Lead in Drinking Water: Sampling Variability and Analytical Issues

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Presenter Disclosures
Marc Edwards

The following personal financial relationships with commercial interests relevant to this presentation existed during the past 12 months:

Funding from Copper Development Association

Miscellaneous consultations with individuals, cities, lawyers, on lead in water problems

Key Points

Our sampling methods miss many hazards

Variability is high, even for cold water in a given city

Lead in water is a public health concern

The Problem of Particulate Lead

- The sampling protocol for the EPA Lead and Copper Rule is based mostly on the assumption that lead in water is soluble
  - Sampling protocols were not designed to accurately measure particulate lead

The real danger from lead in water is from lead particles

Generation of Pb Particles

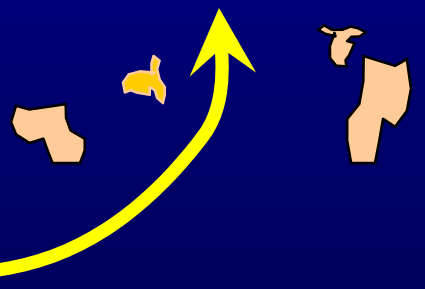
Corrosion or Rusting

Lead Solder, Lead Scale or “Rust” layer

Lead Solder, Lead Pipe or Brass

Detachment During Flow

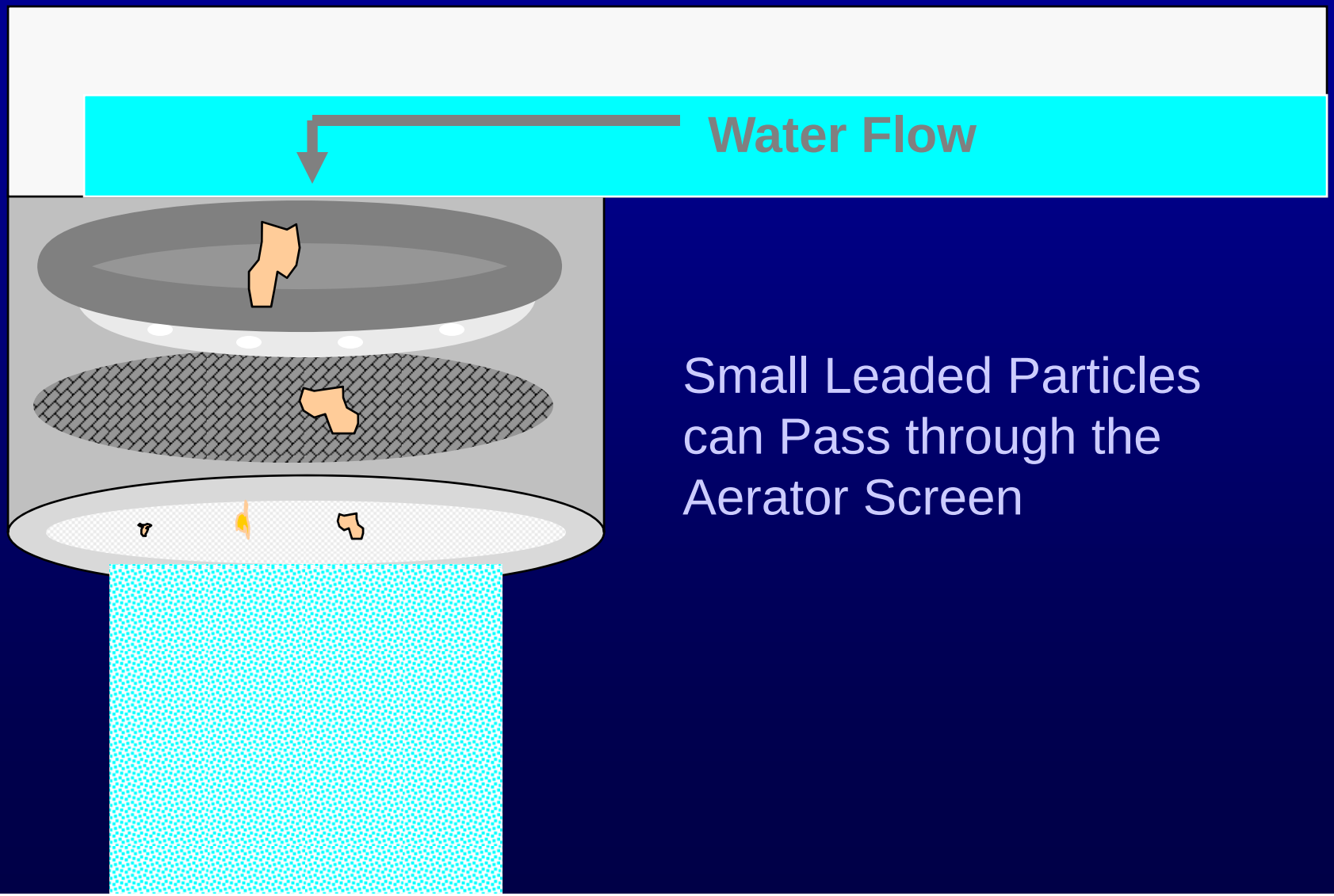
Scouring



Lead Solder, Lead Scale or “Rust” layer

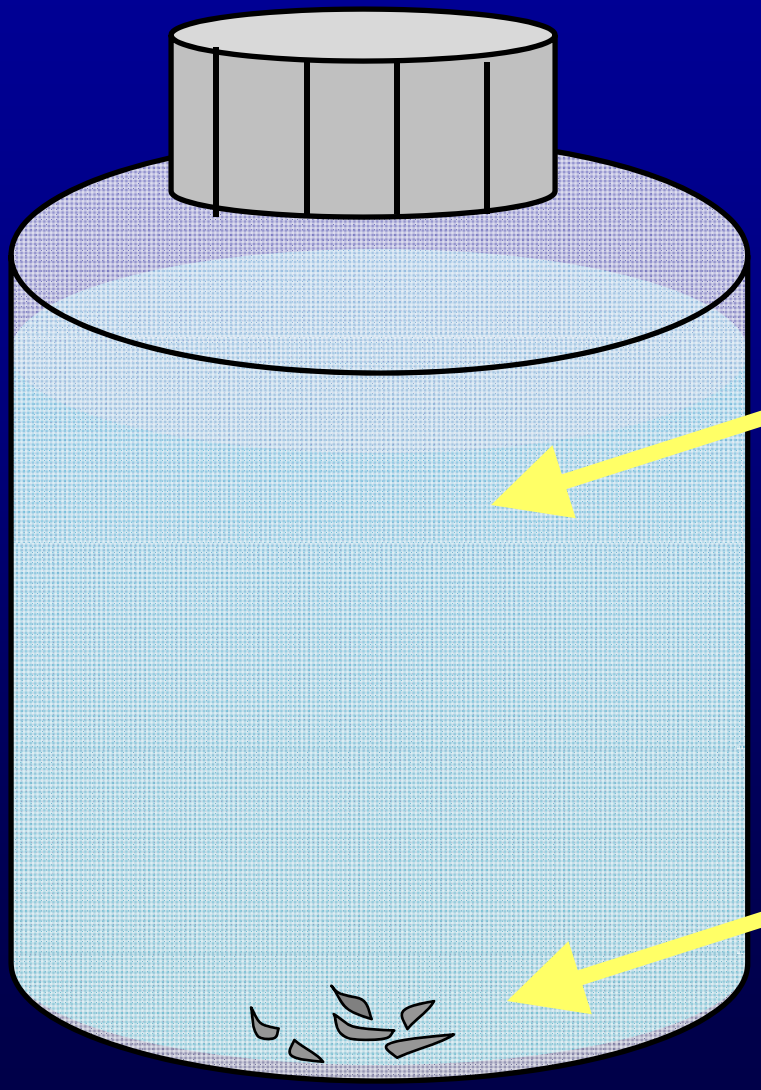
Pb Plumbing Material

Faucet Aerator



Small Leaded Particles can Pass through the Aerator Screen

How Particulate Lead is Missed.

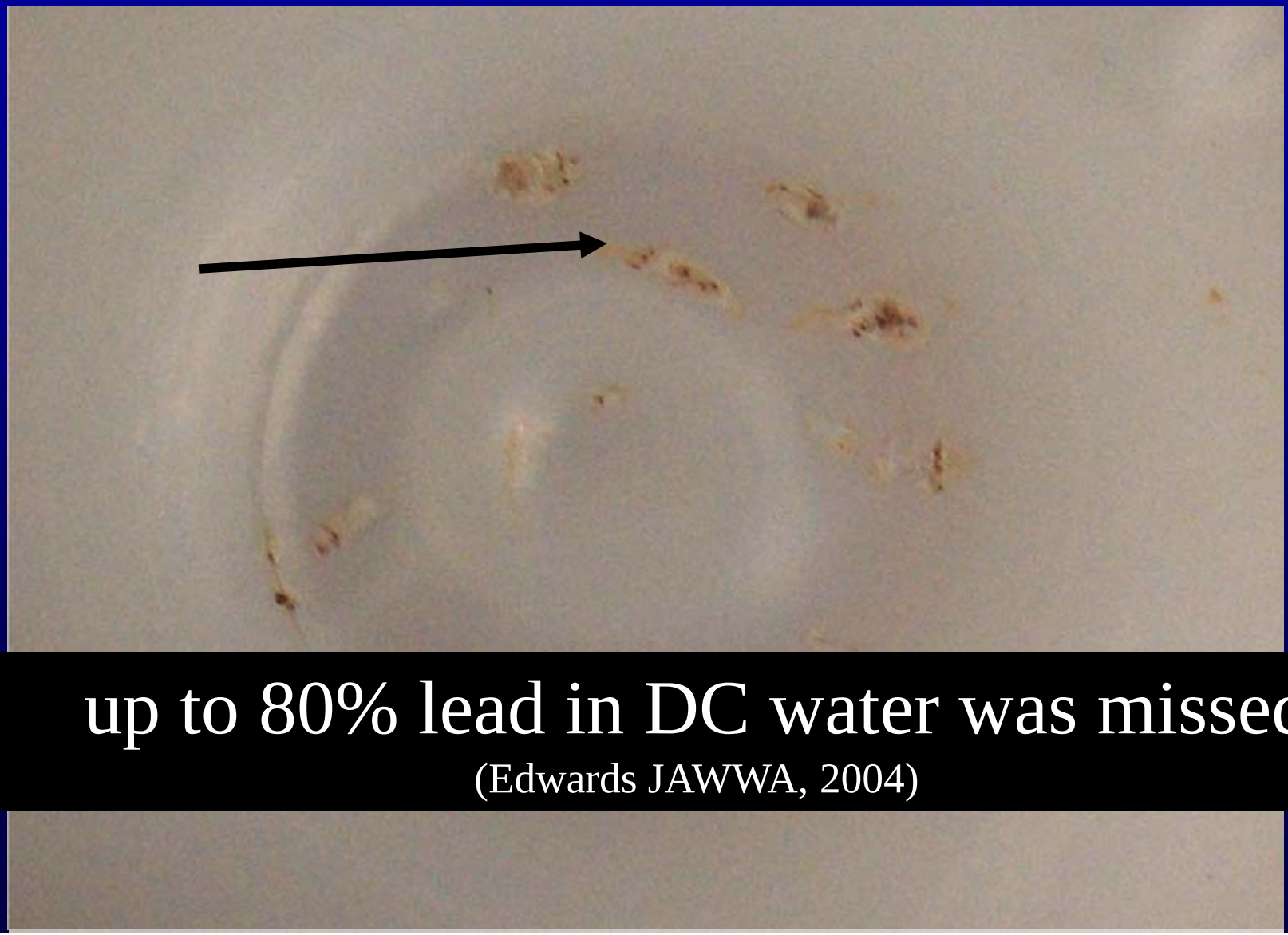


Water poured out for analysis, “misses” lead

Particles sink to bottom and do not dissolve at pH 2

JAWWA June 2007

Weak pH 2 acidification can miss lead in some samples ….



up to 80% lead in DC water was missed

(Edwards JAWWA, 2004)

More Recent Data

Lead in water sample collected that measured 3 ppb using EPA protocol

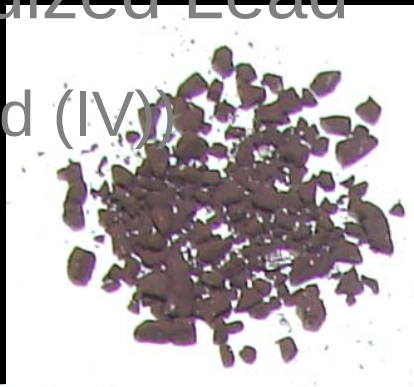
Using stronger acid the sample was shown to actually contain 1560 ppb lead

99.8% of the actual lead was missed

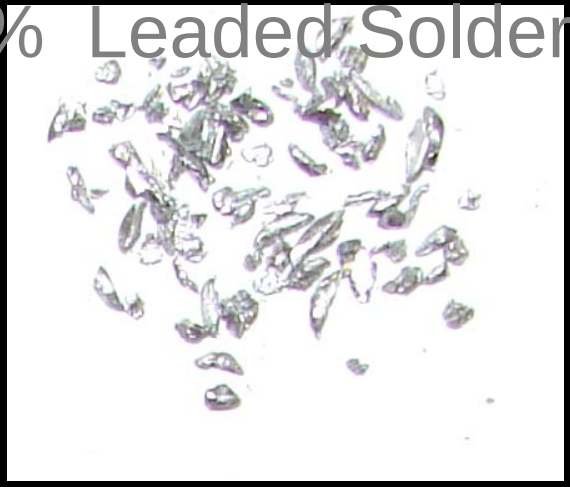
Pure Lead

Oxidized Lead

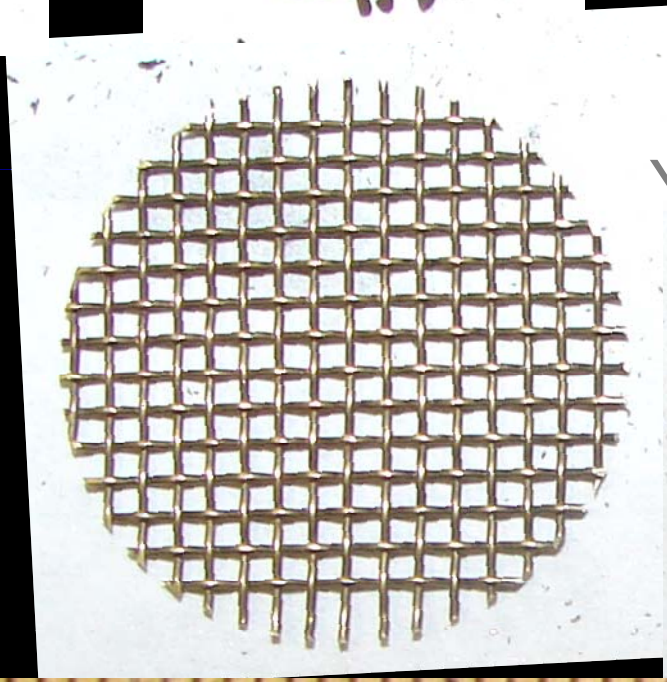
(Lead (IV))



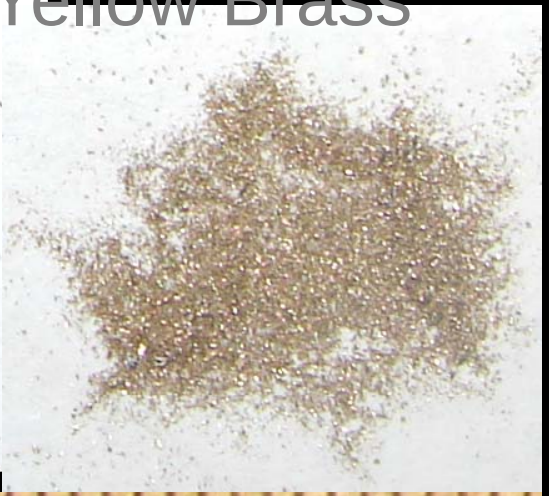
50% Leaded Solder

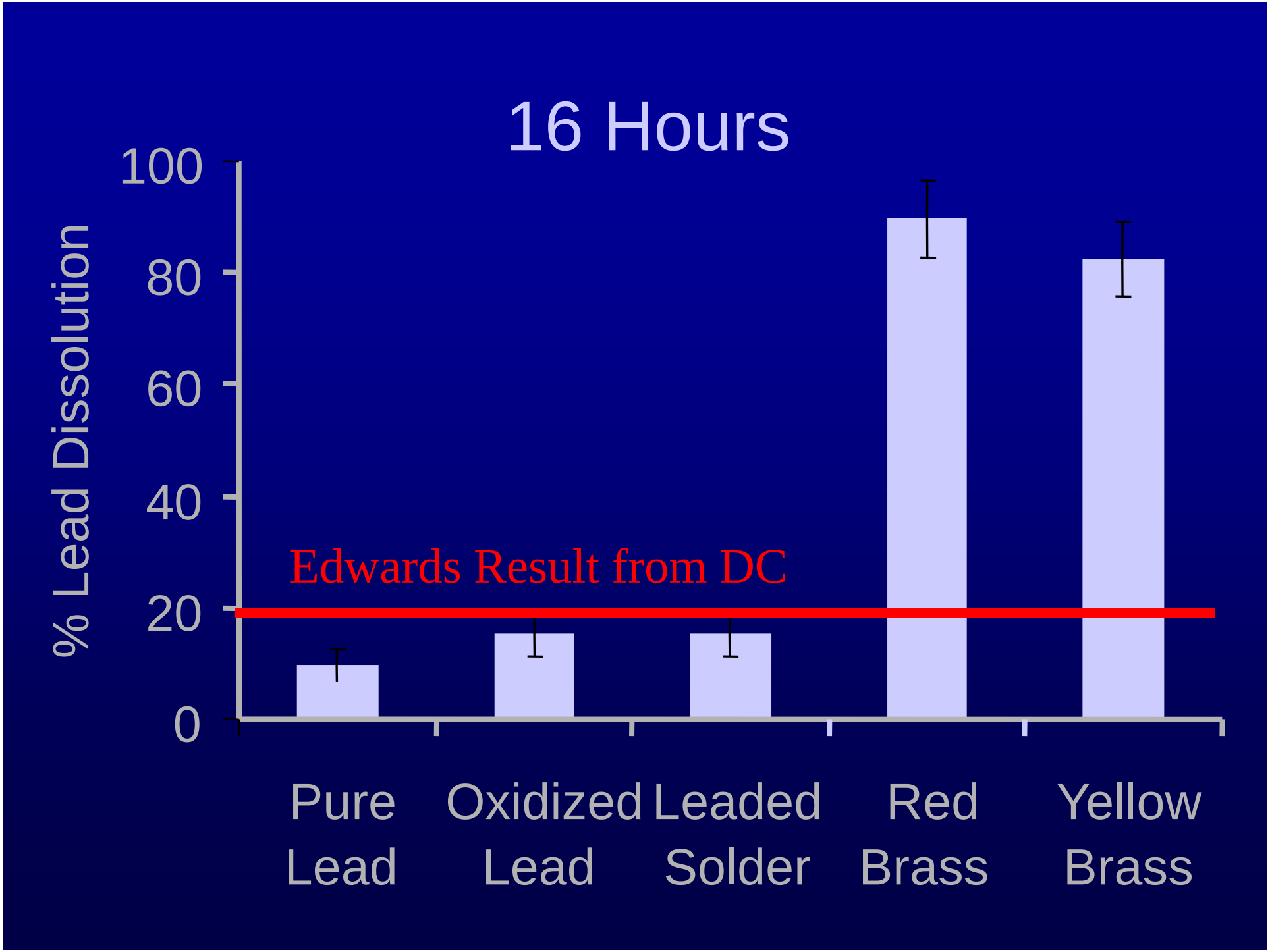


Red Brass



Yellow Brass




16 Hours
% Lead Dissolution
100
80
60
40
20
0
Edwards Result from DC
Pure Lead
Oxidized Lead
Leaded Solder
Red Brass
Yellow Brass

Lead Particles Present in Drinking Water Are at Least 20-60% Bio-available when Ingested

DETECTION OF PARTICULATE LEAD HAZARDS CRITICALLY DEPENDENT ON DETAILS OF SAMPLING

Spikes of lead more likely at higher flow rates

…at very high flows the water may physically scour lead deposits from the pipe

Britton and Richards (1981)

Particulate detachment goes with $(\text{velocity})^2$

Instructions to Consumers: “Slowly and gently turn on the COLD WATER TAP to fill up the bottle in approximately 45 seconds.”

Lower lead

Higher lead

Using tall bottles with small opening lowers detection of lead relative to normal use

Some other sampling issues

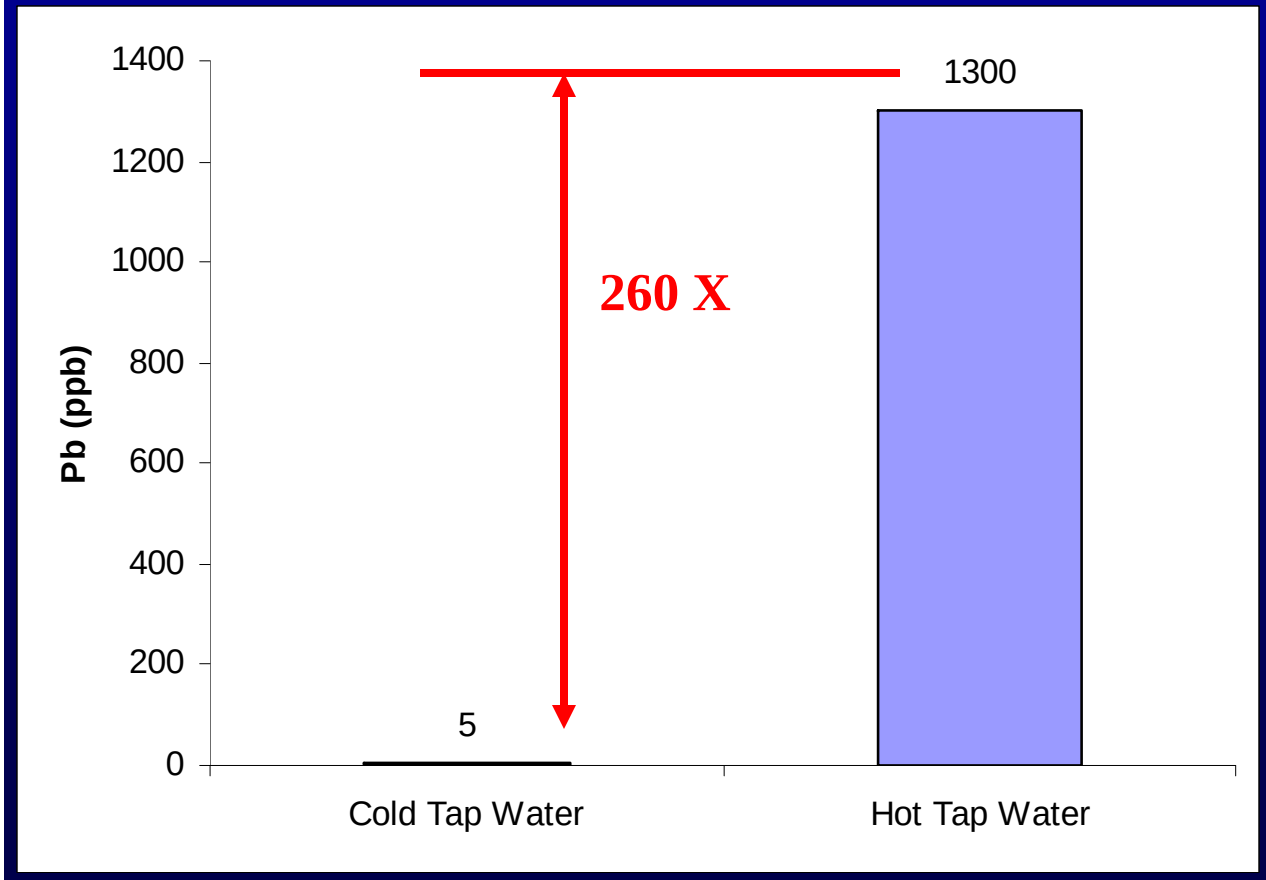
- Cleaning aerators, or extensive flushing, done the night before sampling…minimizes lead sampled

- Never even sample hot water for lead…

  we told you never ever drink hot water or use it for cooking because it probably has high lead

Hot versus Cold Water

LCR only samples cold water
Lead poisoning Case Management generally only samples cold water.
.if any water is sampled



<u>Example from Australia</u>

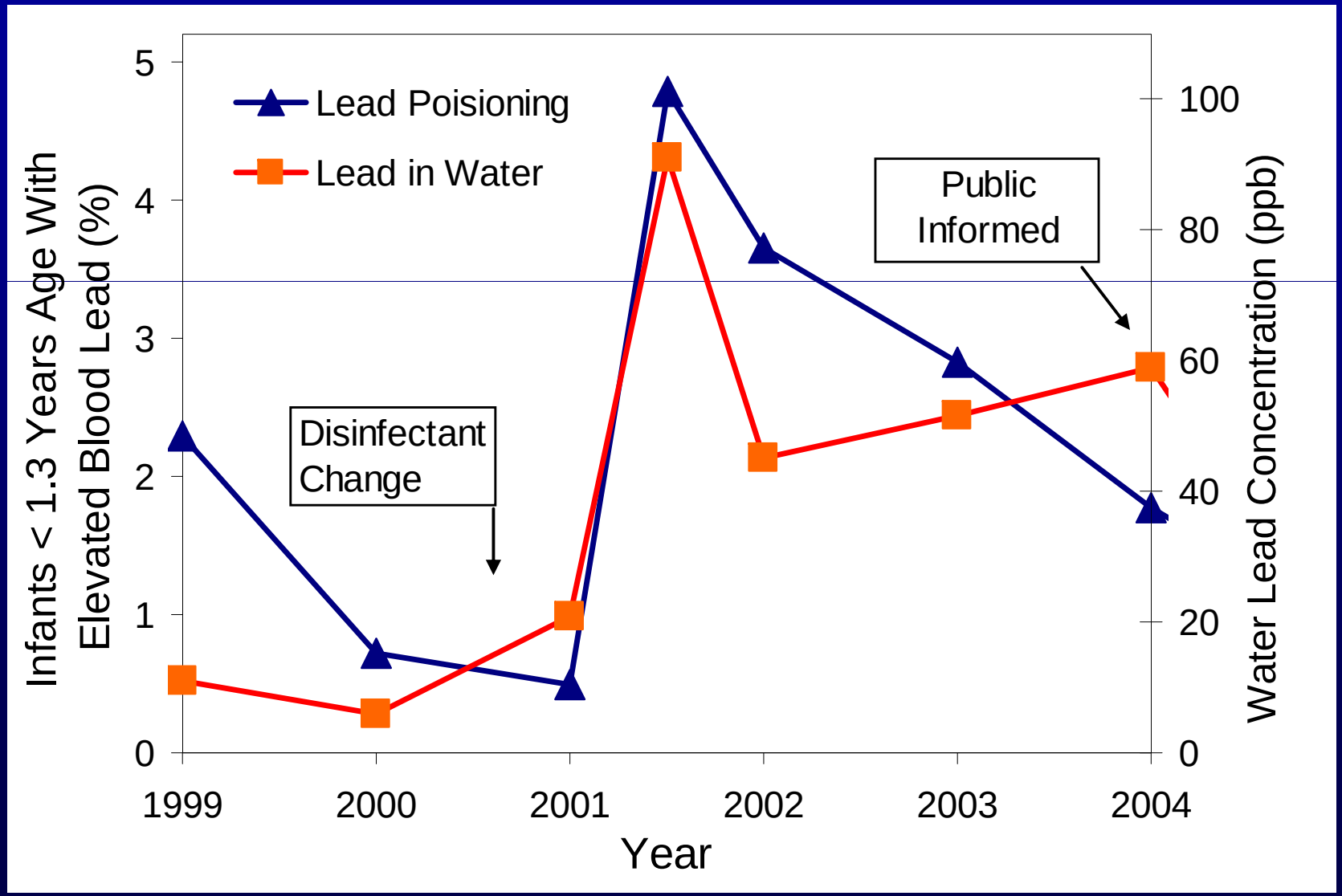
- Hot water was used to prepare instant coffee and cook
- All family members were eventually diagnosed with lead poisoning
- Water heater contained lead solder

Mesch et al., 1996

Hot Water

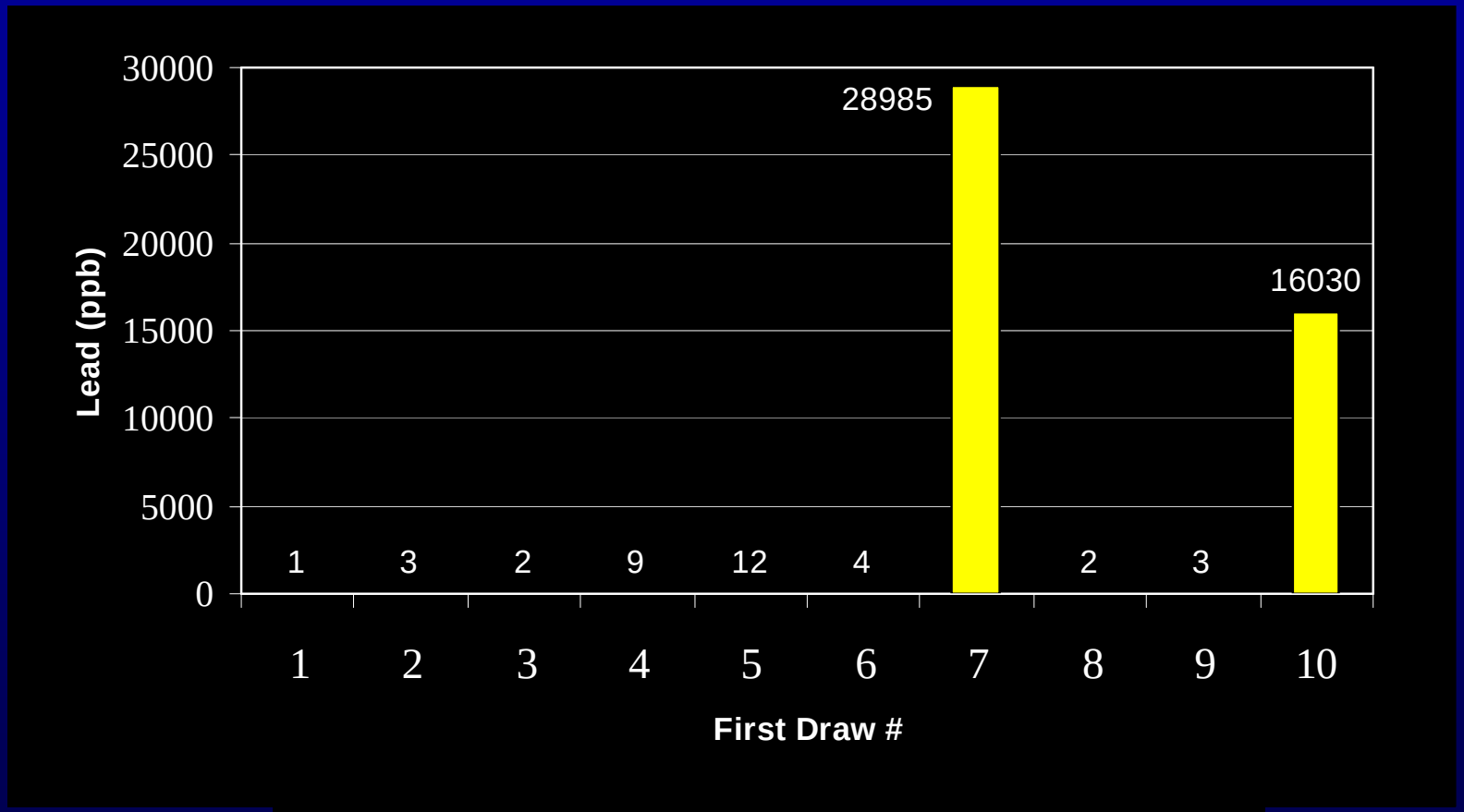
- 67% of hot water from boilers, coffee and cappuccino machines in Perth contained excessive levels of Pb (McCafferty et al)
- Majority of parents in DC with lead poisoned children acknowledged giving hot water to their children for formula. (Lambinidou, 2007).

Washington D.C. 1999-2004



Extreme variability in lead sampling data at some hazardous taps.

Sporadic Lead Spikes



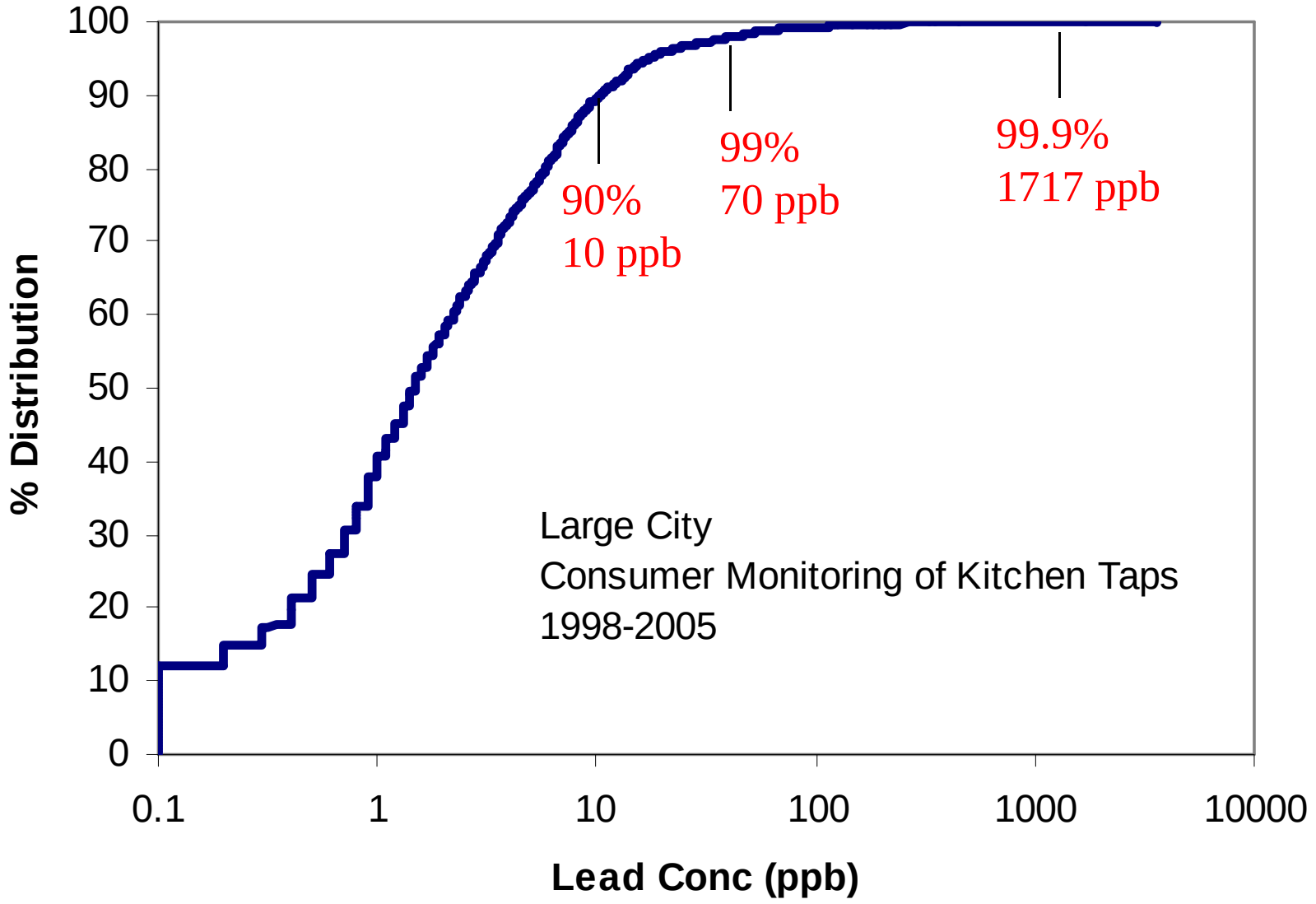
Avg. w/o = 2.5 ppb

Avg. with = 4505 ppb

Repeated 2nd Draw WASA/DC DOH Sample Data From Home of Lead Poisoned Child via FOIA

- 7/26/2003 75 ppb (WASA)
- 3/23/2004 19 ppb (WASA)
- 3/23/2004 11 ppb (DC DOH)
- 10/8/2004 21 ppb (WASA)
- 11/2/2004 583 ppb (WASA)

DC DOH concluded water was safe based on their one sample 3/23


100
90
80
70
60
50
40
30
20
10
0
% Distribution
0.1
1
10
100
1000
10000
Lead Conc (ppb)
90%
10 ppb
99%
70 ppb
99.9%
1717 ppb
Large City
Consumer Monitoring of Kitchen Taps
1998-2005

≈1% of children in this city would be predicted to have elevated blood lead from tap water consumption alone (> 70 ppb)

in a city with 100,000 children that would be 1,000 cases

CONCLUSIONS

- Lead in water poses special challenges in terms of detecting risks and extent of water contamination
  - One time sampling to “prove” safety may be inadequate
  - Stronger acid is needed to detect lead
- There is no evidence that elevated blood lead from contaminated tap water does not occur with fairly high frequency (≈ 0.1-1.0%) in many cities and simply goes undetected.
- Exposure from hot water is a major concern that is completely overlooked by CDC and other agencies

Marc Edwards received his bachelor's degree in Bio-Physics from SUNY Buffalo in 1986. He received his M.S. and Ph.D. in Environmental Engineering from the University of Washington, in 1988 and 1991, respectively. In 2004, Time Magazine dubbed Dr. Edwards "The Plumbing Professor" and listed him amongst the 4 most important "Innovators" in water from around the world. The White House awarded him a Presidential Faculty Fellowship in 1996. In 1994, 1995 and 2005, Edwards received the Outstanding Paper Award in the Journal of American Waterworks Association and he received the H.P. Eddy Medal in 1990 for best research publication by the Water Pollution Control Federation (currently Water Environment Federation). His M.S. Thesis and PhD Dissertation won national awards from the American Water Works Association (AWWA), the Association of Environmental Engineering and Science Professors and the Water Environment Federation (formerly the Water Pollution Control Federation). In 2003 he was awarded the Walter Huber Research Prize from the American Society of Civil Engineers. In 2007 Edwards was awarded a MacArthur Fellowship and was also named Outstanding Faculty Member in the State of Virginia.

Edwards is currently the Charles Lunsford Professor of Civil Engineering at Virginia Tech, where he teaches courses in environmental engineering and applied aquatic chemistry. Since 1995, undergraduate and graduate students advised by Edwards have won 22 nationally recognized awards for their research work on corrosion and water treatment. Edwards has published more than 88 peer reviewed journal articles, made more than 100 national and international conference presentations, and delivered 4 keynote addresses. Edwards was president of the Association of Environmental and Engineering Science Professors from 2003-2005 and he testified to the United States Congress on the issue of lead in Washington DC drinking water. His research group is currently emphasizing research on internal corrosion processes in home plumbing-- a problem costing consumers in the U.S. billions of dollars each year and which also can endanger the safety of potable water. The National Science Foundation, individual water utilities and homeowners' groups, the AWWA Research Foundation, the United States Environmental Protection Agency (U.S. EPA), and the Copper Development Association support that research. His research groups' work has been featured in Time Magazine, Materials Performance, National Public Radio, Prism, Salon, Good Housekeeping, Environmental Science and Technology, Public Works, Earth and Sky, and in newspaper articles around the country.