Spring Valley Public Health Scoping Study

Mary A. Fox, PhD, MPH
Risk Forum
October 16, 2007
The Risk Sciences and Public Policy Institute of the Johns Hopkins Bloomberg School of Public Health is dedicated to the protection of health through education, service, and research in risk and policy. The Institute’s activities are designed to provide practitioners, scientists, and decision makers with the tools necessary to ensure that environmental health policies lead to improved public health.

Certificate Program

Our Certificate Program offers the first intensive series of courses applying risk sciences to public health. The program is available both to working professionals and to students already enrolled in a degree program at Johns Hopkins. more

RSPP! Course Offered Online in 2008!

Introduction to the Risk Sciences and Public Policy, 317.630, will be offered online for third term, Jan. 22 through March 14.

Recent Publications

About the Institute
overview

Academics
overview | courses | seminars and workshops

Research
overview | projects | recent faculty publications

Institute Faculty
overview

Students
overview

Links & Resources
overview | related links | recommended readings | School’s Home Page
American University Experiment Station - Birthplace of Army Chemical Corps

Photo Credit: T. Burke
Johns Hopkins Study Team

Mary Fox
Beth Resnick
Erik Janus
Frank Curriero
Kathryn Kulbicki
Ana Navas-Acien
Ramya Chari
Roni Neff
Keeve Nachman
Joanna Zablotsky
Tom Burke
Spring Valley and Chevy Chase: Census Tracts, ZIP Codes
Timeline (1)

1917-1918  Chemical weapon and counter measures development and testing

1919-1920 Demobilization, transfer to Edgewood, MD

1921 Salvage and restoration of AU grounds

1930s – 80s Residential development

Photo credit: T. Burke
WWI Activities: Examples of chemical weapons made/tested at AUES

Blister agents
- Lewisite (As)
- Sulfur and nitrogen mustard (thiodiglycol)

Choking agents
- Phosgene

Vomiting agents
- Adamsite (As)
- Chloropicrin
## WWI Activities: Examples (1)

<table>
<thead>
<tr>
<th>REP_NO</th>
<th>TITLE</th>
<th>REP_DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM 01-049</td>
<td>PROGRESS REPORT OF MANUFACTURE OF WAR GASES</td>
<td>8/15/1917</td>
</tr>
<tr>
<td>BM 01-010</td>
<td>PERMEABILITY TESTS OF FACE PIECES OF US ARMY GAS MASK</td>
<td>8/17/1917</td>
</tr>
<tr>
<td>BM 00-007</td>
<td>QUANTITITIVE DETERMINATION OF CHLORPICRIN IN AIR</td>
<td>8/18/1917</td>
</tr>
<tr>
<td>BM 01-011</td>
<td>PERMEABILITY TESTS OF FACE PIECES OF US ARMY GAS MASK WITH BENZYL BROMIDE</td>
<td>8/18/1917</td>
</tr>
<tr>
<td>BM 01-004</td>
<td>TESTING EFFICIENCY OF CANISTERS FOR CHLORPICRIN</td>
<td>8/20/1917</td>
</tr>
<tr>
<td>BM 01-002</td>
<td>TESTING EFFICIENCY OF CANISTERS FOR CHLORINE</td>
<td>8/21/1917</td>
</tr>
<tr>
<td>BM 01-003</td>
<td>TESTING EFFICIENCY OF CANISTERS FOR HYDROCYANIC ACID</td>
<td>8/21/1917</td>
</tr>
<tr>
<td>BM 01-007</td>
<td>TESTING EFFICIENCY OF CANISTERS FOR PHOSGENE</td>
<td>8/21/1917</td>
</tr>
<tr>
<td>BM 01-013</td>
<td>PERMEABILITY OF RUBBER FABRIC TO XYLYL BROMIDE</td>
<td>8/23/1917</td>
</tr>
<tr>
<td>BM 01-005</td>
<td>GAS CHAMBER AND PERMEABILITY TEST AGAINST XYLYL AND BENZYL BROMIDES</td>
<td>8/25/1917</td>
</tr>
<tr>
<td>BM 01-012</td>
<td>GAS CHAMBER TESTS ON MAN WEARING BRITIXH BOX RESPIRATOR MASK IN XYLYL BROMIDE, 30ppm</td>
<td>8/25/1917</td>
</tr>
<tr>
<td>BM 01-014</td>
<td>PERMEABILITY OF NEW DOUBLE COATED RUBBERIZED FABRIC TO XYLYL BROMIDE</td>
<td>8/25/1917</td>
</tr>
<tr>
<td>BM 01-019</td>
<td>REPORT OF CANISTER TESTS AGAINST STANNIC CHLORIDE</td>
<td>8/25/1917</td>
</tr>
<tr>
<td>BM 01-028</td>
<td>TOXICITY EXPERIMENTS ON MICE</td>
<td>9/1/1917</td>
</tr>
<tr>
<td>BM 01-029</td>
<td>TOXICITY OF PERCHLORMETHYLCHLORFORMATE, PHOSGENE, CHLORPICRIN, AND ETHYL CHLORFOR</td>
<td>9/1/1917</td>
</tr>
<tr>
<td>BM 01-030</td>
<td>TOXICITY EXPERIMENTS ON DOGS, CATS AND RABBITS</td>
<td>9/1/1917</td>
</tr>
<tr>
<td>BM 01-031</td>
<td>PHYSIOLOGICAL ACTION OF HYDROCYANIC ACID</td>
<td>9/1/1917</td>
</tr>
<tr>
<td>BM 01-032</td>
<td>THE PATHOLOGICAL STUDY OF GASSED ANIMALS</td>
<td>9/5/1917</td>
</tr>
<tr>
<td>BM 01-069</td>
<td>DEMONSTRATION OF INCENDIARY BOMBS, SMOKE CLOUDS AND SMOKE BOMBS</td>
<td>9/5/1917</td>
</tr>
<tr>
<td>BM 02-017</td>
<td>EXPERIMENTAL WORK ON GAS SHELLS</td>
<td>10/1/1917</td>
</tr>
</tbody>
</table>
WWI Activities: Examples (2) studies

<table>
<thead>
<tr>
<th>REP_NO</th>
<th>AGENT</th>
<th>TEST_LOCA1</th>
<th>OPEN_AIR</th>
<th>BOMB_PIT</th>
<th>LAB</th>
<th>HUMAN_EXP</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM 10-056</td>
<td>MULTIPLE AGENTS</td>
<td>AU</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>TRUE</td>
</tr>
<tr>
<td>BM 10-057</td>
<td>DIPHENYLCHLOROARSINE</td>
<td>AU</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
<tr>
<td>BM 10-058</td>
<td>ACROLEIN</td>
<td>AU</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
<tr>
<td>BM 10-059</td>
<td>MULTIPLE AGENTS</td>
<td>AU</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>TRUE</td>
</tr>
<tr>
<td>BM 10-060</td>
<td>ARSENIC TRICHLORIDE</td>
<td>AU</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>BM 10-060</td>
<td>SODIUM CYANIDE</td>
<td>AU</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>BM 10-061</td>
<td>MULTIPLE AGENTS</td>
<td>AU</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
<tr>
<td>BM 10-061</td>
<td>MUSTARD</td>
<td>AU</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
<tr>
<td>BM 10-062</td>
<td>CHLORPICRIN</td>
<td>AU</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>TRUE</td>
</tr>
<tr>
<td>BM 10-062</td>
<td>PHOSGENE</td>
<td>AU</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>TRUE</td>
</tr>
<tr>
<td>BM 10-063</td>
<td>CHLORPICRIN</td>
<td>AU</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>TRUE</td>
</tr>
</tbody>
</table>
Timeline (2) 1993 - 1995

1/93: Bomb found by contractor digging utility trench

2/93: Army Corps remedial investigation begins
   - Review of historical documents, maps to identify Points of Interest
   - Geophysical surveys
   - Excavations/removals
   - Soil sampling – chemicals not at levels of public health concern

6/95 “No further action” – Record of Decision

Photo credit: US ACE
Timeline (3) 1996-Present

DC Department of Health review finds error in location of POI 24

2 large burial pits discovered

Mustard agent found in 14 excavated items

Elevated levels of arsenic in soil at pits and other areas including AU daycare center

Comprehensive arsenic sampling and remediation

Other pits and disposal areas found (e.g., Lot 18)

Photo credit: US ACE
Project Origins

Background:
Mulitple health studies
  • DC Department of Health
  • Agency for Toxic Substances and Disease Registry
  • Informal/Anecdotal community surveys
Lack of trust
Wealthy, politically active community

Community concerns:
What to make of all the health data?
Is an epidemiological study needed?
Johns Hopkins Project Objectives

Conduct a Public Health Scoping Study

1. Review Existing Environmental, Exposure, and Health Data
2. Characterize Health and Environmental Risks
3. Identify Key Information Gaps
4. Provide Recommendations for Further Study
   • Hazard, Exposure or Outcome Tracking
Community Participation Approach

• Outreach to Stakeholders
• Exposure and Health Analysis
  – Community Health Status
  – Epidemiological and Toxicological Literature Review
  – Spatial Analysis of Exposure and Health
  – Assess Health Risks
• Report and Recommendations
Scoping Study Framework

Exposure

Population Health Status

Pollutant Sources, Substances, Hazards

Release to Environment

Environmental Fate and Transport

Environmental Accumulation

Estimates of Dose

Exposure

Estimates of Risk

Health Effects

Health Status & Risk Characterization

Hazard Characterization

Exposure and Spatial Analysis
Data and Resources

• ATSDR Public Health Consultation
• American University Studies
• Army Corps Sampling Data, Documents
• District Health Department’s Data, Reports, Cancer Study
• EPA Air Monitoring System
• EPA Sampling and Risk Assessments
• Mayor’s Spring Valley Scientific Advisory Board Reports
• RAB and Community Members
• Selected Research Literature
Outreach Efforts

Site visits, phone calls and meetings with over 40 individuals representing the following:

- Agency for Toxic Substances and Disease Registry
- American University
- Army Corps of Engineers
- Community Members
- District Health Department
- Elected Officials
- Environmental Protection Agency
- Landscapers
- Mayor’s Scientific Advisory Panel
- Northwest Current
- Restoration Advisory Board
- Sibley Hospital
- Technical Experts
- U.S. Army
- Washington Aqueduct
Site Visits and Field Work

- 3 Site Visits
- American University Archives
- Palisades Library Repository
- The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM)
Outreach Findings

• Understand the Complexity of the Site (90-year Time Lag, Landscape Changes, Poor Historical Documentation)

• Questions/Uncertainties Concerning Exposures and Long Term Public Health Implications

• Recognize Dual Nature of Contamination
  – High Level Disposal Areas
  – Dispersed Low-Level Contamination

• Support an Independent Third Party Review
Health Analysis Components

- Community Health Status
- Hazard Characterization
- Exposure Assessment
- Biomonitoring Studies
- Risk Characterization
Community Health Status

Spring Valley, Washington DC

Legend:
- Spring Valley Project Boundary
- American University & Wesley Seminary

Imagery provided by DC GIS

© 2003, Johns Hopkins University. All rights reserved.
Spring Valley and Chevy Chase: Census Tracts, ZIP Codes

Census Tracts:
Cancer Registry

Zip Codes:
Top 15 Causes of Mortality
# Demographic Comparisons

<table>
<thead>
<tr>
<th>Area Characteristics</th>
<th>Spring Valley(^a)</th>
<th>Chevy Chase(^b)</th>
<th>D.C.</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
<td>23,462</td>
<td>17,152</td>
<td>572,059</td>
<td>281,421,906</td>
</tr>
<tr>
<td>% White</td>
<td>79.42%</td>
<td>78.24%</td>
<td>27.73%</td>
<td>69.12%</td>
</tr>
<tr>
<td>% Black</td>
<td>4.97%</td>
<td>9.21%</td>
<td>59.45%</td>
<td>11.98%</td>
</tr>
<tr>
<td>% Hispanic</td>
<td>6.60%</td>
<td>4.50%</td>
<td>7.87%</td>
<td>12.52%</td>
</tr>
<tr>
<td>% Other</td>
<td>9.01%</td>
<td>8.06%</td>
<td>4.50%</td>
<td>6.38%</td>
</tr>
<tr>
<td>% College Education</td>
<td>82.70%</td>
<td>69.45%</td>
<td>39.07%</td>
<td>24.40%</td>
</tr>
<tr>
<td>Median Income</td>
<td>$100,128.00</td>
<td>$95,757.25</td>
<td>$41,625.15</td>
<td>$41,194.00</td>
</tr>
</tbody>
</table>

\(^a\) Spring Valley is defined by census tracts 001001, 000901, 001002, and 000801

\(^b\) Chevy Chase is defined by census tracts 001500, 001401, 001100, and 001402
# Community Age Distributions

<table>
<thead>
<tr>
<th>Age Category</th>
<th>Spring Valley Zip Code 20016</th>
<th>Chevy Chase Zip Code 20015</th>
<th>U.S. Whites</th>
<th>U.S. All Races</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 20 years</td>
<td>19.4 %</td>
<td>20.1 %</td>
<td>26.1 %</td>
<td>28.60 %</td>
</tr>
<tr>
<td>20 to 39 years</td>
<td>33.1 %</td>
<td>21.5 %</td>
<td>27.6 %</td>
<td>28.98 %</td>
</tr>
<tr>
<td>40 to 59 years</td>
<td>27.5 %</td>
<td>31.5 %</td>
<td>27.6 %</td>
<td>26.15 %</td>
</tr>
<tr>
<td>60 to 79</td>
<td>14.4 %</td>
<td>17.9 %</td>
<td>14.7 %</td>
<td>13.0 %</td>
</tr>
<tr>
<td>80 and up</td>
<td>5.7 %</td>
<td>9.2 %</td>
<td>3.9 %</td>
<td>3.3 %</td>
</tr>
</tbody>
</table>
Top 15 Causes of Death in the US

<table>
<thead>
<tr>
<th>Causes of Death</th>
<th>SV Avg 02-03</th>
<th>CC Avg 02-03</th>
<th>US W 2003</th>
<th>US 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Disease</td>
<td>350.00</td>
<td>300.00</td>
<td>250.00</td>
<td>200.00</td>
</tr>
<tr>
<td>Cancers</td>
<td>300.00</td>
<td>250.00</td>
<td>200.00</td>
<td>150.00</td>
</tr>
<tr>
<td>Stroke</td>
<td>250.00</td>
<td>200.00</td>
<td>150.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Accidents</td>
<td>200.00</td>
<td>150.00</td>
<td>100.00</td>
<td>50.00</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>150.00</td>
<td>100.00</td>
<td>50.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>100.00</td>
<td>50.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Influenza and Pneumonia</td>
<td>50.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Alzheimer’s</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Nephritis, nephrosis</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Septicemia</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Suicide</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Liver Disease</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Parkinson’s</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Homicide</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Crude Rate per 100,000
Community Health Status Findings

- Overall Community Health Status of Spring Valley is Very Good
  - For 11 of Top 15 Causes of Death Mortality Rates in Spring Valley are 20 – 70 % lower than US Rates
- Hypertension and Related Kidney Disease is the Only Spring Valley Mortality Rate that Exceeded Rates in Chevy Chase and the US
  - Chevy Chase Rates Also Higher than US Rates
Age-Adjusted Cancer Incidence Rates 1994-1999

Cancer Site:
- Bladder
- Kidney
- Leukemias
- Liver
- Lung
- Lymphomas
- Skin

Legend:
- SV
- CC
- US W 97
- US 1997

Rate per 100,000
Age Adjusted Cancer Incidence Rates 2000-2004

Cancer Site: Bladder, Kidney, Leukemias, Liver, Lung, Lymphomas, Skin

Rates per 100,000:
- SV
- CC
- US W 03
- US 2003
Age Adjusted Cancer Mortality Rates 1994-1999

Cancer Site

Rate per 100,000

SV
CC
US W 97
US 1997
Community Health Status Findings: Cancer (1 of 2)

Rates for Seven Arsenic-Related Cancer Were Reviewed for 1994-1999 and 2000-2004

Mortality

- In Both Time Periods, Spring Valley Rates Were 30 – 70% Lower than US Rates

Incidence

- In Both Time Periods, Spring Valley Rates for 6 of the 7 Cancers Were 20 – 70% Lower Than US Rates
  - Skin Cancer Rate for Spring Valley was the Same as the US in 2000-2004
Community Health Status Findings: Cancer (2 of 2)

- Although lower than national rates, analysis suggests that kidney, bladder, lung, and skin cancer incidence rates in Spring Valley are slightly higher than Chevy Chase rates.

- This pattern was also found with cancer mortality rates in Spring Valley and Chevy Chase.

- Literature provides epidemiological evidence that these cancers (kidney, bladder, lung & skin) are associated with arsenic exposure.
Literature Review
And Anecdotal Reports

Peabody Library, JHU
<table>
<thead>
<tr>
<th>1. Cancer or tumor</th>
<th>9. Substance Abuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Central Nervous System/Brain or Mood Disorder</td>
<td>10. Hypothyroidism</td>
</tr>
<tr>
<td>4. Cardio- or Cerebro-vascular</td>
<td>12. Weight loss, Failure to gain weight</td>
</tr>
<tr>
<td>5. Skin Condition or Rash</td>
<td>13. Immune or Autoimmune</td>
</tr>
<tr>
<td>7. Gastro-intestinal</td>
<td>15. Chronic Infections</td>
</tr>
<tr>
<td>8. Respiratory</td>
<td>16. Miscarriage</td>
</tr>
</tbody>
</table>

Note: these conditions are in approximate rank order
Potential Health Effects of Weapons-Related Chemicals

- Carcinogens
- Blood Effects
- Neurological Effects
- Liver Effects
- Kidney Effects
- Skin Effects
- Changes in body or organ weight
- Gastrointestinal Effects
- Bone/Skeletal Effects
Literature Review Findings

• Limited Information on Long-Term Effects of Most of the AUES-Related Chemical Weapons

• Some Health Effects of Weapons-Related Chemicals are Consistent with Anecdotally Reported Health Problems in Spring Valley (Cancers, Blood Disorders, Kidney Disease, and Neurological Conditions)
Spatial Analysis
Areas, Points & Boundaries of Interest
# Summary of Soil Arsenic Data

<table>
<thead>
<tr>
<th>Data subset</th>
<th>Sample size</th>
<th>Average</th>
<th>Upper CL for Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Dev. Ctr.</td>
<td>165</td>
<td>44.92</td>
<td>55.32</td>
<td>498</td>
</tr>
<tr>
<td>Lot 18</td>
<td>93</td>
<td>19.53</td>
<td>29.44</td>
<td>329</td>
</tr>
<tr>
<td>BOI</td>
<td>7122</td>
<td>10.84</td>
<td>11.48</td>
<td>1040</td>
</tr>
<tr>
<td>Background</td>
<td>1,257 (all US)</td>
<td>4</td>
<td>7 (75 %ile)</td>
<td>18</td>
</tr>
</tbody>
</table>
Spatial Analysis Questions

• Are Arsenic Levels Higher Within the Boundaries of Interest?

• Are Anecdotal Reports of Cancer More Likely to Be Within in the Boundaries of Interest Areas?

• Are Confirmed DC Cancer Registry Incidence Cases More Likely to Be Within the Boundaries of Interest Areas?
### Pre-Remediation Arsenic Soil Levels at POIs, AOIs & BOIs

<table>
<thead>
<tr>
<th>Area</th>
<th>Location</th>
<th># of Samples</th>
<th>Median</th>
<th>Mean</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points of Interest</td>
<td>Within</td>
<td>5810</td>
<td>4.60</td>
<td>11.13</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>Outside</td>
<td>12,134</td>
<td>4.11</td>
<td>9.16</td>
<td></td>
</tr>
<tr>
<td>Areas of Interest</td>
<td>Within</td>
<td>3729</td>
<td>4.80</td>
<td>12.04</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>Outside</td>
<td>14,215</td>
<td>4.20</td>
<td>9.21</td>
<td></td>
</tr>
<tr>
<td>Boundaries of Interest</td>
<td>Within</td>
<td>7121</td>
<td>4.55</td>
<td>10.84</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>Outside</td>
<td>10,823</td>
<td>4.10</td>
<td>9.12</td>
<td></td>
</tr>
</tbody>
</table>

*Arsenic Levels are Higher Within than Outside Boundaries of Interest*
### Statistical Spatial Analysis of Cancer

<table>
<thead>
<tr>
<th>Arsenic–Related Cancers</th>
<th>Within a Boundary of Interest OR (CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anecdotal N= 25</td>
<td>2.09 (0.81, 5.1)</td>
</tr>
<tr>
<td>DC Cancer Registry N=90</td>
<td>0.60 (0.30, 1.11)</td>
</tr>
</tbody>
</table>

- Anecdotal Health Reports are More Likely to be Within Boundaries of Interest (May Be Due to Targeted Sampling & Reporting)
- Arsenic Related Cancer Cases from the DC Cancer Registry Are Not More Likely to be Within the Boundaries of Interest
Cancer Cases From DC Cancer Registry 1994-2004
Statistical and Spatial Analysis Findings

• Arsenic Levels are Higher Within Than Outside Boundaries of Interest

• Anecdotal Health Reports are More Likely to be Within Boundaries of Interest (May Be Due to Targeted Sampling & Reporting)

• Arsenic Related Cancer Cases from the DC Cancer Registry Are Not More Likely to be in the Boundaries of Interest
Biomonitoring Studies
### Biomonitoring Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Sponsor</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair N = 32</td>
<td>ATSDR 2001</td>
<td>28 children, 4 adults; 8 with detectable levels (.10 to .14 ppm); all below ATSDR 1.0 ppm level of concern</td>
</tr>
<tr>
<td>Hair and Urine N = 66</td>
<td>American University 2001</td>
<td>27 children, 39 adults; 3 had detectable As in hair between .09 and .12 ppm, all below level of concern; 4 adults provided urine samples, all had total Arsenic within normal reporting range</td>
</tr>
<tr>
<td>Hair and Urine N = 32</td>
<td>ATSDR 2002</td>
<td>9 children, 23 adults; 4 had detectable inorganic As in urine (10 to 15 ppb); all below 20 ppb level of concern</td>
</tr>
<tr>
<td>Urine N = 40</td>
<td>ATSDR 2002</td>
<td>6 children, 34 adults; all had total urine Arsenic between non-detect and 76 ppb; 3 had “mild elevations” in inorganic arsenic</td>
</tr>
</tbody>
</table>

Note: Individual with highest level had highest house dust Arsenic level. All hair levels between non-detect and .73 ppm, below level of concern

Note: The household with the highest total Arsenic urine sample had the highest soil level.
Exposure Study Review Findings

• Overall Findings Indicate Exposures Are Below Level of Concern

• The Four Biomonitoring Studies are Difficult to Compare:
  – Different Methods
  – Different Detection Levels
  – Different Environmental Sampling
  – Reflect Different Time Periods of Exposures

• Possible Relationship Between Arsenic in Soil and Dust and Arsenic Levels in Hair and Urine
Risk Assessment

Part 1 - Arsenic Exposure Profile

Part 2 – Characterize pre-remediation soil and related exposures
Arsenic Exposure Profiles

Distribution of Arsenic in US Soil

Map of arsenic distribution based on data from Shacklette HT and Boerngen J. (1984)
Source Contributions to Arsenic Exposure

At Arsenic Soil Levels of 20 Parts Per Million and Lower Food is the Primary Source of Inorganic Arsenic Exposure for Adults and Children
Source Contributions to Arsenic Exposure (Adult High-end, Soil 20 ppm)

- **Food**: 97.73522%
- **Soil**: 1.19405%
- **Drinking Water**: 1.06308%
- **Indoor Air**: 0.00754%
- **Outdoor Air**: 0.00011%
Source Contributions to Arsenic Exposure
(Child High-end, Soil 20 ppm)

- Food: 89.85443%
- Soil: 8.68159%
- Drinking Water: 1.45265%
- Indoor Air: 0.01093%
- Outdoor Air: 0.00040%
Risk Assessment

Features:

Exposure to Dose modeling
• Soil ingestion
• Dermal uptake
• Inhalation – ambient and indoor air

Risk Characterization
• Cancer - estimate lifetime excess risk
• Other – increased lifetime risk Y/N
Risk Assessment Data Sources

Army Corps soil sampling
Washington Aqueduct drinking water data
EPA NATA 1999 data for D.C.
EPA Exposure Factor Handbook 1997
EPA RAGS Parts A and E 1989, 2004
Dermal absorption (As): Wester et al. (1993)
Oral bioavailability (As): Freeman et al. 1995, Roberts et al. 2007
EPA Soil Screening Guidance 1996
Risk Metrics – Cancer and Noncancer

Cancer risk =

\[(\text{Lifetime Dose}) \times (\text{Cancer Risk Factor})\]

Cumulative/Total cancer risk = \(\sum \text{Cancer}_i\)

Where:
- \(i\) represents each carcinogen

Hazard Quotient (HQ) = \(\frac{\text{Exposure Dose}}{\text{RfD}}\)

Cumulative/Total Hazard Index (CHI) = \(\sum HQ_i\)

Where:
- \(i\) represents each non-cancer pollutant
Risk Assessment Inputs: Soil Examples

• Assumptions For Average Child:
  – 200 mg soil a day
  – 350 days per year for 9 years

• Assumptions For High-end Child:
  – 400 mg soil a day
  – 350 days per year for 9 years

• Assumptions For Adult:
  – 100 mg soil a day
  – 350 days per year for 9 years (Average) or 30 years (High)

• Used Soil Sampling Data from Boundaries of Interest, Lot 18 and Child Development Center
Other soil sampling

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Sample size</th>
<th>Average</th>
<th>Upper CL for Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lot 18 Metals (except for arsenic)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>82</td>
<td>24,773</td>
<td>27,638</td>
<td>55,100</td>
</tr>
<tr>
<td>Antimony</td>
<td>21</td>
<td>9.74</td>
<td>16.89</td>
<td>56.40</td>
</tr>
<tr>
<td>Barium</td>
<td>74</td>
<td>143</td>
<td>211</td>
<td>2,240</td>
</tr>
<tr>
<td>Beryllium</td>
<td>68</td>
<td>1.05</td>
<td>1.17</td>
<td>2.60</td>
</tr>
<tr>
<td>Cadmium</td>
<td>50</td>
<td>2.31</td>
<td>4.92</td>
<td>67</td>
</tr>
<tr>
<td>Chromium</td>
<td>74</td>
<td>146</td>
<td>169</td>
<td>524</td>
</tr>
<tr>
<td>Cobalt</td>
<td>74</td>
<td>28.50</td>
<td>33.86</td>
<td>135</td>
</tr>
<tr>
<td>Copper</td>
<td>77</td>
<td>177</td>
<td>253</td>
<td>2,380</td>
</tr>
<tr>
<td>Lead</td>
<td>76</td>
<td>215</td>
<td>365</td>
<td>4,300</td>
</tr>
<tr>
<td>Manganese</td>
<td>74</td>
<td>742</td>
<td>978</td>
<td>7,270</td>
</tr>
<tr>
<td>Mercury</td>
<td>74</td>
<td>7.96</td>
<td>15.49</td>
<td>241</td>
</tr>
<tr>
<td>Nickel</td>
<td>74</td>
<td>69.44</td>
<td>81.46</td>
<td>275</td>
</tr>
<tr>
<td>Selenium</td>
<td>54</td>
<td>0.94</td>
<td>1.12</td>
<td>3.00</td>
</tr>
<tr>
<td>Silver</td>
<td>74</td>
<td>2.50</td>
<td>4.80</td>
<td>20.9</td>
</tr>
<tr>
<td>Strontium</td>
<td>33</td>
<td>12.29</td>
<td>16.75</td>
<td>145</td>
</tr>
<tr>
<td>Thallium</td>
<td>71</td>
<td>1.59</td>
<td>1.90</td>
<td>3.60</td>
</tr>
<tr>
<td>Tin</td>
<td>71</td>
<td>25.91</td>
<td>44.69</td>
<td>426</td>
</tr>
<tr>
<td>Titanium</td>
<td>74</td>
<td>410</td>
<td>477</td>
<td>1,770</td>
</tr>
<tr>
<td>Vanadium</td>
<td>78</td>
<td>107</td>
<td>128</td>
<td>473</td>
</tr>
<tr>
<td>Zinc</td>
<td>74</td>
<td>263</td>
<td>442</td>
<td>5,690</td>
</tr>
<tr>
<td><strong>Specialty Sampling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiodiglycol</td>
<td>546</td>
<td>595</td>
<td>602</td>
<td>2,100</td>
</tr>
<tr>
<td>CVAA_CVAO</td>
<td>271</td>
<td>0.03782</td>
<td>0.04252</td>
<td>0.2</td>
</tr>
<tr>
<td>Cyanide</td>
<td>266</td>
<td>0.20</td>
<td>0.20</td>
<td>0.32</td>
</tr>
</tbody>
</table>
Soil Remediation
March 2007

Legend:
- Spring Valley Project Boundary
- American University & Wesley Seminary
- Remediation Pending (Soil Removal not started/completed)
- Soil Remediation Completed
- Not Selected for Remediation

Data provided by: Parsons Engineering & USACE

© 2003, Johns Hopkins University. All rights reserved.
# Background Cancer Risks from Arsenic (per 100,000)

<table>
<thead>
<tr>
<th>Background Arsenic Soil Levels in the U.S. Average = 4 ppm, High-end = 7 ppm</th>
<th>Adult Average</th>
<th>Adult High-end</th>
<th>Child Average</th>
<th>Child High-end</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>3.1</td>
<td>4.2</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

As a Point of Reference, the U.S. EPA National Drinking Water Standard for Arsenic Corresponds to Risks Ranging from 57 to 98 for Child Exposure Scenarios.
### Site-Related Increased Cancer Risk Estimates (per 100,000) from Pre-Remediation Arsenic Soil Levels

<table>
<thead>
<tr>
<th></th>
<th>Adult Average</th>
<th>Adult High-end</th>
<th>Child Average</th>
<th>Child High-end</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boundaries of Interest</strong></td>
<td>0.5</td>
<td>0.89</td>
<td>3.2</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>Lot 18</strong></td>
<td>1.1</td>
<td>3.9</td>
<td>7.4</td>
<td>39</td>
</tr>
<tr>
<td><strong>Child Dev. Ctr.</strong></td>
<td>3.0</td>
<td>8.3</td>
<td><strong>19</strong></td>
<td><strong>83</strong></td>
</tr>
</tbody>
</table>

“Acceptable” Range = 0.1 to 10
Occupational Cancer Risk Estimate

• Landscaper Scenario
  – 5 Days of Work Per Week
  – 50 Weeks Per Year
  – 30 Year Career
  – High-End Soil Concentration

• Risk Estimate = 30 Excess Cases per 100,000

“Acceptable” Risk up to 100
Non-Cancer Exposures Evaluated
Pre-Remediation Soil Arsenic Exposure Compared with Non-Cancer Health-Based Guidance Levels

<table>
<thead>
<tr>
<th>Location/Data subset</th>
<th>Adult Average</th>
<th>Adult High-end</th>
<th>Landscaper</th>
<th>Child Average</th>
<th>Child High-end</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundaries of Interest</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Lot 18</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&gt;1</td>
</tr>
<tr>
<td>Child Dev. Ctr.</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&gt;1</td>
</tr>
</tbody>
</table>

<1 is Considered Below Level of Concern
Arsenic Risk Assessment Findings (1)

The Exposure and Risk Estimates Calculated are Likely Overestimates of Actual Risks and Reflect Dual Nature of Contamination

**Adult**

No Elevated Cancer or Non-Cancer Risks Calculated for Any of the Adult Scenarios
Arsenic Risk Assessment Findings (2)

Child

• No Elevated Non-Cancer Risks for the Average Child Scenario

• Potential Cancer Risks Calculated are Elevated Above the Level of Concern for the Average and High End Child Scenarios at Pre-Remediation Soil Levels

• Potential Non-Cancer Exposures Are Elevated Above the Level of Concern for the High-End Child at Pre-Remediation Soil Levels
Non-Arsenic Compounds – Exploratory Assessment

Cumulative Risk Assessment was Conducted for Non-Arsenic Compounds that Were Detected in Spring Valley

Limitations:

– Limited Sampling Data
– Non-Representative Sample
  • Most Samples from Lot 18
Non-Arsenic Compound Findings

• No Elevated Cancer Risks for Adults or Children
  – All Cancer Risk Estimates Less Than 2 per 100,000

• No Elevated Exposures for the Adult Scenarios for Any of the Non-Cancer Health Effects

• Potential Exposure to the Non-Arsenic Chemicals are Above the Level of Concern for a High-End Child at Pre-Remediation Soil Levels at Lot 18 (HI = 1.06)
Risk Assessment Findings

• Risk Assessment Findings Reflect the Dual Nature of Contamination

• Adult Average and High and Child Average Exposures and Risks are Low

• Children’s High-End Exposures and Risks Elevated from Pre-Remediation Soil at Hot Spots
## Summary of Health Findings

<table>
<thead>
<tr>
<th>Health Concerns</th>
<th>Anecdotal Community Reports</th>
<th>Scoping Study Community Health Analysis</th>
<th>Scoping Study Review of Literature</th>
<th>Scoping Study Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Kidney Diseases</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Blood Disorders</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Neurological Conditions</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Recommendations

Health

• Examine Additional Years of Mortality and Cancer Registry Data

• Further Investigation of Non-Cancer Outcomes of Concern (Blood Disorders, Neurological and Kidney Diseases)
  – Develop Strategy for Case Finding and Verification and, if Warranted, Other Epidemiological Follow-Up

• Obtain/Review Detailed Data From the ATSDR Biomonitoring Studies
  – If Warranted, Consider a Systematic Exposure Study
Recommendations (2)

Environmental Sampling and Potential Exposures

• Continue Tracking Environmental Sampling Data
• Conduct Post-Remediation Sampling to Demonstrate Exposure Reductions
• Ensure Future Sampling Design and Implementation Address Community Health Concerns
• Establish Notification/Communication Protocol Regarding Digging or Potential Soil Disturbance Within the Study Area
• Examine Water Sampling Results to Evaluate Potential for Water-Related Exposure Pathways
Recommendations (3)

Response Capacity and Ongoing Risk Communication

• Continue Public Health Outreach, Response, and Risk Communication
• Reinforce Preventive Community and Household Measures to Reduce Exposure to Soil
Technical commentary

Limitations

“Small numbers” problem – health outcomes
Past exposures?
Groundwater?

Epidemiological issues

Comparison population?
Technical commentary

Value of multi-disciplinary analysis
Community health status
Spatial analysis – map of cancers distributed across site
Risk assessment to inform public health
  Its not ALL about the “numbers”
Who is at risk and why
Link to project report
