Welcome to the CLU-IN Internet Seminar

The Long-Term Impact of Metal Smelting Operations on Arsenic Availability in Urban Lakes of the South-Central Puget Sound Region

Sponsored by: University of Washington Superfund Research Program

Delivered: June 26, 2013, 2:00 PM - 4:00 PM, EDT (18:00-20:00 GMT)

Instructor:

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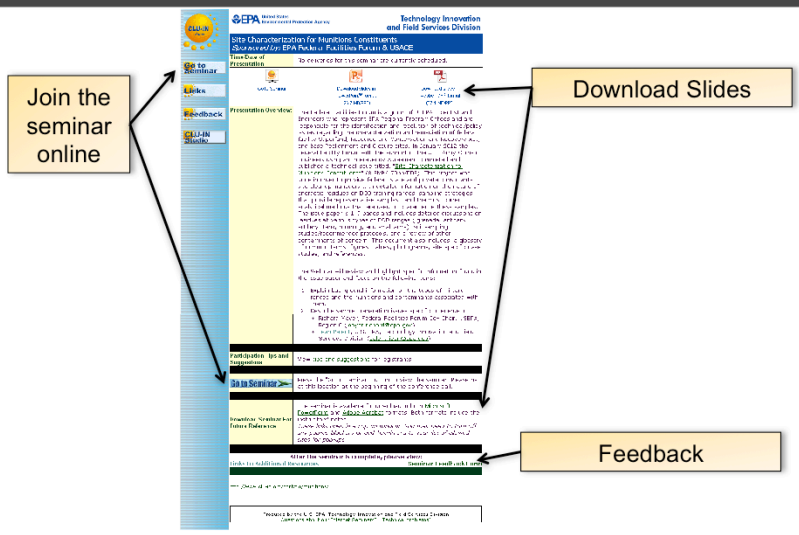
Seminar Homepage



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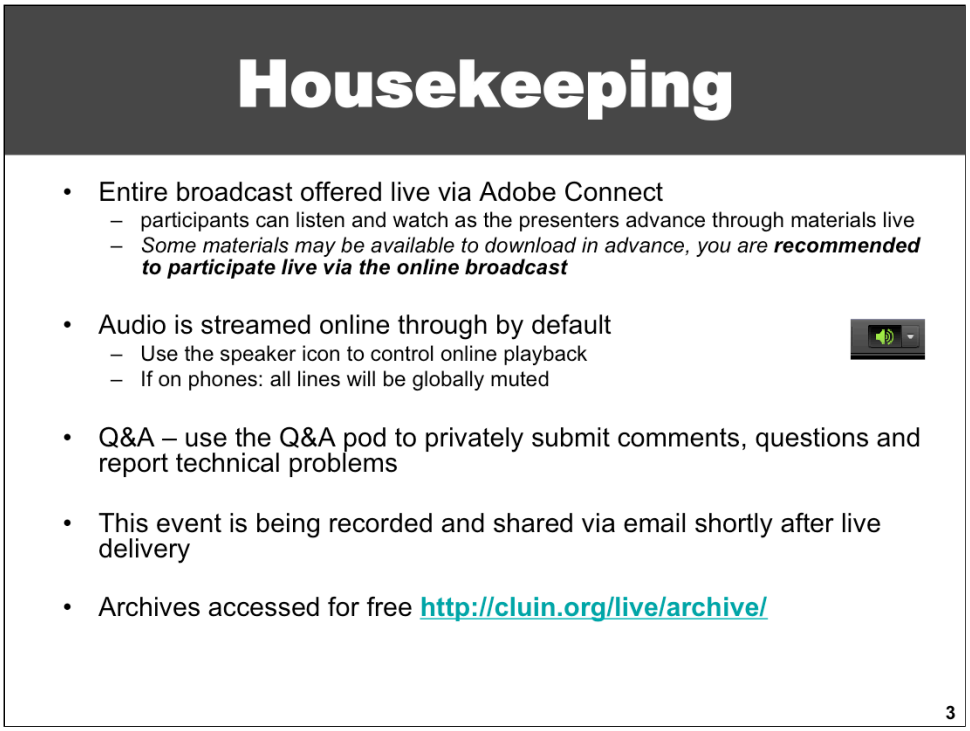

Although I'm sure that some of you have these rules memorized from previous CLU-IN events, let's run through them quickly for our new participants.

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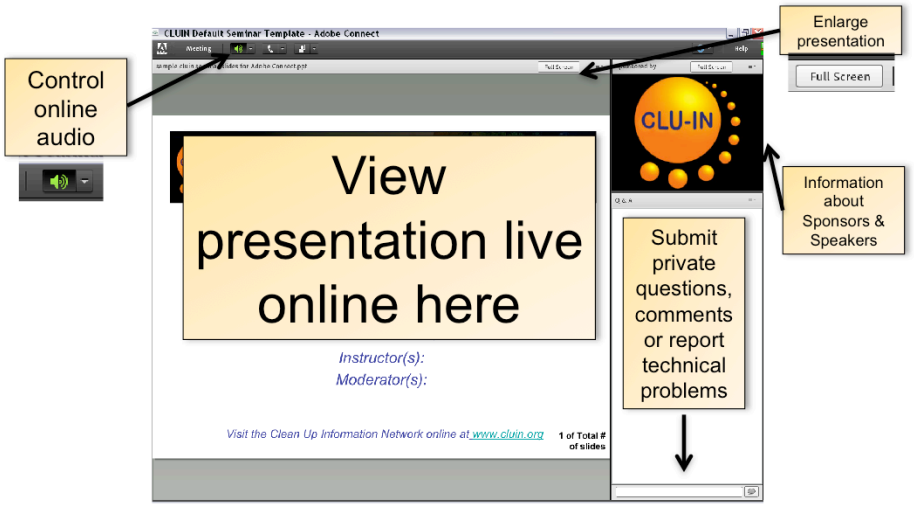
You should note that throughout the seminar, we will ask for your feedback. You do not need to wait for Q&A breaks to ask questions or provide comments. To submit comments/questions and report technical problems, please use the ? Icon at the top of your screen. You can move forward/backward in the slides by using the single arrow buttons (left moves back 1 slide, right moves advances 1 slide). The double arrowed buttons will take you to 1st and last slides respectively. You may also advance to any slide using the numbered links that appear on the left side of your screen. The button with a house icon will take you back to main seminar page which displays our agenda, speaker information, links to the slides and additional resources. Lastly, the button with a computer disc can be used to download and save today's presentation materials.

With that, please move to slide 3.

New online broadcast screenshot



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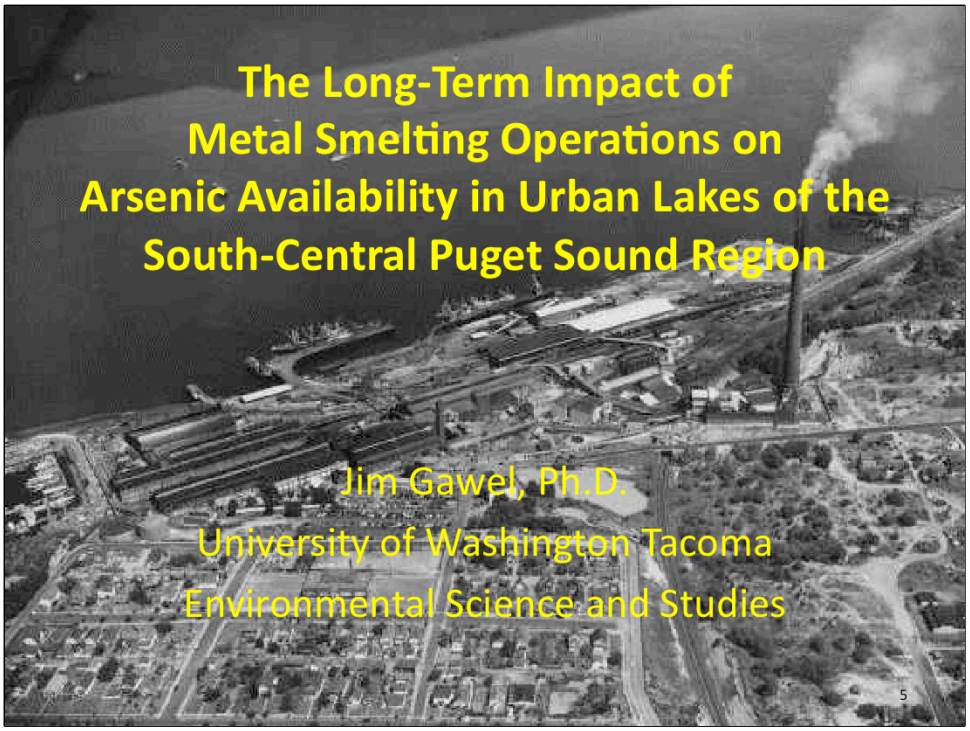
The Long-Term Impact of
Metal Smelting Operations on
Arsenic Availability in Urban Lakes of the
South-Central Puget Sound Region
Jim Gawel, Ph.D.
University of Washington Tacoma
Environmental Science and Studies
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Research Team
• UWT Undergraduates: Lindsay Tuttle, Sarah Burdick, Michelle Miller, Jessica Asplund, Shawna Peterson, Kara Ziegler and Alexandra Ehle
• Bellarmine High School: Amanda Tollefson and Brian Rurik
• UW Seattle Faculty: Becca Neumann
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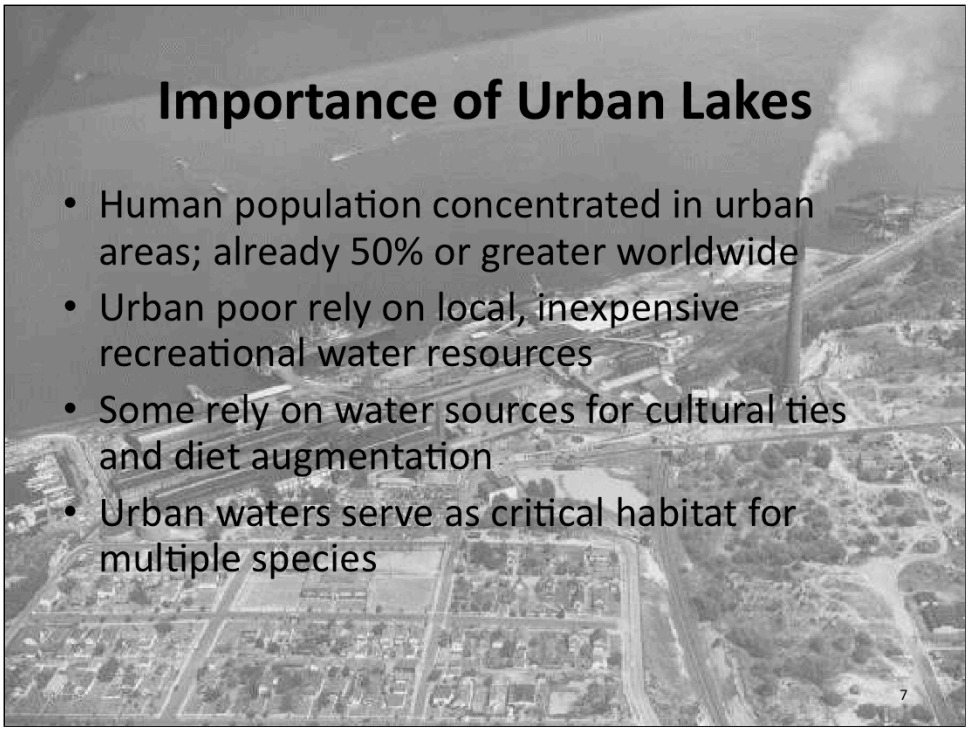
Importance of Urban Lakes
• Human population concentrated in urban areas; already 50% or greater worldwide
• Urban poor rely on local, inexpensive recreational water resources
• Some rely on water sources for cultural ties and diet augmentation
• Urban waters serve as critical habitat for multiple species
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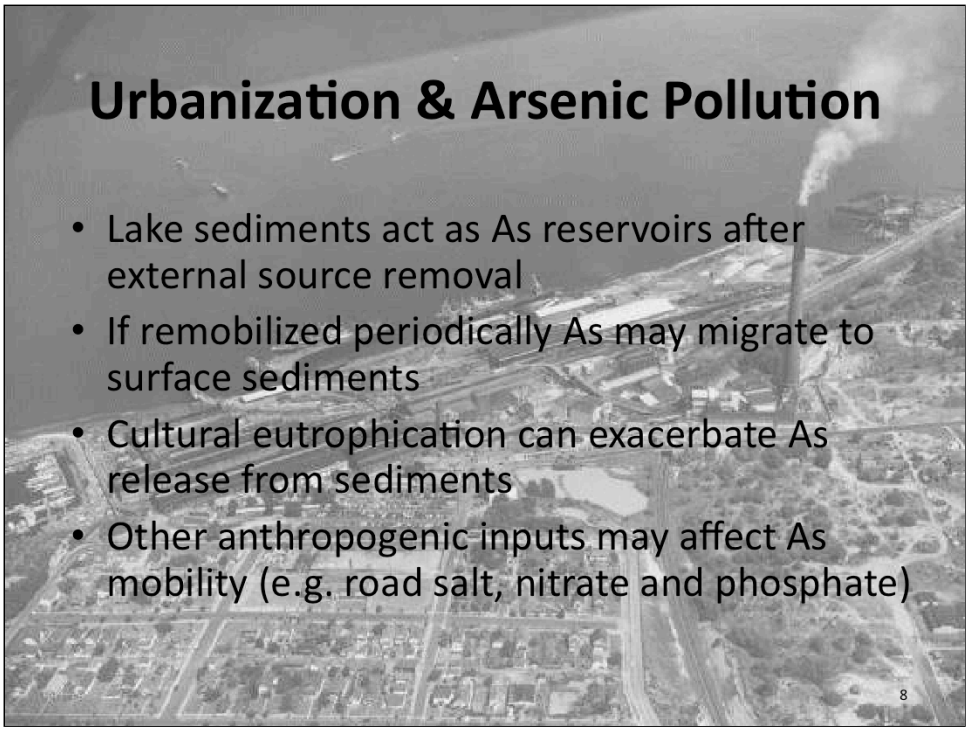
Urbanization & Arsenic Pollution
• Lake sediments act as As reservoirs after external source removal
• If remobilized periodically As may migrate to surface sediments
• Cultural eutrophication can exacerbate As release from sediments
• Other anthropogenic inputs may affect As mobility (e.g. road salt, nitrate and phosphate)
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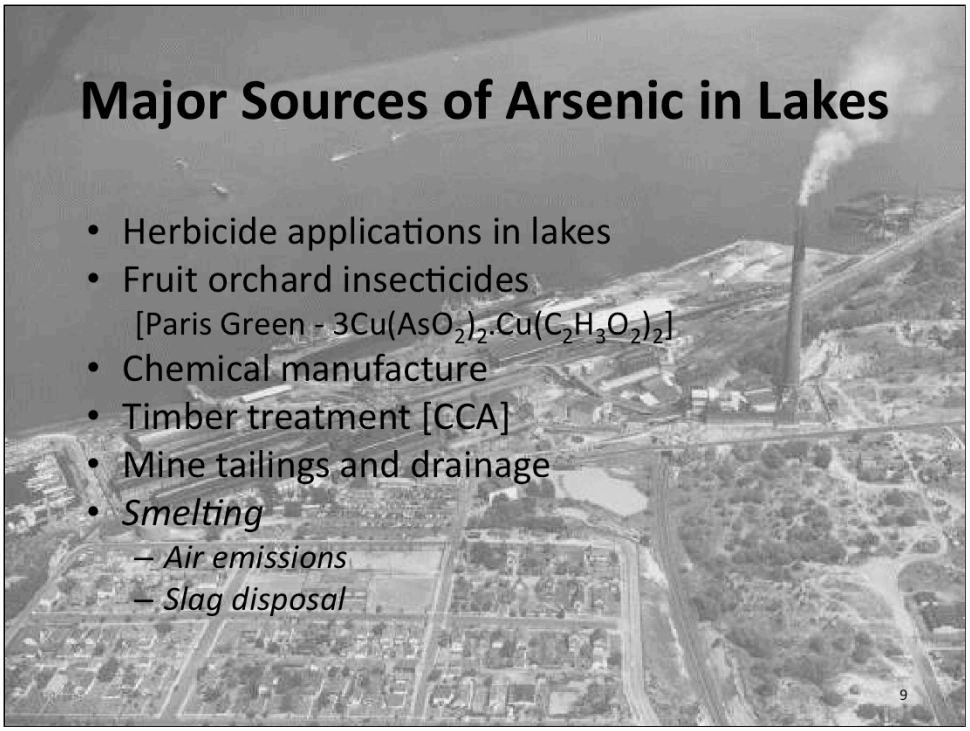
Major Sources of Arsenic in Lakes
• Herbicide applications in lakes
• Fruit orchard insecticides
[Paris Green - $3Cu(AsO_2)_2.Cu(C_2H_3O_2)_2$]
• Chemical manufacture
• Timber treatment [CCA]
• Mine tailings and drainage
• *Smelting*
– *Air emissions*
– *Slag disposal*
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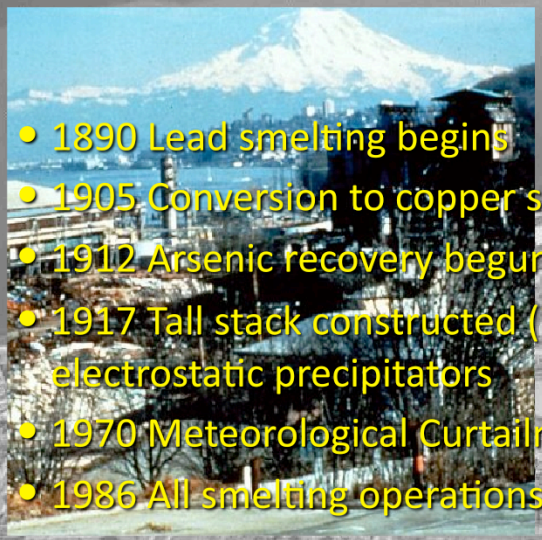
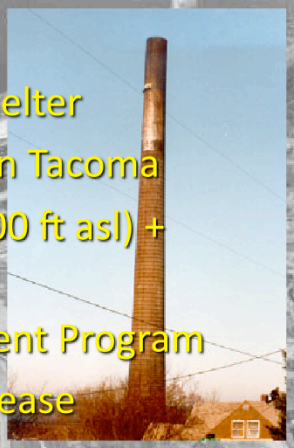
ASARCO





- 1890 Lead smelting begins
- 1905 Conversion to copper smelter
- 1912 Arsenic recovery begun in Tacoma
- 1917 Tall stack constructed (700 ft asl) + electrostatic precipitators
- 1970 Meteorological Curtailment Program
- 1986 All smelting operations cease

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Ongoing Study Breakdown

- Spatial distribution of As and Pb in lake sediments
- Temporal distribution in sediments
- Arsenic mobility and release to water column
- *Chemical, biological, and physical controls on As mobility, bioavailability and toxicity*

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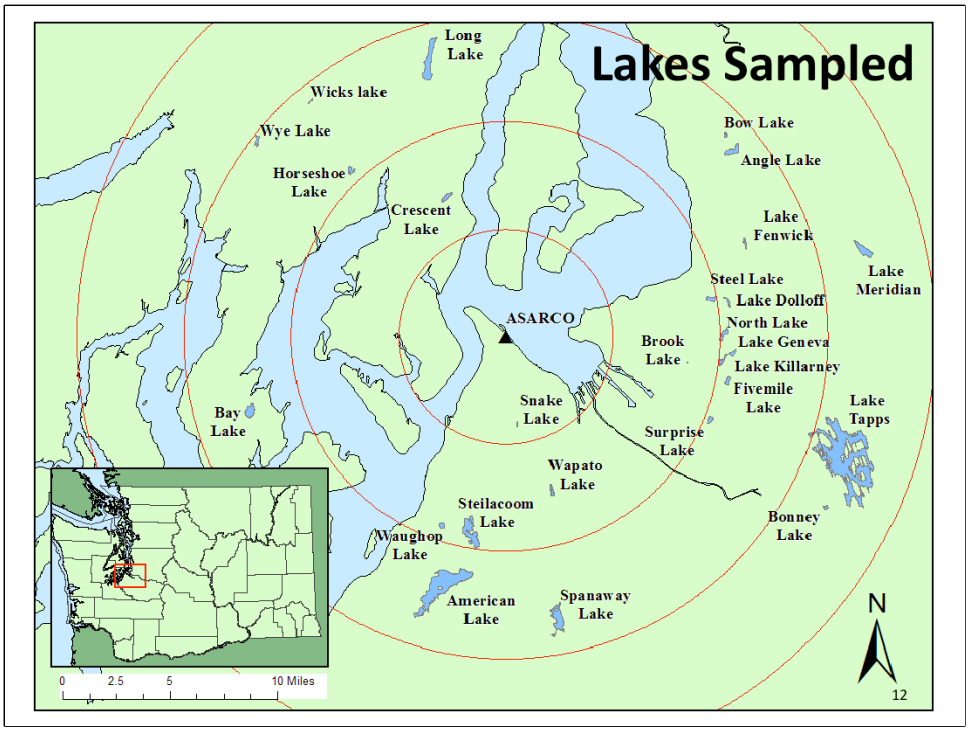
Lakes Sampled
Long Lake
Wicks lake
Wye Lake
Horseshoe Lake
Crescent Lake
Bow Lake
Angle Lake
Lake Fenwick
Lake Meridian
Steel Lake
Lake Dolloff
North Lake
Lake Geneva
Lake Killarney
Fivemile Lake
Lake Tapps
ASARCO
Brook Lake
Snake Lake
Surprise Lake
Bay Lake
Wapato Lake
Steilacoom Lake
Bonney Lake
Waughop Lake
American Lake
Spanaway Lake
N
0 2.5 5 10 Miles
12

Wind Patterns

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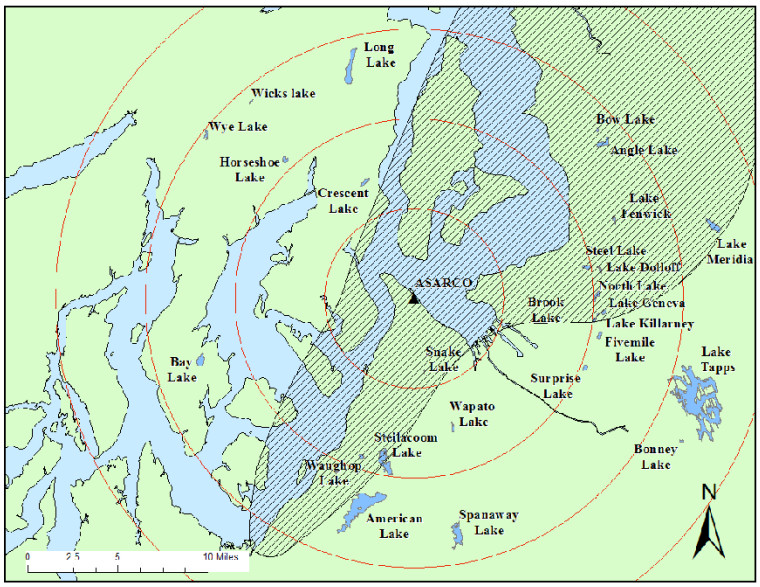

http://www.ecy.wa.gov/PROGRAMS/tcp/area_wide/AW/Toolbox_chap2_figures/Tier2Maps.pdf

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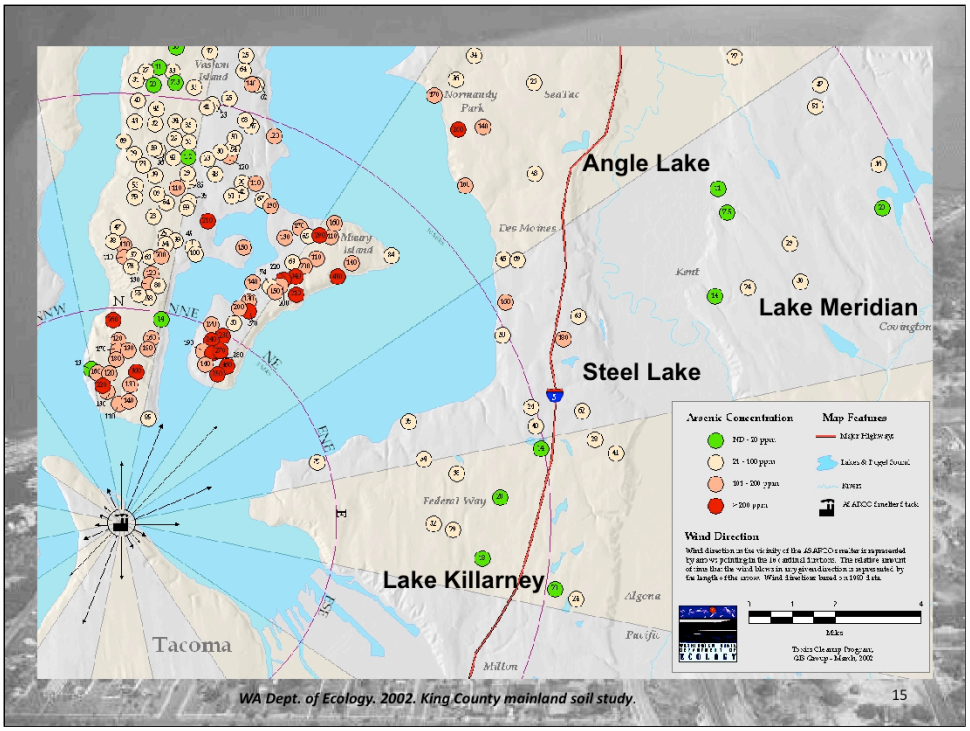

WA Dept. of Ecology. 2002. King County mainland soil study.

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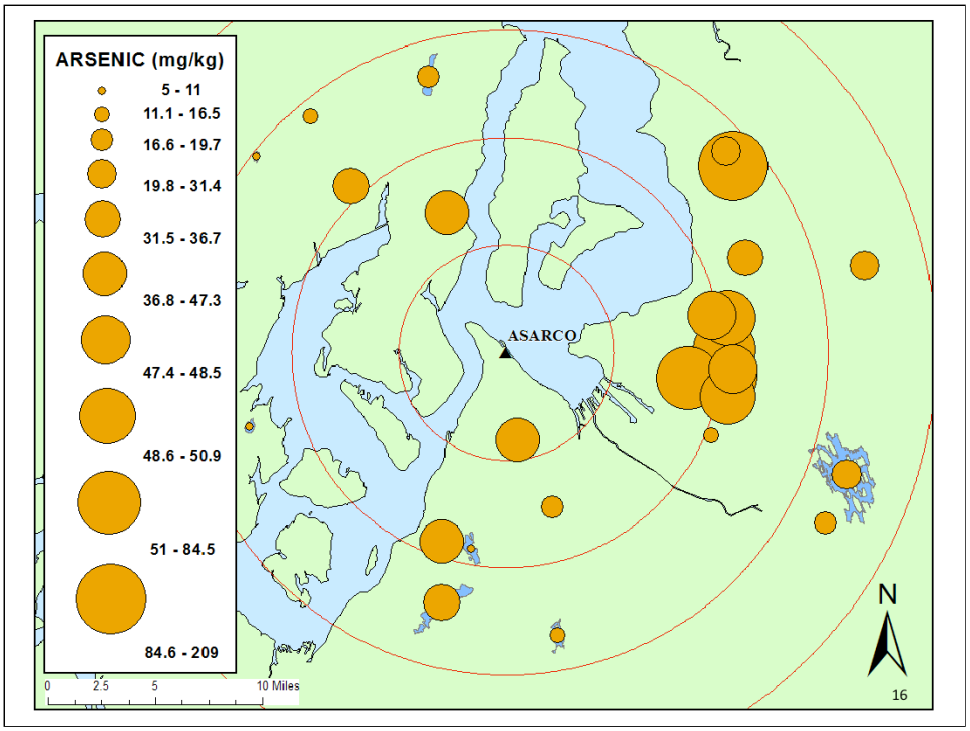
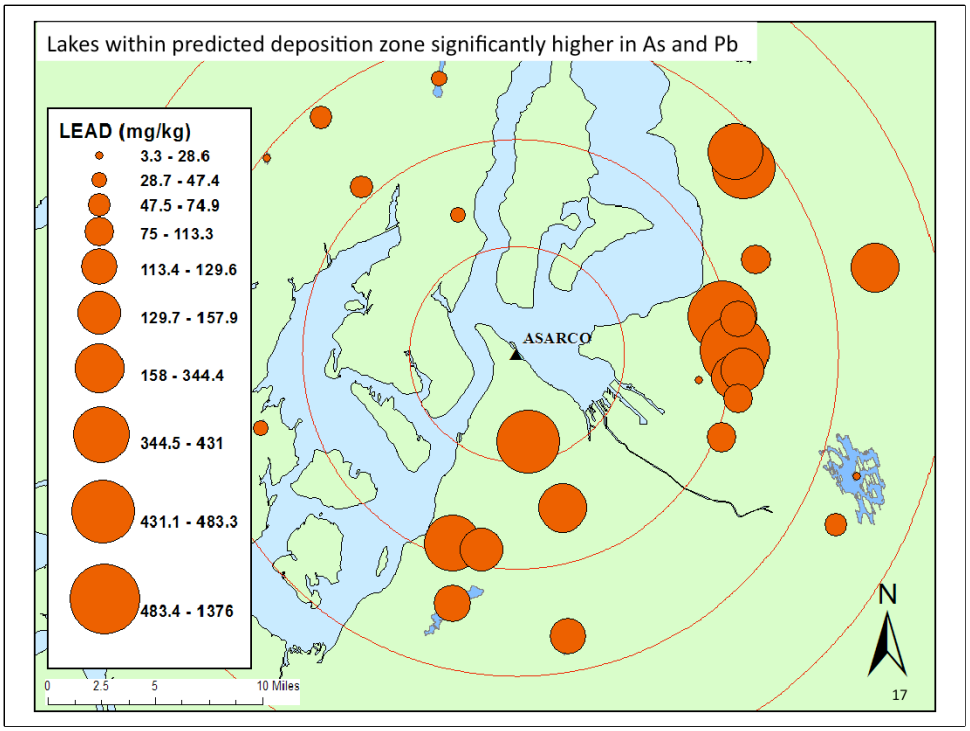
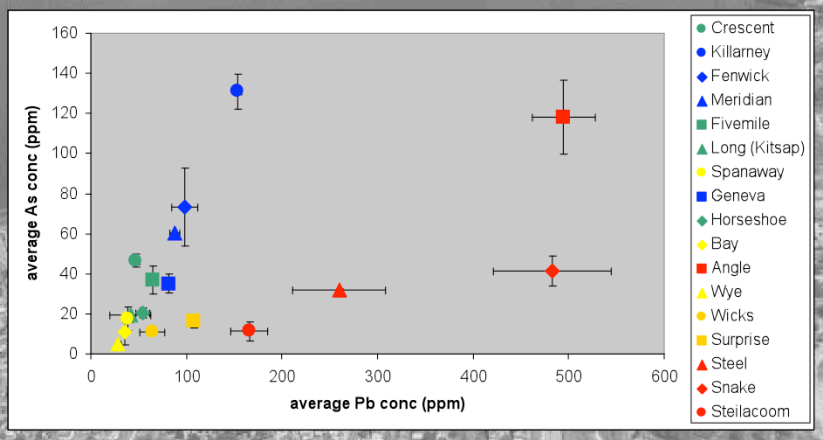

ARSENIC (mg/kg)
5 - 11
11.1 - 16.5
16.6 - 19.7
19.8 - 31.4
31.5 - 36.7
36.8 - 47.3
47.4 - 48.5
48.6 - 50.9
51 - 84.5
84.6 - 209
ASARCO
0
2.5
5
10 Miles
N
16


Lakes within predicted deposition zone significantly higher in As and Pb
LEAD (mg/kg)
3.3 - 28.6
28.7 - 47.4
47.5 - 74.9
75 - 113.3
113.4 - 129.6
129.7 - 157.9
158 - 344.4
344.5 - 431
431.1 - 483.3
483.4 - 1376
ASARCO
0
2.5
5
10 Miles
N
17

As vs. Pb in Surface Sediments



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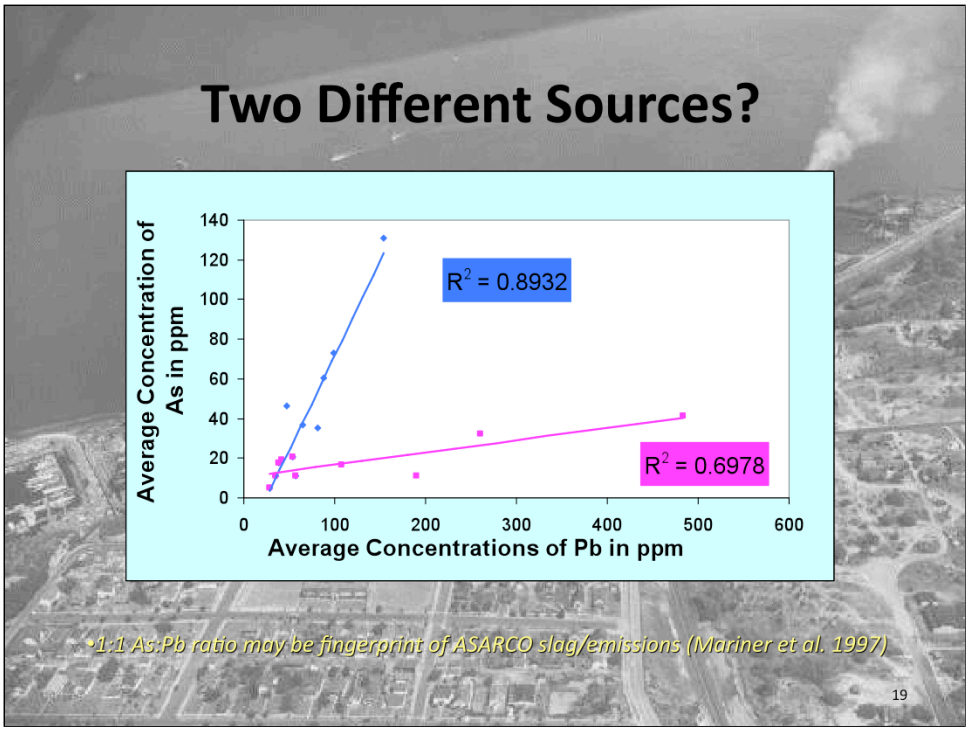
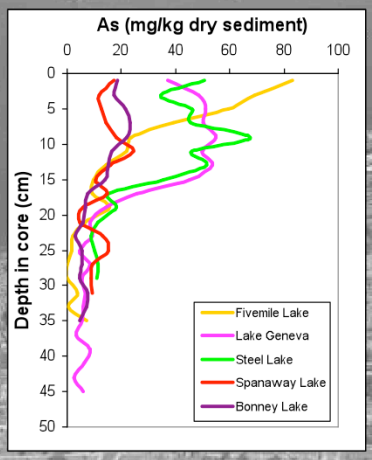
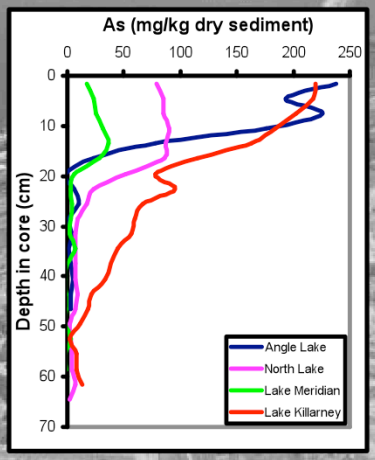


Slag deposition or atmospheric transport or road runoff influences?

As in Sediment Cores





- *Significant correlation between As and Pb in all cores except Brook and Spanaway*

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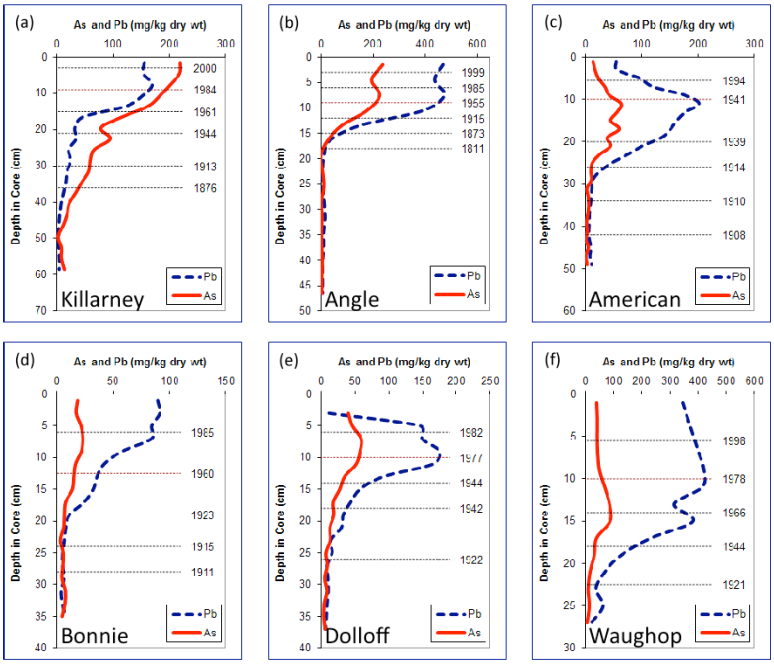
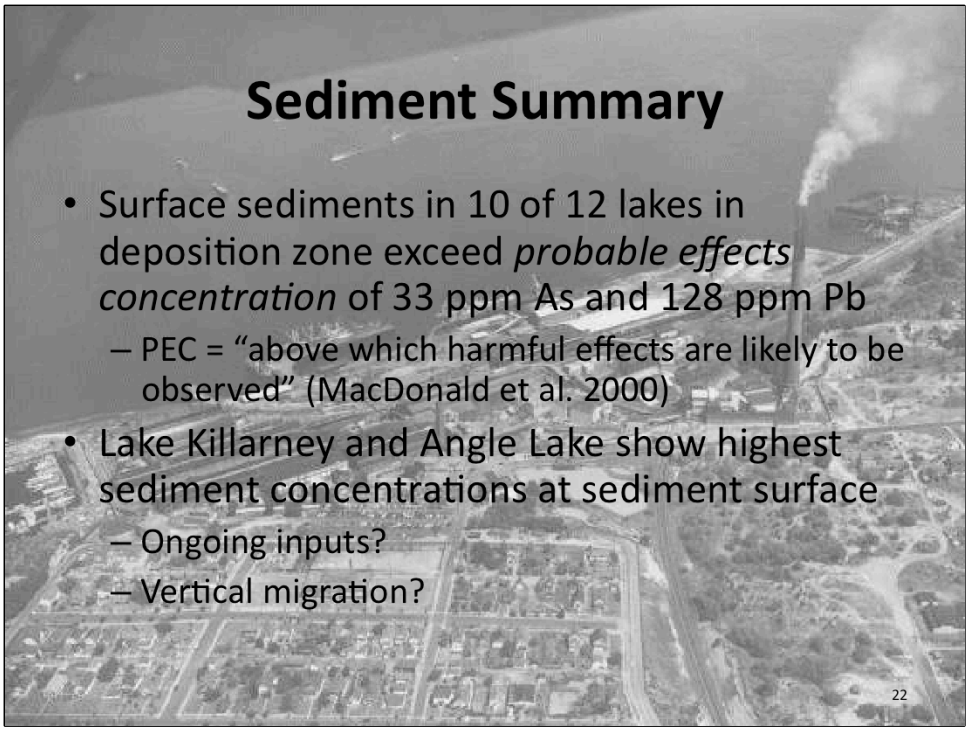

(a)
As and Pb (mg/kg dry wt)
Depth in Core (cm)
2000
1984
1961
1944
1913
1876
Pb
As
Killarney
(b)
As and Pb (mg/kg dry wt)
Depth in Core (cm)
1999
1985
1955
1915
1873
1811
Pb
As
Angle
(c)
As and Pb (mg/kg dry wt)
Depth in Core (cm)
1994
1941
1939
1914
1910
1908
Pb
As
American
(d)
As and Pb (mg/kg dry wt)
Depth in Core (cm)
1965
1960
1923
1915
1911
Pb
As
Bonnie
(e)
As and Pb (mg/kg dry wt)
Depth in Core (cm)
1982
1944
1942
1922
Pb
As
Dolloff
(f)
As and Pb (mg/kg dry wt)
Depth in Core (cm)
1998
1978
1966
1944
1921
Pb
As
Waughop

21


Sediment Summary
• Surface sediments in 10 of 12 lakes in deposition zone exceed *probable effects concentration* of 33 ppm As and 128 ppm Pb
– PEC = "above which harmful effects are likely to be observed" (MacDonald et al. 2000)
• Lake Killarney and Angle Lake show highest sediment concentrations at sediment surface
– Ongoing inputs?
– Vertical migration?
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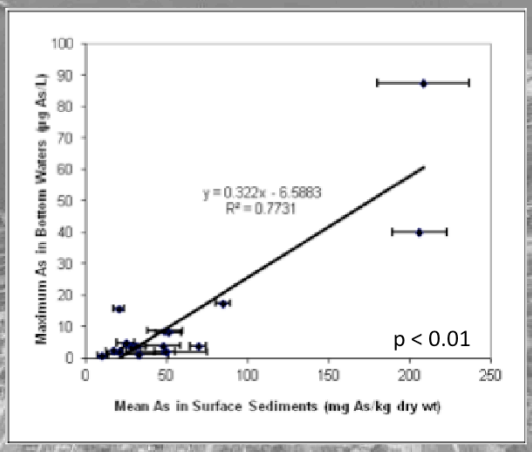
Sediment/Water Transfer



- *Similar ratio seen in Lake Washington by Peterson and Carpenter (1986)*
- *Similar ratio in suite of lakes in Massachusetts by Lattanzi et al. (2007)*

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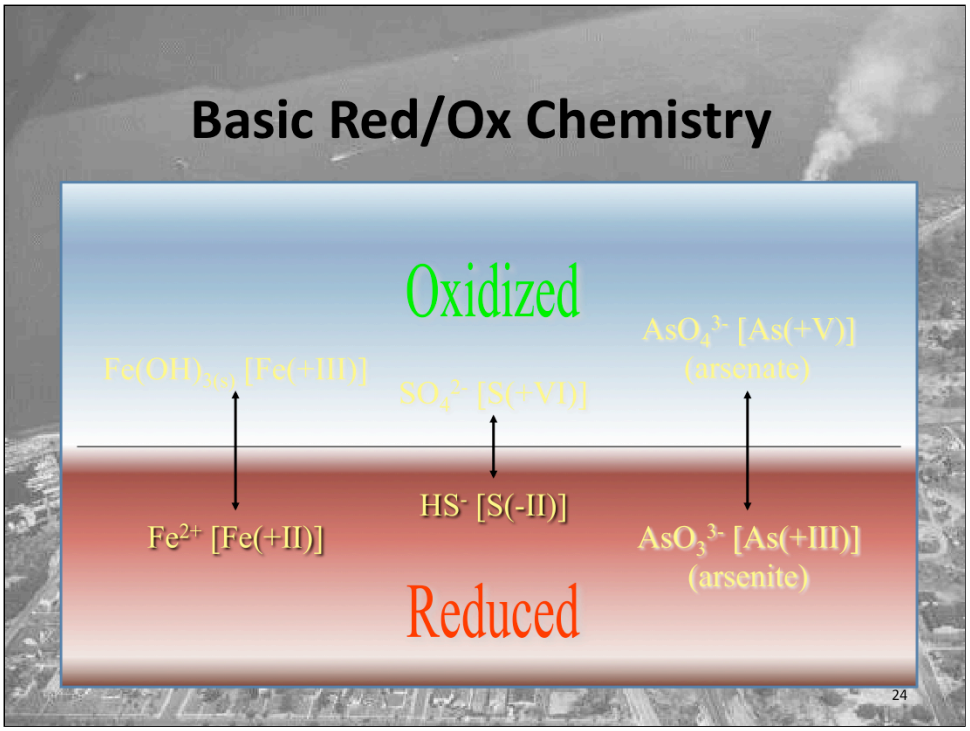
Basic Red/Ox Chemistry
Oxidized
$Fe(OH)_{3(s)}$ [Fe(+III)]
SO_4^{2-} [S(+VI)]
AsO_4^{3-} [As(+V)]
(arsenate)
HS^- [S(-II)]
Fe^{2+} [Fe(+II)]
AsO_3^{3-} [As(+III)]
(arsenite)
Reduced
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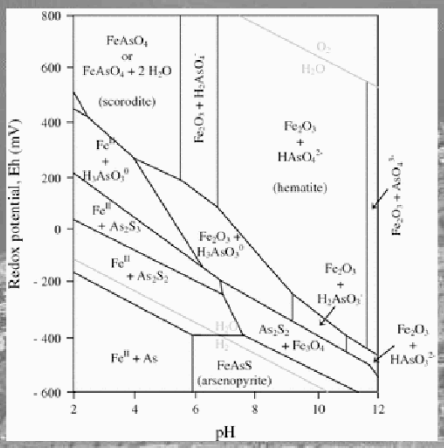
Effect of Eh and pH on As/Fe/S



Daus et al. (2002), ∑As=∑S=∑Fe=10^{-6} M

- Primary inorganic forms:
  - arsenate [As(V):$H_2AsO_4^-$]
  - arsenite [As(III): H_3AsO_4]
- As(V) binds readily to Fe(III)-oxides and may precipitate
- As(III) is more soluble and toxic
- As(III) may bind to S(-II) and Fe(II) and precipitate

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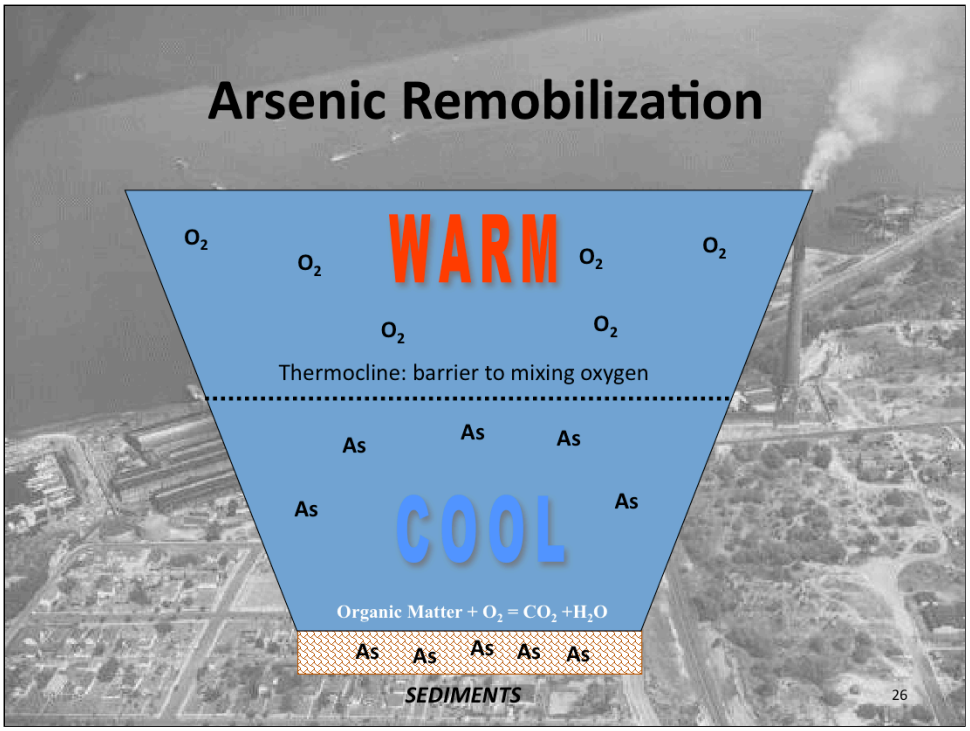
Arsenic Remobilization
WARM
O_2
O_2
O_2
O_2
O_2
O_2
Thermocline: barrier to mixing oxygen
As
As
As
As
As
COOL
Organic Matter + O_2 = CO_2 +H_2O
As
As
As
As
As
SEDIMENTS
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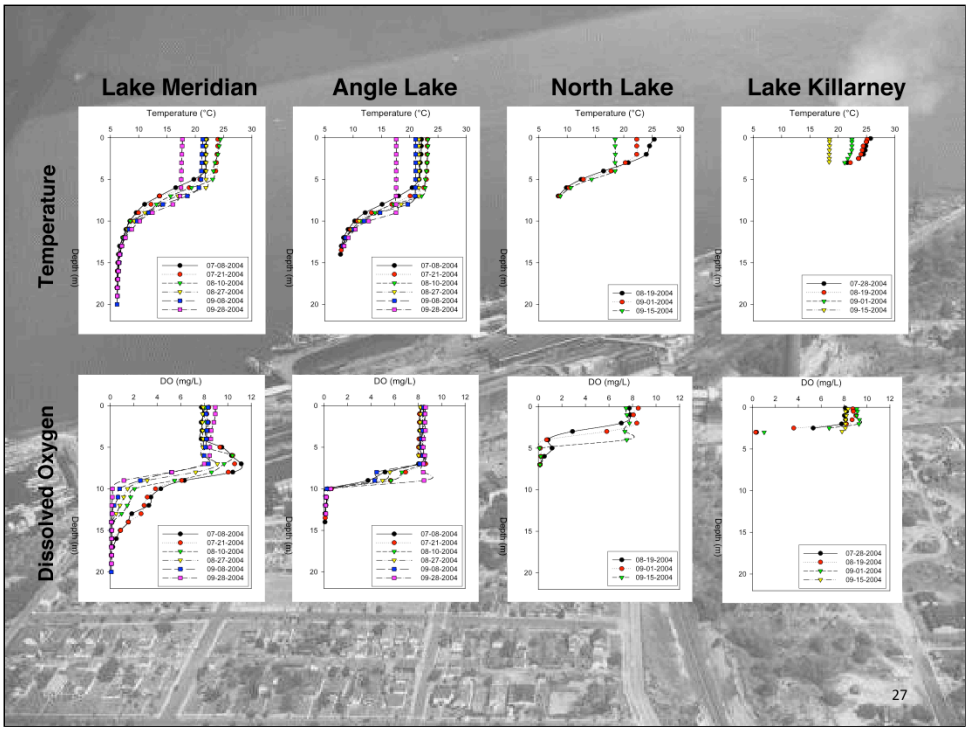
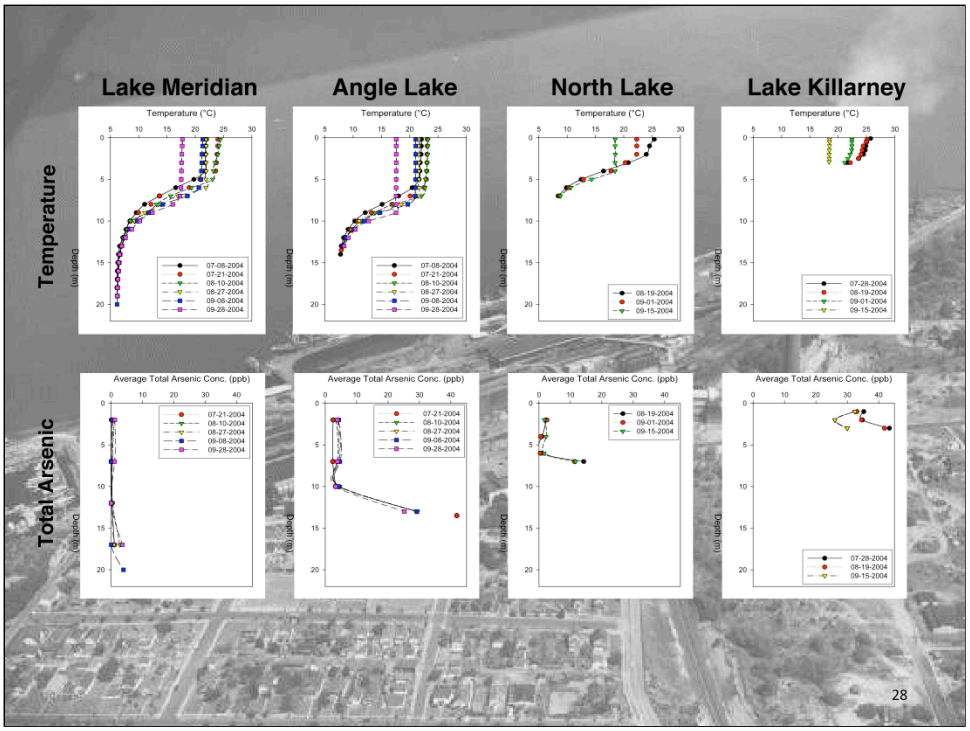
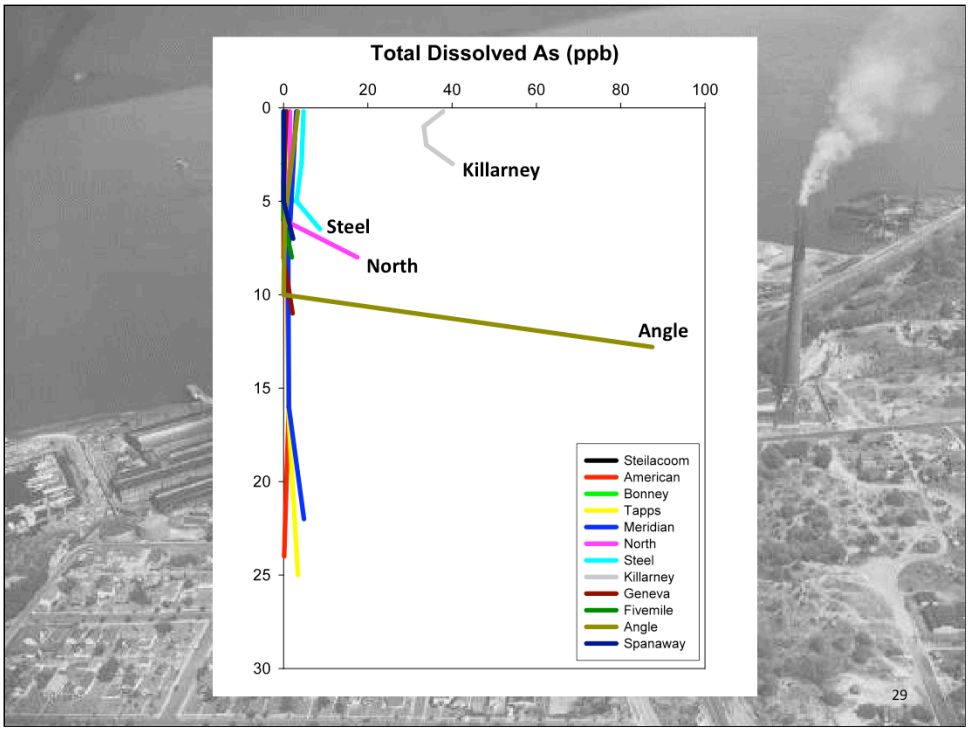
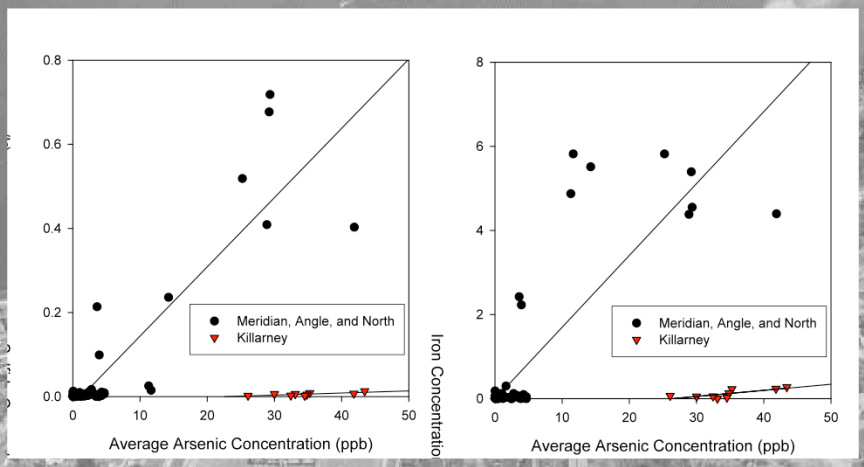

Lake Meridian
Angle Lake
North Lake
Lake Killarney
Temperature
Dissolved Oxygen
Temperature (°C)
DO (mg/L)
Depth (m)
07-08-2004
07-21-2004
08-10-2004
08-27-2004
09-08-2004
09-28-2004
08-19-2004
09-01-2004
09-15-2004
07-28-2004


Lake Meridian
Angle Lake
North Lake
Lake Killarney
Temperature
Total Arsenic
Temperature (°C)
Average Total Arsenic Conc. (ppb)
Depth (m)
07-08-2004
07-21-2004
08-10-2004
08-27-2004
09-08-2004
09-28-2004
08-19-2004
09-01-2004
09-15-2004
07-28-2004
28


Total Dissolved As (ppb)
0
20
40
60
80
100
0
5
10
15
20
25
30
Killarney
Steel
North
Angle
Steilacoom
American
Bonney
Tapps
Meridian
North
Steel
Killarney
Geneva
Fivemile
Angle
Spanaway
29

As:Fe:S in Select Lakes



- *Generally dissolved As, Fe, and S increase proportionately under reducing conditions*
- *Killarney does not match that pattern, why?*

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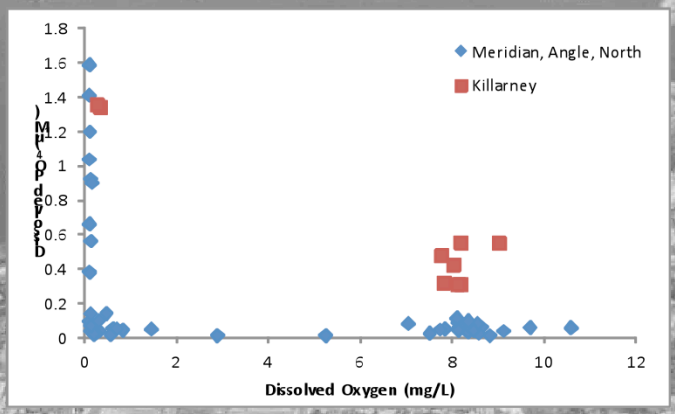
DO vs PO_4 in Select Lakes



- PO_4 still elevated in Killarney in the presence of high DO
- Highest PO_4 when near bottom water goes anoxic (calm, warm weather)

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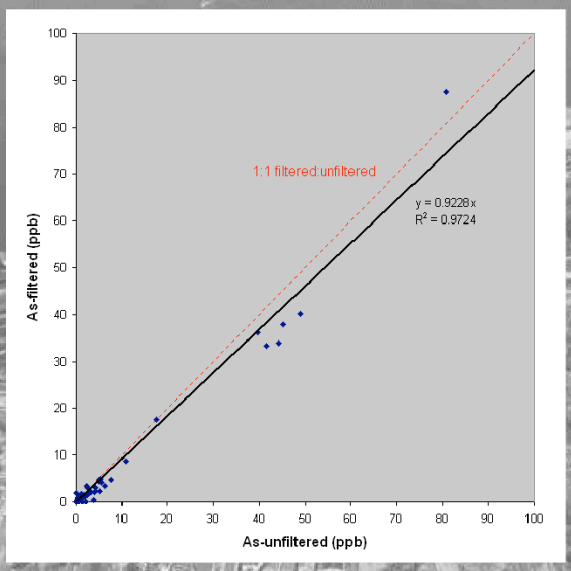
Filtered vs. Unfiltered



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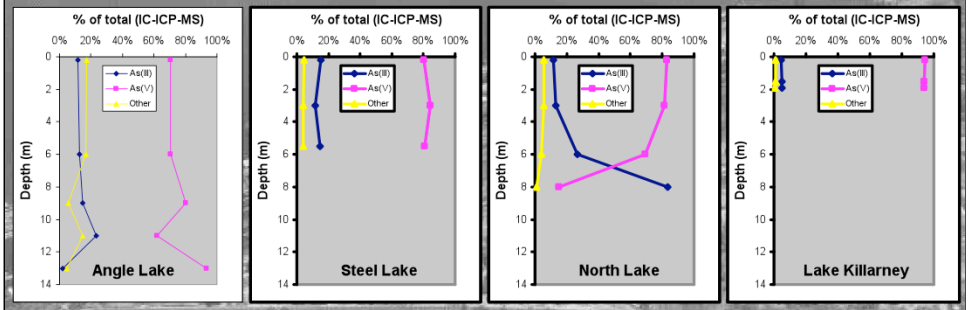
Dissolved Arsenic Speciation



- *Analysis by Applied Speciation Inc.*
- *Highly mobile As(V) in these lakes in general, with only North Lake having As(III)*

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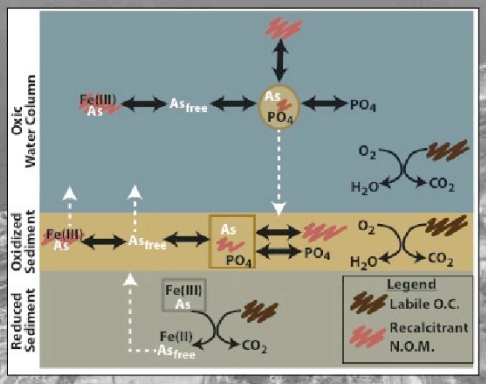
Proposed Model for As Mobility in Presence of Oxygen



Current hypothesis:

(1) Microbially available orgC for reductive dissolution of arsenic-bearing sediments

(2) NOM and/or phosphate to keep arsenic from sorbing to settling particles

(3) Shallow water column that resists stratification

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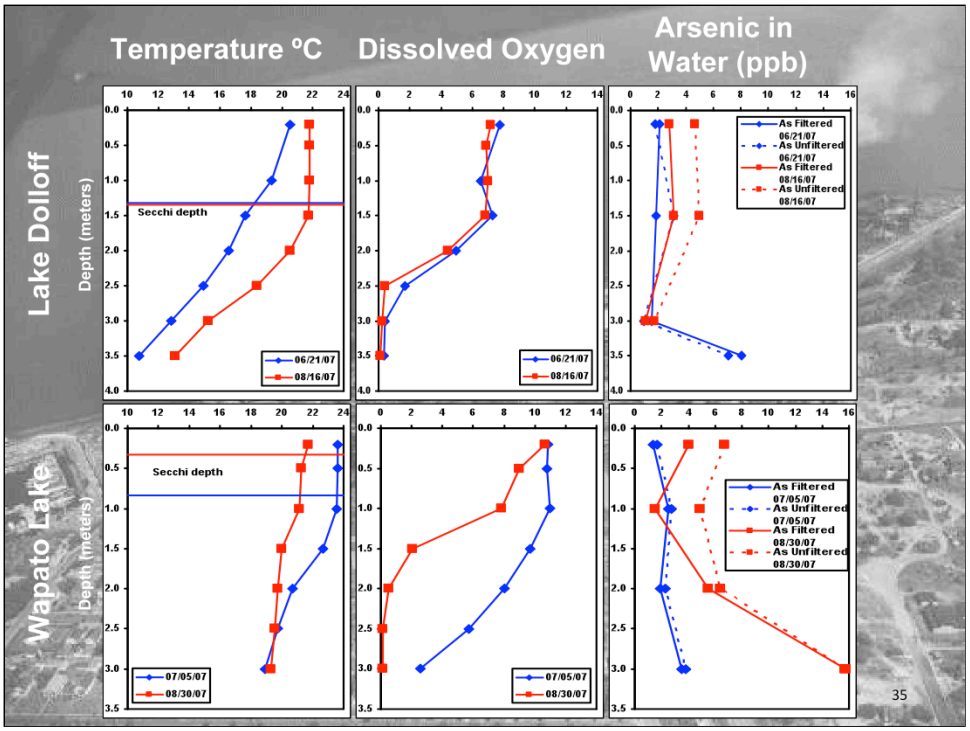
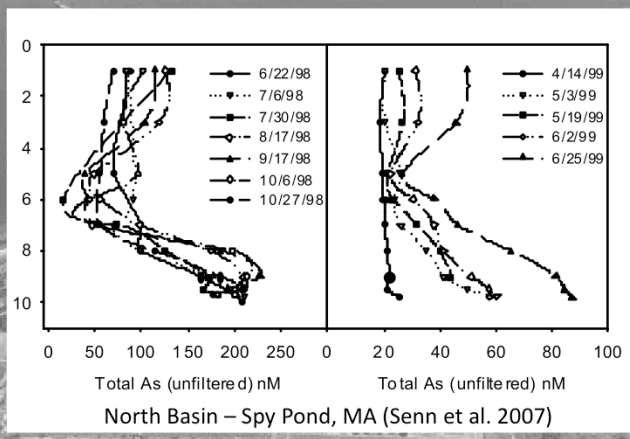

Temperature ºC
Dissolved Oxygen
Arsenic in Water (ppb)
Lake Dolloff
Depth (meters)
Secchi depth
06/21/07
08/16/07
As Filtered
06/21/07
As Unfiltered
06/21/07
As Filtered
08/16/07
As Unfiltered
08/16/07
Wapato Lake
Depth (meters)
Secchi depth
07/05/07
08/30/07
As Filtered
07/05/07
As Unfiltered
07/05/07
As Filtered
08/30/07
As Unfiltered
08/30/07
35

Not Just in Washington



North Basin – Spy Pond, MA (Senn et al. 2007)

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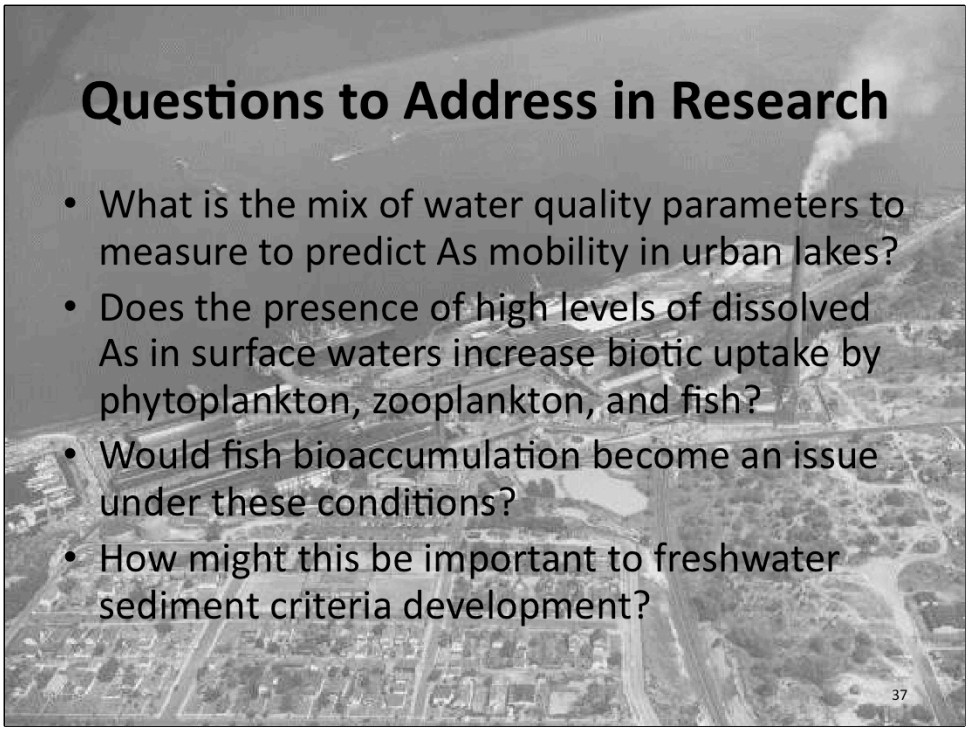
Questions to Address in Research
• What is the mix of water quality parameters to measure to predict As mobility in urban lakes?
• Does the presence of high levels of dissolved As in surface waters increase biotic uptake by phytoplankton, zooplankton, and fish?
• Would fish bioaccumulation become an issue under these conditions?
• How might this be important to freshwater sediment criteria development?
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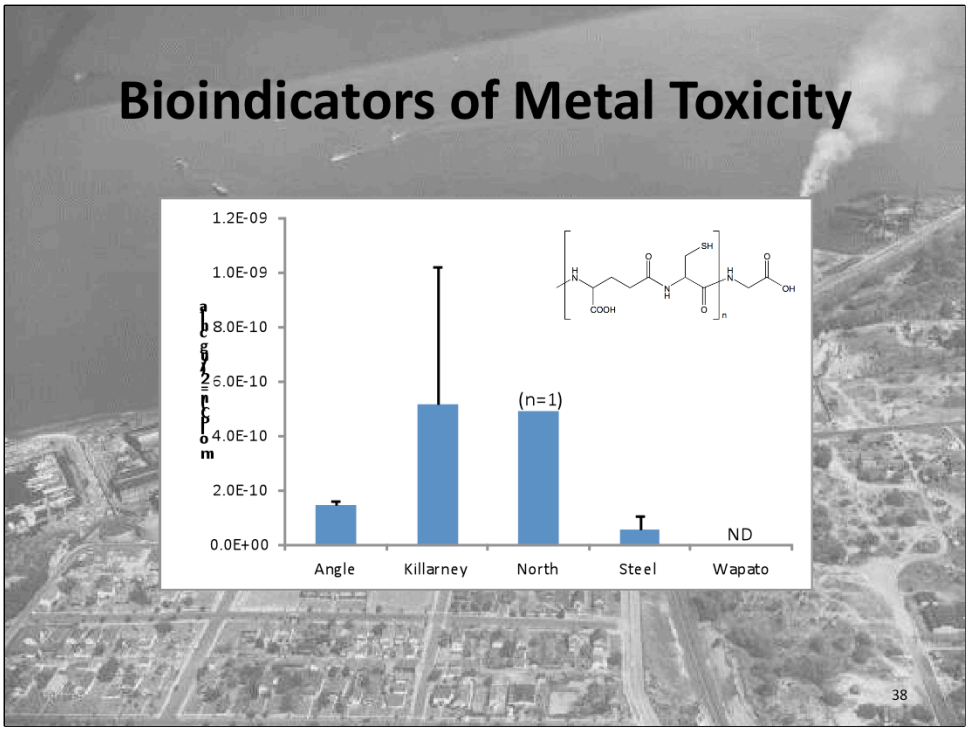
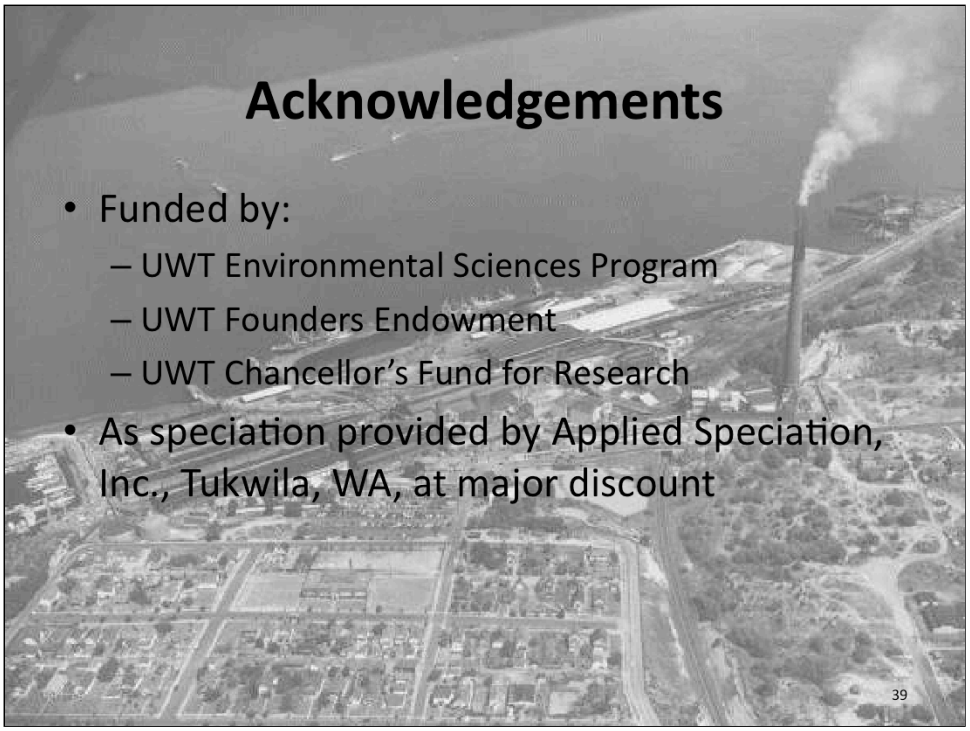

Bioindicators of Metal Toxicity
1.2E-09
1.0E-09
8.0E-10
6.0E-10
4.0E-10
2.0E-10
0.0E+00
(n=1)
ND
Angle
Killarney
North
Steel
Wapato
38


Acknowledgements
• Funded by:
– UWT Environmental Sciences Program
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– UWT Chancellor's Fund for Research
• As speciation provided by Applied Speciation, Inc., Tukwila, WA, at major discount
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To All My UW Tacoma and Bellarmine Researchers!
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Links page

- Dr. Jim Gawel (jimgawel@uw.edu)
- Environmental Sciences and Studies at University of Washington Tacoma:

  http://www.tacoma.uw.edu/interdisciplinary-arts-sciences/courses/environmental-studies
- University of Washington Superfund Research Program:
  http://depts.washington.edu/sfund/
- US EPA Region 10:
  http://www.epa.gov/aboutepa/region10.html
- Dr. Bruce Duncan, Regional Science Liaison, US EPA Region 10 (duncan.bruce@epa.gov)
- Superfund Research Program- National Institute of Environmental Health Sciences(NIEHS)
  http://www.niehs.nih.gov/research/supported/srp/

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http://www.linkedin.com/groups/Clean-Up-Information-Network-CLUIN-4405740

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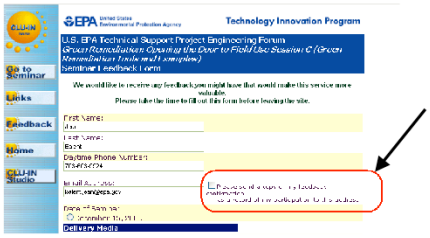
Thank you for your time!

Please click **here** to give the UW-SRP your feedback!



Need confirmation of your participation today?

Fill out the CLU-IN feedback form and check box for confirmation email.

If you have additional questions or comments, please contact:

Katie Frevert, *University of Washington Superfund Research Program (UW-SRP)*
kfrevert@u.washington.edu
Tel (206)685-5379

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Thank you again for your attention and comments. I want to remind each of you that we are looking for your specific responses to many of the issues discussed today in our feedback form following this session.
Also, there are several resources and related documents included in the links to more resources on this page.

If you have any additional questions or comments, please feel free to contact myself or fill out a comment form on CLUIN.

Thank you and have a great afternoon.