Keeping water on the land: how, where and when?

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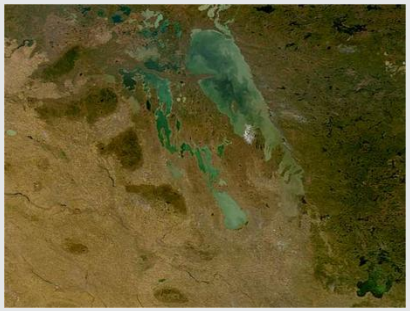
Watershed Systems Research Program

University of Manitoba

CWRA luncheon and AGM
Winnipeg - May 14, 2013

Watershed Systems Research Program (WSRP)

- Established by the Government of Manitoba in 2010
- Based at U of M
- **Goal: enhance the quality of water resources in Lake Winnipeg and its basin**
- Primary concern: nutrients (e.g. phosphorus)



- Fundamental research question:

  What are the controlling sources and pathways by which contaminants are exported from Prairie river watersheds to Lake Winnipeg?

The three-tiered, Prairie-specific water issue

Floods

Droughts

Water quality

Towards an effective water management strategy

Manage the amount of/rate at which runoff enters waterways

Store/recycle/reuse water

Control the amount of nutrients & sediments entering waterways

Improving water quality in the Prairies

Nutrient sources
(e.g., farm lands, sewage outlets)

Transport mechanism
(mainly runoff)

Endpoints
(streams, LW)

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Management practices: Tried?

Precise fertilizer application techniques

Yes

Conservation tillage

Yes

Vegetated buffer strips

Yes

Runoff management/storage

No

Algae bloom remediation

Yes

Improving water quality in the Prairies

Nutrient sources
(e.g., farm lands, sewage outlets)

Transport mechanism
(mainly runoff)

Endpoints
(streams, LW)

Management practices: Led to significant improvement?

Precise fertilizer application techniques

No

Conservation tillage

Not consistently

Vegetated buffer strips

Not consistently

Runoff management/storage

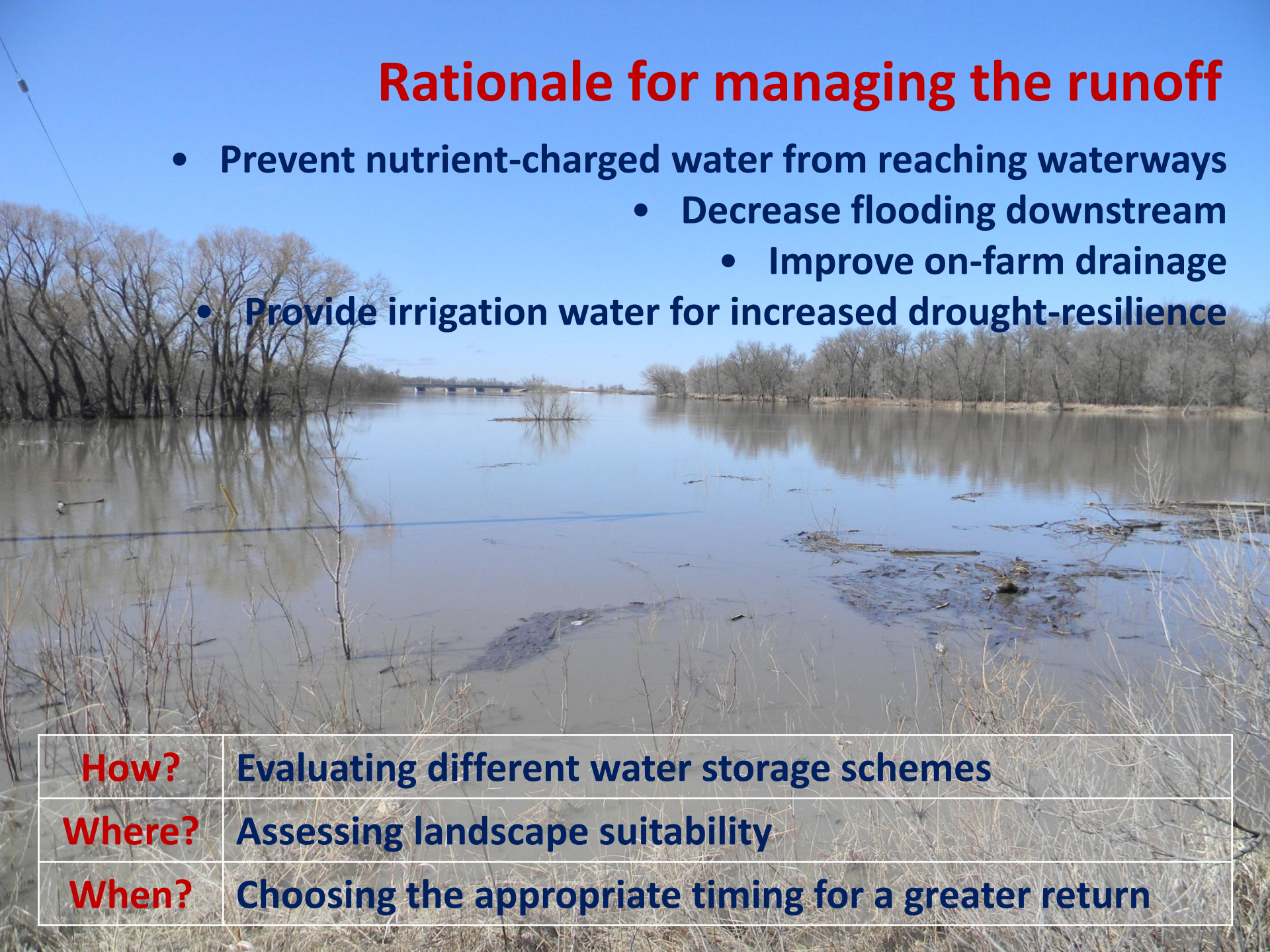
Probably will

Algae bloom remediation

No

Rationale for managing the runoff

- Prevent nutrient-charged water from reaching waterways
- Decrease flooding downstream
- Improve on-farm drainage
- Provide irrigation water for increased drought-resilience



How?	Evaluating different water storage schemes
Where?	Assessing landscape suitability
When?	Choosing the appropriate timing for a greater return

How to keep water on the land?

- Different management strategies likely needed for different Manitoba landscapes
- Several potential options:
  - Back-flood dams
  - Expanded ditches
  - On-farm ponds
  - Managed vegetated buffer strips
  - Farm dams
  - Wetlands (unaltered, restored, constructed)

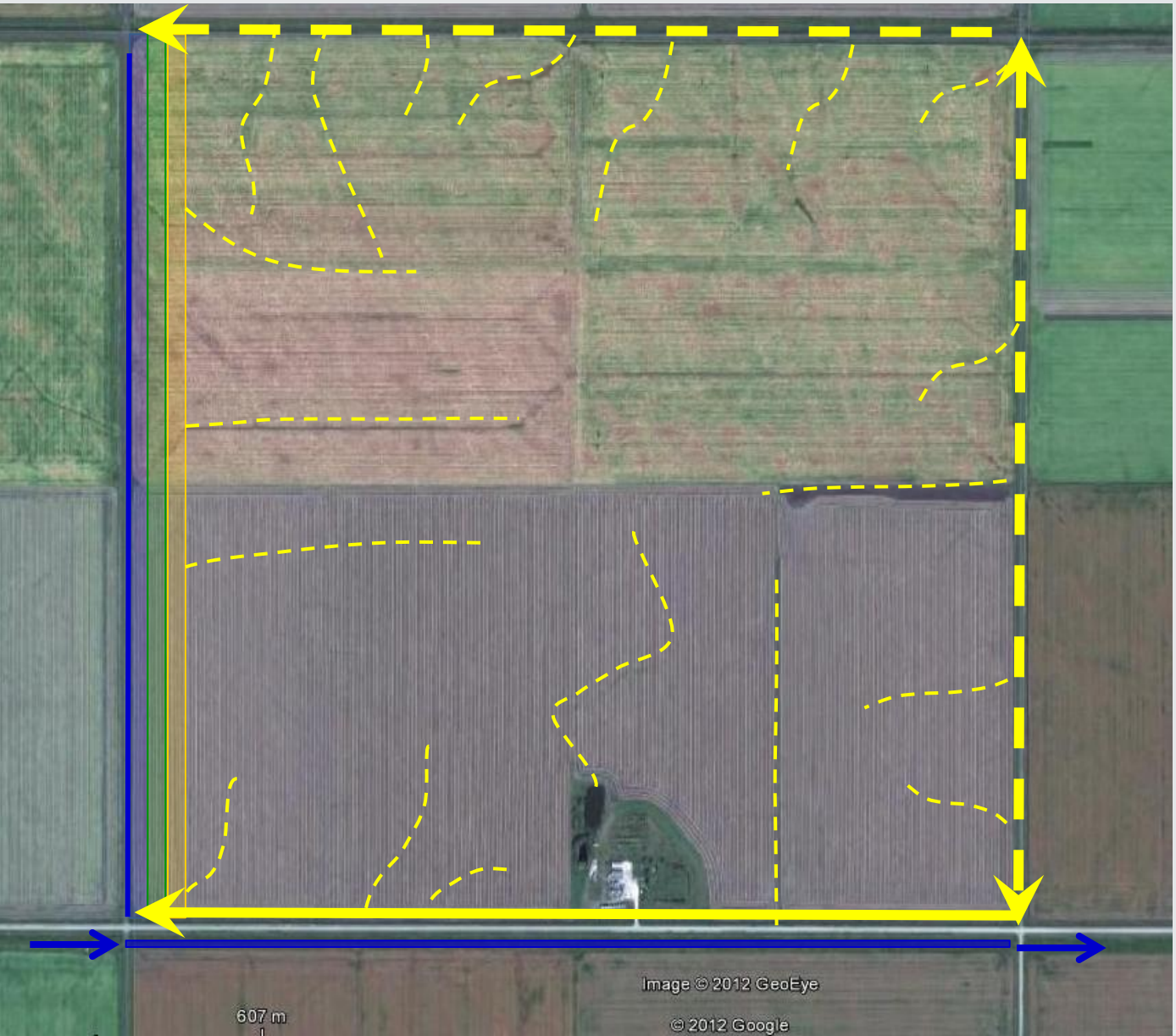
How to keep water on the land?

Starting from the existing drainage system

How to keep water on the land?

Option 1: Back-flood dams

How to keep water on the land?



Option 2: Expanded ditches

How to keep water on the land?

Option 3: On-farm ponds

How to keep water on the land?

Scenario modelling

Scenario	Annual runoff discharge (m^3)	Release of P to nearby waterway (kg $year^{-1}$)	Retention/ recycle of P on farm (kg $year^{-1}$)	Net benefit ($/year)
No water management	Decreased flooding downstream?			Farm-based benefits? (different from EG&S)
Retention pond used for irrigation		Increased water quality?	Bioenergy production?	
VBS present and harvested				
Ditch harvested			Nutrient-charged irrigation water supply?	
Restored/constructed wetland				
Etc.				

How to keep water on the land?

Research questions

- What would be the impact of the different water storage schemes on surface or subsurface runoff?
- How do we make sure that water storage structures are disconnected from groundwater?

Where to keep water on the land?

- **Two spatial scales to consider**:
  - Each water storage scheme developed and managed at the farm/community scale
  - All water storage schemes must complement one another within a watershed
- **Long lists of applicability criteria:**
  - Not all water storage schemes/options can be deployed anywhere

Winnipeg Free Press - PRINT EDITION

2013/05/02

Dugouts could change the game

Water holes called cheap solution to flooding, lake pollution

What was said…

Dugouts CAN BE cheap, low-tech, useful for flood- and drought-proofing and water quality control

What was NOT said…

Dugouts are not universal substitutes for wetlands and could create adverse effects if ill-located

Where to keep water on the land?

Minimum criteria for on-farm ponds

1) Persistent water quality issues

→ Targeting the most problematic areas

2) Dominant agricultural land use

→ Focusing on farm-scale benefits

3) Flat areas

→ Choosing low slopes for easy construction

4) Poor drainage areas

→ Targeting areas vulnerable to floods, excess moisture

5) Non-recharge areas

→ Making sure that near-surface water retention is possible

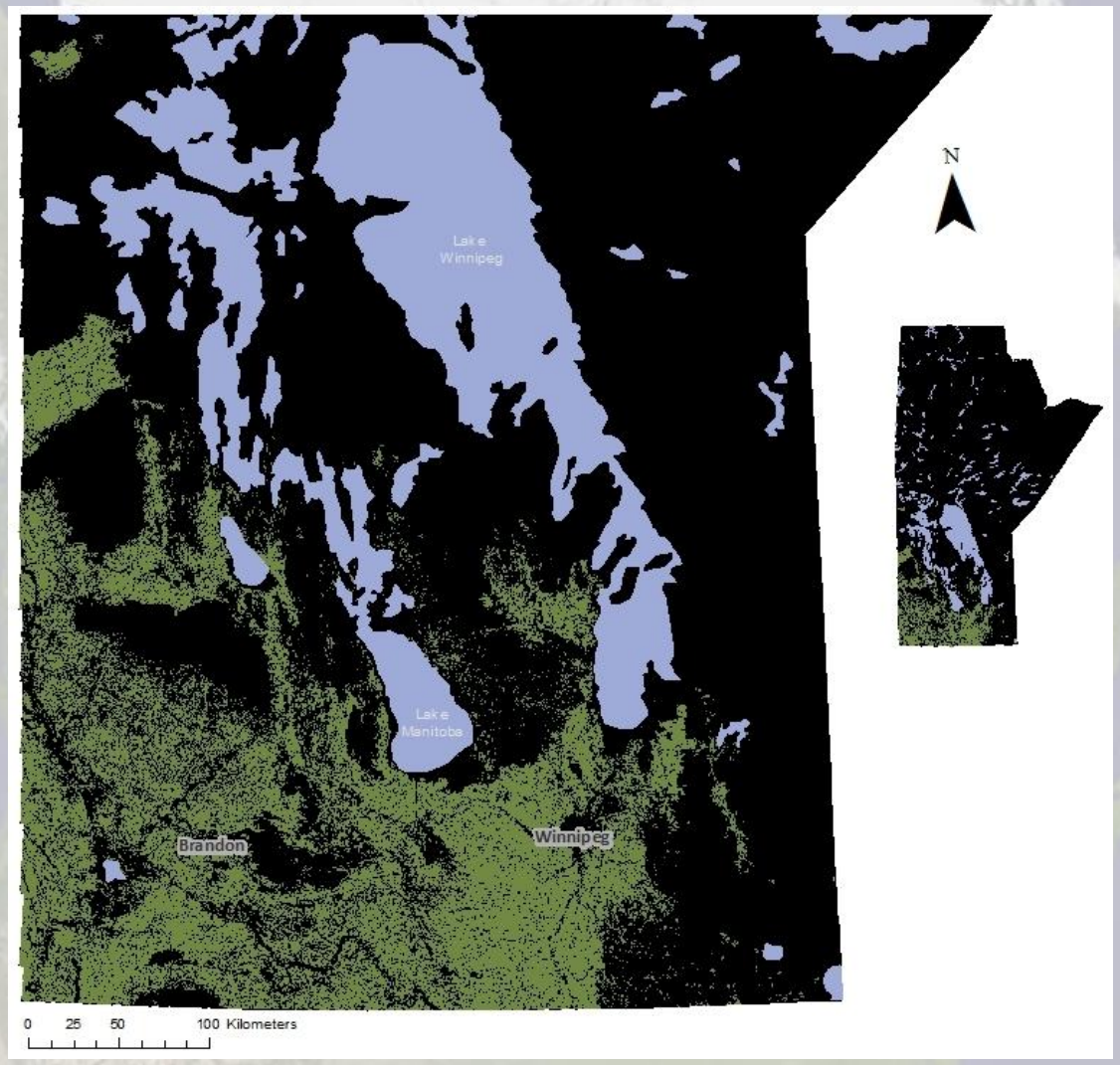
6) Low-salinity areas

→ Reducing the risk of evaporation-driven hyper-salinization

Where to keep water on the land?

Minimum criteria for on-farm ponds

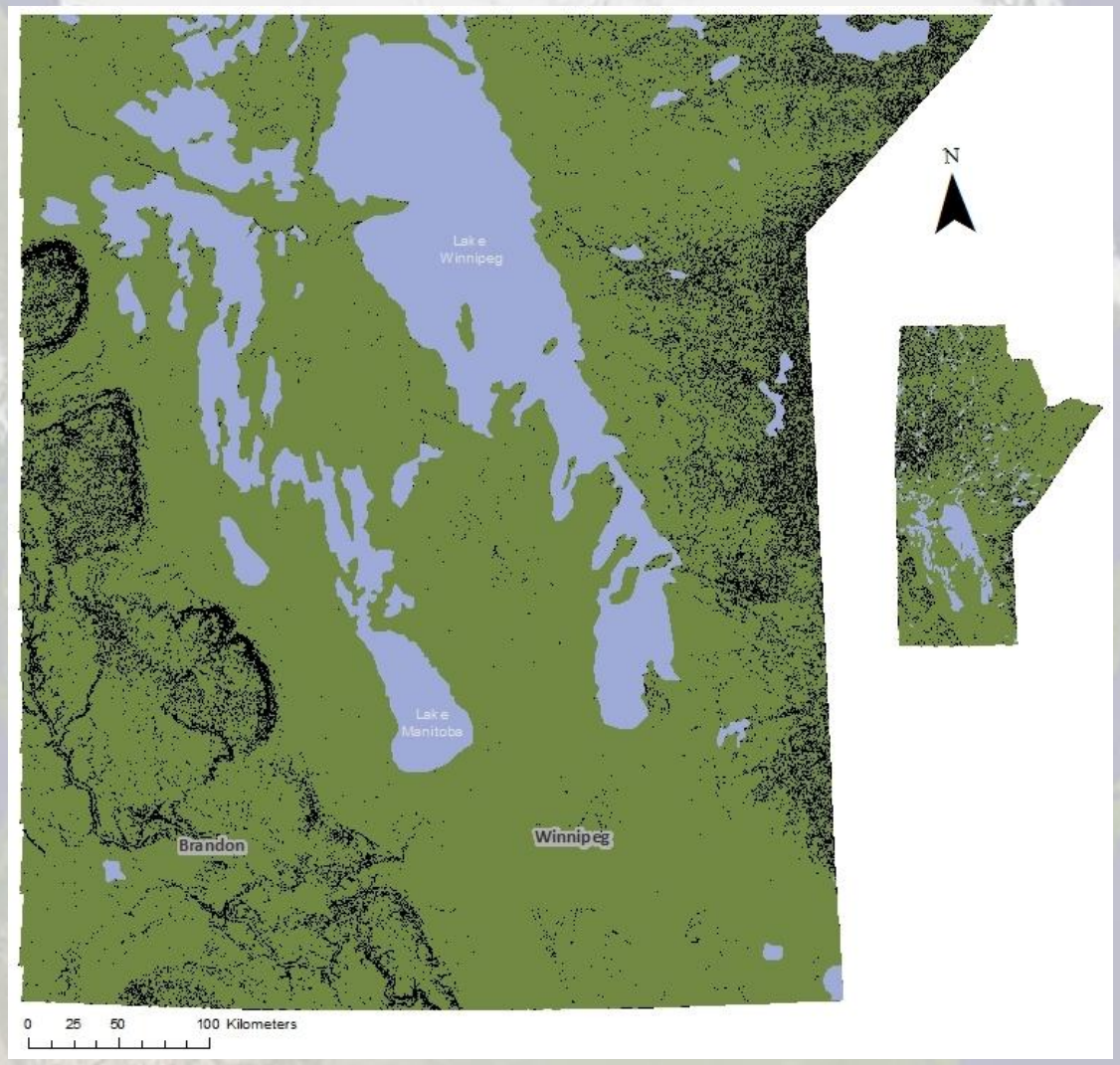
Areas satisfying the "dominant agricultural land use" criterion



Where to keep water on the land?

Minimum criteria for on-farm ponds

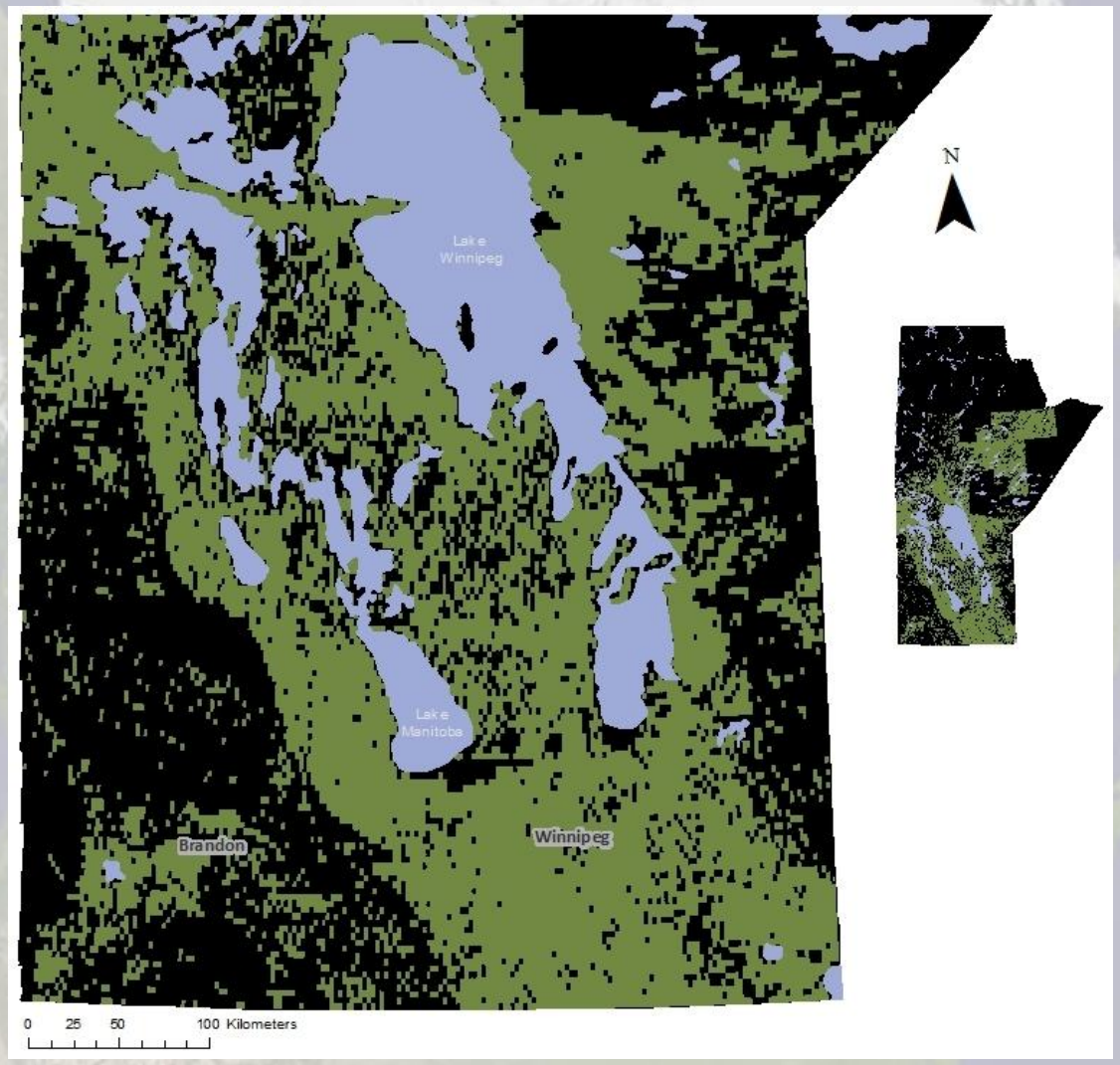
Areas satisfying the “low slope” criterion



Where to keep water on the land?

Minimum criteria for on-farm ponds

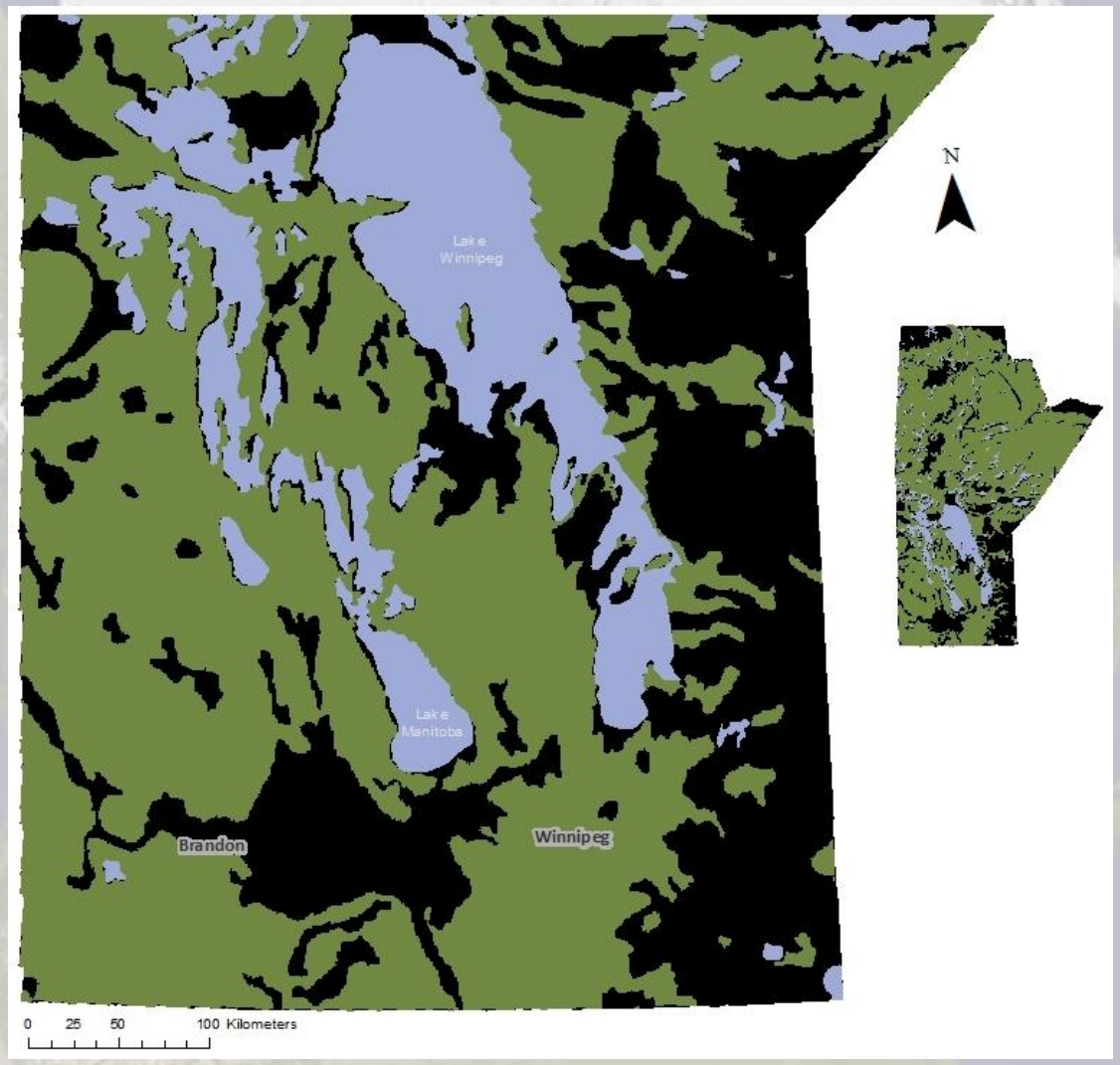
Areas satisfying the “poor drainage” criterion



Where to keep water on the land?

Minimum criteria for on-farm ponds

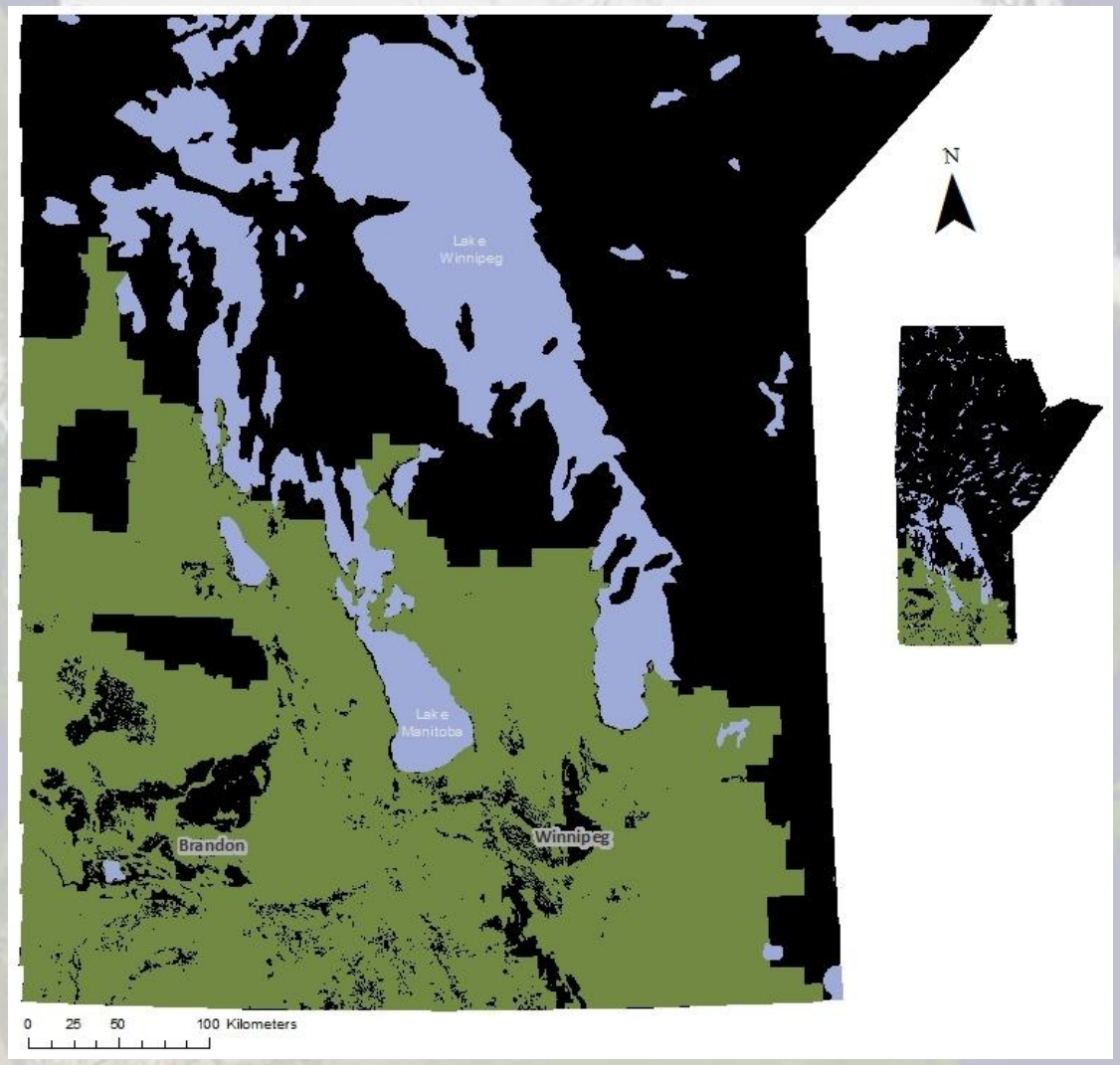
Areas satisfying the “non-recharge soil layers” criterion



Where to keep water on the land?

Minimum criteria for on-farm ponds

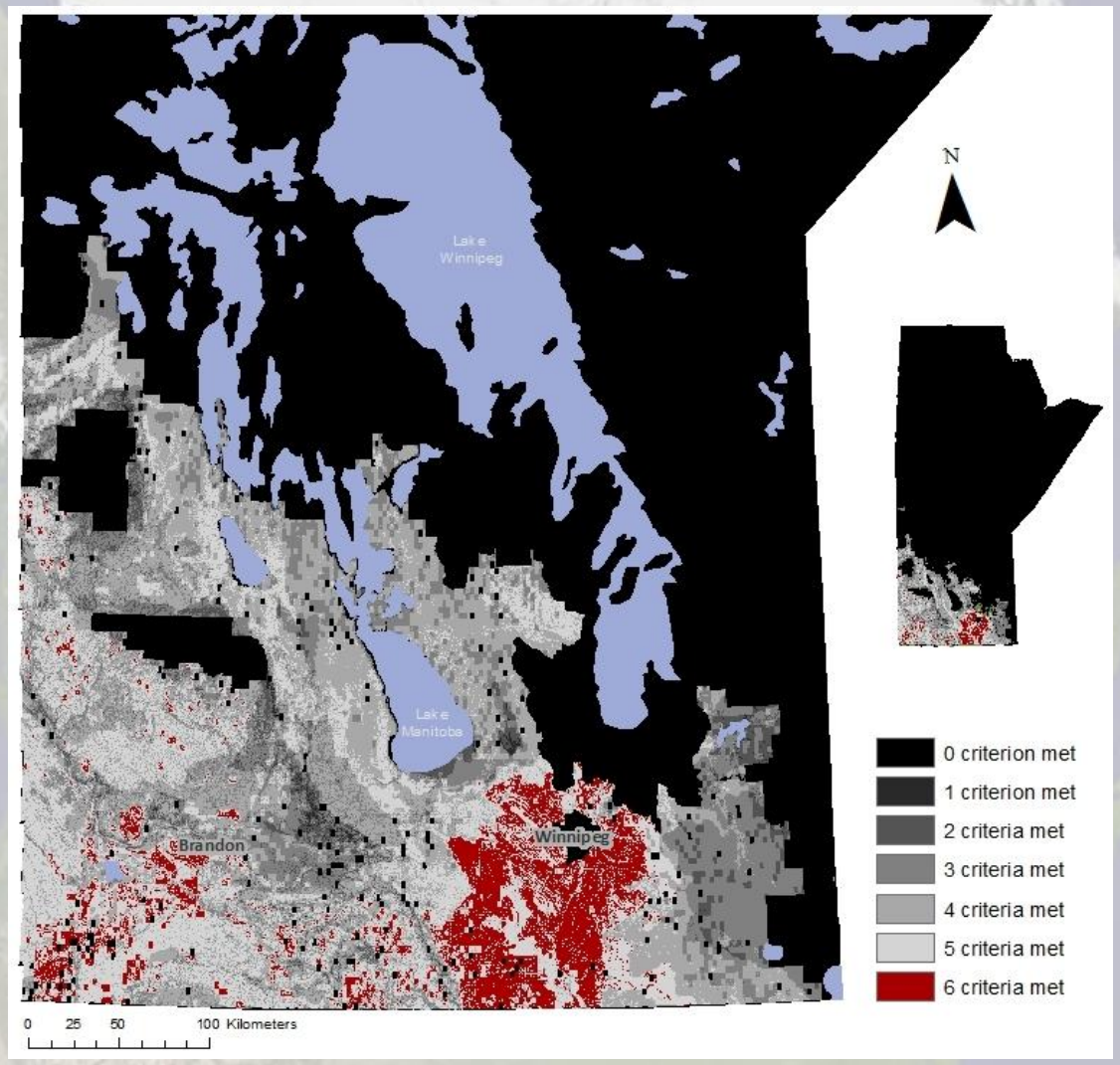
Areas satisfying the “low soil salinity” criterion



Where to keep water on the land?

Minimum criteria for on-farm ponds

"Final" spatial decision-making map



Where to keep water on the land?

The necessity of spatial modelling

Data compiled so far for the province:

- Elevation above sea level (DEM)
- Gross drainage area
- Non-contributing area (static, 2-year flood)
- Land use / land cover (LULC)
- Bedrock and surficial geology
- Local terrain slope, soil drainage category, soil salinity
- Erosion risk
- Growing degree days variables
- Monthly and annual P (rain, snow, total), PE, P-PE
- Natural drainage density (streams, rivers and major drains)
- Artificial drainage density (ditches)
- Flow and water level data at selected outflow points
- Water quality data at selected outflow points

Where to keep water on the land?

The necessity of spatial modelling

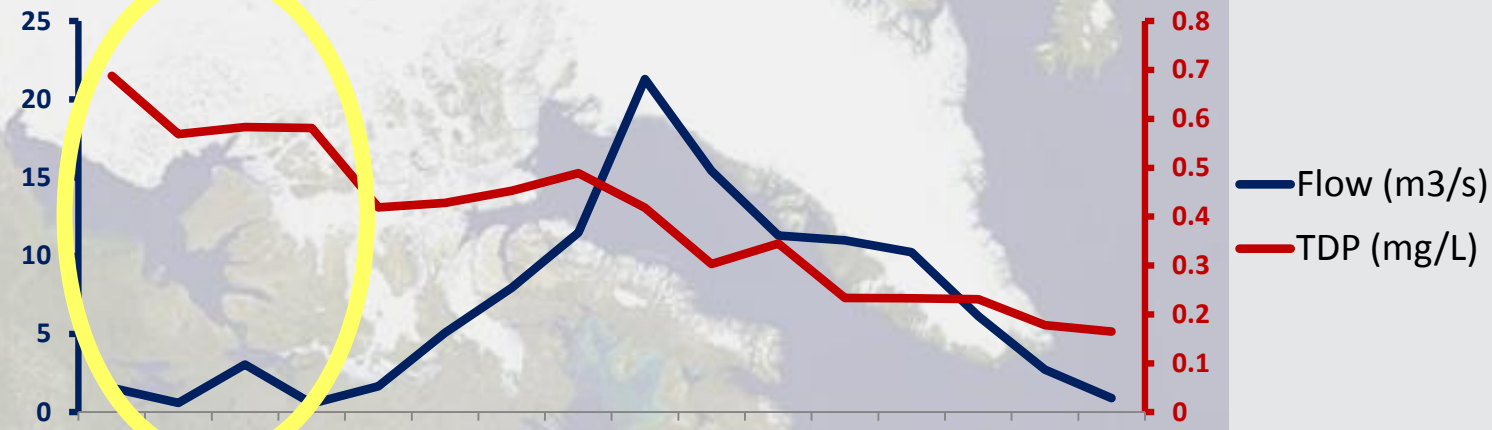
From the farm scale to the watershed scale:

- How many small water retention structures are needed in a watershed of a given size?
- Where should they strategically be located?

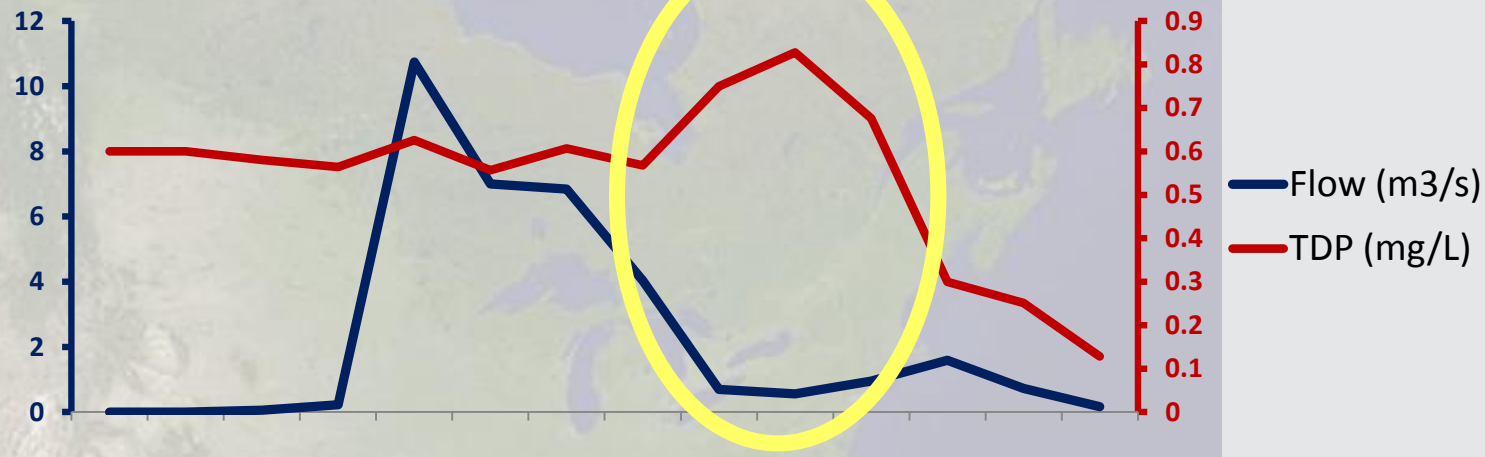
When to keep water on the land?

Rising or falling hydrograph?

Miami, MB
Spring 2009



Miami, MB
Spring 2004



When to keep water on the land?

Detention versus retention?

- **Detention option:**
  - Water is stored temporarily then released downstream
  - Challenge: identifying timing of storage and release
- **Retention option**
  - Water is stored and re-used on farm with no downstream release
  - Potential issues: enough flow for downstream recharge and environmental flow requirements?

Next steps

- **Feasibility study just completed**
  - How, where and when questions (and others) formulated
- **Selection of contrasted, research-intensive pilot sites under way**
  - Testing different designs
  - Monitoring water movement and water quality
- **Inventory of water storage structures already (or soon to be) in place in progress**
  - Getting a better idea of why people want to store water
  - Providing guidance to measure “before” and “after” conditions

Take-home messages

- **Keeping water on the land ≠ flooding land**

- Managing runoff by storing and/or re-using water might be the **only available solution for tackling all water issues simultaneously**

- **Location might be more critical than design parameters**

- **Several questions without answers**
  - Field-intensive research is needed
  - Until research results are known, proceed with caution


Thank you!
Watershed Systems
Research Program
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Where to keep water on the land?

The necessity of spatial modelling

Suitability criteria are highly variable for different water storage options. For example:

- **For expanded ditches**:

  Same criteria as on-farm ponds

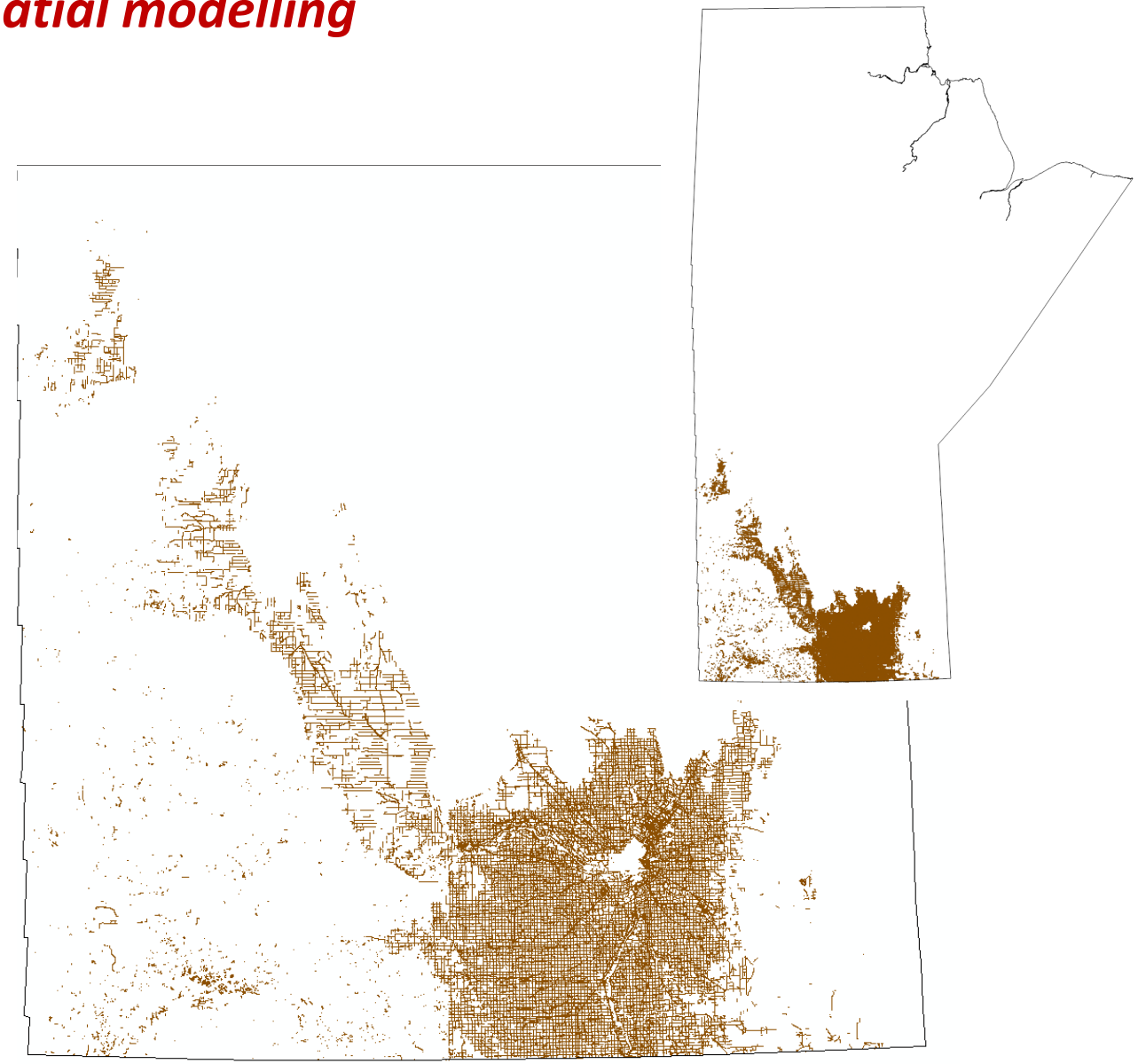
  +

  Focus has to be on terminal ditches

Where to keep water on the land?

The necessity of spatial modelling

MB ditch network



Where to keep water on the land?

The necessity of spatial modelling

Suitability criteria are highly variable for different water storage options. For example:

- **For unaltered/restored wetlands**:

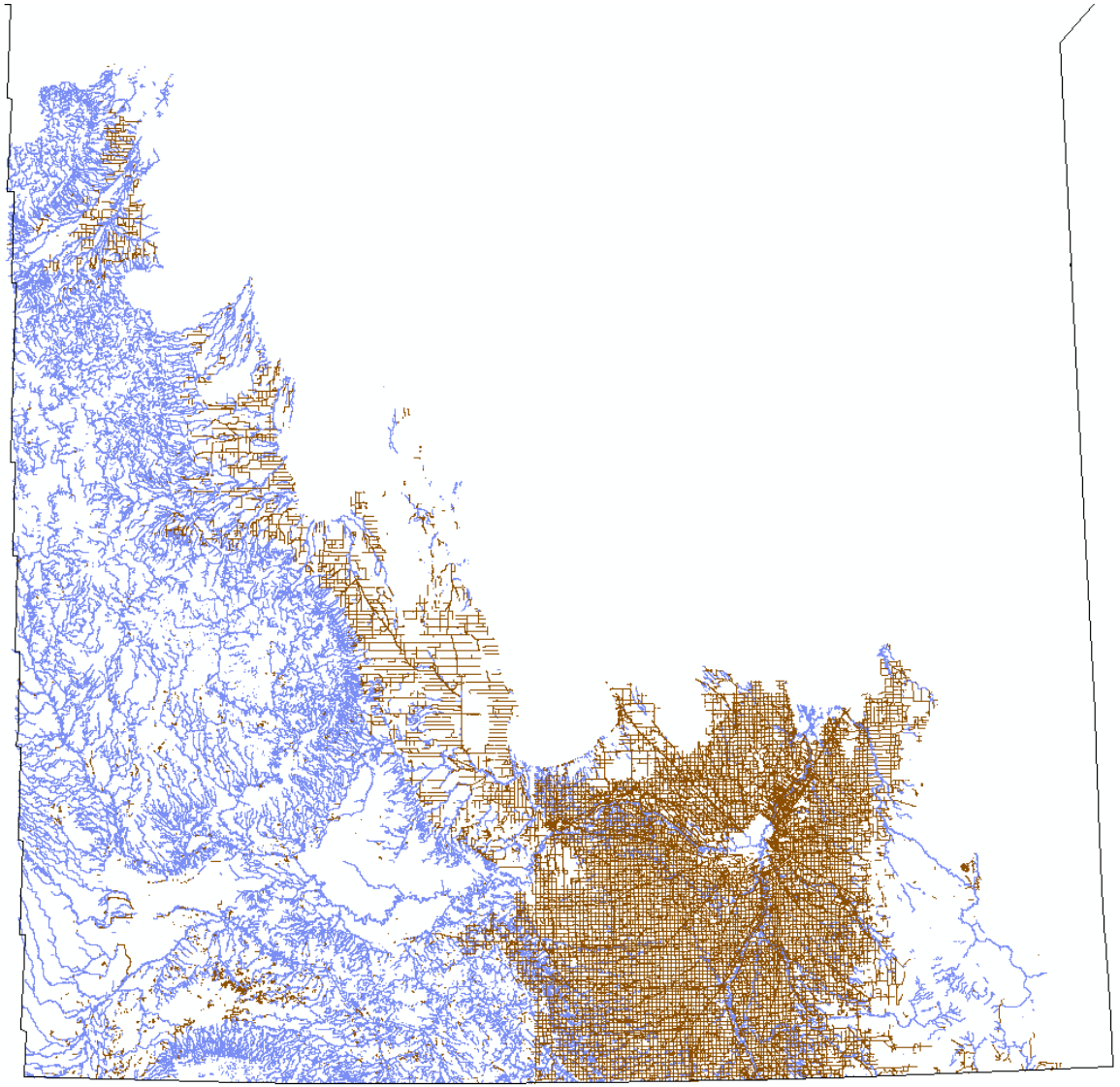
  Wetlands within certain distance of ditches and natural waterways could be focused on in priority

Where to keep water on the land?

The necessity of spatial modelling

MB stream network

MB ditch network



Where to keep water on the land?

The necessity of spatial modelling

Suitability criteria are highly variable for different water storage options. For example:

- **For unaltered/restored wetlands**:

  Wetlands with a dependence flow path longer than their influence flow path could be focused on in priority

Where to keep water on the land?

The necessity of spatial modelling

Dependence map: shows which uphill/upstream locations drain through a particular wetland.

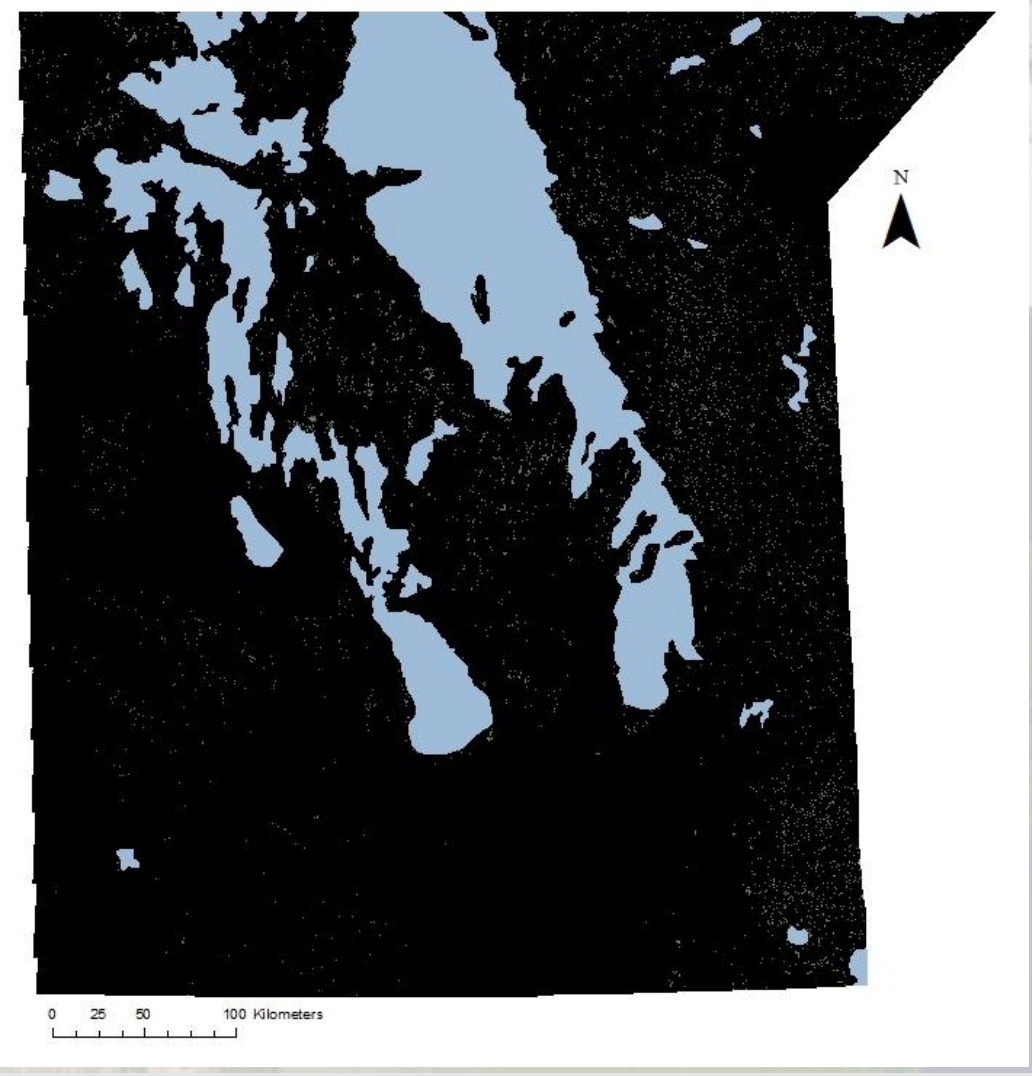
Influence map: shows where water starting from a particular wetland will drain.

High-resolution elevation data (LiDAR) needed to make accurate spatial predictions

Where to keep water on the land?

The necessity of spatial modelling

Wetlands with dependence > influence



Where to keep water on the land?

The necessity of spatial modelling

Drainage potential