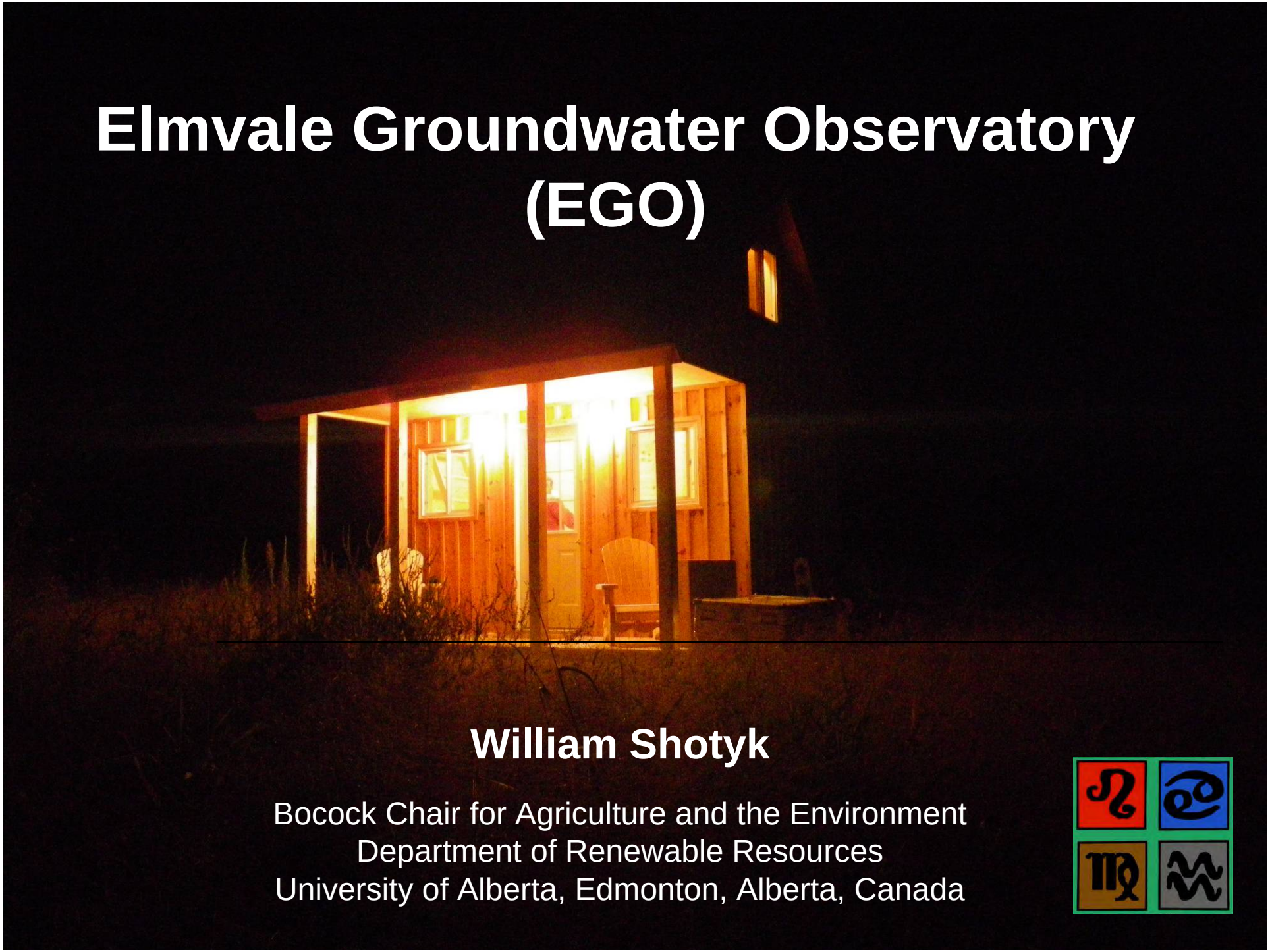
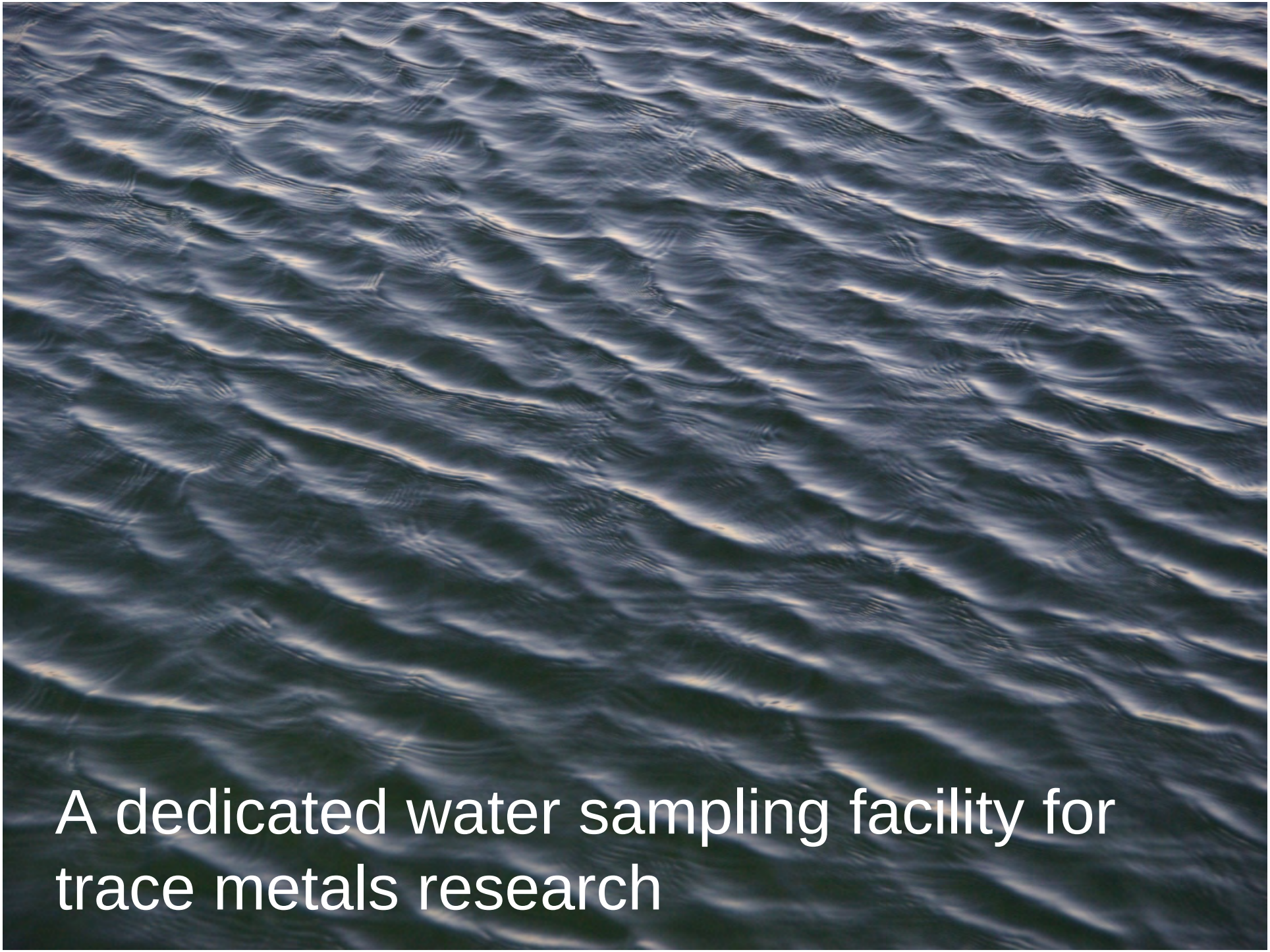
Elmvale Groundwater Observatory (EGO)



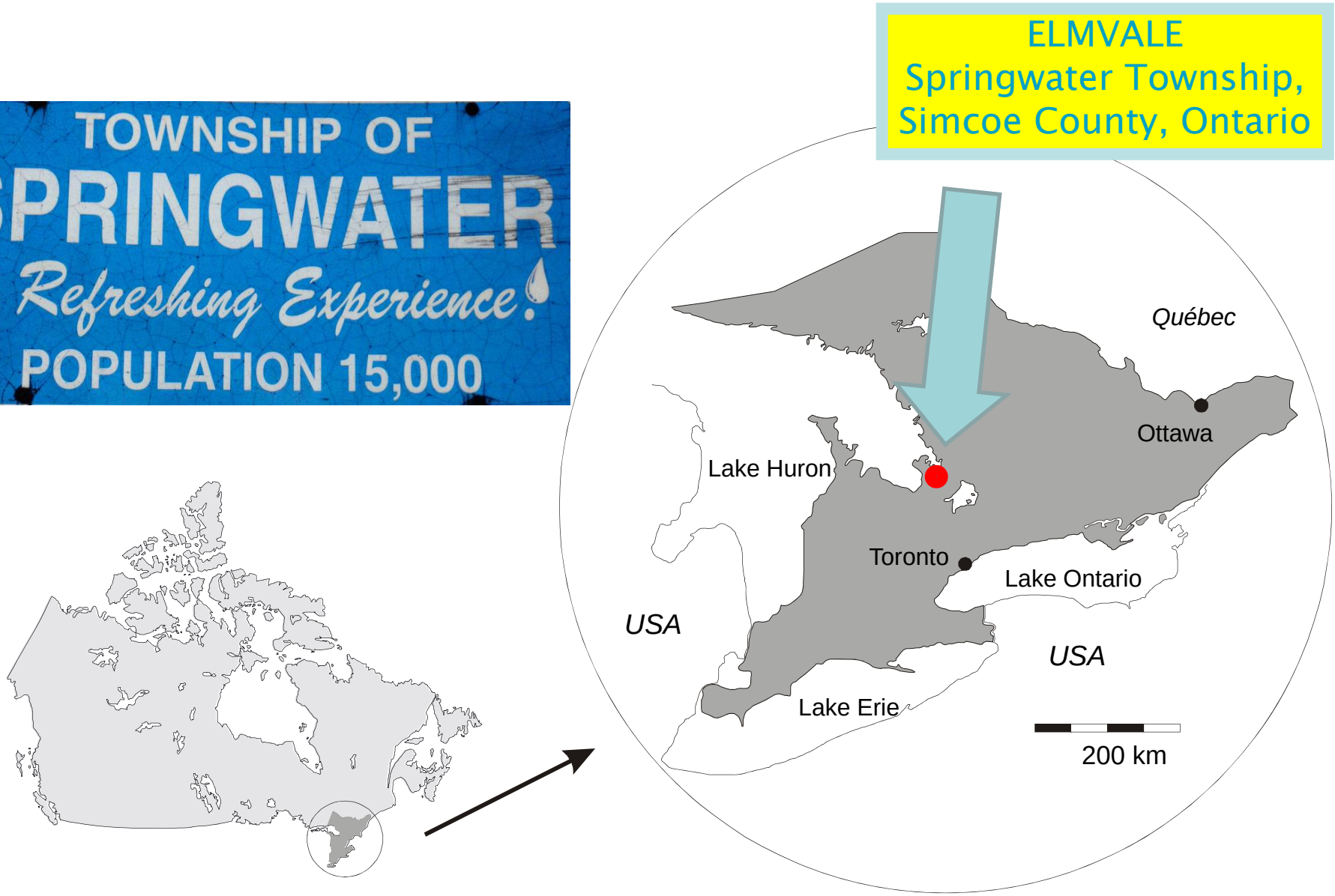
William Shotyk

Bocock Chair for Agriculture and the Environment
Department of Renewable Resources
University of Alberta, Edmonton, Alberta, Canada



A dedicated water sampling facility for trace metals research

TOWNSHIP OF
SPRINGWATER
A Refreshing Experience!
POPULATION 15,000


ELMVALE
Springwater Township,
Simcoe County, Ontario
Québec
Ottawa
Lake Huron
Toronto
Lake Ontario
USA
USA
Lake Erie
200 km

ORIGINAL ARTESIAN WELL

depth 12.8 m
flow 10 L/min

typical chemical composition:

pH 8
ca. 175 mg/l carbonate alkalinity

Ca	27.8 ± 0.4 mg/l
Mg	23.1 ± 0.3 mg/l
Na	6.9 ± 0.2 mg/l
K	1.7 ± 0.0 mg/l
Si	8.7 ± 0.1 mg/l

(n=30)

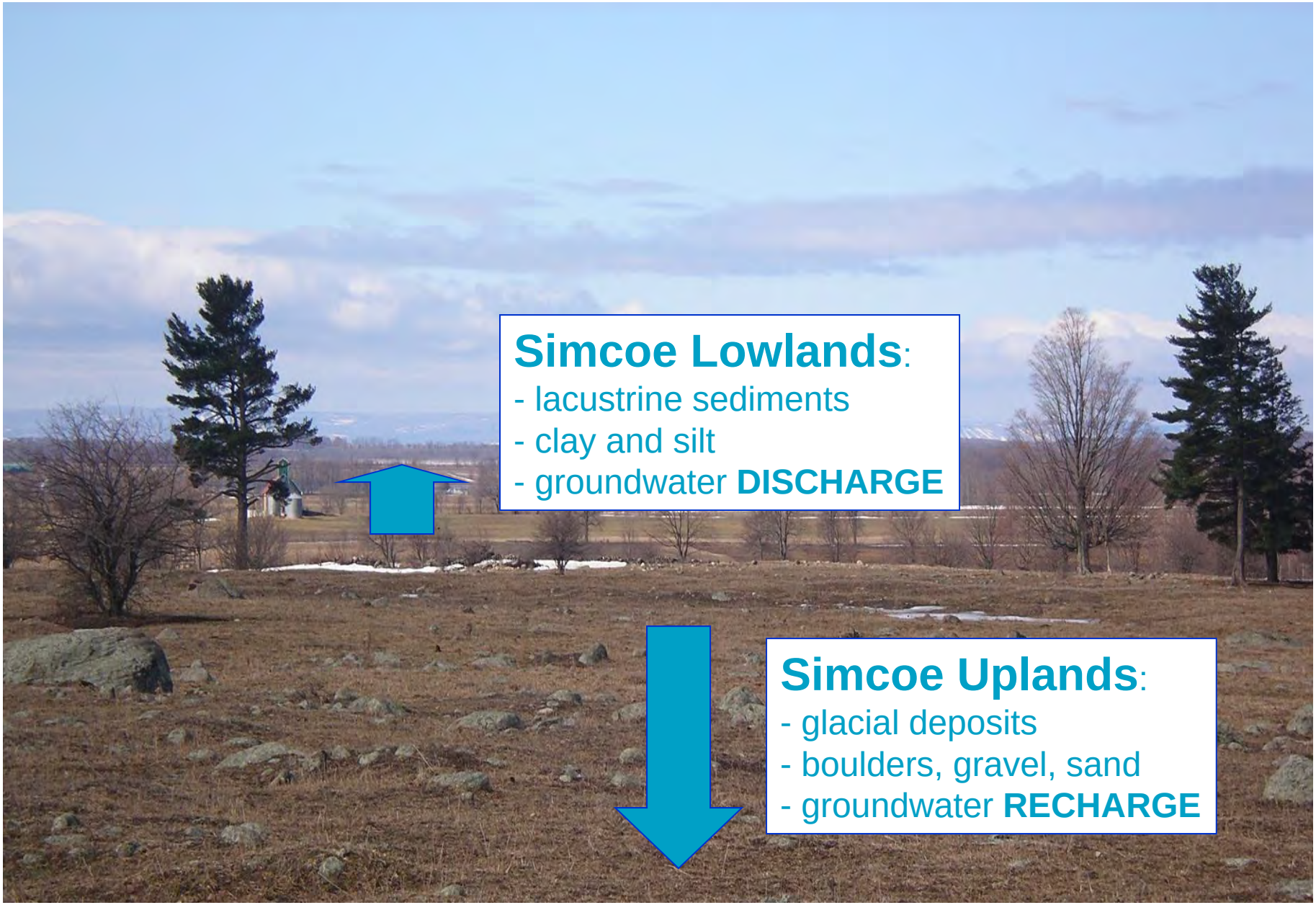
March 2010

No tritium has been found to date

PARNELL:
Depth 8.5 m
^{3}H: 9.5 ± 0.9; 10.0 ± 0.9; 10.6 ± 0.9
(tritium units)

TEMOLDER:
Depth 9.1 m
^{3}H: 14.3 ± 1.3; 15.1 ± 1.1
(tritium units)

But tritium is found in other nearby springs

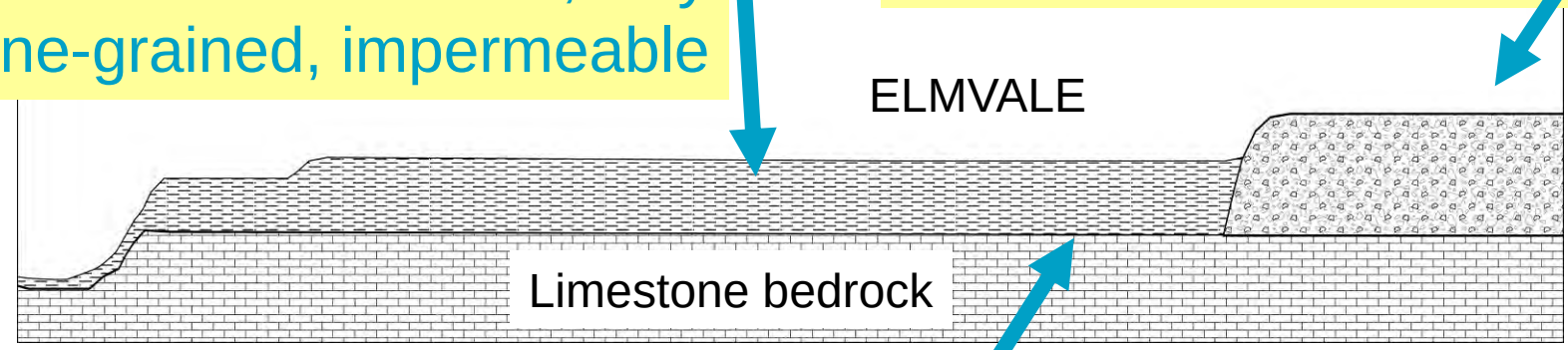


View of the Elmvale Clay Plain (with its abundant springs) from the Simcoe Uplands, with Blue Mountain in the distance (seen from French's Hill)

Simplified geological cross section

Simcoe Lowlands
[Elmvale Clay Plain]
(lacustrine deposits)
silt, clay
fine-grained, impermeable

Simcoe Uplands
(glacial deposits)
rocks, gravel, sand
coarse-grained, permeable



channels of sand
(permeable, water-bearing layers)
ie. the aquifer

not to scale

Location of original artesian flow: this supplies water to house and barn

Location of three dedicated groundwater research wells

EGO-1, constructed in **316 surgical stainless steel**, installed May 2009. Used to determine stratigraphy and water flow rate, but also for groundwater research.

Original artesian flow. The brass tap was replaced with stainless steel by Tommy Noernberg (May 2007), and the depth of the well recorded.

EGO-2, constructed in **acid-washed high density polyethylene (HDPE),** installed September 2009. For trace metals research.

Both valves were made by Tommy



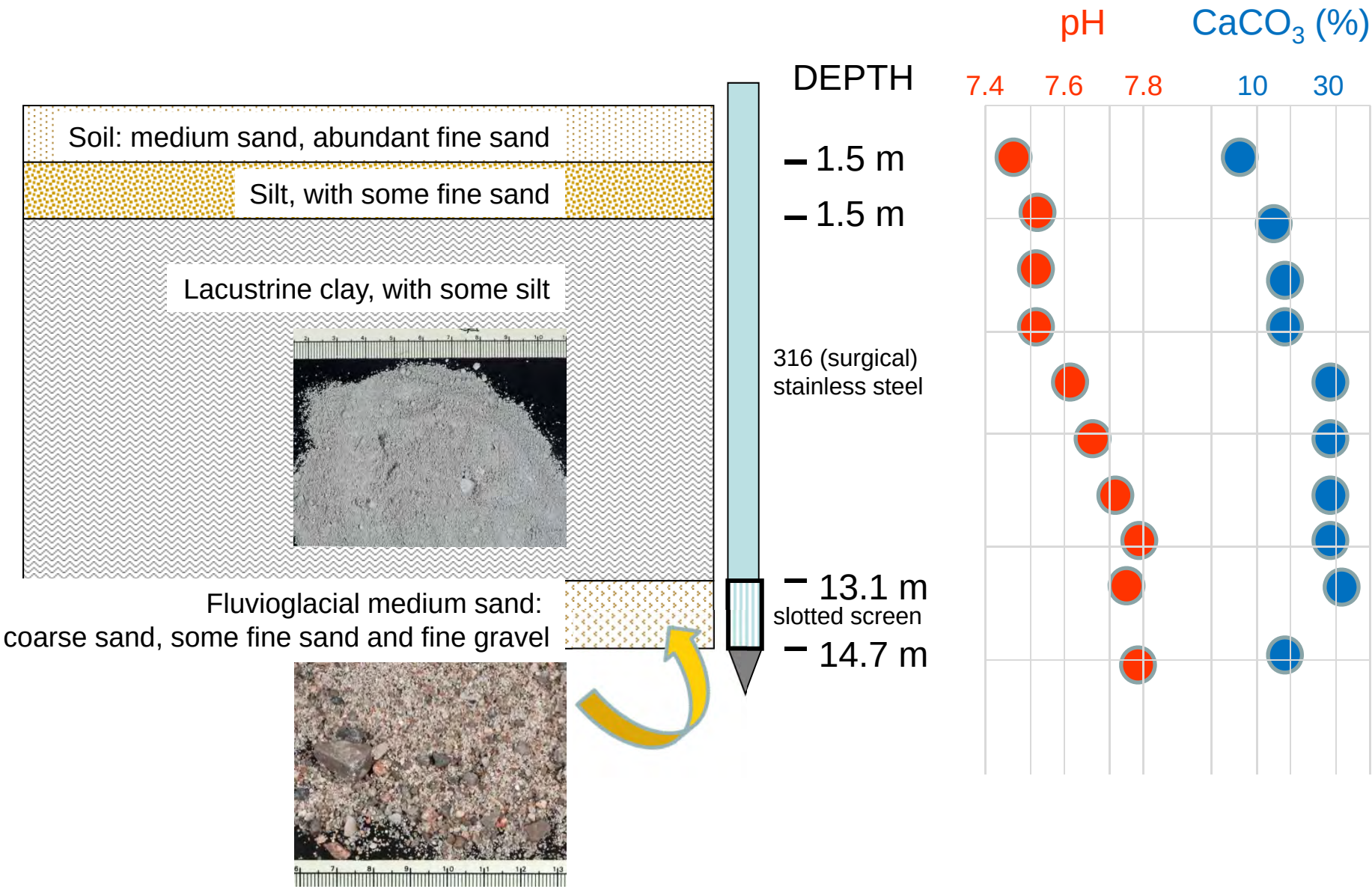




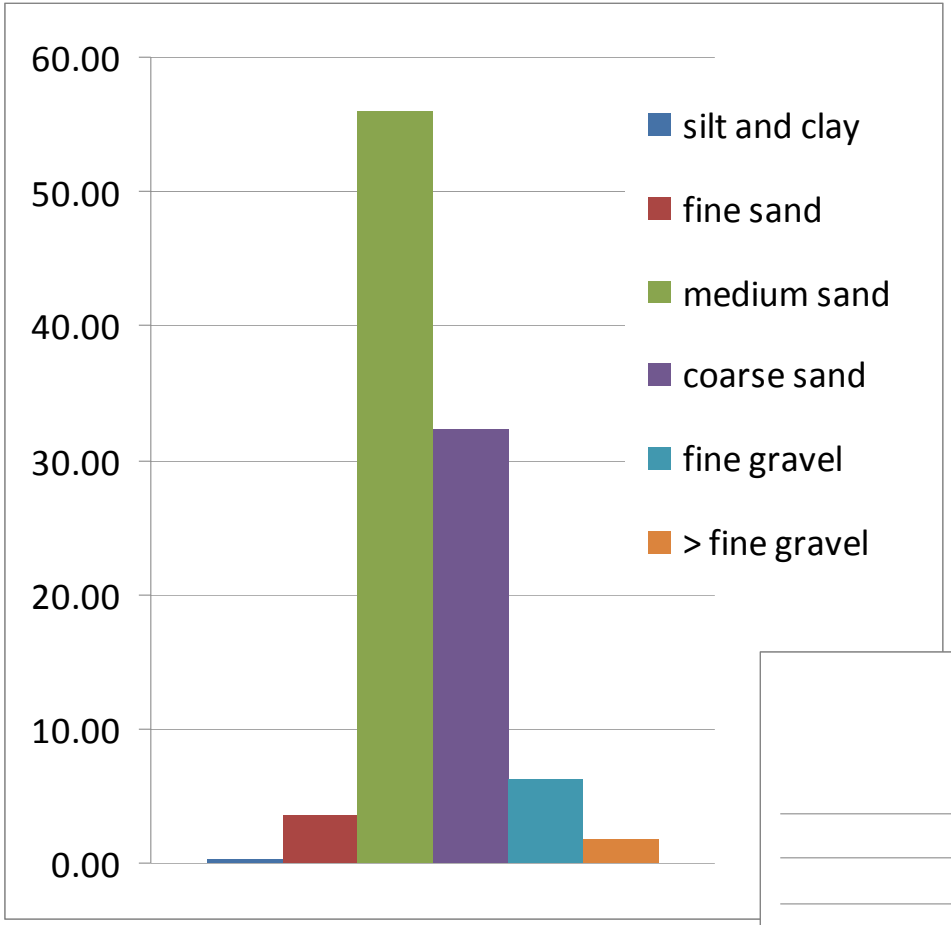


21.5.09 Using a rotary rinsing drill, after ca. 5 ft of soil and 30 ft of clay, the aquifer was reached consisting of ca. 8 ft of sand. Christian Scholz described the stratigraphy.

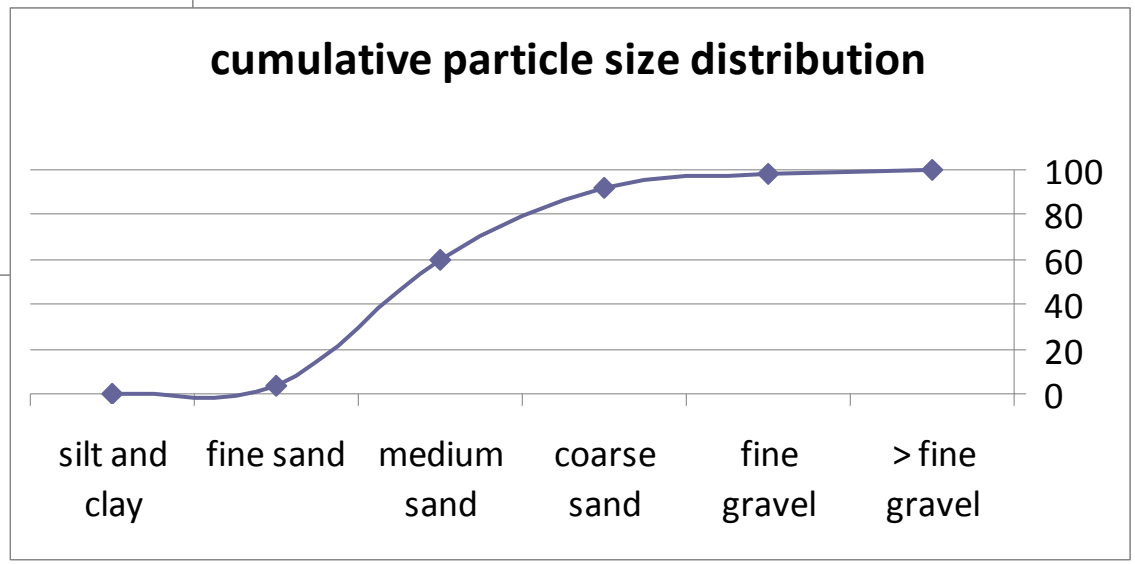
Schematic illustration of the stratigraphy of the research wells



Particle size analysis, aquifer material (medium-coarse sand)



55.9 % medium sand (630-200 µm)
32.3 % coarse sand (2000-630 µm)



SEPT 2009: installation of EGO-2 (HDPE)

This valve, constructed of Teflon and polypropylene, was dismantled, leached in acid, and packed twice in polyethylene, prior to shipping to Canada

HDPE tubes (purchased from Carl Hamm GmbH, Essen, Germany, manufactured by Rotek in Denmark) were leached in nitric acid for two weeks and packed twice in polyethylene, before shipping to Canada.

IMPACT EVALUATION

FLOWING WELL

FISH HATCHERY

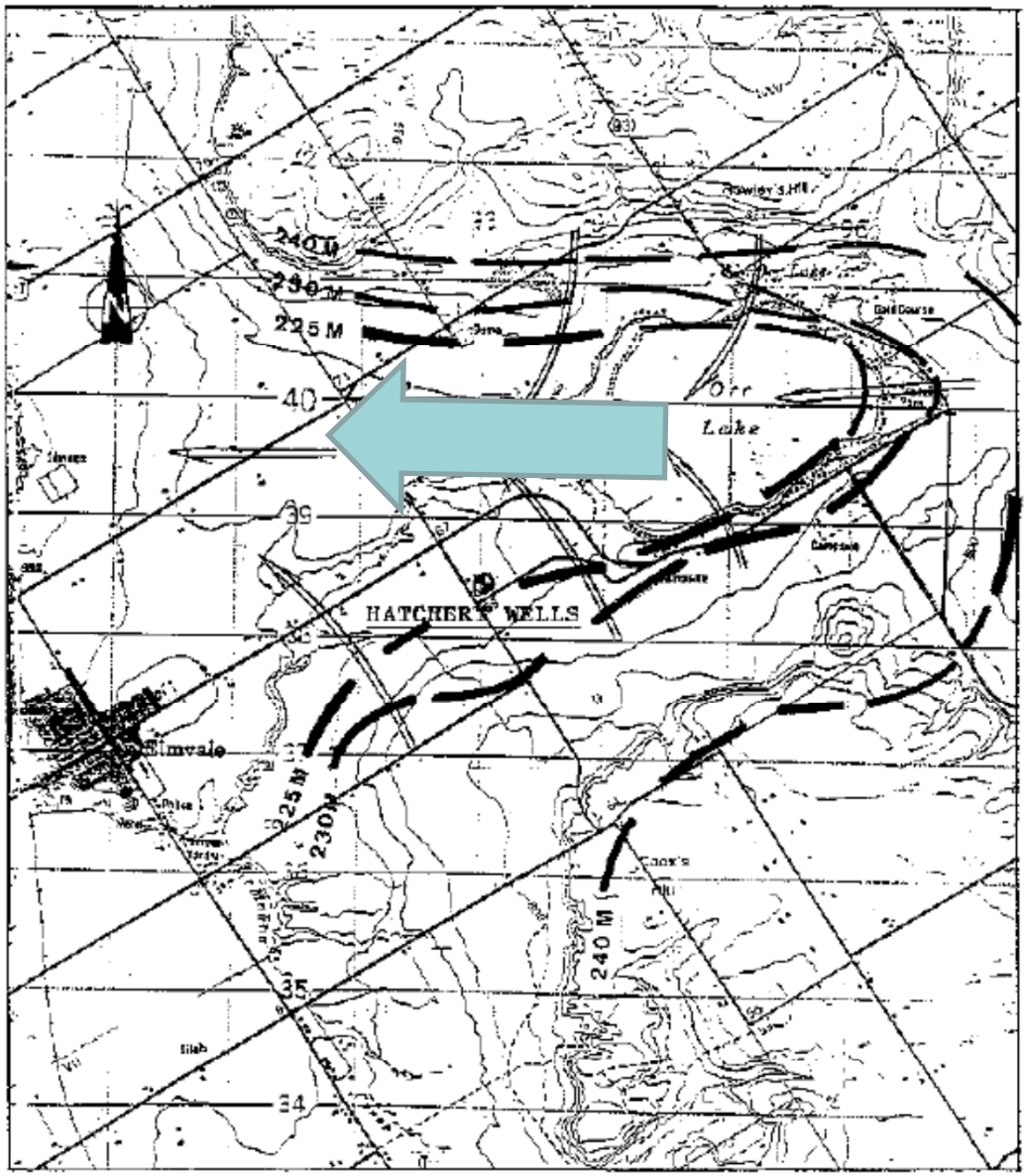
TOWNSHIP OF SPRINGWATER

Prepared for: Mr. R. Belluz

August 22, 1997
Project 9717

IAN D. WILSON ASSOCIATES LIMITED
CONSULTING HYDROGEOLOGISTS

STRATFORD, ONT. 519-271-794

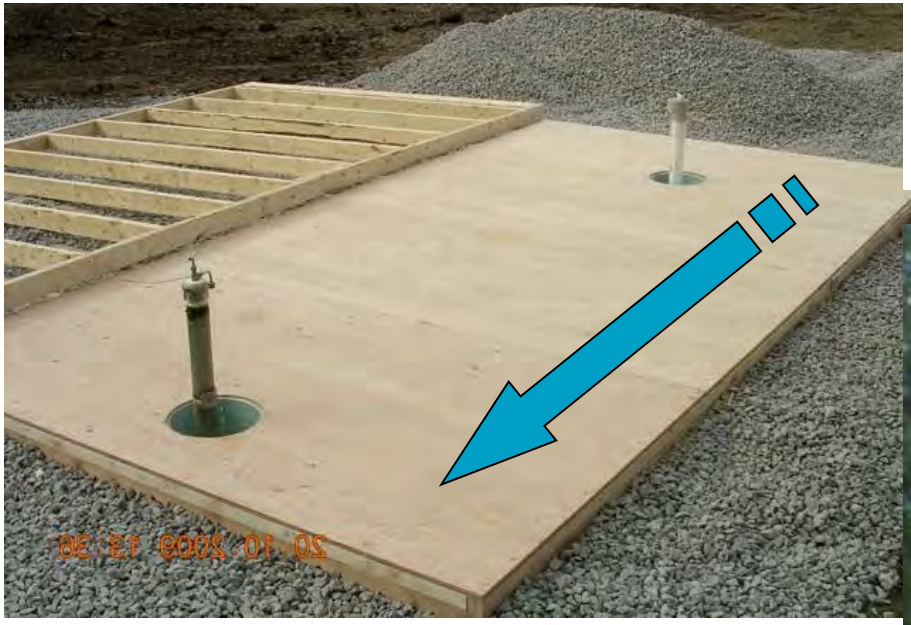


DRAWING SHOWING
APPROXIMATE CONTOURS
OF THE
PIEZOMETRIC SURFACE
AND
DIRECTIONS OF
GROUNDWATER FLOW

SCALE 1:50,000

FIGURE 4

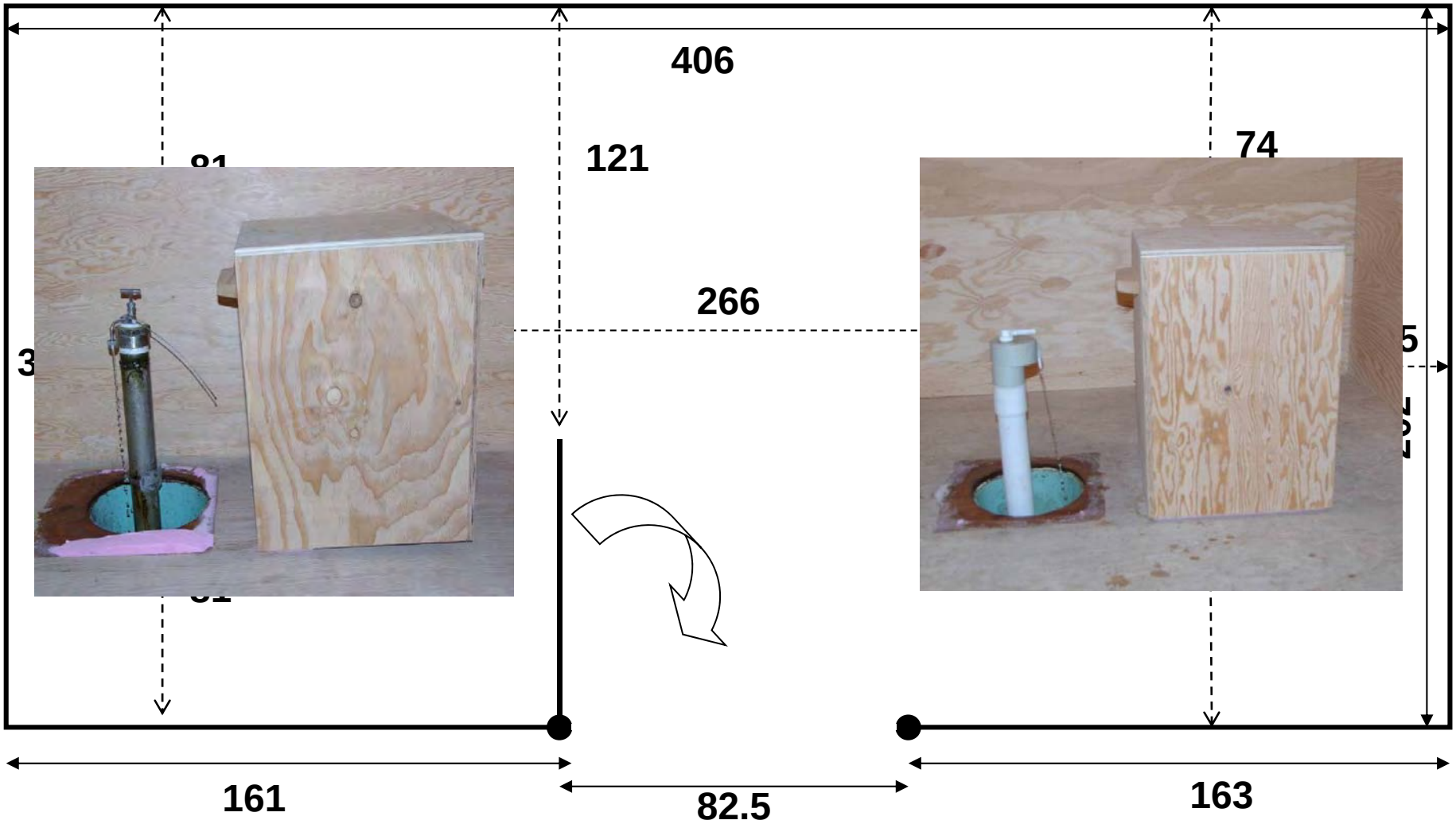
Hydrological studies of the area indicate that the hydrological gradient is from E to W



Based on the hydrology, the polyethylene well was located upstream of the stainless steel well to minimize the risk of contamination.

This small cabin was constructed by Stephen Ogden, not only to protect the wells, but also to provide a “clean” location which would allow water sampling to be undertaken regardless of the weather

Main Floor Sampling Area



Each well has an insulated cover to ensure that the water does not freeze in winter

All measurements in cm

7.1.10

EGO-1
(May 2009)
Surgical (316) stainless steel well and valve

EGO-2
(Sept 2009)
Acid-washed, high density polyethylene (Rotek, DK) well with polypropylene and Teflon valve

Both wells flow continuously at a rate of ca. 1 L/min. The volume of water in the wells is exchanged ca. 50 times per day.

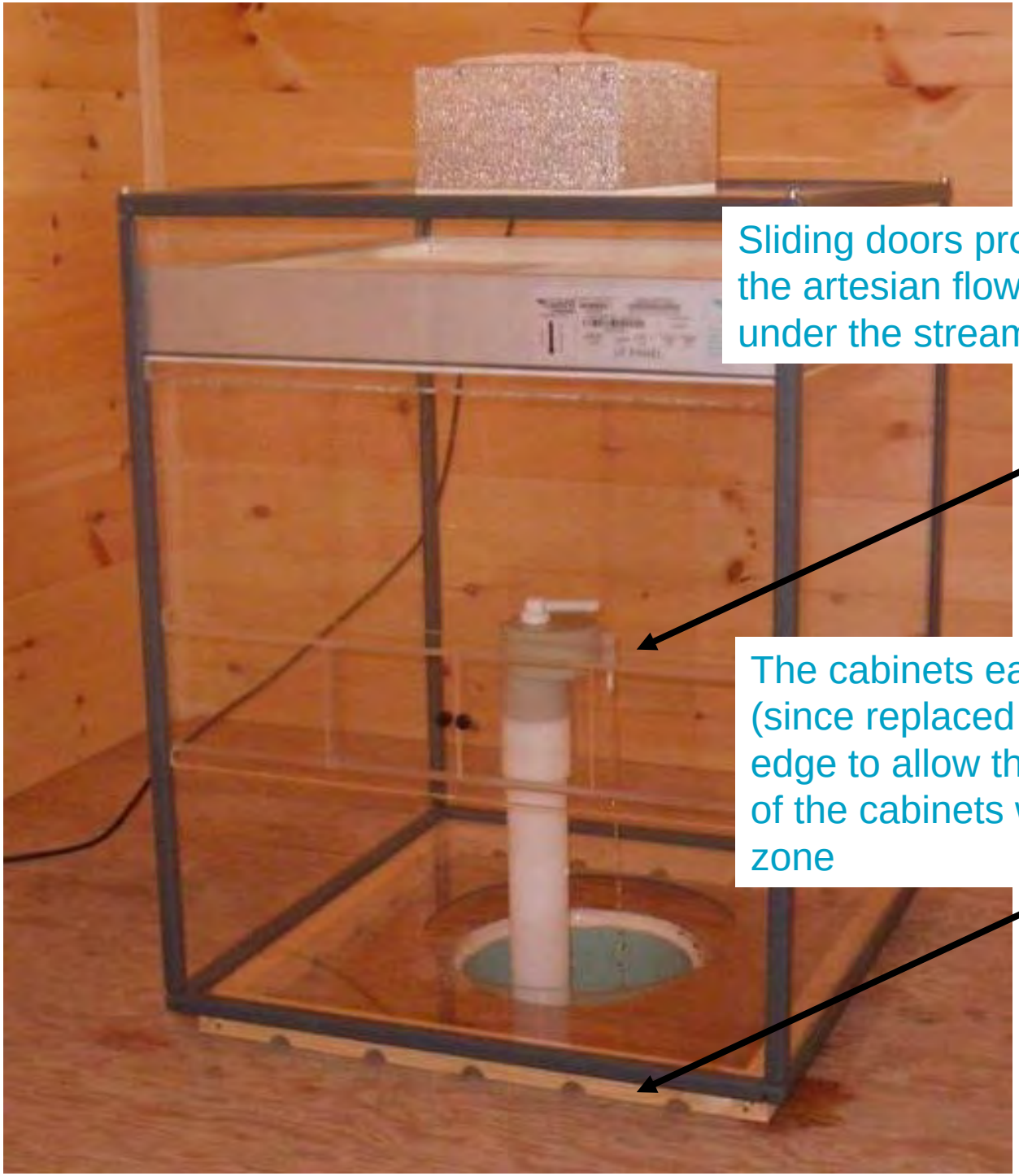
to watch and listen to the water, check out YouTube “groundwater research wells”

Sept 2010

Clean Air Cabinet, HDPE well

To eliminate the risk of sample contamination by ambient air, clean air cabinets were designed by James Zheng who also kindly supplied the filters and loaned us the portable laser particle counter

Clean Air Cabinet, SS well



Sliding doors provide access for sampling the artesian flow at the height of the outlet, under the stream of filtered air

The cabinets each rest on a wooden frame (since replaced with plexiglas) with serrated edge to allow the filtered air to exit the base of the cabinets well below the sampling zone

September 2010:
Tommy built the cabinets, installed them, and tested them

Particle Counts:

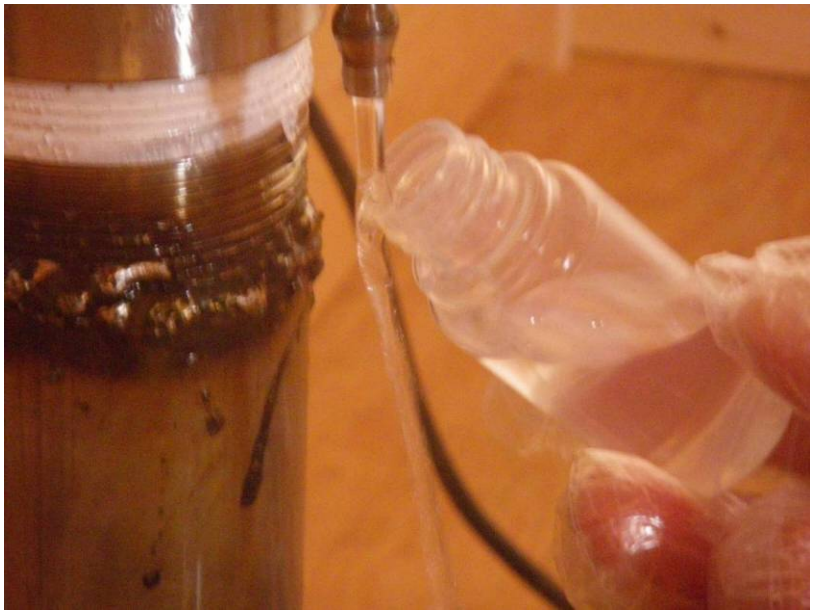
In cabin, ambient air, <u>before</u> sampling, > 1.5 M particles > 0.3 µm per ft^3

In cabin, ambient air, <u>after</u> sampling, > 6.4 M particles > 0.3 µm per ft^3

In Clean Air Cabinets during sampling, ZERO particles > 0.3 µm per ft^3

In May of 2011, two room air filters were added, to improve the quality of ambient air

Water sampling in CAC, HDPE well

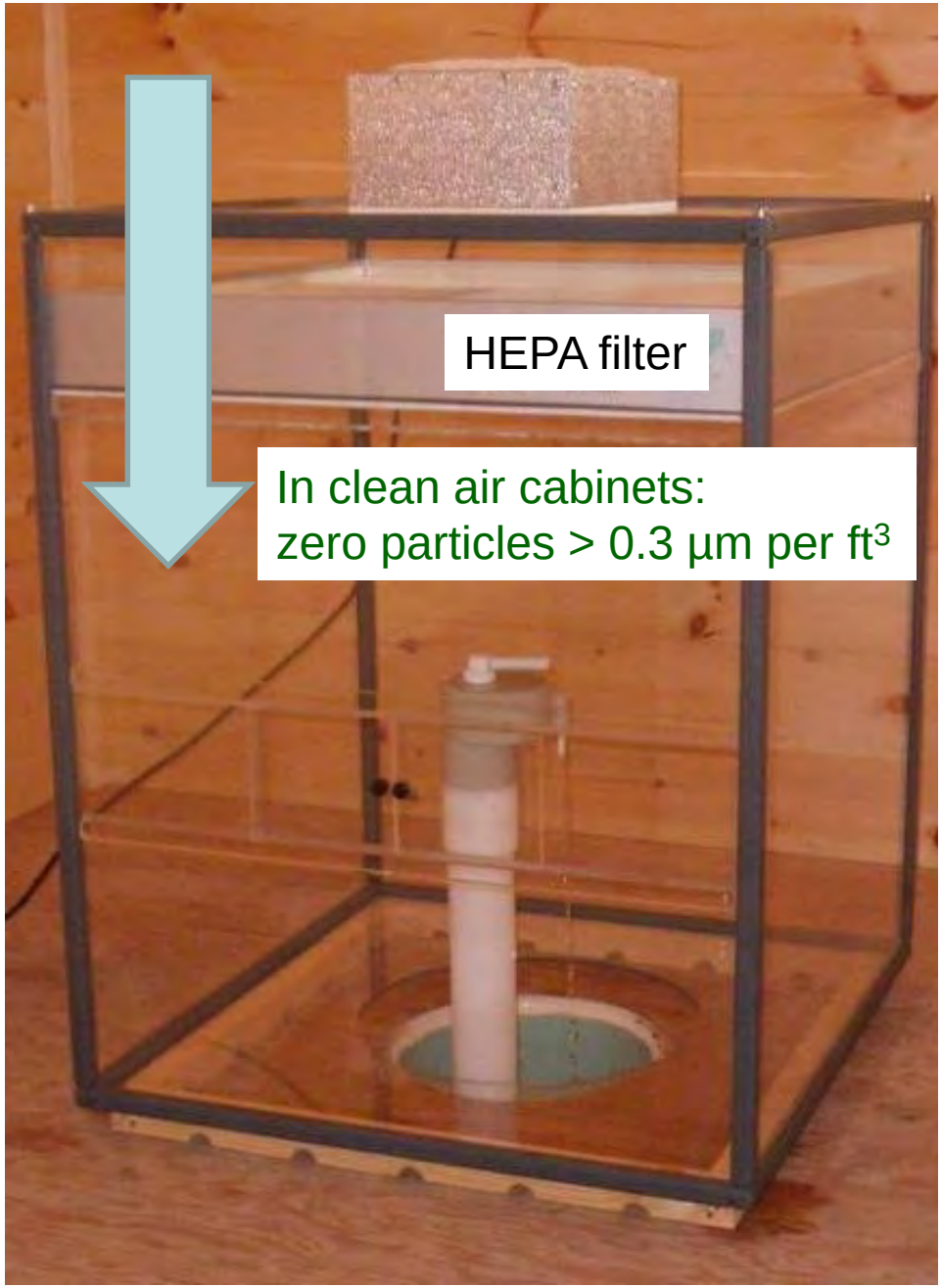


Water sampling in CAC, SS well

Suiting up for water sampling……

In cabin, ambient air:
> 1.5 x 10^6 particles > 0.3 µm per ft^3

Hand-held laser particle counter

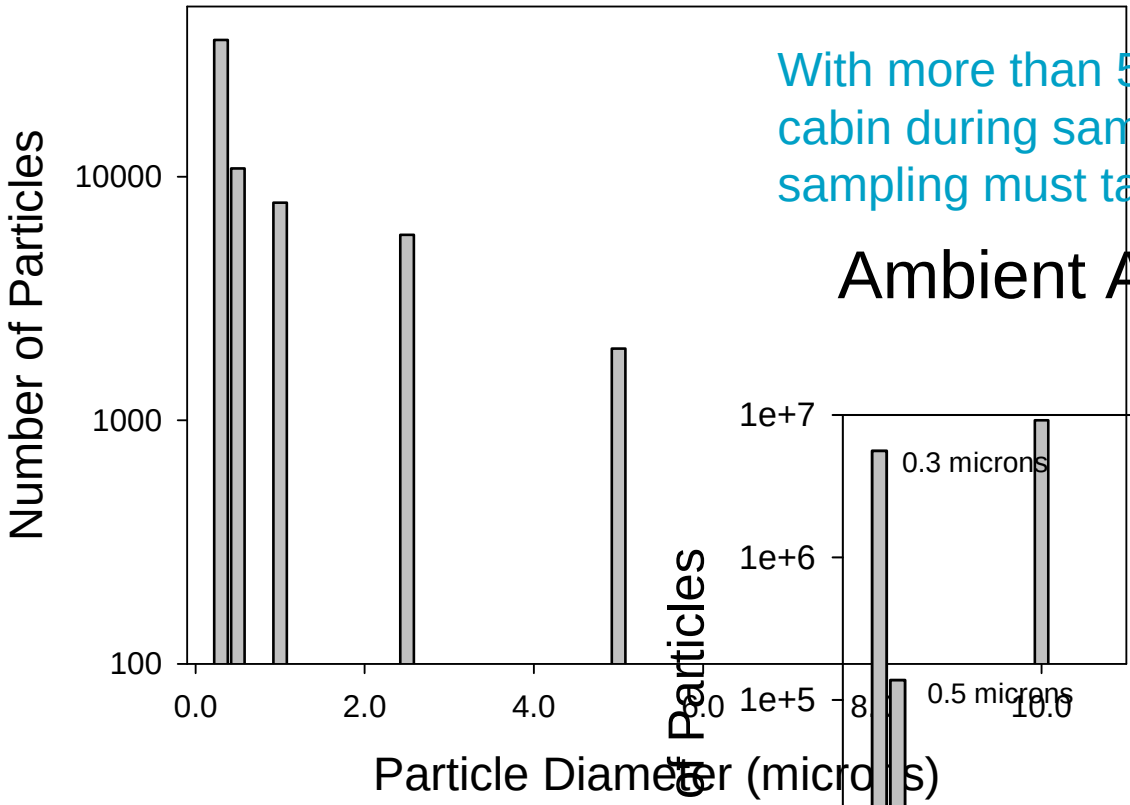


March 2011

James measuring air quality in the cabin, and within the cabinets, March 2011, using laser particle counter

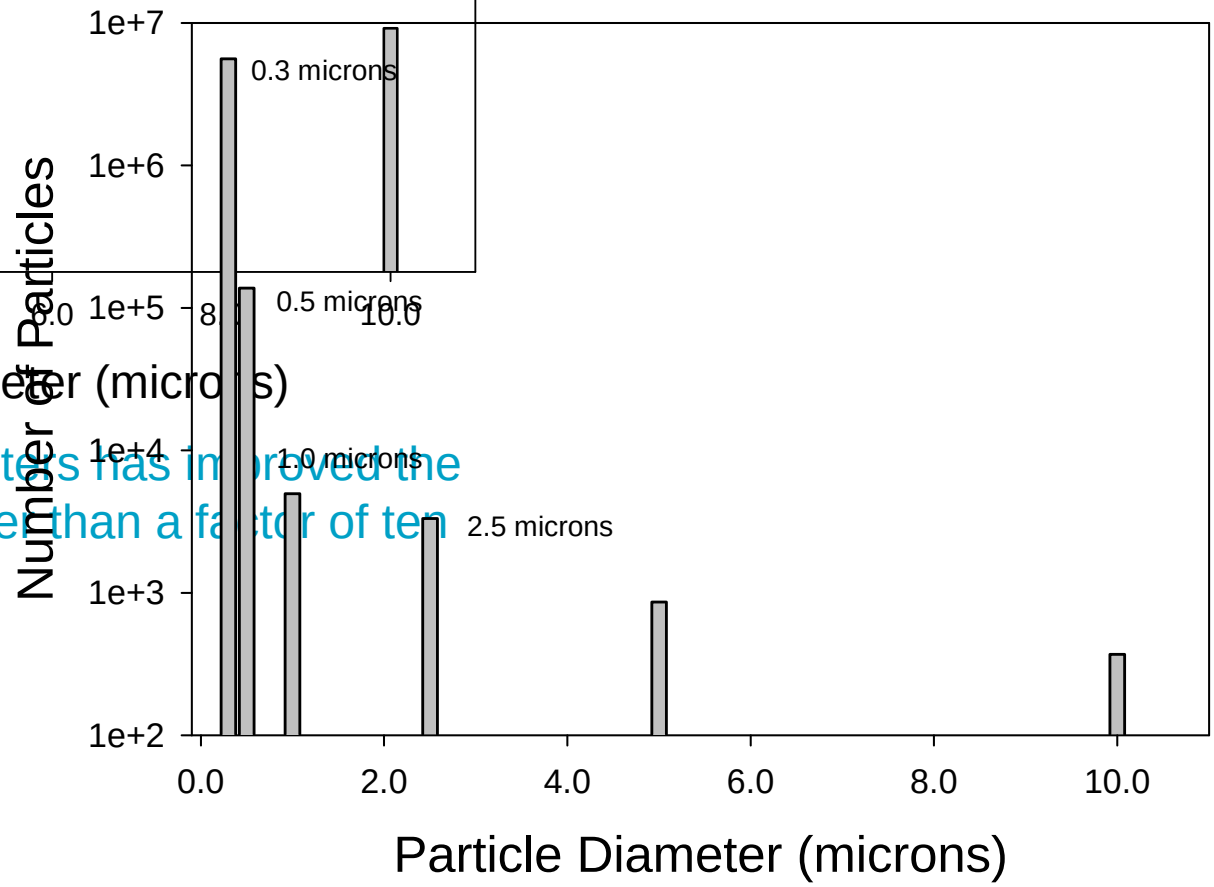
Air quality was also measured outdoors, when fresh snow was also sampled (for comparison with the groundwater)

Ambient Air, Cabin, before sampling



With more than 5 M particles per ft^3 of air in the cabin during sampling, it becomes clear why water sampling must take place within the cabinets

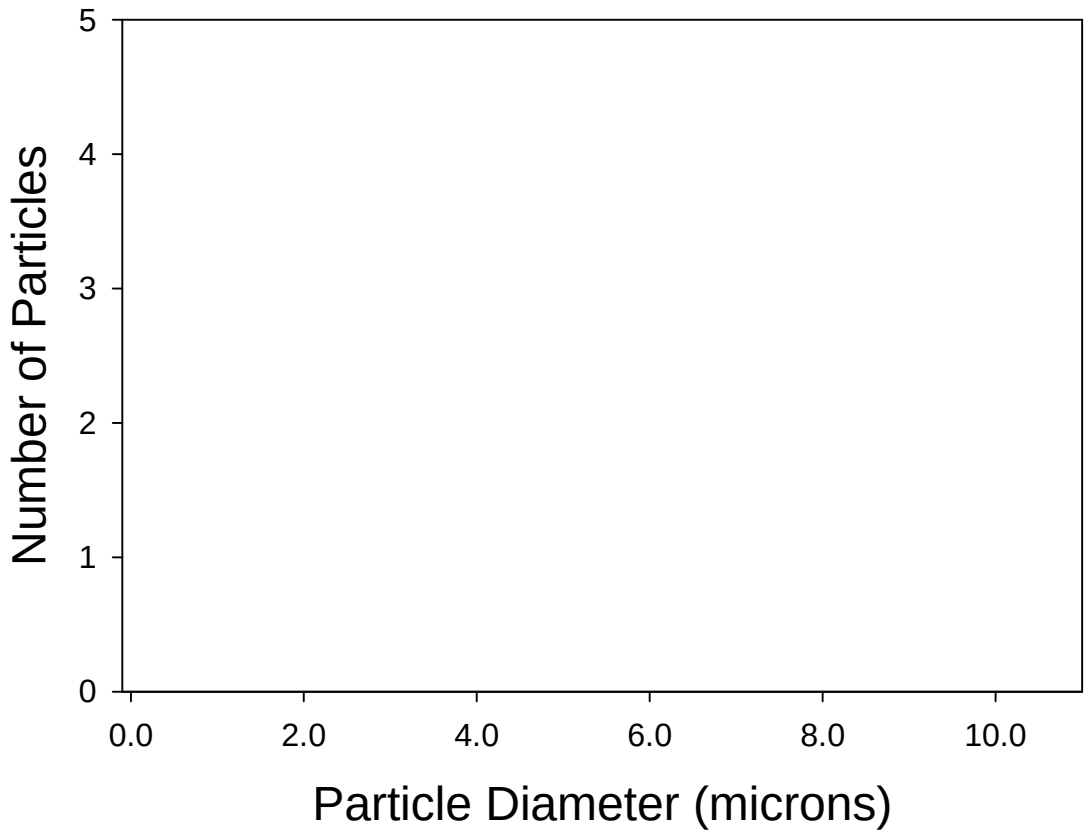
Ambient Air, Cabin, after sampling



Adding the two room air filters has improved the ambient air quality by better than a factor of ten

May 2011

Clean Air Cabinet, during sampling



During water sampling, within the clean air cabinets, there are no measurable particles

May 2011

University of Heidelberg, Germany, where all the trace metal measurements were made, until 2010

Dr. Michael Krachler who made all of the ICP-MS measurements until 2008

Stefan Rheinberger made the ICP-MS measurements during 2009 and 2010.

Comparing the composition of groundwater with atmospheric inputs (obtained by collecting and testing snow) allows the natural filtration of water by soils to be quantified. In the case of Pb, for example, removal is estimated to be on the order of 99.995 %

Elements Depleted in Groundwater, Relative to Snow

M/Z	Element (ng/L)	Stainless Steel Well (n=10)	HDPE Well (n=10)	Arctic Ice (Devon Island, 3.3 K to 7.9 K yr BP) n=6	Snow, 6.3.11, Springwater Township (n=10)
45	Sc	1.1 ± 0.1	1.2 ± 0.1	0.65 ± 0.17	3.9 ± 2.0
52	**Cr**	**2.2 ± 0.3**	**1.5 ± 0.4**	4.1 ± 1.3	323 ± 553
60	**Ni**	**37.4 ± 7.1**	**32.6 ± 6.0**	NA	249 ± 294
109	Ag	0.64 ± 0.29	0.65 ± 0.30	0.67 ± 1.2	5.0 ± 4.5
111	Cd	3.6 ± 1.1	3.6 ± 1.1	2.3 ± 0.8	12.3 ± 14.3
121	Sb	3.0 ± 0.5	3.0 ± 0.4	0.10 ± 0.04	44.7 ± 48.6
208	**Pb**	**3.0 ± 0.9**	**1.0 ± 0.3**	5.1 ± 1.4	552 ± 607
209	Bi	0.05 ± 0.02	0.04 ± 0.01	0.10 ± 0.05	5.4 ± 5.3
232	Th	0.48 ± 0.25	0.54 ± 0.27	NA	6.4 ± 3.7

From W. Shotyk. *A dedicated "clean lab" sampling facility for studying the natural filtration of trace metals by soils: the artesian springs of the Elmvale Groundwater Observatory*.The 22nd V.M. Goldschmidt Conference, June 24-29, 2012, Montreal, Quebec.

Elements Enriched in Groundwater, Relative to Snow

M/Z	Element (ng/L)	Stainless Steel Well (n=10)	HDPE Well (n=10)	Ancient Arctic Ice (Devon Island, 3.3 K to 7.9 K yr BP)	Snow, 6.3.11, Springwater Township (n=10)
7	Li (µg/l)	5.0 ± 0.4	4.7 ± 0.3	NA	0.05 ± 0.01
75	As	1685 ± 152	1608 ± 133	3.0 ± 0.7	28.7 ± 7.5
74	Ge	8.6 ± 0.2	8.7 ± 0.1	NA	4.5 ± 1.7
98	Mo	1764 ± 145	1710 ± 103	0.82 ± 0.09	528 ± 592
184	W	207 ± 51	209 ± 46	NA	58.1 ± 24.0
185	Re	1.8 ± 0.5	1.7 ± 0.4	NA	0.25 ± 0.35
238	U	1143 ± 311	1144 ± 280	0.50 ± 0.18	3.4 ± 2.8

From W. Shotyk. *A dedicated "clean lab" sampling facility for studying the natural filtration of trace metals by soils: the artesian springs of the Elmvale Groundwater Observatory*.The 22nd V.M. Goldschmidt Conference, June 24-29, 2012, Montreal, Quebec.

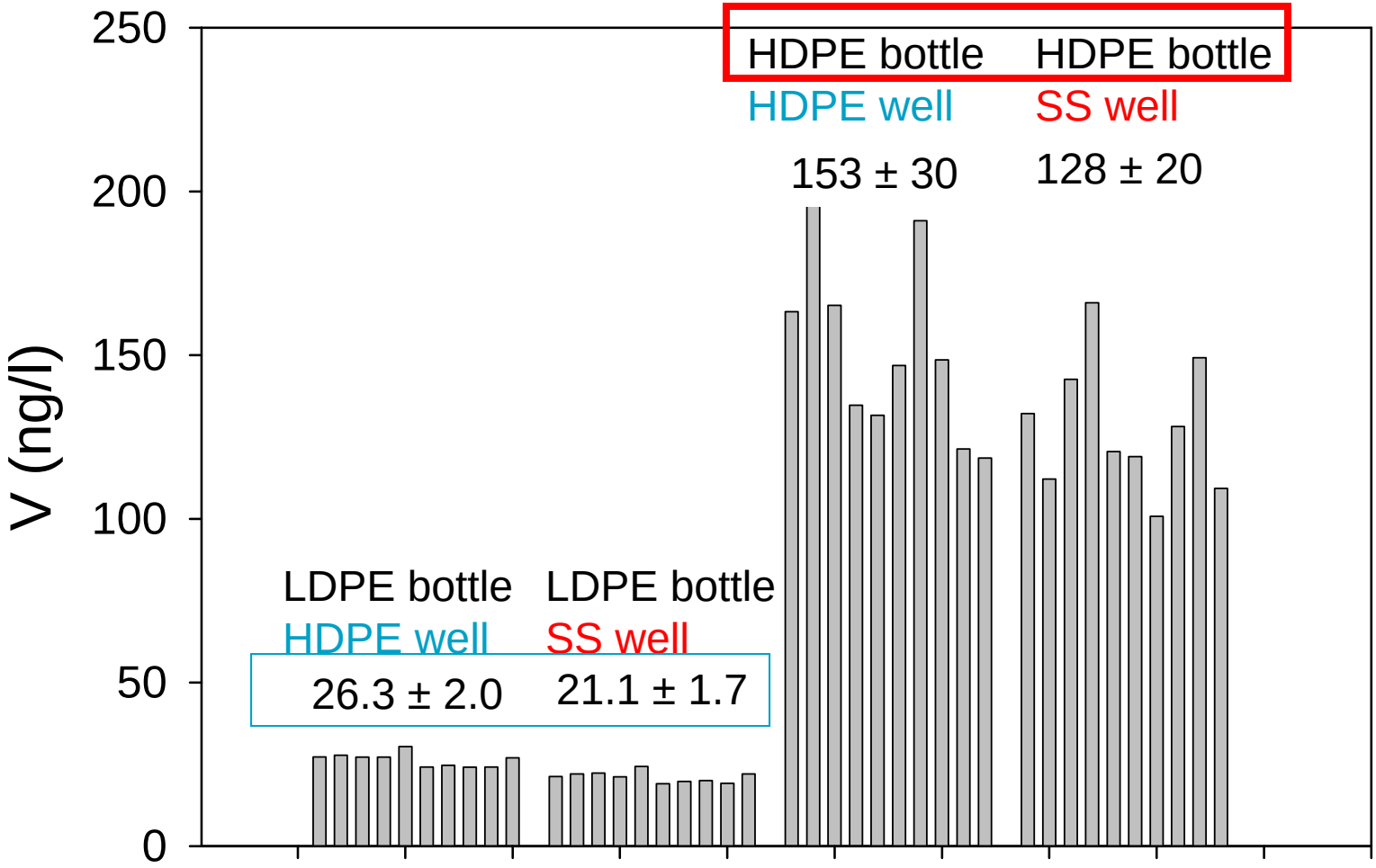
Elements neither Enriched nor Depleted in Groundwater, Relative to Snow

M/Z	Element (ng/L)	Stainless Steel Well (n=10)	HDPE Well (n=10)	Ancient Arctic Ice (Devon Island, 3.3 K to 7.9 K yr BP)	Snow, 6.3.11, Springwater Township (n=10)
9	Be	2.4 ± 0.3	2.3 ± 0.4	NA	1.5 ± 0.4
59	Co	14.4 ± 0.3	15.5 ± 0.4	2.5 ± 1.0	12.7 ± 8.9
205	Tl	1.0 ± 0.3	1.1 ± 0.3	0.24 ± 0.05	0.7 ± 0.3

All of the trace element data shown here was obtained by sampling the groundwater in acid-washed HDPE bottles, provided by Dr. James Zheng of the Glaciology Division, Geological Survey of Canada, Ottawa

From W. Shotyk. *A dedicated "clean lab" sampling facility for studying the natural filtration of trace metals by soils: the artesian springs of the Elmvale Groundwater Observatory*.The 22nd V.M. Goldschmidt Conference, June 24-29, 2012, Montreal, Quebec.

LDPE vs. HDPE bottles



The HDPE bottles are suitable for sampling for many trace metals, but not for vanadium !

SUMMARY

A dedicated sampling facility has been created for the study of trace metals in natural freshwaters.

The concentrations of many elements are at or below the levels found in ancient Arctic ice (3.3 – 7.9 K yr BP).

The extreme “clean lab” methods, procedures and protocols which have been developed for the study of polar snow and ice, must be rigorously employed.

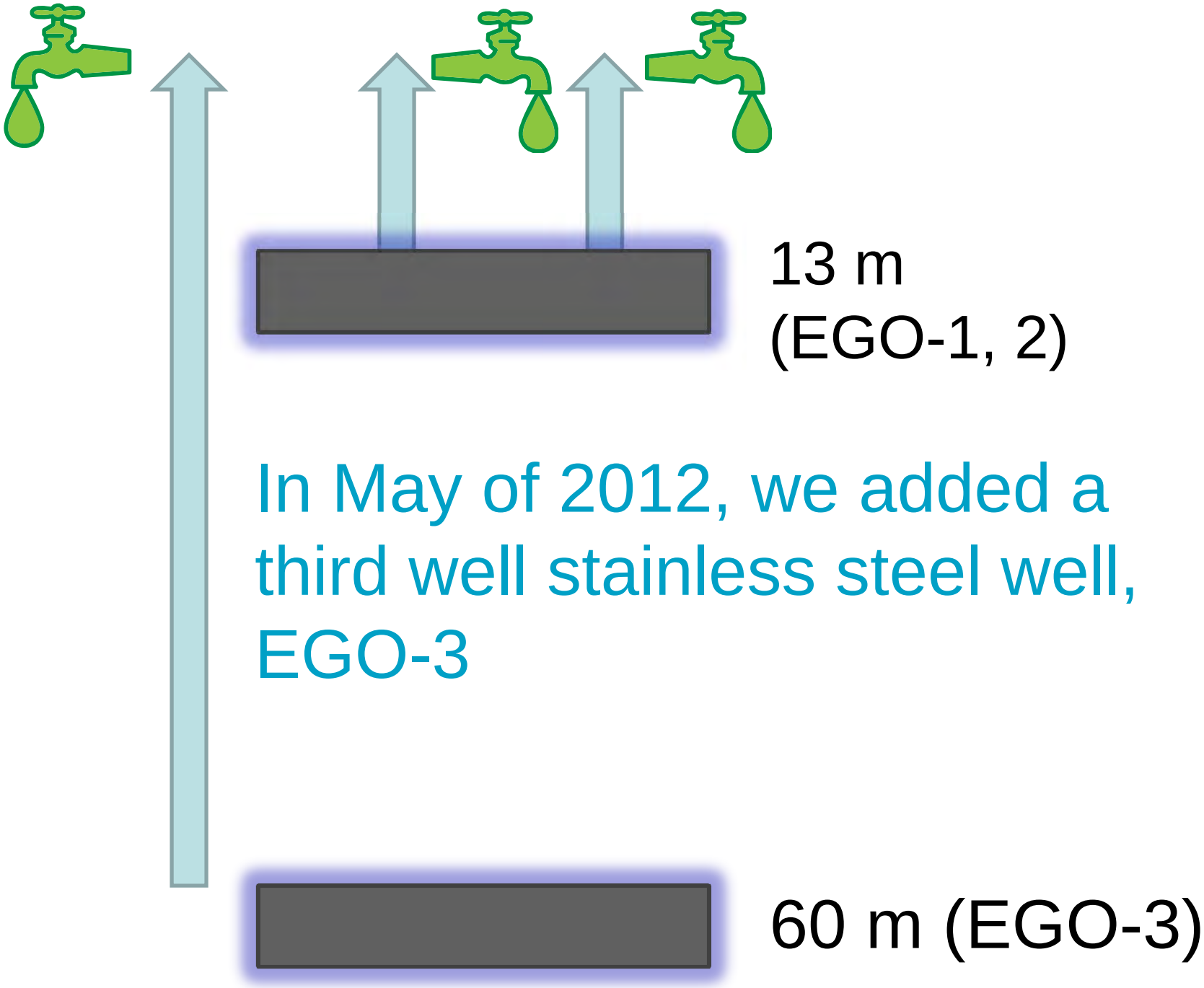
Some elements are depleted in the groundwater, relative to atmospheric inputs (e.g. Cr, Ni, Sb, Pb), whereas others are enriched (Li, As, Mo, W, Re, U), during the evolution of the groundwater.

FURTHER READING

Shotyk, W. and Krachler, M. (2009) Determination of trace element concentrations in natural freshwaters: how low is “low”, and how low do we have to go? *Journal of Environmental Monitoring* 11:1747 - 1753, DOI: 10.1039/b917090c.

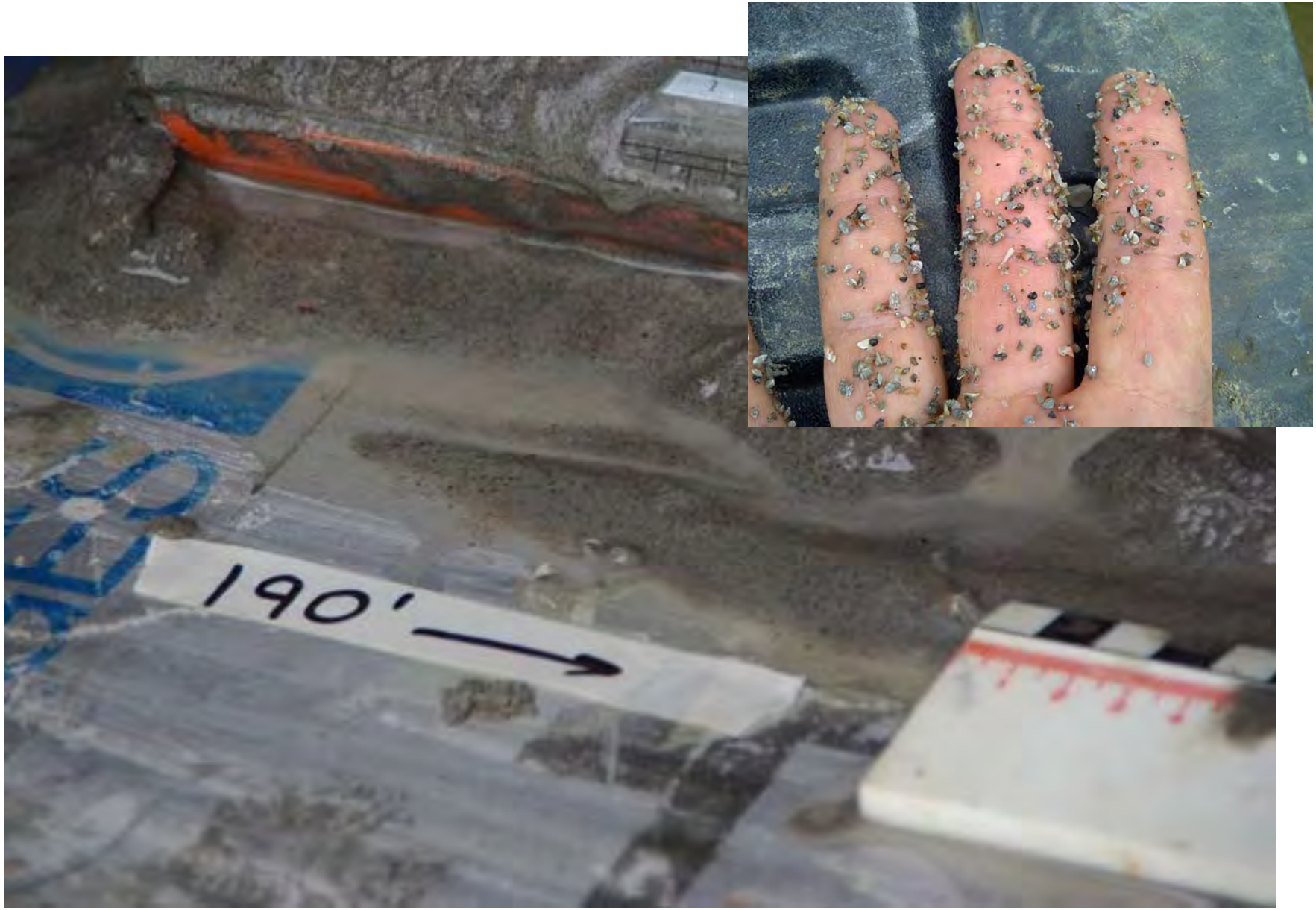
Shotyk, W., Krachler, M., Aeschbach-Hertig, W., Hillier, S. and Zheng, J. (2010) Trace elements in recent groundwater of an artesian flow system and comparison with snow: enrichments, depletions, and chemical evolution of the water. *Journal of Environmental Monitoring* 12:208-217.

NEWS UPDATE: announcing EGO-3


13 m
(EGO-1, 2)
In May of 2012, we added a third well stainless steel well, EGO-3
60 m (EGO-3)

Installing EGO-3, Elmvale ONT May 2012

Approximately 60 m of sediment core was collected, requiring an additional 7 days. The stratigraphy varied from varved lacustrine sediments to glacial till.



But finally, at 190 ft, aquifer sand was reached and it proved to be artesian

The well was allowed to run for 2-3 days, to allow the particles to be flushed out

The well was constructed entirely of 316 surgical stainless steel, including this valve

Rick Buckley and Jamie Archer taking a drink from the new well

We are deeply indebted to Jamie Archer and his experienced crew at Canadian Soil Drilling for their time, skills, and expertise

A second cabin was constructed later that summer, again by Steve Ogden, to house the new well. This cabin is smaller than the first, but provides enough space for another clean air cabinet to protect the water during sampling.

SPECIAL THANKS TO:

CSD
CANADIAN SOIL DRILLING
12493 Hwy 27 North, Midhurst, ON, L0L 1X0

Jamie Archer and Peter Fleming,
Canadian Well Drilling, Midhurst ONT

Rick Buckley, President,
Pro Core Drilling, Brantford, ONT

Stephen and Neil Ogden, Ogden Farms, Parry Sound, ONT

University of Heidelberg:
Werner Aeschbach-Hertig, Andreas Funke, Michael Krachler,
Stefan Rheinberger, Christian Scholz,

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Tommy Noernberg, University of Alberta
Martin Otz, NanoTrace Technologies, USA
Michael Powell, M Powell International, London ONT
Stephen Hillier, James Hutton Institute, UK
Claudio Zaccone, University of Foggia, IT
James Zheng, GSC, Ottawa, CAD

AND finally

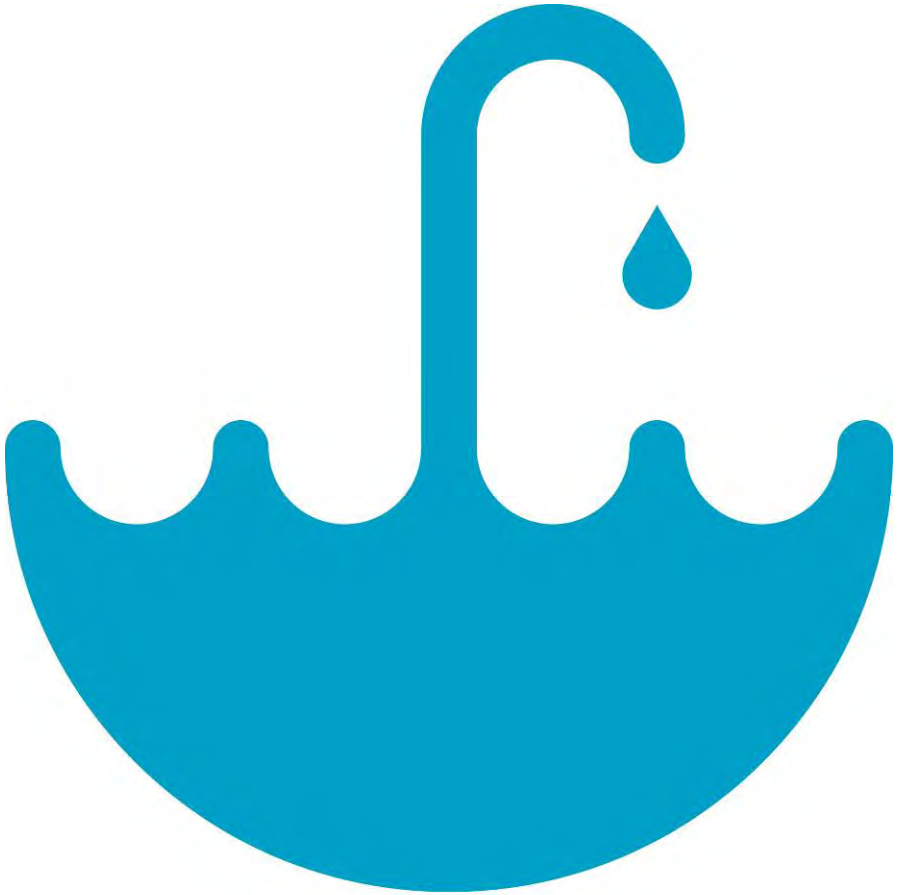
the elmvale foundation

a federally registered charity

(84826 6193 RR0001)

for environmental science education

www.elmvale.org



celebrate water

For more information, contact shotyk@ualberta.ca
OR bill@elmvale.org

Revised 15.2.13