

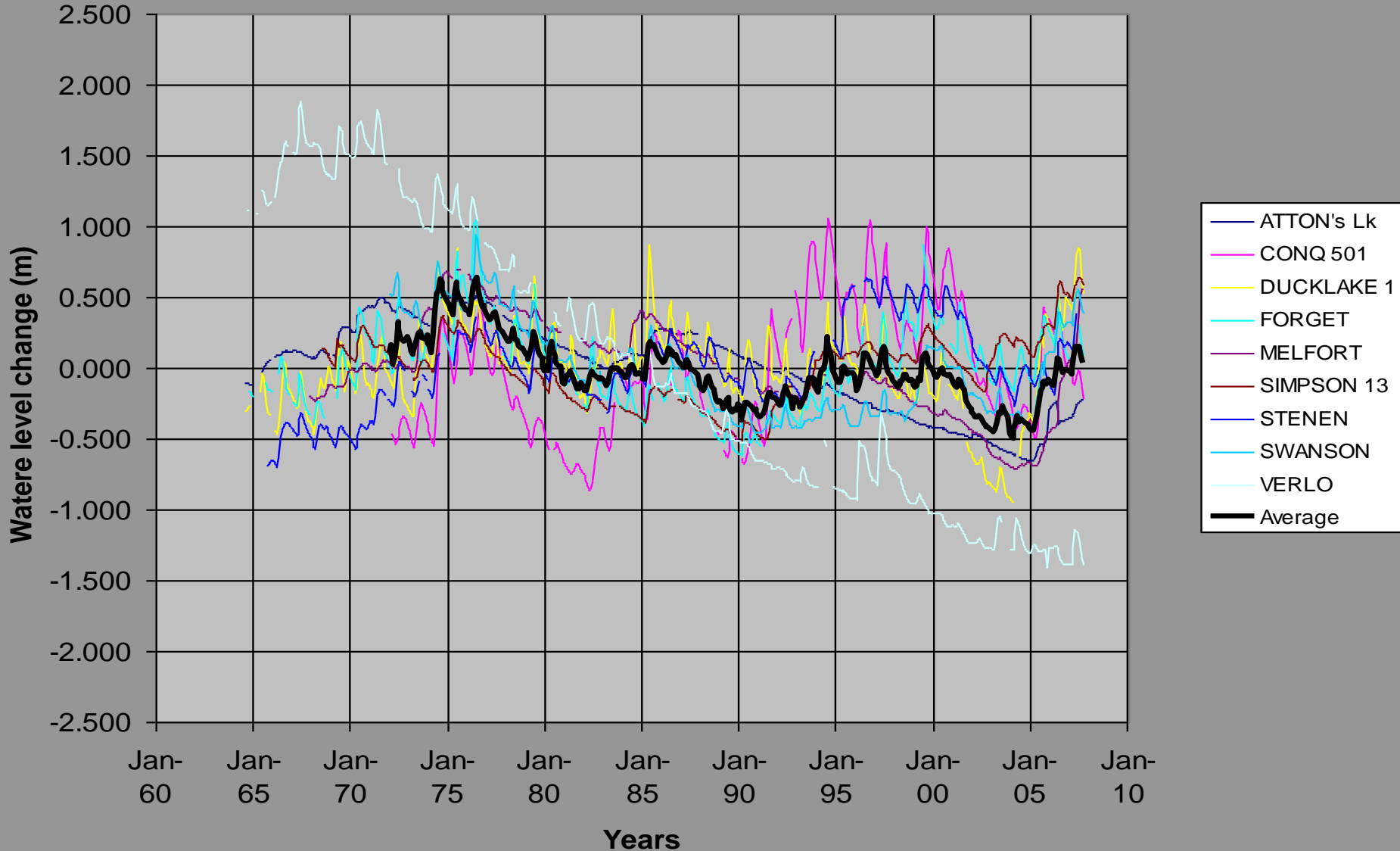
Characterizing drought: groundwater, wetlands and lakes
(also Fluxnet Canada measurements of water and energy fluxes)
Garth van der Kamp and many others



**Alan Barr, Masaki Hayashi,
Harm Maathuis, Randy
Schmidt, Saul Marin, Oliver
Sonnentag, Tianshan Zha,
Clement Agboma,**

Shallow observation wells in SK – water level changes 1964-2007

Water-table drawdown during the 2001-2003 drought averaged about 0.5 m, corresponding to ~ 150 mm groundwater storage depletion

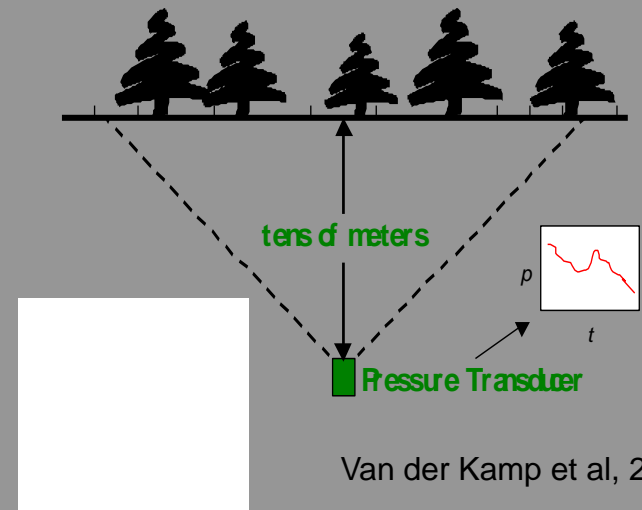


Overview of the Geological Weighing Lysimeter Instrumentation

► Fundamentals

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

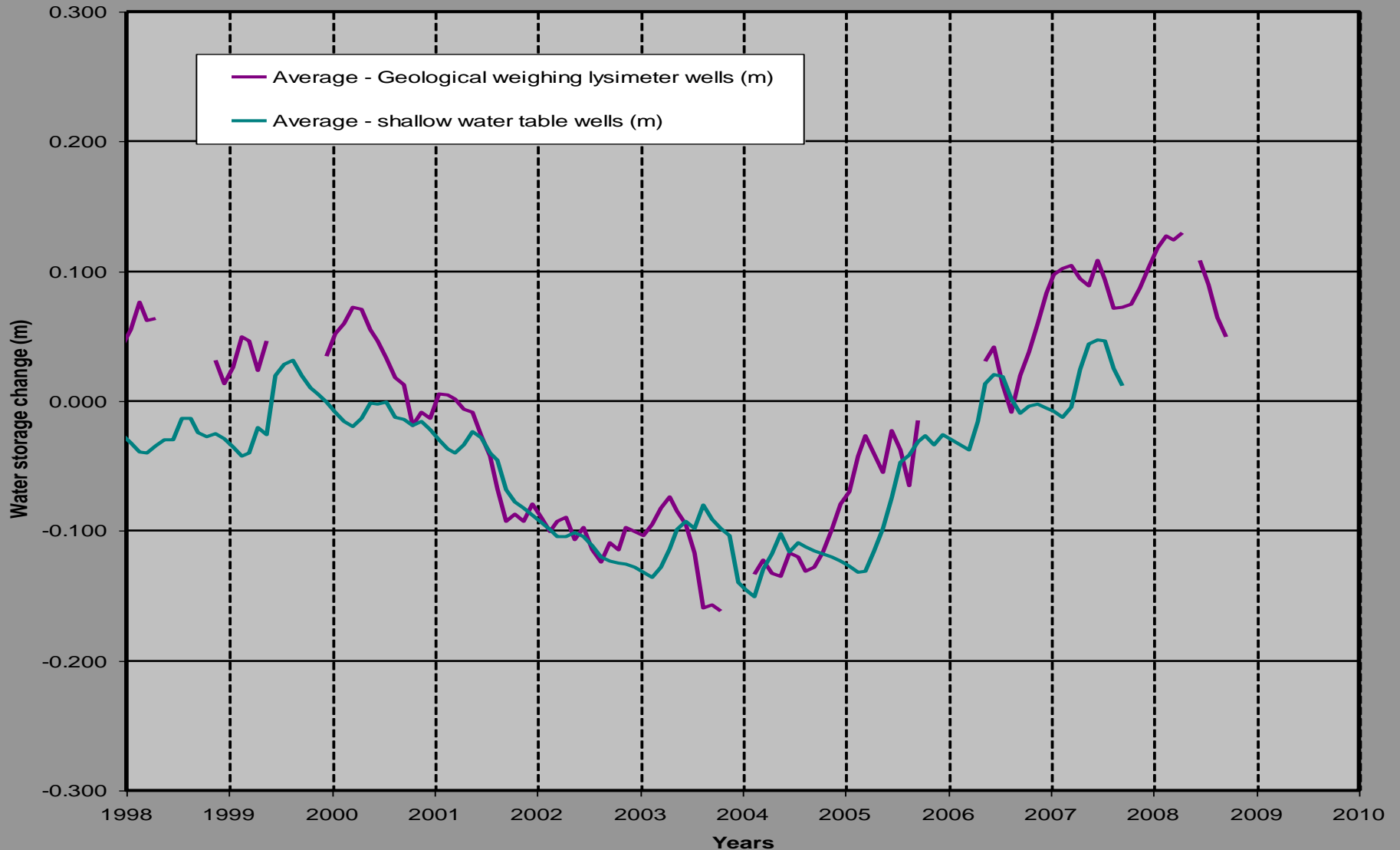
Conceptual Sketch of Geological Weighing Lysimeter Installation



Van der Kamp et al, 2003

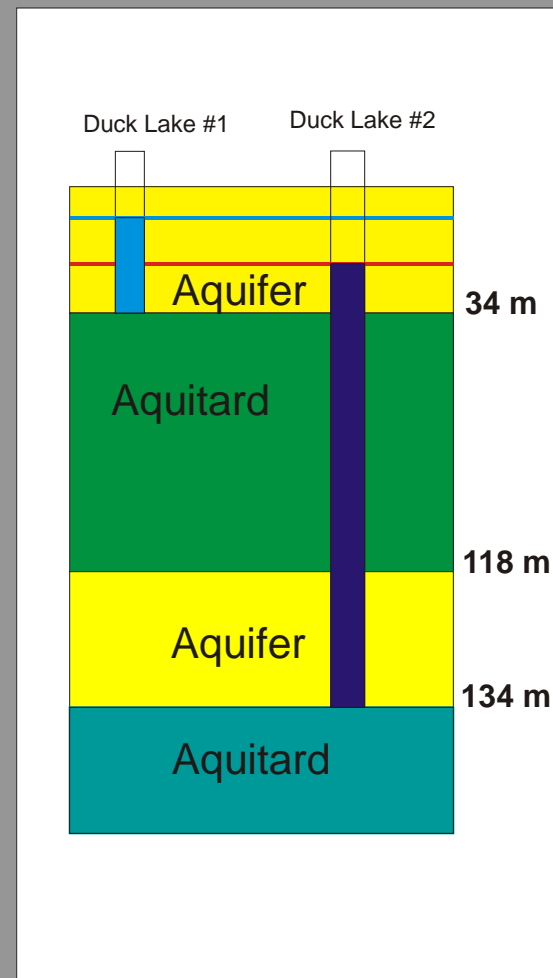
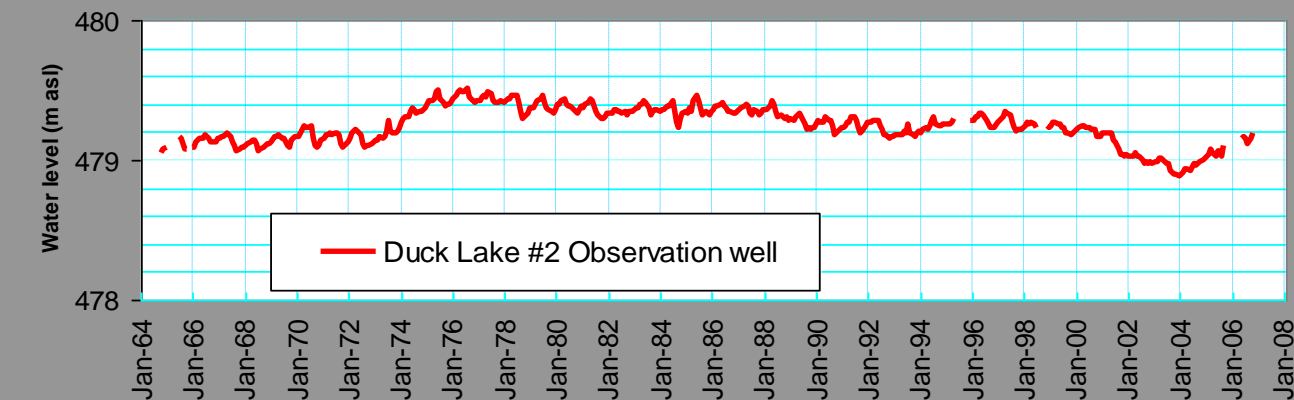
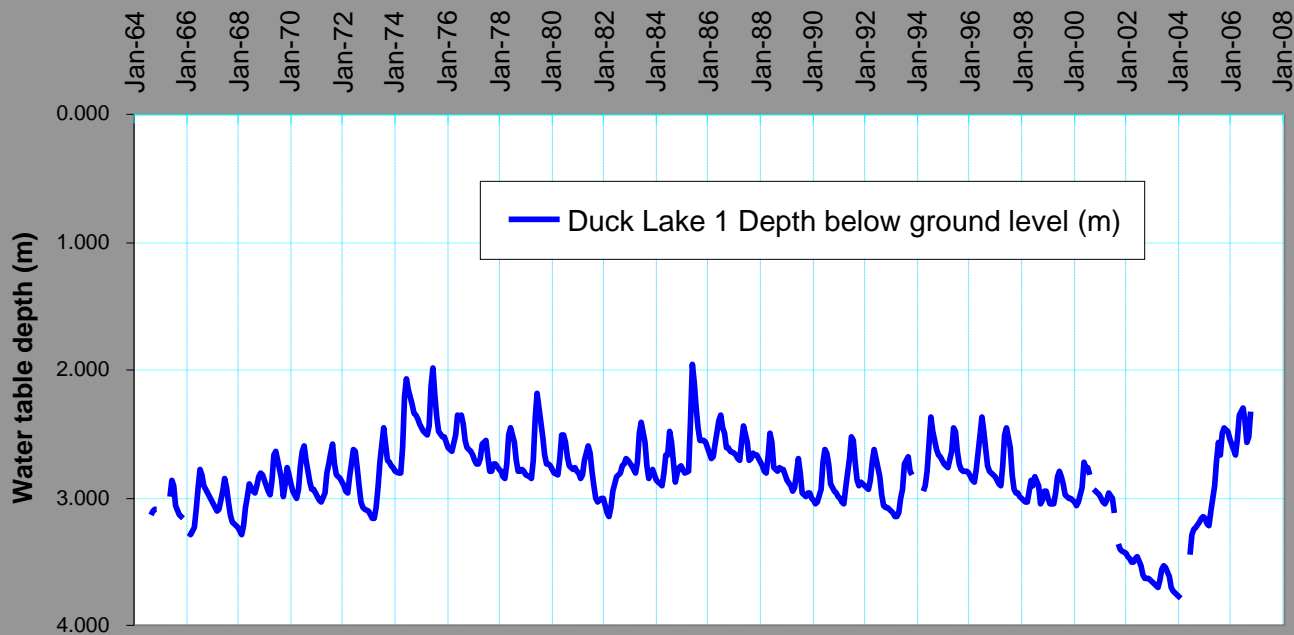
Regional water storage changes in southern Saskatchewan, 1998 - 2008:

- Average of 4 Geological Weighing Lysimeter wells,
- Average of 9 water table wells in sand aquifers (assuming specific yield = 0.30).

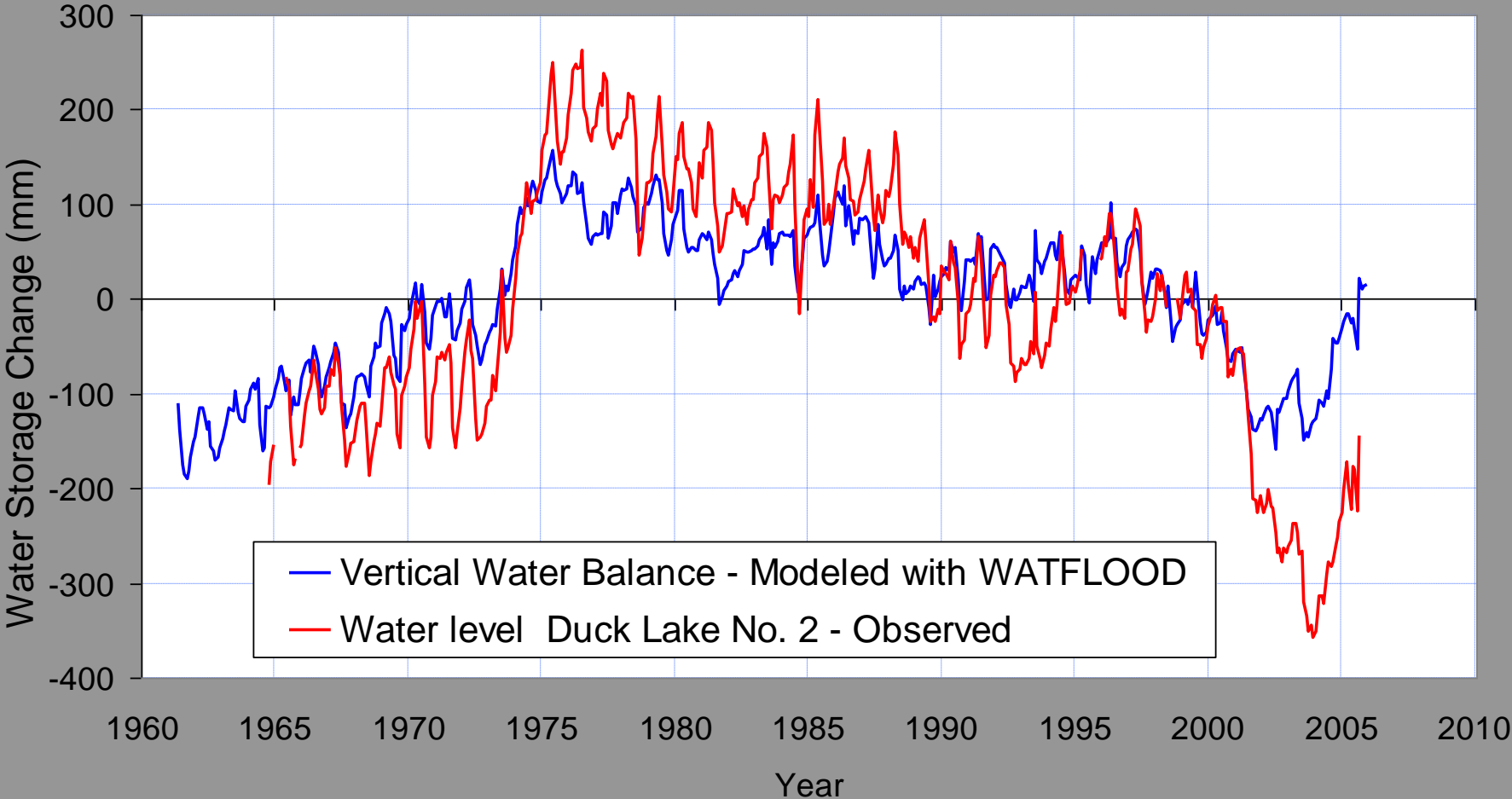


Duck Lake SK Observation wells: water levels, 1964-2006

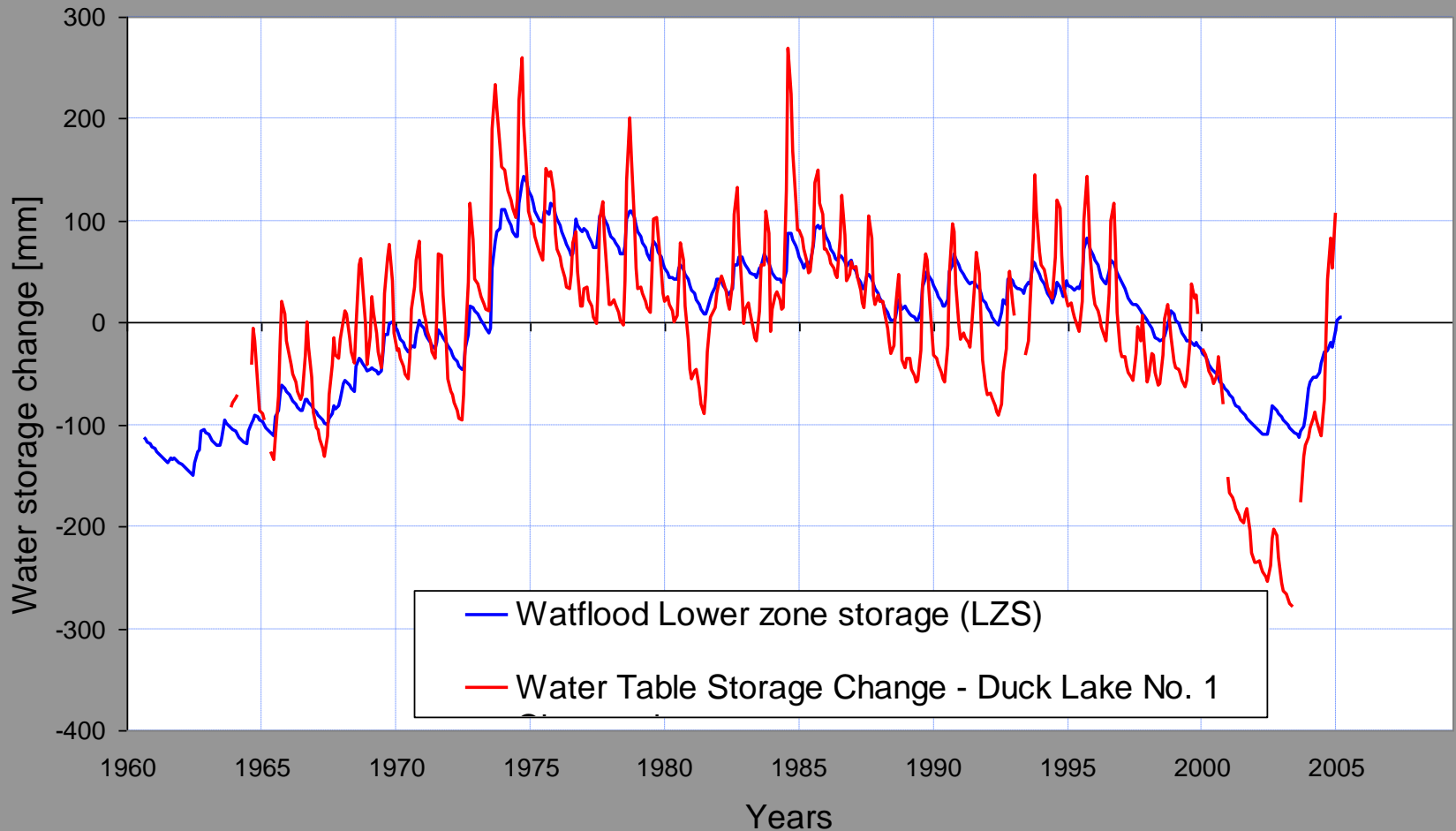
[Source: SK Watershed Authority, www.swa.ca]



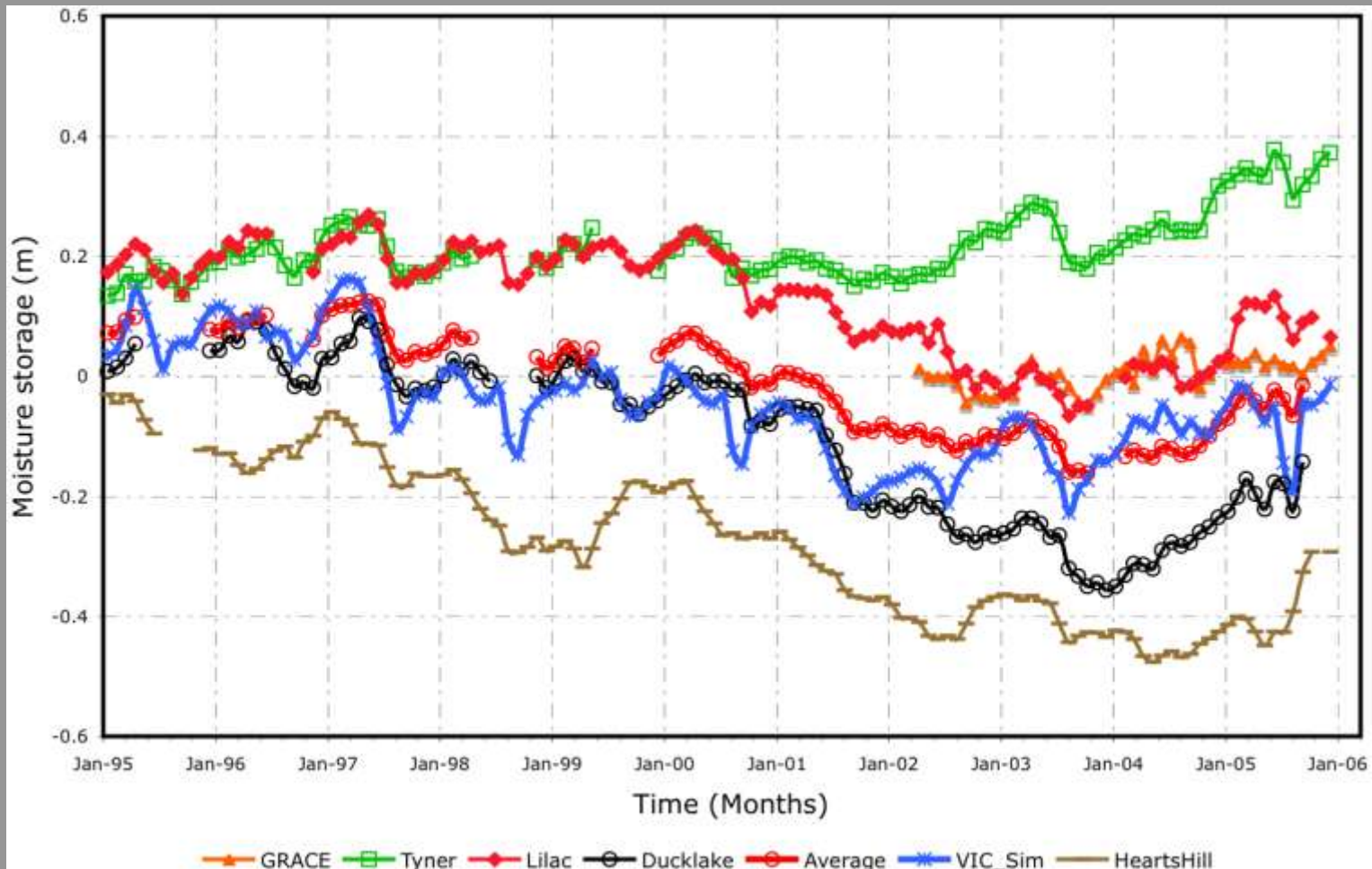
Comparison of Duck Lake No. 2 (geological weighing lysimeter) water level record with Watflood simulation of the vertical water balance



Comparison of Duck Lake No. 1 (water table storage change) with Watflood simulation of the changes of groundwater storage



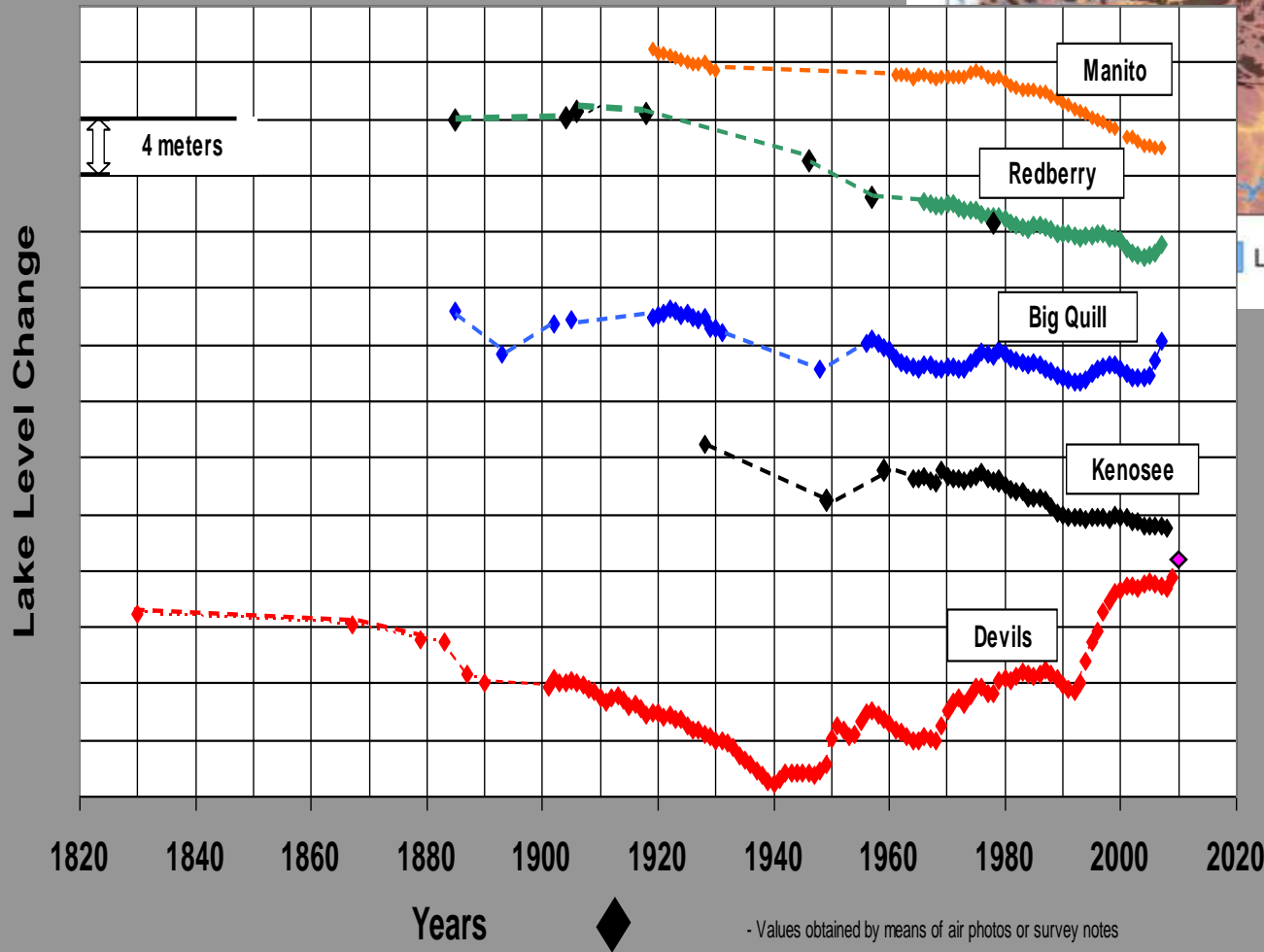
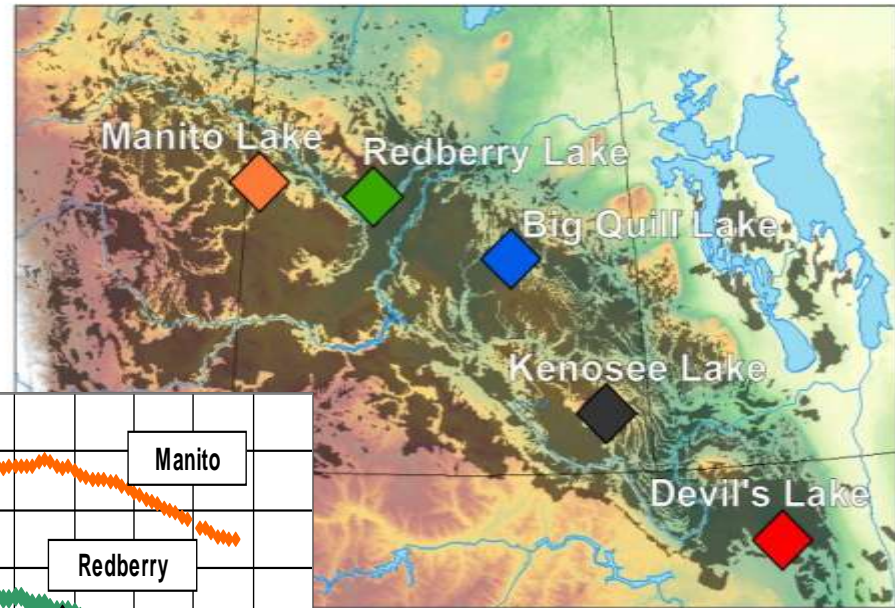
Modeling the moisture balance of the Upper Assiniboine River Basin [PhD Thesis, Agboma, Memorial University]



Agboma et al, 2010. Moisture Storage Patterns Derived from a Hydrologic Model Validated with Outputs from GRACE and Geological Weighing Lysimeters. In preparation

Prairie lakes 1820 – 2009:

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



Century-long dry and wet periods have always occurred and are still occurring, (unpredictably) – e.g. Devils Lake and Red River flooding since mid-1990's

- Values obtained by means of air photos or survey notes

Manito Lake, SK 1922-2005

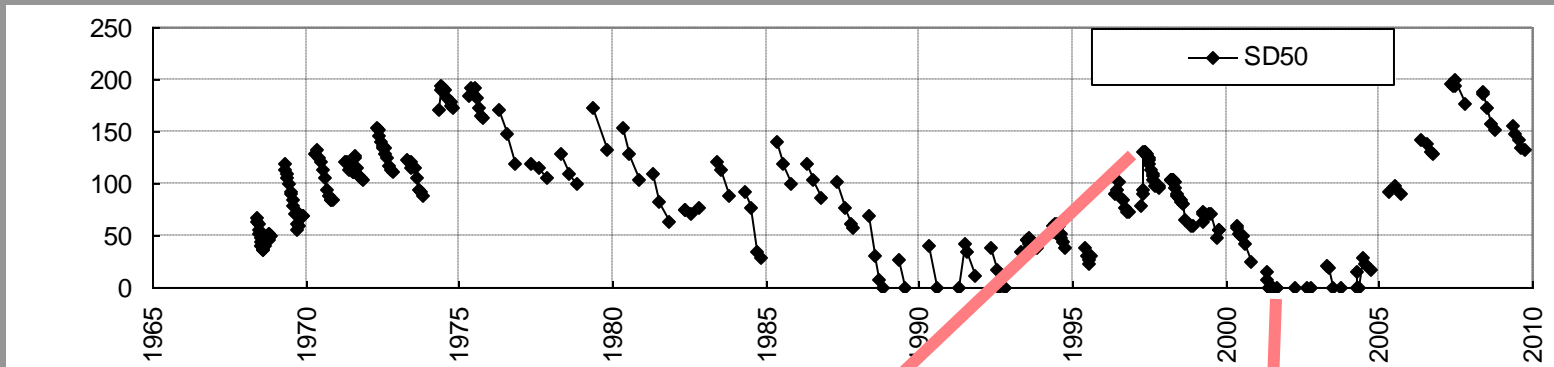
The water level has
dropped by 6 m
since 1922.

Sugar Loaf island is
now a peninsula



St. Denis National Wildlife Area (NWA), Wetland SD50

Max Depth (cm)



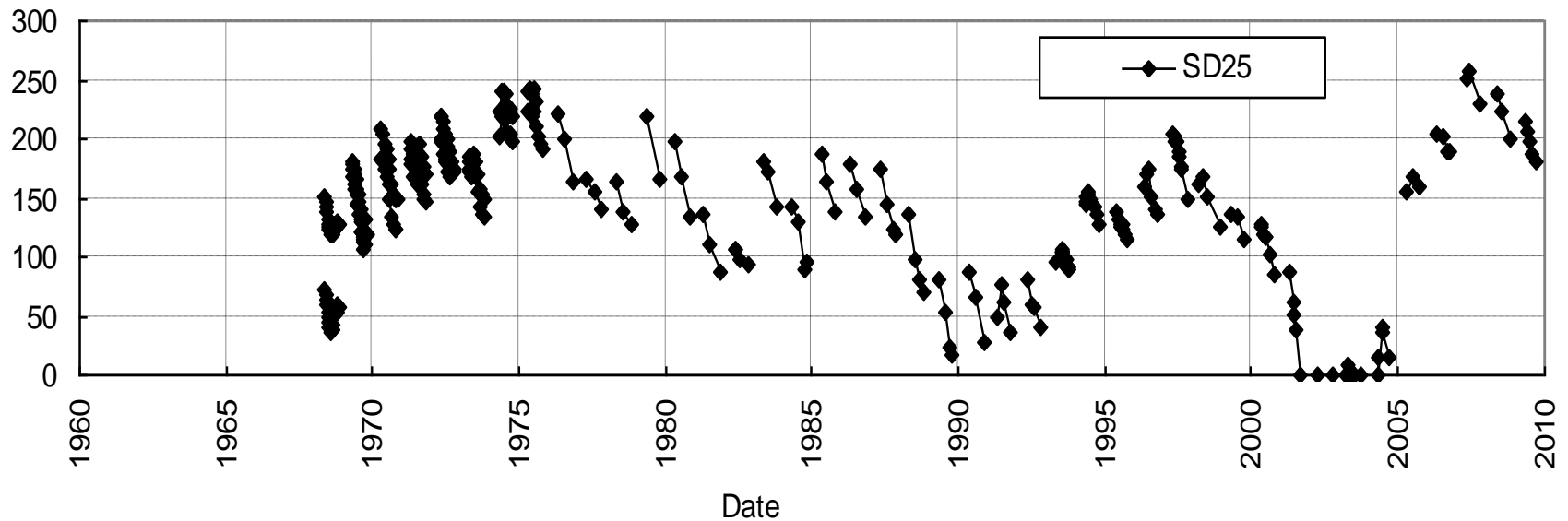
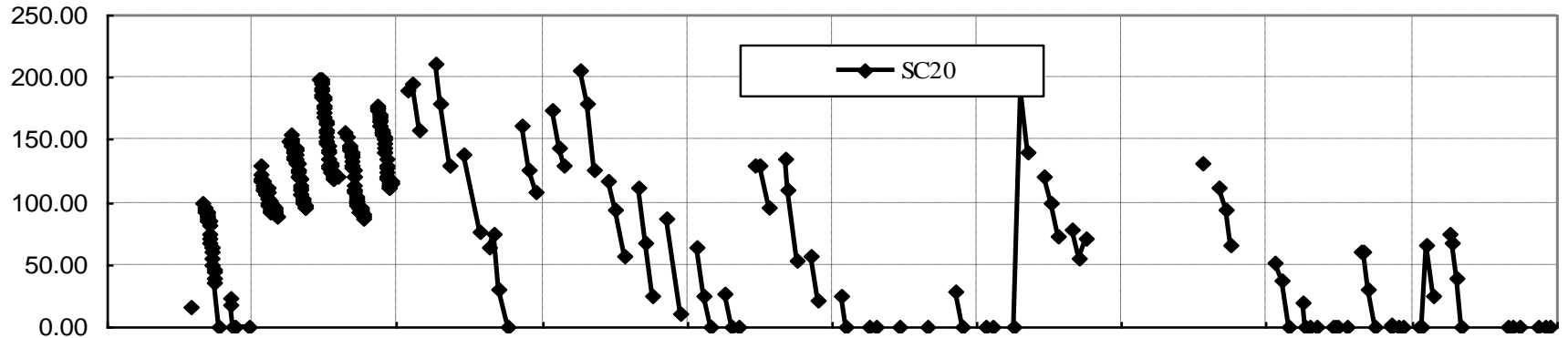
Year



Wetland water depths records for semi-permanent ponds:

Swift Current #20, 1962-2009

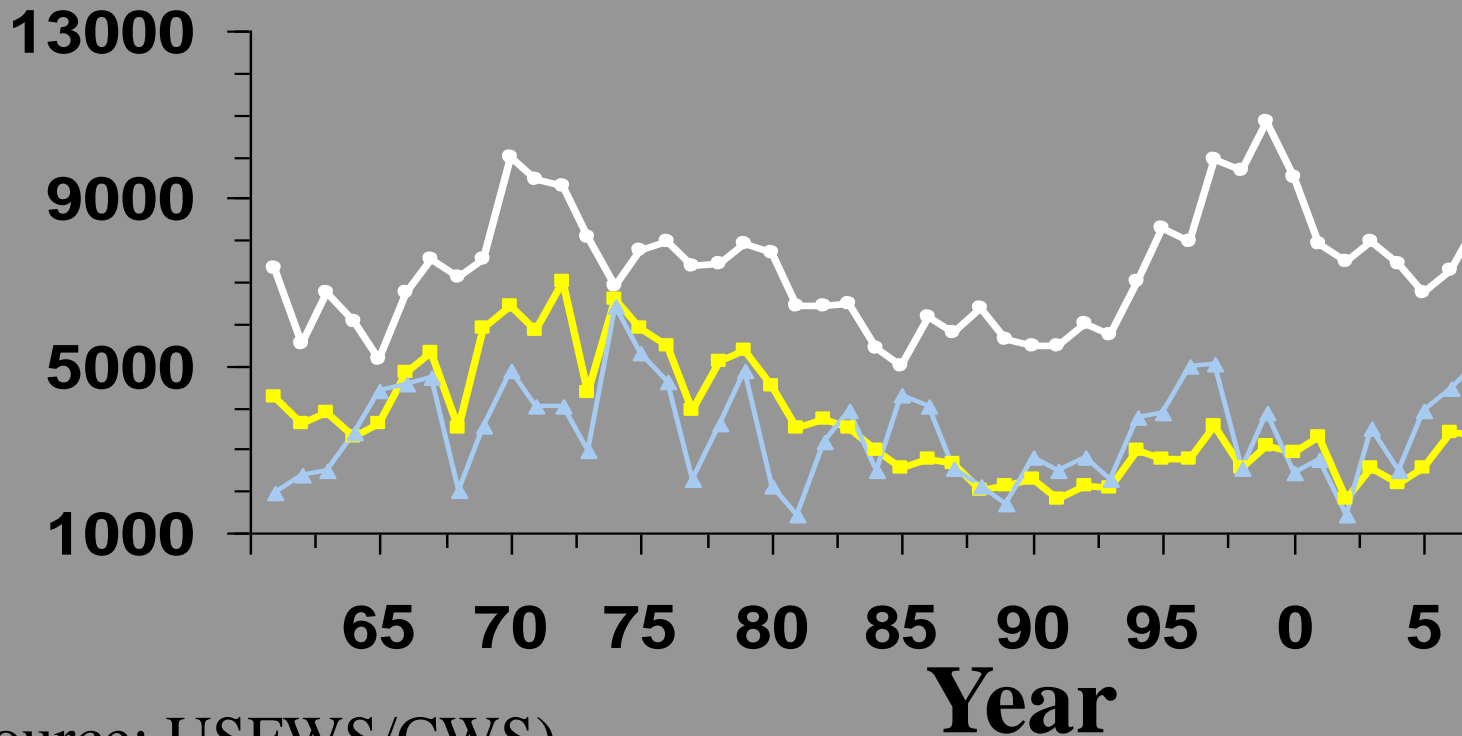
St Denis NWA # 25, 1968-2009



Ducks/Ponds in Canadian prairie region (thousands)



—○— Mallard —■— Pintail —▲— Ponds (Cdn)

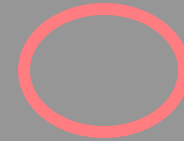


(Source: USFWS/CWS)

Lakes with little or no surface outflow



No surface outflow:



Sandy Lake

White Gull Lake

Birchbark Lake ?

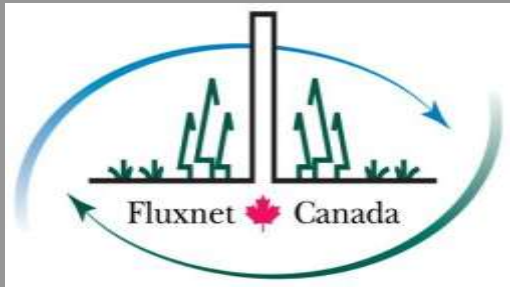
Crean Lake ?

White Swan Lake?

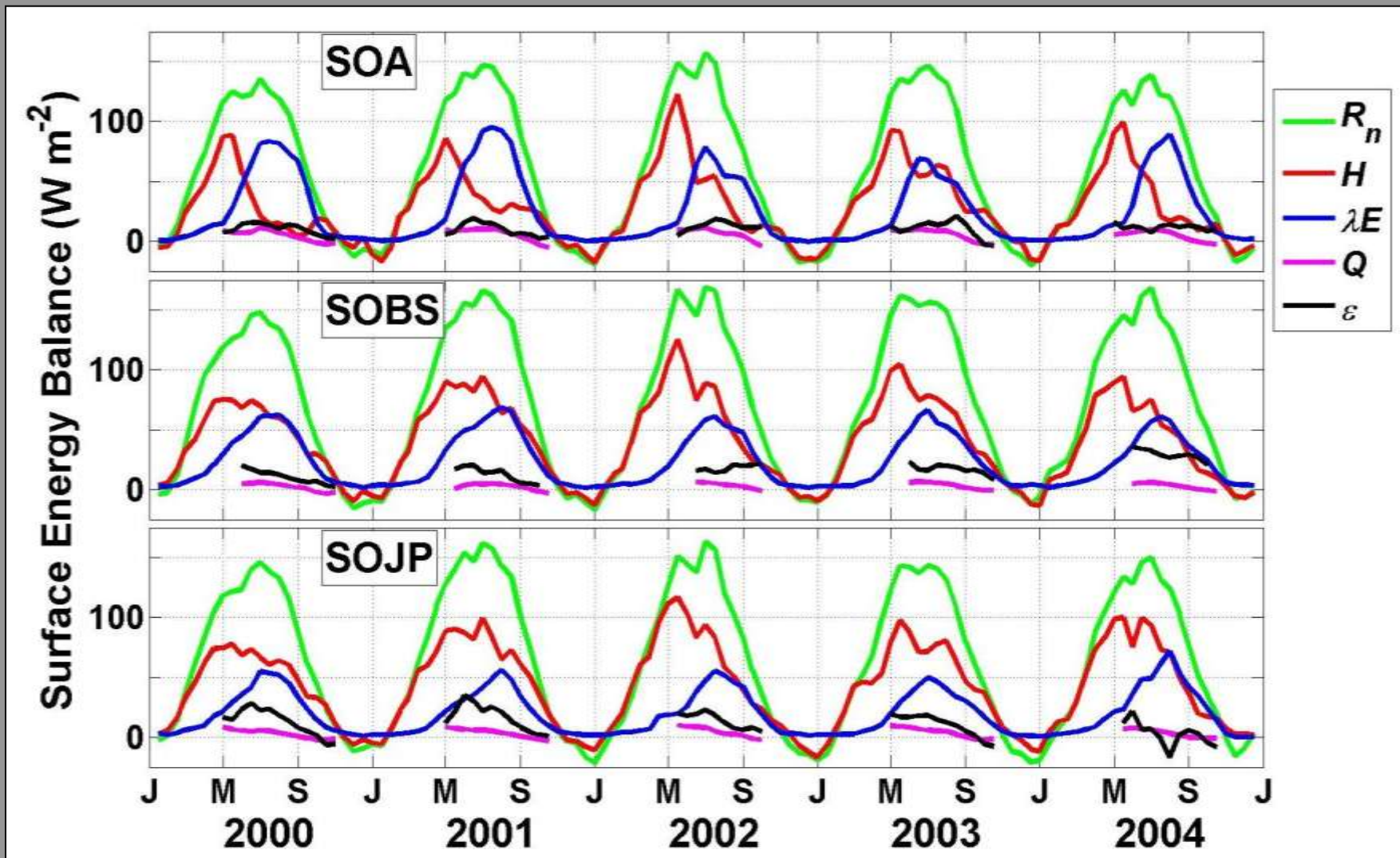
Amyot Lake ?

Fluxnet/BERMS

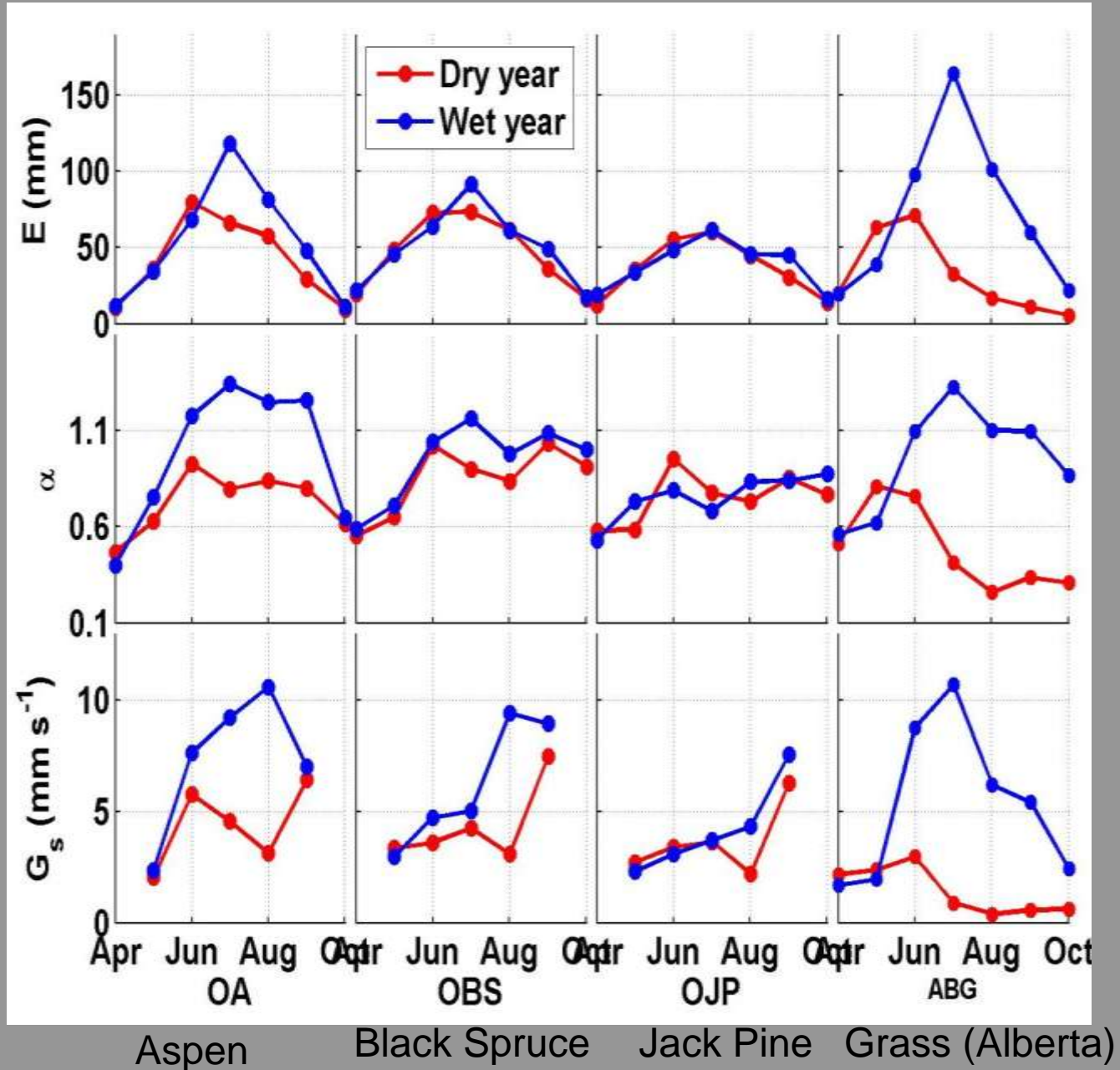
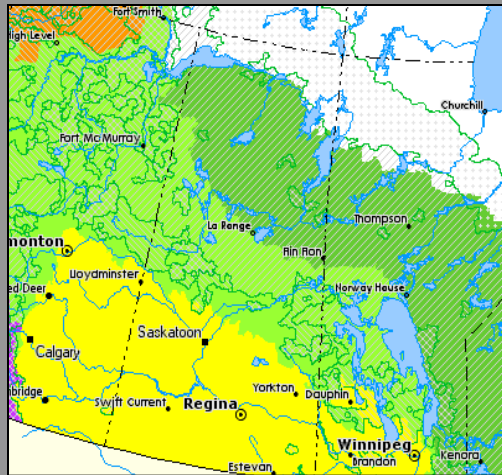
Towers for measuring the carbon, water and energy uptake of different forest types in the PAMF area, 1994 -



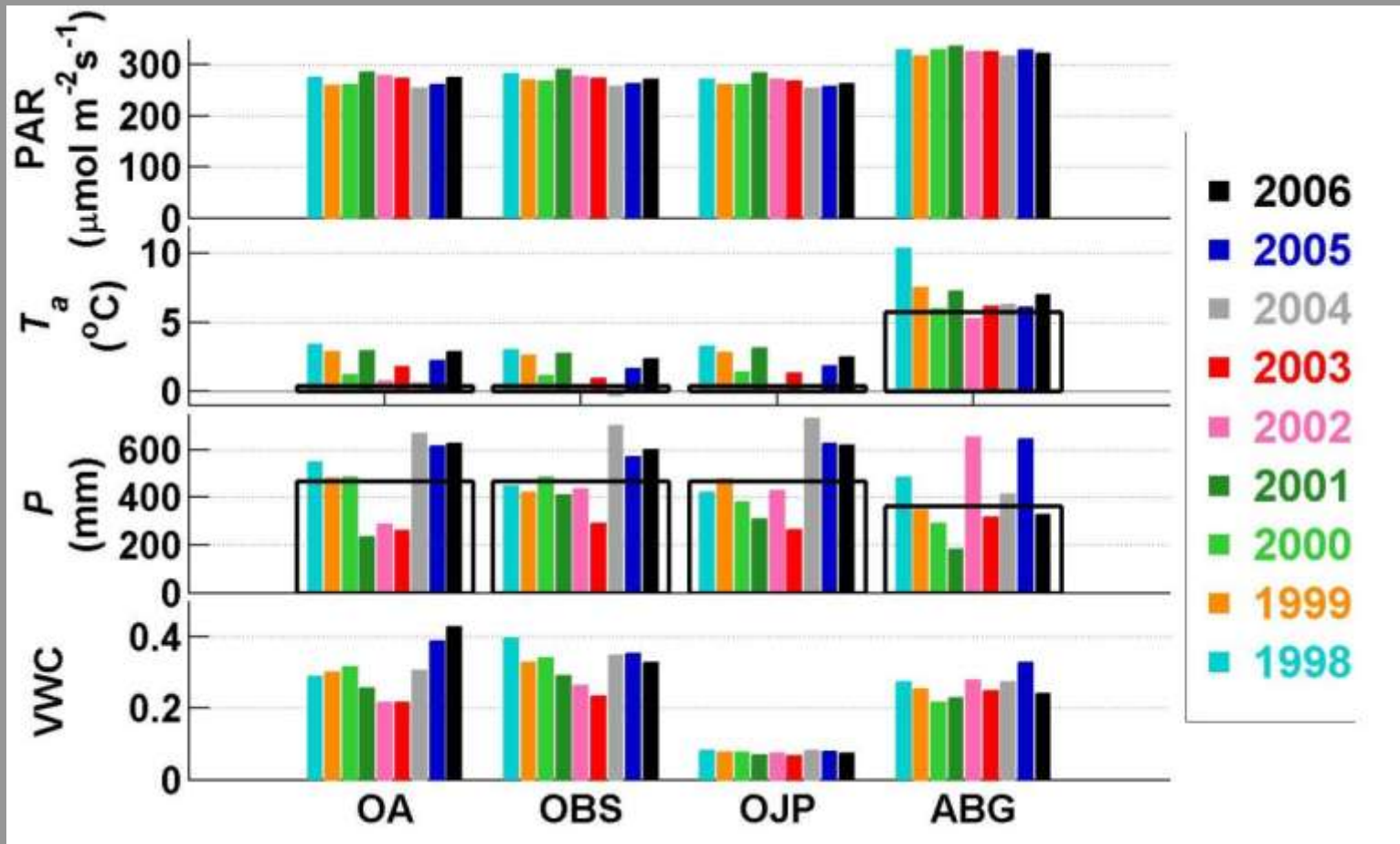
Five years of flux data, 2000-2004: Old Aspen (SOA), Old Black Spruce (SOBS) and Old Jack Pine (SOJP)



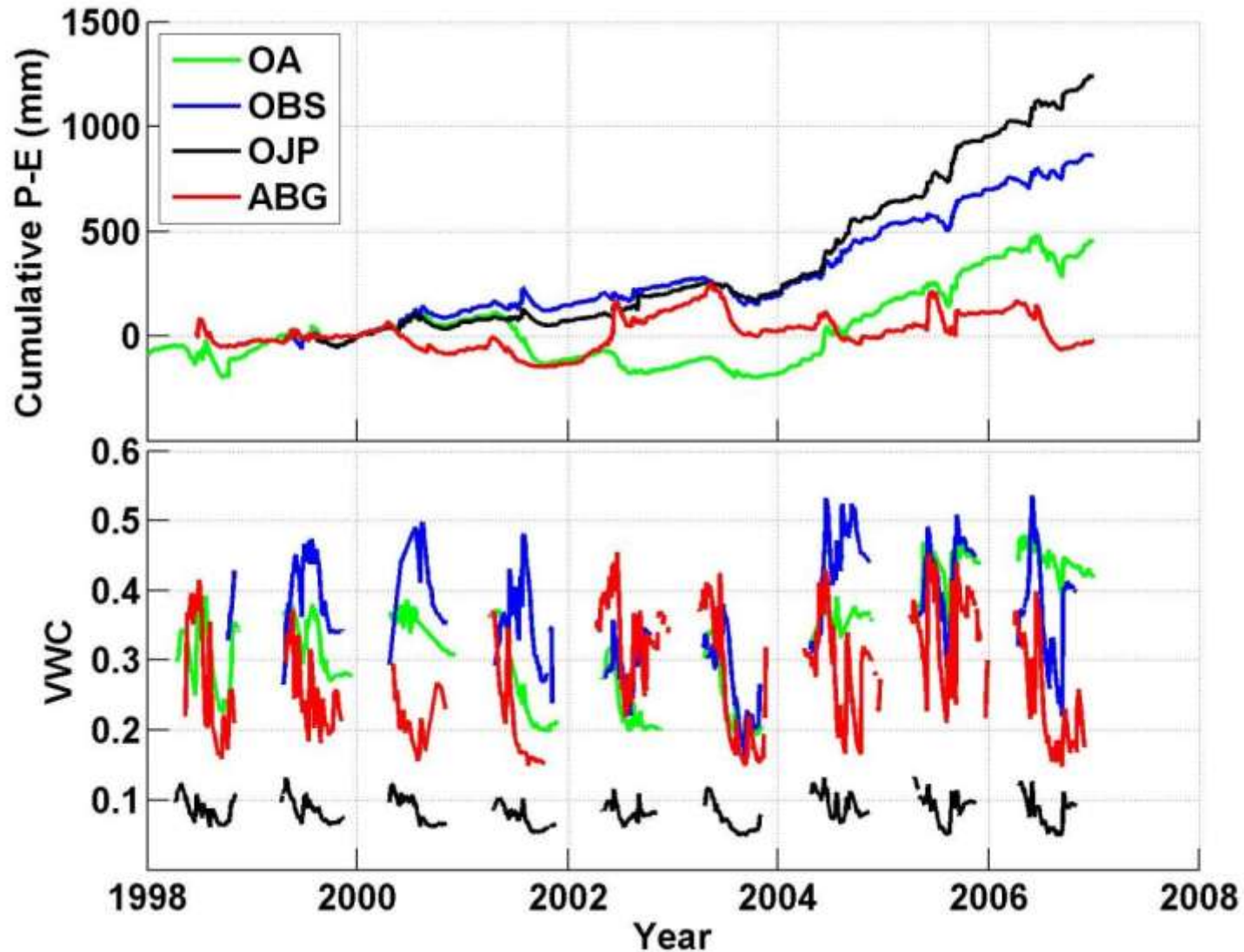
Comparison of monthly ET for forest versus grassland between dry year and wet year 2005 [Zha et al, in prep.]



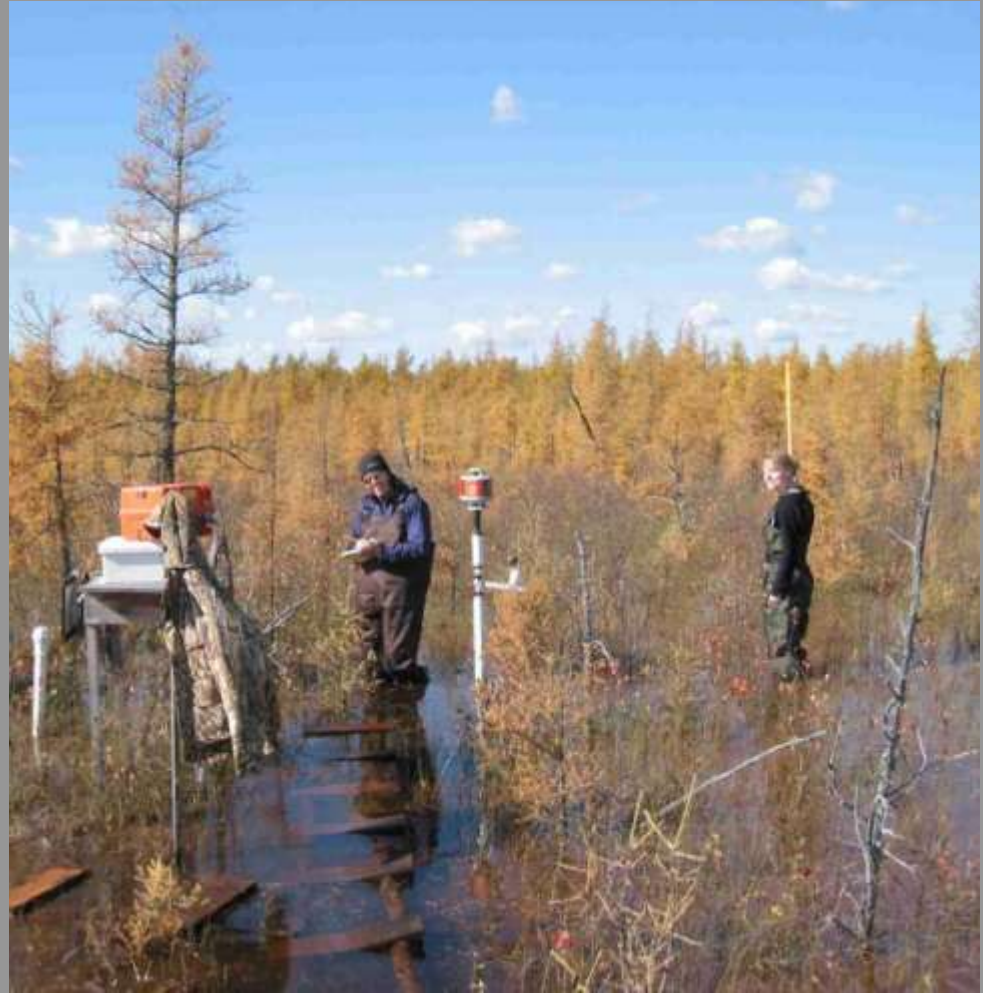
Interannual Variation in Climatic Factors



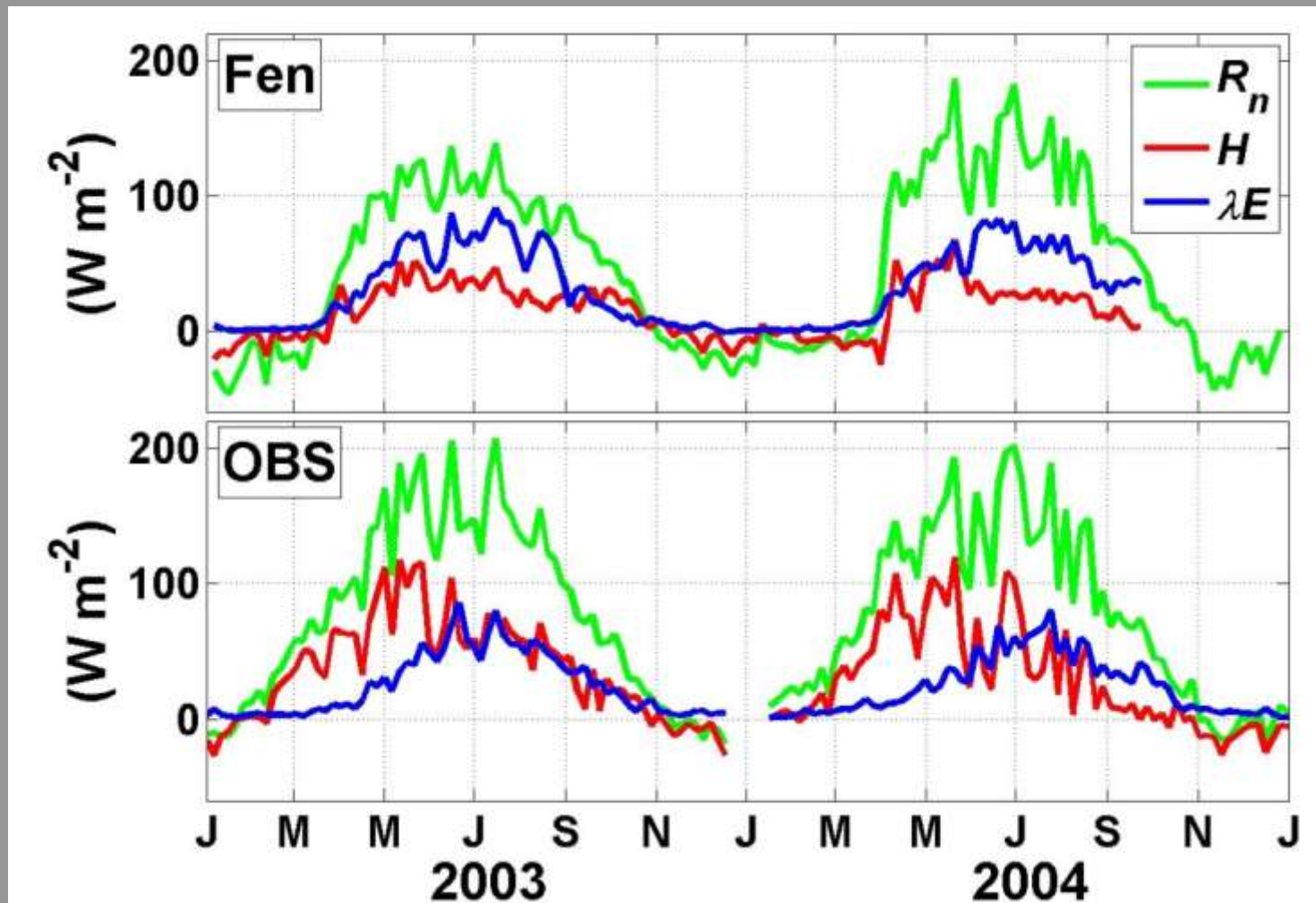
Cumulative P-E and Daily Mean VWC



Effect of annual climate variation on a fen

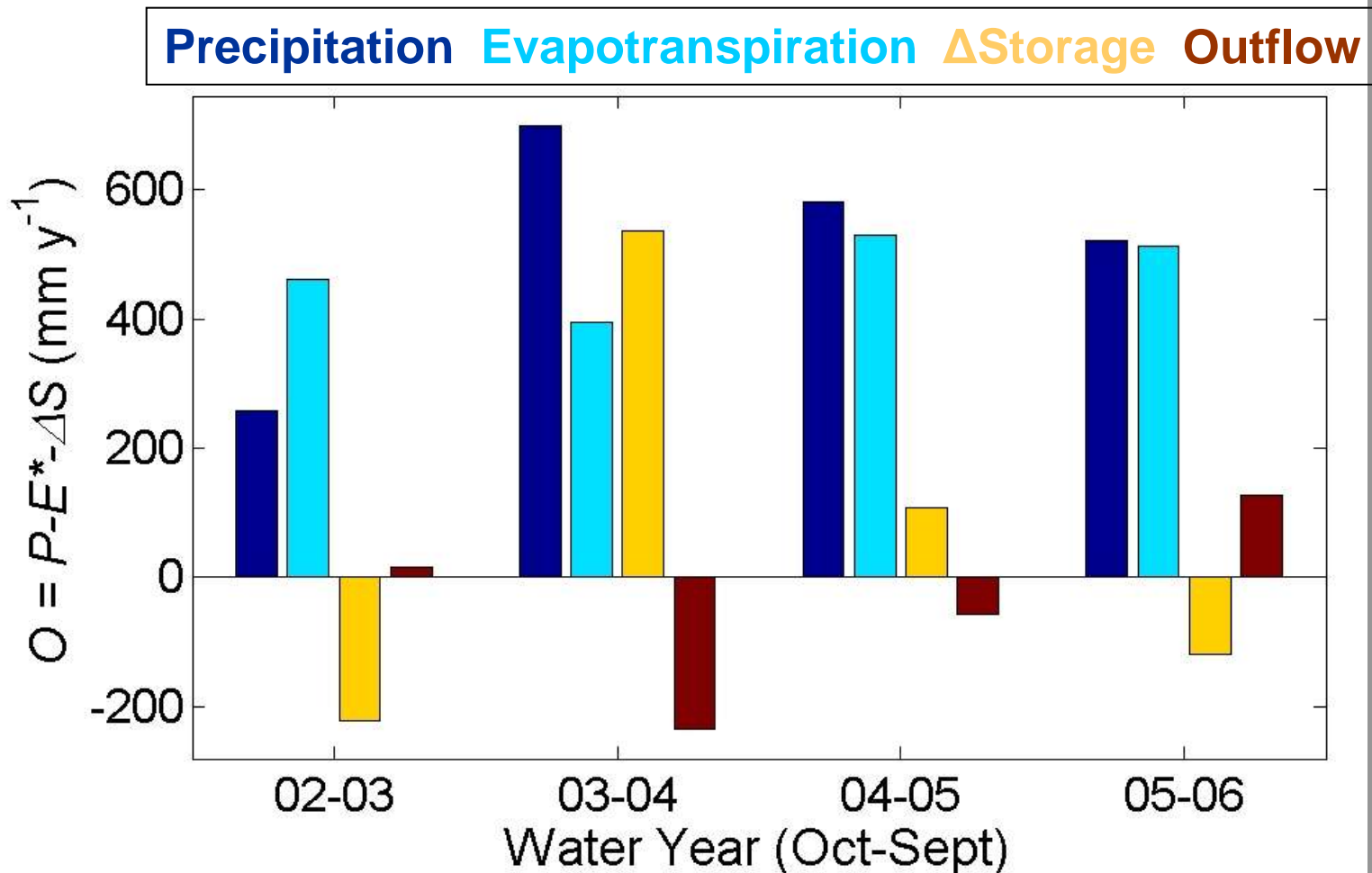


Two years of flux data: Fen and Old Black spruce



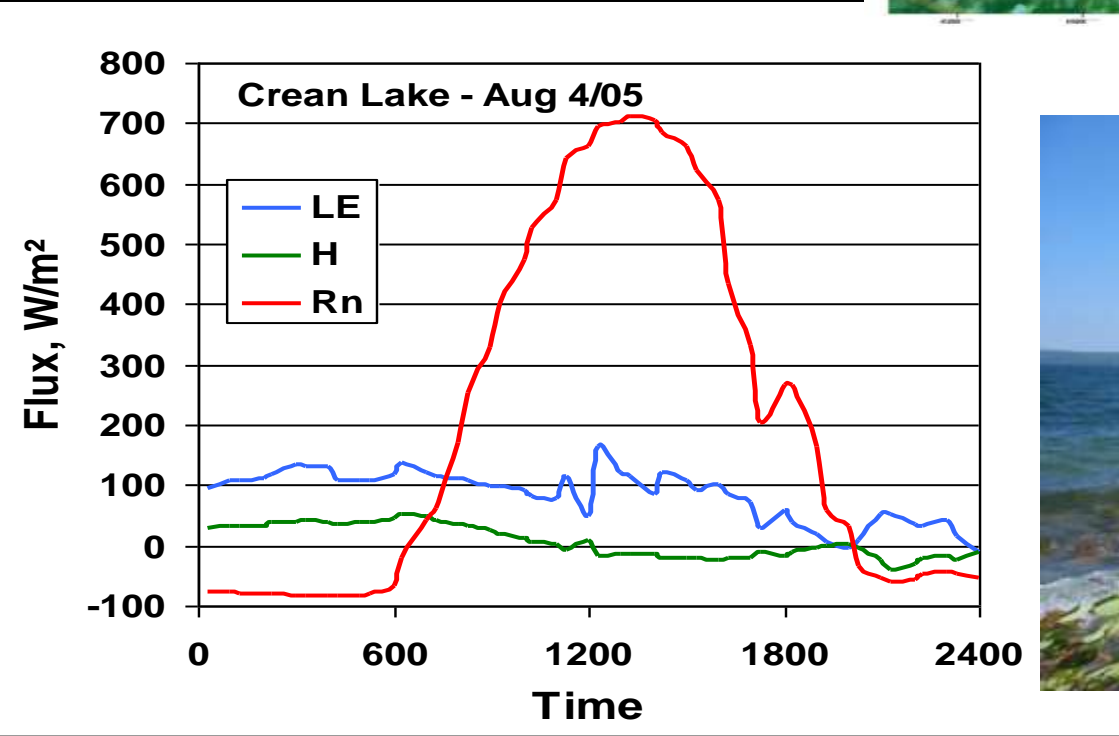
Annual Water Balance at the BERMS Fen (Oct – Sept water years)

Note: $E^* = E / 0.8$; ΔS has large inter-annual variability; and substantial inflow occurs following the 2003 drought.

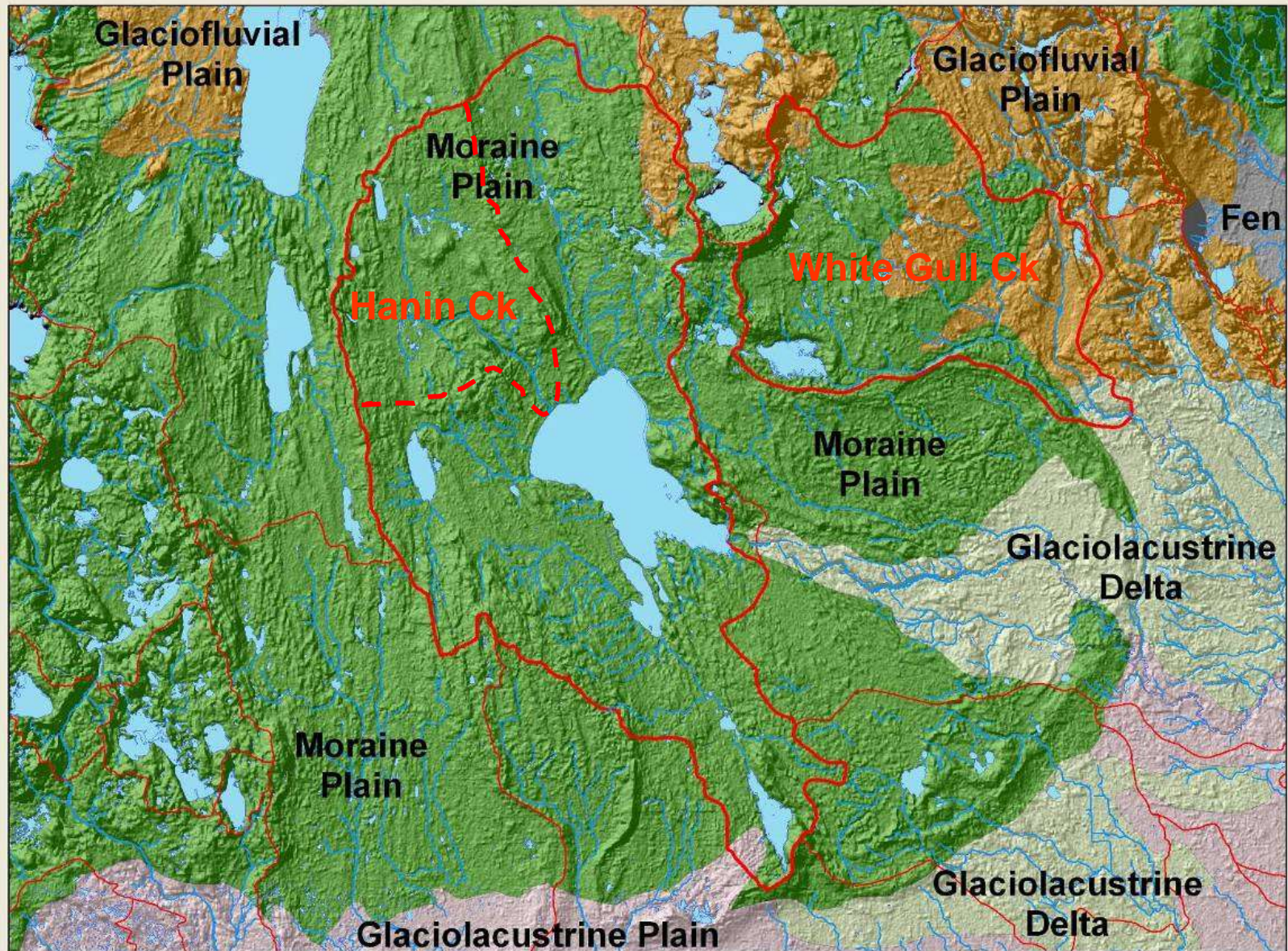


Crean Lake Evaporation, 2005

[Granger and Hedstrom]



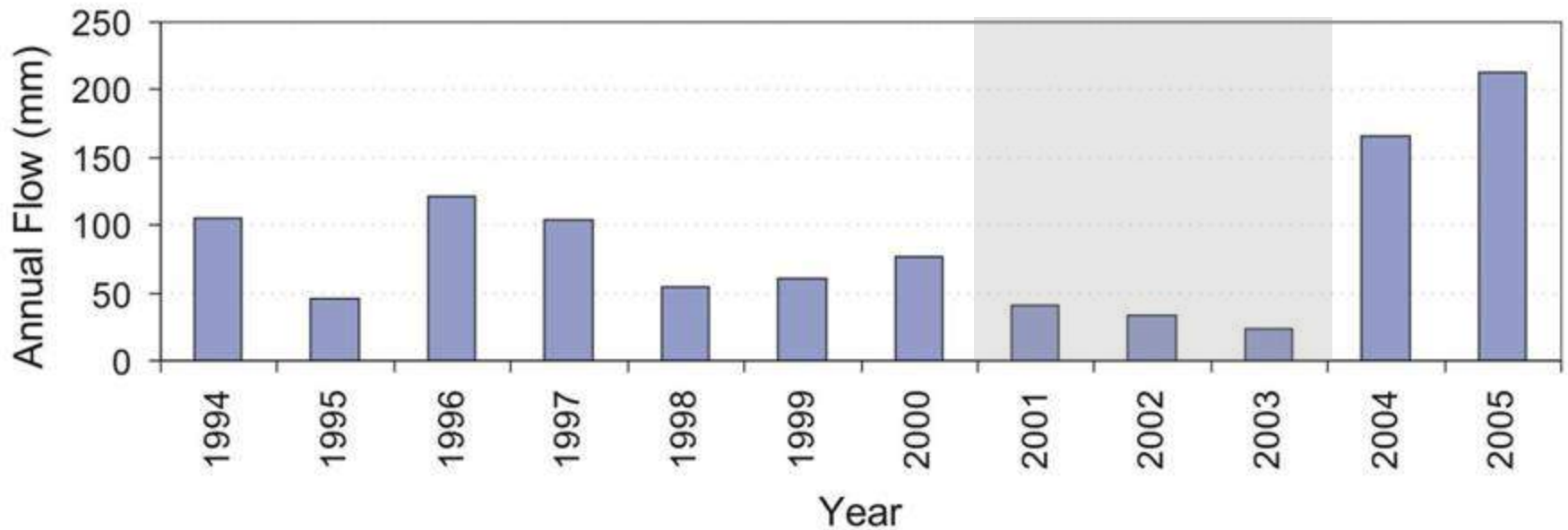
Taking a closer look at the White Gull Creek basin



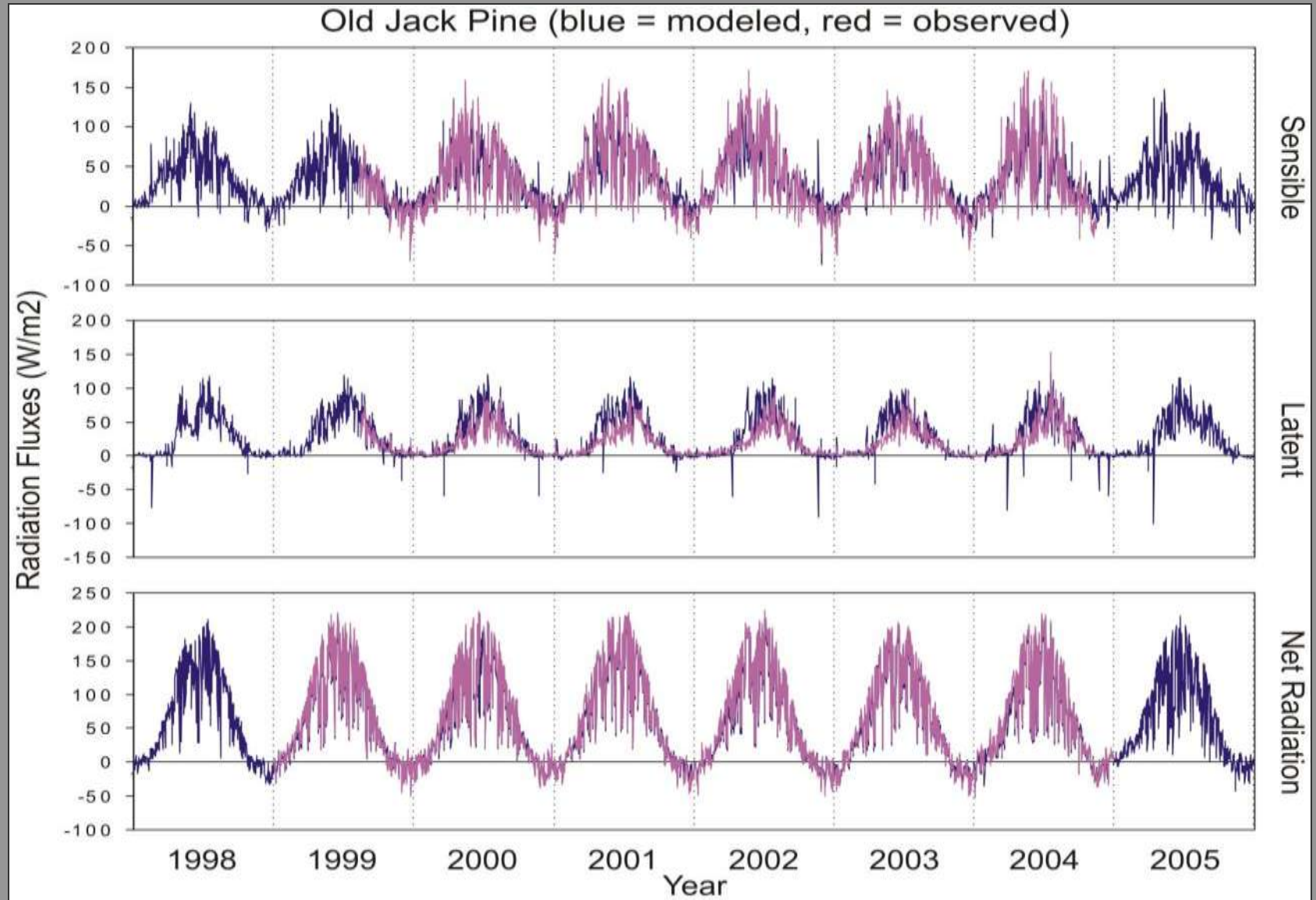
Gauged Streamflow

White Gull Basin

Annual Flow in White Gull Creek at Highway 106
(as mm over gross drainage area of 629 km²)



Watclass modeling of energy fluxes



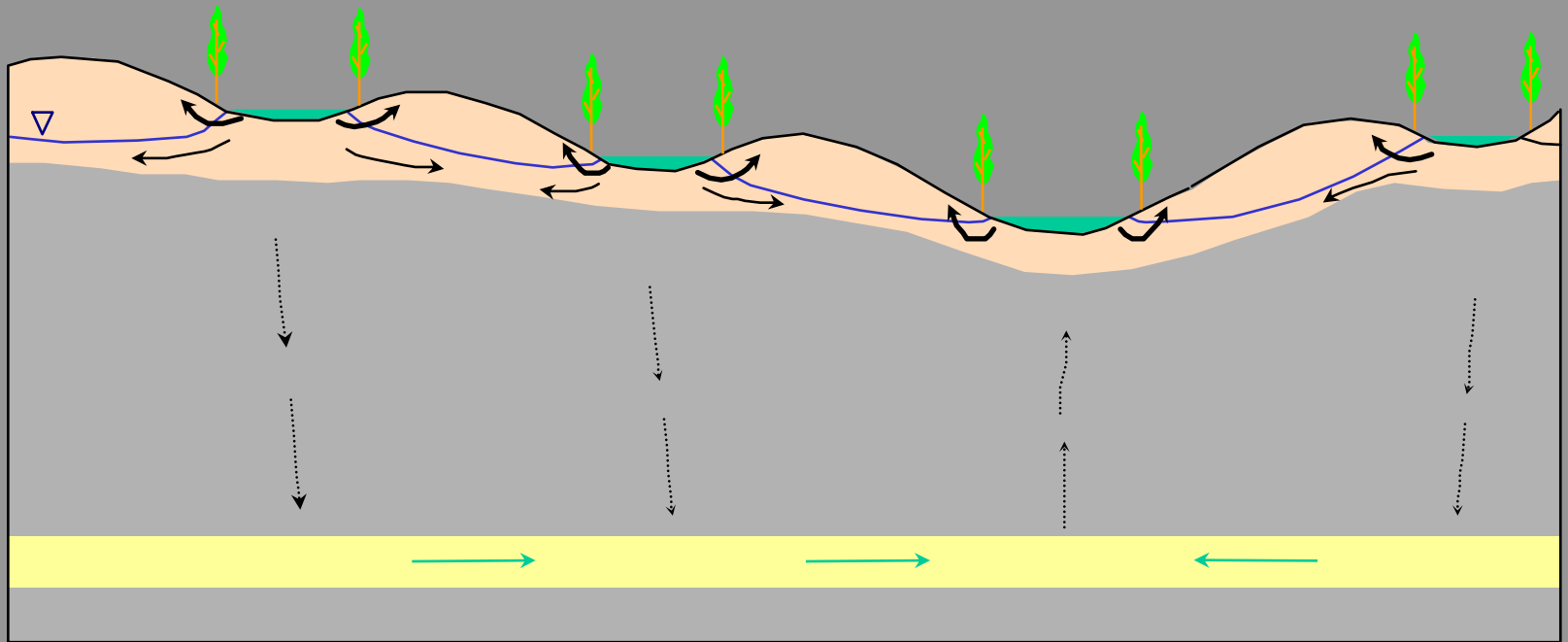
Thank you



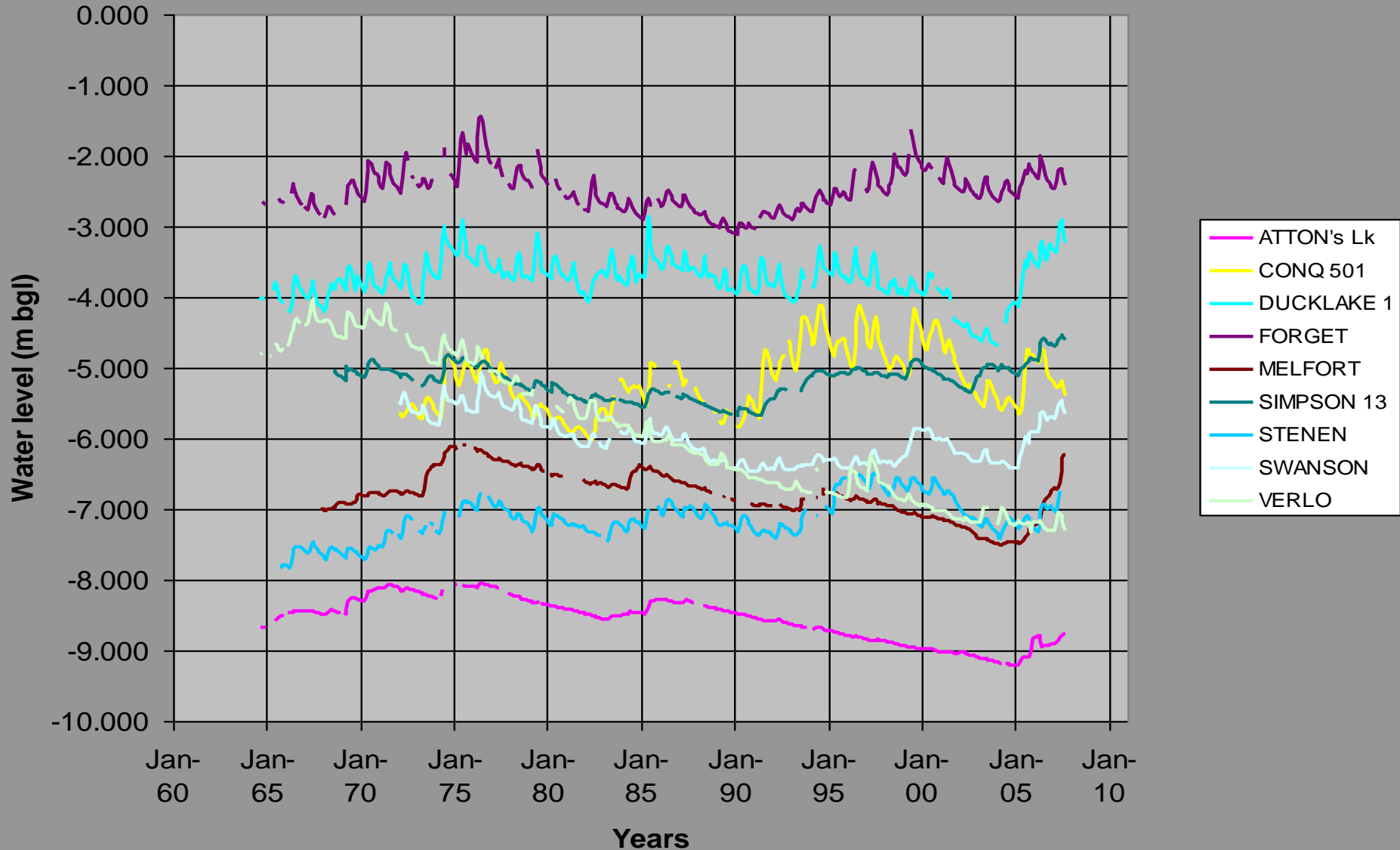
Pond # 90, St Denis NWA, October 2007

Wetlands and groundwater:

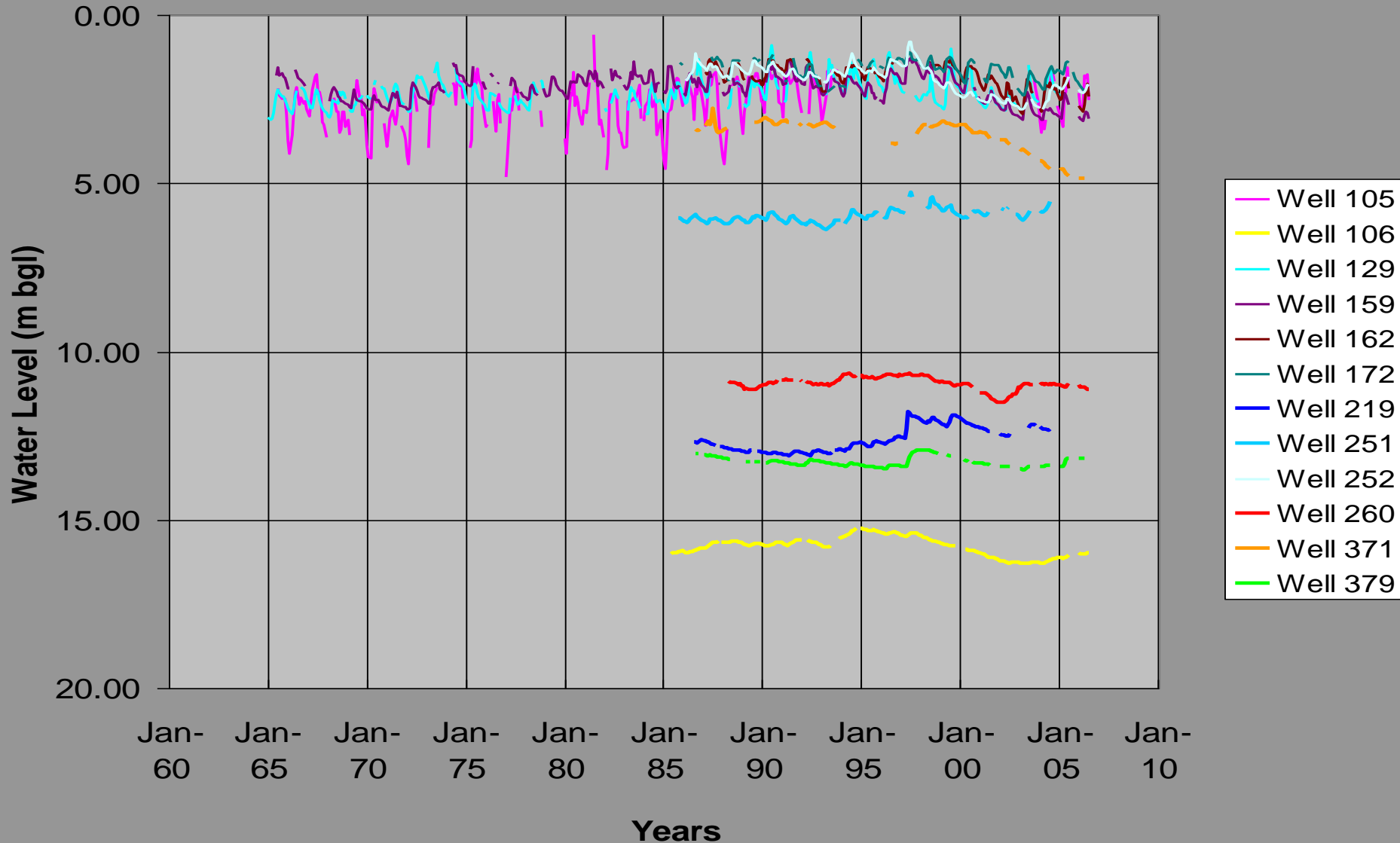
- The central ponds interact strongly with the riparian vegetation through shallow groundwater flow.
- Groundwater exchange with regional aquifers is very slow and has little effect on the wetland water balance



Shallow observation wells in SK – water level records 1964-2007: water table depths below ground level (m)



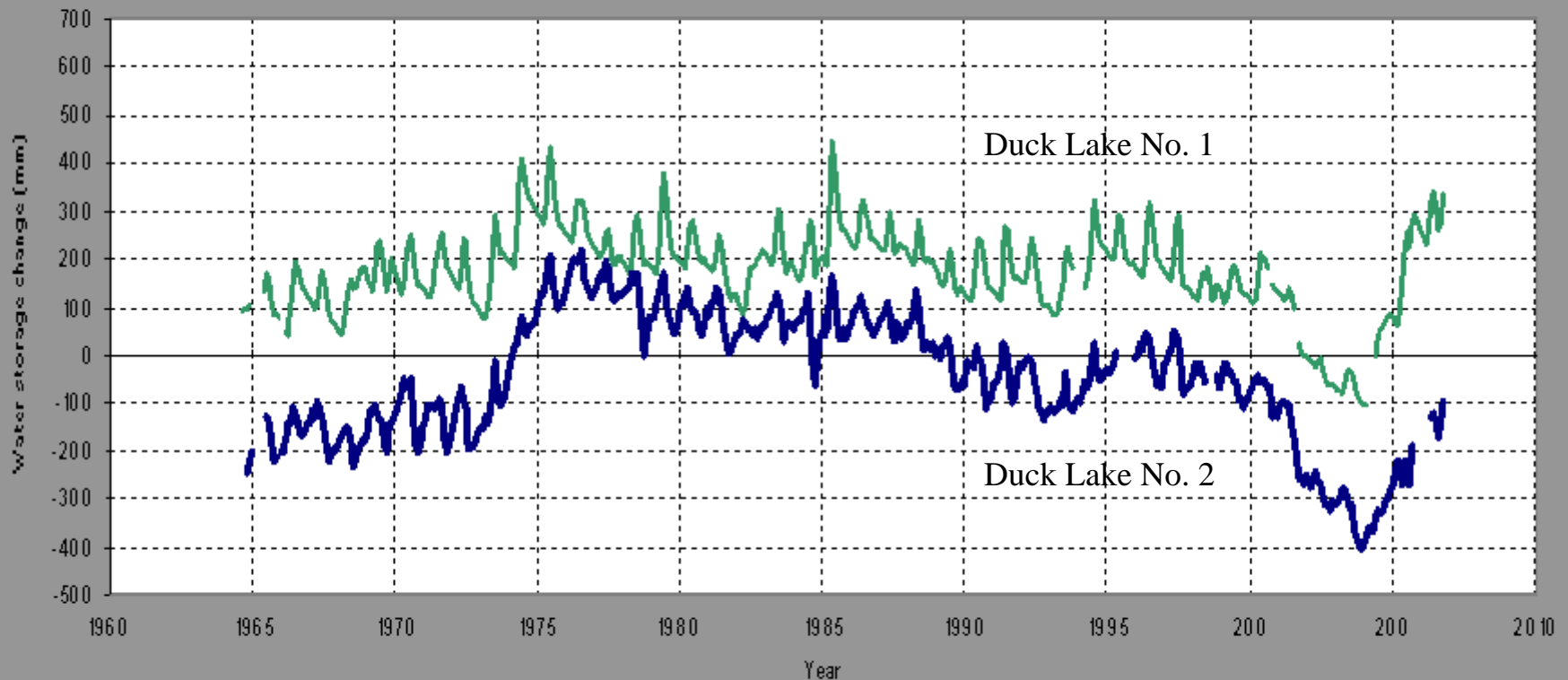
Shallow observation wells in AB – water level records 1965-2006: water table depths below ground level (m)



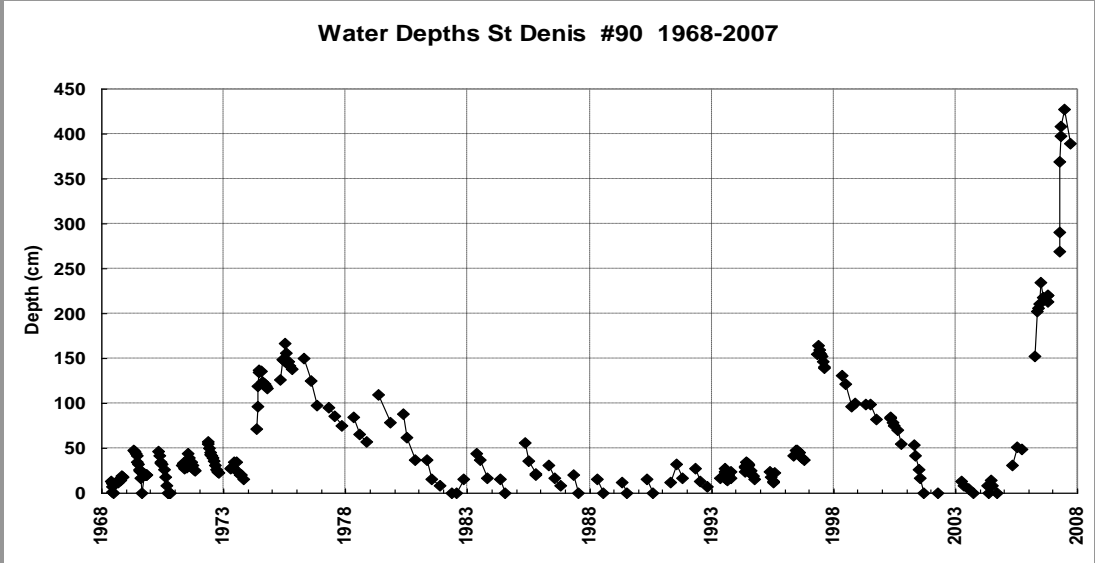
Water storage changes observed for Duck Lake SK observation wells 1965-2007:

Duck Lake No. 1 – Shallow water table well with specific yield = 0.30

Duck Lake No. 2 – Deep well in confined aquifer (geological weighing lysimeter)



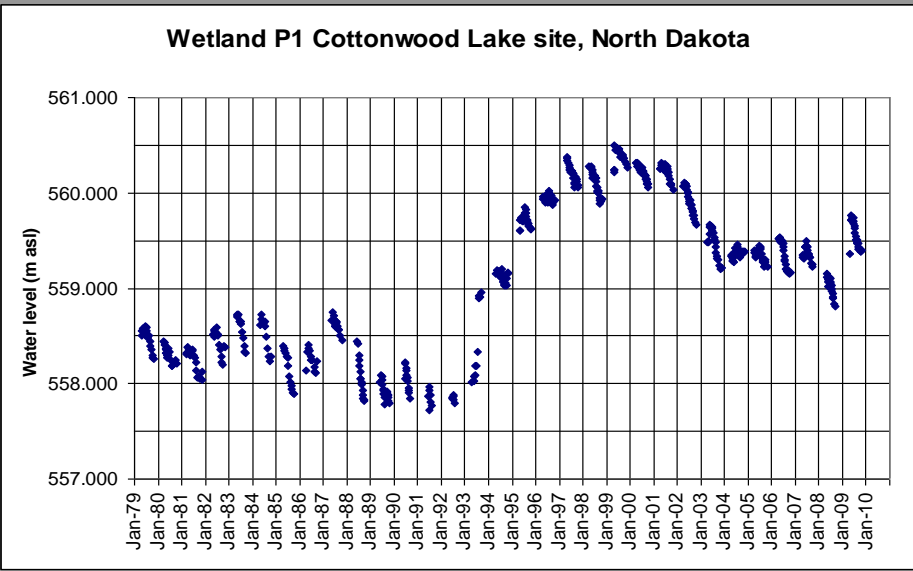
Wetlands, land-use change and climate variability 1968-2007



St Denis NWA – no significant drainage, little land-use change

Variability of precipitation is the key driver of wetland variability !

St Denis NWA



The USGS Cottonwood County wetland research site, near Devils Lake. There has been no land-use change at this site.

North Dakota [USGS]

Effective drainage areas –

pond 90 St Denis:

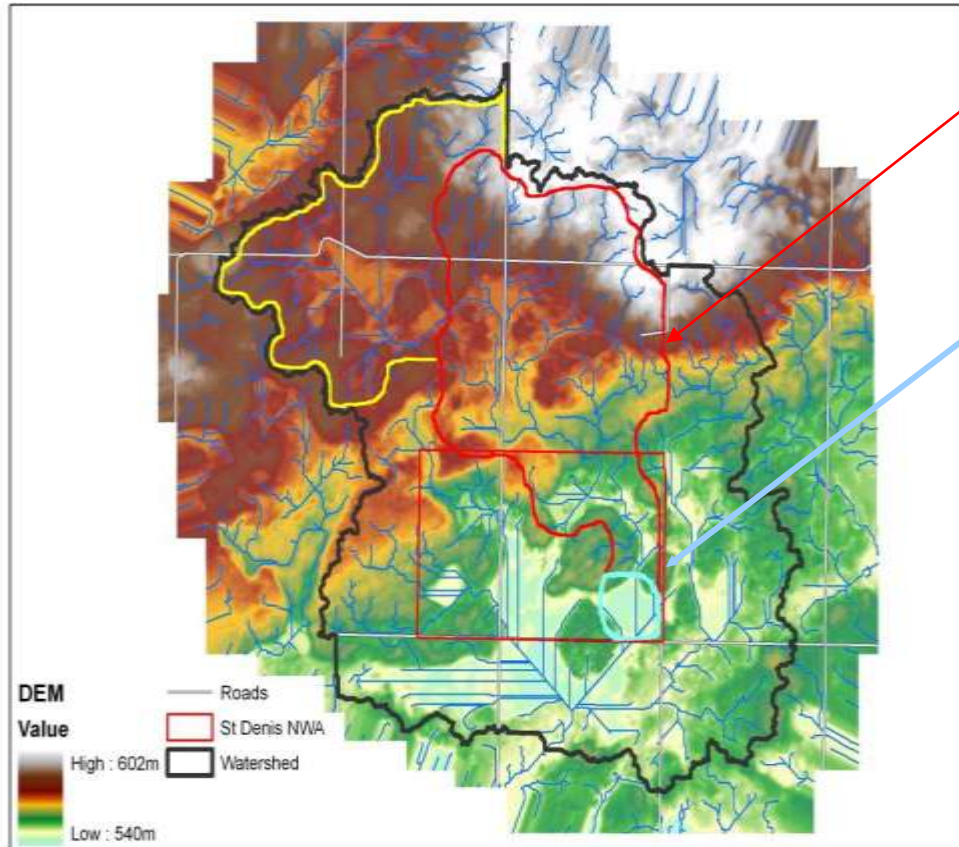
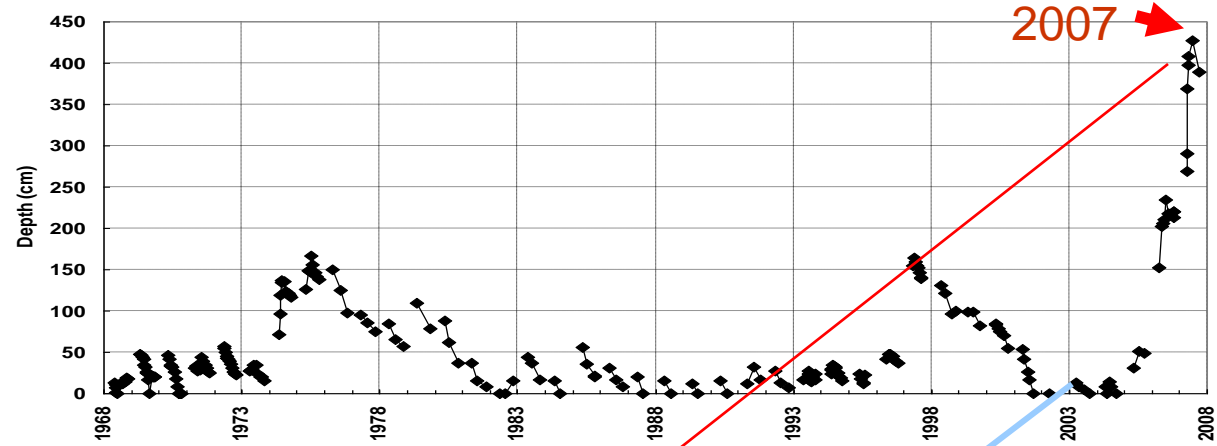
Blue – 2003

Red - 2007

Yellow + red: gross watershed

Black – gross watershed for St Denis NWA,

Water Depths St Denis #90 1968-2007



October 2007