Geoscience, Faculty of Science

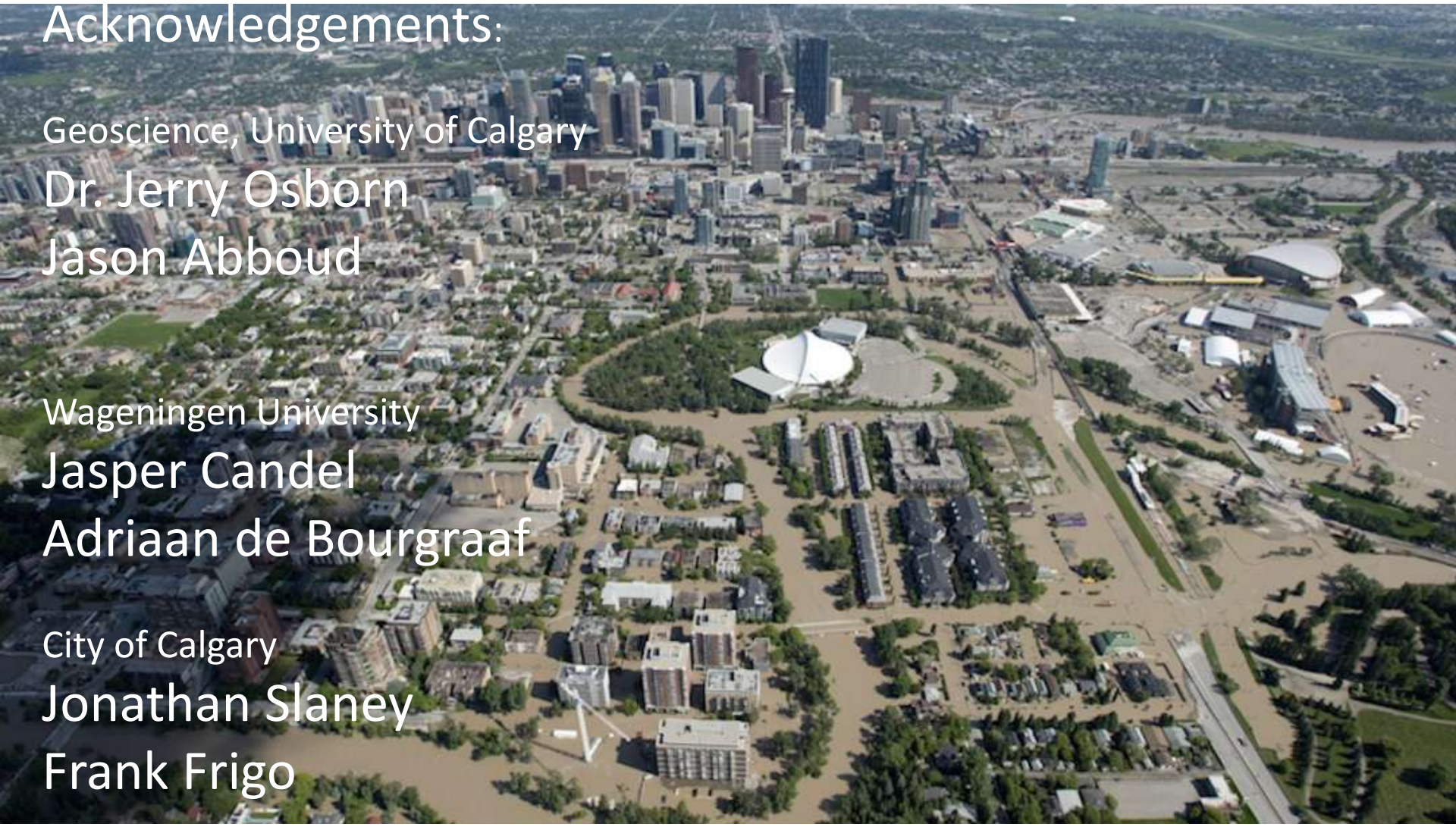
The Role of Groundwater in Flooding

Cathy Ryan

Professor, P.Eng., P.Geol.

ICLR, Toronto
September 24, 2014

- River flooding and prediction
- Flood mapping in Calgary
- Groundwater and monitoring wells
- Groundwater flooding in Calgary
- Summary comments



Acknowledgements:

Geoscience, University of Calgary

Dr. Jerry Osborn

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Adriaan de Bourgraaf

City of Calgary

Jonathan Slaney

Frank Frigo


3 ST NW

4th St. SW

www.ctvnews.ca

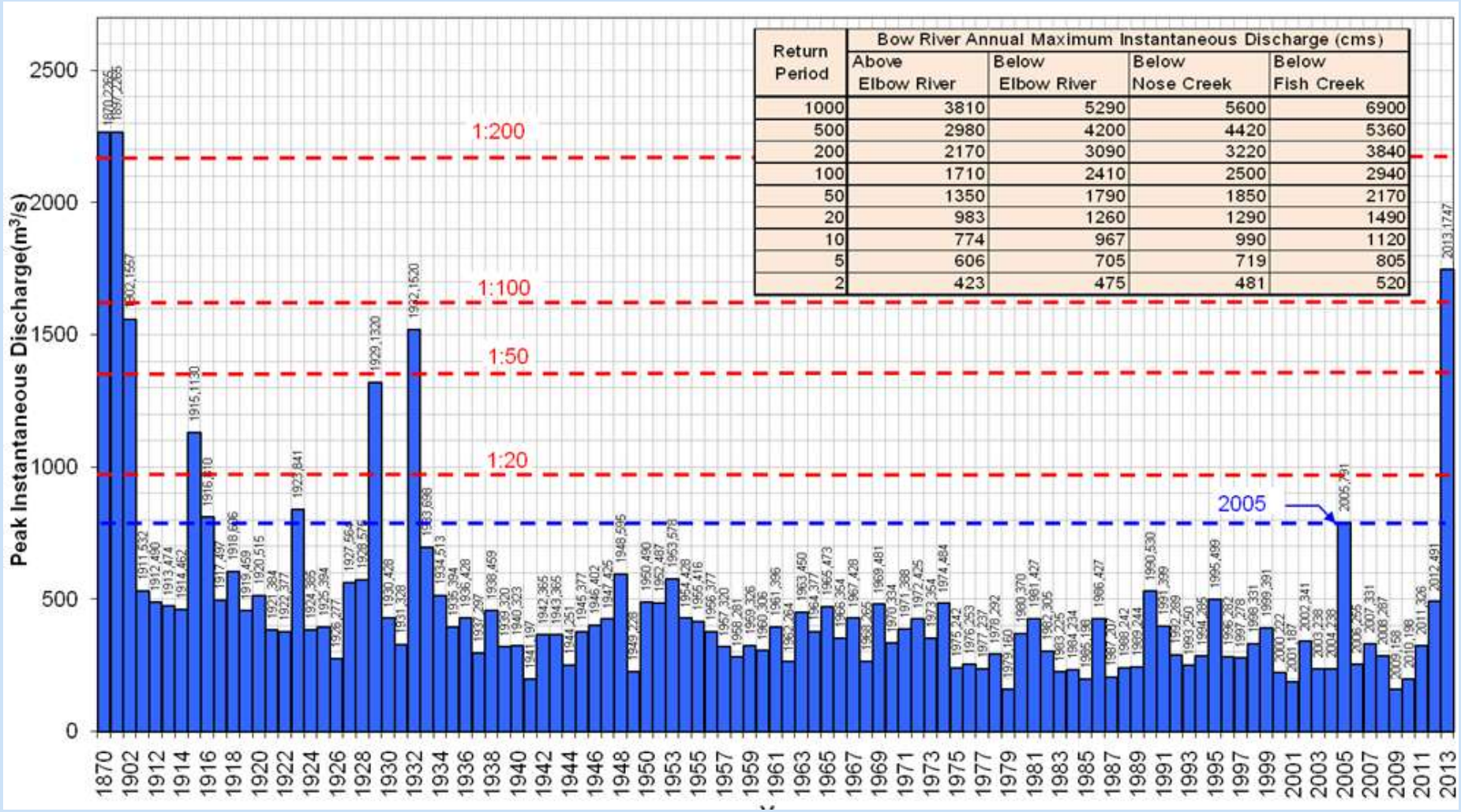
www.ctvnews.ca

www.windsorstar.com/news/Gallery+stunning+photos+from+flooded+Calgary/9218651/story.html


Elbow at Highway 66 Bridge


Bow River in Inglewood upstream of Bird Sanctuary

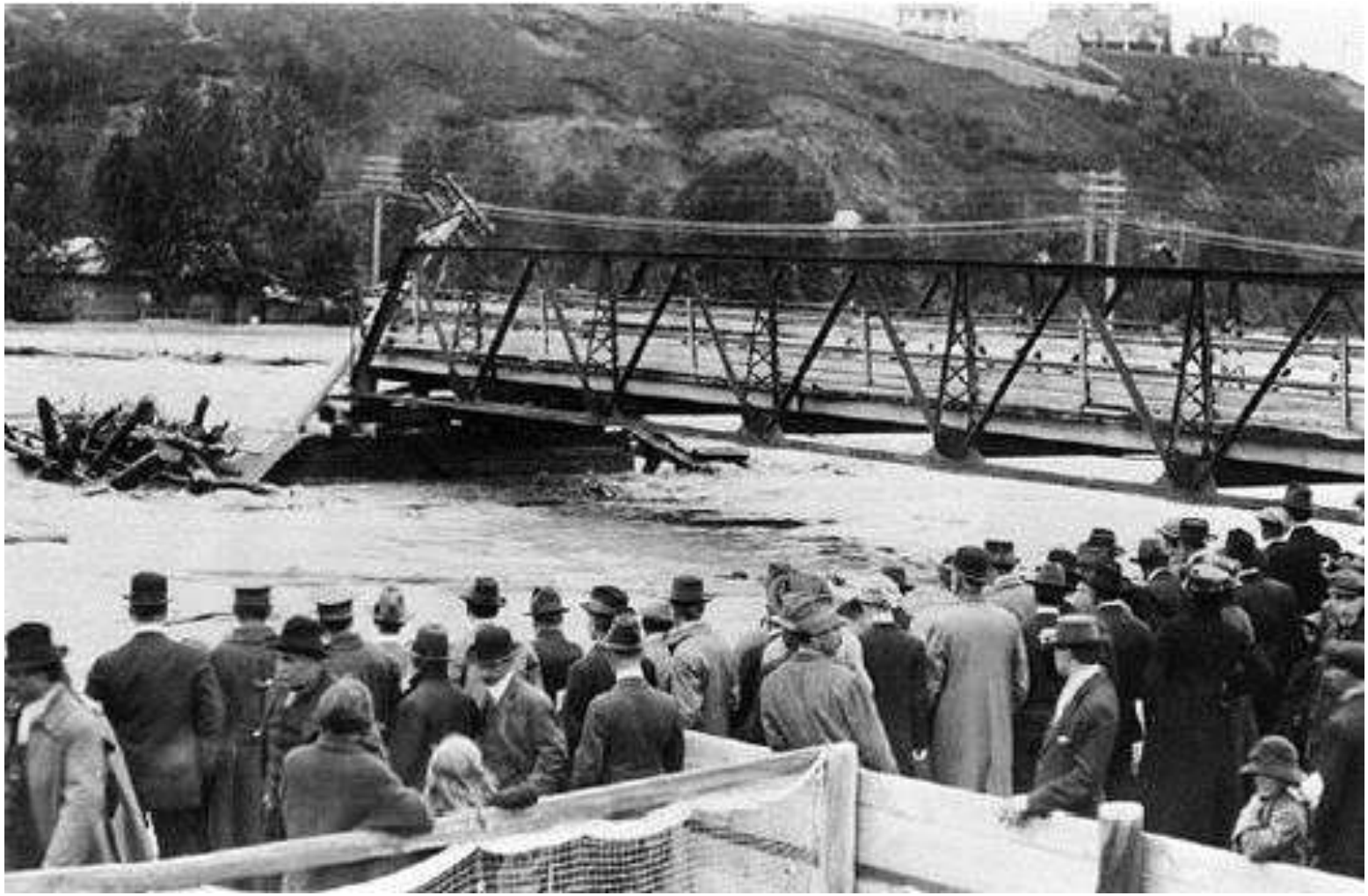
Past Flood Events – Bow @ Calgary



Return Period	Bow River Annual Maximum Instantaneous Discharge (cms)			
	Above Elbow River	Below Elbow River	Below Nose Creek	Below Fish Creek
1000	3810	5290	5600	6900
500	2980	4200	4420	5360
200	2170	3090	3220	3840
100	1710	2410	2500	2940
50	1350	1790	1850	2170
20	983	1260	1290	1490
10	774	967	990	1120
5	606	705	719	805
2	423	475	481	520

1897, South bank of Bow River

1915, old Center St. Bridge



THE WEATHER

THE CALLGARY DAILY HERALD

5 O'CLOCK EDITION

CALGARY, ALBERTA, MONDAY, JUNE 3, 1929

22 PAGES

HUNDREDS OF CITY HOMES MENACED BY RIVERS

Baldwin Gov't Votes to Hand In Resignation

MacDONALD TO AGAIN TRY MINORITY GOV'T

Ghost River Dam Menaced by Floods

Worst Floods Since '02 Ravage Calgary And South Districts

Rivers Still Rising On Monday Afternoon

Twenty-Fifth Avenue Bridge Is Washed Out

Two Streams Pouring Flood Waters Over Big Sections of the City

THE SITUATION AT A GLANCE

Swollen Highwood Flowing Through High River Streets

Livestock Being Carried Down Stream

KING'S BIRTHDAY OBSERVED QUIETLY

HEAVIEST RAIN IN YEARS STRIKES SOUTHERN ALBERTA

SEVEN SEATS STILL IN DOUBT; LABOR HOLDS SAFE LEAD

The Day in Parliament

CANADA CONVEYS CONGRATULATIONS TO KING GEORGE

King George Sixty-Four; Ill in Bed

Bow and Elbow Rivers Continue to Rise Far Above Danger Levels

The Weather

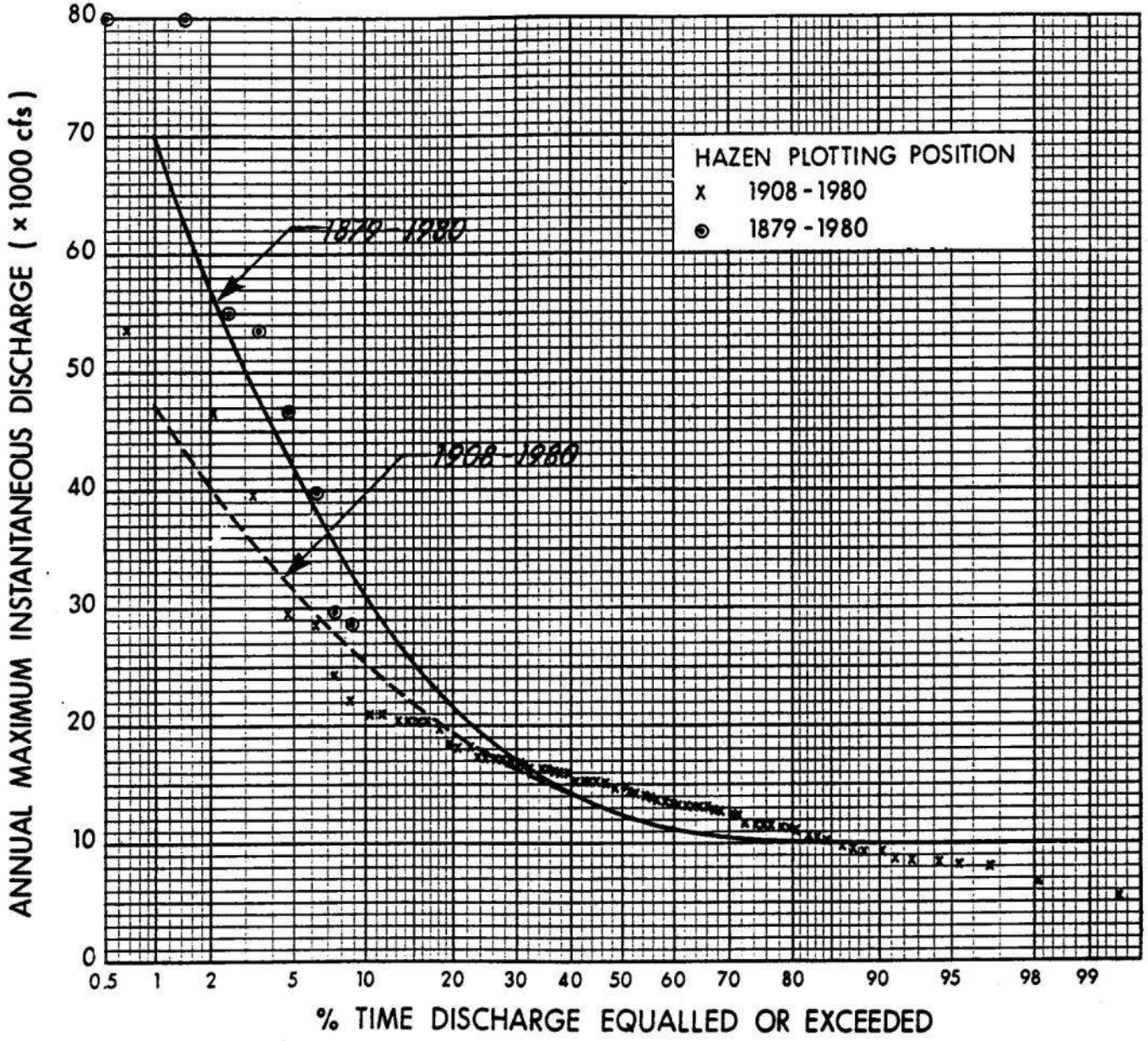
SHOWERY

1929

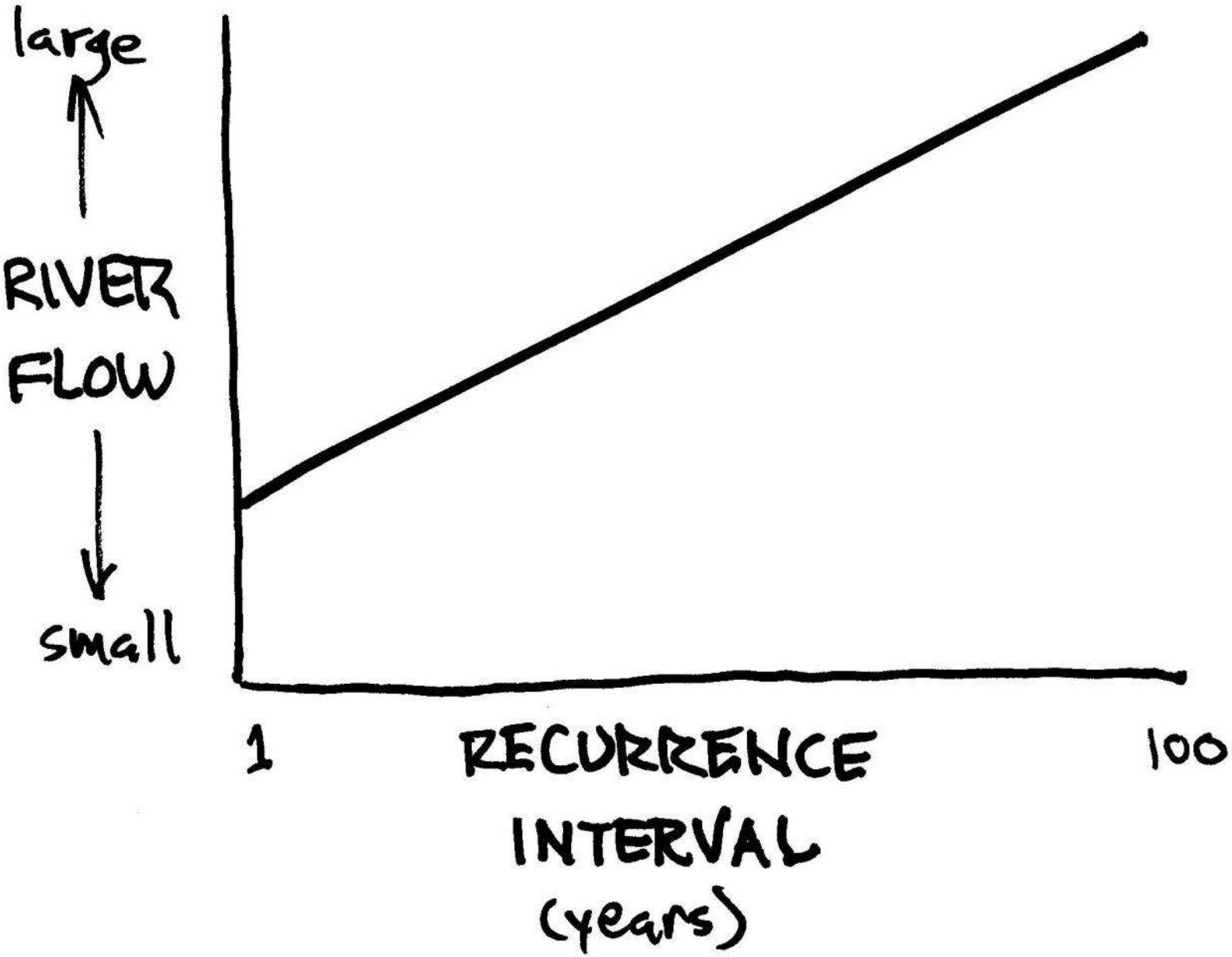
www.rightnow.io/breaking-news/waterton-abstorm-waterton-lakes-national-park_bn_1371688987055.html

1932: Memorial Drive

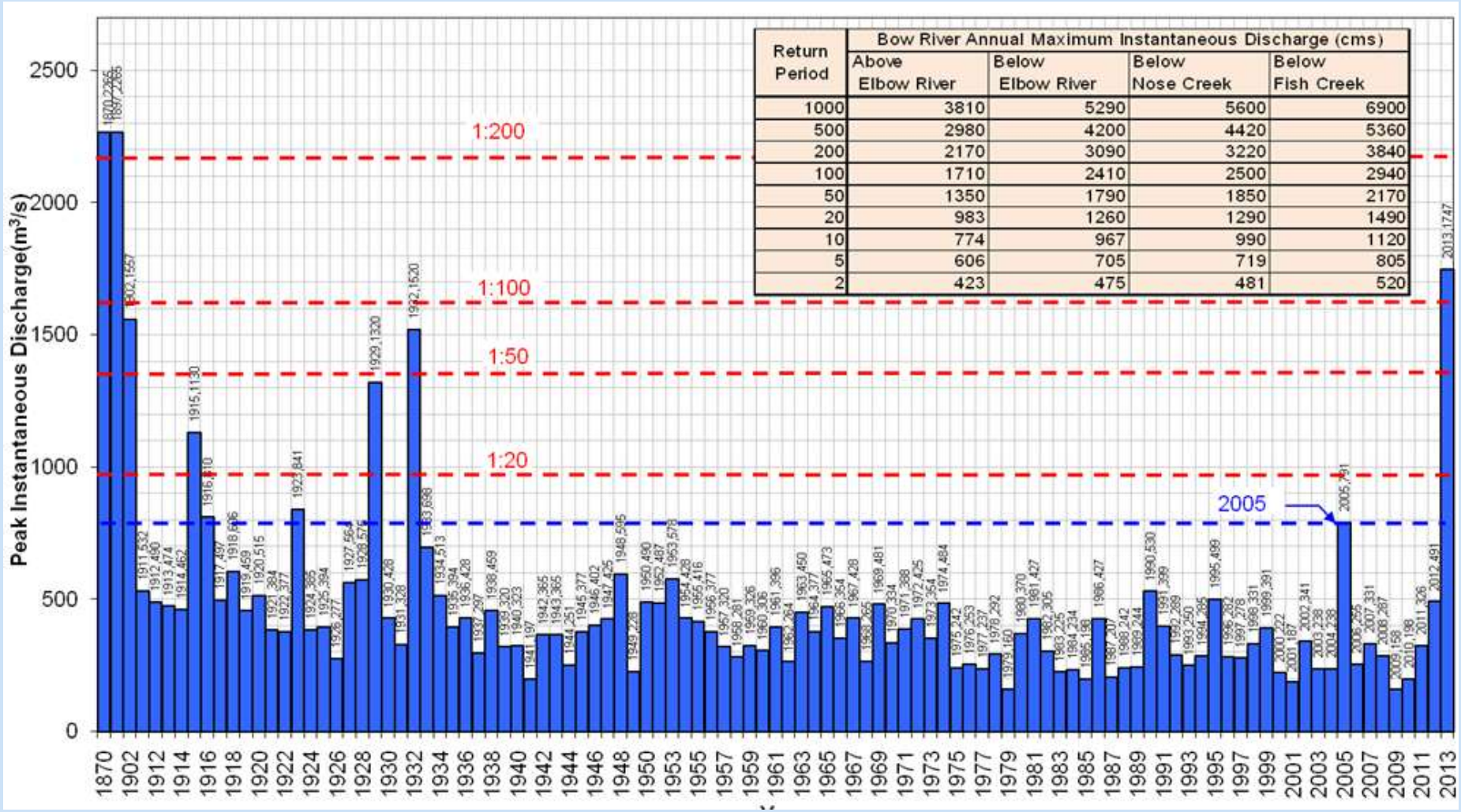
1932: Sunnyside



Alberta Environment, Calgary Floodplain Study, 1983


large
RIVER FLOW
small
1
RECURRENCE INTERVAL (years)
100

Past Flood Events – Bow @ Calgary



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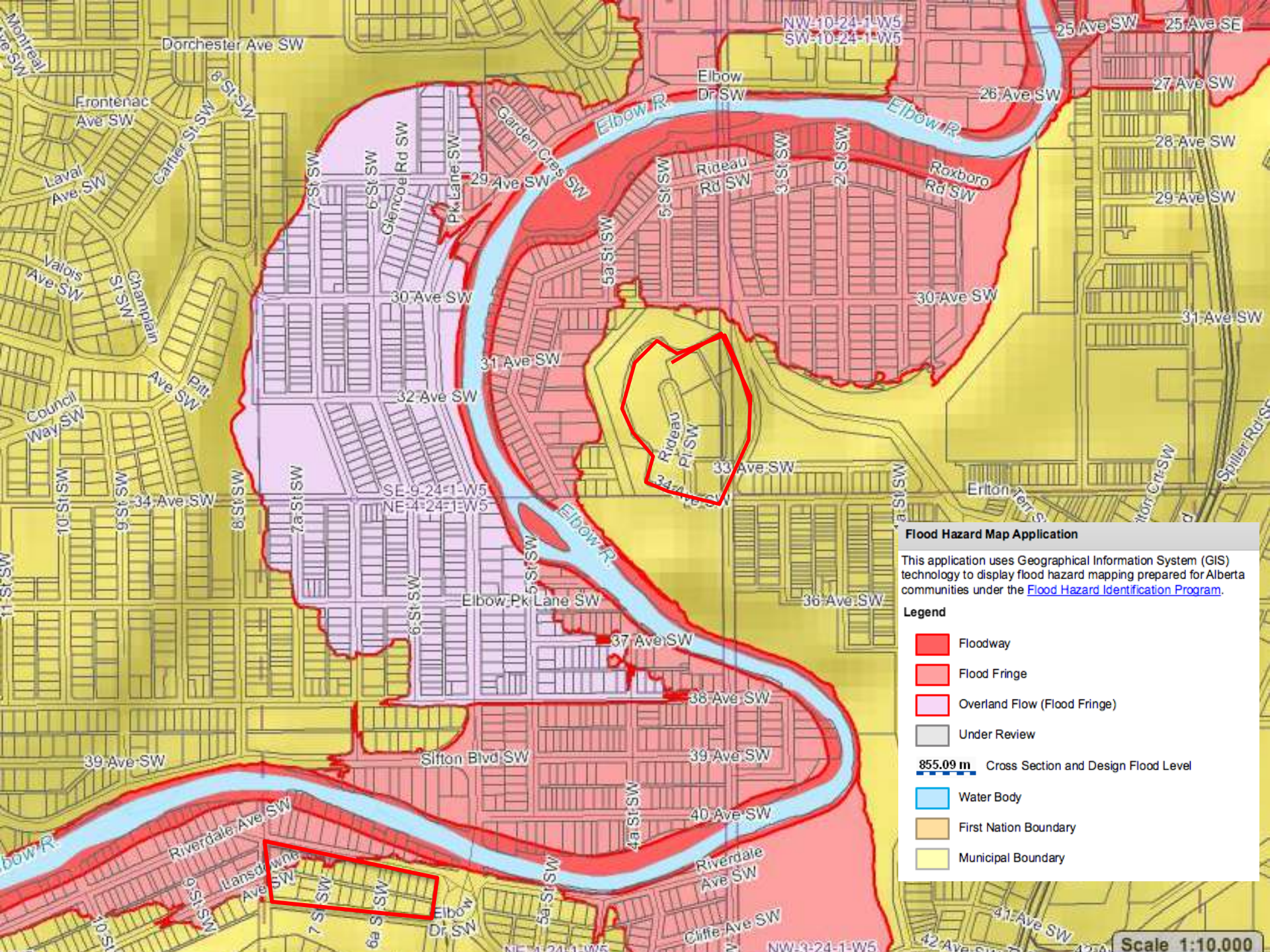
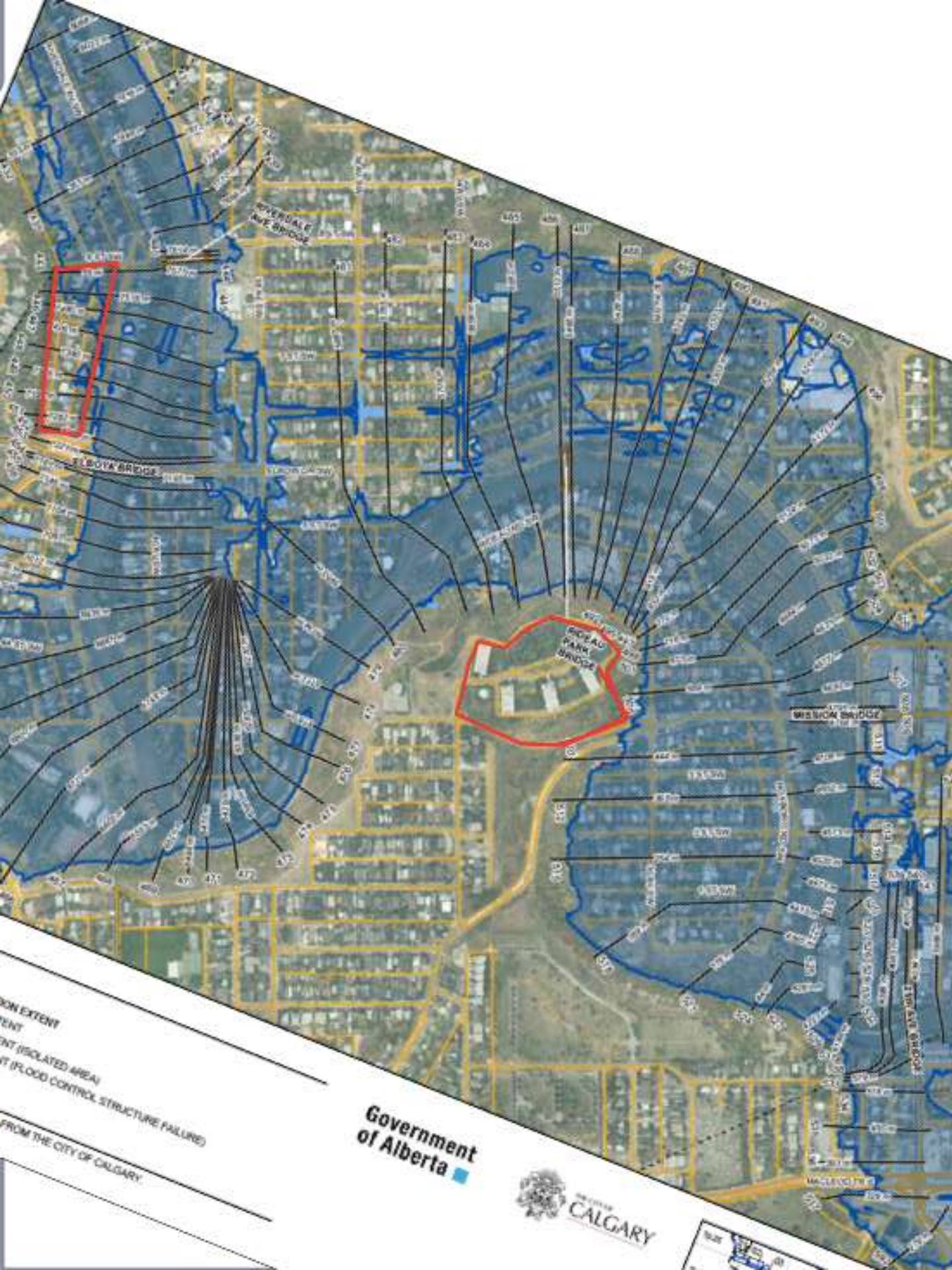

Flood Hazard Map Application
This application uses Geographical Information System (GIS) technology to display flood hazard mapping prepared for Alberta communities under the Flood Hazard Identification Program.
Legend
Floodway
Flood Fringe
Overland Flow (Flood Fringe)
Under Review
855.09 m
Cross Section and Design Flood Level
Water Body
First Nation Boundary
Municipal Boundary
Scale 1:10,000
Elbow R.
Elbow Dr SW
Dorchester Ave SW
Frontenac Ave SW
Laval Ave SW
Cartier St SW
Garden Cres SW
Glencoe Rd SW
Pk Lane SW
29 Ave SW
Rideau Rd SW
Roxboro Rd SW
25 Ave SW
25 Ave SE
26 Ave SW
27 Ave SW
28 Ave SW
29 Ave SW
30 Ave SW
31 Ave SW
32 Ave SW
33 Ave SW
34 Ave SW
36 Ave SW
37 Ave SW
38 Ave SW
39 Ave SW
40 Ave SW
41 Ave SW
42 Ave SW
Rideau Pl SW
Valois Ave SW
Champlain St SW
Pitt Ave SW
Council Way SW
Elbow Pk Lane SW
Slfton Blvd SW
Riverdale Ave SW
Riverdale Ave SW
Cliffe Ave SW
Elbow Dr SW
Erlton
Spiller Rd SE
NW-10-24-1-W5
SW-10-24-1-W5
SE-9-24-1-W5
NE-4-24-1-W5
NW-3-24-1-W5


RIVERDALE AVE BRIDGE
ELBOYA BRIDGE
CROWCHILD TRAIL BRIDGE
CROWCHILD TRAIL
MACLEOD TRAIL
ON EXTENT
ENT
NT (ISOLATED AREA)
T (FLOOD CONTROL STRUCTURE FAILURE)
FROM THE CITY OF CALGARY
Government of Alberta
CALGARY

No flood insurance without new maps

Study surveyed senior executives at 13 Canadian insurance firms on extreme flooding

The Canadian Press Posted: Sep 15, 2013 1:05 PM MT | Last Updated: Sep 15, 2013 1:05 PM MT

"The big cost now ... is flooding basements, by a country mile," said Feltmate. "So it's really high on their radar screen."

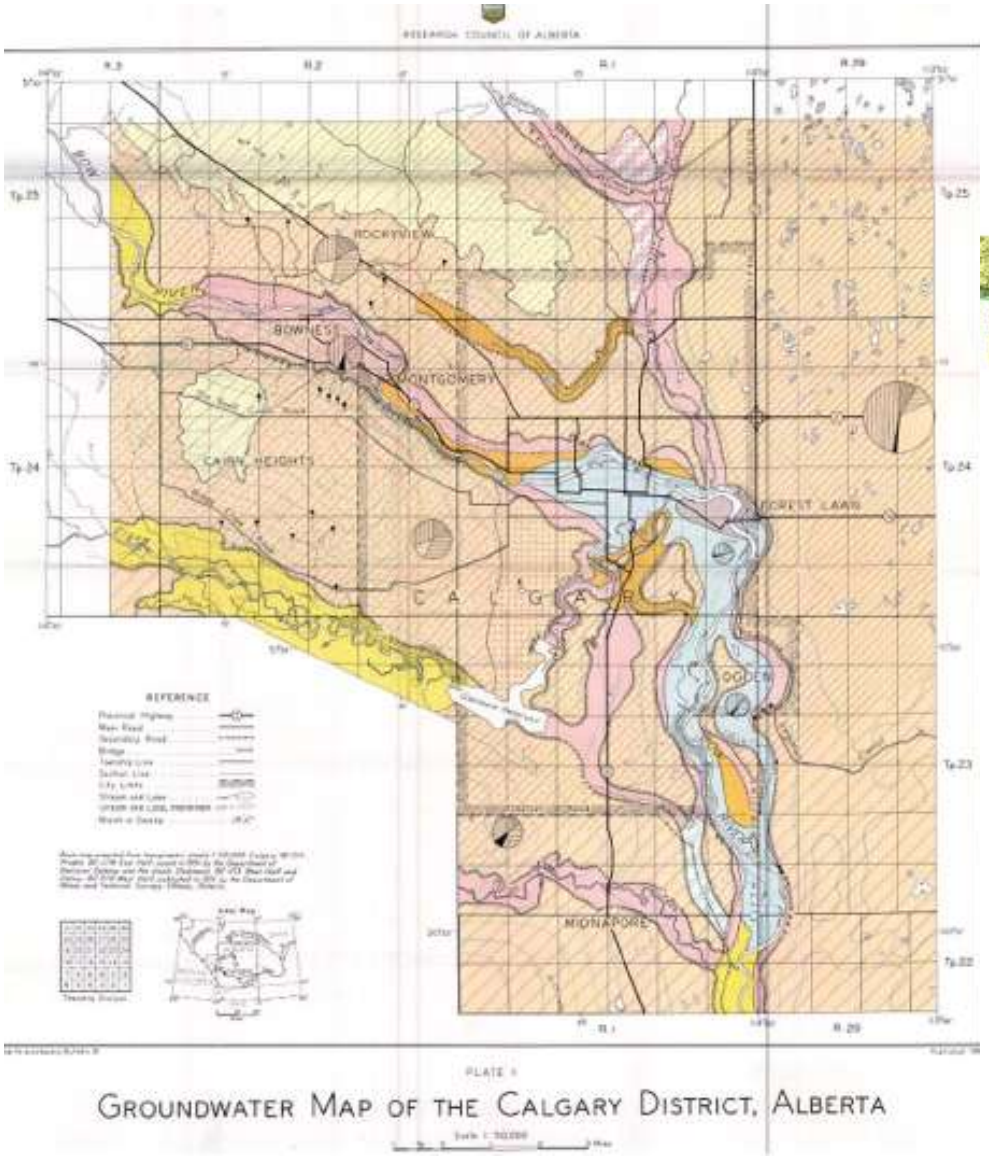
Canada has seen 289 flood disasters since 1900, the largest such category, more than the number of hail, wildfire and winter storm disasters combined in the same period.

Floods are expensive. The southern Alberta floods last summer are estimated to have cost private insurers $2.25 billion, even though damage to residences was generally not covered.

To my knowledge, no river flooding maps consider groundwater

Flood maps and….

Groundwater Resources in the Calgary Area (Meyboom, 1961)



GROUNDWATER MAP OF THE CALGARY DISTRICT, ALBERTA

www.sustainablecalgary.ca

Typical vertical cross-section

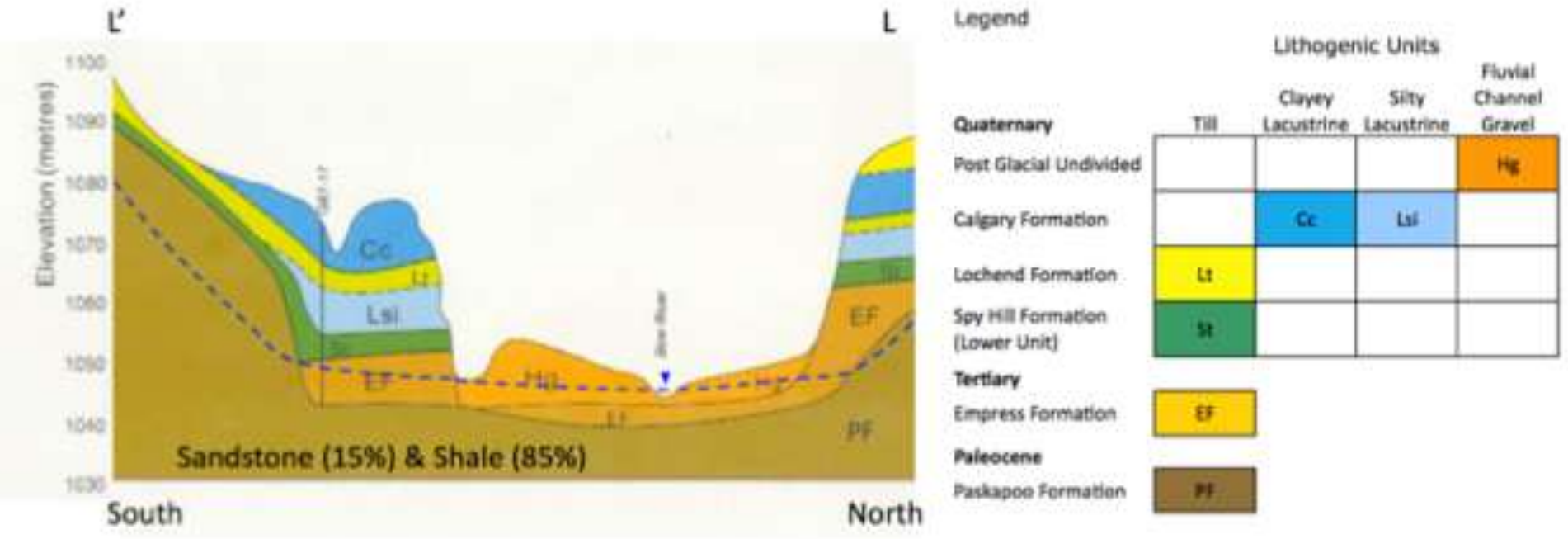
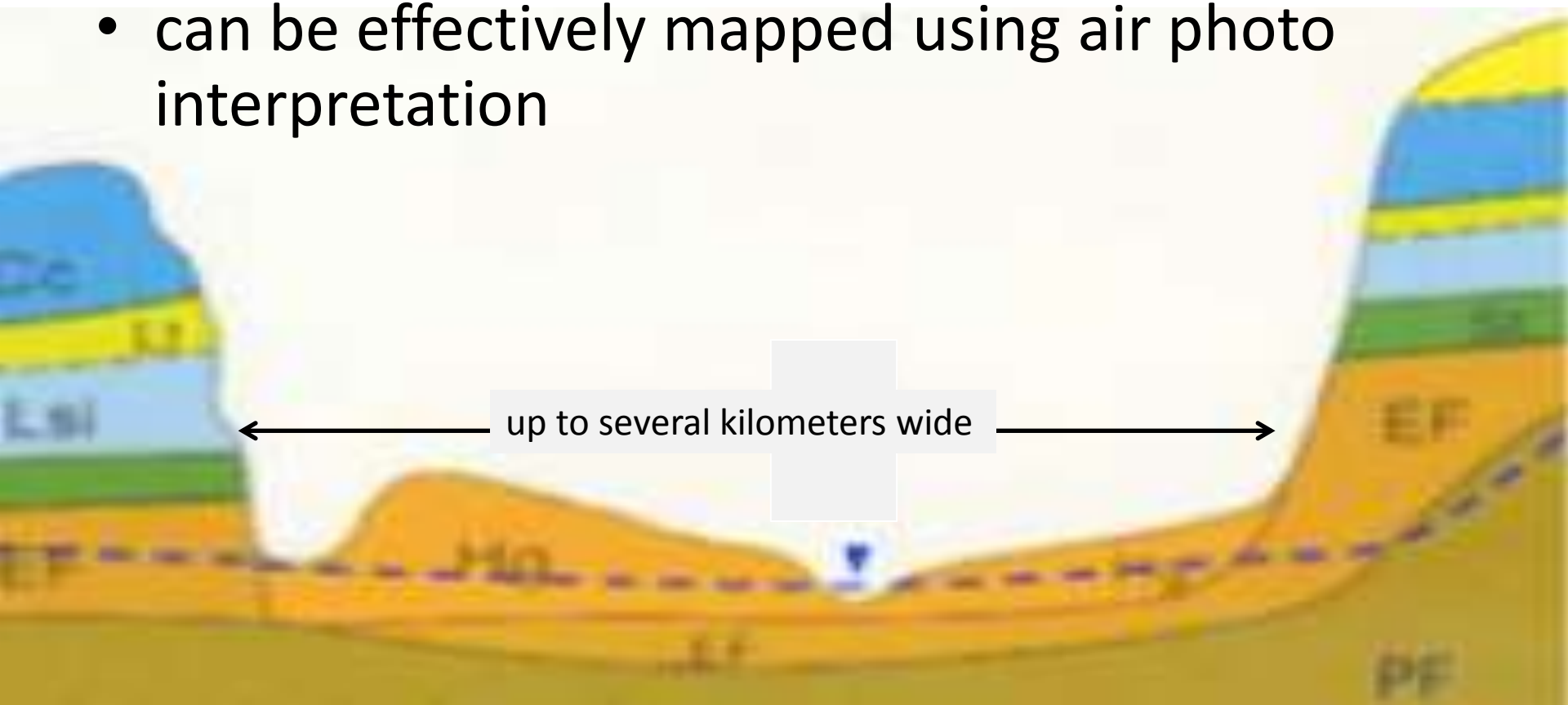


Figure 3) Cross section L to L' across the Bow River Valley. Alluvial aquifer sand and gravel sediments deposited by the post-glacial and modern Bow River are shown in orange. The alluvial valley sediments are overlain by glacial and lacustrine clays, subsequently eroded by the Bow River. The underlying bedrock is the sandstone and shale Paskapoo Formation (brown), which was also eroded by the glacial Bow River. Adapted from Moran (1986).

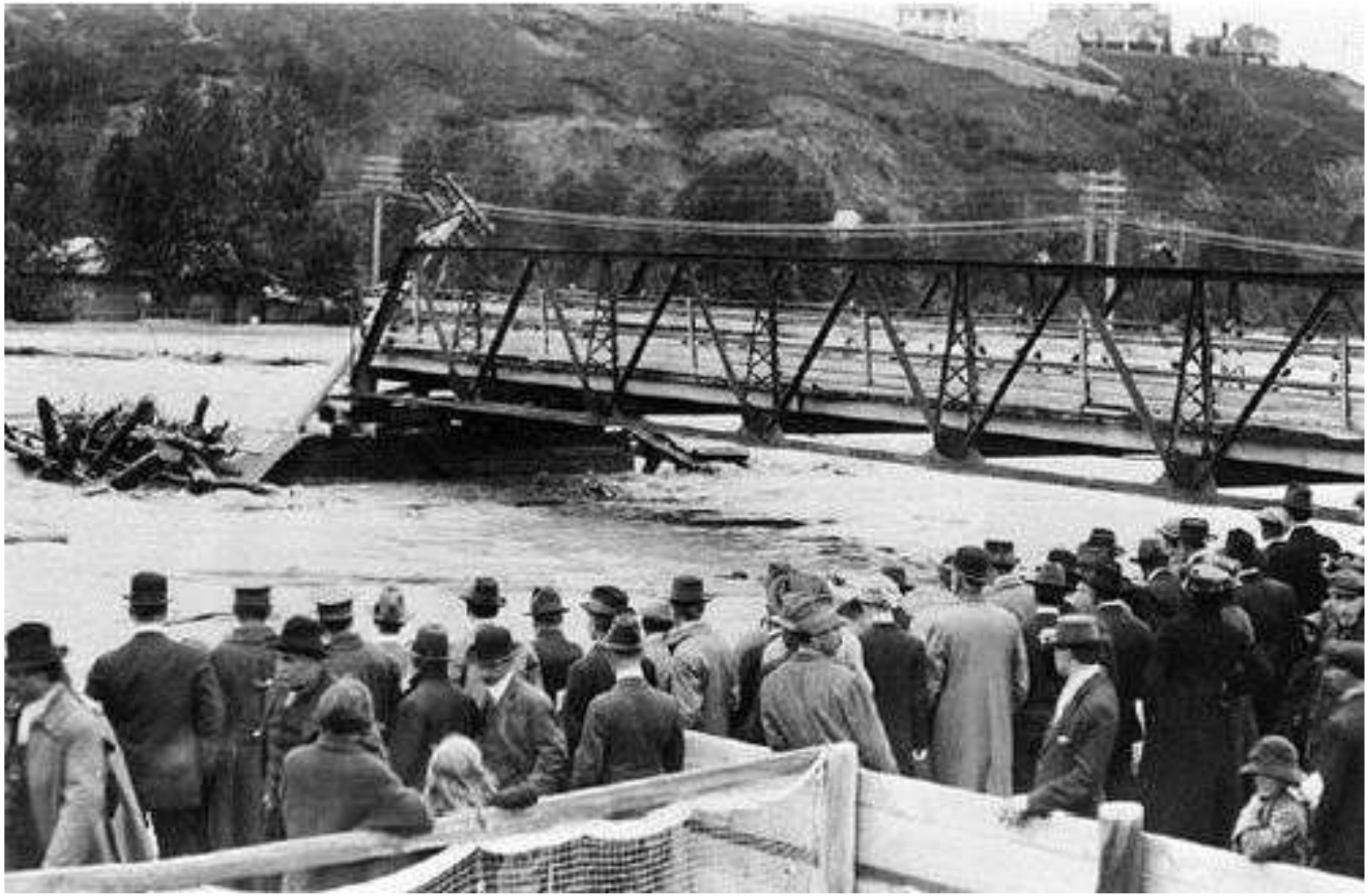
Cantafio, 2012

Alluvial aquifers

- river-deposited, under and beside river
- highly permeable (esp. in upper reaches) *'lattice-like'; stream insects found up to 2 km away from river (Ward and Stanford, 1988)*
- can be effectively mapped using air photo interpretation



1915, old Center St. Bridge



Escarpment beside alluvial aquifer

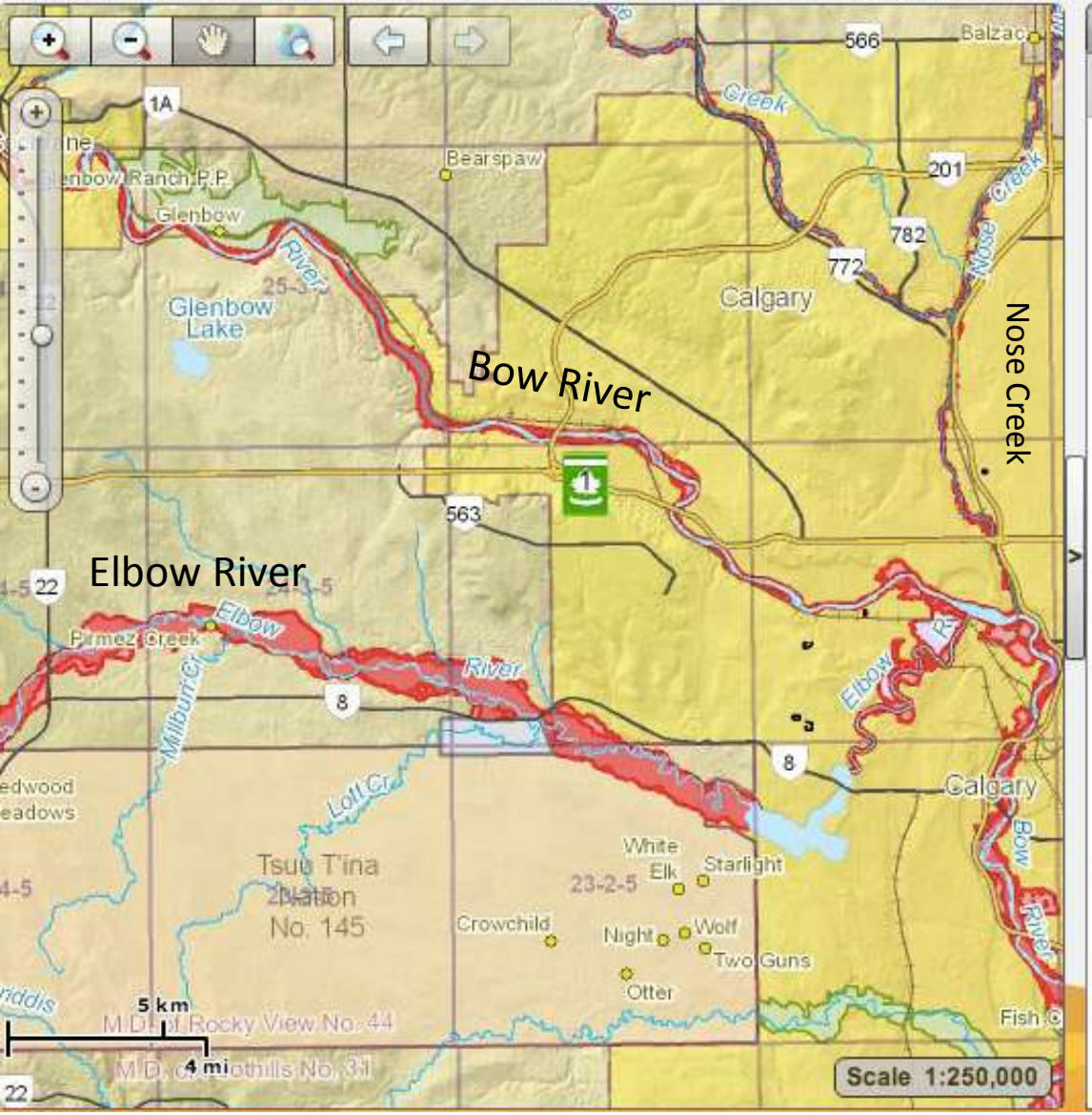
Escarpment beside alluvial aquifer

Get trail-fit without leaving town

CALGARY - Prepare for spring days in the Rockies by hiking in the hills and stairs in town now.

BY THE CALGARY HERALD APRIL 10, 2008

Carrie P.



Introduction | Find | Measure | Print

Flood Hazard Map Application

This application uses Geographical Information System (GIS) technology to display flood hazard mapping prepared for Alberta communities under the Flood Hazard Identification Program.

Legend

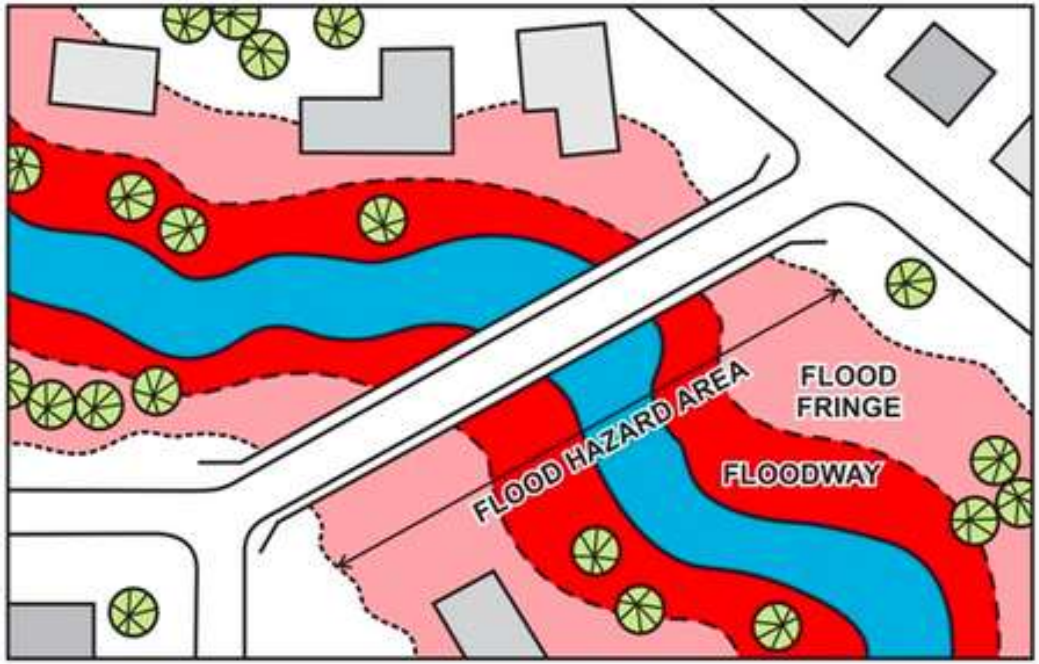
- Floodway
- Flood Fringe
- Overland Flow (Flood Fringe)
- Under Review
- 855.09 m — Cross Section and Design Flood Level
- Water Body
- First Nation Boundary
- Municipal Boundary

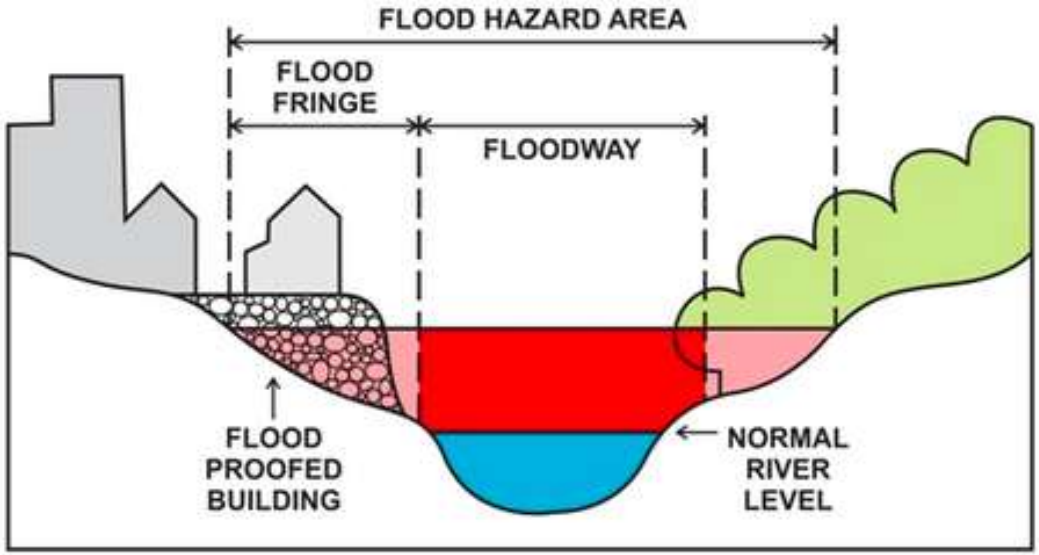
Limitations

Flood hazards have not been identified in all communities and may exist in areas without flood hazard mapping. New mapping will be added to the application when available.

Flood hazard areas and design flood levels are based on a design flood under encroachment conditions. The current design flood standard in Alberta is the 100-year flood, determined when a flood hazard study is undertaken. Encroachment conditions assume a future scenario when the flood fringe is fully developed.

Alberta flood mapping





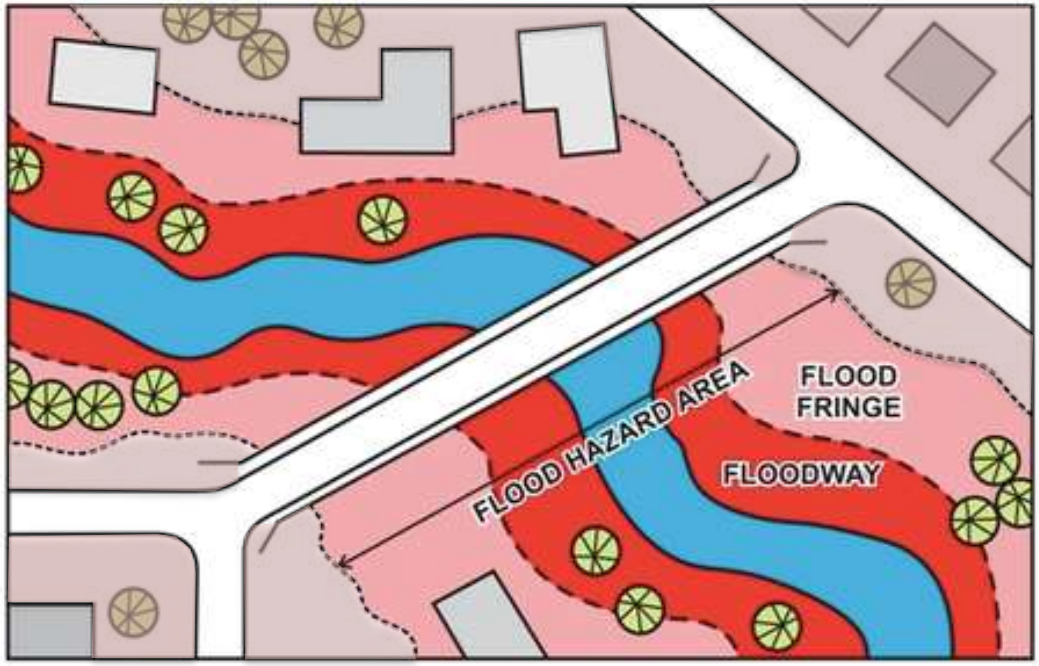
Flood Hazard Area: The flood hazard area is typically divided into floodway and flood fringe zones and may also include areas of overland flow.

Floodway: The portion of the flood hazard area where flows are deepest, fastest and most destructive. The floodway typically includes the main channel of a stream and a portion of the adjacent overbank area. New development is discouraged in the floodway.

Flood Fringe: The portion of the flood hazard area outside of the floodway. Water in the flood fringe is generally shallower and flows more slowly than in the floodway. New development in the flood fringe may be permitted in some communities and should be flood proofed.

Overland Flow: Areas of overland flow are part of the flood hazard area outside of the floodway, and are typically considered special areas of the flood fringe.

Alberta flood mapping



We need a new Area:

Groundwater Flood Hazard Area: Region where basement flooding by groundwater inundation is likely to occur.

Flood Hazard Area: The flood hazard area is typically divided into floodway and flood fringe zones and may also include areas of overland flow.

Floodway: The portion of the flood hazard area where flows are deepest, fastest and most destructive. The floodway typically includes the main channel of a stream and a portion of the adjacent overbank area. New development is discouraged in the floodway.

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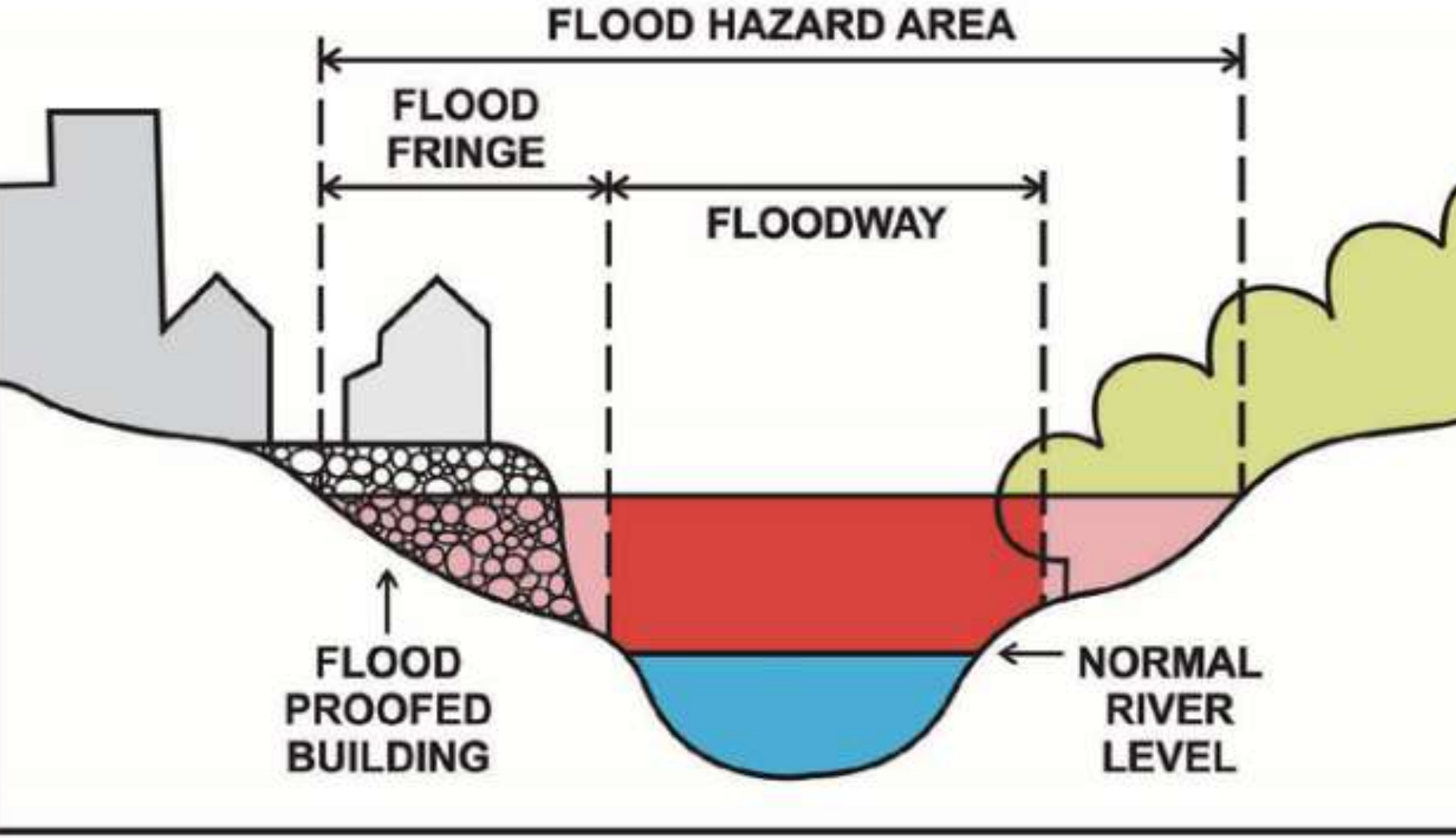
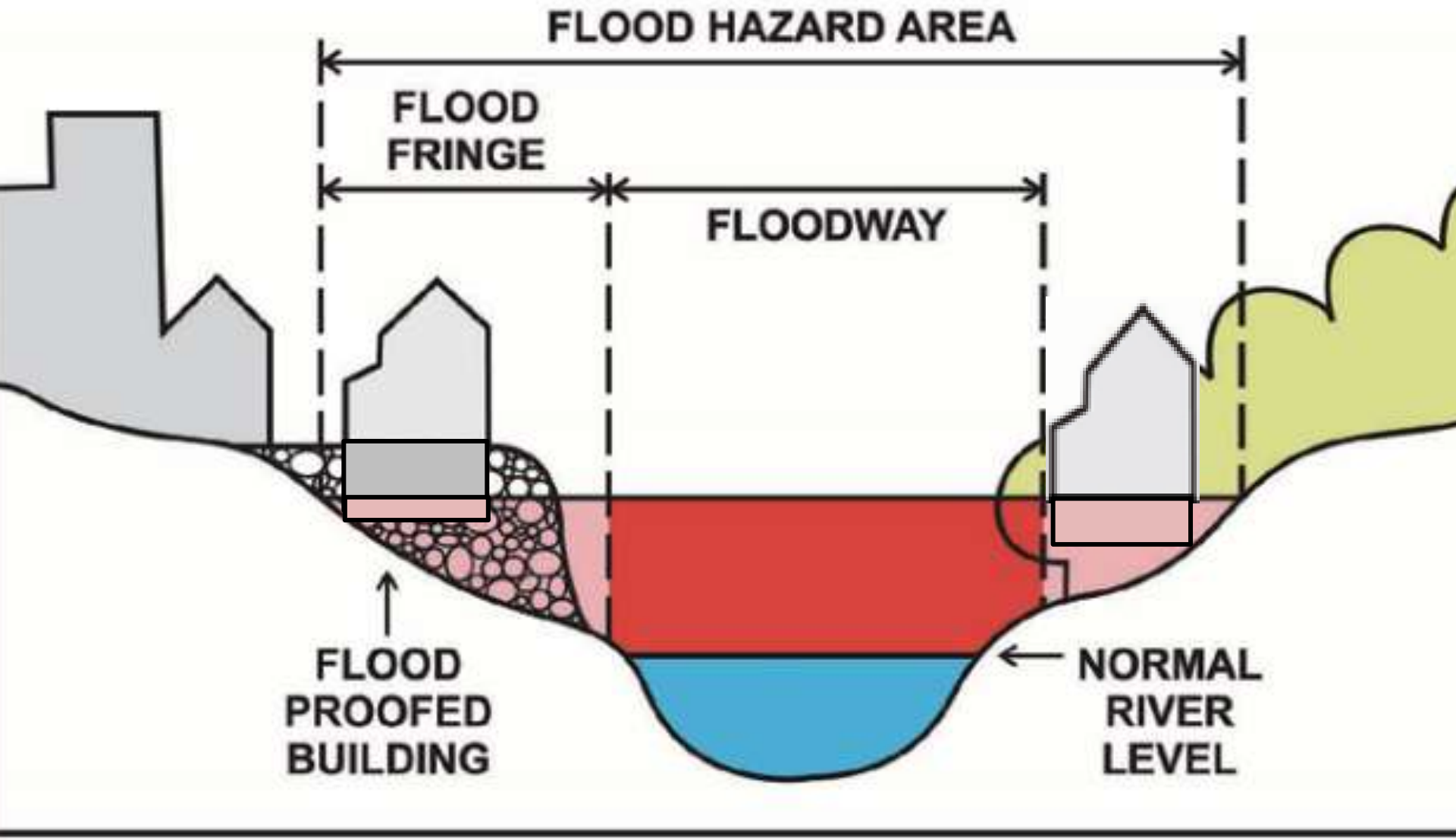


Alberta flood mapping



- River flooding and prediction
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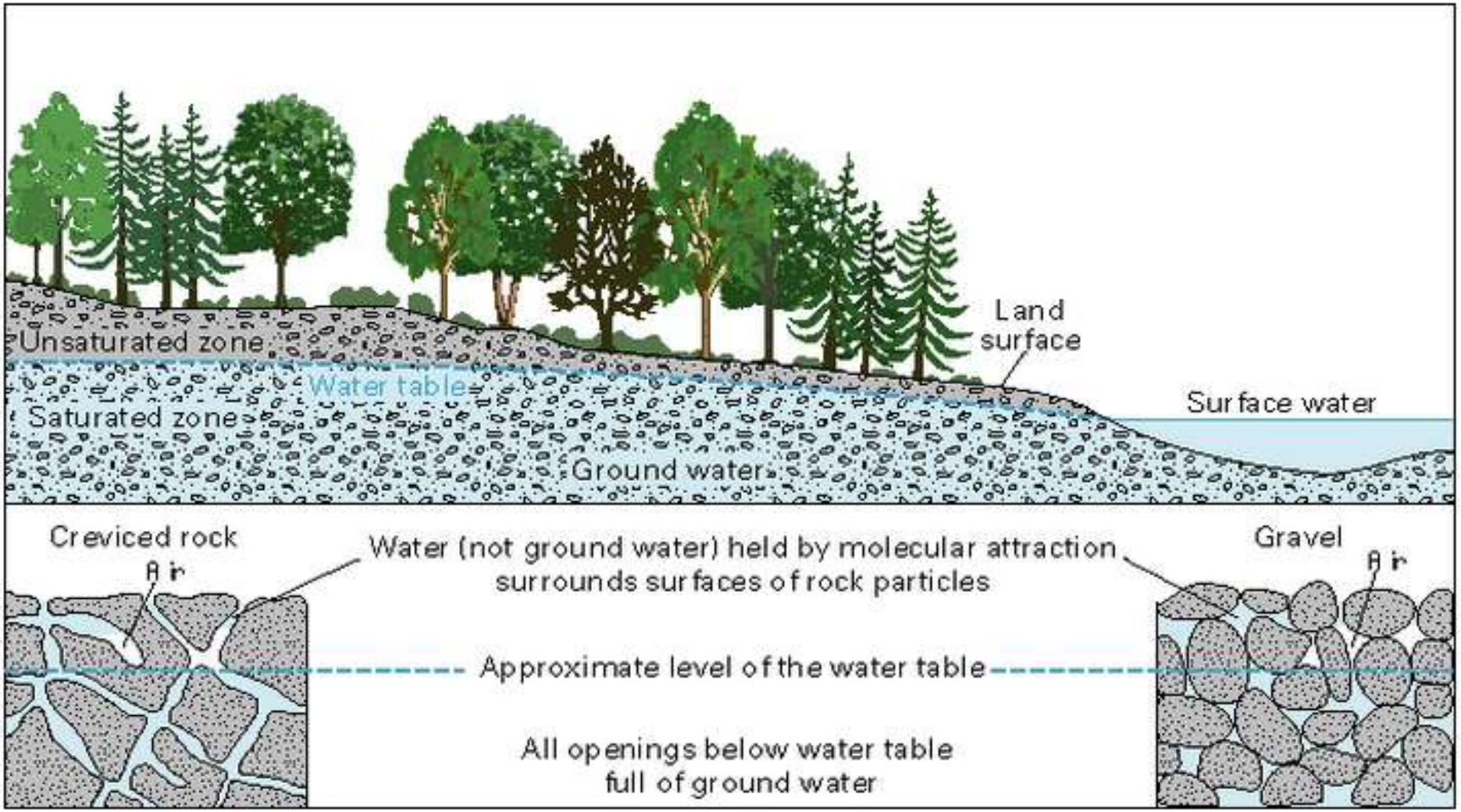
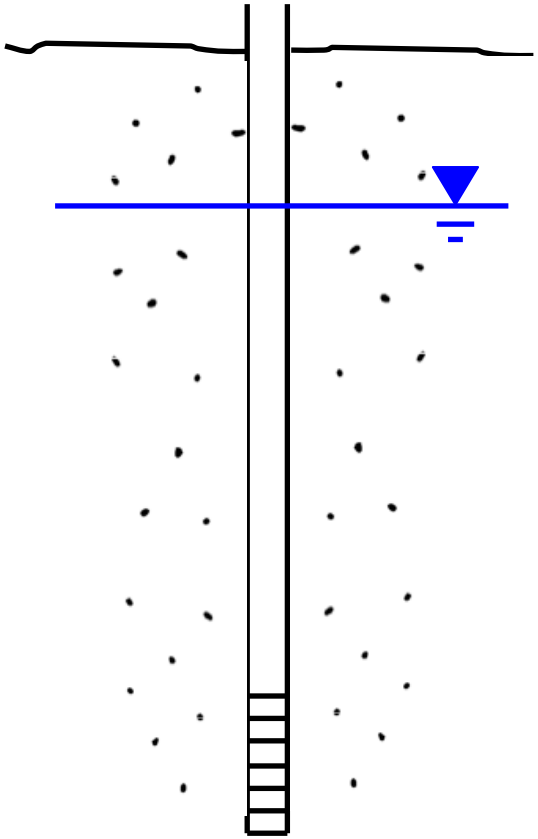
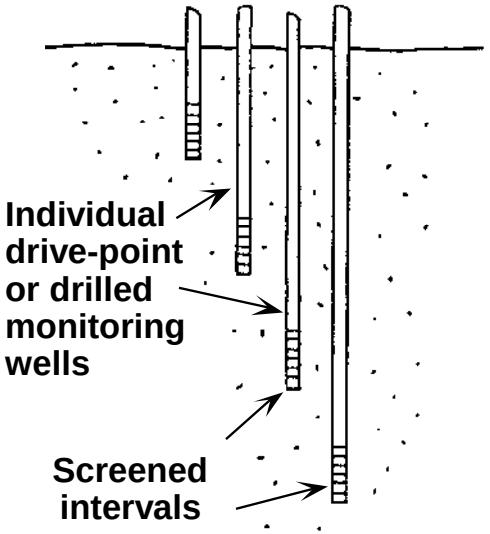
Groundwater is water in the ‘saturated zone’ under the ground surface



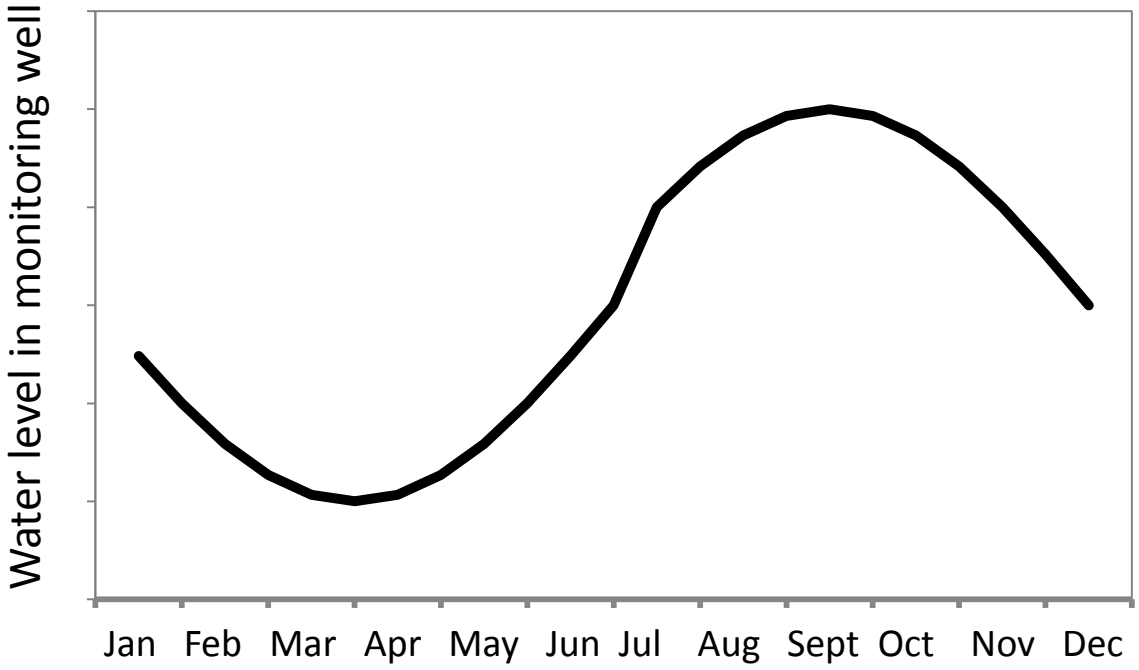
Groundwater monitoring wells – tools of the trade



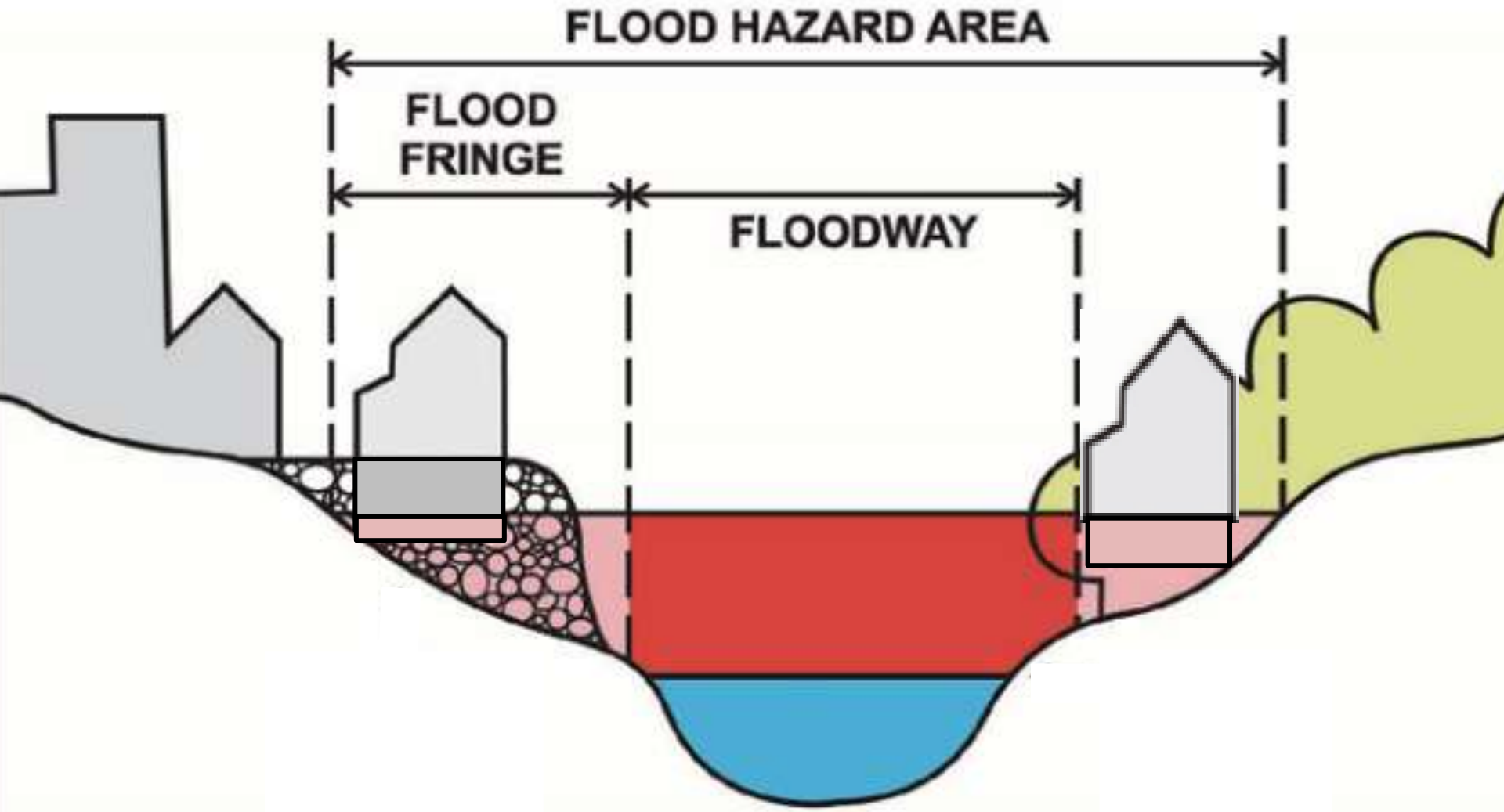
Well Cluster



Groundwater level monitoring



What if we had groundwater monitoring wells in flooded areas?



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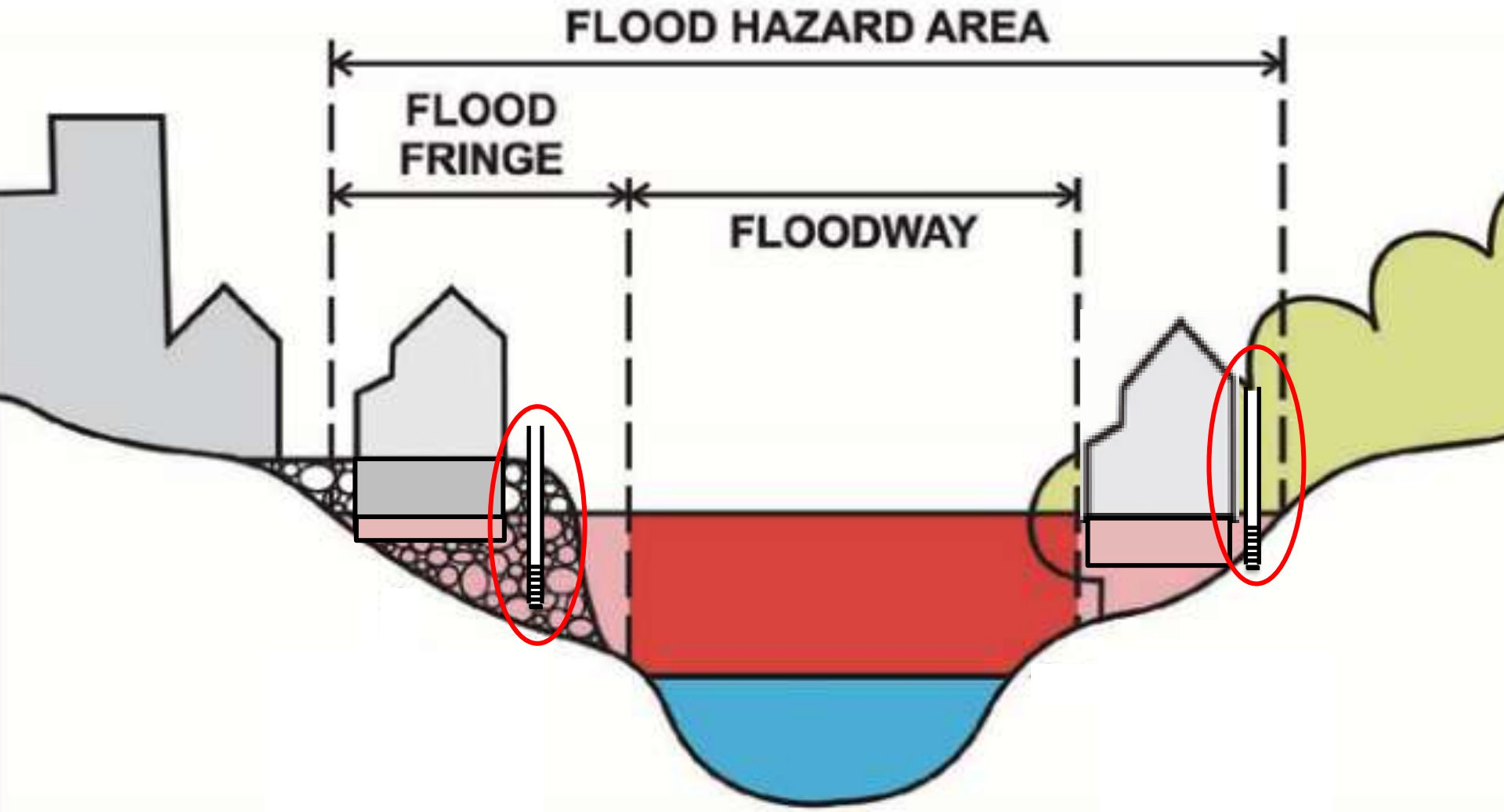

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Downtown Calgary
Roxboro
Rideau
Elbow Park
Upper Mount Royal
Roxboro
Rideau Park
Google earth

Flood 2005: Lessons Learned

C. Greene, A. Roome-Sandrin, T. Simieritsch, M. Towey

June 14, 2006

ENVIRONMENTAL SCIENCE 502

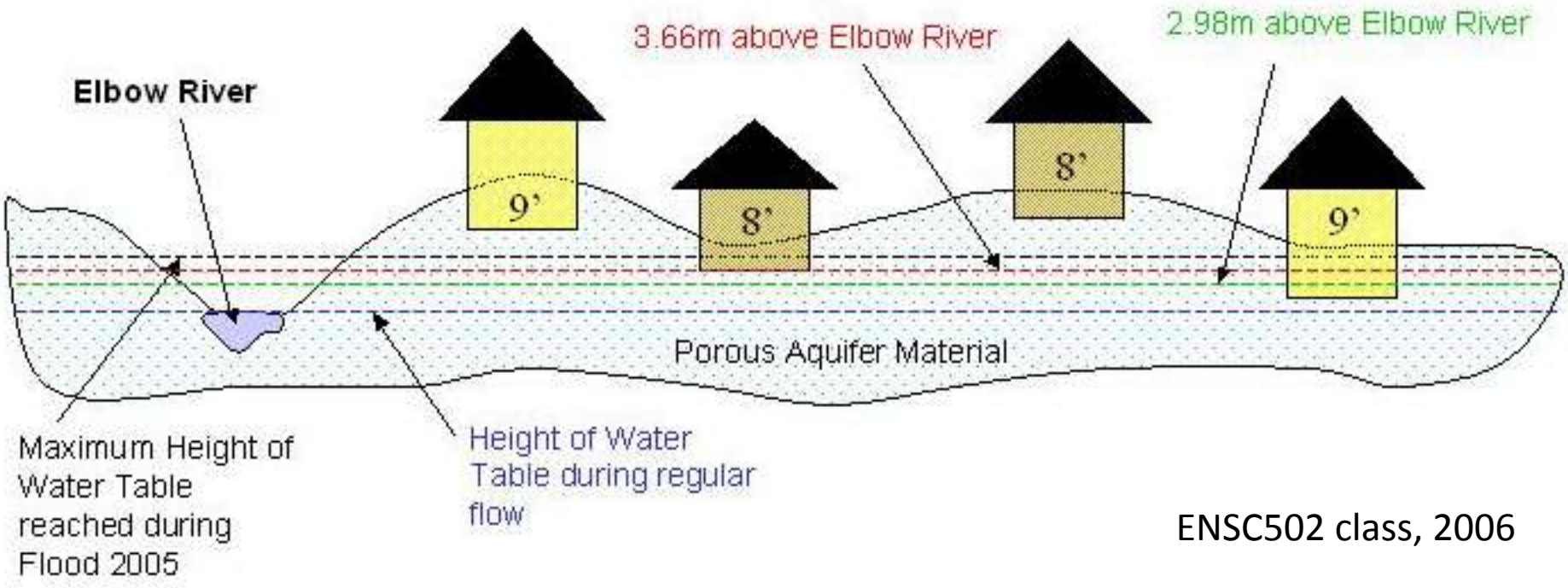
Flood 2005 – lessons learned

- Overland flow only accounted for 17% of the total damage reported by residents
- Underground seepage (not overland flow) responsible for most of flood damage
- Setback only moderately appropriate for minimizing damage
- Ground elevation was as predictive of damage as distance from river/floodway

ENSC502 class, 2006

A better approach to regulation?

- Regulate basement depths with respect to river stage and water table elevation
- consider zoning areas based on basement elevation above the 1:100 year river stage (and groundwater level)



ENSC502 class, 2006

Flooding in Redwood Meadows (ENSC501 2013)

http://www.redwoodmeadows.ab.ca/rwm-flood-2013/

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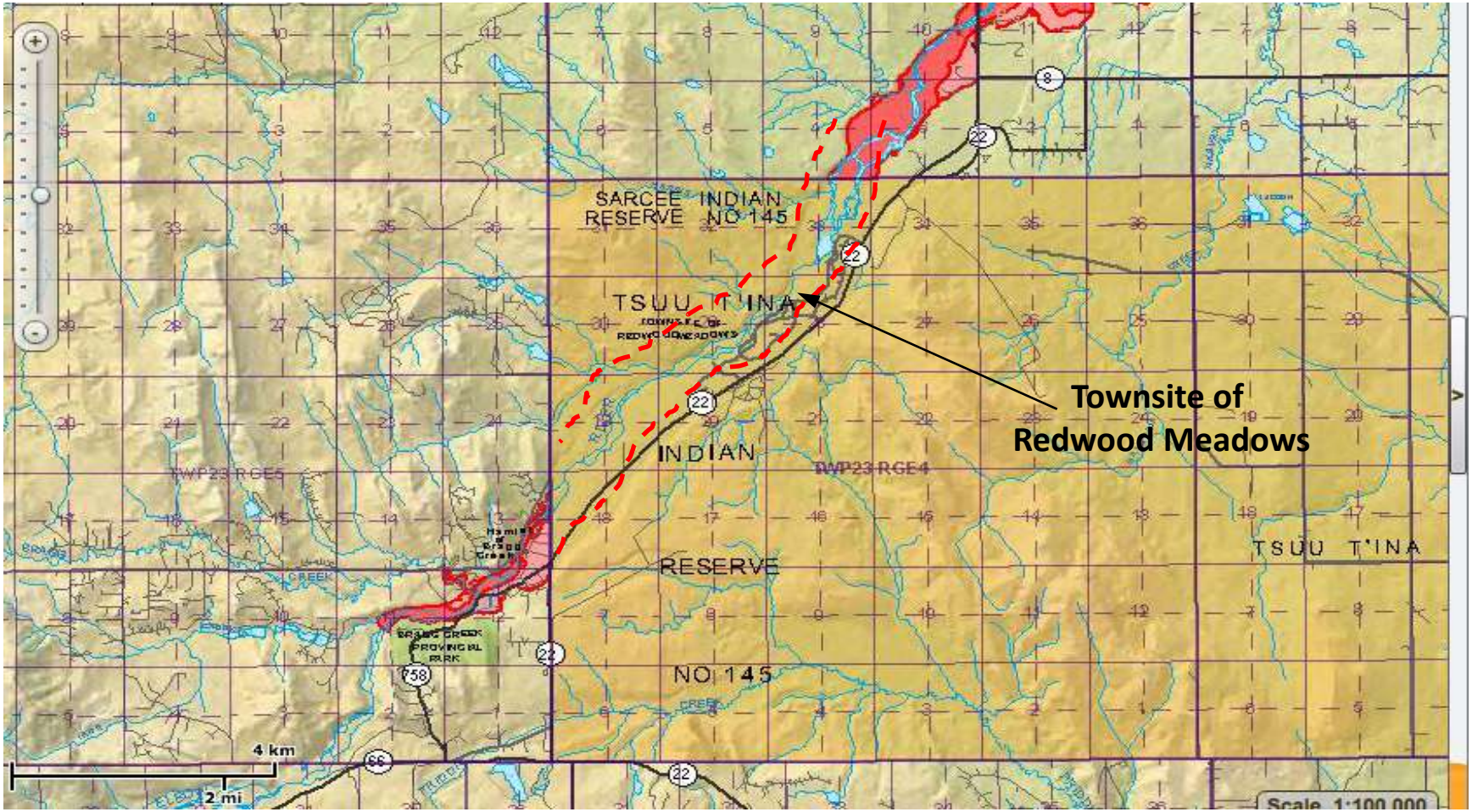
ENSC501 Field School II, 2013 co-researchers

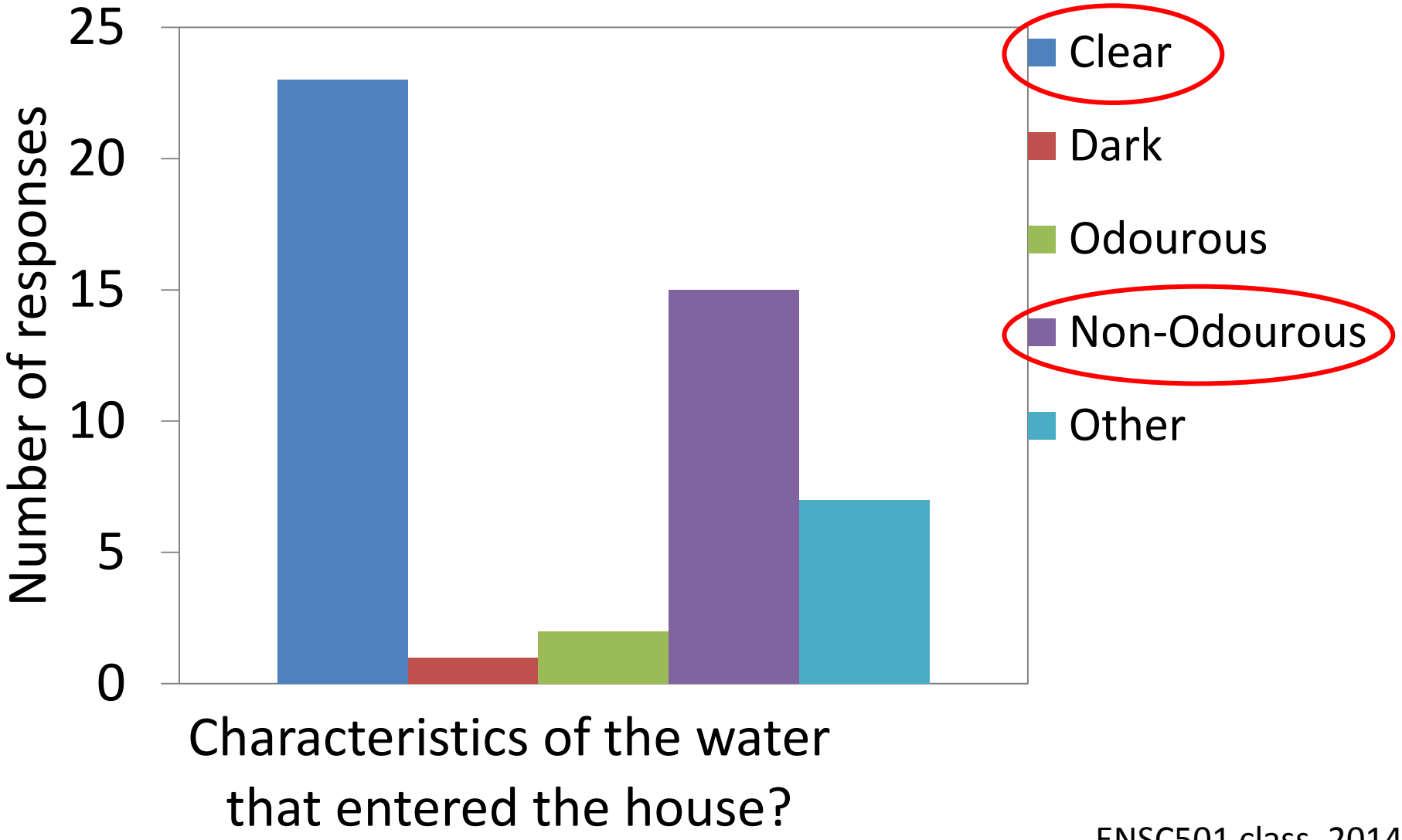
N. Chin, A. Chung, L. D'Silva, M. DeCock, D. Doerksen, R. Donais, T. Fairfield-Bilyk, A. Grant, P. Jones, S. Karim, A. Kerford, A. Klein, J. Kolodziej, E. Kordich M. Kovacs, L. Laframboise, G. Lam, B. Linaker, R. Lorimer, A. Ma, K. McGeary, K. Moreira, S. Muminovic, T. Paradis, G. Perepelkin, A. Pulwicki, T. Rajabi, M. Revay, N. Rider, S. Ross, J. Sekhon, A. Smillie, S. Spaho, K.Stuart, K. Sutcliffe, M. Tang, E. Timmins, E. Webb, L. Wonneck and N. Taube, H. Jabusch

Provincial flood maps



ENSC501 class, 2014

Flooding in RWM homes



ENSC501 class, 2014

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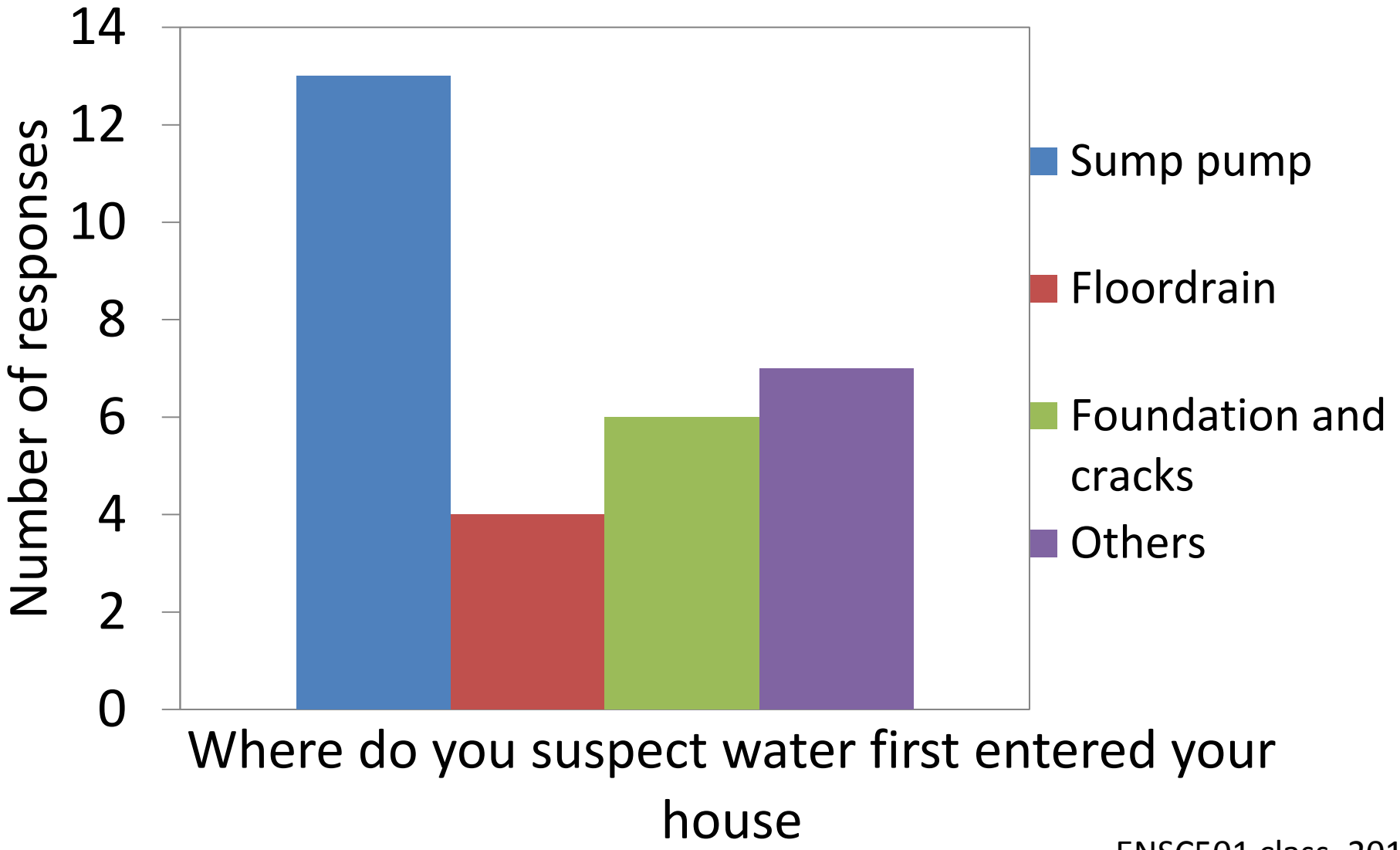

ENSC501 class, 2014

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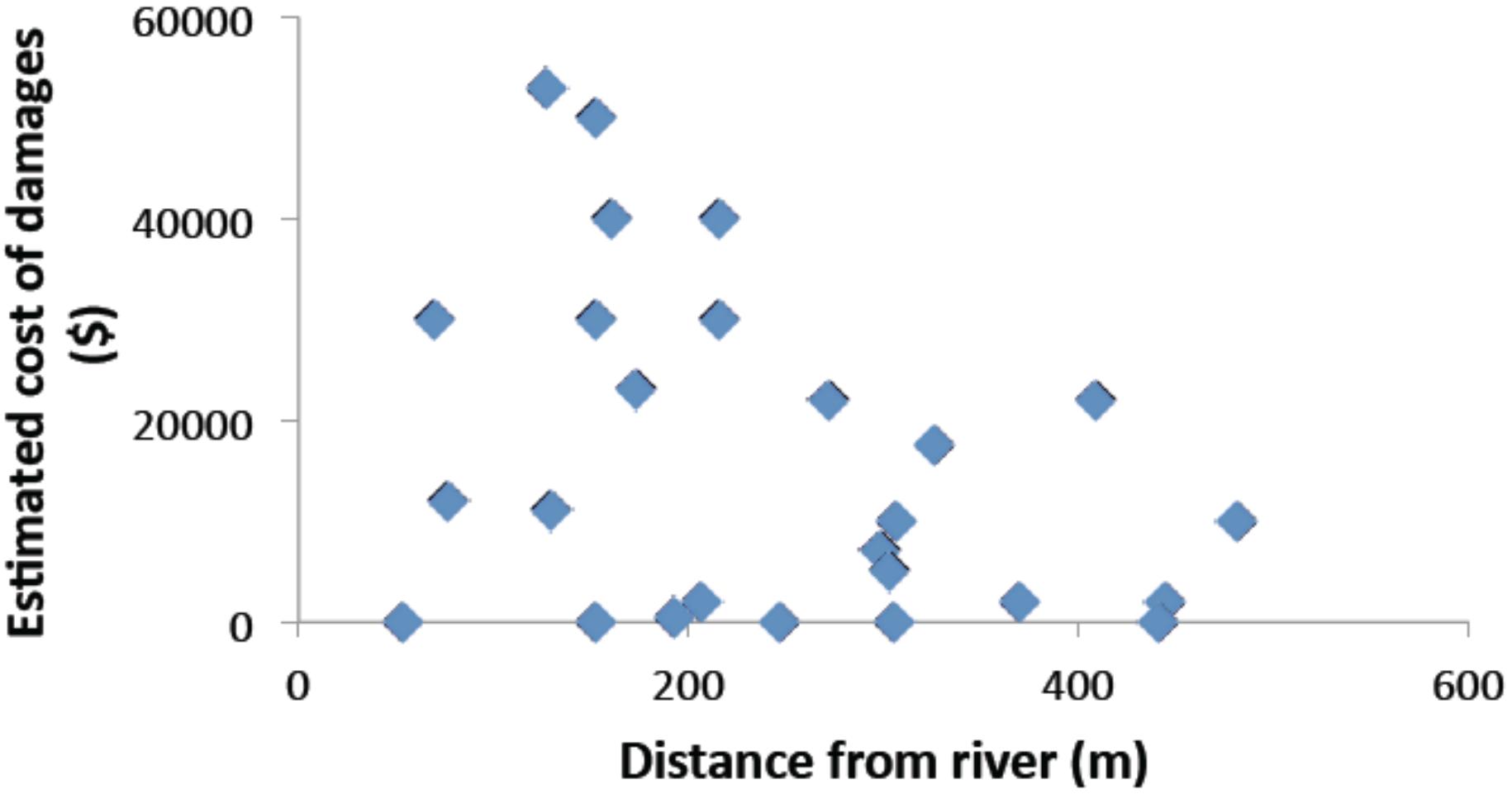
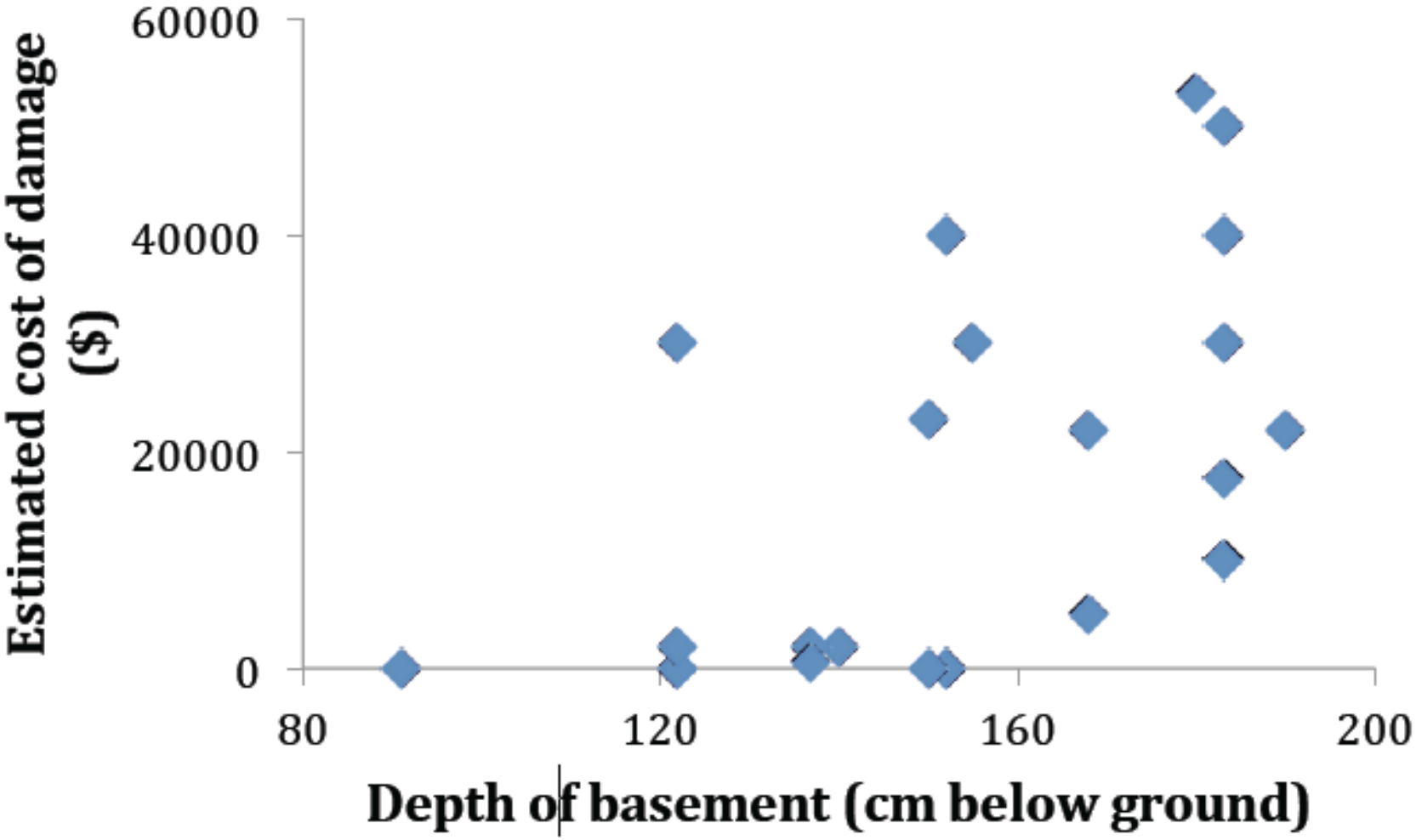


ENSC501 class, 2014

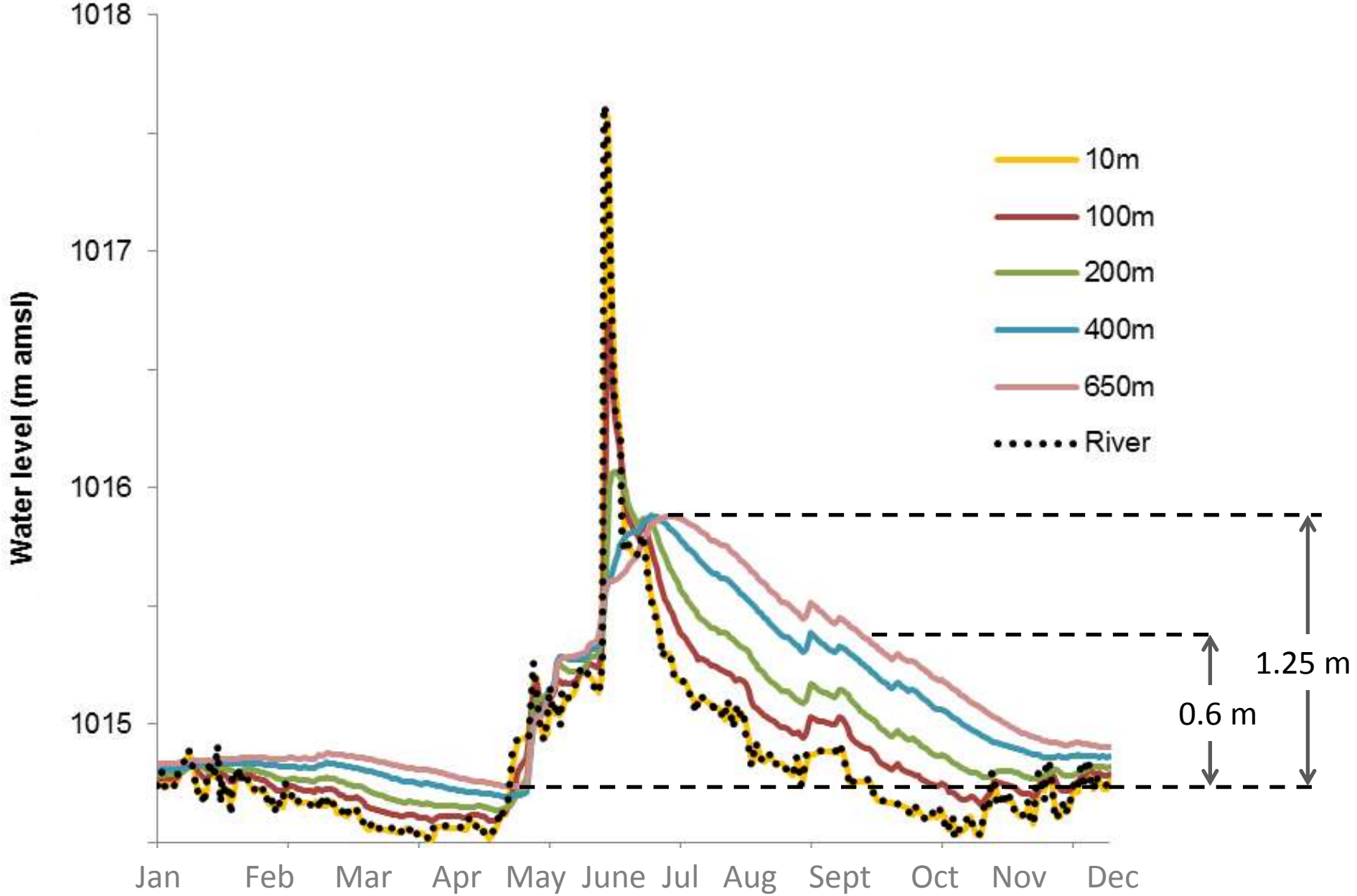
Flooding in RWM homes



ENSC501 class, 2014

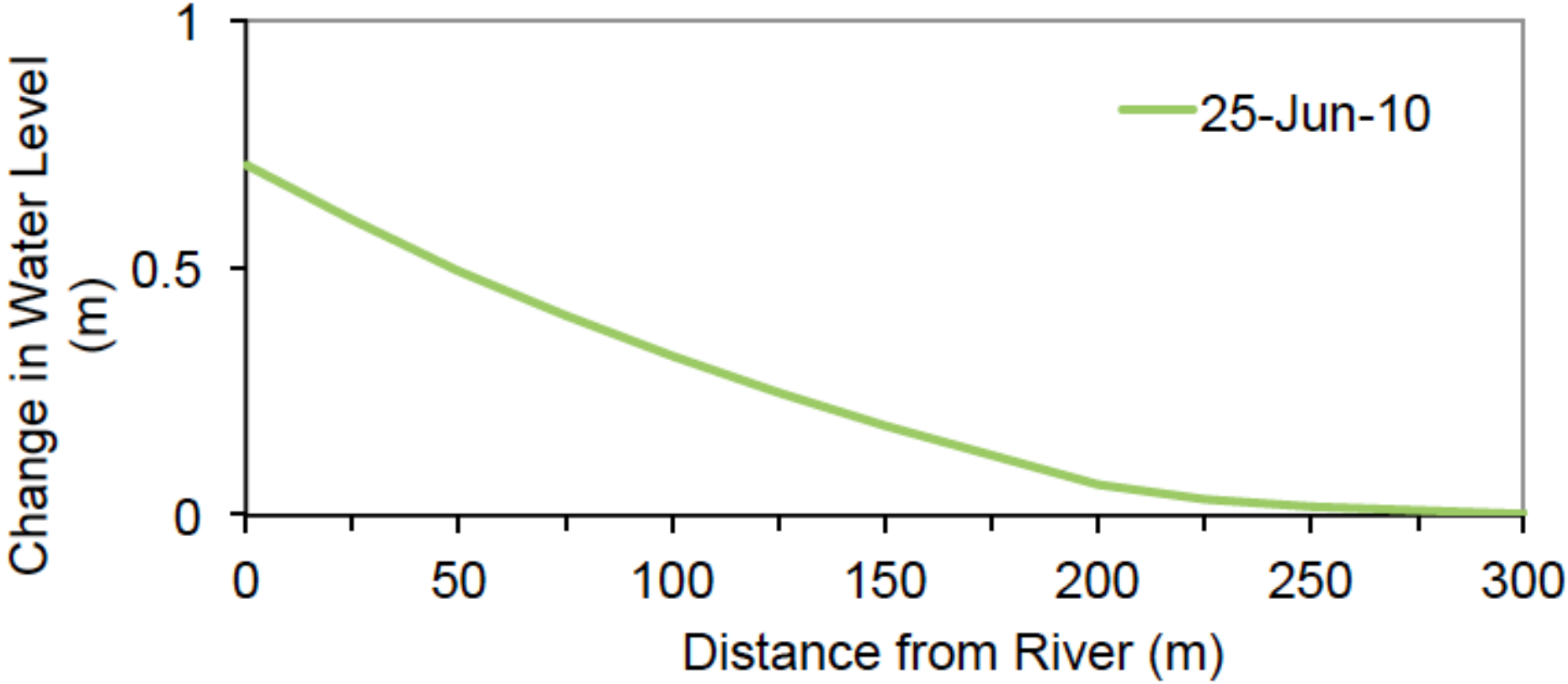
How far back would high groundwater levels propagate?

Simulated propagation of high river stage into alluvial aquifer

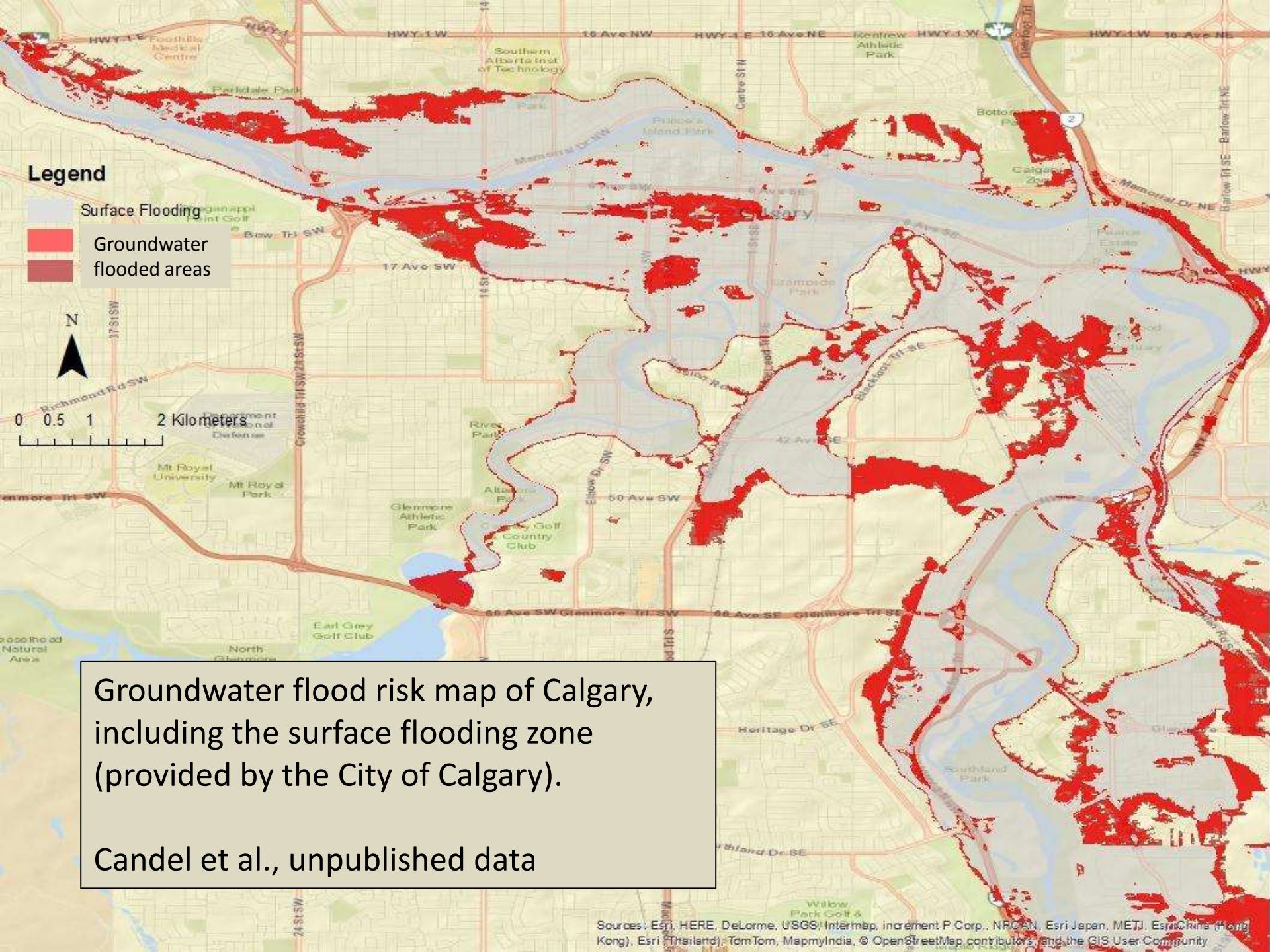


Candel et al., unpublished

Water level responses in alluvial



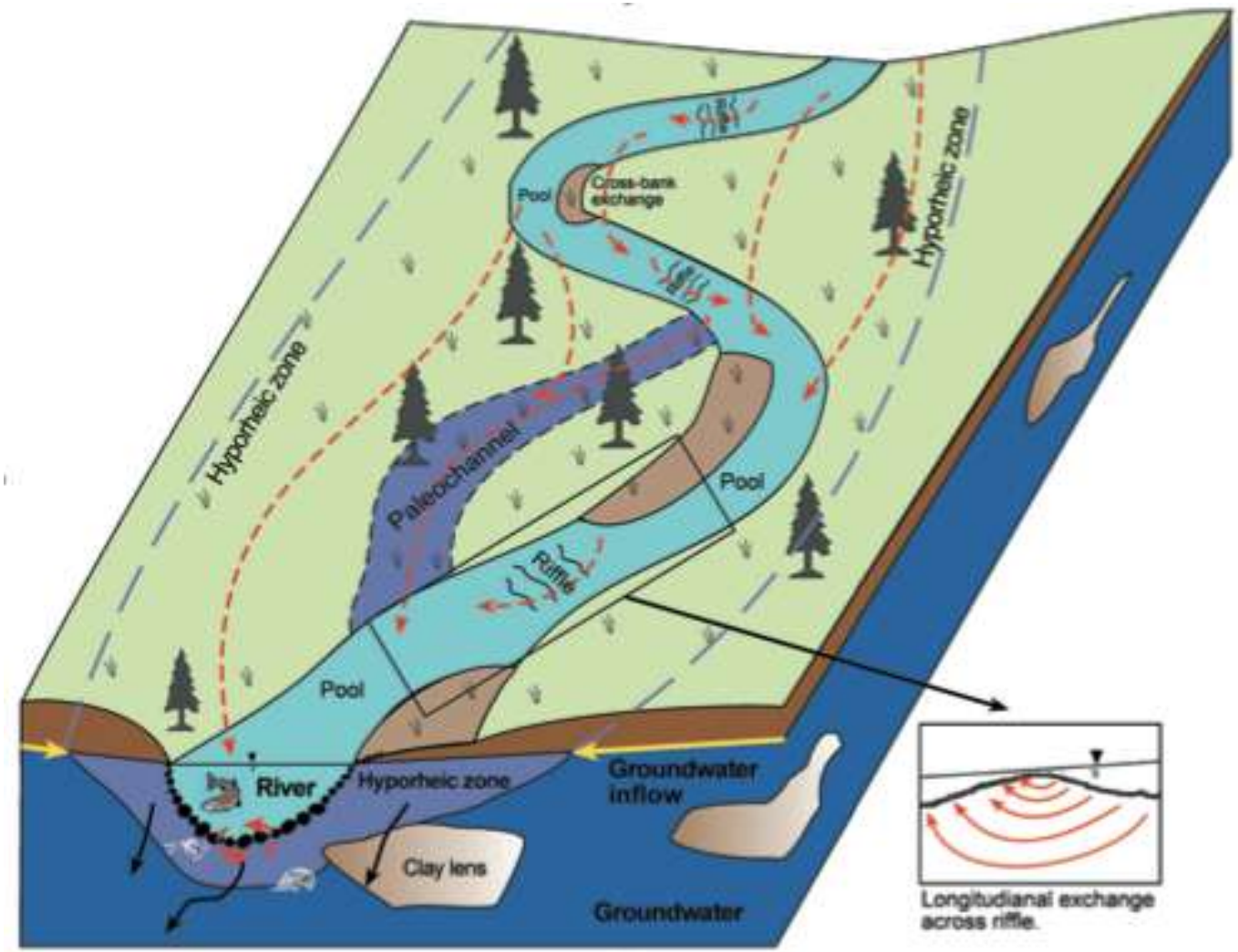
Role of paleo-channels?



Groundwater flood risk map of Calgary, including the surface flooding zone (provided by the City of Calgary).

Candel et al., unpublished data

Role of paleochannels in gw flooding?



Tonina and Buffington, 2009.

Ongoing work @ UC

- Door-to-door survey of more than 300 residents affected by 2013 flood
- Environmental geophysics to understand variations in alluvial aquifer
- Identification and monitoring of groundwater monitoring wells to calibrate groundwater model

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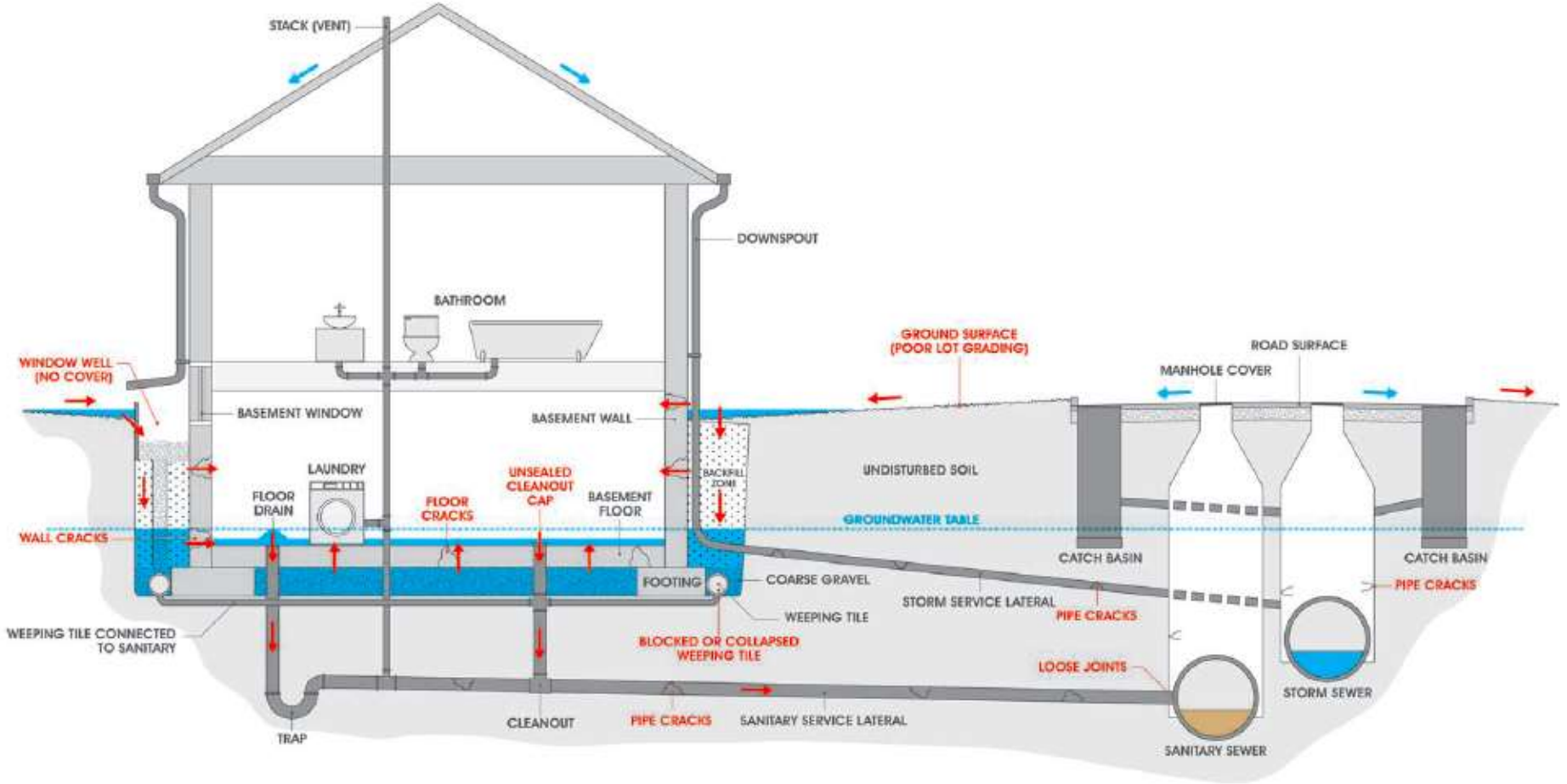
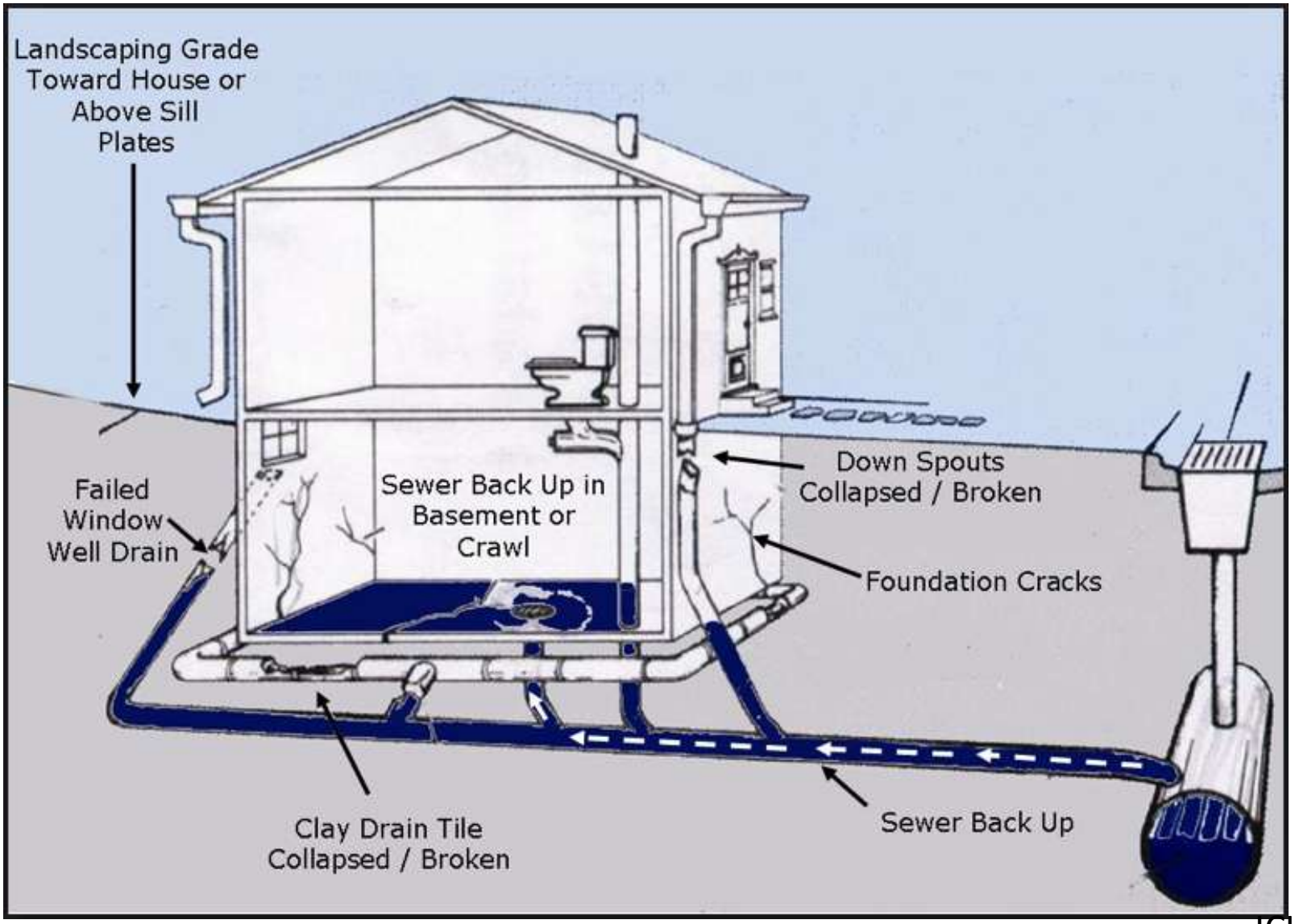
Differentiating between ‘groundwater flooding’ and sewage backup?



ICLR, 2009

How does groundwater enter homes most easily?



What does the scientific literature say?

"Groundwater flooding is poorly understood, often confused with surface water flooding, and has not been widely recognized as a problem, either in the UK or internationally."

Hughes et al., 2011

Important changes are coming to your home insurance policy no. [redacted]

Your renewal documents will be mailed to you soon[1]

Dear Client,

Thank you for choosing us to look after your home insurance needs. It's almost time to renew your policy[1], so I want to let you know that your renewal documents will be mailed to you within a few days. Once you receive them, please take a moment to review them carefully in order to better understand your coverage.

Adjustments are being made to your water damage coverage and your insurance deductible

In particular, water damage coverage and the deductible amount for your Alberta property or properties are changing. Let me assure you that you will receive complete details of these changes in your renewal documents. After reviewing them, if there's anything you would like to discuss, or if you have new insurance needs, please contact us at the toll-free number below. Our goal is to continue to provide you with great value and high-quality coverage.

We're here to help

Calgary group blasts plan that could force hundreds of homes to put flood information on property title

JEN GERSON | August 14, 2013 | Last Updated: Aug 14 8:38 PM ET
More from Jen Gerson | @jengerson

Residents walk through flood waters in Calgary on June 24, 2013. The Alberta government says homeowners and small businesses affected by last month's severe flooding can expect a rebuild, but they won't be entitled to hardwood floors or granite counter tops. Nathan Denette / THE CANADIAN PRESS

Calgary Grade 2 student questions to Dr. Jerry Osborn

- Should we have built on the floodplain?
- Should we continue to build on it?

---*St. Stephen School*

- Should we rebuild places like High River or should people not live there?

---*St. Albert School*

What could the insurance industry do to identify groundwater flooding?

- Strategic groundwater investigation and water level monitoring
- Validated groundwater modelling
- Consider basement floor elevation with respect to river stage elevation

Conclusions

- gw inundation can significant
- basement floor elevation w.r.t river state is relevant
- can “look like” sewer back-up
- paleo-channels might be important
- Field investigation, gw monitoring wells needed

Thanks for your time and attention!

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