SPRING VALLEY PUBLIC HEALTH SCOPING STUDY

FINAL REPORT

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Prepared by the Johns Hopkins Bloomberg School of Public Health, under contract with the District of Columbia Department of Health

Mary Fox
Beth Resnick
Erik Janus
Frank Curriero
Kathryn Kulbicki
Ana Navas-Acien
Ramya Chari
Roni Neff
Keeve Nachman
Joanna Zablotsky
Tom Burke

Please direct requests for further information to Robin Dranbauer at rdranbau@jhsph.edu or 410-614-4587.

Executive Summary

During and immediately after World War I, chemical warfare research and testing was conducted on the American University campus and the surrounding areas, now known as Spring Valley. The discovery of buried ordinance in 1993 by utility workers led to the establishment of a multi-agency effort led by the U.S. Army Corps of Engineers (USACE) to identify and remediate hazards in the Spring Valley area. The Spring Valley site presents many challenges including the ninety year time-lag, a lack of documentation of buried material locations, and a significantly changed landscape due to the extensive development on the campus and surrounding areas.

Over the past decade, there have been a number of efforts by the Centers for Disease Control and Prevention Agency for Toxic Substances and Disease Registry (ATSDR), and the District of Columbia Department of Health (DCDOH) to evaluate potential environmental exposures and public health concerns. A number of areas contaminated with buried waste or ordinances have been identified. Cleanup of these sites has either been completed or is underway. Most of the chemical contaminants from past ordinance testing have degraded over the almost 90 years since the war and are no longer detectable in the environment. Arsenic is the most pervasive and persistent contaminant and levels above what naturally occurs in soil were measured throughout the community. Over 1500 properties have been monitored and those with soil levels above 20 parts per million (ppm), a health protective remediation level, have been or are being remediated.

This Public Health Scoping Study was conducted by the Johns Hopkins Bloomberg School of Public Health (JHSPH) at the request of the DCDOH in response to a recommendation by the Mayor's Spring Valley Scientific Advisory Panel. The purpose of the study is to provide a synthesis of existing environmental exposure and health data, characterize potential health risks to the Spring Valley community, identify key information gaps, and provide recommendations for further study and tracking of contaminant exposures and health outcomes. The components of the study include: outreach; community health assessment; review of existing information on potential hazards and health effects of concern; spatial analysis and mapping of contamination and selected health outcomes; and a risk assessment to characterize potential community risks from site related exposures.

<u>Findings</u>

- Community health status of Spring Valley is very good. Mortality rates for most of the top 15 causes of death compare favorably with national rates and are lower than those of Chevy Chase, D.C., a comparison community with similar demographic characteristics.

- Spring Valley age-adjusted cancer incidence and mortality rates for selected cancers of concern (bladder, kidney and renal pelvis, leukemias, lung and bronchus, lymphomas and skin) are generally much lower than the U.S. rates. In recent years (2000 – 2004) rates of skin cancer incidence are the same as the U.S. rates.

- The examination of cancer incidence and mortality data indicated that rates of cancer known to be associated with arsenic exposure (bladder, kidney and renal pelvis, lung and bronchus, and skin) are slightly higher in Spring Valley than in Chevy Chase. This

finding should be interpreted with caution since the numbers of cases and deaths are low and rates calculated are likely to be highly variable.

- There persists a lack of information on the long-term effects of chemical weapon exposures. However, the available scientific literature on the health effects of chemicals (including some chemical weapon breakdown products) sampled for in soils in Spring Valley is consistent with some anecdotally reported health outcomes in the community, such as cancers, blood disorders, neurological and skin conditions.

- A spatial analysis of cancer incidence did not indicate a relationship between cancer incidence and proximity to known contaminated areas. A similar analysis of anecdotal health outcomes did reveal a spatial relationship with known contaminated areas. This finding may reflect the limitations of the anecdotally reported data.

- The risk assessment examined average community and worst-case exposure scenarios for both adults and children. Risks are generally low for adults, including workers (e.g., landscapers). In the worst case, for children's exposures to unremediated soil, cancer and non-cancer risks are elevated, but the probability of adverse effects is small.

These findings are consistent with those from previous studies done by ATSDR and DCDOH and should provide reassurance to the Spring Valley community. These findings support continued remedial activities, monitoring, and evaluation of potential exposures and health outcomes in the community. The study was limited to the available environmental monitoring data, and community level reportable health outcome data. It was beyond the scope of the study to evaluate individual health outcomes and exposures. Similarly, the study could not consider past community exposures over the 90 years since active weapons testing at the site.

<u>Recommendations</u>

<u>Health</u>

- Strengthen community health analysis by working with the DC Health Department to obtain additional years of mortality and cancer registry data.

    - Examine time trends in major causes of death and relevant demographic information for Spring Valley and comparison areas to determine historical mortality patterns.

    - Examine additional years of cancer registry data as they become available to assess temporal patterns and improve the statistical power of the cancer analysis.

- Collect additional information on non-cancer outcomes of concern (blood disorders, neurological and kidney diseases) potentially related to AUES-chemical exposures.

    - Identify and examine available scientific literature on incidence and prevalence.

    - Conduct targeted interviews with community members and health care providers to confirm diagnoses.

  - If warranted, on the basis of literature reviews and interviews, consider further epidemiological study.

Environment and potential on-going exposures

- Update and maintain the existing Spring Valley database by working with the Spring Valley agency partners to obtain current environmental sampling and health outcome data.

- Obtain and analyze the raw data from the biomonitoring studies from ATSDR and, if warranted, work with the DC Health Department to develop a protocol for a systematic exposure study of homes including controls.

- Demonstrate exposure reductions resulting from remediation.

  - Work with the Spring Valley agency partners to access and analyze remediation-related sampling including information on fill material. If necessary, work with agency partners to plan and conduct a targeted post-remediation sampling program to demonstrate exposure reductions.

  - Quantify risk reductions by revising the risk assessment using post-remediation sampling data.

- Ensure future sampling study design and implementation addresses community health concerns by conducting continued outreach with community members and working collaboratively with the agency partners.

Response capacity and communication

- Establish notification/communication protocol regarding digging or potential soil disturbance within the study area through coordination with agency partners on outreach and education efforts.

- Continue tracking water sampling results to evaluate potential for water-related exposure pathways by coordinating with Agency partners to access and analyze water sampling results.

- Continue public health outreach, responses and risk communication efforts through continued contacts with community members and agency partners.

- Reinforce preventive community and household measures to reduce exposure to soil through coordination with agency partners on outreach and education efforts.

I. BACKGROUND

Project origins

Chemical warfare research, testing, and disposal were conducted during and immediately after World War I on the American University Campus and surrounding areas now known as Spring Valley. In 1993, while digging a utility trench, a contractor unearthed buried military ordnance. This led to the establishment of the Spring Valley Formally Used Defense Site (FUDS), consisting of approximately 661 acres and 1200 residences as well as American University and Wesley Seminary (see Map 1).

Over the eight decades since American University Experiment Station (AUES) activities, the University campus experienced substantial growth and the surrounding area was developed into the residential area known as Spring Valley. (See Appendix A for a map showing the timeline of development of Spring Valley residential properties, Map A1.)

The USACE in partnership with the DCDOH, the U.S. Environmental Protection Agency (EPA), ATSDR, DC government officials, the Spring Valley Restoration Advisory Board (RAB), and the American University (AU) have worked on the identification and remediation of hazards in the Spring Valley FUDS.

The Spring Valley site presents many challenges including the ninety year time-lag, a lack of documentation of buried material locations, and a significantly changed landscape due to the extensive development on the campus and surrounding areas.

There are health, safety and environmental concerns regarding the World War I activities in the Spring Valley area. In response to these concerns, in March, 2006 the DCDOH contracted with JHSPH to conduct a public health scoping study.

Statement of Work

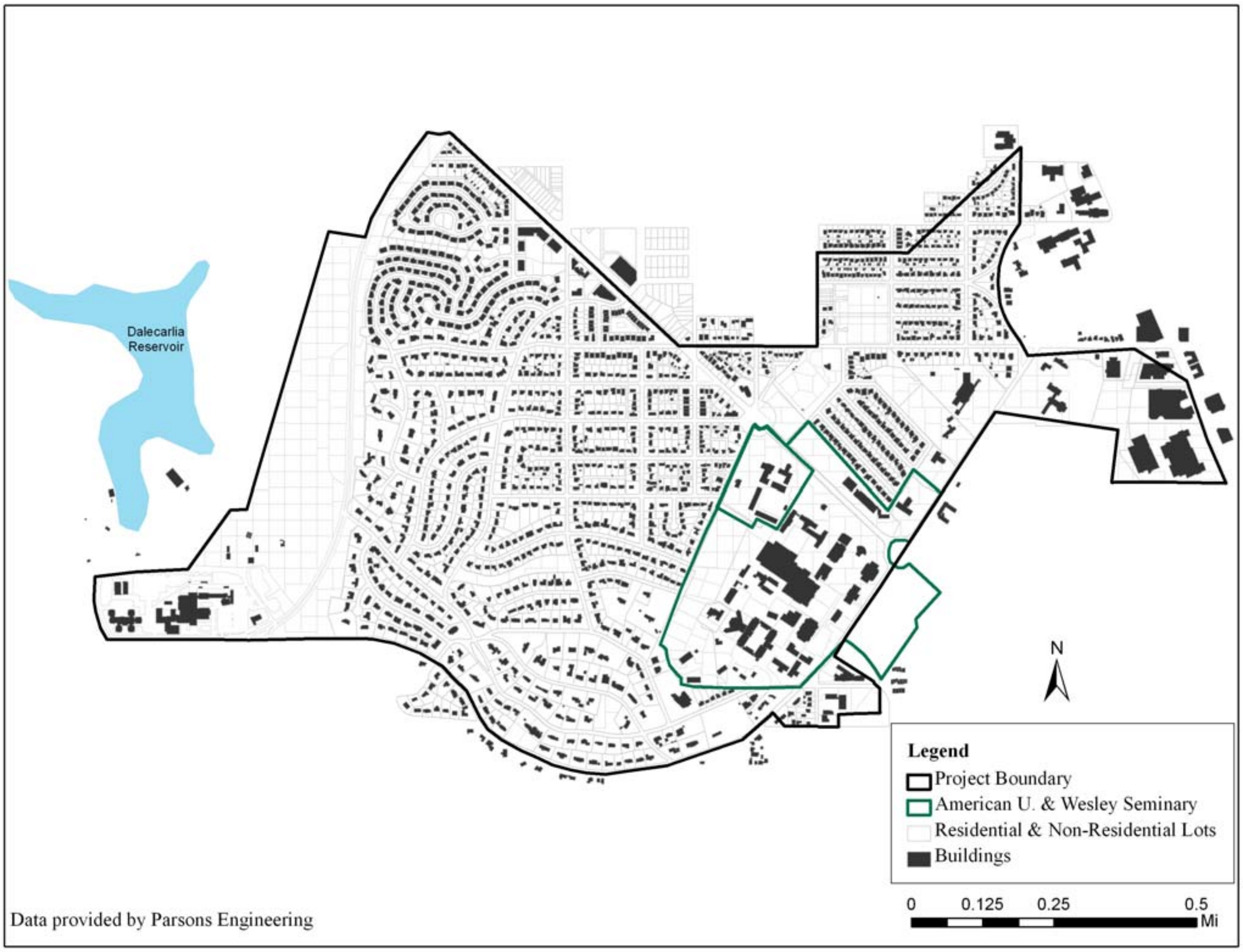
The purpose of this scoping study is to provide a synthesis of existing environmental, exposure, and health data, characterize potential risks to the Spring Valley community, identify key information gaps, and provide recommendations for further study and tracking of contaminants, exposures, and health outcomes.

Approach

<u>Outreach</u>

The Hopkins investigators communicated with over forty community members, agency partners, technical experts, and other interested parties through site visits, conference calls and attendance at public meetings. The purpose of the outreach effort was to identify and gather information necessary for the study, as well as inform the community and other interested parties about the study progress and results. The Hopkins investigators conducted the outreach efforts in accordance with the guidelines from the Johns Hopkins Institutional Review Board (IRB).

Map 1. Spring Valley FUDS Boundary (Study Area)



For the protection of confidentiality, no participant names or individual responses are revealed in this report.

The Hopkins investigators adapted the “snowball” sampling technique for the outreach effort. This technique involves asking each outreach participant for referrals to others with information relevant to the investigation and contacting those individuals in turn (Trochim 2006). The preliminary outreach list was developed through discussion with the DCDOH and interested community members at an initial project meeting and, as the project progressed, other interested parties contacted the Hopkins investigators directly. Each identified individual was contacted and requested to participate in either a meeting or telephone call to last approximately 30 minutes. The same format was used for each call or meeting: an overview of the Johns Hopkins public health scoping study was provided; the participant’s feedback on the proposed activities and approaches was solicited; participants were asked to describe their involvement with the site, their specific questions and concerns, and their recommendations for future activities and others to contact.

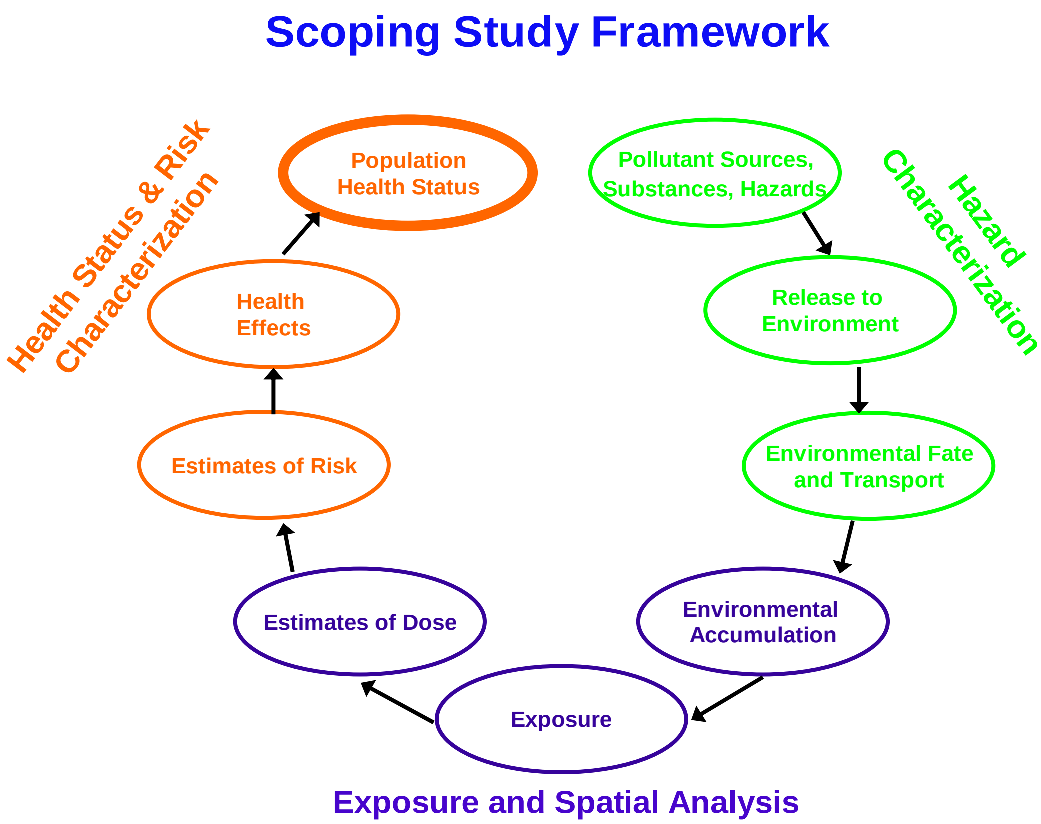
Data Gathering

Hopkins investigators gathered and reviewed key summary documents including environmental monitoring, human biomonitoring, census, health surveillance, and supporting geography. Data and reports were obtained from agency partners, technical experts, community members, and other interested parties by direct request and field work at archives and document repositories. Due to resource and time constraints, the majority of data utilized was readily available in electronic format. Data, such as the anecdotal health reports, which were considered critical to the study but only available in hard copy, were converted to electronic formats for use in the study analysis. The available data have varying geographic boundaries. Investigators utilized the smallest geographic area of analysis available which includes the Spring Valley FUDS boundary, census tracts, and zip code. Maps displaying the geographic areas corresponding to each analysis are provided throughout the report. The study data is housed within a Spring Valley database that was developed by the investigators and is managed within the ArcGIS9.2 Geographic Information System (GIS). Information in this database is classified into three components related to environmental exposures, health outcomes, and supporting geography.

Site-Specific Analysis

In addition to a review of key exposure related documents that inform the long-term health of the community, four health related analyses were conducted. A general community health assessment of available vital statistic and registry data provides a profile of population health in Spring Valley and the neighboring community of Chevy Chase, DC, a community with similar demographic characteristics. A site-specific environmental health risk analysis addresses the issues of chemical persistence and exposure, toxicity, and spatial distribution. The site-specific analysis has three components: identification of potential health hazards; spatial analysis of exposure and outcomes; and characterization of exposure-related health risks. Figure 1 presents the scoping study framework, the circular ring shows the types of data that were reviewed for each aspect of the analysis.

Figure 1. Scoping Study Framework



Site-specific analysis: Community health assessment
Community health status indicators, such as mortality rates and population characteristics for the Spring Valley area, were compiled. Spring Valley community information was compared to Chevy Chase, DC and to national data where available, to develop a description of population health in Spring Valley. The community health assessment includes: a comparison of crude mortality rates for the top 15 causes of death in the US, and a descriptive analysis of cancer incidence and mortality. The cancer sites of interest are those that are recognized as known or potential arsenic-related cancers: skin, bladder, lung and bronchus, liver and intrahepatic bile duct, kidney and renal pelvis, leukemias, and lymphomas (EPA 1998; ATSDR 2005; Chen et al. 2005; Matansoki, personal communication, July 7, 2006).

Site-specific analysis: Identification of potential health hazards
The hazard characterization includes a review of epidemiological and toxicological research literature on the long-term health effects of various chemicals of concern including arsenic, chemical weapons and their breakdown products, and other environmentally persistent chemicals known to have been used at the American University Experiment Station (AUES). This review of literature identifies the types of health outcomes that might result from exposure over time.

Site-specific analysis: Spatial analysis of exposure and outcomes
A geographical information system (GIS) database was designed to support the spatial component of the health risk analysis. The database allows the integration of multiple sources of data including environmental exposures, health data (including anecdotal reports), Census data, site-related infrastructures and neighborhood development, and geographic boundaries. The database was used for mapping and descriptive and statistical analyses of exposure and health.

Site-specific analysis: Risk Assessment
To complete the evaluation of chemical exposure health risks, the hazard information described above was supplemented with exposure and dose-response data. Available exposure and exposure-response data was combined to estimate potential exposure-related health risks for the Spring Valley area. The analysis included data on soil, water, and air. Various exposure scenarios were developed to estimate and evaluate exposures and risks for adults, workers and children. Risks were evaluated by comparing estimated exposures to reference exposures from research studies with known health outcomes. Risk analysis was conducted for arsenic and other contaminants.

II. RESULTS

Summary of Outreach

The JHSPH investigators communicated with community and agency partners through site visits, conference calls and attendance at public meetings. The purpose of the outreach effort was to identify and gather information necessary for the study as well as inform the community and other interested parties about the study progress and results.

<u>Outreach Participants</u>
The JHSPH investigators contacted over forty representatives from the community, partner agencies, and other relevant organizations listed below. The multi-faceted outreach effort included visits to the Spring Valley site, field work, face-to-face meetings, conference calls, and public meetings.

JHSPH Outreach Participants

- District of Columbia Health Department (DCDOH)
- Technical Experts
- Community Members
- Elected Officials
- U.S. Environmental Protection Agency (EPA)
- Sibley Hospital
- Northwest Current Newspaper
- Landscapers
- American University
- Restoration Advisory Board (RAB)
- Mayor’s Scientific Advisory Panel
- Washington Aqueduct
- U.S. Army Corps of Engineers (USACE)
- Agency for Toxic Substances and Disease Registry (ATSDR)
- U.S. Defense Department

Findings: Outreach
Although the outreach participants had a wide range of involvement, specific site knowledge, and individual health concerns, the following common themes emerged:

- Complexity of the site: There was agreement on the complexity of the Spring Valley site. In particular, the ninety year time lag since the initial activities; the lack of documentation of burial areas; the changing landscape of the area due to development, and the absence of any medical records from the World War I time period were recognized as major obstacles to identifying exposure-related health problems in Spring Valley.

- Geographic variability of contaminants: The outreach respondents were in agreement that the geographic variability of contaminant levels in Spring Valley can be broken into two categories: the disposal pit areas and the more widespread lower contaminant level areas. There was consensus that the major health, safety and environmental concerns are regarding the disposal pit areas.

- Questions/uncertainties on potential health effects: Given the complexities of the Spring Valley site and variations of contaminant levels outlined above, the outreach participants acknowledged uncertainties with regards to determining exposure-related health problems in Spring Valley. There was consensus that it would be helpful to monitor and track contaminant levels, exposures, and health outcomes.

- Support for an independent investigation: Given the uncertainties regarding exposure-related health problems in Spring Valley respondents were very supportive of a third party investigation to provide recommendations for further study or tracking of contaminants, exposures, and health outcomes.

Site-specific analysis: Review of key exposure documents

JHSPH investigators conducted analyses on the soil sampling data from the USACE and EPA sampling efforts as well as mortality and cancer registry data. Results of these analyses appear below. JHSPH investigators did not initiate any new sampling or biomonitoring, but did conduct a review of available biomonitoring and in-home sampling data to evaluate the results in relation to long-term health and other community concerns. The documents reviewed were the ATSDR Exposure Investigations reports dated February 2001, March 2002 and Summer 2002, the study conducted for American University (Washington Occupational Health Associates, 2001) and the USACE/Parsons report on indoor air sampling at 5065 Sedgwick Street (Parsons, 2004). The raw data from the ATSDR investigations were requested, but were not provided to JHSPH.

<u>Biomonitoring Exposure Studies</u>

Biomonitoring studies provide measures of the level of a contaminant in human body fluids or tissue. Biomonitoring combined with environmental sampling can be an effective tool for measuring population exposure. The choice of an appropriate biomarker is essential to effective biomonitoring studies. At Spring Valley measurements of arsenic in hair and urine were chosen as the biomarkers for biomonitoring studies. These studies are summarized in Table 1 below.

In general, the results of these studies provide reassurance that the levels of exposure to arsenic in the Spring Valley community are low. Measurements of arsenic in hair and urine are consistently either below detectable levels or lower than established levels of public health concern. These findings are consistent with the environmental sampling for arsenic that has been conducted throughout the community.

There are some limitations to the biomonitoring study results. Since arsenic is excreted rapidly, urine provides a measure of an individual's exposure only within the past few days. Urine samples can also be influenced by dietary sources of arsenic such as seafood. Therefore, urine arsenic levels provide little information about long-term or chronic exposure. Measures of arsenic in hair provide a better biomarker of long-term exposure. Hair samples for arsenic indicate exposure over the past several months.

Table 1. Arsenic (As) Biomonitoring Exposure Studies

Study	**Sponsor**	**Date**	**Results**
Hair, N=32	ATSDR	February 2001	28 children and 4 adults tested; 8 with detectable levels (0.10 to 0.14 ppm); all below ATSDR 1.0 ppm level of concern
Hair and urine, N = 66	American University	February 2001	27 children and 39 adults tested; 3 had detectable Arsenic in hair between 0.09 and 0.12 ppm, all below level of concern; 4 adults provided urine samples, all had total Arsenic within normal reporting range
Hair and urine, N = 32 (in 13 households)	ATSDR	March 2002	9 children and 23 adults tested; 4 had detectable inorganic As in urine (10 to 15 ppb); all below 20 ppb level of concern Individual with highest level had highest house dust As level. All hair levels between non-detect and 0.73 ppm, below level of concern
Urine, N = 40	ATSDR	Summer 2002	6 children and 34 adults; all had total urine As between non-detect and 76 ppb; 3 had "mild elevations" in inorganic arsenic The household with the highest total Arsenic urine sample had the highest soil level.

Indoor Dust and Air Sampling Studies

In 2002, ATSDR reported on an exposure investigation of 13 Spring Valley homes. Arsenic was sampled in household dust at the front and rear entrances of the homes and in the hair and urine of the occupants. The homes were among the 20 with the highest arsenic levels in outdoor soil. The resulting arsenic levels in the household dust were considered low (range non-detectable to 63 micrograms per gram [μg/g] dust) and not a cause of concern. The total urinary arsenic results were within the range of general population levels. Urinary inorganic arsenic (adjusted for creatinine or urine concentration) was below reportable levels. Only one correlation was noted; the person with the highest total urinary arsenic also had the highest arsenic level in household dust. The findings did also demonstrate the transfer of soil arsenic from outdoors to indoors.

The USACE, contracting with Parsons, conducted indoor air arsenic (particulate matter) and bulk and wipe sampling of dust arsenic at 5065 Sedgwick Street in the Sedgwick Trench area. The arsenic in dust and bulk sampling were measured in micrograms per square foot ($\mu g/ft^2$) so the results were not comparable to the ATSDR Exposure Investigation (described above). Air sampling results from four locations in the home ranged from 0.0003 to 0.0008 ug/m^3. The two highest results were from the exterior of the home at a side door and in the basement, the lowest value was from the second floor. The EPA Region III risk-based concentration is 0.00041 ug/m^3 for arsenic and the average of the results taken in the home was slightly higher at 0.0005 ug/m^3. The dust and other bulk sample results ranged from non-detect to 83.1 $\mu g/ft^2$. The three highest dust results (13.5, 22.2, and 83.1 ug/ ft^2) were sampled from undisturbed or rarely accessed areas like the tops of basement duct work and inside the fireplace.

Findings: Exposure Studies

- The four biomonitoring studies conducted at Spring Valley were done using different methods, often with different detection levels and different environmental sampling. The studies are therefore difficult to compare and interpret. While the overall findings indicate no measurable exposures of public health concern, there may be indications of a relationship between soil and dust levels and levels of arsenic in hair and urine.

- The two in-home sampling studies were also conducted with different methodologies and are not comparable. The findings at the Sedgwick Street home indicate that there may be a build-up of dust arsenic in undisturbed places within the home that are potential exposure sources if disturbed (e.g., cleaned).

Site-specific analysis: Community Health Status

The Spring Valley Community: Site Information and Demographics

The public health scoping study focused on the Spring Valley FUDS which covers approximately 668 acres in the northwest portion of the District of Columbia (DC). A majority of the land area is single family residences, as well as the campus of the American University. While there are some commercial properties, including retail stores and medical facilities there are no industrial facilities. The Dalecarlia Reservoir is located just outside the Spring Valley site boundary to the west.

Table 2 shows a comparison of the Spring Valley population to Chevy Chase, DC, all of DC, and the US for the year 2000. Chevy Chase, DC was used as a comparison population to Spring Valley as it was the most comparable DC neighborhood based on a review of demographic information. As shown in Table 2, the Spring Valley and Chevy Chase populations are less racially diverse, more educated, and wealthier than the DC total population and the nation. The marked demographic differences between Spring Valley and DC overall make health data comparisons difficult; therefore, health data comparisons with DC are not presented. (Map A2 in Appendix A shows the locations of the Spring Valley and Chevy Chase census tracts.)

Table 2. Comparison of Population Characteristics by Area, 2000 Census

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

[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.

Cause-Specific Mortality

For the analysis of general community health status, recent mortality data requested from the DCDOH for the top 15 causes of death in the US were reviewed (Table 3). Data for Spring Valley (SV) and Chevy Chase (CC) were provided for 2002-2003 and the two years of data were averaged for this study. Data on US whites and all races for 2003 are also presented for comparison (Hoyert et al. 2006). We compared the crude rates (per 100,000 population) for ZIP Codes 20016 (representing Spring Valley) and 20015 (representing Chevy Chase) and for the US. Map A3 (see Appendix A) displays the ZIP Code areas. ZIP Code was the smallest geographic area of analysis available. We did not obtain individual death records, only summary counts, so it was not possible to adjust for age differences. The age distributions are presented in Table 4 and the mortality findings are discussed considering age differences.

Table 3 and Figure 2 present the comparison of crude mortality rates by cause of death. Overall community health in Spring Valley is very good with crude mortality rates for the most common causes of death well below those of the white population and the nation overall, and most below rates in Chevy Chase. The last column in Table 3 presents a ratio of Spring Valley rates to US rates. Ratios less than one identify death rates that are lower in Spring Valley than the nation; ratios greater than one identify death rates that are higher than US rates. For several causes of death; influenza and pneumonia, Alzheimer's, and Parkinson's diseases, Spring Valley and Chevy Chase crude mortality rates are higher than in the US (although rates in Spring Valley are slightly lower than those in Chevy Chase). These elevations are likely explained by the fact that there is a larger proportion of population over 60 years of age in Spring Valley and particularly in Chevy Chase, as compared to the nation (See Table 4). The rates of nephritis, nephritic syndrome and nephrosis in Spring Valley are slightly higher than Chevy Chase, but only one-third of the US rate. For essential hypertension and related kidney disease, Spring Valley and Chevy Chase rates exceed those of the US. The rates in Spring Valley are slightly higher than Chevy Chase. Further information on essential hypertension and related kidney disease and nephritis, nephritic syndrome and nephrosis follows.

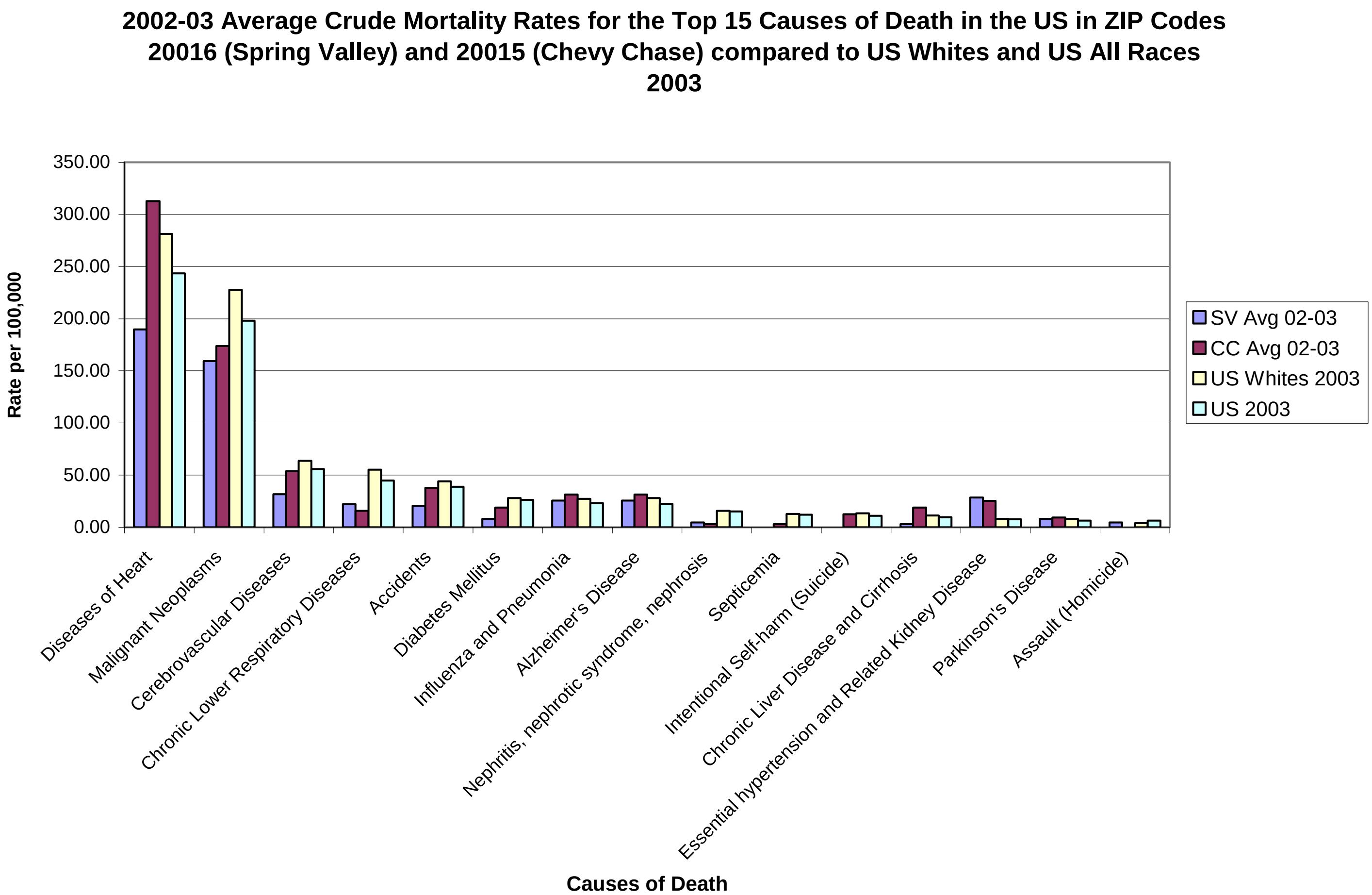
Essential hypertension is more prevalent in black adults and white males, and family history is a predisposing factor. Poor diet, obesity and high sodium intake contribute to the disease in susceptible persons (Beers and Berkow 1999). Other risk factors include sedentary lifestyle, excessive alcohol consumption and chronic emotional stress (Pugh and Werner 2000). Exposure to environmental chemicals is not a common risk factor for essential hypertension. Exposure to environmental chemicals (e.g., heavy metals such as cadmium, lead, and uranium) and certain drugs (some analgesics, antibiotics, chemotherapeutics) can cause nephritis and nephrosis (Klaassen et al. 1997). Potential kidney disease risks associated with chemicals in soil in Spring Valley are explored further in the risk assessment.

Table 3. **Crude Mortality Rates per 100,000 for Spring Valley (ZIP Code 20016), Chevy Chase (ZIP Code 20015) (Average 2002-2003) and US 2003 white population and US 2003 all races.**

Top 15 Causes of Death	SV Avg 02-03 (# deaths)	CC Avg 02-03 (# deaths)	US Whites 2003	US 2003	SV/US Ratio
Diseases of Heart	189.65 (119)	312.82 (99)	281.30	243.44	0.78
Malignant Neoplasms	159.37 (100)	173.79 (55)	227.73	197.89	0.81
Cerebrovascular Diseases	31.87 (20)	53.72 (17)	63.70	56.03	0.57
Chronic Lower Respiratory Diseases	22.31 (14)	15.80 (5)	55.29	44.91	0.50
Accidents	20.72 (13)	37.92 (12)	44.16	38.83	0.53
Diabetes Mellitus	7.97 (5)	18.96 (6)	27.95	26.37	0.30
Influenza and Pneumonia	25.50 (16)	31.60 (10)	27.26	23.15	1.10
Alzheimer's Disease	25.50 (16)	31.60 (10)	27.99	22.55	1.13
Nephritis, nephrotic syndrome, nephrosis	4.78 (3)	3.16 (1)	15.94	15.09	0.32
Septicemia	0.00 (0)	3.16 (1)	12.85	12.11	0.00
Intentional Self-harm (Suicide)	0.00 (0)	12.64 (4)	13.47	11.19	0.00
Chronic Liver Disease and Cirrhosis	3.19 (2)	18.96 (6)	11.35	9.77	0.33
Essential Hypertension and Related Kidney Disease	28.69 (18)	25.28 (8)	8.00	7.80	3.68
Parkinson's Disease	7.97 (5)	9.48 (3)	8.06	6.40	1.25
Assault (Homicide)	4.78 (3)	0.00 (0)	4.12	6.30	0.76

Abbreviations: Avg, Average; CC, Chevy Chase; SV, Spring Valley; US, United States.

Figure 2. **Crude Mortality Rates per 100,000 for ZIP Codes 20016 and 20015 Average 2002-03 and US Whites and All Races**



To help interpret the crude mortality rates, the ages of the 20016 (SV) and 20015 (CC) ZIP Code populations were compared to those of US whites and US all races for the year 2000. Table 4 presents each population broken into 20-year age groups. ZIP Code 20016 (SV) has a smaller proportion of children under twenty (19.4%) than 20015 (CC) (20.1%) as well as US whites or US all races (26.1 and 28.6%). In addition, 20016 (SV) has the largest proportion of population in the age 20 – 39 age group (33.1%). ZIP code 20016 (SV) has about the same proportion of population in the 40 to 59 and 60 to 79 age groups as US whites and has a slightly larger proportion than the US all races. ZIP code 20015 (CC) has a higher proportion of population in the 40 to 59 and 60 to 79 age groups than the nation overall (5 percentage points higher). In the oldest age group (80 years old and above), the US has the smallest percent population at 3.3%, followed by US whites at 3.9% with Spring Valley at 5.7% and Chevy Chase at 9.2%.

Given these age differences, one would expect ZIP Code 20016 (SV) mortality rates to be similar or somewhat lower than US rates. Except for primary hypertension, related kidney disease, and several causes of death common in the elderly, (influenza and pneumonia, Alzheimer's and Parkinson's) mortality rates in the last few years are lower in ZIP Code 20016 (SV) than in the total US population, suggesting a population that is healthier overall than the general population.

Table 4. Percent population by age for 2000 for ZIP Codes* 20016, 20015, and US Whites and US All Races

Age Category	Zip Code 20016 (SV)	Zip Code 20015 (CC)	U.S. Whites	U.S. All Races
Less than 20 years	19.4 %	20.1 %	26.1 %	28.60 %
20 to 39 years	33.1 %	21.5 %	27.6 %	28.98 %
40 to 59 years	27.5 %	31.5 %	27.6 %	26.15 %
60 to 79	14.4 %	17.9 %	14.7 %	13.0 %
80 and up	5.7 %	9.2 %	3.9 %	3.3 %

* Data shown are for ZIP Code Tabulation Areas as reported by the Census Bureau.

Analysis of Selected Cancers of Concern

The following descriptive analysis of incidence and mortality for several cancers known or potentially related to arsenic exposure builds upon prior work by the DC Department of Health. The cancer sites of interest are those that are recognized or potential arsenic-related cancers: skin, bladder, lung and bronchus, liver and intrahepatic bile duct, kidney and renal pelvis, leukemias, and lymphomas (EPA 1998; ATSDR 2005; Chen et al. 2005; Matansoki, personal communication, July 7, 2006). Data on cancer incidence and mortality for these seven cancers were requested and received from the DC cancer registry. The data cover a time period from 1994 to 2004 and the dataset was divided into two roughly equal parts (1994 – 1999 and 2000 – 2004) to examine any trends or patterns.

The analysis of cancer data differs from the preceding mortality analysis in two ways. Individual records were obtained, and the rates presented below are age-adjusted to the year 2000 US population. For the cancer analysis, Spring Valley and Chevy Chase are defined by census tracts rather than the larger ZIP Code areas. The Spring Valley census tracts are 000801, 000901, 001001, and 001002. The Chevy Chase census tracts are 001100, 001401, 001402, and 001500. Annual average incidence and mortality rates for Spring Valley and Chevy Chase in the 1994 - 1999 period are compared to the US rates for 1997 (Ries et al. 2006). Annual average incidence and mortality rates for Spring Valley and Chevy Chase in the 2000 - 2004 period are compared to the US rates for 2003 (Ries et al. 2006). One death due to lung cancer in Chevy Chase and one lymphoma case in Spring Valley are not included because the ages were not known and therefore could not be incorporated into the age-adjustment calculation. The corresponding rates are marked (#) on the figures. Rates calculated with fewer than 5 cases or deaths are marked (*).

Tables 5-8 and figures 3-6 show the cancer incidence and mortality data for Spring Valley, Chevy Chase and the US. The last column of each table contains a ratio of the Spring Valley rate divided by the US rate. As evident in the figures and by the ratio in the tables, both cancer incidence and mortality rates for the selected cancers of concern are consistently lower than corresponding rates in the white population and the national overall (except in the case of skin cancer incidence in 2000 – 2004 where Spring Valley rates equal the nation's).

In comparing cancer incidence rates in Spring Valley and Chevy Chase, the rates in Spring Valley are often slightly higher than those in Chevy Chase, with the exception of bladder and liver and intrahepatic bile duct in the 1994 – 1999 period and leukemia and liver and intrahepatic bile duct in the 2000-2004 period. Except for bladder cancer incidence in the earlier period, the incidence of cancers most strongly associated with arsenic exposure (bladder, kidney and renal pelvis, lung and bronchus, skin) are consistently elevated in Spring Valley as compared to Chevy Chase.

Table 5. Estimated annual average age-adjusted cancer incidence (per 100,000 population) for Spring Valley and Chevy Chase, 1994 – 1999, and US 1997 with SV/US Ratio

Cancer Incidence 1994 – 1999	**SV Avg. Rate (# cases)**	**CC Avg. Rate (# cases)**	**US '97 Whites**	**US 1997**	**SV/US Ratio**
Bladder	6.55 (10)	12.26 (20)	22.9	21.00	0.31
Kidney and Renal Pelvis	2.46 (3)	1.56 (2)	11.0	10.90	0.23
Leukemias	10.78 (15)	8.91 (12)	13.6	12.90	0.84
Liver and Intrahepatic Bile Duct	1.22 (2)	1.78 (3)	4.4	5.40	0.23
Lung and Bronchus	15.87 (24)	12.84 (21)	67.2	66.60	0.24
Lymphomas	11.76 (17)	9.69 (13)	23.9	22.70	0.52
Skin	9.46 (13)	8.48 (12)	20.7	17.60	0.54

Abbreviations: CC, Chevy Chase; SV, Spring Valley; US, United States.

Table 6. **Estimated annual average age-adjusted cancer incidence (per 100,000 population) for Spring Valley and Chevy Chase, 2000 – 2004, and US 2003 with SV/US Ratio**

Cancer Incidence 2000 - 2004	SV Avg. Rate (# cases)	CC Avg. Rate (# cases)	US '03 Whites	US 2003	SV/US Ratio
Bladder	14.22 (18)	8.50 (11)	22.9	20.80	0.68
Kidney and Renal Pelvis	9.38 (11)	4.24 (6)	13.3	13.00	0.72
Leukemias	3.51 (4)	9.01 (11)	12.4	11.80	0.30
Liver and Intrahepatic Bile Duct	0.69 (1)	3.41 (4)	4.7	5.90	0.12
Lung and Bronchus	23.37 (29)	6.51 (9)	63.6	62.70	0.37
Lymphomas	8.88 (10)	8.50 (7)	23.7	22.50	0.39
Skin	18.75 (22)	12.29 (15)	22.3	18.70	1.00

Abbreviations: CC, Chevy Chase; SV, Spring Valley; US, United States.

Figure 3. Comparison of Estimated Annual Age-Adjusted Cancer Incidence Rates for Spring Valley and Chevy Chase Census Tracts 1994-1999 and US Whites and US All Races 1997

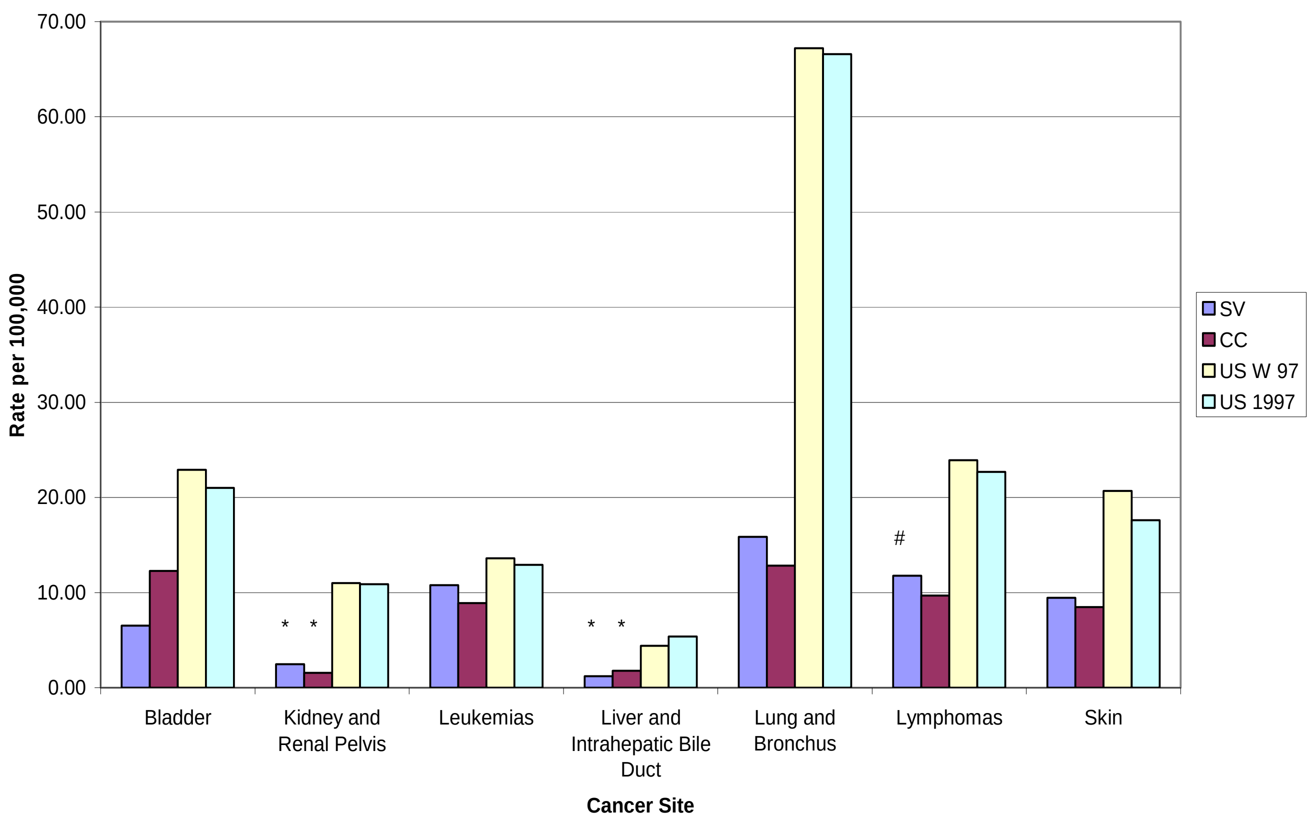
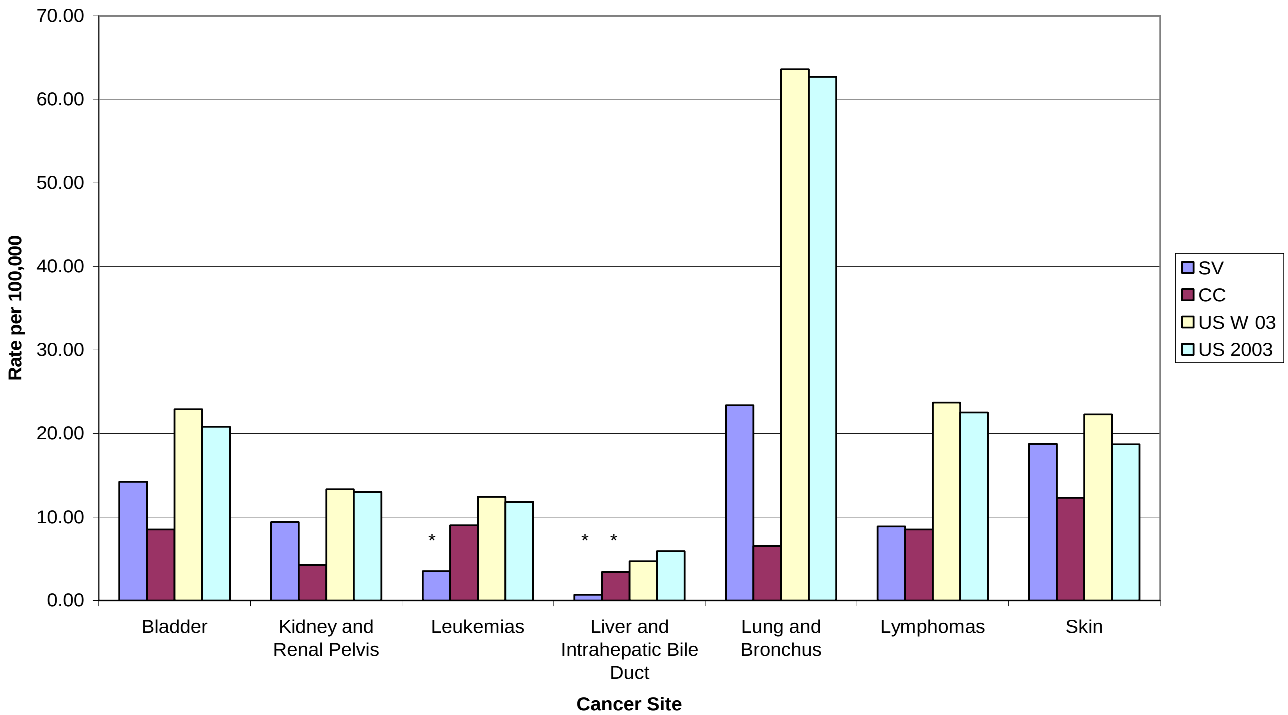


Figure 4. Comparison of Estimated Annual Age Adjusted Cancer Incidence Rates for Spring Valley and Chevy Chase Census Tracts 2000-2004 and and US Whites and US All Races 2003



NOTES: An asterisk (*) identifies a rate calculated with fewer than 5 cases. A number sign (#) indicates that one case could not be included in the calculation due to lack of age data.

For the cancer mortality data comparing Spring Valley and Chevy Chase, the data over the two time periods does not show a consistent pattern. In the 1994 – 1999 period, the cancer mortality rates in Spring Valley are lower than those of Chevy Chase. In the later period, however, bladder, kidney and renal pelvis, liver and intrahepatic bile duct, lung and bronchus, lymphoma and skin cancer mortality rates are higher in Spring Valley. Many of the mortality rates in both time periods are based on very few cases and are therefore likely to be highly variable. When compared with the US mortality rates in the white population and overall, Spring Valley is consistently lower.

Table 7. **Estimated annual average age-adjusted cancer mortality (per 100,000 population) for Spring Valley and Chevy Chase, 1994 – 1999, and US 1997 with SV/US Ratio**

Cancer Mortality 1994 - 1999	SV Avg. Rate (# cases)	CC Avg. Rate (# cases)	US ’97 Whites	US 1997	SV/US Ratio
Bladder	2.06 (3)	2.66 (4)	4.5	4.40	0.47
Kidney and Renal Pelvis	0.00 (0)	2.54 (4)	4.3	4.30	0.00
Leukemias	2.80 (4)	4.03 (6)	7.9	7.70	0.36
Liver and Intrahepatic Bile Duct	0.00 (0)	1.81 (4)	4.1	4.50	0.00
Lung and Bronchus	13.38 (20)	20.86 (32)	57.3	57.50	0.23
Lymphomas	2.95 (4)	3.63 (5)	9.7	9.40	0.31
Skin	1.41 (2)	2.02 (4)	3.1	2.70	0.52

Abbreviations: CC, Chevy Chase; SV, Spring Valley; US, United States.

Table 8. **Estimated annual average age-adjusted cancer mortality (per 100,000 population) for Spring Valley and Chevy Chase, 2000 – 2004, and US 2003 with SV/US Ratio**

Cancer Mortality 2000 - 2004	SV Avg. Rate (# cases)	CC Avg. Rate (# cases)	US ’03 Whites	US 2003	SV/US Ratio
Bladder	2.27 (3)	0.91 (2)	4.4	4.30	0.53
Kidney and Renal Pelvis	2.55 (3)	0.00 (0)	4.3	4.20	0.61
Leukemias	0.83 (1)	1.93 (2)	7.6	7.40	0.11
Liver and Intrahepatic Bile Duct	1.64 (2)	0.33 (1)	4.6	5.00	0.33
Lung and Bronchus	16.59 (21)	5.11 (8)	54.5	54.20	0.31
Lymphomas	5.45 (6)	3.79 (6)	8.1	7.80	0.70
Skin	1.44 (2)	0.00 (0)	3.0	2.70	0.53

Abbreviations: CC, Chevy Chase; SV, Spring Valley; US, United States.

Figure 5. Comparison of Estimated Annual Age Adjusted Cancer Mortality Rates for Spring Valley and Chevy Chase Census Tracts 1994-1999 and US Whites and US All Races 1997

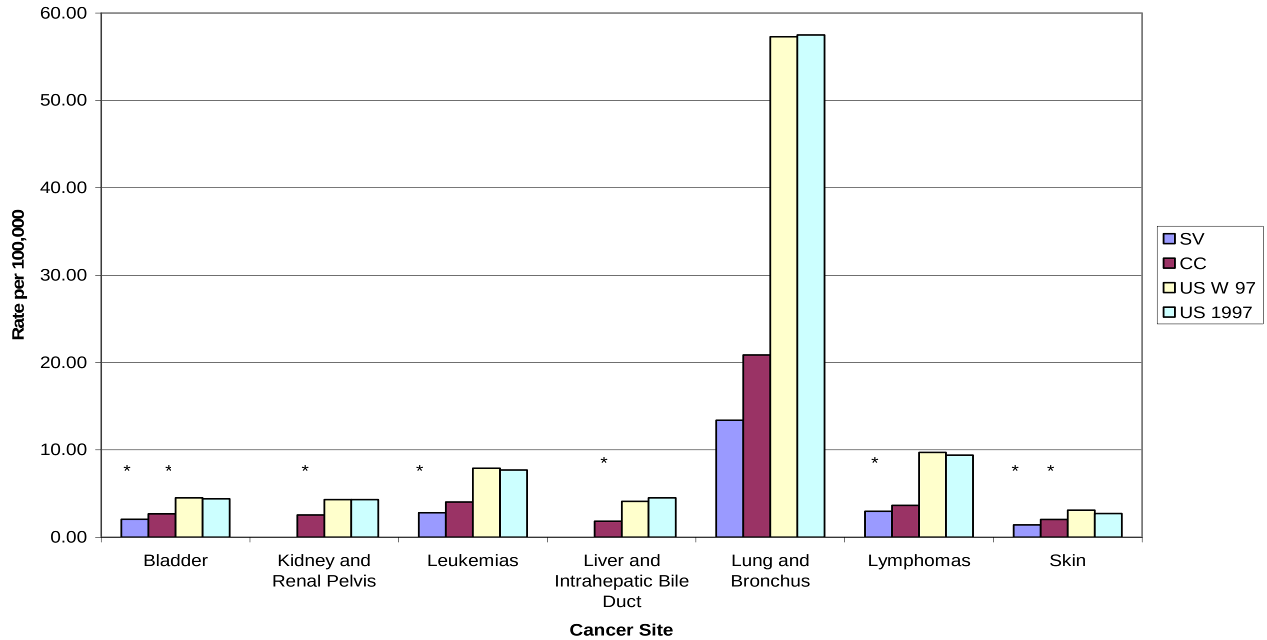
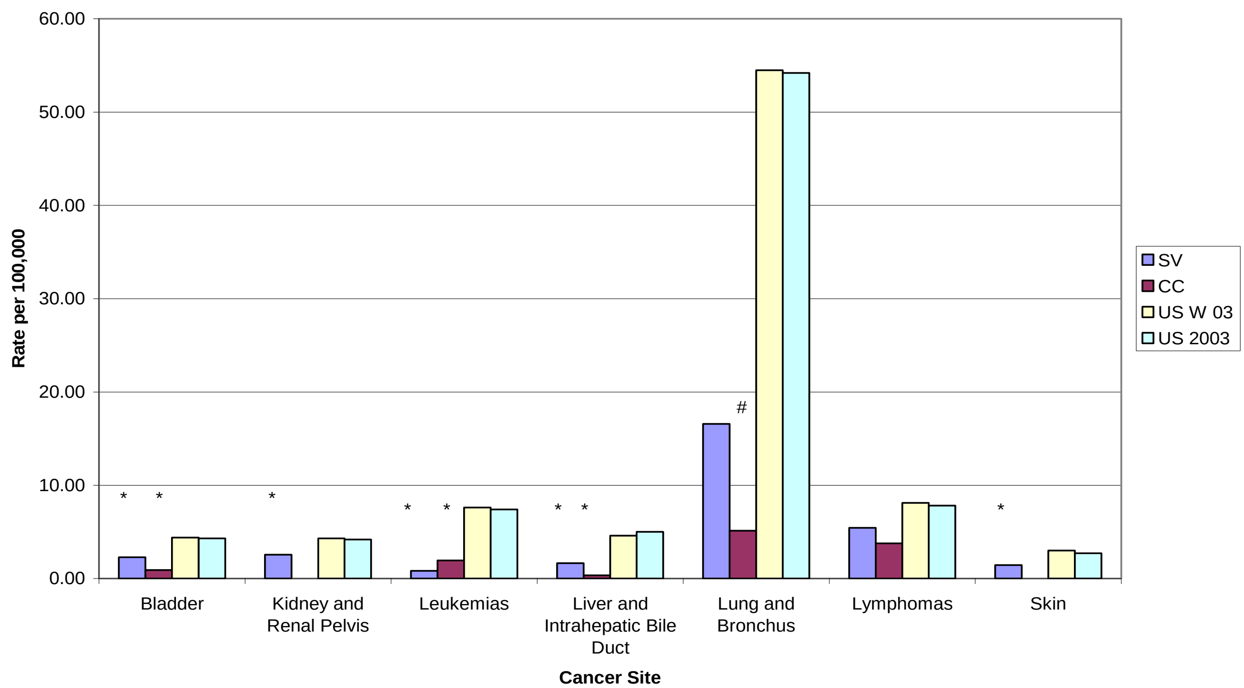


Figure 6. Comparison of Estimated Annual Age Adjusted Cancer Mortality Rates for Spring Valley and Chevy Chase Census Tracts 2000-2004 and US Whites and US All Races 2003



NOTES: An asterisk (*) identifies a rate calculated with fewer than 5 cases. A number sign (#) indicates that one case could not be included in the calculation due to lack of age data.

Findings: Community Health Assessment

- Overall, Spring Valley is a healthy community. Crude mortality rates are lower than those of the Chevy Chase comparison community and 20 to 70% lower than the US rates for 11 of the top 15 causes of death in the nation.

- Essential hypertension and related kidney disease, the 13th most common cause of death, is the only Spring Valley mortality rate that exceeded those of Chevy Chase and the US.

- Similarly, the Spring Valley age-adjusted incidence and mortality rates for selected cancers of concern (bladder, kidney and renal pelvis, leukemias, liver and intrahepatic bile duct, lung and bronchus, lymphomas, and skin) are 20 to 80% lower or, for skin cancer in recent years (2000-2004) the same as rates for the US overall.

- The comparison of Spring Valley cancer incidence data to Chevy Chase for both time periods shows a pattern of slightly higher rates for cancers known to be associated with arsenic exposure, kidney and renal pelvis, lung and bronchus, skin, and bladder (2000-2004 period only). This pattern is also found in the mortality data comparison for the 2000 – 2004 period. This finding should be interpreted with caution since the numbers of cases and deaths are low and rates calculated are likely to be highly variable. (When the number of events [cases or deaths] is low a single event will cause a large change in the rate, leading to variability in the rate over time.)

Site-Specific Analysis: Review of Anecdotal Community Surveys and Identification of Potential Hazards

Community Surveys

Three non-scientific surveys of diseases observed in Spring Valley were obtained. These three surveys were conducted informally and targeted specific locations within Spring Valley with known health concerns. There was considerable overlapping information in the three surveys, but taken together, they comprised approximately 200 reports of disease. In some cases, multiple conditions were recorded for individuals. In other instances, a condition experienced by multiple people was reported once (e.g., rugby players' skin rashes). Numerous reports did not specify the health problem or illness. The rank ordering by frequency presented below is approximate due to the nature of the reporting.

The informal disease reports have been categorized in Table 9 to identify major concerns, presented in approximate rank order of highest to lowest frequency. More than half of the reported illnesses are cancers. Specific cancers reported more than 10 times are brain, breast, and leukemia or lymphoma. Other relatively frequently reported conditions include a variety of conditions affecting the central nervous system, brain function or mood (Alzheimer's, Parkinson's, dyslexia, memory problems, learning disability, and depression), blood disorders (anemia, aplastic anemia or unspecified blood disorder), and cardio- or cerebro-vascular diseases (heart disease and stroke).

Table 9. Compilation of anecdotal reports of disease rank ordered by frequency

Disease or Condition	Number of Reports
Cancer or tumor	100
Central Nervous System/Brain or Mood Disorder	17
Blood Disorder	14
Cardio- or Cerebro-vascular	13
Skin Condition or Rash	9
Peripheral neuropathy	7
Gastro-intestinal	6
Respiratory	4
Substance abuse	3
Hypothyroidism	3
Carbon monoxide poisoning	2
Weight loss, failure to gain weight	2
Immune or Auto-immune	2
Juvenile arthritis	1
Chronic infections	1
Miscarriage	1
Hydrocephalus	1

Long-term effects of chemical weapons and other site-related chemicals

In Veterans at Risk, the Institute of Medicine reviewed research literature and categorized the chronic health conditions associated with exposure to mustard agents and Lewisite according to the strength of scientific evidence (IOM, 1993). Although the health conditions were chronic in nature, the exposures may have been acute (of short duration). Causal relationships were indicated between exposure to mustard agents and respiratory and skin cancers, other respiratory and skin conditions, leukemia, several eye conditions, bone marrow depression and subsequent immunosuppression; psychological disorders and sexual dysfunction (resulting from scarring of skin). Causal relationships were *suggested* between exposure to mustard agents and acute nonlymphocytic leukemia and reproductive dysfunction due to genetic damage to germ cells. The research reviewed indicated a causal link between Lewisite exposure and chronic respiratory diseases.

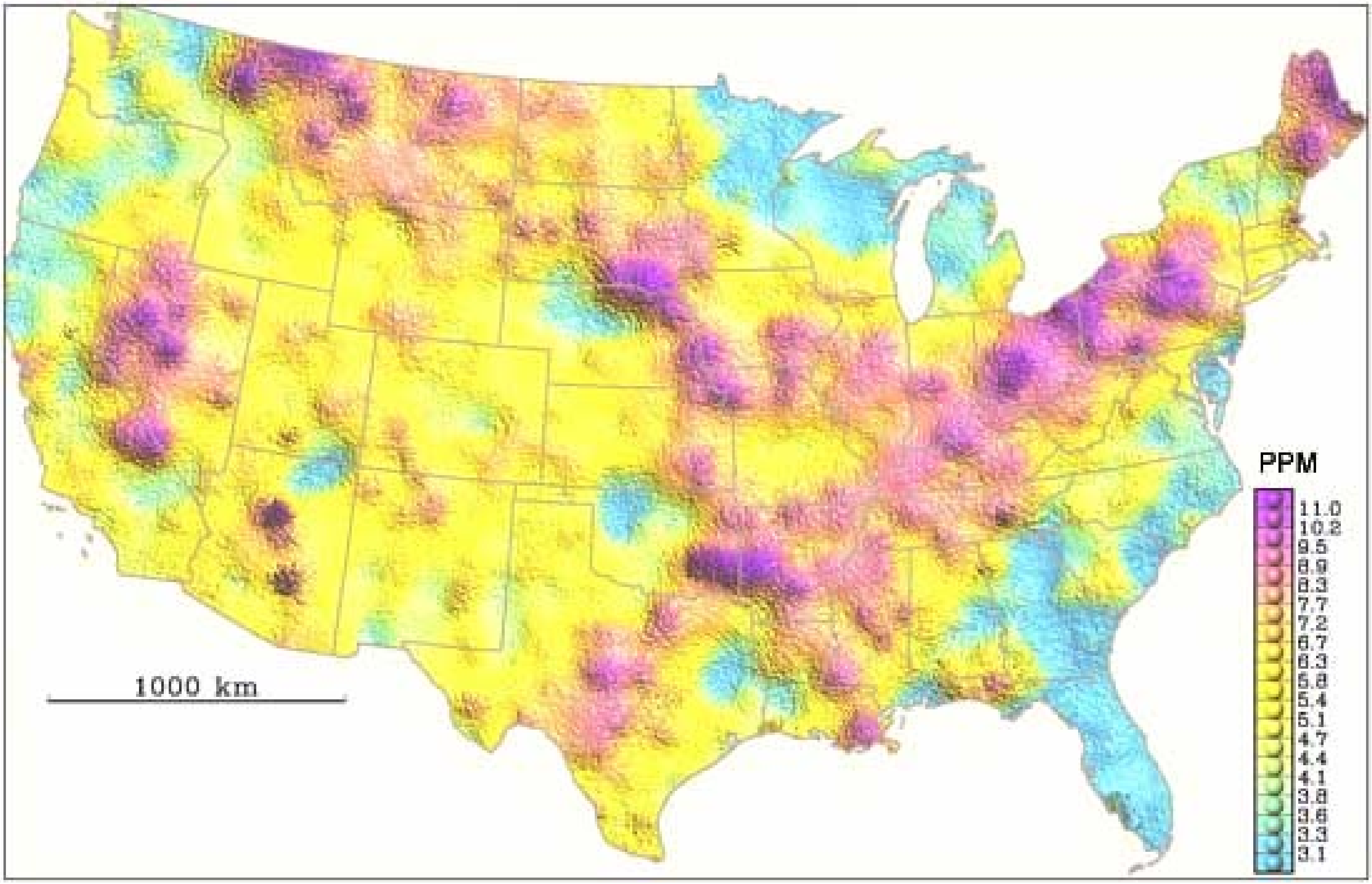
More recent reports and reviews are mostly consistent with the findings of Veterans at Risk (Ghanei et al. 2004; Balali-Mood et al. 2005; Sidell et al. 1997; Somani and Romano 2001). For example, occupational cohorts exposed to sulfur mustard experience increased respiratory diseases including cancer and respiratory mortality. However, the suggested links to reproductive effects at low sulfur mustard exposures are questioned (Ghanei et al. 2004; Balali-Mood et al. 2005). There remains a lack of information on long-term effects of most of the AUES-related chemical weapons.

Arsenic is a contaminant of concern in Spring Valley because it was used in high amounts, and is an environmentally persistent component of the chemicals weapons developed, tested, and disposed at AUES. Arsenic also occurs naturally in soil and rock and is present throughout the environment. The concentration of arsenic in the environment can vary widely due to natural conditions and human activities. As illustrated in Map 2, arsenic levels in soils in the United States vary with an average level of 3-4 ppm (Gustavsson et al. 2001; Shacklette and Boerngen 1984). Arsenic combines with other elements into two forms: inorganic (contains no carbon) or organic (contains both carbon and hydrogen). Inorganic forms of arsenic are generally more toxic than organic forms (EPA 1998; ATSDR 2005a).

Health effects from arsenic exposure can differ widely depending on the age, health, and nutritional status of person exposed; dose; duration and route (e.g., dermal, ingestion, inhalation) of exposure; and genetic susceptibility. Inorganic arsenic has been determined to be a human carcinogen; long-term exposure via ingestion can increase the risk of skin cancer and cancer in the lungs, bladder, liver, kidney and prostate (ATSDR 2005a). Intermediate to long term (months to years) exposure via ingestion is also associated with numerous non-cancer health effects in humans such as vascular changes, keratosis, and diabetes mellitus (ATSDR 2005a).

Other chemicals that were sampled in subsurface soil (and for which data were provided to Hopkins investigators) are listed in Table 10, along with information on environmental source (naturally occurring or thought or known to be AUES-related) and health effects observed in human or animal studies. The health effects information was compiled from the EPA's Integrated Risk Information System (IRIS), the Hazardous Substances Databank at the National Library of Medicine, and ATSDR's Toxicological Profiles. These chemicals include some naturally occurring constituents of soil, as well as environmentally persistent AUES-related chemicals. Some of the chemicals were sampled to determine the normal or background soil concentrations for the area. Potential health risks from exposure to chemicals detected in soil samples are evaluated in the risk assessment.

Map 2. Distribution of arsenic levels in soil in continental US[1]



[1] Map sources: Shacklette and Boerngen 1984.

Table 10. Health Effect Information for Chemicals Sampled in Spring Valley Soil

Sampled Chemicals	Environmental Source(s)	Health Effects (Animal [A] or Human [H] data)	Route of Exposure
Aluminum	Naturally occurring	Neurological (A, H)	Oral
Antimony	Naturally occurring	Decreased longevity, changes in blood glucose and cholesterol (A)	Oral
Arsenic	Used at AUES	Skin, Vascular, Diabetes, Cancer (H)	Oral
Barium	Naturally occurring	Kidney (A)	Oral
Beryllium	Naturally occurring	Gastrointestinal (A), Cancer	Oral
Cadmium	Naturally occurring	Kidney, Cancer (H)	Oral
Chromium	Naturally occurring	Cr III: No effects observed (A), Cr VI: Respiratory, Cancer (A, H)	Oral
Cobalt	Naturally occurring	Blood (A, H), Cancer	Oral (sub-chronic)
Copper	Naturally occurring	Gastrointestinal, Liver, Blood, Body Weight (A, H)	Oral (sub-chronic)
CVAA_CVAO	Degradation of Lewisite	Cancer (See arsenic above)	Oral
Cyanide	Naturally occurring	Decreased body weight, Endocrine, Myelin degeneration (nervous system) (A)	Oral
Dinitrotoluene 2,4	Degradation of trinitrotoluene	Neurological (A)	Oral
Dinitrotoluene 2,6	Degradation of trinitrotoluene	Cancer (A) (associated with exposure to mix of Dinitrotoluene 2,4 & 2,6)	Oral
Dithiane14	Degradation of Sulfur Mustard	Respiratory (nasal lesions) (A)	Oral
Lead[a]	Naturally occurring, Ordnance material	Neurological (H)	Oral, Inhalation
Lewisite	Made/tested at AUES	NA	NA
Manganese	Naturally occurring	Neurological (H)	Oral
Mercury	Naturally occurring, Combustion processes, Used at AUES	Neurological (H)	Inhalation
Nickel	Naturally occurring	Decreased body, organ weight (A), Cancer	Oral
Nitrobenzene	Component of explosives	Blood, Kidney, Liver, Adrenal (A)	Oral
Nitroglycerine	Exposive	Methemoglobinemia (A, H), Cancer	Oral
Oxathiane14	Degradation of Sulfur Mustard	NA	NA
Selenium	Naturally occurring	Liver, Loss of hair and nails (H)	Oral
Silver	Naturally occurring	Skin (color change) (H)	Intravenous
Strontium (permanganate salt)	Used at AUES	Skeletal/Bone (A)	Oral
Sulfur Mustard	Made/tested at AUES	Cancer, Skin, Eye, Neurological, Respiratory, Possible Leukemia (H) (NRC 1993)	Inhalation, dermal
Tetryl	Explosive	Skin and eye irritant (A, H), Liver disease and cancer (A)	Oral
Thallium compounds	Naturally occurring	Alopecia, Changes in blood chemistry (A)	Oral
Thiodiglycol	Degradation of Sulfur Mustard	Kidney weight, Body weight (A)	Oral
Tin	Naturally occurring	Blood (A)	Oral
Titanium	Naturally occurring	Titanium is of low toxicity.	NA
Trinitrotoluene246	Explosive	Liver (A)	Oral
Vanadium	Naturally occurring	Decreased hair cysteine (A)	Oral
Zinc	Naturally occurring	Blood, Enzyme activity (H)	Oral

Abbreviations: A, animal; H, human, NA, not available.

[a] Lead is not included in the risk assessment because the health-based references for lead correspond to blood lead levels that are not available in the scoping study exposure dataset.

The health effects associated with exposure to these chemicals include: cancer (11 chemicals); blood (8 chemicals); neurological (7 chemicals); liver (5 chemicals); kidney (4 chemicals); skin (4 chemicals); changes in body or organ weight (3 chemicals); gastrointestinal (2 chemicals); and bone/skeletal (1 chemical). These health effects correspond to some of the more frequently reported health problems in the community surveys, e.g., cancers, blood disorders, neurological and skin conditions. The risk assessment presented below evaluates only the chemicals from this list that were detected in Spring Valley soils. The risk assessment includes an exploratory evaluation of cumulative risks related to potential exposure to mixtures of the detected chemicals that share a common type of toxicity (defined as affecting the same target organ or body system).

Findings: Review of Anecdotal Community Surveys and Identification of Potential Hazards

- There remains a lack of information on long-term effects of most of the AUES-related chemical weapons.

- The toxicological and epidemiological literature on the health effects of chemicals sampled in soils in Spring Valley are consistent with some of the more frequently reported health problems in the anecdotal community surveys, such as cancers, blood disorders, neurological and skin conditions.

Site-Specific Analysis: Statistical Analysis of Exposure and Health

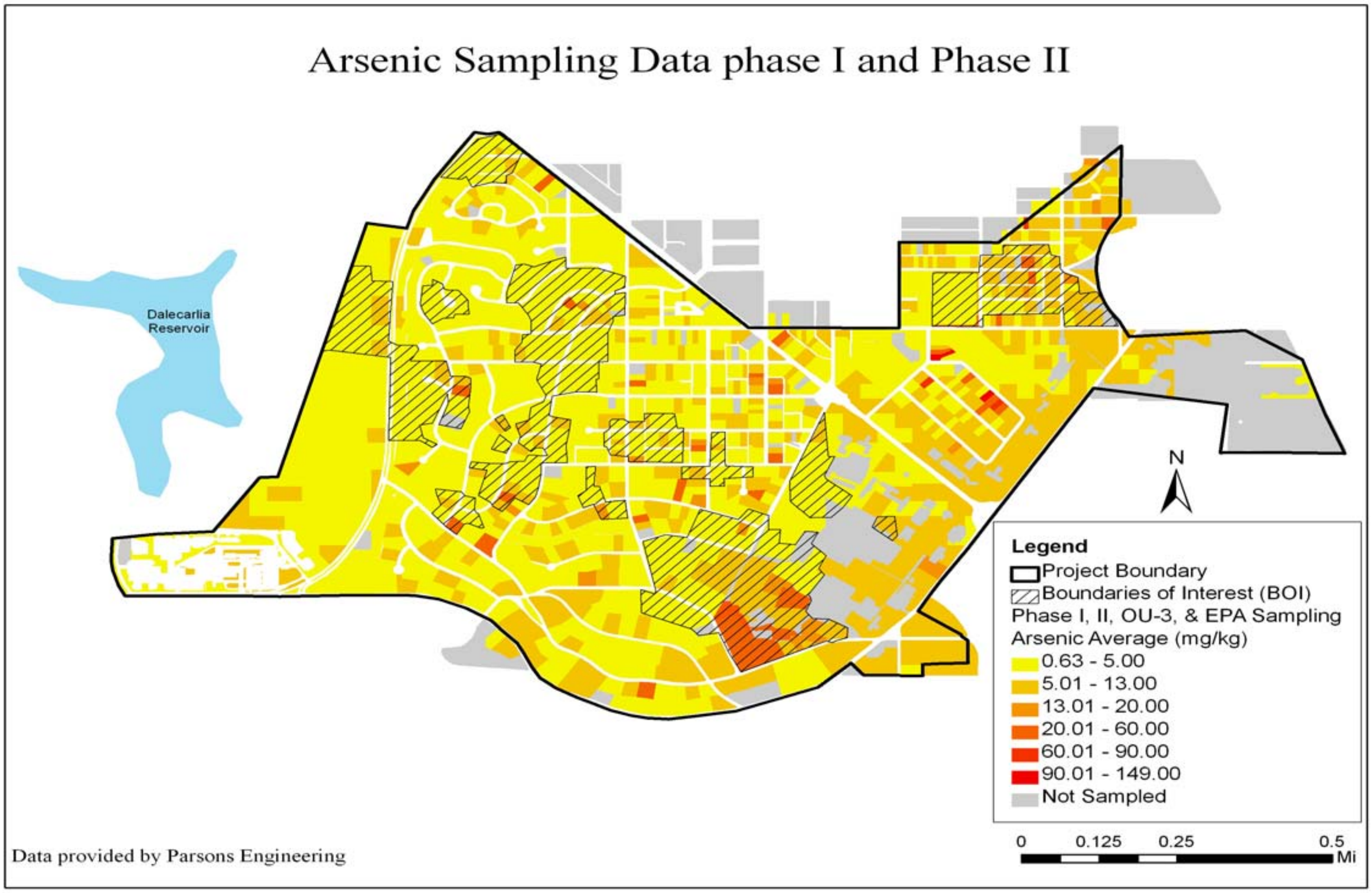
JHSPH investigators characterized potential risks to the Spring Valley community and identified key information gaps including a statistical analysis of the spatial relationships between potential environmental exposures and health outcomes. The Spring Valley database was used to support the following three statistical analyses: mapping arsenic exposure, associating arsenic exposure to identified areas of geographic concern, and associating identified geographic areas of concern to available health outcomes. The latter two analyses provide an exploratory link between arsenic and health.

<u>Mapping Arsenic Exposure</u>

The main arsenic sampling was conducted in two phases by the USACE. There were 1554 properties with monitored arsenic in Phase 1, 200 of which were selected for follow up Phase II monitoring (if the Phase I result exceeded 13 mg/kg it was included in Phase II). Map A4 displays the Phase I properties and averaged results and Map A5 displays the Phase II properties and averaged results (see Appendix A). Although the mean arsenic level from Phase II samples (14.08 mg/kg) was significantly greater than the mean arsenic level for Phase I samples (5.5 mg/kg) (p-value < 0.01), there was no significant difference for the subset of 200 matched properties that were monitored both in Phase I and Phase II (p-value$=0.31$). Note the matched analysis is further adjusted for spatial dependence.

Therefore, properties that were designated for more intensive follow up (Phase II monitoring) did not reveal levels of arsenic on average any greater than those found in their respective Phase I monitoring. All arsenic samples from each property were then averaged to generate a property-level arsenic concentration. This property-level dataset was used to develop an exposure map (Map 3).

Map 3. Arsenic sampling results combined.



Associating Arsenic Exposure to Identified Geographic Areas of Concern

Spatial trends in the arsenic levels (Map 3) were explored with respect to the following:

- Points of Interest (POIs);
- Areas of Interest (AOIs); and
- Boundaries of Interest (BOIs).

The POIs and AOIs are areas of concern, identified by the USACE and other agency partners, using historical documentation-reports, maps, photos, and geophysical surveys. The BOIs were created by the Hopkins investigators to encompass both defined AOIs and the POIs in an effort to geographically reconcile these areas of concern. The AOIs, POIs, and BOIs are displayed in Map 4.

Specifically, investigators tested if the mean arsenic levels within these interest areas were different than the mean levels observed in the outside surrounding area. Table 11 summarizes these results indicating the levels of arsenic on average were significantly greater inside these areas of concern, as compared to outside, and this finding was consistent across the different identified geographic areas (POIs, AOIs, and BOIs). For any given area of concern, the discrepancy between the calculated mean and median arsenic levels is a clear indication of the positive skewness for the underlying data distributions. Non parametric statistical tests (for testing differences in medians) and tests based on log transformed data were also performed, the results of which were all consistent with those presented in Table 11.

Map 4. Areas-, Points-, and Boundaries-of-Interest.

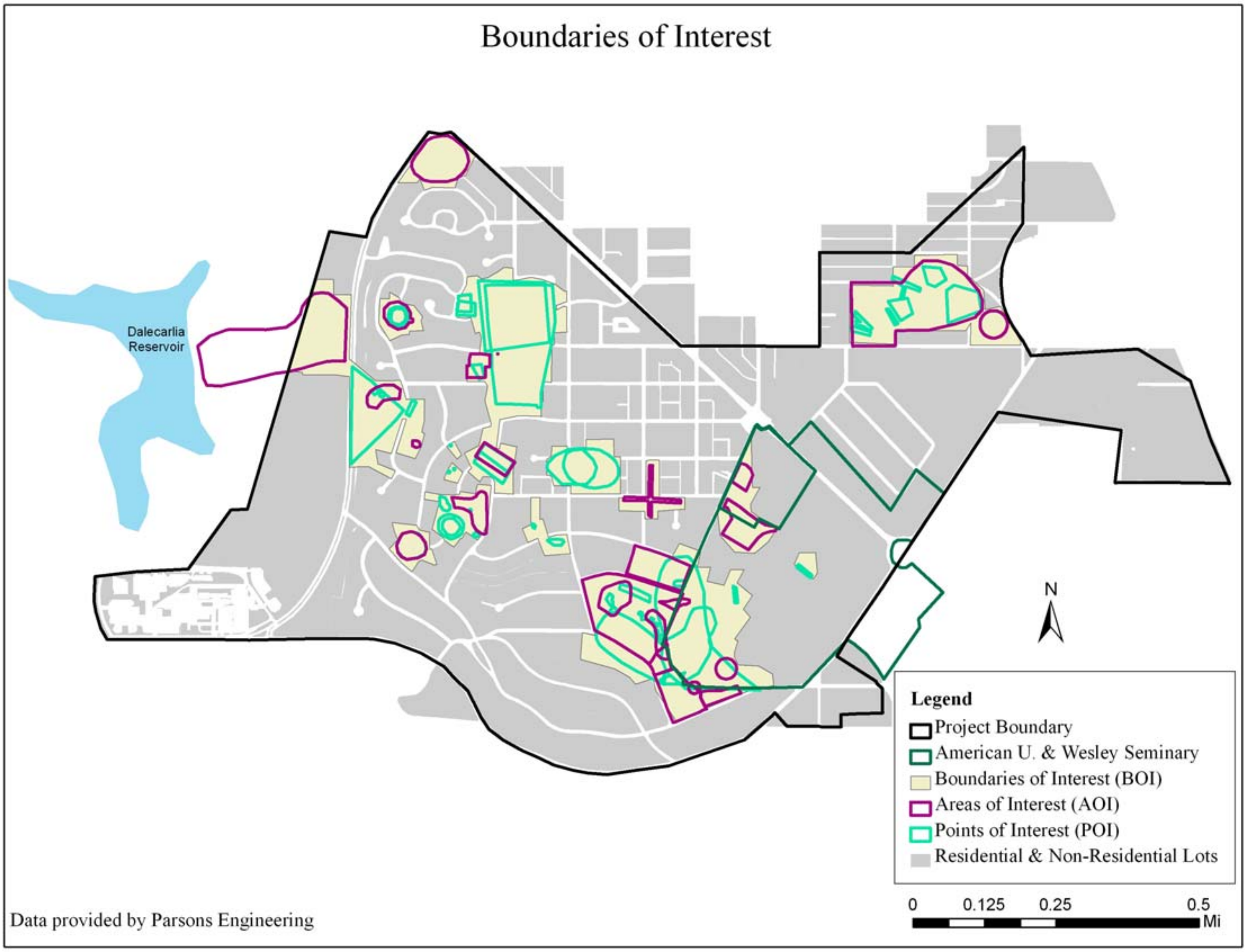


Table 11. Summary statistics including number of arsenic samples (N), minimum (Min), maximum (max), median (Median), and mean (Mean) stratified by area of concern type (POI, AOI, BOI) and location indicator (Within the area of concern, outside in the surrounding area). Also included are the p-values (P-value) for testing whether the mean arsenic level within the areas of concern are significantly greater than the levels observed in the outside surrounding area for Spring Valley. Arsenic is measured in parts per million.

		N	Min	Max	Median	Mean	P-value*
POI	Within	5810	0.29	1040.00	4.60	11.13	< 0.01
	Outside	12,134	0.31	613.00	4.11	9.16	
AOI	Within	3729	0.35	1040.00	4.80	12.04	< 0.01
	Outside	14,215	0.29	613.00	4.20	9.21	
BOI	Within	7121	0.29	1040.00	4.55	10.84	< 0.01
	Outside	10,823	0.31	613.00	4.10	9.12	

* p values represent the probability of obtaining results as or more extreme than those observed, given that there is no difference in the areas of interest and the areas outside of the areas of interest.

Associating Identified Geographic Areas of Concern to Health Outcomes

The analysis here focuses on the geographic location of Spring Valley health outcomes and considers both confirmed cases in the DC Cancer Registry and the anecdotal health reports. The approach taken is an informed cluster analysis, assessing whether health outcomes are clustering within close proximity to the identified geographic areas of concern. This is in contrast to a general geographic cluster analysis of health outcomes, the results of which would not provide any immediate evidence of a potential link to arsenic exposure. BOIs are the only identified area of concern considered since they represent a geographic reconciled version of the other defined areas and likely provide a more public health conservative approach for the analysis compared to using either POIs or AOIs.

The method applied is described as follows. Investigators considered all reported cancer outcomes (all cancers and specific cancers), mapped their locations to Spring Valley properties, overlaid the map of geographic areas of interest (BOI), and then counted the number of reported health outcomes that were within a certain distance of BOIs. With knowledge that there are a total of 1,577 properties in Spring Valley where a possible health outcome could occur, (all residential properties and some properties on the American University campus) and that there are a total of 338 properties located within a BOI, (710 within 100 feet [ft] of a BOI, 903 within 200 ft of a BOI, 1013 within 300 ft of a BOI) complete cross tabulations of properties that experienced a health outcome (Yes, No) by properties within a BOI (Yes, No) can be generated. Shown in Table 12 are the 25 reported anecdotal reports of arsenic related cancers, 9 of which were located within a BOI and the 90 reported DC Registry arsenic related cancers, 13 of which were located within a BOI. Arsenic related cancers include bladder, kidney and renal pelvis, liver and intrahepatic bile duct, lung and bronchus, skin, leukemia, and lymphoma. Map A6 displays the distances around each BOI (see Appendix A).

Table 12. 2 x 2 contingency tables for the 1,577 Spring Valley properties having a reported Arsenic related cancer (Yes, No) cross classified by the property's location within a BOI (Yes, NO) for data from both the anecdotal health reports and the DC cancer registry. There were 25 arsenic related cancers in the anecdotal health reports and 90 reported in the DC cancer registry.

Anecdotal Health Reports

		BOI Yes	BOI No	
Arsenic	Yes	9	16	25
Cancer	No	329	1223	1552
		338	1239	1577

DC Cancer Registry

		BOI Yes	BOI No	
Arsenic	Yes	13	77	90
Cancer	No	325	1162	1487
		338	1239	1577

Table 13 provides the odds ratios for associations considering proximity to BOIs for both the anecdotal and DC registry based arsenic-related cancers, as well as for all anecdotally reported cancers, and all anecdotally reported health problems. The odds ratio, a common tool used in epidemiological students, measures how likely it is that the location of the health outcome report (or registry record) will fall within a BOI or within a certain distance of the BOI. The confidence interval (determined based on the two-sided Fisher's Exact Test) shows the range of statistically plausible values for the odds ratio. If the confidence interval for the odds ratio includes 1.0 (equally likely), the odds ratio is not statistically significant. Confidence intervals that are strictly greater than 1.0 (meaning their lower limit is greater than 1.0) supports the assertion of a significant association between locations of the health outcome report (or registry record) and proximity to a BOI.

The odds ratio for reported arsenic cancers (and 95% confidence intervals) from the anecdotal health reports is 2.09 (0.81, 5.1). That means that it is about twice as likely for an anecdotally reported cancer to fall within a BOI than outside a BOI. This association is not statistically significant. For registry-reported cancers the odds ratio is 0.60 (0.30, 1.11). Registry-reported cancers are not likely to fall within a BOI. This association and others explored to detect any clustering based on arsenic related cancers recorded by the registry did not reveal any statistically significant associations.

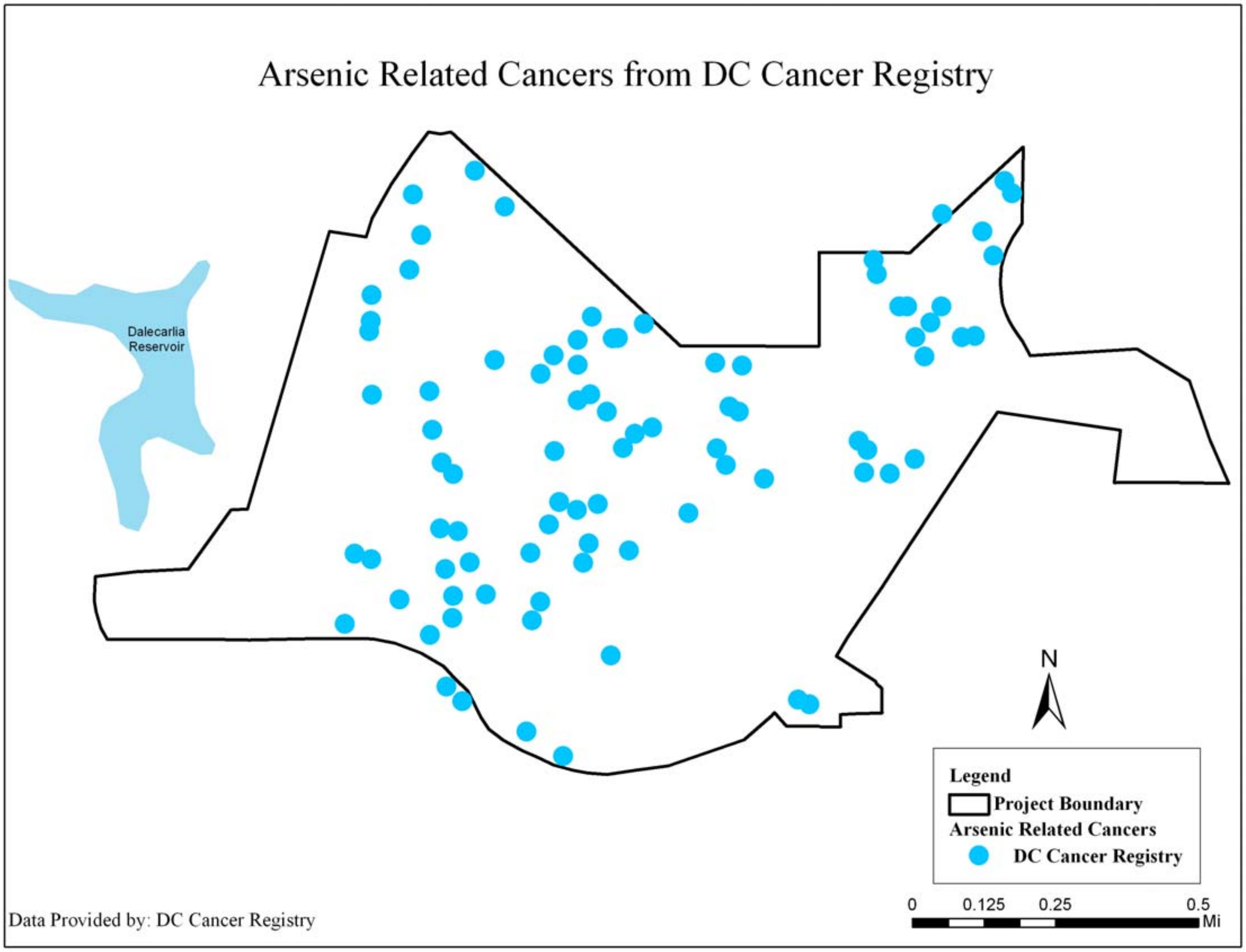
Table 13. Odds ratios (and 95% confidence intervals) for reported health outcomes, from both the anecdotal health reports and the DC Cancer Registry and their association with proximity to the BOIs. Also shown are different stratifications for available anecdotal information.

BOI Proximity	**Arsenic Related Cancers**	
	Anecdotal (N=25)	**DC Registry** (N=90)
Within a BOI	2.09 (0.81, 5.1)	0.60 (0.30, 1.11)
Within 100ft of a BOI	6.95 (2.20, 26.45)	0.96 (0.62, 1.53)
Within 200ft of a BOI	8.66 (2.13, 75.94)	0.92 (0.58, 1.44)
Within 300ft of a BOI	6.52 (1.60, 57.21)	1.18 (0.74, 1.93)
All Anecdotal Reported Cancers (N=91)	**All Anecdotal Cancers**	
Within a BOI	2.56 (1.60, 4.06)	
Within 100ft of a BOI	4.70 (2.79, 8.24)	
Within 200ft of a BOI	3.98 (2.24, 7.53)	
Within 300ft of a BOI	5.14 (3.10, 9.03)	
All Anecdotal Reported Events (N=165)	**All Anecdotal Events**	
Within a BOI	4.20 (2.97, 5.95)	
Within 100ft of a BOI	6.84 (4.48, 10.75)	
Within 200ft of a BOI	6.98 (4.21, 12.24)	
Within 300ft of a BOI	2.97 (1.67, 5.62)	

There is consistent evidence that the anecdotal health reports cluster within and around the BOIs. This is expected based on knowledge that sampling design used to collect the data was influenced by the known locations of the POIs and AOIs. Fortunately, this bias is not included with the registry-based data and the registry-confirmed cancers show no evidence of clustering around BOIs (see Map 5).

Map 5. **Distribution of registry-confirmed cancer cases and deaths in Spring Valley, 1994-2004[a]**

[a] Cancers mapped are bladder, kidney and renal pelvis, leukemias, liver and intrahepatic bile duct, lung and bronchus, lymphomas, and skin.



Spatial Analysis Key Findings

- No statistical difference between the Phase I and Phase II property arsenic levels.
- Arsenic levels are higher within the areas of concern than outside of them.
- Anecdotal health reports are more likely to be within areas of concern, but this is to be expected giving the sampling design.
- Arsenic related cancers cases from the DC Cancer registry were not found to be more likely in the areas of concern.

Profile of Arsenic Exposure from All Sources

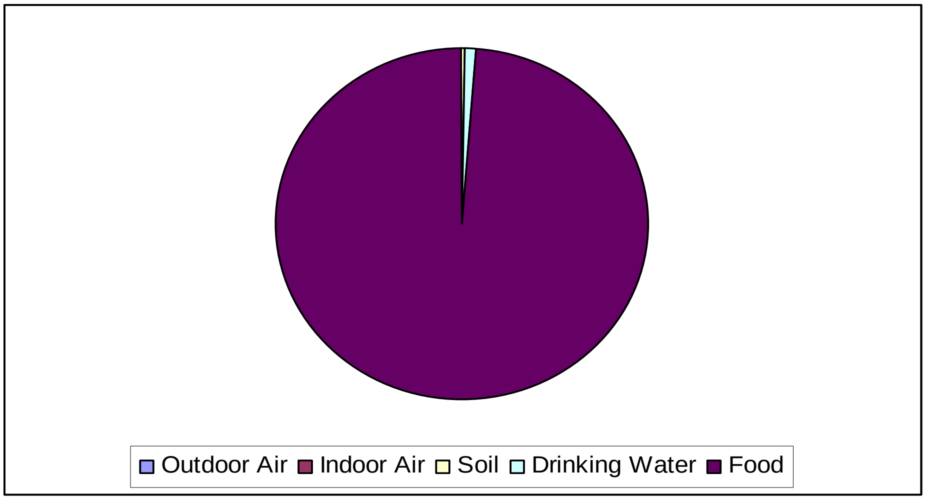
To help characterize and provide context for the risk estimates for Spring Valley exposures to arsenic in soil, we developed a profile of <u>inorganic</u> arsenic exposure from several sources including indoor and outdoor air, and ingestion of drinking water, soil and food. The relative contribution (percent of the total exposure) of each source is calculated. Exposure profiles are presented for an adult and child resident, for both average and high-end background exposures as well as exposures at the 20 ppm remediation endpoint. Data were selected to represent background exposures to Spring Valley residents to the extent possible.

The data used for the arsenic exposure profile includes the Washington, DC-area background soil (4 ppm for average exposures, 7 ppm for high-end levels) and the 20 ppm soil arsenic remediation endpoint, drinking water data for 2001 – 2005 from Dalecarlia and McMillan Reservoirs (Washington Aqueduct in December, 2006), EPA National Air Toxics Assessment (EPA, 1999), and food data from Tao and Bolger (1999). Tao and Bolger (1999) estimated daily intake of inorganic and organic arsenic by combining data on arsenic levels in food taken from the Food and Drug Administration (FDA) Total Dietary Study (1991-1997) with data on food intake rates from the USDA Nationwide Food Consumption Survey (1987-1988). Exposures were estimated in a manner consistent with the risk assessment presented above. Further details of the data and approach are available upon request.

<u>Background Soil Exposures</u>

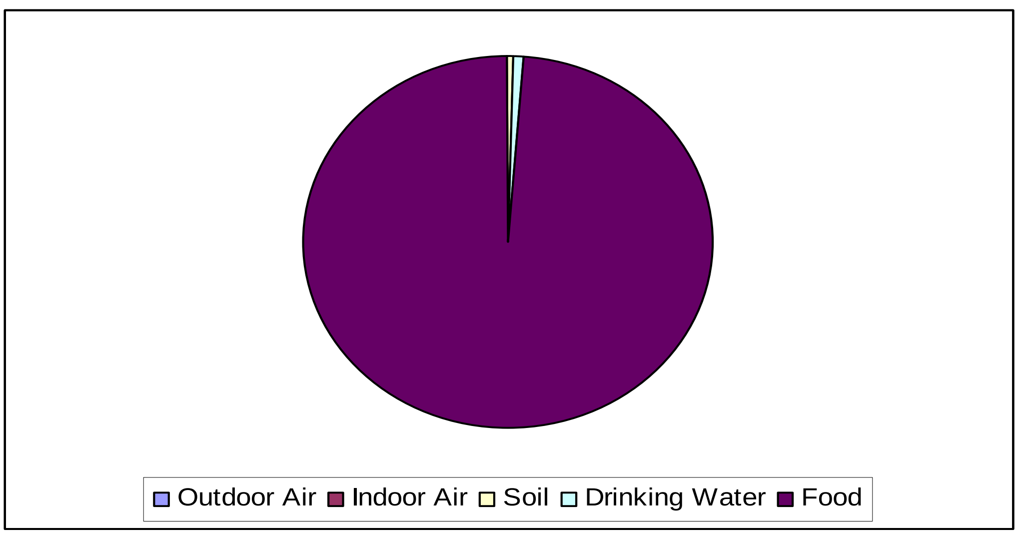
For both adults and children at average and high background soil exposures, food represents the largest source of <u>inorganic</u> arsenic exposure, contributing 95% or more of the total exposure (see Figures 7 – 10). Except for the child at high-end, drinking water represents the second largest source of exposure. For the child at high-end, soil is the second largest contributor at about 3% of the total arsenic exposure. The contribution of inhaled indoor and outdoor air to arsenic exposure is negligible for both adult and child average and high-end scenarios.

Figure 7. Source Contributions to Arsenic Exposure (Adult Average, Soil Background 4 ppm)



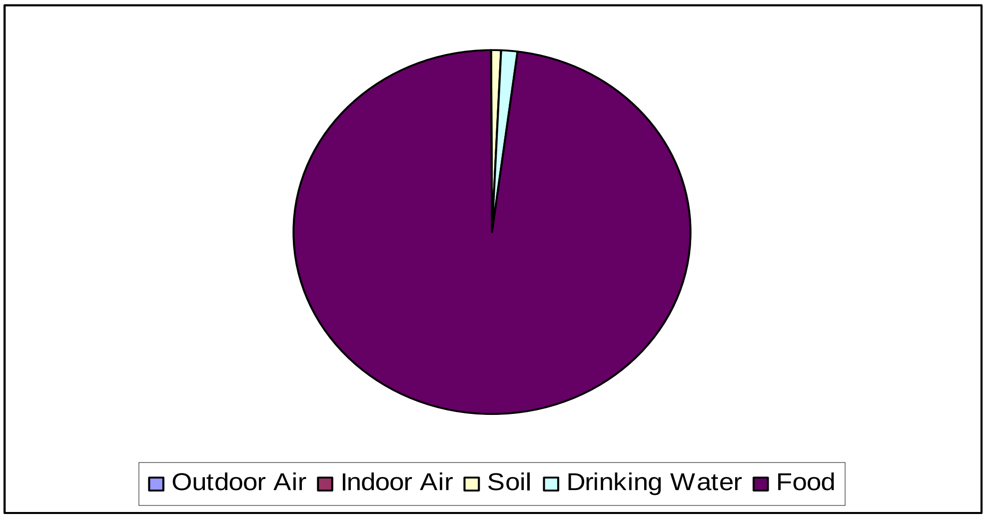
Outdoor Air	0.00018%
Indoor Air	0.00126%
Soil	0.24506%
Drinking Water	1.14312%
Food	98.61038%

Figure 8. Source Contributions to Arsenic Exposure (Adult High-end, Soil Background 7 ppm)



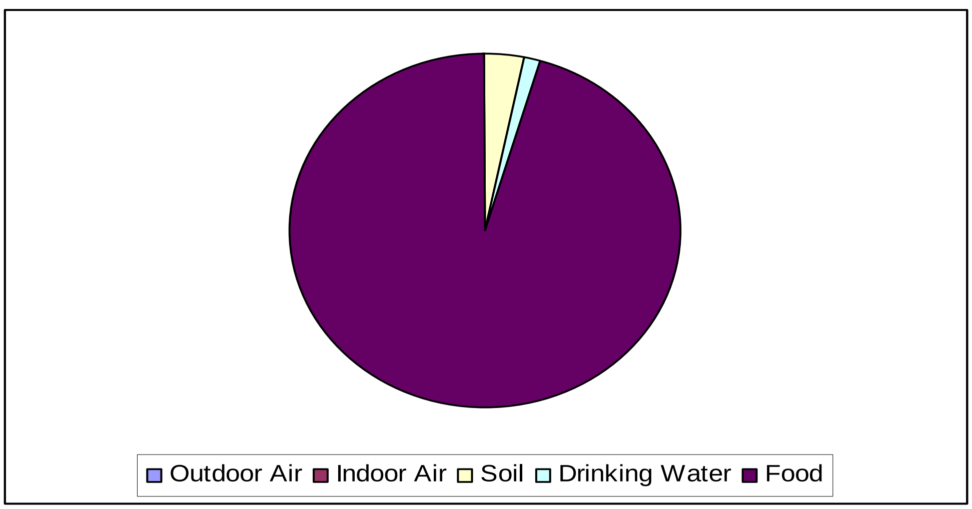
Outdoor Air	0.00011%
Indoor Air	0.00760%
Soil	0.42079%
Drinking Water	1.07140%
Food	98.50010%

Figure 9. Source Contributions to Arsenic Exposure (Child Average, Soil Background 4 ppm)



Outdoor Air	0.00073%
Indoor Air	0.00198%
Soil	0.95806%
Drinking Water	1.39103%
Food	97.64821%

Figure 10. Source Contributions to Arsenic Exposure (Child High-end, Soil Background 7 ppm)

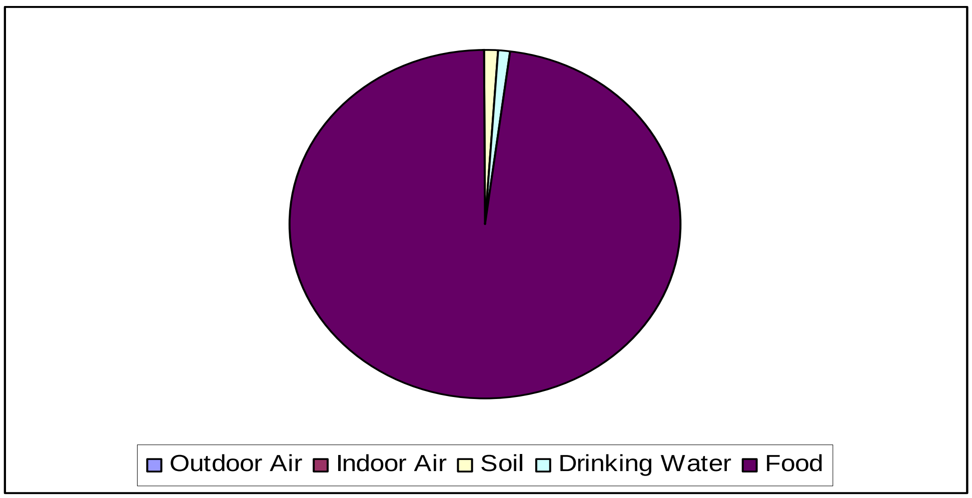


Outdoor Air	0.00043%
Indoor Air	0.01159%
Soil	3.22184%
Drinking Water	1.53950%
Food	95.22665%

Soil Remediation Endpoint Exposures

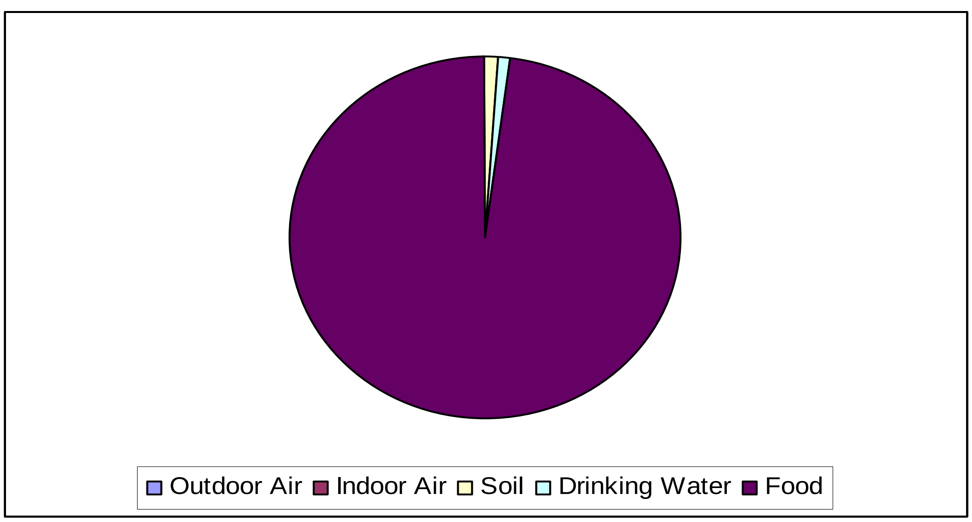
For both adults and children at average and high exposures at the soil remediation endpoint, food represents the largest source of inorganic arsenic exposure contributing ~90% or more of the total exposure (see Figures 11 – 14). In this set of exposure estimates (soil arsenic at the remediation endpoint), soil is the second largest contributor to inorganic arsenic exposure at ~1.2% for adults and ~5 – 9% for children. The contribution of inhaled indoor and outdoor air remains negligible for all populations and scenarios.

Figure 11. Source Contributions to Arsenic Exposure (Adult Average, Soil Remediation Endpoint 20 ppm)



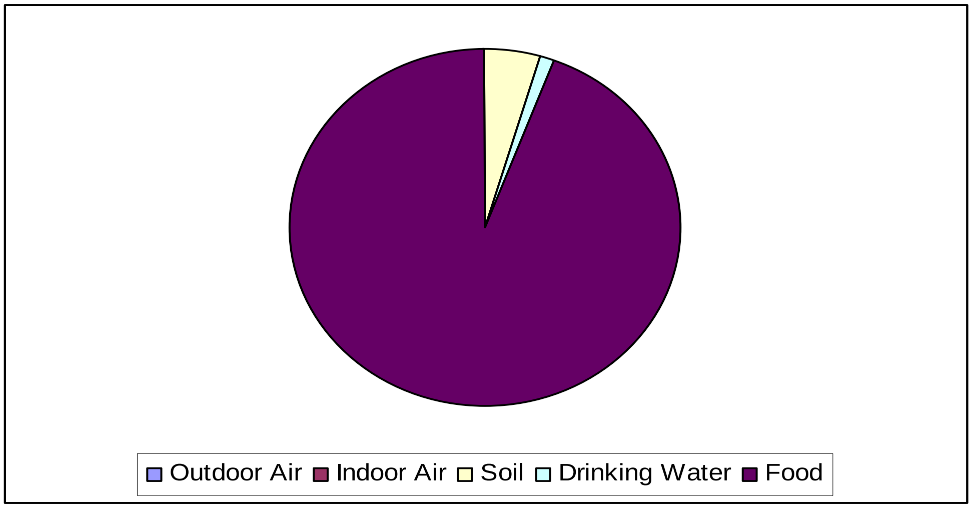
Outdoor Air	0.00017%
Indoor Air	0.00125%
Soil	1.21434%
Drinking Water	1.13201%
Food	97.65222%

Figure 12. Source Contributions to Arsenic Exposure (Adult High-end, Soil Remediation Endpoint 20 ppm)



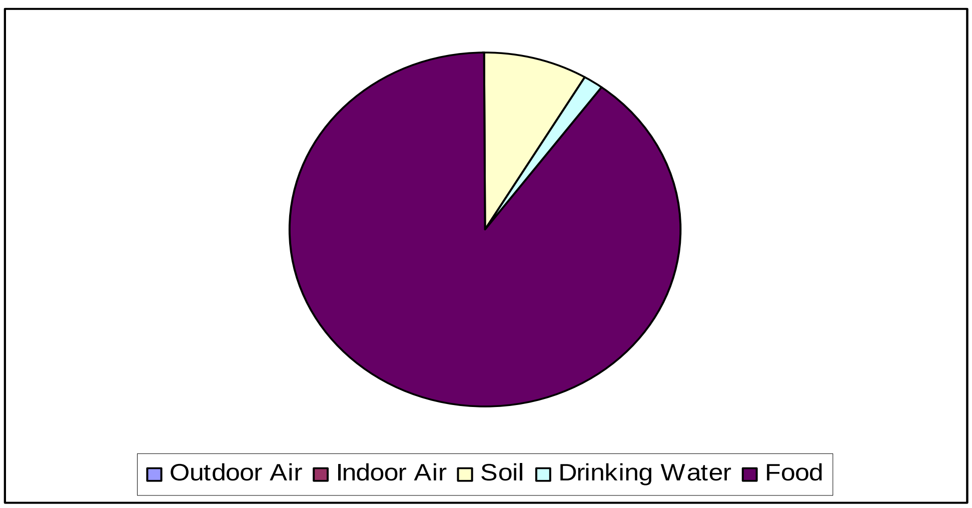
Outdoor Air	0.00011%
Indoor Air	0.00754%
Soil	1.19405%
Drinking Water	1.06308%
Food	97.73522%

Figure 13. Source Contributions to Arsenic Exposure (Child Average, Soil Remediation Endpoint 20 ppm)



Outdoor Air	0.00070%
Indoor Air	0.00191%
Soil	4.62821%
Drinking Water	1.33948%
Food	94.02971%

Figure 14. Source Contributions to Arsenic Exposure (Child High-end, Soil Remediation Endpoint 20 ppm)



Outdoor Air	0.00040%
Indoor Air	0.01093%
Soil	8.68159%
Drinking Water	1.45265%
Food	89.85443%

Exposure Profile Key Findings

- At background levels of soil arsenic, food and drinking water (that meets or exceeds established water quality standards) are the primary and secondary sources of inorganic arsenic exposure for most adults and children, with food contributing 95% or more of the total exposure. In a "high-end" exposure scenario, soil ingestion becomes the second largest source of inorganic arsenic exposure at 3% of total exposure.

- At the 20 ppm soil arsenic remediation endpoint, food remains the largest source of inorganic arsenic exposure for adults and children, contributing about 90% of more of the total exposure. Soil ingestion becomes the second largest source of inorganic arsenic exposure at ~1.2% for adults and ~5 – 9% of total exposure for children.

Site-Specific Analysis: Risk Assessment

<u>Introduction</u>

Risk assessment is a process that combines available information on exposure and research on health effects to estimate increased cancer incidence or identify exposures that exceed a level of concern. The methodology used here followed that of EPA (1989 and 2004).

The health risks from a lifetime of exposure to Spring Valley soils were estimated for a number of different exposure pathways:

- Ingestion of arsenic and other chemicals in soil
- Ingestion of arsenic in drinking water
- Dermal exposure to arsenic and other chemicals in soil
- Inhalation of chemicals attached to particulate matter (both outdoors and indoors)

Exposures to chemicals occurring at workplaces or outside the study area were not considered.

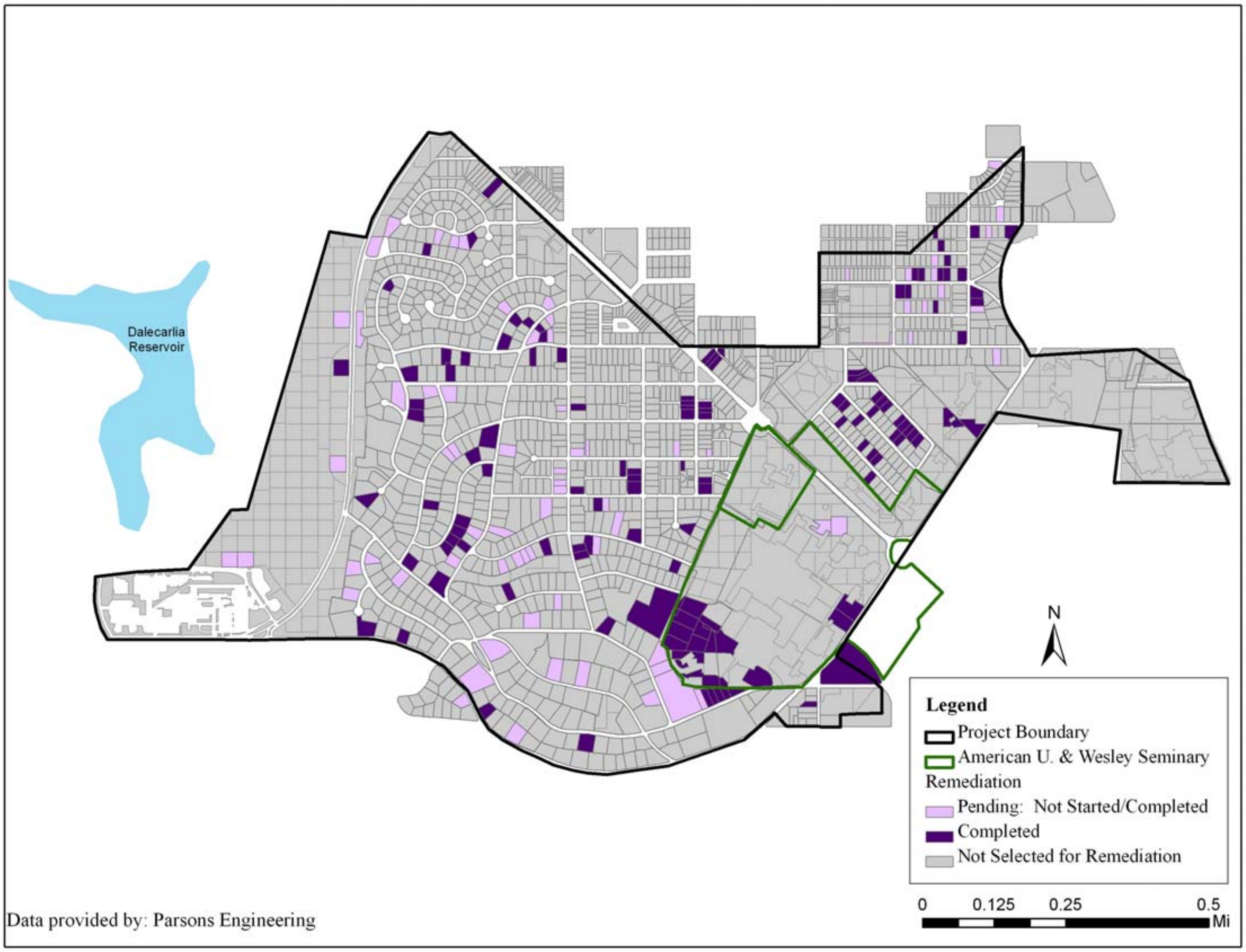
A total of five exposure scenarios were developed: adult and child average, adult and child high-end, and adult worker (landscaper). A potential worst-case child scenario, a child with pica, was considered and is discussed below. Pica is a medical condition characterized by habitual eating of non-food items, such as soil (Moya et al. 2004). Inputs to the exposure scenario calculations include a number of variables, such as concentration of arsenic in soil and bioavailability of arsenic from soil, and assumptions, such as years lived in the residence. For example, the EPA's standard assumptions of average length of residence for adults and children (assumed to be 9 years) and the high-end length of residence (assumed to be 30 years) were used.

Data on the concentrations of arsenic and other chemicals in soil were obtained from the USACE sampling program. Subsets of the soil sampling data were also used in the risk assessment, including from the Child Development Center, Lot 18, Boundaries-of-Interest (BOI), and the specialty sampling for the chemical weapons and their breakdown products. The arithmetic average concentration with 95% confidence interval was calculated for each subset of data. Average exposure scenarios are calculated with the average concentration. The high-end scenarios use the upper confidence limit on the average.

Pre-remediation sampling data was used in the risk assessment. As a consequence, the risk assessment reflects past exposures for many properties and locations. Map 6 displays the status of remedial activities as of March 2007.

Other details of these exposure scenarios and the risk assessment overall are available upon request.

Map 6. Status of Remedial Activities by Property (as of March 2007)



Risk Metrics and Interpretation

Human health risk assessments consider cancers separately from other types of health effects. The health risk-based reference values for cancer (slope factors) allow estimation of excess lifetime cancer for an individual. The individual cancer risk calculation involves multiplying the lifetime average daily dose derived from the exposure scenarios described above by the available cancer slope factor. As with the non-cancer causing pollutants, the pollutant-specific cancer risks are summed to yield a total cancer risk by population of concern. The same calculations are used to estimate cancer risk for children and adults, although the underlying data is usually from epidemiological, occupational, or toxicological research on adults (humans or animals).

A standard metric for cumulative assessment of non-cancer health effects of pollutants singly or in mixtures is the hazard quotient (HQ - single chemical) or hazard index (HI - mixture). The HQ is calculated by dividing the exposure measurement or estimate by the Reference Dose (RfD) or similar health-based reference value representing the dose at which no adverse health effects would be expected over a lifetime. Under the additive assumption that allows the assessment of mixtures, HQs for the non-cancer health effects are summed to yield a cumulative or total non-cancer HI.

If the non-cancer HQ or HI is less than one, the exposure does not exceed the dose level of concern and no adverse health effects would be expected at that exposure. If the HQ or HI is greater than or equal to one, the exposure exceeds the dose level of concern and further investigation of the risk is warranted. For the general population, an increase in individual cancer risk in the range of 0.1 to 10 per 100,000 over a lifetime is considered "acceptable". For workers, higher cancer risks at up to 100 per 100,000 may be considered "acceptable".

Risk Assessment Results: Arsenic Cancer and Non-cancer

Background soil arsenic in US

Because arsenic is naturally present in the environment, a certain amount of baseline risk is expected. Table 14 summarizes the individual cancer risk estimates for baseline or natural background soil arsenic exposures for the US, at an average of 4 ppm (with upper confidence limit of 7 ppm) (Shacklette and Boerngen 1984; Gustavsson et al. 2001). (See Map 2 above). The background risks estimated range from 2-3 per 100,000 for the adult exposure scenarios and ~4 to 17 per 100,000 for the child exposure scenarios. As a point of reference, the national drinking water standard for arsenic is 0.01 milligrams per liter, corresponding to risks ranging from 57 to 98 per 100,000 for the child exposure scenarios.[2] Site-related incremental cancer risks presented in tables to follow are calculated by subtracting the baseline or background risk from the total risk.

[2] In 2005, drinking water from the Washington Aqueduct was at or below 0.0006 milligrams per liter.

Table 14. Baseline Lifetime Increased Cancer Risk (per 100,000) at Background Soil Arsenic

	Adult Average	Adult High-end	Child Average	Child High-end
Background Average = 4 ppm, High-end = 7 ppm	1.5	3.1	4.2	17

Site-related incremental cancer risks from arsenic in soil were estimated for selected locations within the study area including the boundaries-of-interest (BOI), Lot 18, and the Child Development Center (Table 15). These locations were selected because they reflect the range of soil arsenic levels measured within the study area. Risks at the Child Development Center are estimated to be the highest. All of the site-related cancer risks for an adult resident fall within the "acceptable" range (0.1 to 10 per 100,000). For a child resident, site-related incremental cancer risks are elevated on the basis of sampling data from the Child Development Center and from high-end exposures to soils sampled at Lot 18.

Table 15. Site-related Incremental Increase in Cancer Risk (per 100,000) for Exposure Arsenic in Soil

	Adult Average	Adult High-end	Child Average	Child High-end
Boundaries-of-Interest	0.5	0.9	3.2	7.7
Lot 18	1.1	3.9	7.4	39
Child Dev. Ctr.	3.0	8.3	19	83

Non-cancer Hazard Quotients (HQ) from arsenic exposure for adult and child residents at 'average' and 'high-end' and landscapers are presented in Table 16. The HQ does not provide an estimate of risk, but provides a way to evaluate exposure. If the HQ is greater than 1, exposures exceed a dose level of health concern. All exposures at DC-area background levels are below the level of concern. Adult HQs, including the occupational landscaper, are also less than 1. For a child resident in the "high-end" exposure scenario, arsenic in soil at the Child Development Center and Lot 18 exceed the level of concern.

Table 16. Non-cancer Hazard Quotient results for arsenic exposures at selected locations

Location/Data subset	Adult "Average"	Adult "High-end"	Land-scaper	Child "Average"	Child "High-end"
Background	<1	<1	<1	<1	<1
Boundaries-of-Interest	<1	<1	<1	<1	<1
Lot 18	<1	<1	<1	<1	>1
Child Dev. Ctr.	<1	<1	<1	<1	>1

Special Scenarios: Landscaper and Pica

For the occupational scenario of a landscaper, the exposure scenario represents a work schedule of 50 5-day work weeks per year for 30 years. The soil concentration used was 55 ppm (upper confidence limit on the average) from the Child Development Center. The site-related cancer risks for this scenario are about 30 per 100,000, less than the occupational maximum "acceptable" risk of 100 per 100,000, but higher than the site-related risks of the adult resident. Non-cancer risks for the landscaper are below the level of concern.

A child with pica would be a "worst-case" for child exposures in the study area. Pica is a relatively rare condition but can result in high soil ingestion (Moya et al. 2004). Potential risks to a child with pica in the Spring Valley area could be as high as or higher than those presented for the child at high-end exposure.

Risk Assessment Results: All other contaminants detected (excluding arsenic)

In addition to arsenic sampling, USACE conducted "specialty sampling" for chemical weapons and their breakdown products in subsurface soils. At Lot 18, USACE sampled soil for selected metals and elements and sulfur mustard breakdown products. There are fewer numbers of these samples available and the concentrations were often estimated. However, as presented previously in Table 10, there are a number of health effects that are related to more than one of the chemicals in the sampling data. There are several carcinogens in addition to arsenic and multiple chemicals with human or animal evidence of effects on blood, the gastrointestinal system, the kidney or liver, the respiratory tract, the neurological system, or the skin. Whether these mixtures were actually present at any particular location was not evaluated. The analysis assumes that exposure to each mixture of concern might occur. A total cancer risk and cumulative Hazard Index analysis was conducted for these hypothetical mixtures.

This analysis found no elevated cancer risks for adults or children. It also found no elevated exposures for the adult scenarios and an "average" child for any of the non-cancer health effects. Only one potential mixture exposure is of concern for the child resident at a high-end exposure. The potential mixture associated with effects on blood has a HI exceeding 1. The chemical contributing most to the HI is antimony.

Risk Assessment Limitations

The risk assessment results must be interpreted with caution given the many limitations of the data, the uncertain nature of the risk assessment process, and the changes underway from remedial activities. Many of the sampling data values were estimated and not explicitly quantified. Some non-arsenic chemicals were found in sub-surface soils so human exposure (contact) was unlikely. These were included in the risk assessment to evaluate potential "worst-case" exposures. Many of the inputs to the risk assessment are default estimates and may not accurately reflect residents' actual activities. Most importantly, many of these potential exposures have been eliminated by remedial activities. Overall, the exposures and risks presented above are likely over-estimates of the actual exposures and risks.

Risk Assessment Key Findings

- The assessment corroborates recommendations reached previously by the Mayor's Science Advisors and the ATSDR that, although arsenic may be the most reliable indicator of chemical contamination, other contaminants sampled in Spring Valley may contribute to exposures of potential concern for health.

- In the worst case, children's exposures to pre-remediation levels and related cancer and non-cancer risks are elevated, but the probability of adverse effects is small.

- Ingestion of soil is the most important pathway of exposure for the child exposure scenarios, contributing about 60% or more to exposure estimates. Reducing soil ingestion can be achieved with common sense precautions such as hand washing after outdoor activities and before eating.

III. REVIEW AND DISCUSSION OF KEY FINDINGS

Outreach

- There was agreement on the complexity of the Spring Valley site. In particular, the ninety year time lag since the initial activities; the lack of documentation of burial areas; the changing landscape of the area due to development, and the absence of any medical records from the World War I time period were recognized as major obstacles to identifying exposure-related health problems in Spring Valley.

- The outreach respondents were in agreement that the geographic variability of contaminant levels in Spring Valley can be broken into two categories: the disposal pit areas and the more widespread lower contaminant level areas. There was consensus that the major health, safety and environmental concerns are regarding the disposal pit areas.

- Given the complexities of the Spring Valley site and variations of contaminant levels outlined above, the outreach participants acknowledged uncertainties with regards to determining exposure-related health problems in Spring Valley. There was consensus that it would be helpful to monitor and track contaminant levels, exposures, and health outcomes.

- Given the uncertainties regarding exposure-related health problems in Spring Valley respondents were very supportive of a third party investigation to provide recommendations for further study or tracking of contaminants, exposures, and health outcomes.

Review of Exposure Studies

- The four biomonitoring studies conducted at Spring Valley were done using different methods often with different detection levels and different environmental sampling. The studies are therefore difficult to compare and interpret. While the overall findings indicate no measurable exposures of public health concern, there may be indications of a relationship between soil and dust levels and levels of arsenic in hair and urine.

- The two in-home sampling studies were also conducted with different methodologies and are not comparable. The findings at the Sedgwick Street home indicate that there may be a build-up of dust arsenic in undisturbed places within the home that are potential exposure sources if disturbed (e.g., cleaned).

Community health assessment

- Overall, Spring Valley is a healthy community. Crude mortality rates are lower than those of the Chevy Chase comparison community and 20 to 70% lower than the US rates for 11 of the top 15 causes of death in the nation.

- Essential hypertension and related kidney disease, the 13th most common cause of death, is the only Spring Valley mortality rate that exceeded those of Chevy Chase and the US.

- Similarly, the Spring Valley age-adjusted incidence and mortality rates for selected cancers of concern (bladder, kidney and renal pelvis, leukemias, liver, lung and bronchus, lymphomas, and skin) are 20 to 80% lower or, for skin cancer in recent years (2000-2004) the same as rates for the US overall.

- The comparison of Spring Valley cancer incidence data to Chevy Chase for both time periods shows a pattern of slightly higher rates for cancers known to be associated with arsenic exposure, kidney and renal pelvis, lung and bronchus, skin, and bladder (2000-2004 period only). This pattern is also found in the mortality data comparison for the 2000 – 2004 time period. This finding should be interpreted with caution since the numbers of cases and deaths are low and rates calculated are likely to be highly variable. (When the number of events [cases or deaths] is low a single event will cause a large change in the rate, leading to variability in the rate over time.)

Review of Anecdotal Community Surveys and Identification of Potential Hazards

- There remains a lack of information on long-term effects of most of the AUES-related chemical weapons.

- The toxicological and epidemiological literature on the health effects of chemicals sampled in soils in Spring Valley are consistent with some of the more frequently reported health problems in the community surveys, such as blood disorders, cancers, neurological and skin conditions.

Spatial Analysis

- There is no statistical difference between the Phase I and Phase II property-level arsenic concentrations.

- Arsenic levels are higher within the areas of concern than outside of them.

- Anecdotal health reports are more likely to be within areas of concern, but this is to be expected giving the sampling design.

- Arsenic related cancers cases from the DC cancer registry were not found to be more likely in the areas of concern.

Exposure Profile

- At background levels of soil arsenic, food and drinking water (meeting established water quality standards) are the primary and secondary sources of inorganic arsenic exposure for most adults and children with food contributing 95% or more of the total exposure. In a "high-end" exposure scenario, soil ingestion becomes the second largest source of inorganic arsenic exposure at 3% of total exposure.

- At the 20 ppm soil arsenic remediation endpoint, food remains the largest source of inorganic arsenic exposure for adults and children, contributing about 90% of more of the total exposure. Soil ingestion becomes the second largest source of inorganic arsenic exposure at ~1.2% for adults and ~5 – 9% of total exposure for children.

Risk Assessment

- The exposure and risk estimates calculated likely overestimate actual exposures and risks.

- The assessment re-affirms concerns and recommendations reached previously by the Mayor's Science Advisors and the ATSDR that, although arsenic may be the most reliable indicator of chemical contamination, other contaminants sampled in Spring Valley may contribute to exposures of potential concern for health.

- In worst-case scenarios of children's exposures to unremediated soils, cancer and non-cancer risk estimates are elevated but the probability of adverse effects is small.

- Ingestion of soil is the most important pathway of exposure for all child scenarios, contributing about 60% or more to exposure estimates. Reducing soil ingestion is best achieved with common sense precautions such as hand washing after outdoor activities and before eating.

<u>Discussion of Key Findings</u>

Considering the findings overall, the community can be reassured that indicators of health are very good and there is no association between locations of registry-confirmed cancers and points- or areas-of-interest. However, the slightly elevated rates of the four well-established arsenic-related cancers (bladder, kidney and renal pelvis, lung and bronchus, and skin) in Spring Valley as compared to Chevy Chase are worthy of additional investigation, as is the finding of elevated mortality due to essential hypertension and related kidney disease.

Other health conditions of concern to the community including blood disorders, kidney diseases and neurological conditions also warrant further attention. These health outcomes appear in the anecdotal community reports, the research literature on the health effects of some of the chemicals sampled in Spring Valley soils, and in the risk assessment findings (blood effects only). These health outcomes are not reportable (i.e., there is no surveillance system for these conditions as there is for deaths and cancers). Further follow-up will require careful planning to develop an approach to identify and verify cases and, if warranted, conduct other epidemiologic follow-up studies to understand potential disease-related exposures.

The findings underscore the importance of the on-going remedial activities. The risk assessment indicated elevated risks to children from high-end and worst-case exposures to pre-remediation soils. As the USACE continues with remediation, communication with the community will remain a priority. Future sampling activities should be reviewed with an emphasis on obtaining information necessary to inform community health.

The exposure studies looking at arsenic in homes or in biomonitoring were limited in scope and the raw biomonitoring data were not made available to JHSPH. Food and other sources of inorganic arsenic exposure make interpreting arsenic biomonitoring studies difficult. Additional analysis of the raw data from the exposure investigations may be helpful to better characterize the current status of arsenic exposures to the Spring Valley community. If warranted on the basis of further analyses of the existing data, a systematic exposure study that includes homes near points- or areas-of-interest, as well as control homes away from known contaminated areas, may be needed.

IV. RECOMMENDATIONS

Health

- Strengthen community health analysis by working with the DC Health Department to obtain additional years of mortality and cancer registry data.
  - Examine time trends in major causes of death and relevant demographic information for Spring Valley and comparison areas to determine historical mortality patterns.
  - Examine additional years of cancer registry data as they become available to assess temporal patterns and improve the statistical power of the cancer analysis.
- Collect additional information on non-cancer outcomes of concern (blood disorders, neurological and kidney diseases) potentially related to AUES-chemical exposures.
  - Identify and examine available scientific literature on incidence and prevalence.
  - Conduct targeted interviews with community members and health care providers to confirm diagnoses.
  - If warranted, on the basis of literature reviews and interviews, consider further epidemiological study.

Environment and potential on-going exposures

- Update and maintain the existing Spring Valley database by working with the Spring Valley agency partners to obtain current environmental sampling and health outcome data.

- Obtain and analyze the raw data from the biomonitoring studies from ATSDR and, if warranted, work with the DC Health Department to develop a protocol for a systematic exposure study of homes including controls.

- Demonstrate exposure reductions resulting from remediation.

    - Work with the Spring Valley agency partners to access and analyze remediation-related sampling including information on fill material. If necessary, work with agency partners to plan and conduct a targeted post-remediation sampling program to demonstrate exposure reductions.

    - Quantify risk reductions by revising the risk assessment using post-remediation sampling data

- Ensure future sampling study design and implementation addresses community health concerns by conducting continued outreach with community members and working collaboratively with the agency partners.

Response capacity and communication

- Establish notification/communication protocol regarding digging or potential soil disturbance within the study area through coordination with agency partners on outreach and education efforts.

- Continue tracking water sampling results to evaluate potential for water-related exposure pathways by coordinating with Agency partners to access and analyze water sampling results.

- Continue public health outreach, responses and risk communication efforts through continued contacts with community members and agency partners.

- Reinforce preventive community and household measures to reduce exposure to soil through coordination with agency partners on outreach and education efforts.

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Please Note: On-line documents were accessed between January and April 2007 and were active at the time of report release.

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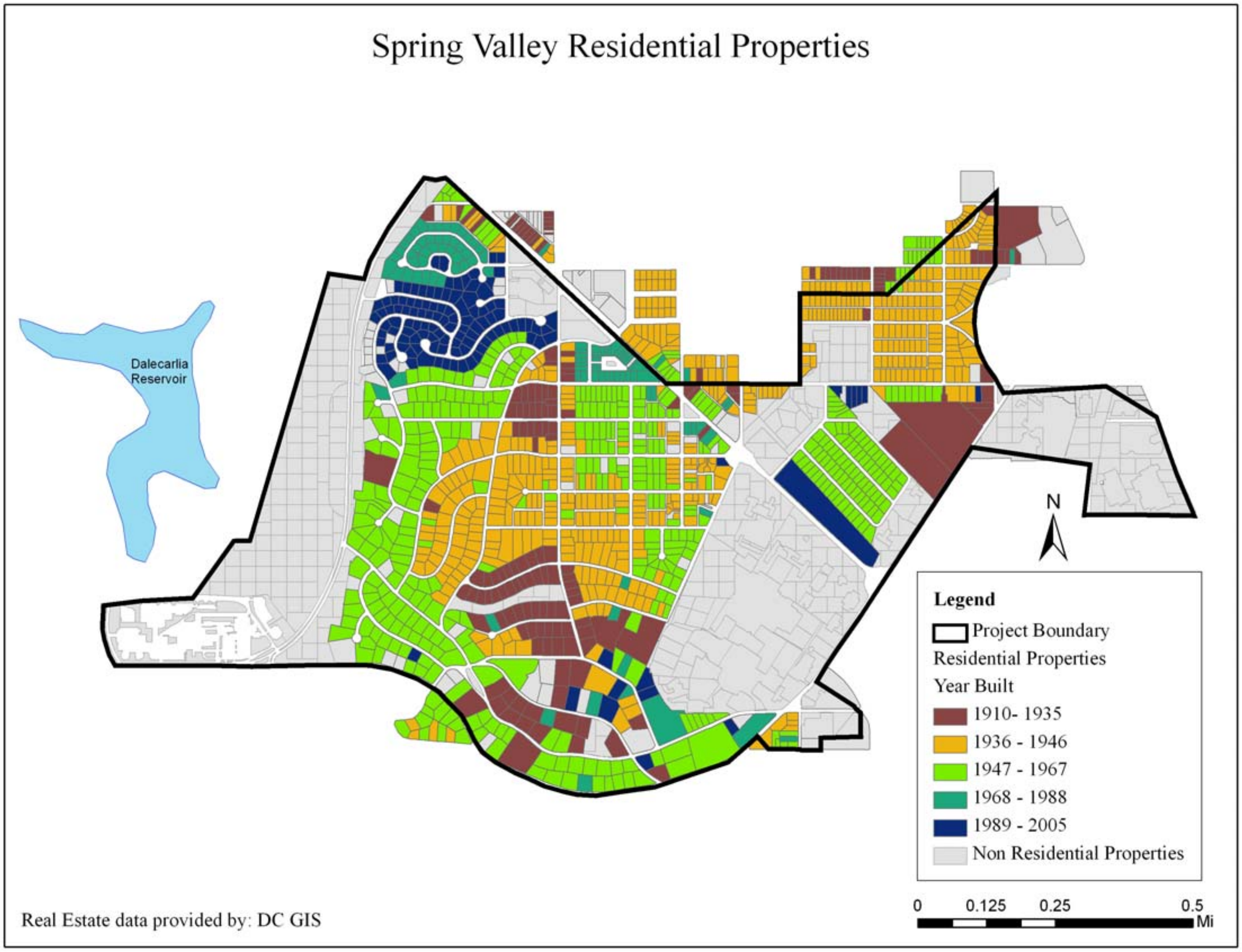
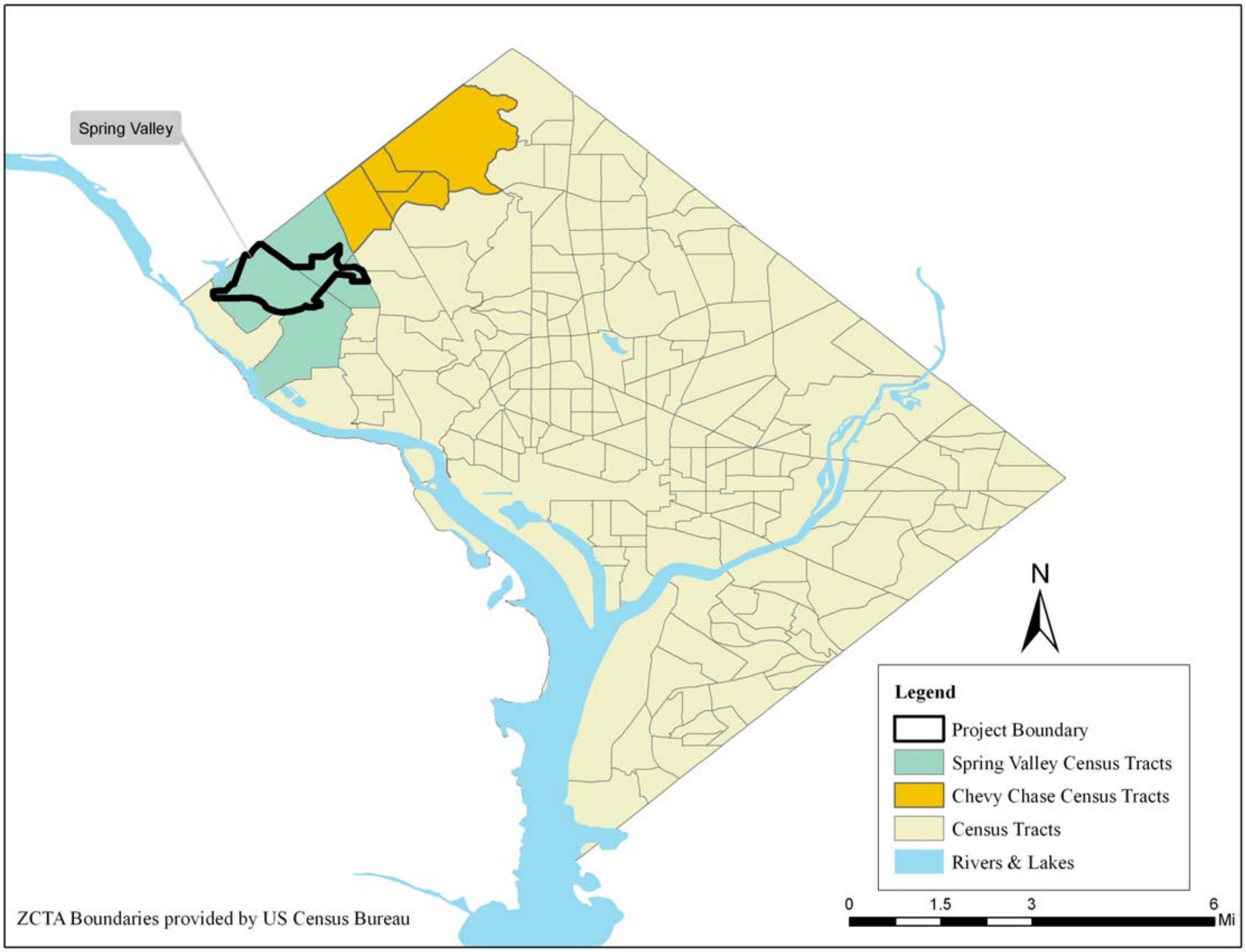
APPENDIX A: Additional Maps

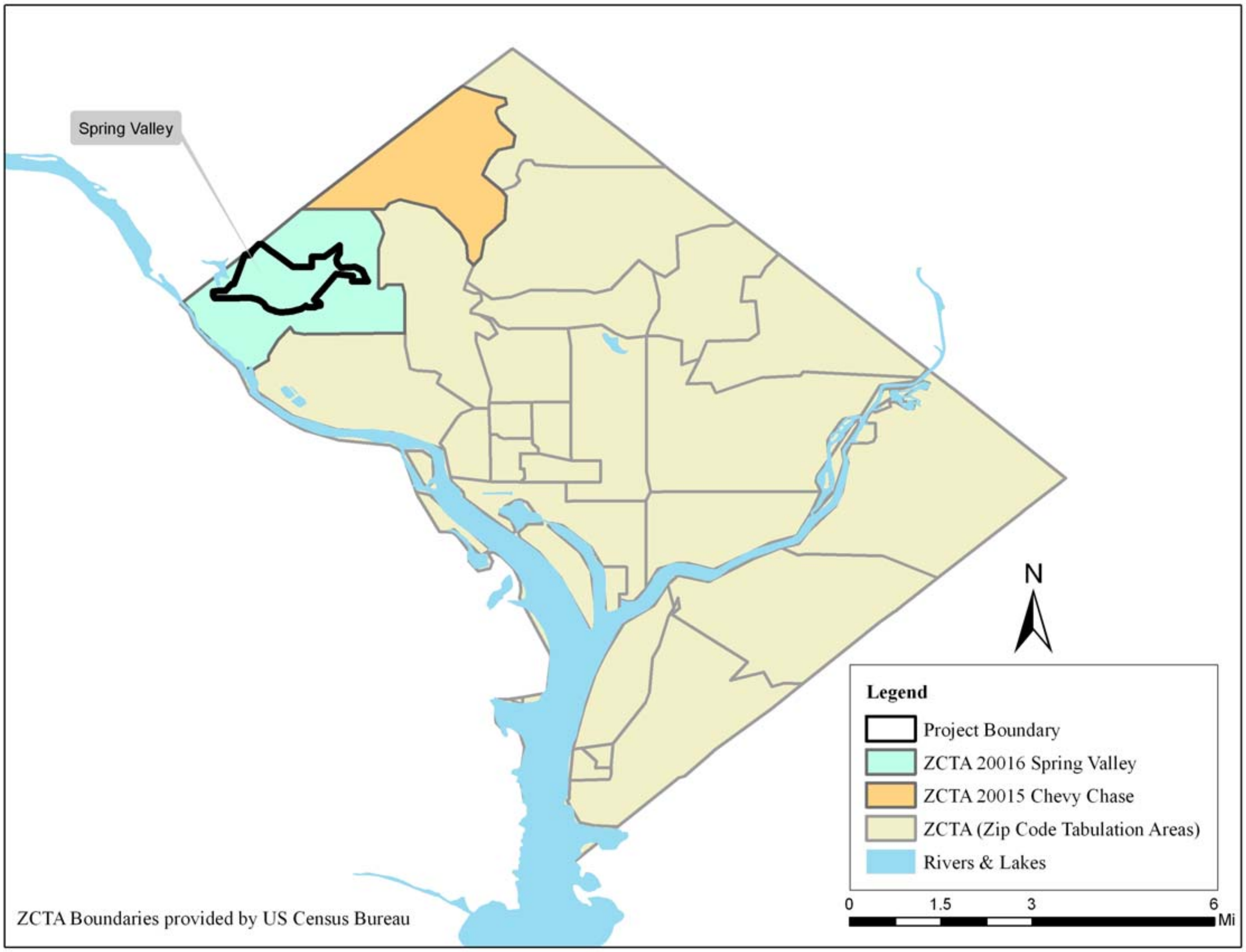
A1. Timeline of property development in Spring Valley



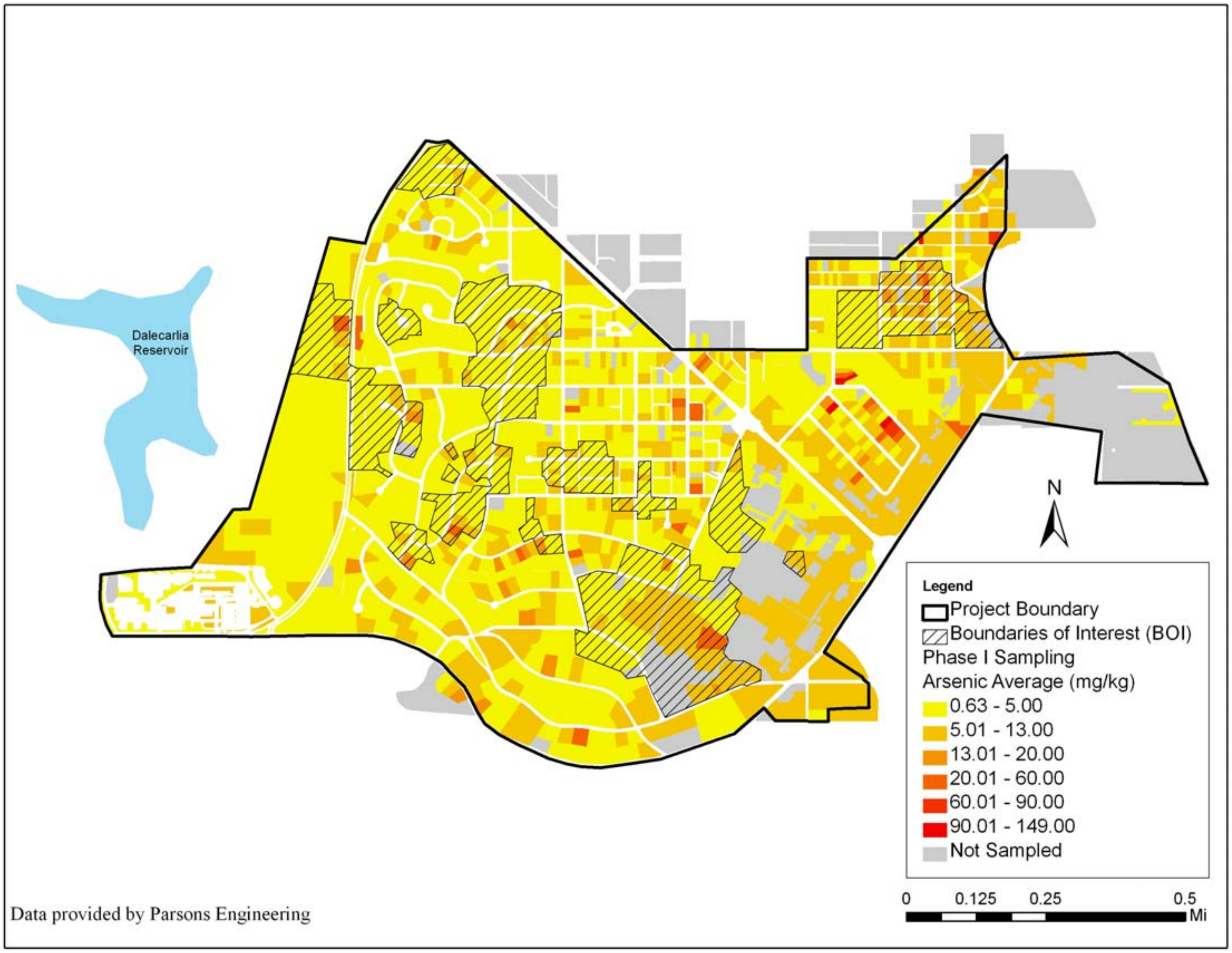
A2. Census tracts corresponding to descriptive health analysis



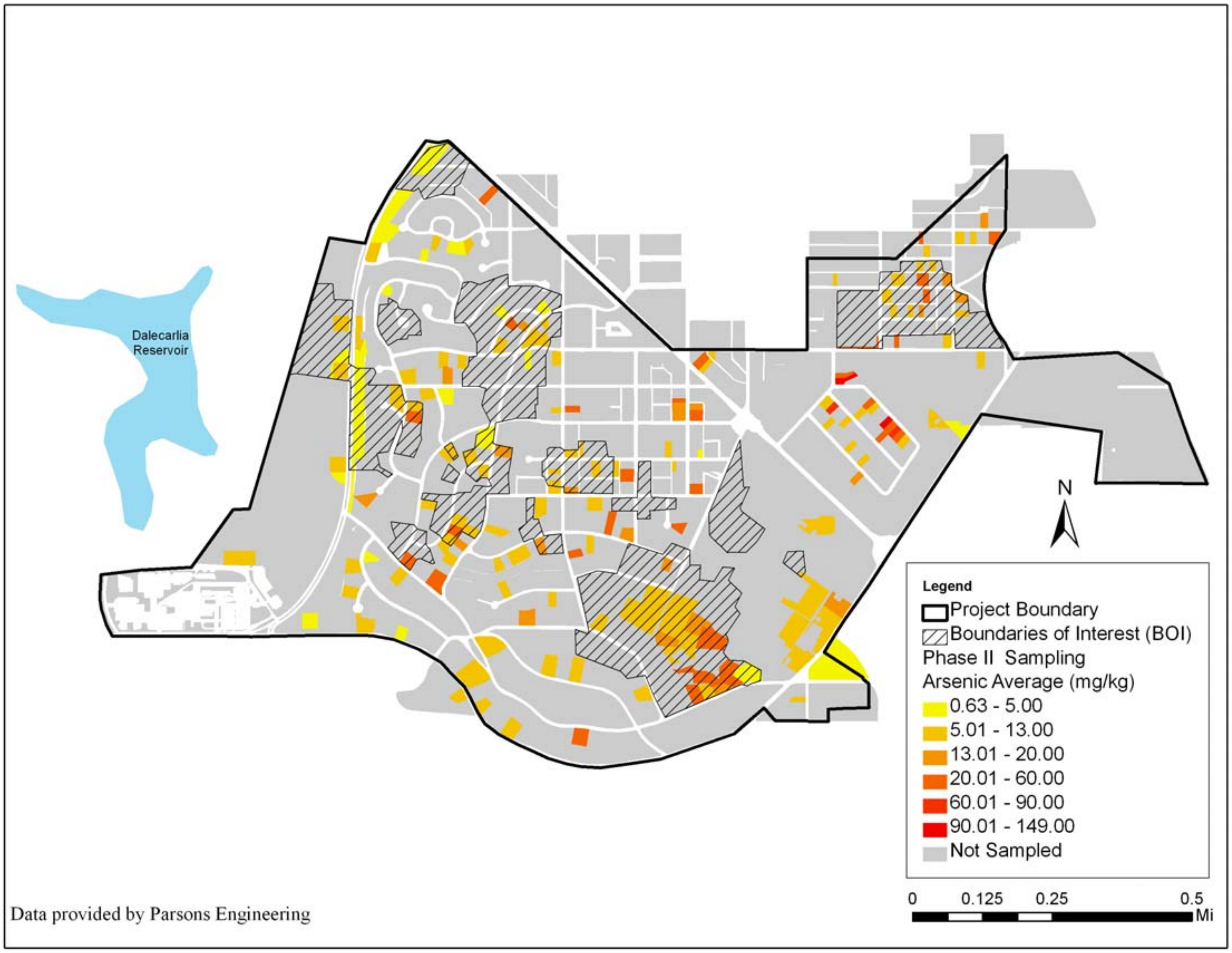
A3. ZIP Codes corresponding to descriptive health analysis



A4. Phase I soil arsenic sampling averaged by property



A5. Phase II soil arsenic sampling averaged by property



A6. Distances around Boundaries-of-Interest corresponding to statistical analysis