

Long-term water level changes in closed-basin lakes of the Canadian prairies and the role of groundwater

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Little Fish Lake, AB, May 2005

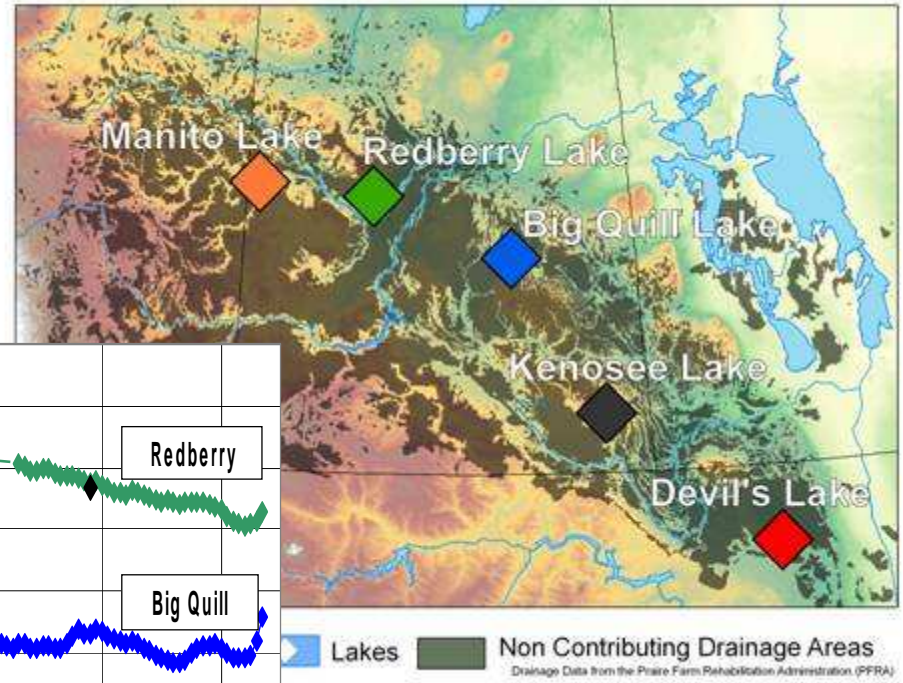
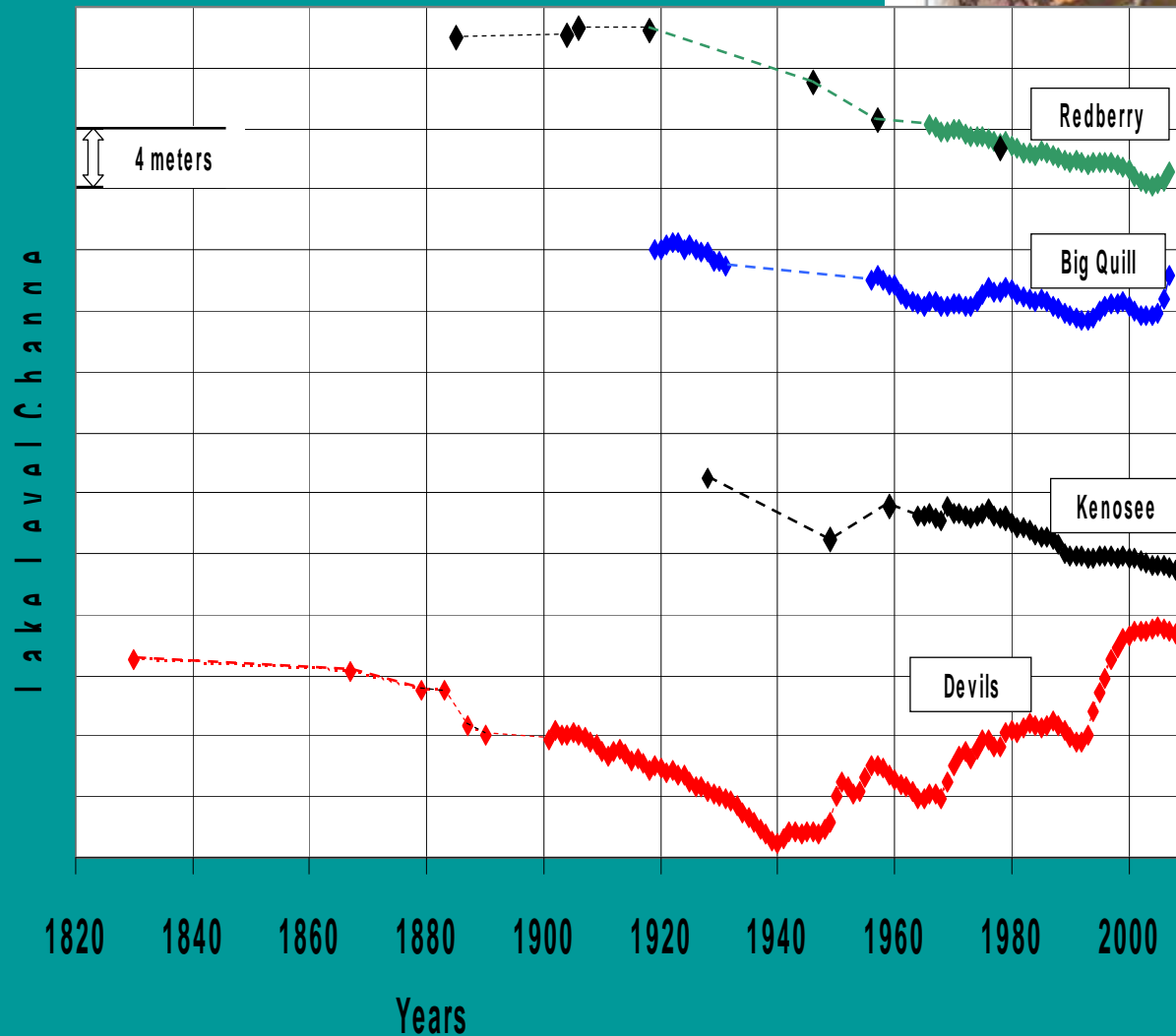


Environment
Canada

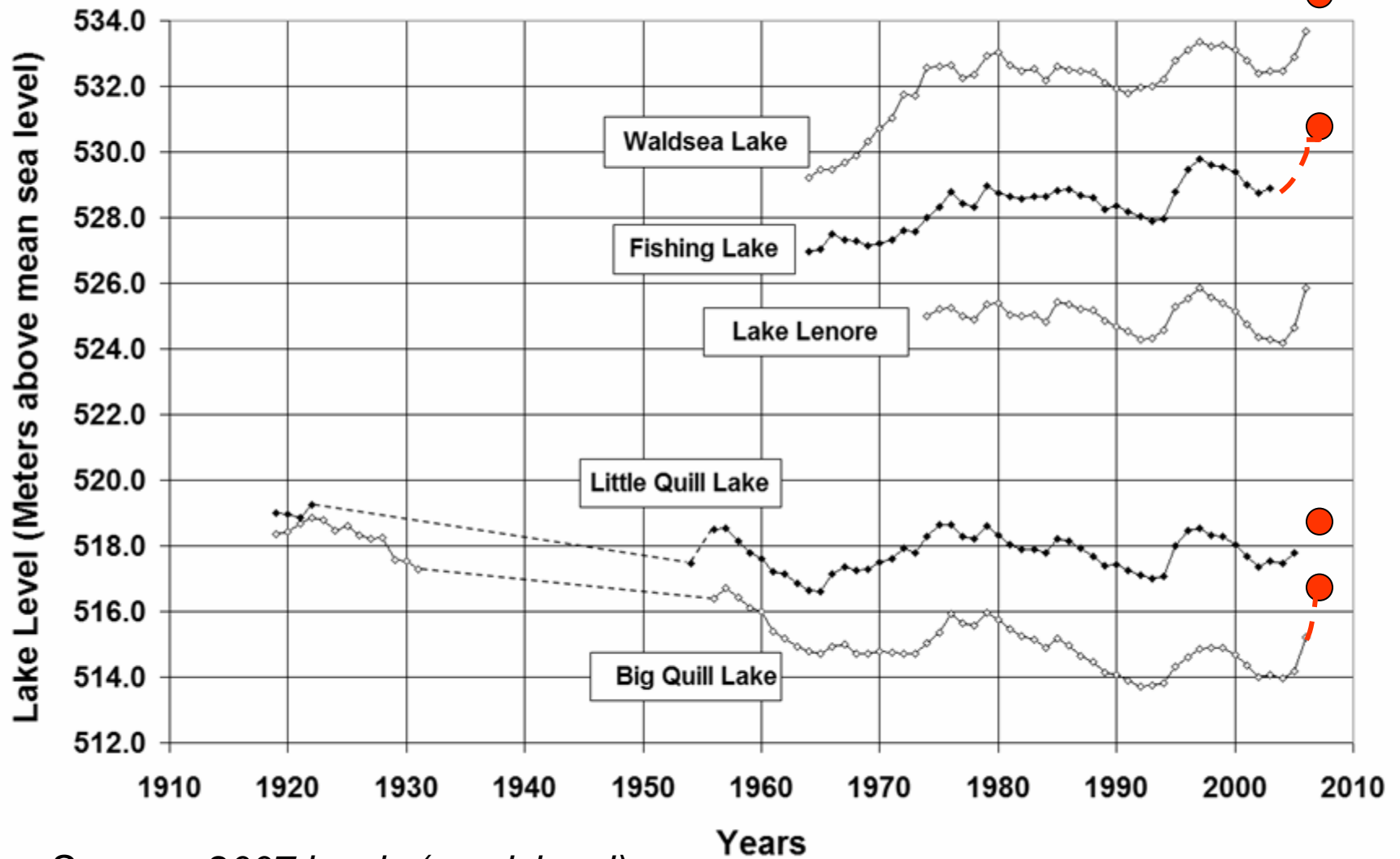
Environnement
Canada

Prairie lakes 1820 – 2004:

The water levels in Canadian prairie lakes have been falling while nearby Devil's Lake (ND) is rising since 1940:



Five lakes in eastern SK

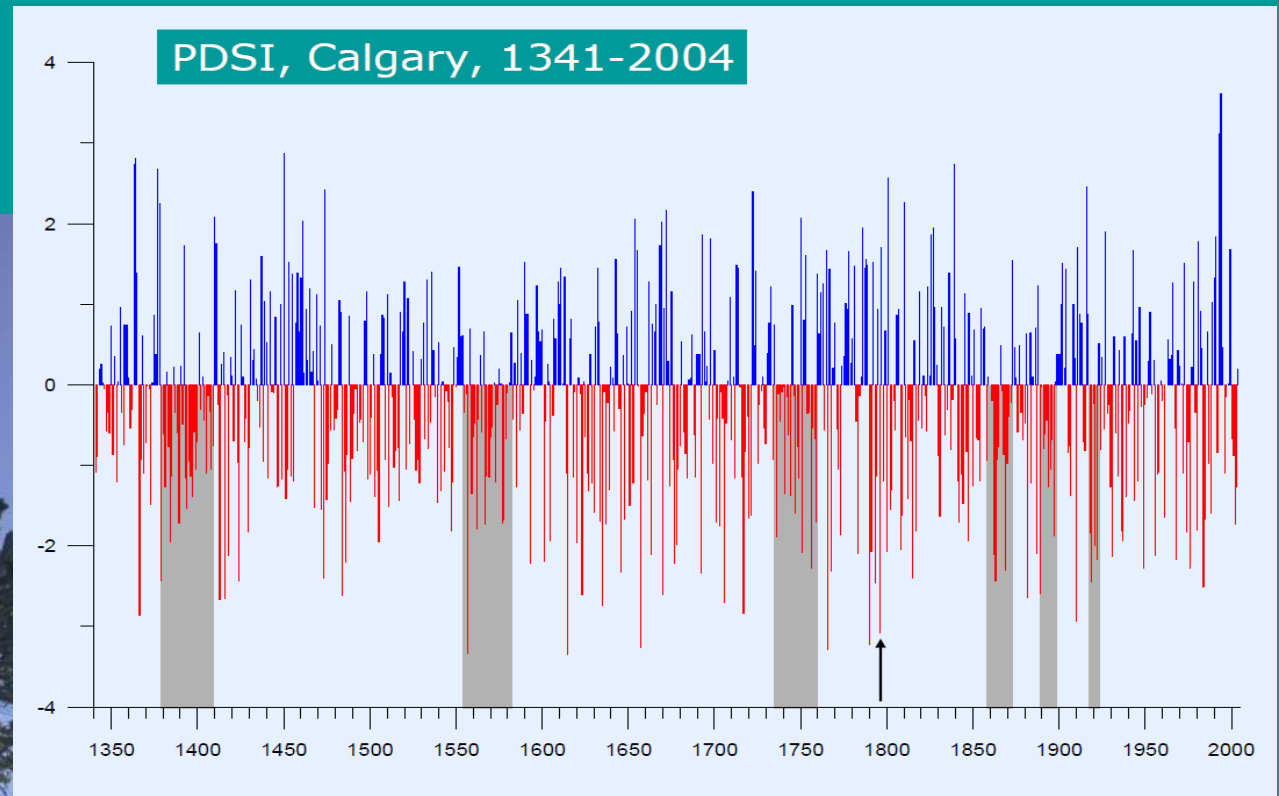
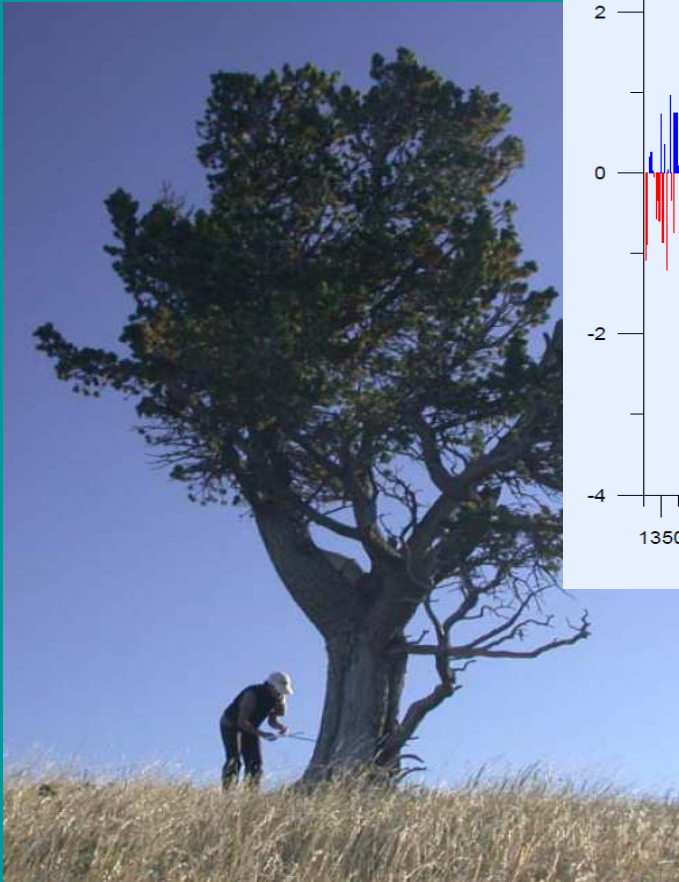


● Summer 2007 levels (provisional)

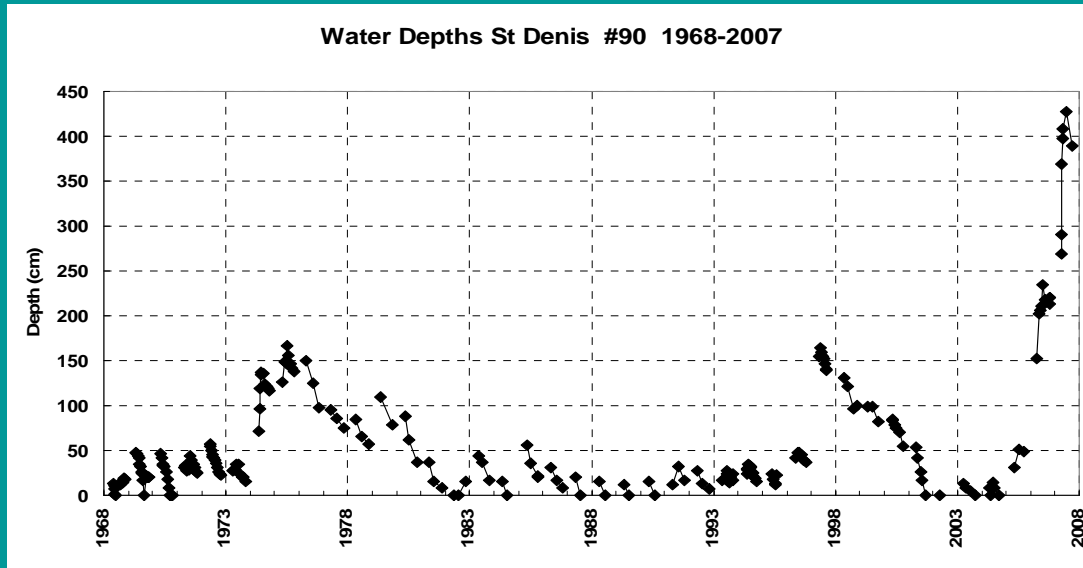
Flooding at Fishing Lake SK, summer 2007



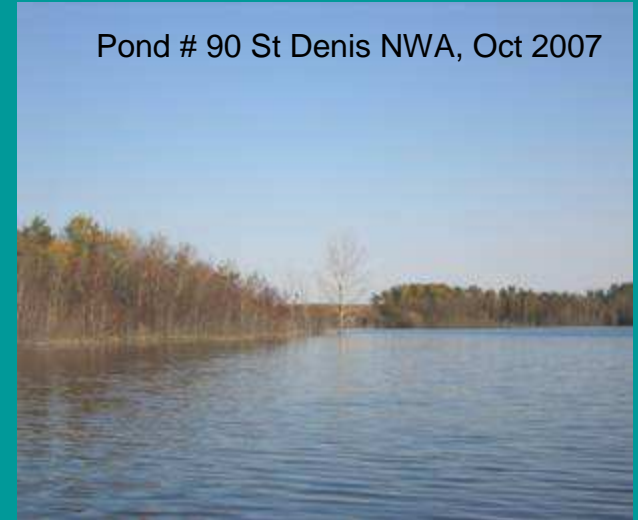
Long-term fluctuations of prairie climate based on tree-rings 1350-2000 (Sauchyn et al)



Wetlands, land-use change and climate variability 1968-2007

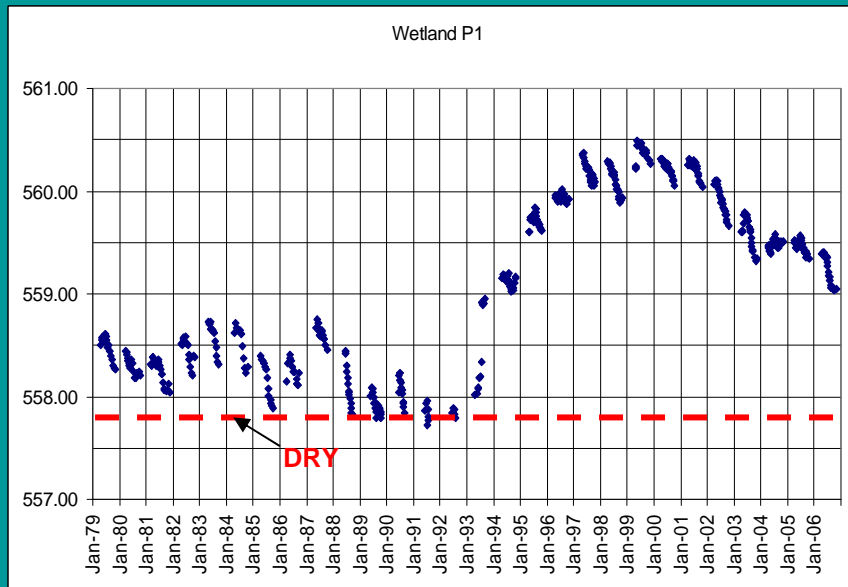


Pond # 90 St Denis NWA, Oct 2007

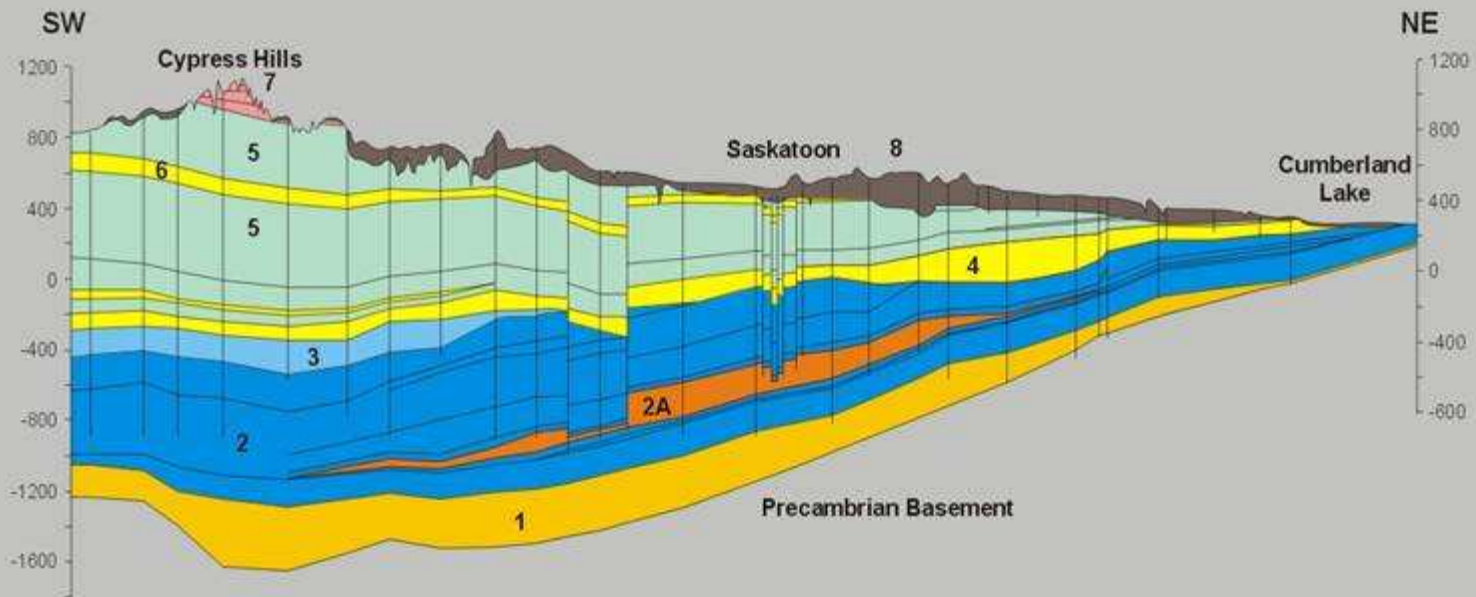


St Denis
NWA

North Dakota
[USGS]



The USGS Cottonwood County wetland research site, near Devils Lake. There has been no land-use change at this site. Change to wet conditions in 1993.



- | | | | |
|-----------|--|----------|--------------------------------------|
| 1 | Basal Clastic Aquifer | 5 | Cretaceous Aquitard |
| 2 | Carbonate - evaporite
Aquifer/Aquitard Unit | 6 | Judith River Fm. Aquifer |
| 2A | Prairie Evaporite | 7 | Eastend to Ravenscrag
Fm. Aquifer |
| 3 | Triassic - Jurassic
Aquifer/Aquitard Unit | 8 | Quaternary Aquifer and
Aquitard |
| 4 | Mannville Group | | |

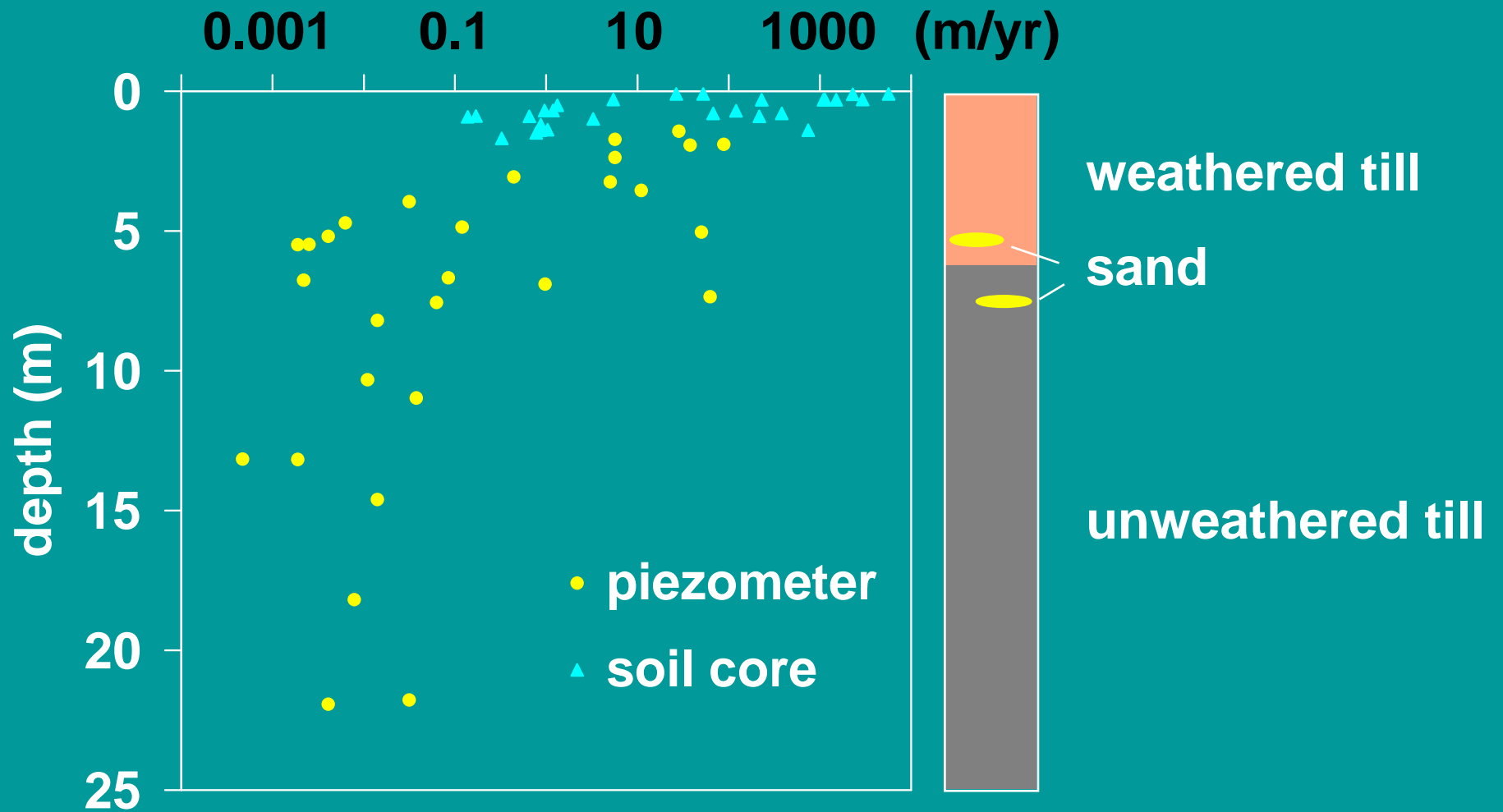
Principal hydrogeological units of southern Saskatchewan (cross section after Meneley, 1972)

Clay-rich glacial till
plus sand/gravel aquifers



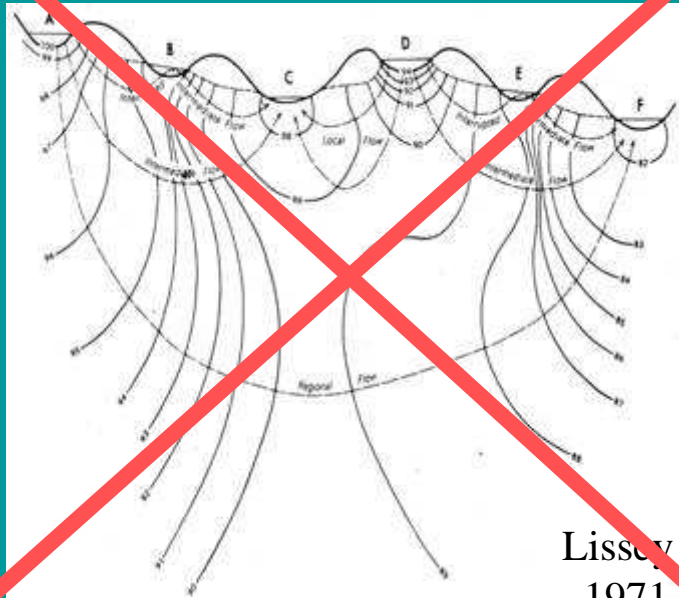
Hydraulic Conductivity (K) of Glacial Till

St. Denis National Wildlife Area, Saskatchewan



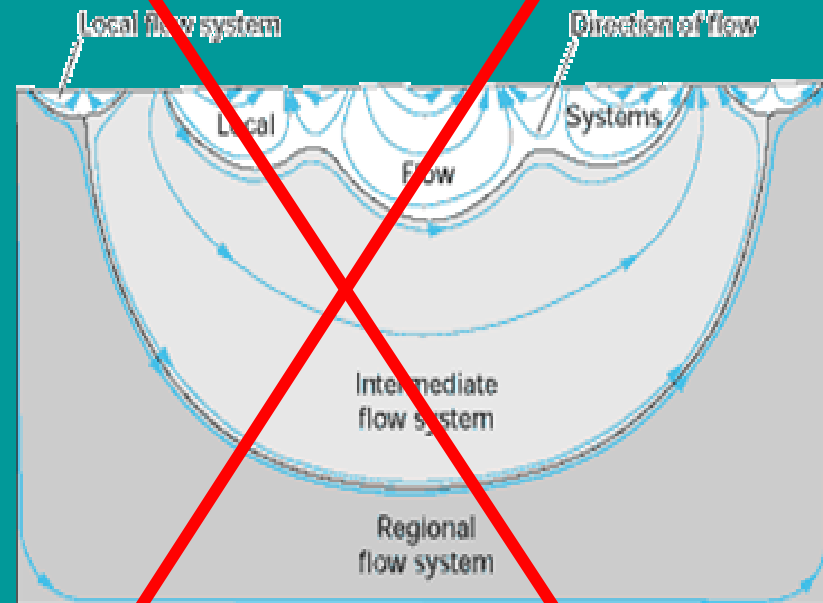
Original data: *J. Hydrol.* 207:42; *Hydrol. Process.* 18:2011

Lissey, 1971



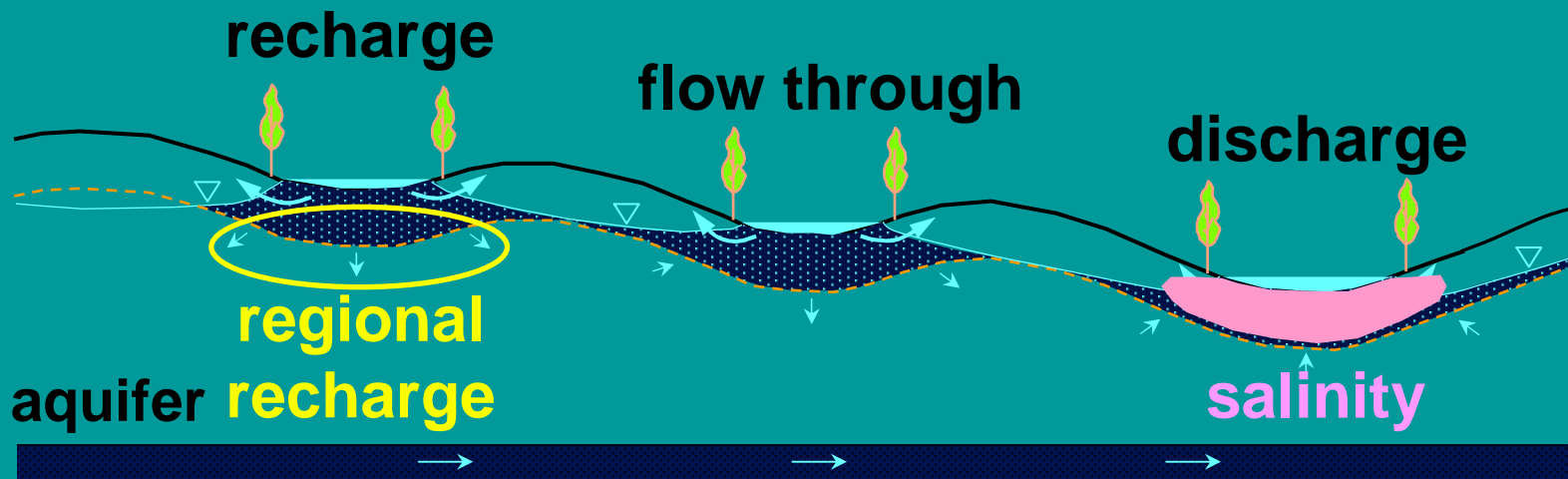
Lissey, 1971

Toth, 1963



Revised Model of Wetland Complex

(van der Kamp & Hayashi, 2009. *Hydrogeology Journal*. 17: 203-214)



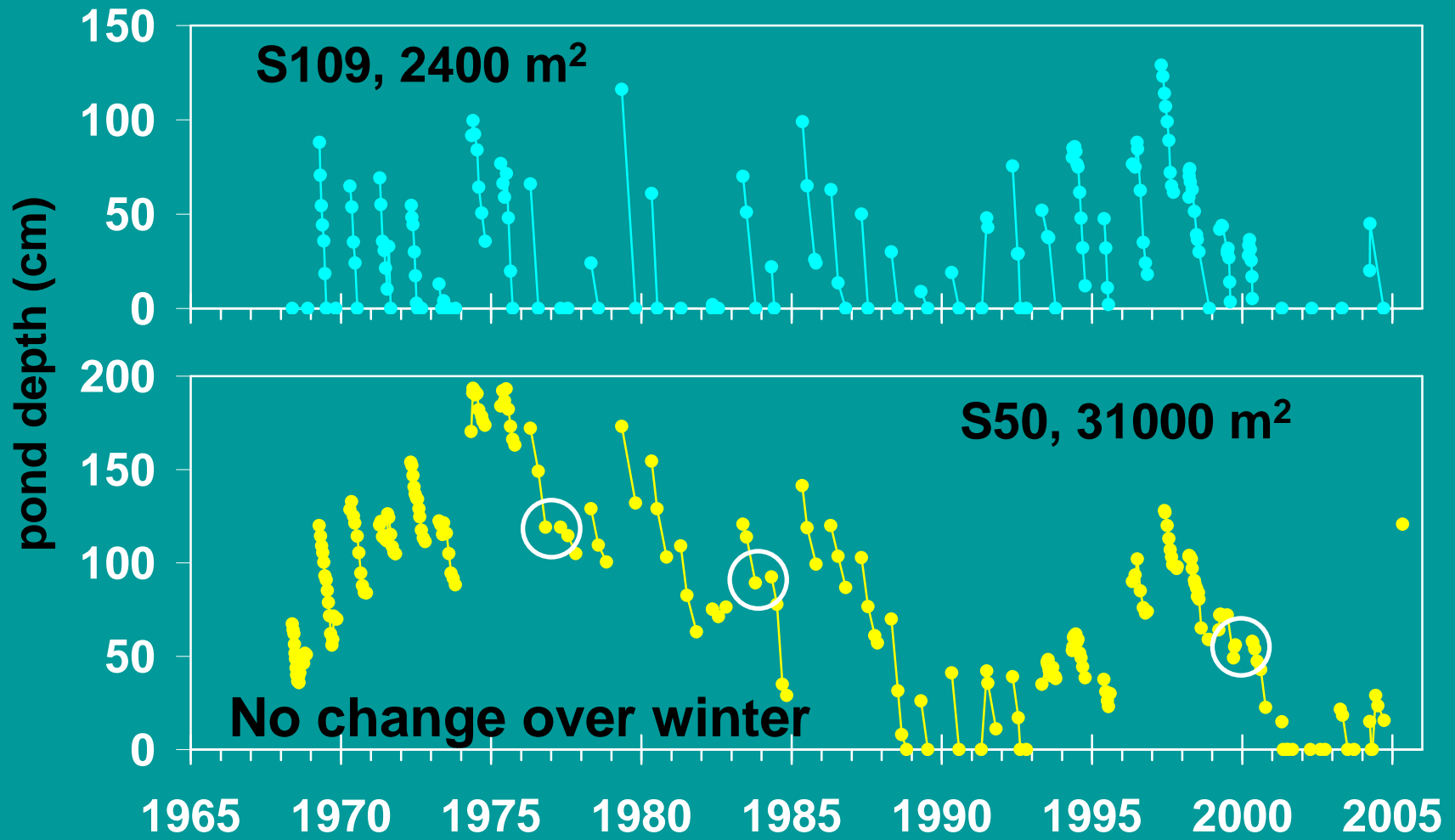
Shallow groundwater exchange with riparian zone.

Deeper flow in low-permeability till is very small.

Inter-till aquifer may provide connection.

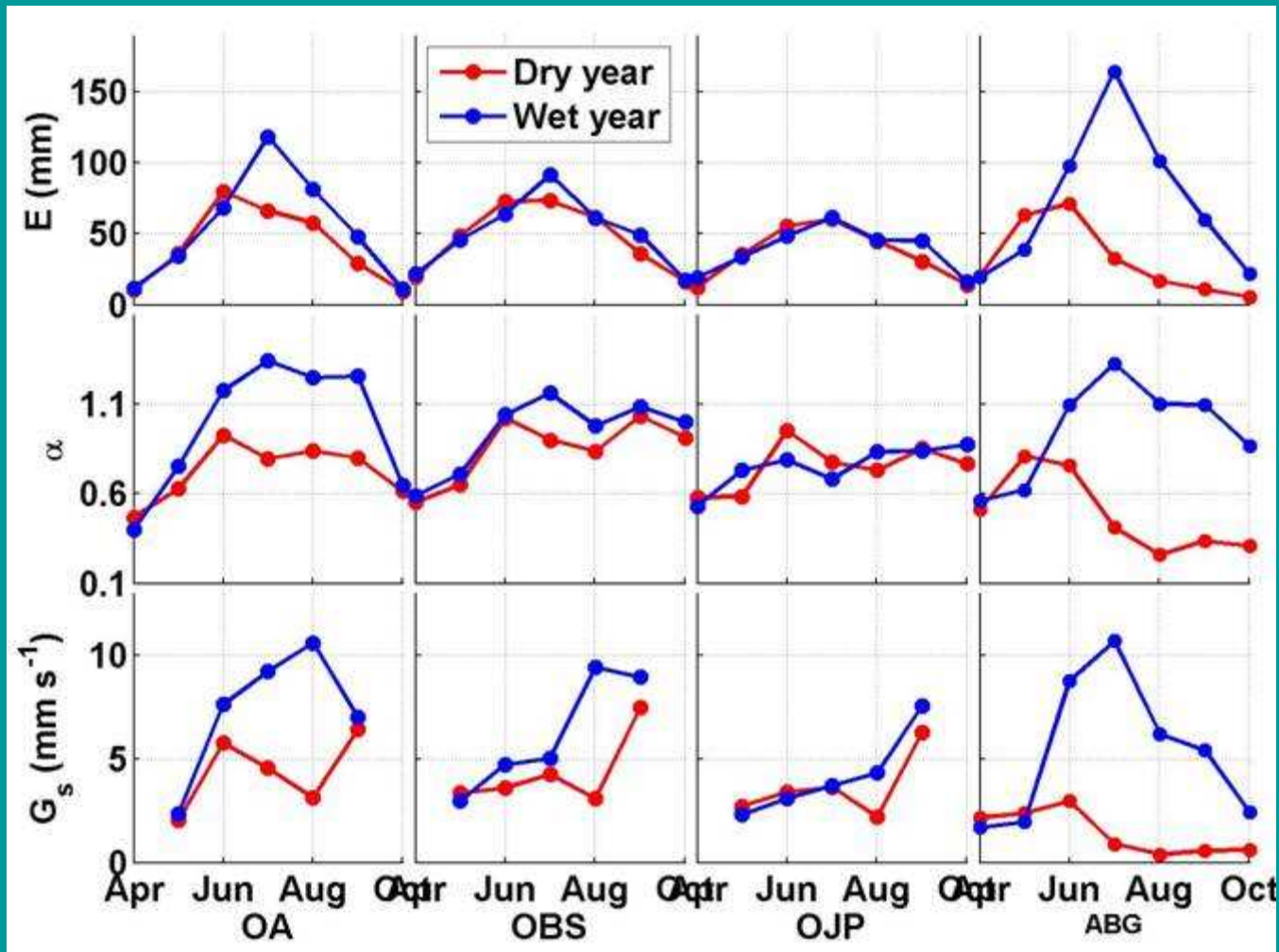
Salts accumulate under discharge wetland.

Water Depth in St. Denis Wetlands



Saskatchewan BERMS Forest flux sites (Old Aspen – OA, Old Black Spruce - OBS and Old Jack Pine – OJP) compared with Alberta Grassland site (ABG):

Comparison of Monthly E , α and G_s Between Dry year (2003 for SK Sites, 2001 for ABG) And Wet Year 2005 [Zhan et al. in prep]

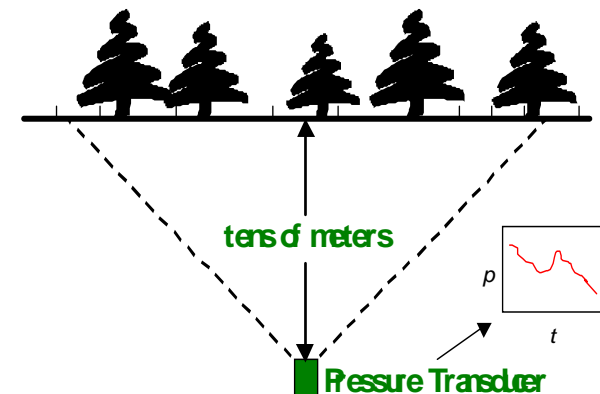


Overview of the Weighing Lysimeter Instrumentation

► Fundamentals

- Change of mechanical surface loading is instantaneously transmitted to deep saturated formations resulting in change of pore water pressure;
- Piezometers in saturated formations can therefore detect pore pressure changes due to hydrological processes such as:
 - ✓ Snow accumulation;
 - ✓ Rainfall;
 - ✓ Evapotranspiration

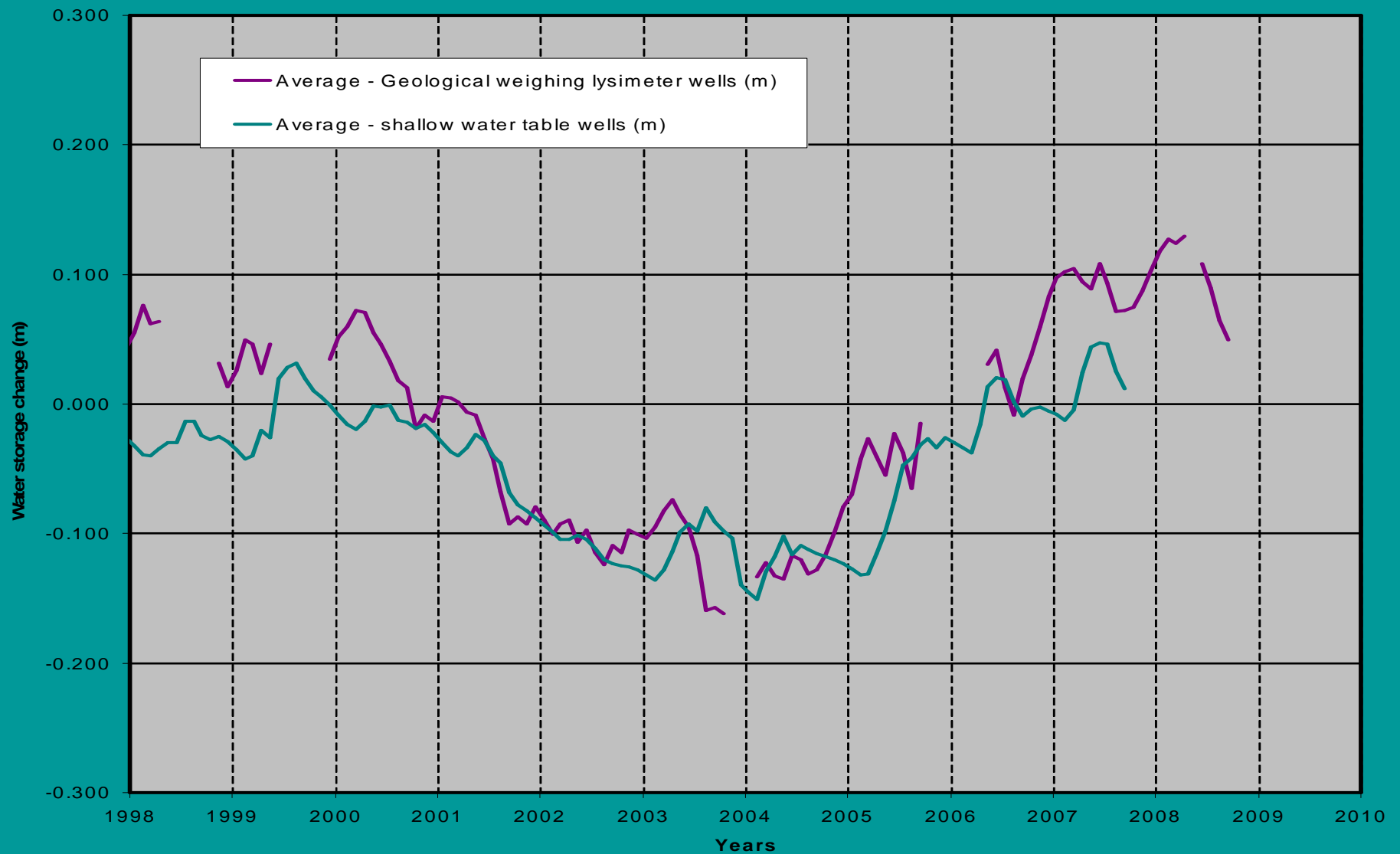
Conceptual Sketch of Piezometric Weighing Lysimeter Installation



Van der Kamp et al, 2003

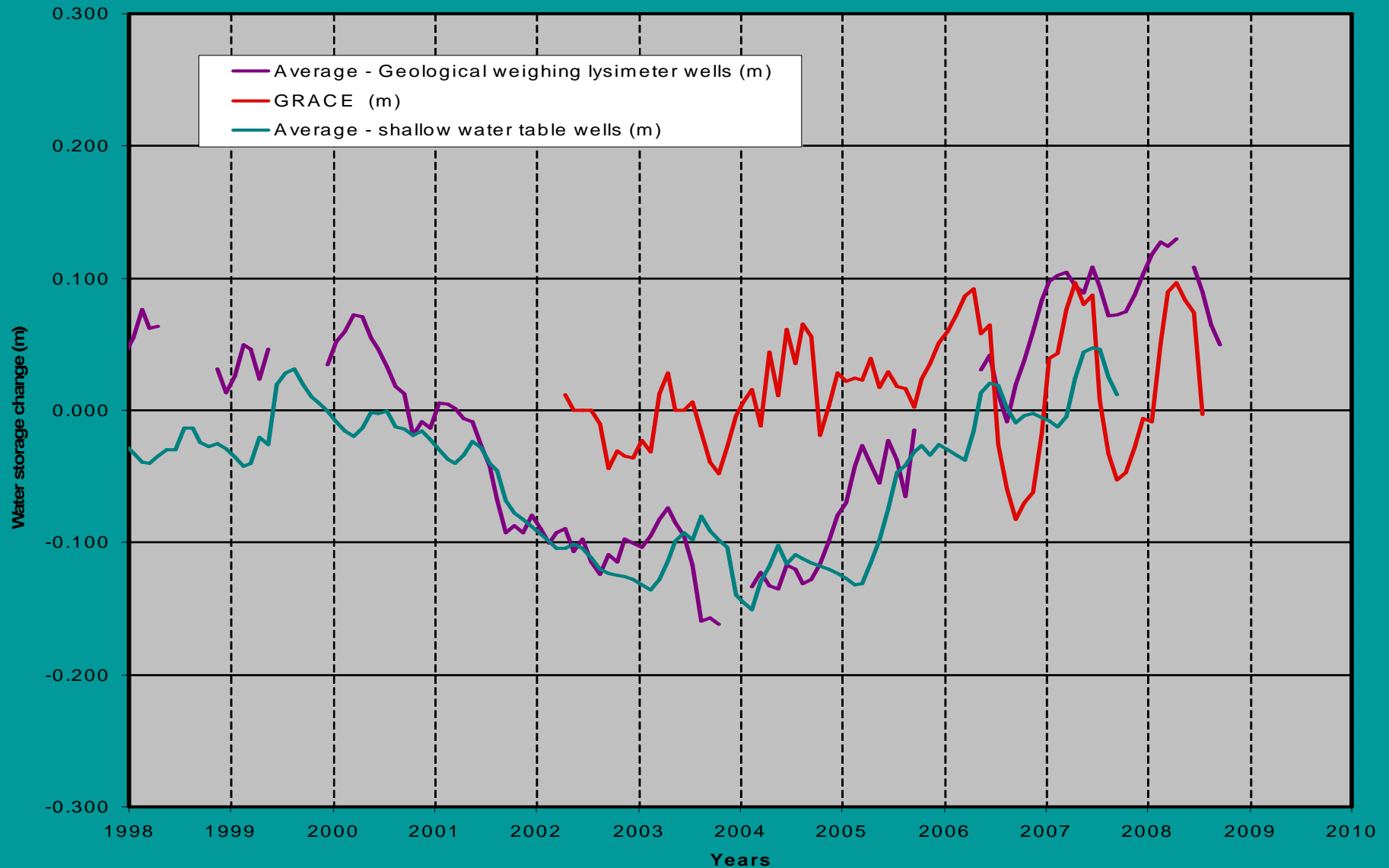
Regional water storage changes in southern Saskatchewan:

- Average of 4 Geological Weighing Lysimeter wells,
- Average of 9 water table wells, multiplied by 0.3 for specific yield.

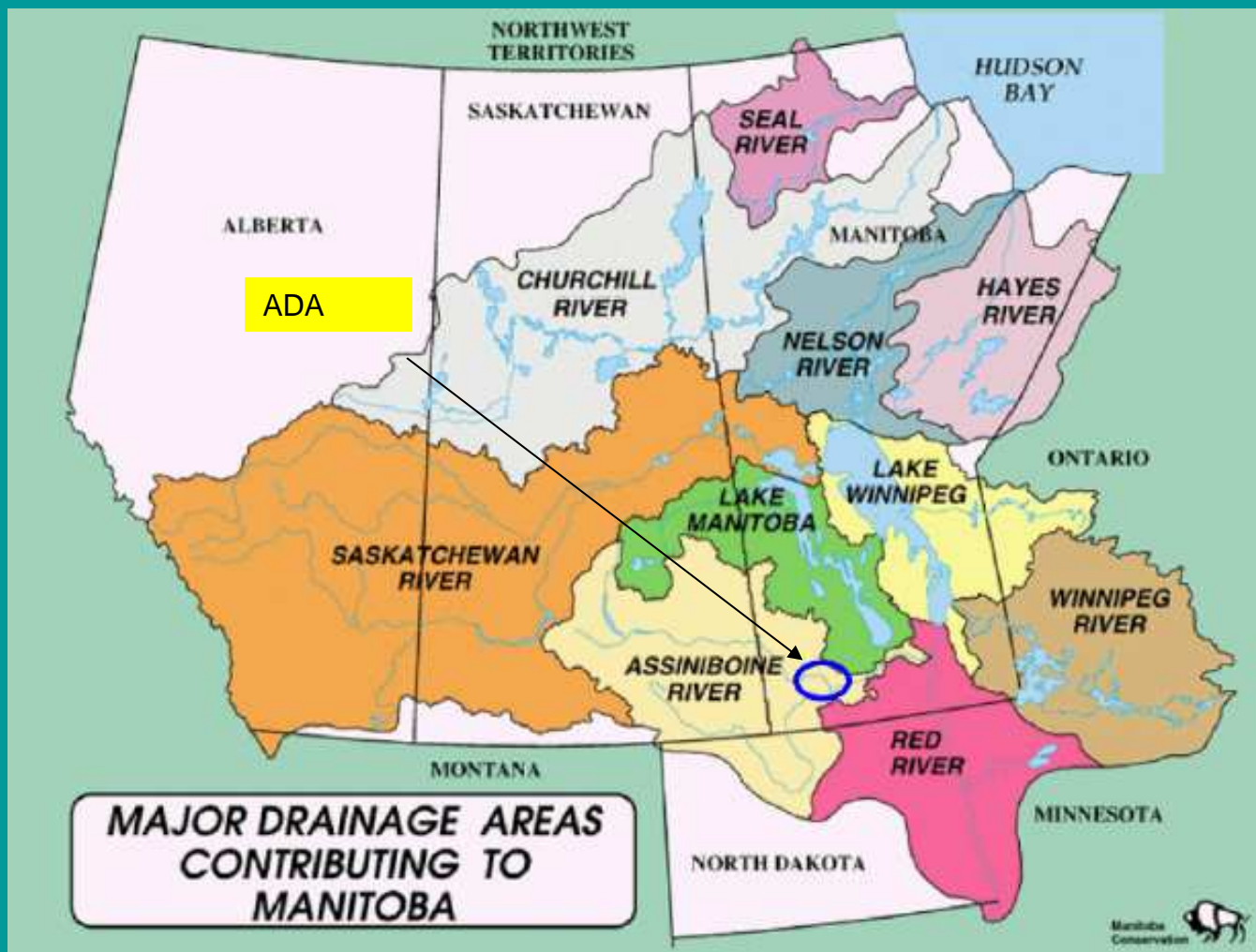


Regional water storage changes in southern Saskatchewan:

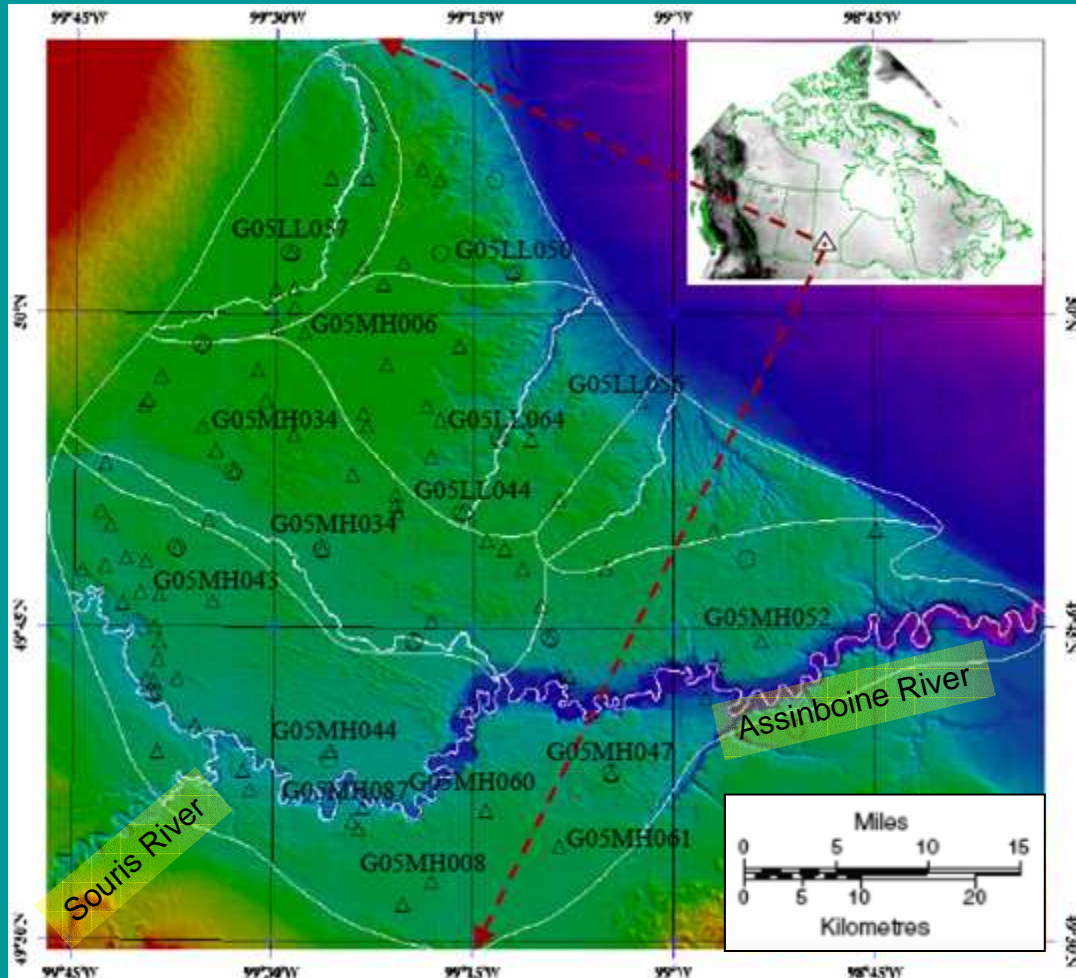
- GRACE for southern Saskatchewan [provided by Yirdaw and Snelgrove]
- Average of Geological Weighing Lysimeter wells
- Average of water table wells



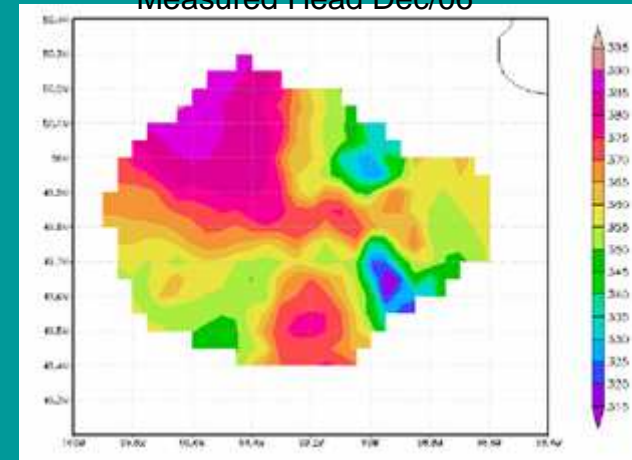
Assiniboine Delta Aquifer (ADA)



ADA Data



Measured Head Dec/06

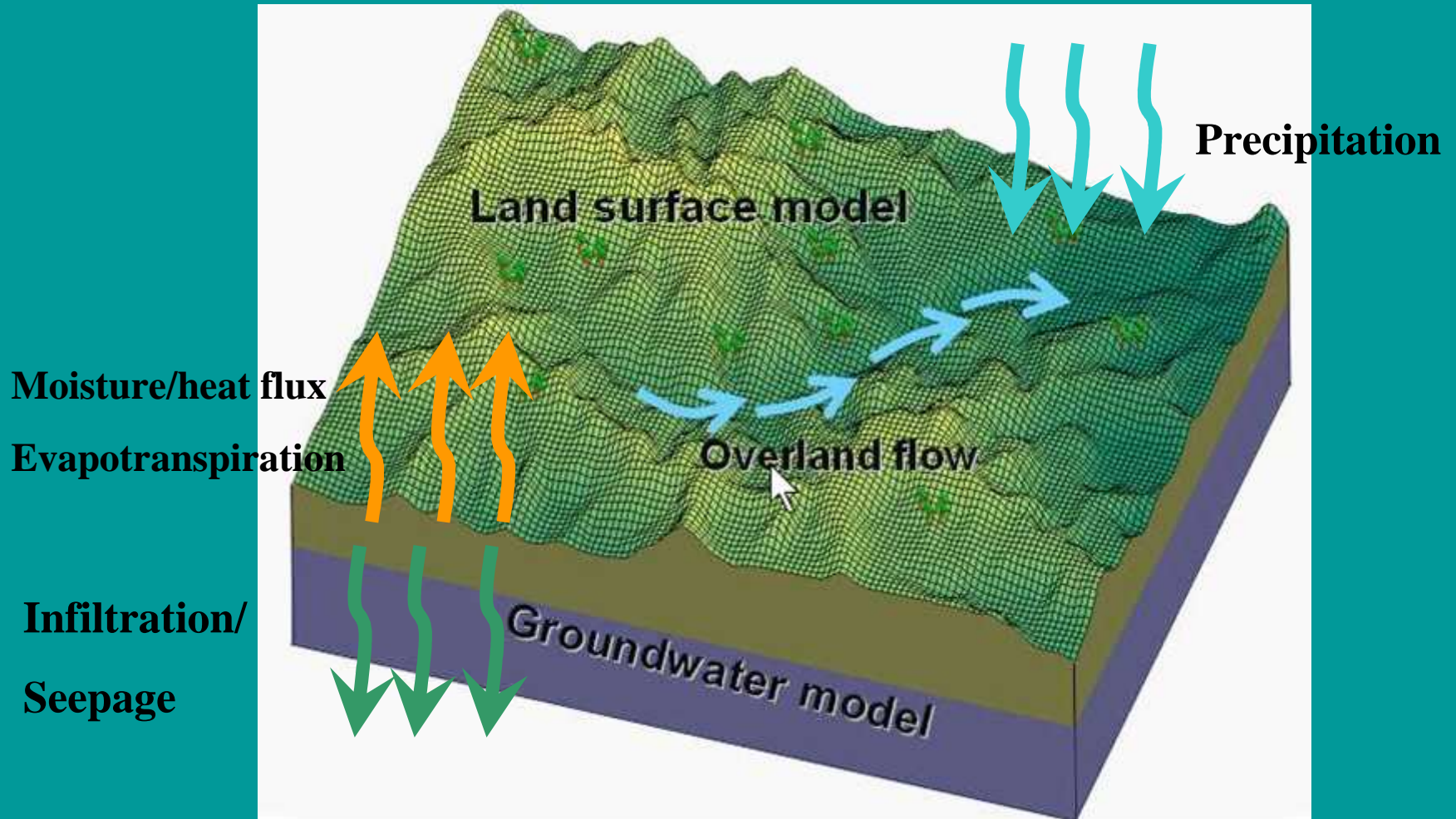


Example of Interpolated Groundwater Head

△ - observation wells
○ - rain gauges

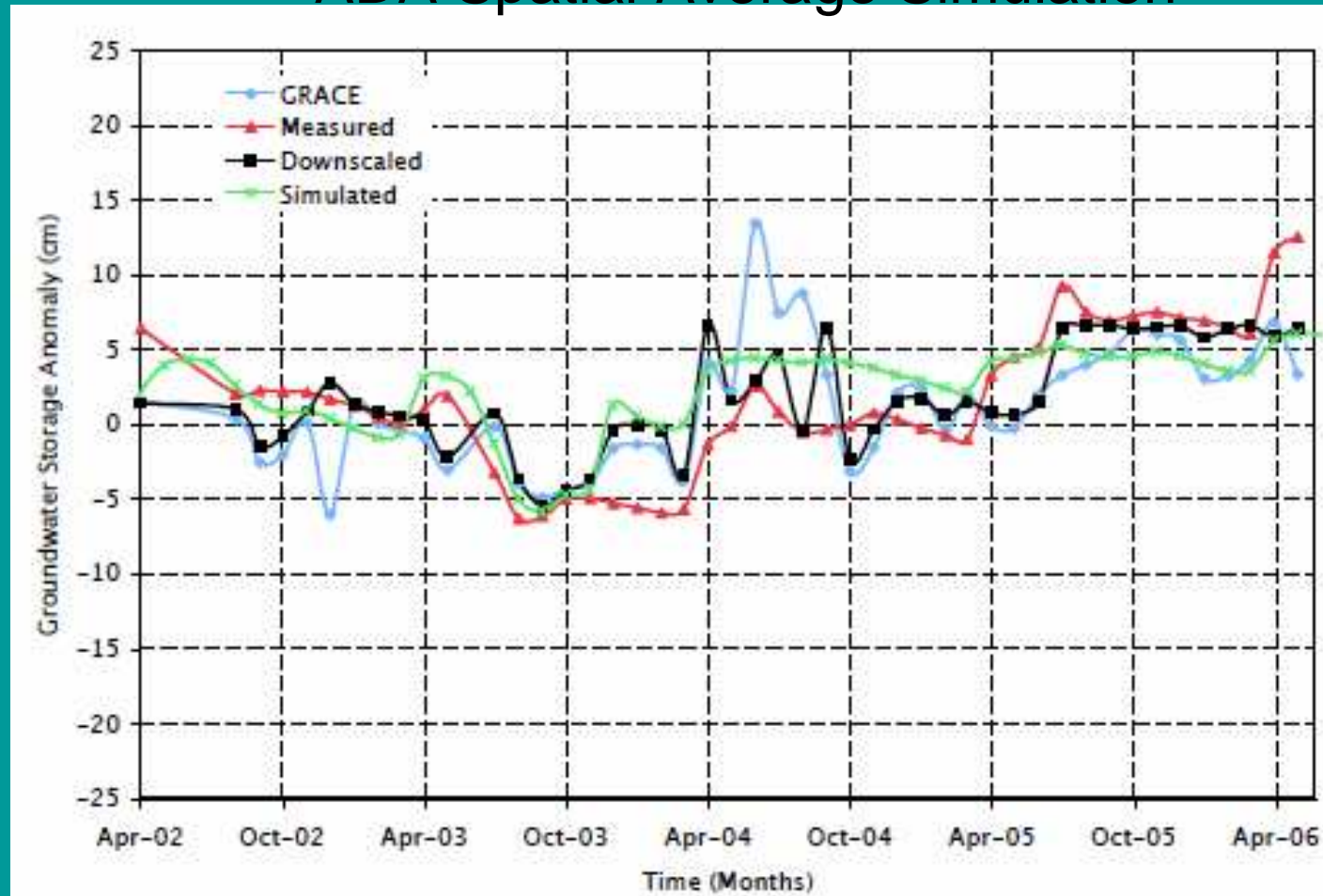
Area \approx 4000 km²

ParFlow-CLM Modelling



Modelling Results

ADA Spatial Average Simulation



Infiltration Capacity of the Top Soil

Measured by single-ring infiltrometers

Average, standard deviation, and # of samples

	Grassed			Cultivated		
	Avg.	SD	#	Avg	SD	#
Unfrozen	300	390	11	23	13	15
Frozen	19	36	6	0.3	0.6	3

unit : mm/hour