The Increasing Importance of Biomonitoring Data to Interpret Changing Risk Estimates for Legacy Mining Communities

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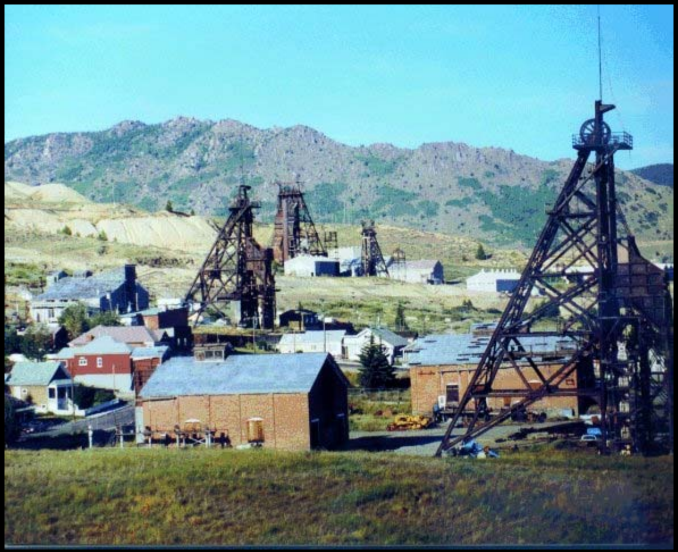
Outline

- Lead and arsenic as risk-drivers at legacy mine sites
- Changes coming for derivation of lead and arsenic cleanup levels
- Role of ***blood lead studies*** at legacy mine sites
- Role of ***urine arsenic studies*** at legacy mine sites
- Conclusions

Lead and Arsenic at Legacy Mine Sites

- Lead typically dominates at lead and zinc sites
- Arsenic typically dominates at copper sites
- Large legacy sites may have complex history of mining, smelting and refining operations with both lead and arsenic issues



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Assessing Risks for Lead and Arsenic

- Nationally, several movements are underway to reassess elements of lead and arsenic risk assessment
- At legacy mine sites, human health risk estimates for lead and arsenic may be impacted by:
  - lower toxicological benchmarks for lead and arsenic
  - altered exposure parameter assumptions
- Meanwhile, actual exposures to people will be unchanged

Lead – Upcoming changes

- IEUBK model default assumptions will be changing
  - Higher default RBA
  - Diet intake, etc.
- CDC recently recommended lowering current blood lead target level
  - Driven by IQ studies, reduced levels in general population and lower analytical detection limits
  - Already lower in California and Europe, Canada considering
- Implications for legacy mine sites (short term)
  - PRG may decline from 400ppm to 250-300 ppm
- Incremental risk approach considered (long term)
  - California proposed in 2009
  - USEPA SAB instructed OPPT to consider for dust standards
  - Health Canada also considering

Arsenic – Possible Changes

- Cancer slope factor
  - Current CSF is 1.5 (mg/kg-day)-1
  - CSF proposed in 2010 is 25.7 (mg/kg-day)-1
  - 17-fold increase would decrease risk-based screening level proportionately
  - EPA SAB panel recommended additional justification in D-R assessment, but didn't recommend major changes
  - Expect new CSF issued by ???
- Implications for legacy mine sites
  - Not clear if all EPA regions will accept and use the new CSF (Region 8 filed a formal memorandum of non-concurrence on draft CSF)
  - If accepted, will force most clean up levels to be derived based on background
  - ROD reviews could result in major changes in remedies

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Biomonitoring Studies Provide Reality Check on Risk Estimates

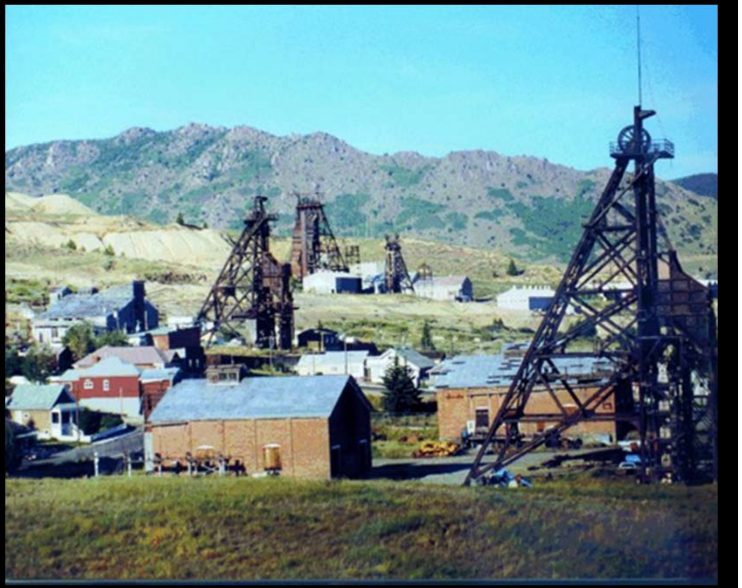
- Biomonitoring is the measurement of a chemical or its metabolites in body tissues and fluids
- Biomonitoring data can improve our understanding of exposure
  - Can contribute to a multiple lines of evidence approach
  - Enable critical assessment and validation of theoretical predicted risks
  - Guide consequential risk management decisions for all legacy mining communities into the future
  - May also allow better understanding of how our bodies interact with the environment

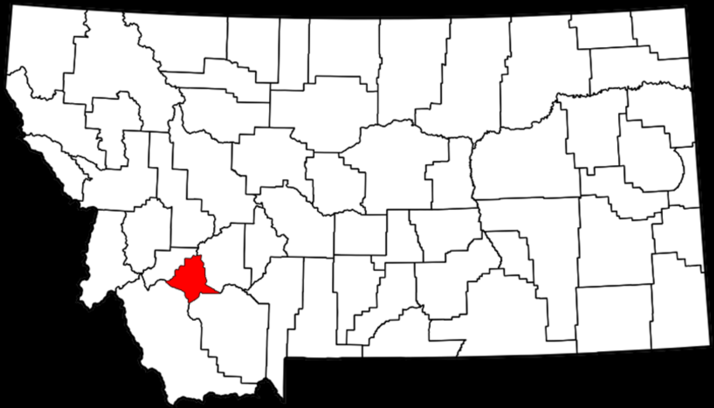
Case Studies Show that Blood Lead and Urine Arsenic Reflect All Exposures

- For residential soils, children 1 to 7 years old are usually the focus
- Blood lead concentrations reflect exposure from all sources over the past several months, urine arsenic reflects the past 72 hours
- Blood and urine samples are collected at peak exposure times (late summer)
- To assess exposure pathways, studies may also include samples of yard soil, indoor dust, tap water and homegrown produce, and for lead, paint analyses
- Detailed questionnaires elicit information about other household exposures
- EPA's IEUBK model for lead is based on such studies

Studies of Lead at Butte

- Over 100 years of mining history
  - Over 500 underground mines
  - Four open pit mines, including the Berkeley Pit
  - Operations included silver mills, copper and zinc concentrators/smelters





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Butte

- Added to NPL September 1983
- 3rd Five-Year ROD Review released July 2011
- EPA action levels for lead
  - ***1,200 mg/kg in residential yards*** and play areas
  - 2,300 mg/kg at waste rock dumps or other source areas outside of residential areas
- Used to determine ongoing response actions by EPA
- Also used by Butte-Silver Bow County as part of the ***residential metals abatement program***, which addresses both mining and non-mining (e.g., lead-based paint) sources of lead

Butte Exposure Study and Risk Assessments

- 1990 exposure study by University of Cincinnati yielded structural equation model of exposure pathways
  - Included blood lead assessment of 294 children up to age 6
  - Geometric mean BLL of children in Butte was 3.5 µg/dL, similar to U.S. levels at that time
  - Large study sample & over-representation of high risk areas
  - Residence location (i.e., age of neighborhood) and housing age strongest predictors of paint lead, soil lead, and dust lead concentrations

Butte Exposure Study and Risk Assessments

- 1990 exposure study (cont.)
  - Lead-based paint →lead contaminated soil →lead contaminated house dust
    - Only house dust lead directly related to blood lead
    - Soil lead's indirect effect on blood lead is both small and weak
  - Variability in soil lead
    - 39% due to lead-based paint, rest due to heterogeneous distribution of lead in soil and lead from other sources
  - Gardening or eating home grown produce shown not to contribute to elevated BLLs
- Studies yielded low lead relative bioavailability estimates (10% to 12%) used in HHRAs
- Multiple lines of evidence supported lead clean up level

2006 Studies of Lead in Rico, Colorado

- Historical mining community undergoing remediation
- Lead exposure study undertaken in 2006 to monitor effects of remediation
- ***May*** – 118 people (67% households) participated
  - BLL 3 µg/dL in 17 children
  - BLL 1.7 µg/dL in 95 adults
- ***Sept.*** – 112 people participated
  - BLLs 2.6 µg/dL in 12 children
  - BLLs 1.9 µg/dL in 92 adults
- BLLs correlated with house dust better than with soil

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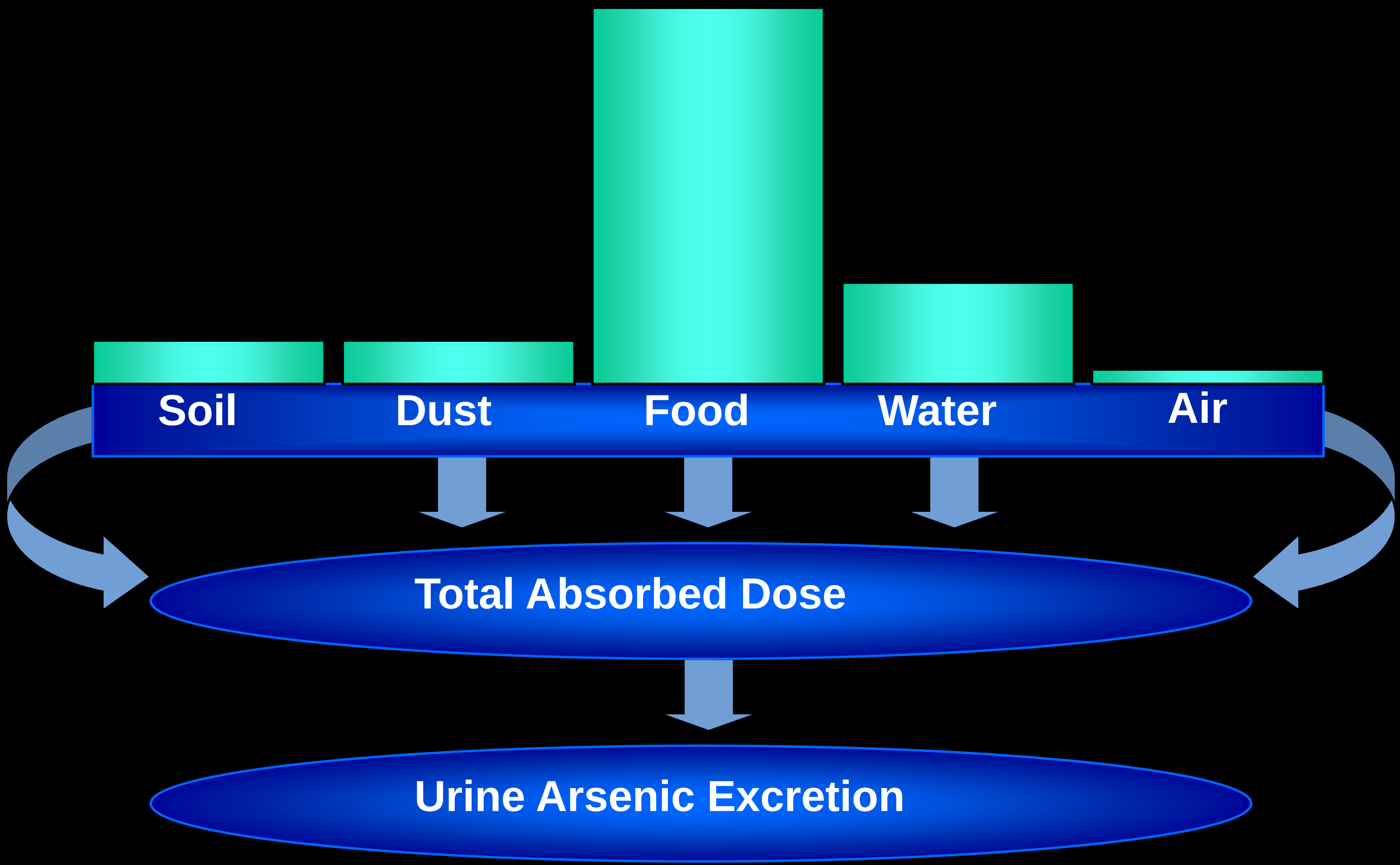
Lead Study Summary

- Blood lead exposure studies were conducted in numerous mining and smelting communities during the 1980s and 1990s
- Generally, the strongest correlations for BLLs were with dust lead concentrations, and operating smelters exerted a greater effect on BLLs via outdoor dust deposition and track-in to indoor dust
- Far fewer exposure studies have been conducted since 2000, although some communities have ongoing surveillance testing of BLLs
- The nation-wide decline in BLLS since the 1990s makes it difficult to discern local trends vs. nationwide trends
- Contemporary exposure studies are needed to determine primary exposure sources and to update assumptions and parameters for exposure models

Urine Arsenic as Indicator of Exposure: Background Example



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Biomonitoring studies support lack of exposure below 100 ppm

- Anaconda (1990) – Mean urine arsenic increased about 30% as soil arsenic increased from 50 to 400ppm
- Bingham Creek Channel study (1993) – No association between soil arsenic and urine arsenic
- Middleport, NY (2004) – No association between soil arsenic and urine arsenic

1990 Butte Urine As (µg/L)			
	All soil < 50 ppm As	Soil As 50-100 ppm*	Soil As > 100 ppm*
N	31	83	26
Mean	13.0	14.1	13.1
Std. Dev.	6.5	8.9	7.1
Median	13.0	12.0	11.5
95%-tile	25.0	30.5	27.0
Maximum	26.5	43.5	28.0

*One or more samples

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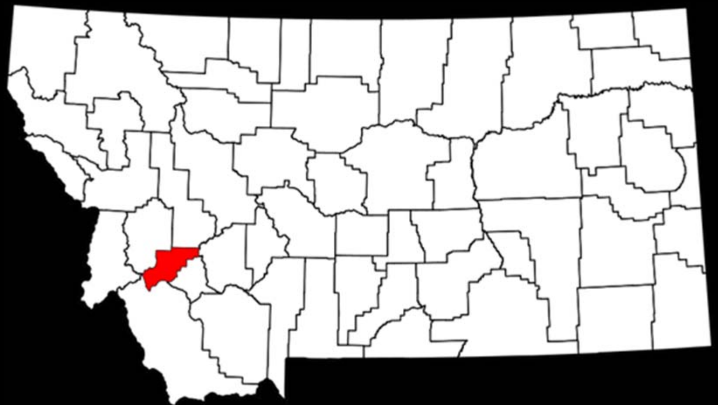
Studies of Arsenic at Anaconda

- Processed copper ore from Butte from about 1884 – 1980
  - Milling and smelting operations
- Added to NPL September 1983
- Site covers an area of approximately 300 square miles
- 1996 Community Soils ROD
- 4th Five-Year ROD Review completed September 2010



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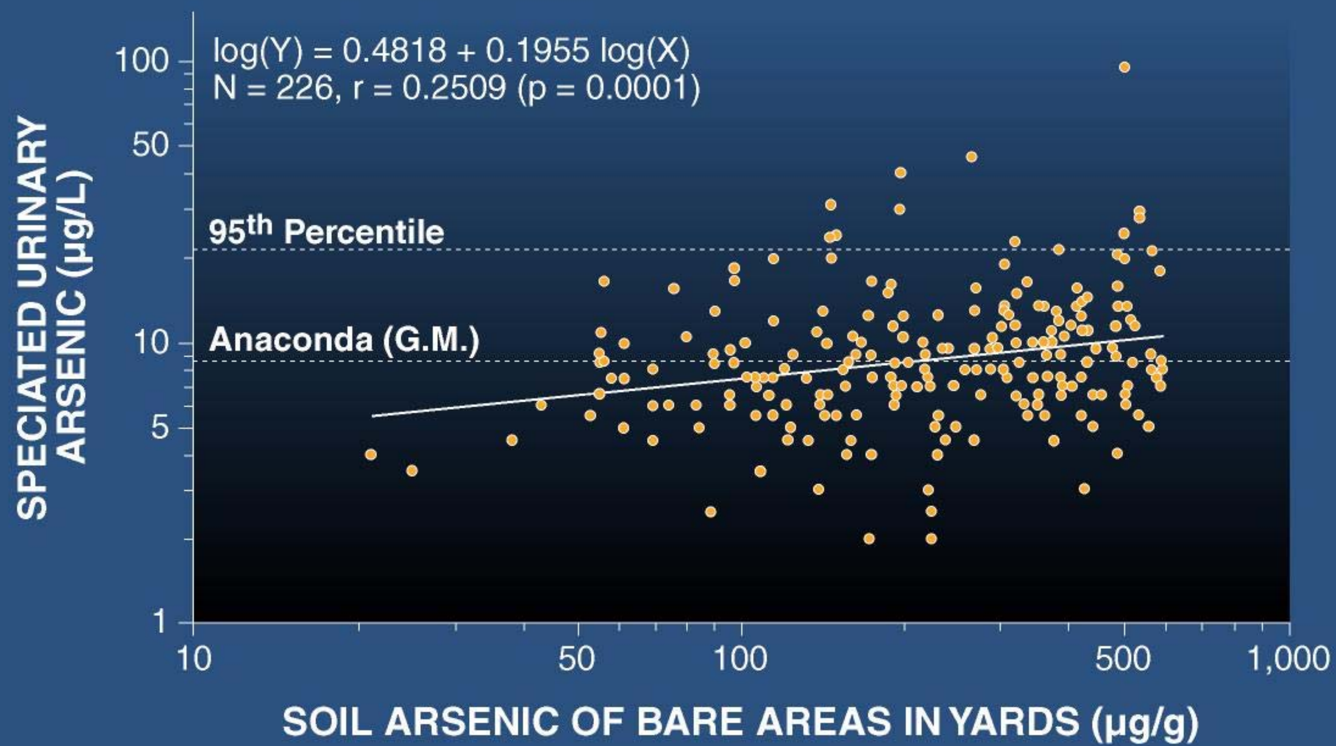
Anaconda Site – Soil Action Levels

- EPA action levels for arsenic
  - 250 mg/kg in residential yards
  - 500 mg/kg in commercial/industrial soils
- Residential action level corresponds to 8 in 100,000 risk level based on:
  - Site-specific soil ingestion study
  - Relative bioavailability 18% for soil, 26% for dust
  - Site-specific indoor dust data
  - Demonstration of reduced winter dust concentrations
  - Lower exposures demonstrated in biomonitoring study

Anaconda Exposure Study
1992 Univ. Cincinnati



Source: Adapted from Hwang et al. (1997a)

BE0021 0703 Urinary vs. Soil As

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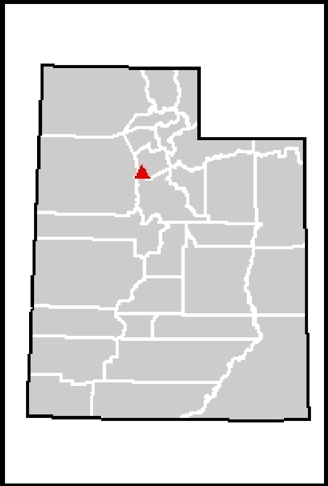
Bingham Creek Channel Arsenic Exposure Study 1993, University of Cincinnati

- 971 children less than 6 years old and 378 older siblings and adults
- Arsenic soil and water concentrations:
  - Average of 27 ppm in soil (range 4 to 623 ppm)
  - Average of 10 ppm in residential floor dust (range 1 to 130 ppm)
  - Average of 3.5 ppb in tap water (range 1 to 11 ppb)
- Urine (creatinine-corrected) 5.20 µg/l (range 0.7 to 27.5 µg/l) for children <72 months



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Bingham Creek Channel Arsenic Study Conclusions

- Urinary arsenic concentrations were associated with:
  - Child's age
  - Season of sample collection
  - Time spent outdoors
  - Concentration of arsenic in drinking water
- Association between urinary arsenic and arsenic in handwipe samples not significant
  - high variability of measures within an individual over time
  - dominance of other factors (e.g. food/water) vs. dust and soil as contributors to urinary arsenic

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Middleport, NY 2003 Arsenic Exposure Study, (Tsuji et al 2004)

- Former arsenic pesticide facility near Buffalo
- 439 study participants, including 77 children <7 years old
- Soil arsenic soil ranged from 5.2 to 340 ppm with an average of 28 ppm (and 22.5 ppm at homes with children < 7 years)
- Dust concentrations averaged 20 ppm (and 22ppm at homes with children < 7 years)

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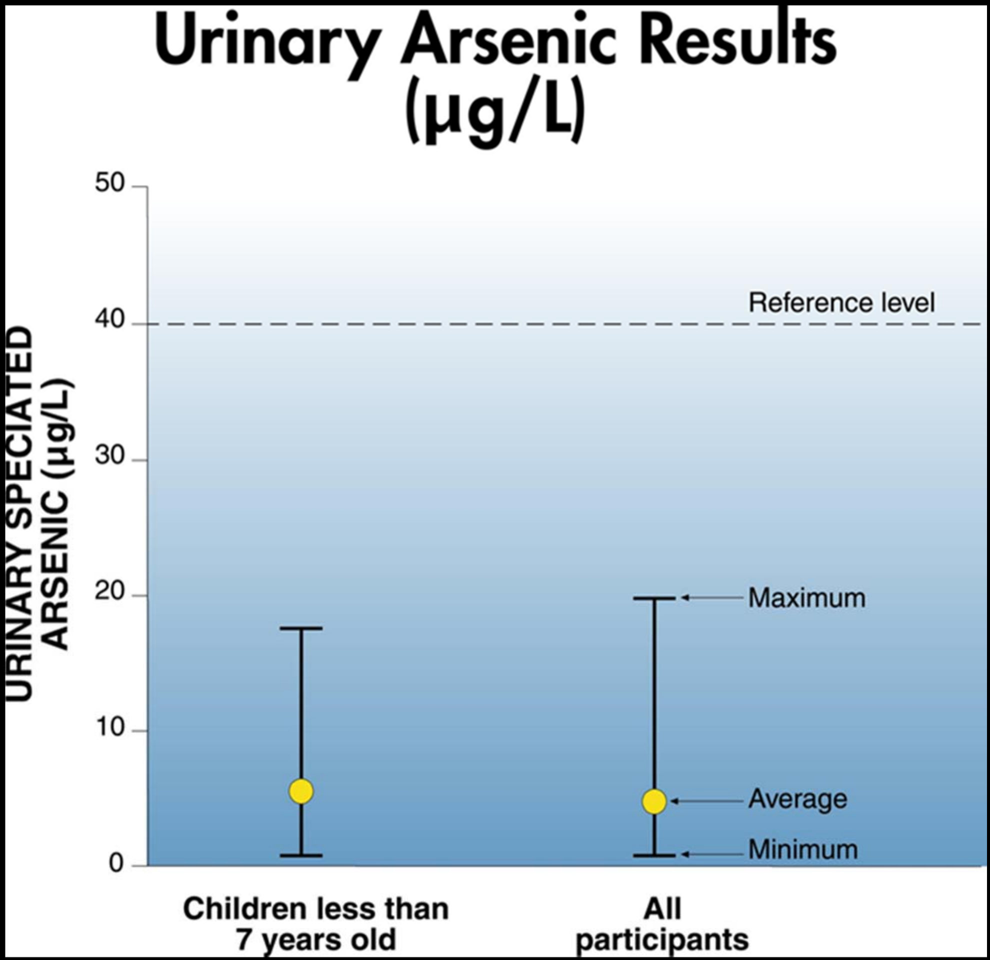
Key findings of the Middleport biomonitoring study

- Speciated and inorganic urinary arsenic levels were low
- Urinary arsenic levels were generally not correlated with soil or house dust
- House dust concentrations were not correlated with soil concentrations
- Site-specific risk assessment supported by study showing low relative bioavailability



Putting Lead and Arsenic Risks in Context

- Critical importance of understanding the factors that affect site-related lead and arsenic exposures to allow:
  - a meaningful interpretation of site-specific risk estimates
  - evaluation of the protectiveness of existing or proposed remedies
- Risk assessments that incorporate site-specific exposure information alone will not address this need
- Role for biomonitoring studies
  - Complement interpretation of theoretical risk estimates for common risk drivers
  - Provide data for assessing remedy protectiveness at legacy mine sites

Longer Term Research Needs

- Contemporary biomonitoring studies (especially for lead)
- Examine exposure assumptions:
  - Soil ingestion rates
  - Evaluate role of exterior dust
  - Relative soil/dust intakes
  - Relative bioavailability
  - Lead absolute bioavailability in children
  - Blood lead GSD