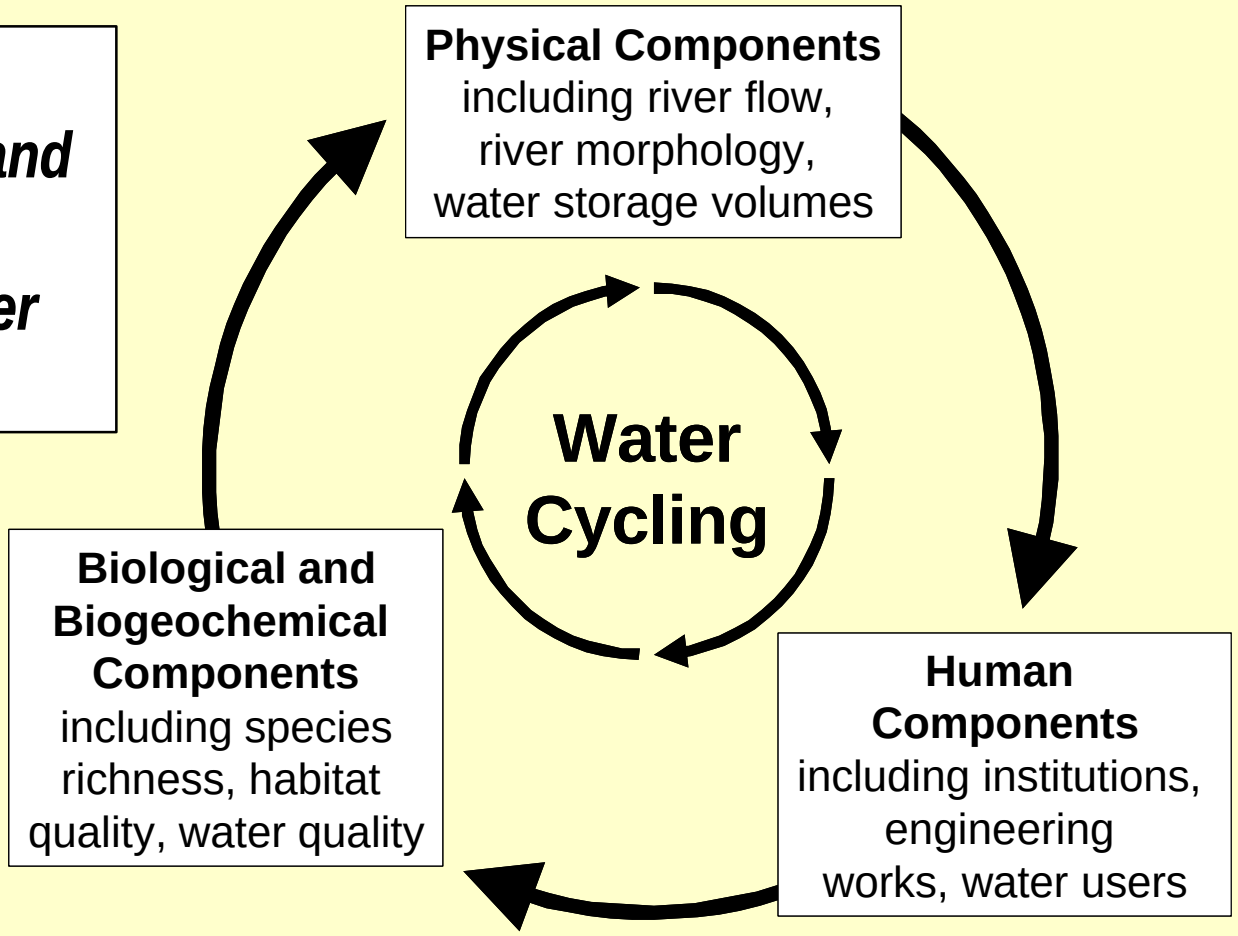
- social science study to assess the socio-economic impacts of climate change induced water resource availability
- key water withdrawal and in-situ use sectors

Questions for the SSRB Study

1. What is the current water use by sector and by SSRB sub-basin?
2. What might water use look like in 2040?
3. What is user vulnerability to changes in water availability under climate change?
4. What would the economic cost of water availability changes be due to climate change?
5. What government policies and programs might help us adapt to this change?

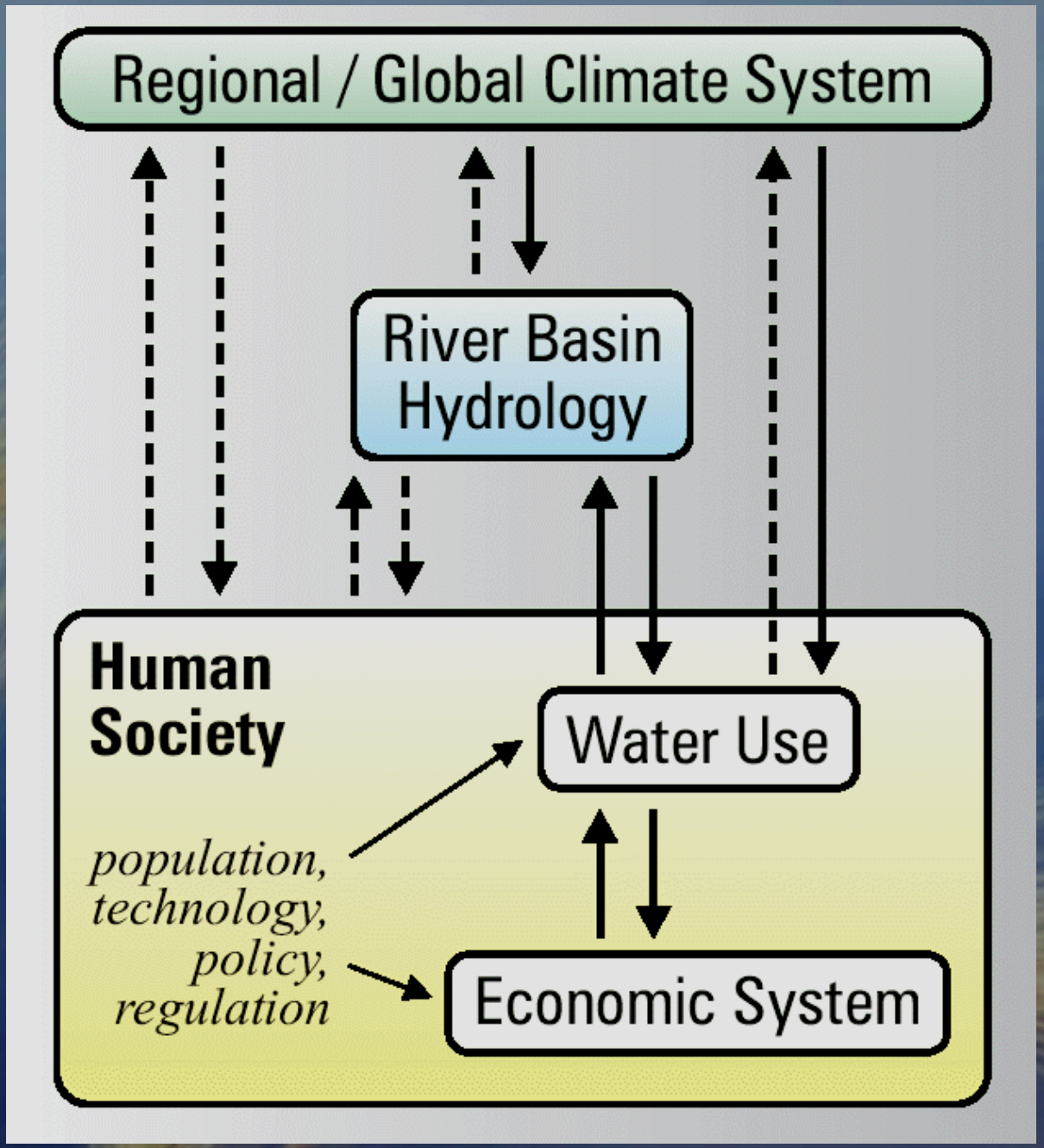
The Global Water System

…all of the physical, chemical, biological, and anthropogenic manifestations of water in the Earth System



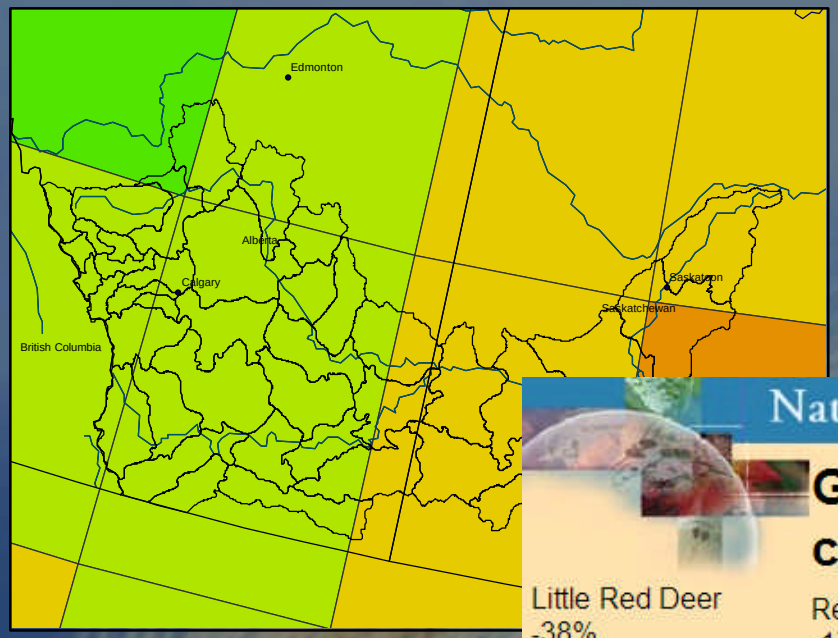
after Vorosmarty et al. 2003

SSRB Study Framework



An end-to-end analysis

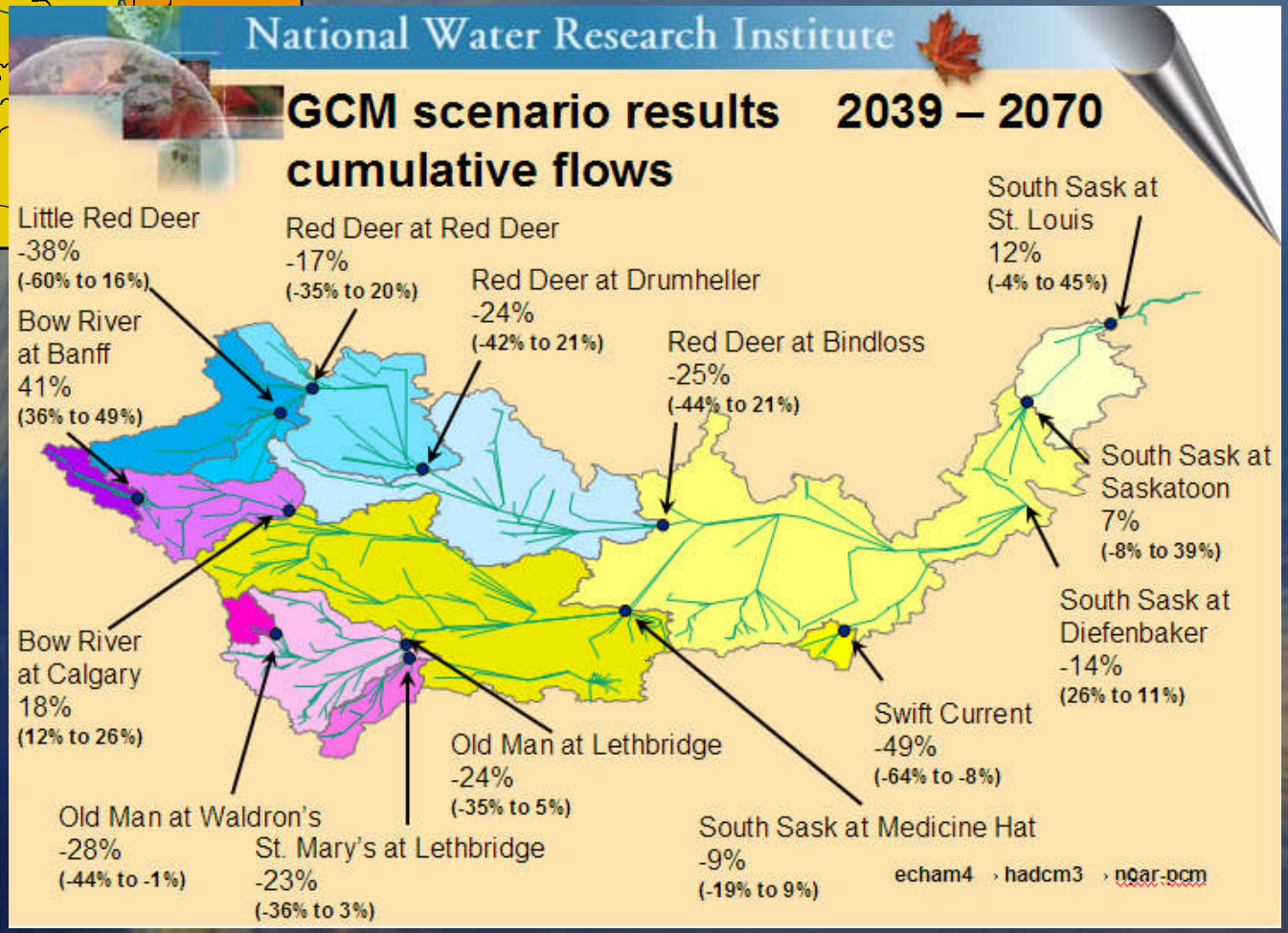
1. Predict future water availability using hydrologic model forced by downscaled climate scenarios,
2. Document current water use patterns and the economic value of withdrawal and in-situ uses,
3. Simulate water uses under present and future climate
4. Estimate the economic cost of changes due to climate change
5. Examine policies and programs that govern water use and adaptation to changing water availability.



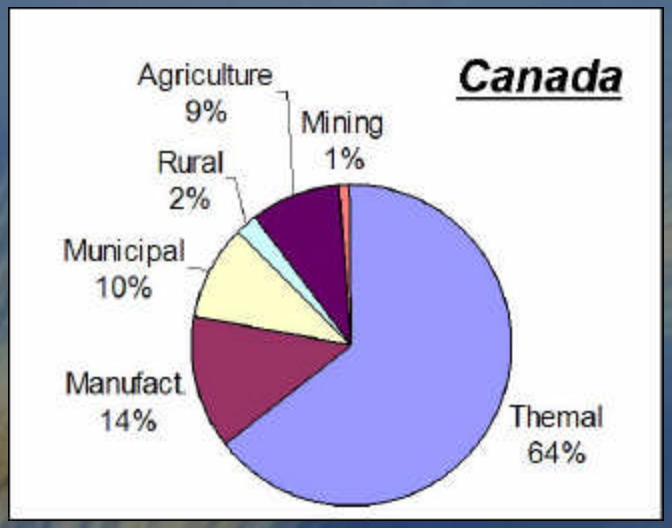
GCM downscaling

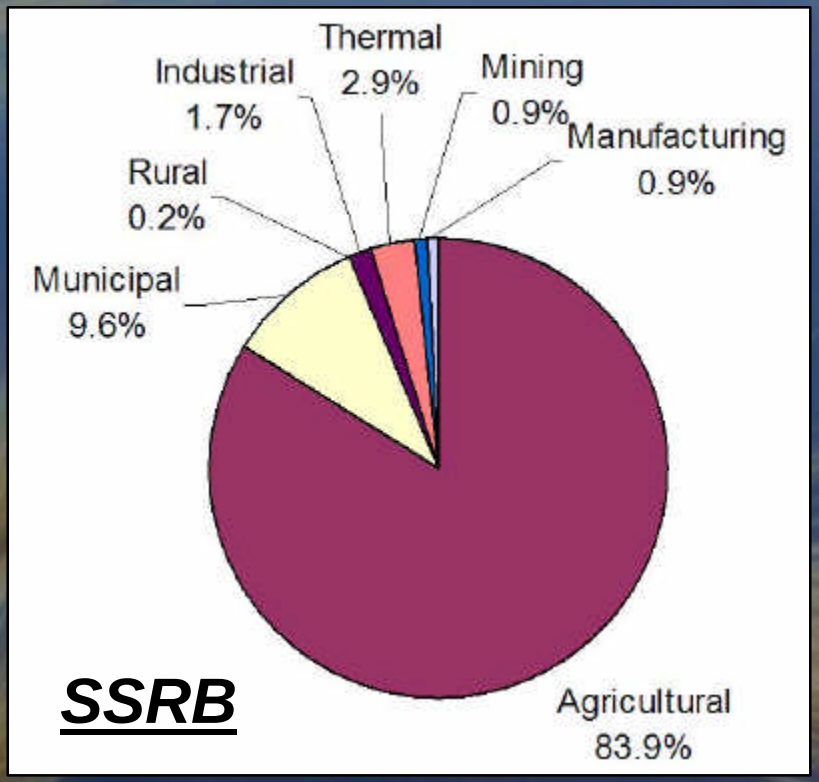
↓

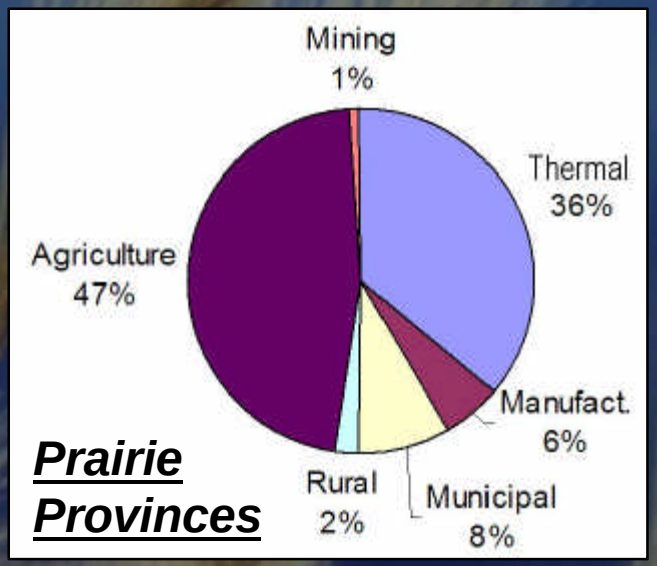
Hydrologic model



Water Withdrawal Use by Sector (1996)







WTP to avoid a water shortage of 10%

	WATER USE	SHORT RUN (unanticipated)		LONG RUN (anticipated)	
	million cubic meters	Weighted Average $ per m^3	Total $ millions	Weighted Average $ per m^3	Total $ millions
MUNICIPAL					
Households	156	1.39	22	1.27	20
Businesses	71	2.17	16	1.41	10
Industrial	45	2.17	10	1.41	6
IRRIGATION	**2,864**	**0.193**	**55**	**0.10**	**29**
LIVESTOCK	58	46.32	268		
INDUSTRY	174	14.20	248	0.272	5
MINING	9.86	48.58	48	0.023	0.02
HYDRO	379,225	0.00024	9	0.00011	4
THERMAL	1,023	0.627	64	0.00162	0.16

Findings and Implications

CLIMATE CHANGE:

- Climate scenarios suggest risk of significant decreases in water availability.
  - Significant variability in outcomes across scenarios.
  - Scenarios bracket zero net losses
  - Average of scenarios is decrease of 10%
- Significant differences across sub-basins and rivers.
  - Prairies drier while the foothills are wetter.
  - Though the prairies will be drier there will still be significant instream flows.

NET WATER SUPPLY (MCM)	RED DEER RIVER	BOW RIVER	OLDMAN	SOUTH SASK	SSRB TOTAL
MODELED (1961-1990)	**1937**	**2487**	**2461**	**1338**	**8223**
AVERAGE CC SCENARIO	**1602**	**2970**	**1956**	**900**	**7428**
AVERAGE GAIN/LOSS	**-335**	**483**	**-506**	**-437**	**-795**
as a fraction of BASE NWS	-0.17	0.19	-0.21	-0.33	-0.10
MAXIMUM GAIN (or min loss)	**417**	**651**	**-116**	**20**	**981**
as a fraction of BASE NWS	0.22	0.26	-0.05	0.02	0.12
MINIMUM GAIN (or max loss)	**-856**	**298**	**-863**	**-755**	**-2176**
as a fraction of BASE NWS	-0.44	0.12	-0.35	-0.56	-0.26

Findings and Implications

SOCIO-ECONOMIC GROWTH (2046):

(primarily from Hydroconsult Report (2004) on Non-Irrigation Demand)

- Total withdrawals rise up 100% in Medium Growth Scenario
  - Population will likely double (from 1.5 to 3.1 million)
  - Municipal Withdrawals up by only 70% due to increased efficiency
  - Livestock watering up by 40% due to herd growth
  - Industrial withdrawals up by 270% due to increased activity
  - Thermal Electric withdrawals up 140% due to demand for power
- However, in 1996 total consumption by non-irrigation users was only 155 MCM
  - this is 1.9% of available water based on 1961-90 water regime.
  - Rises to 3.8%
- Implication: Non-irrigation water demand not a significant risk to water resources in SSRB.

NET WATER SUPPLY (MCM)	RED DEER RIVER	BOW RIVER	OLDMAN	SOUTH SASK	SSRB TOTAL
MODELED NWS (1961-90)	**1937**	**2487**	**2461**	**1338**	**8223**
AVERAGE FORECAST NWS	**1602**	**2970**	**1956**	**900**	**7428**
GAIN due to Climate Change	**-335**	**483**	**-506**	**-437**	**-795**
Gain as a fraction of BASE NWS	-0.173	0.194	-0.205	-0.327	-0.097
ACTUAL NON-IRRIGATION CONSUMPTION 1996	**41**	**55**	**26**	**32**	**155**
as a fraction of BASE NWS	0.021	0.022	0.036	0.010	0.019
2046 LOW GROWTH	**70**	**85**	**36**	**62**	**253**
as a fraction of BASE NWS	0.036	0.034	0.050	0.020	0.031
2046 MED GROWTH	**84**	**110**	**41**	**74**	**309**
as a fraction of BASE NWS	0.043	0.044	0.056	0.024	0.038
2046 HIGH GROWTH	**98**	**143**	**46**	**88**	**376**
as a fraction of BASE NWS	0.051	0.057	0.064	0.029	0.046

NET DEMAND FOR WATER: Change due to Climate – Change due to Growth in Non-irrigation consumption

CHANGES IN NET DEMAND (MCM)	RED DEER RIVER	BOW RIVER	OLDMAN	SOUTH SASK	SSRB TOTAL
GAINS due to climate change (average of scenarios)	**-335**	**483**	**-506**	**-437**	**-795**
as a fraction of BASE NWS	-0.173	0.194	-0.205	-0.327	-0.097
AVG CC and LOW GROWTH	**-364**	**454**	**-515**	**-468**	**-893**
as a fraction of BASE NWS	-0.188	0.183	-0.209	-0.350	-0.109
AVG CC and MED GROWTH	**-378**	**428**	**-520**	**-479**	**-949**
as a fraction of BASE NWS	-0.195	0.172	-0.211	-0.358	-0.115
AVG CC and HIGH GROWTH	**-392**	**396**	**-526**	**-493**	**-1016**
as a fraction of BASE NWS	-0.203	0.159	-0.214	-0.369	-0.124

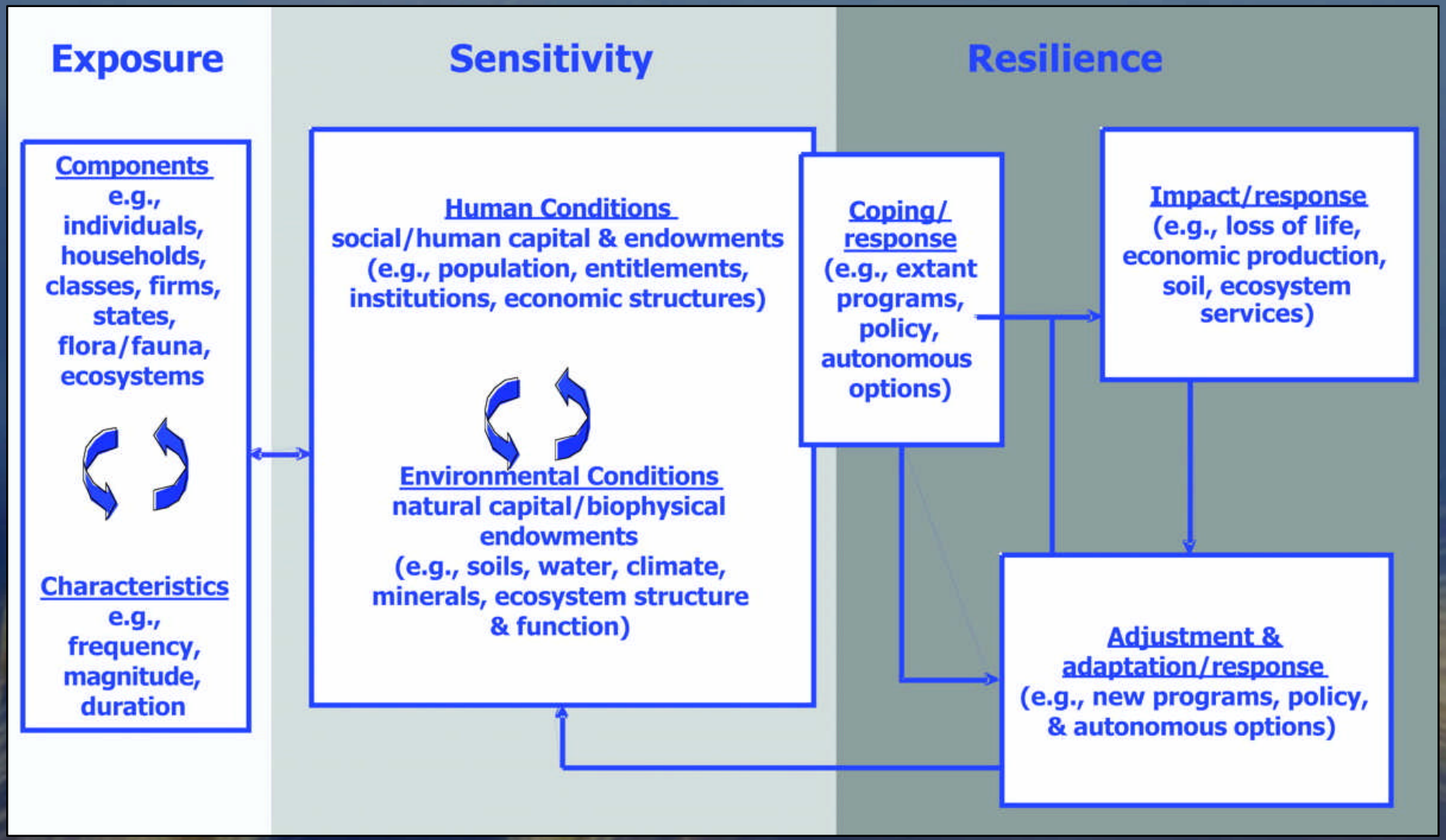
Findings and Implications

IRRIGATION:

- Large relative to climate change effects
  - in 1996 total SSRB irrigation demand was 2521 MCM
  - 1996 was drier than average over 1976-2004
  - this is 31% of available water based on 1961-90 water regime.
- Gross diversions rising in 1976-2004 period
  - 1.1% per year in OR, 0.10% in BR
  - Bow and Oldman use +-70% of licensed allocations
  - Growth in diversions despite improvements in water use efficiency
  - Return flows likely to fall over time so increase net diversions
- Some capacity to expand outside of Oldman River since in-stream flows still high in SK-SSR

GROSS DIVERSIONS (MCM)	RED DEER RIVER	BOW RIVER	OLDMAN	SOUTH SASK	SSRB
1996 IRRIGATION Withdrawals	**499**	**612**	**932**	**478**	**2521**
as a fraction of BASE NWS	0.258	0.246	0.379	0.357	0.307
as a fraction of AVG CLIMATE SCEANARIOS	0.312	0.206	0.477	0.531	0.339
Following data is based on total diversions in Bow and Oldman Rivers for 1976-2004: SOURCE: Alberta Irrigation Districts Annual Irrigation Diversions: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr8782					
Average Diversion 1976-2004 (MCM)		**1309**	**1146**		
1996 as a fraction of average 1976-2004 diversions		1.03	1.22		
1996 as a fraction of License		77%	66%		
Annual growth in diversions 1976-2004		0.10%	1.12%		
percent return flow 1976-2002		36%	17%		

Assessing Vulnerabilities



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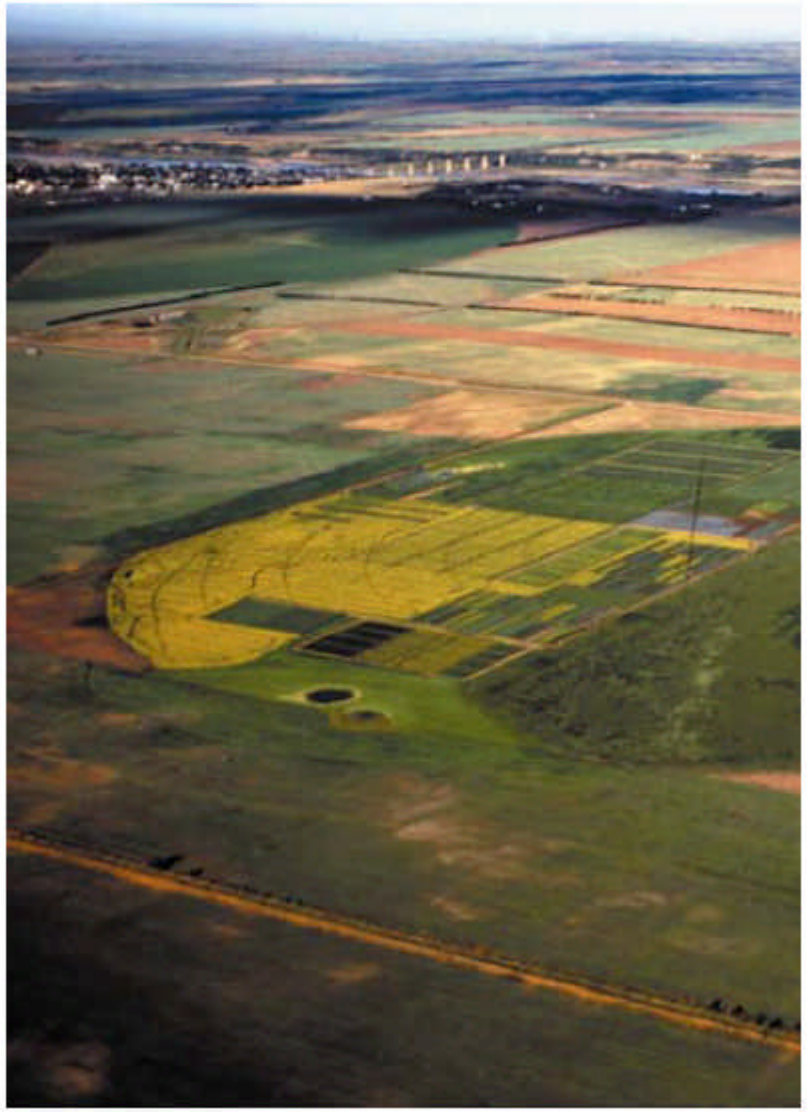
Climate Change and Water in the Prairies Conference

June 21-23, 2006
Saskatoon

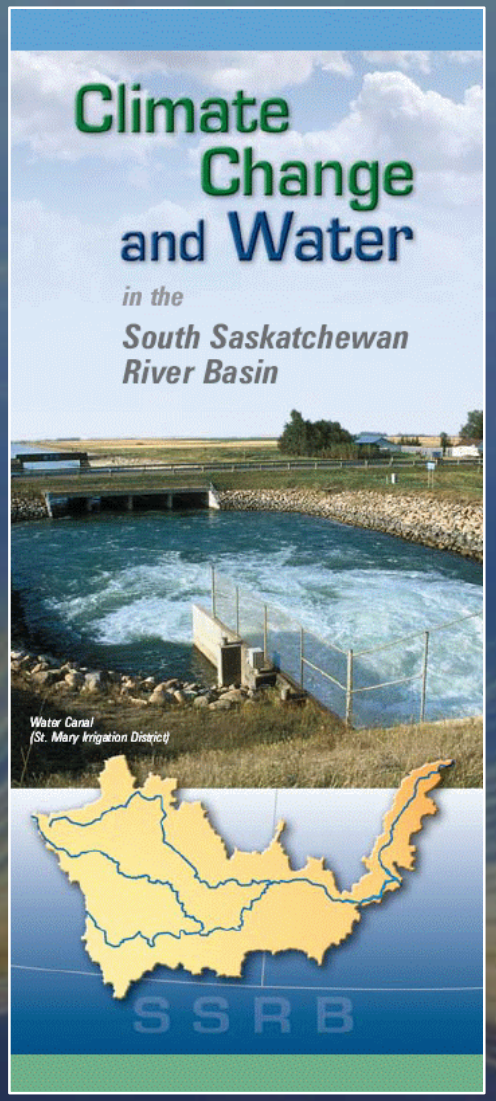
(http:/saskriverbasin.ca/)



Thank you

Partners

- Agriculture and Agri-Food Canada (AAFC-PFRA)
- Alberta Agriculture, Food and Rural Development (AAFRD)
- Alberta Environment
- Centre for Rural Studies and Enrichment
- Climate Change Impacts and Adaptation Program (CCIAP)
- Environment Canada
  - National Water Research Institute (NWRI)
  - Water Policy and Coordination Directorate
- Prairie Adaptation Research Collaborative (PARC)
- Prairie Provinces Water Board (PPWB)
- Saskatchewan Research Council
- Saskatchewan Watershed Authority
- University of Alberta
- University of Calgary
- University of Lethbridge
- University of Regina
- University of Saskatchewan
- Partners for the Saskatchewan River Basin



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