Health Consultation

PRIVATE WELL WATER QUALITY
WILLIAMSON WV SITES
(A/K/A WILLIAMSON AREA)

CITY OF WILLIAMSON, MINGO COUNTY, WEST VIRGINIA

APRIL 6, 2005

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:
West Virginia Department of Health and
Human Resources
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Private Well Water Quality

Williamson WV Sites

(a/k/a Williamson area)

Williamson, Mingo County, West Virginia

April 1, 2005

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Foreword

This document summarizes public health concerns related to private water well quality in the Lick Creek, Rawl, Merrimac, and Sprigg areas. People who could come into contact with these chemicals are residents of households who use this water.

A number of steps are necessary to complete this document.

Evaluating exposure: The West Virginia Department of Health and Human Resources (WVDHHR) starts by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is found on the site, and how people might be exposed to it. The WVDHHR typically does not collect environmental samples. WVDHHR relies on information provided by the West Virginia Department of Environmental Protection (WVDEP), U.S. Environmental Protection Agency (EPA), other governmental agencies, businesses, and other sources of valid information.

Evaluating health effects: If evidence indicates that people are being exposed, or could be exposed, to hazardous substances, WVDHHR scientists will take steps to determine whether that exposure could be harmful to human health. The report focuses on public health - the health impact on the community as a whole. The evaluation is based on existing scientific information.

Developing recommendations: In this report, the WVDHHR outlines its conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to contaminants. The role of the WVDHHR at these sites is primarily advisory. For that reason, these reports will typically recommend actions to be taken by other agencies, including the WVDEP and EPA.

Soliciting community input: The evaluation process is interactive. WVDHHR starts by soliciting and evaluating information from various governmental agencies, the organizations responsible for cleaning up sites, and the community surrounding the site. Any conclusions about the site are shared with groups and organizations that provided the information.

If you have questions or comments about this report, we encourage you to:

write: Program Manager
ATSDR Cooperative Partners Program
West Virginia Department of Health and Human Services
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Summary and Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) issued a health consultation for the Williamson WV Sites on February 10, 2004. The health consultation found that there was no public health hazard from chemicals from the Norfolk Southern railcar clean-out area, the Rawl Sales and Processing Strip Mine (from the area where there was an alleged PCB spill), or the Old Williamson Landfill area. The health consultation reviewed existing private well water data as part of the environmental assessment. Two recommendations were made concerning the use of the well water in this site. First, people who may not be able to regulate manganese in their body should consider using another source of drinking water. Second, infants should not be fed formula mixed with this water because of the high levels of manganese and sulfates.

Prior to the release of the initial health consultation, residents at this site requested assistance from Wheeling Jesuit University [1]. The residents asked for assistance because they were concerned about the quality of private well water in the area. They believe that coal mining and a coal slurry impoundment has affected their well water. In February 2004, staff of Wheeling Jesuit University (the University) sampled water from a small number of private water wells in the same area covered in the initial health consultation (Lick Creek, Rawl, Merrimac, and Sprigg areas). Additional samples from private water wells were collected and submitted by residents in April 2004. University staff also sampled water from a local spring that some local residents use for drinking and a nearby municipal water source.

University staff members offered to let the West Virginia Department of Health and Human Resources (WVDHHR) review the water quality data from their study because of WVDHHR's past involvement with the site [2]. This health consultation reviews the chemical content of household well water and a local spring sampled at this site to determine if chemicals in the water are high enough to likely cause any health problems.

The exposure pathways reviewed for this second health consultation are ingestion and dermal exposure to water from private water wells. The University sampling data were reviewed. The dermal pathway includes exposures to chemicals in the water from bathing, showering, and other uses where water comes into contact with the skin. The ingestion pathway involves water used for cooking and incidental ingestion. The drinking water pathway was not considered because the residents were not drinking the water from the wells selected for sampling. In fact, because much of the local well water smells, tastes and looks bad, 42% of the people in Lick Creek, Rawl, Merrimac and Sprigg areas (the site) reportedly do not drink it [3].

This health consultation does not address the public health implications that result from the lack of potable water in homes. WVDHHR recognizes the need for an approved and safe drinking water source at this site that supplies good quality water to the residents. This issue is outside the scope of this health consultation. WVDHHR has reviewed and approved construction plans for the water line extension from the Williamson Utility Board [3] and ranked this project on the priority list for West Virginia Drinking Water State Revolving Fund construction monies. The project did not rank high enough to receive loan funds from this source. However, the water line extension project has recently been approved for funding from Small Cities Block Grant and Abandoned Mine Lands Program monies.

The WVDHHR prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

Site Description and History

In February 2004, University staff took samples from 12 private water wells and one spring located in the Lick Creek, Rawl, Merrimac and Sprigg communities. University staff took an additional sample of water decanted from a hot water tank and one sample of municipal water available nearby in February. In April 2004, residents again sampled five of these wells and three additional private water wells. The samples taken in April 2004 were taken after heavy rains.

The site is about 1.9 miles southeast of the town of Williamson, the county seat for Mingo County, West Virginia. The communities of Lick Creek, Rawl, Merrimac, and Sprigg lie along 6.9 miles of State Route 49 near the Tug Fork River. The community of Lick Creek extends for about 1.5 miles along either side of Lick Creek. Rawl is about 0.75 mile upstream from the mouth of Lick Creek. Merrimac is about 1 mile upstream from the mouth of Lick Creek and Sprigg is about 3.5 miles upstream from the mouth of Lick Creek (Figure 1). Three churches and five businesses are in this area. There are no schools in the area.

The elevations in this area range from 650 to 1950 feet. The area has steep forested mountains and narrow valleys. Most residential and commercial development in the area lies in these narrow valleys. The soils in these valleys are very deep and well drained [4].

A geologic structure, called the Lick Creek Syncline, is a short shallow fold in the rocks that begins at the mouth of Lick Creek and extends four miles to Pigeon Creek. The presence of this syncline suggests that groundwater flows from the southeast and northwest toward Lick Creek [5]. However, mining, blasting, and drilling activities can change the way that groundwater flows in an area. Groundwater at this site may not always flow toward the Lick Creek Syncline because these influences have occurred at this site.

Of the ten mineable seams of coal in this area, most have been mined. Coal mine maps show more than 100 instances of surface and deep coal mining in the area prior to 1977. Twenty-nine additional mining permits have been issued in this area since 1977. Coal mining activities can introduce many minerals to the groundwater, such as iron, manganese, and sulfur. Sixty-four percent of the wells in the Lick Creek area have been affected by coal mining that occurred before 1977 [3]. The WVDEP determined this by comparing the chemical composition of the water from more than 60 wells at this site to the chemical composition of various mine discharges in this area.

The residents at this site use water from drilled wells (88%), hand-dug wells (9%), springs (2%), and no water source (1%). Many people in the area also haul water to their homes from other sources. No public water or sewers are currently available at this site [3].

Residents report that their well water smells of rotten eggs, sulfur, kerosene, and sewer gas. Much of the water from these wells contains black flakes and is slimy. The water creates red and black stains on appliances, walls, clothing, and dishes [3]. Metal fixtures, hot water tanks, and well pumps corrode within a short length of time. Residents report that hot water tanks and well pumps have to be replaced often, some after only two years of use [1].

The initial health consultation reported that a child living at Rawl was reported to be poisoned by drinking water that contained arsenic. The drinking water source was water from a stream or spring. The water was collected in a tank of unknown composition. There were reports of dead animals in the water in the tank. The family did not drink the water. However, the mother reported that the child sucked on a washcloth while in the bathtub. No tests were done to confirm the arsenic content of the water. This water source is no longer in use [2].

Possible impact of coal slurry on well water quality

Groundwater in areas where coal mining has occurred often contains high amounts of chemicals such as iron, manganese, and sulfates. The presence of these chemicals may indicate that the groundwater has been impacted by coal mining. Each coal seam and rock strata disturbed to mine coal contains varying amounts of these chemicals. The West Virginia Department of Environmental Protection (WVDEP) can analyze the metal content of water in wells and in water coming from mine sites to determine if the mining activity from that mine has impacted the water quality of that well. This is called a stiff analysis [5].

The University staff assumed that if coal slurry was getting into the well water at this site that the well water at this site would reflect the elemental constituents of that slurry [1]. The coal slurry sampled from Eastern Associated coal mines was selected for comparison purposes. This coal mine is located about 5 miles from this site. However, each coal seam has its own chemical content. WVDEP samples show that more than one coal mining operation is affecting wells on Lick Creek. Even adjacent wells on Lick Creek appear to be impacted by different coal seams. Without more data specific to the coal slurry content from the Rawl Sales and Processing Impoundment and a stiff analysis comparing its content to that of private water well metals, no conclusion can be reached about whether this coal slurry impoundment is affecting the wells in this area. The University sample data is not adequate to determine if the coal slurry impoundment on the Rawl Sales and Processing strip mine has affected the well water at this site.

Possible impact of surface water on well water quality

Residents say that the water quality in many of the water wells becomes poorer after a significant rain. Local residents call these “blackwater” events. The WVDEP found that 61% of the wells sampled on Lick Creek contained fecal coliform bacteria [5]. The presence of fecal coliform bacteria in well water may be an indication that the well is not constructed to keep out surface water or that sources of sewage may be impacting the well. University staff did not assess if well construction was sufficient to keep surface water out of the water wells that were sampled. Therefore, whether surface water or groundwater movement is responsible for the change in the water quality of these wells after a significant rain is unknown. It cannot be concluded that “blackwater” events are caused solely from changes in groundwater.

Demographics

About 660 people in 255 residences live in Lick Creek, Rawl, Merrimac, and Sprigg. People ages 19 and younger make up 29% of the residents; people ages 20 B 64 57%; and people 65 and older, 14% [6]. The average earnings per capita in Mingo County are $12,445 [7].

Community Health Concerns

Community members are concerned that exposure to local well water may be the cause of cancers, kidney stones, kidney failure, birth defects, breathing problems, arsenic poisoning, Attention Deficit Disorder, Alzheimer’s disease, typhoid, hepatitis, strep throat, dry skin, rotten tonsils, ulcers, blood in urine and stools, and stomach illness (parasites) [2][3].

Discussion

A. Relationship of well water chemicals to groundwater content

Some groundwater in West Virginia contains high amounts of iron and manganese. The WVDEP 2004 Biennial Report to the legislature stated, "Concentrations of dissolved iron and manganese are especially prevalent in Pennsylvanian aged sandstones. Concentrations of iron ranged as high as 40 mg/L [milligrams per liter] and manganese ranged as high as 1 mg/L in West Virginia groundwater" [8]. The University samples found iron in well water up to 59 mg/L and manganese up to 4 mg/L.

Although the chemical content of the well water tested is related to the groundwater in this area, the chemical content of the well water from this study cannot be said to be the same as that in the groundwater. Reasons for this include:

- Twelve wells were tested over an approximately 12-square-mile area. WVHDDR believes this is not a large enough sample size to make a general statement about the chemical content of the groundwater throughout this area.
- The quality control and quality assurance procedures for sampling were not adequate to assure accurate data.
- Water samples taken by University staff members were tested without filtering except in the cases where visible particles were in the water. Usual laboratory methods for drinking water test without filtering. However, standard sampling methods for groundwater filter it before testing for metals (except for chromium). Removing particles in the water by filtering may change the chemical content of the water. Therefore, groundwater sample results from other sources cannot be compared with the chemical content of these well water samples.
- A mixture of several aquifers is likely to affect each well tested. Each aquifer may have a different chemical content.
- The well water is corrosive to metals. Metal, such as from the well casing, pipes, and the well pump, was in contact with the well water prior to sampling. The effect of this corrosion on the total amount of chemicals found in the water cannot be determined.
- The effect of the household water treatment systems on the chemical content of the water cannot be determined.

B. Data Review and Selection of Chemicals of Concern

University personnel sampled water from 15 private water wells, one spring, one hot water tank and one nearby municipal water source. Residents sampled water in eight private water wells after heavy rains.

University personnel took 12 private water well samples. These wells were in Lick Creek, Rawl, Merrimac, and Sprigg. Well depth was reported by residents to be from 26 to 200 feet. One well was a 26-foot deep, hand-dug well. All the other wells were drilled wells. Wells were selected at different elevations within these areas. A sample was collected from the water line entering the household when possible. University staff took samples at the cold water taps in four of the 12 households where samples could not be collected from the water line. Water was allowed to run at the sample point for one minute prior to filling the sample containers. All households had extensive water treatment systems.

After enough rain fell to substantially raise the level of the Tug Fork River, the residents themselves took eight water samples from their wells. University personnel had previously sampled five of these eight wells. These samples were taken because residents indicated that their water quality deteriorates after a heavy rain. Residents call this a “blackwater” event. The local residents used methods explained to them by University personnel to take these samples. Residents shipped the samples to the University.

Some local residents use a spring on the east side of the Norfolk Southern Railroad tracks for drinking water. University staff sampled this water.

The University staff took one sample of water from the clean-out tap of a hot water heater. Water was collected in a 5-gallon container. The solids were allowed to settle briefly before the water was put into sample bottles.

University personnel took one sample of public water supplied by the Williamson Utility Board at a local business. Lead was found in the water at a level of 0.016 mg/L. This is over the EPA Action Level of 0.015 mg/L for lead. The EPA Action Level requires that a public water system control the corrosiveness of their water *if more than 10% of the tap water samples are over the Action Level*. No conclusions about compliance with the EPA Action Level can be reached on the basis of one sample. WVDHHR records do not show that the Williamson Utility Board has had recent regulatory violations of the EPA Action Level for lead. None of the chemical tests on this water was over the EPA National Primary Drinking Water Regulations (primary standards) that public water supplies are required to meet.

When testing the water, the Water Quality Laboratory at Heidelberg College used EPA standard methods for drinking water. EPA does not accredit the laboratory. The following 21 metals and elements in the water were analyzed; aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, silica, sodium, strontium, vanadium, and zinc.

The conclusions in this report are affected by the availability and reliability of the information that was reviewed. The quality control and quality assurance procedures for sample collection were not adequate to assure accurate data. No one reviewed the laboratory quality control and quality assurance procedures. The conclusions in this health consultation will be qualified on the basis of these quality control and quality assurance issues.

Selection of Chemicals of Concern

The first step in the assessment of human health risk is the selection of chemicals of concern. This process compares data from the site to environmental guideline comparison values (CVs). CVs established on the basis of an evaluation of toxicology literature for a given substance are screening tools. Exposure to a chemical below its corresponding CV indicates that adverse health effects are unlikely. Many safety factors are included in the derivation of these values, making them very conservative (i.e., protective of public health). Chemicals found above a CV are considered chemicals of concern. Exposure to chemicals above a CV *does not necessarily mean* that an adverse health effect will result. Exposure above a CV simply indicates *a need for further evaluation* to determine if the exposure *could have caused* adverse health effects at this site.

Some chemicals have both carcinogenic and non-carcinogenic CVs. For chemicals with both carcinogenic and noncarcinogenic CVs, the most conservative CV (i.e., the lowest) was selected. The CVs selected are for chemicals in drinking water.

This report uses the EPA primary standards and National Secondary Drinking Water Regulations (secondary standards) as CVs where ATSDR health-based CVs for drinking water are not otherwise available. In this report, the EPA primary and secondary standards are used only as a means to select chemicals of concern.

EPA does not regulate private water systems, so neither the EPA primary nor secondary standards are directly applicable to private water wells The EPA primary standards are *regulatory* standards that apply to public water systems. EPA's secondary standards, *guidelines* set by EPA for public water systems, cover chemicals that can affect the taste, color, or odor of the water or that could cause tooth or skin discoloration.

Environmental CVs that were developed for potential adverse health effects were selected instead of the secondary standards for aluminum, copper, manganese, and zinc. The secondary standard for iron was used as the CV for iron because no other environmental CVs for iron in drinking water have been established.

Chemicals were selected as chemicals of concern if test results indicated that the chemical was in the environment in amounts above the selected CV or if no CVs had been established for that chemical. The chemicals of concern selected for this site are listed in Table 1.

Using this selection method the following metals were not found in amounts high enough to be considered as chemicals of concern:

- for samples taken by the University staff: aluminum, beryllium, cadmium, cobalt, copper, nickel, strontium, and zinc and
- for samples taken by the residents after a rainfall event: aluminum, barium, beryllium, cadmium, chromium, selenium, strontium, and vanadium.

In addition, four of the 21 metals and elements found in the water were not reviewed in this report for the following reasons:

- Calcium, magnesium, and potassium are needed for good health. High levels of these elements are not known to cause adverse health effects. These chemicals were not found at levels where adverse health effects would be expected.
- Silica is not considered a potential health hazard when it is in water. The source of the silica is likely small particles of sandstone rock, or sand. Silica can be hazardous if inhaled as a dust. However, the inhalation hazard for silica does not exist at this site.

C. Human Exposure Pathway Analysis

An exposure pathway consists of five parts:

1. a source of contamination,
2. movement of the contaminant(s) into and through the environment (in soil, air, groundwater or surface water) to bring it into contact with people,
3. a place where humans could be exposed to the contaminant(s),

4. a way for humans to be exposed to the contaminant(s) (such as by drinking the water or breathing the air), and
5. one or more people who may have been or may be in contact with the contaminant(s).

Exposure pathways are considered *complete* when all five of these elements existed at some point in the past, exist in the present, or are likely to occur in the future. Exposure pathways are considered *potential* when one or more of the elements is missing or uncertain but could have existed in the past, could be occurring now, or could exist in the future. Pathways are considered *eliminated* when one or more of these five items does not exist or where conditions make exposures highly unlikely.

A completed pathway means that people have been exposed to chemicals. That said, however, the existence of a completed pathway *does not necessarily mean that a public heath hazard existed* in the past, exists currently, or is likely to exist in the future. Chemicals found in the completed pathways were evaluated to determine whether adverse health effects could have occurred in the past, are occurring in the present, or could occur in the future.

Chemicals can get into the body in three ways:

- The chemicals can be ingested, either by drinking water, using the water for cooking or taking in small amounts of contaminants through normal hand-to-mouth activities (incidental ingestion).
- The chemicals can get into the body through the skin. This is called dermal exposure. Many chemicals, such as metals, are not absorbed through the skin easily.
- The chemicals can get into the body by breathing air containing chemicals or particles that are small enough to get into the part of the lung where they can be absorbed. This is called inhalation.

<u>Completed Pathways</u>

Ingestion of and dermal exposure to chemicals in household water – completed pathways for the past, present, and future

Metals and elements found in the well water may be naturally occurring or may be related to past coal-mining activities. Metals and elements in the well water may also result from the corrosion of metal objects, such as the metal well casing, water pumps, hot water tanks, and pipes, in contact with the water. These metals and elements may be either dissolved in the water, found as small particles in the water, or may be attached to small particles in the water such as clay or sand (silica).

People in households that use this water can come in contact with these chemicals when the water is ingested, when food is eaten that has absorbed chemicals from this water, or by incidental ingestion. The full drinking water pathway is not considered for well water because the residents in the households where the water was sampled report that they cannot drink the water because of the taste, smell, and slimy nature of the water. The drinking water pathway was considered for the spring water only. Although the chemicals tested for do not readily pass through the skin into the body, the dermal pathway was also evaluated.

Although data for the past is limited, residents report long-standing water quality issues that are associated with high levels of iron, manganese, and sulfates. The assumption was made that the chemicals in these samples have been at these levels in the water in the past. It is assumed that these chemicals will occur in the water in the future.

Eliminated Pathways

Ingestion of chemicals from the hot water tank – eliminated pathway for the past, present, and future

The content of the water from the hot water heater was not considered a direct exposure source. Hot water heaters are designed to allow solids in the water to settle to the bottom of the tank. Hot water pipes remove the water from the top of the tank. The collection of solids in the hot water tank may be particularly rapid at this site because of the corrosive nature of this water. Hot water tank manufacturers recommend that these solids be removed from the tank regularly from the spigot at the side of the tank. Opening this spigot suspends the solids in the bottom of the tank into the water being drained from the tank. Water drained from this spigot would be expected to have high concentrations of metals. The water drained from the spigot at the side of the hot water tank does not reflect the quality of the water from the hot water tap. People come into contact with hot water at the hot water tap. People are not ingesting the water from the spigot of the hot water tank. Therefore, the ingestion of water drained from the spigot of the hot water tank is eliminated for the past, present, and future because no direct exposures to this water occur.

Inhalation of chemicals in steam from household water – eliminated pathway for the past, present, and future

Residents are concerned that they are breathing the metals in the water in the steam from showering and bathing. Metals, other than mercury, do not vaporize (become a gas in the air) at water temperatures used in showering and bathing.[1] This makes metals in the steam highly unlikely. The inhalation pathway is eliminated for the past, present, and future because no inhalation exposures result from metals in steam from shower or bath water.

D. Exposure Analysis

Estimating Exposure Doses

Exposure doses are estimates of how much chemical may get into a person's body based on the person's actions and habits. The calculations rely on assumptions that identify how much, how often, and how long a person may be exposed to chemicals in the water, as well as environmental sample data that accurately reflect the chemical composition of the water. Tables 2 and 3 in Appendix A list the assumptions used in these calculations. The exposure dose calculations are explained in Appendix B. Table 4 lists the results of adding the estimated exposure doses for ingestion and dermal exposures. The review of the possible health consequences from chemical exposures examined estimated exposure doses from both ingestion and dermal exposures.

Selection of Chemicals to be Reviewed for Noncarcinogenic Effects

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1 Even boiling water does not contain metals in its steam. Note that one of the ways to remove metals from water is to distill it. The distilling process boils water, collects the steam and cools it. The steam becomes water when it cools. This distilled water is free of metals because the metals are not present in the steam coming from the water.

Health-based comparison values (CVs), such as ATSDR minimal risk levels (MRLs), and EPA reference doses (RfDs), are CVs containing exposure concentrations protective of public health. Where estimated exposure doses were below these health-based comparison values, the chemical of concern was eliminated from further review. This means that exposures to these chemicals at these levels are not expected to result in adverse health effects.

All chemicals of concern for which estimated exposure doses were over the health-based CV, or for which no health-based CV had been established, were selected for further review. Tables 2 and 3 in Appendix A outline the comparisons of estimated exposure doses and the CVs. Table 4 lists the results of adding the estimated exposure doses for ingestion and dermal exposures. Estimated exposure doses noted in bold type in Table 4 will be reviewed for potential adverse health effects.

The review for possible adverse health effects is accomplished by comparing the estimated exposure doses for these chemicals to research such as that outlined in the ATSDR toxicological profiles. An exposure dose where no effects are observed is known as the no-observed-adverse effect level (NOAEL). The lowest exposure dose where an adverse health effect is observed is called the lowest-observed-adverse effect level (LOAEL).

Selection of Chemicals to be Reviewed for Carcinogenic Effects

Theoretical cancer risks were calculated on the basis of current environmental data. Cancers can develop over many years. The method assumes that past exposures to carcinogenic chemicals were the same as those at currently measured levels.

WVDHHR calculated a theoretical excess cancer risk for arsenic exposures. Arsenic is the only chemical of concern at this site that has an EPA calculated cancer slope factor (CSF). Exposures for each age group were averaged over a 70-year lifetime. The estimates obtained for each age group were added together. This gives a theoretical excess cancer risk for a person who is exposed to the chemical over the total exposure time noted in the exposure frequency assumptions. This number was multiplied by the CSF (Tables 2 and 3).

The theoretical excess cancer risks obtained using this method are only estimates of risk because of the uncertainties and conservative assumptions made in calculating the CSFs. The actual risk of cancer is probably lower than the calculated number. The true risk is unknown and could be as low as zero. However, the method assumes no safe level for exposure to a carcinogen. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk. Therefore, the risk of cancer is likely actually lower, perhaps by several orders of magnitude. One order of magnitude is 10 times greater or lower than the original number, two orders of magnitude are 100 times, and three orders are 1,000 times.

Finally, using a reasonable evaluation of the probable or actual exposure scenarios and considering the uncertainties noted above, WVDHHR ranked the theoretical excess cancer risks using the following criteria. Theoretical cancer risks less than 1 in 10,000 were considered very low risk and are not discussed in the text. Theoretical cancer risks between 1 and 9.9 in 10,000 were classified as a low risk, 10 and 99 as a moderate risk, and greater than 99 in 10,000 as a significant risk.

E. Possible Health Consequences from Chemical Exposures at this site

Chemicals Selected for Review for Noncarcinogenic or Carcinogenic Effects

On the basis of these criteria and the data reviewed, WVDHHR selected arsenic, iron, lead, manganese, sodium, and zinc in water found in private wells sampled on this site for further review. The exposure doses reviewed are from both normal household (non-drinking) ingestion and dermal exposures (Table 4) except for spring water, which was reviewed for the drinking water pathway. The following four points summarize our findings:

- This analysis found that no adverse noncarcinogenic health effects are likely for children or adults exposed to arsenic, iron, and zinc in the well water.
- Children exposed to lead in the amounts found in the well water may experience changes in blood enzyme activity, changes in muscle function, and decreased ability to learn.
- People on sodium-restricted diets (i.e., an intake of no more than 500 mg of sodium a day) should restrict the use of local groundwater unless tests run on the water show that the amount of sodium in the water is below 20 mg/L.
- The carcinogenic risk from exposure to arsenic from both incidental ingestion and dermal exposures ranged from <1 to 7 in 10,000 people. This is a low to very low risk of developing cancer from exposure to arsenic in the water.

Arsenic – noncarcinogenic health effects

It is not unusual to find some arsenic in groundwater in West Virginia. The exposure dose over the health-based CV for arsenic, 0.0003 mg/kg/day, from ingestion and dermal exposures to private well water at this site was found to be 0.0036 mg/kg/day for a child and 0.0006 mg/kg/day for an adult. These doses were found in well water sampled by residents under "blackwater" conditions after a heavy rain.

This estimated exposure dose was compared to a study by Tseng et al. (1968) that showed skin changes, such as darkening in patches and the development of corns or warts distinctive to arsenic exposure, occurring at a LOAEL of 0.014 mg/kg/day. Applying a safety factor of 3 to the LOAEL to account for human variability results in a value of 0.0046 mg/kg/day. This is greater than the estimated exposure dose for well water under "blackwater" conditions. Therefore, no adverse noncarcinogenic health effects are likely for people exposed to arsenic in the water for normal, non-drinking, household uses [9].

Arsenic – carcinogenic effects

Several studies have shown that inorganic arsenic can increase the risk of lung, skin, bladder, liver, kidney, and prostate cancers. The calculated theoretical excess cancer risk for a person exposed to the greatest amount of arsenic found in well water, after a heavy rain, is 7 in 10,000 people. This is a theoretical estimate, adding both ingestion and dermal exposure risks. A similar estimate of cancer risk, using the amount of arsenic in the water sampled by University staff, prior to heavy rains, is <1 in 10,000. A person in a household would have a risk of cancer somewhere between <1 and 7 in 10,000, depending on the level of arsenic found in the water. This level of theoretical cancer risk from exposure to arsenic in on-site water is considered low to very low.

Iron – noncarcinogenic effects

Iron is a very common element in the earth's crust. Water naturally contains iron. In some areas, such as where coal is present or has been mined, iron can be found in water in concentrations that can affect water quality. Iron is an essential nutrient needed for good health. High levels of iron ingestion are generally not harmful.

Water that is high in iron often contains iron bacteria that make a red-brown slime that can clog water systems. Iron bacteria do not cause any diseases in humans. Iron bacteria are responsible for corrosion of piping and plumbing [10]. Water containing a type of iron called Aferric iron@ appears to have black or rust colored particles, which are small particles of iron [11]. Iron in water more than 0.1 to 0.2 mg/L can cause the water to taste bitter or astringent. Iron was found in private well water at this site as high as 57 mg/L.

The highest exposure doses to iron from household (non-drinking) ingestion and dermal exposures to private well water were found to be:

- 0.328 mg/kg/day for a child and 0.053 mg/kg/day for an adult from exposure to iron in University staff-sampled well water.
- 0.746 mg/kg/day for a child and 0.122 mg/kg/day for an adult from exposure to iron in well water sampled by residents under "blackwater" conditions after a heavy rain.

Iron found in water at these levels is not expected to cause adverse health problems in the general population, although water containing iron at these levels tastes, contains black particles, is slimy, and stains porcelain and laundry.

Some people have a genetic disease called hemochromatosis. People with this condition accumulate iron in their bodies. This is a relatively common genetic disease. Some estimates are that one person out of every 300 has this condition. The accumulation of iron can damage the liver, heart, and pancreas. This condition may make Alzheimer's more severe. People with this disease accumulate iron from any source and need medical treatment to reduce the amount of iron in their body. Avoiding iron in the diet, including water, does not prevent, control, or cure this condition. However, to assist with their therapy, which seeks to remove as much iron from the body as possible, people with hemochromatosis should avoid ingesting water containing a lot of iron [12].

Lead – noncarcinogenic effects

Lead, a naturally occurring metal, can be found in all parts of the environment. Lead is used in the production of batteries, ammunition, solder, and pipes. Lead in water is often from solder, pipes or fixtures that are releasing lead as they corrode. Lead has many adverse health effects, particularly to children exposed to this chemical. The highest exposure doses to lead from household (nondrinking) ingestion and dermal exposures were found to be:

- 0.0003 mg/kg/day for a child and 0.0001 mg/kg/day for an adult from exposure to lead in University staff-sampled well water.
- 0.0014 mg/kg/day for a child and 0.0002 mg/kg/day for an adult from exposure to lead in well water sampled by residents under "blackwater" conditions after a heavy rain.

The exposure dose for a child ingesting and contacting water under "blackwater" conditions approaches the NOAEL of 0.0015 mg/kg/day for hematologic, neurologic, and reproductive health effects seen in studies on rats (Krasovskii et al. 1979). The LOAEL for this study was

0.005 mg/kg/day. Rats were found to have changes in motor ability and conditioned responses and showed changes in enzyme activity in sperm cells. Applying a safety factor of 30 to the LOAEL to account for human variability and extrapolating the value from rats to human beings results in a value of 0.00017 mg/kg/day. The estimated exposure doses for children are greater than this number. Therefore, children exposed to lead in the highest amounts found in the well water tested may experience some changes in blood enzyme activity, changes in muscle function or decreased ability to learn [13].

Manganese – noncarcinogenic effects

Manganese is usually found in water that contains iron. While people need manganese in the diet for good health, too much of the chemical has been shown to cause health problems. Most people get more manganese from their diet than from water. A diet high in vegetables will have more manganese than other diets. However, more manganese is absorbed from water than from food [14]. Assessing exposure to manganese is complex because people ingest manganese in food, water, and some mineral supplements. In addition, people have different responses to manganese in the body.

Amounts of manganese more than 0.1 mg/L cause water to taste bad, have black sediment, and will stain laundry and plumbing. Manganese was found in the well water at this site up to 4 mg/L.

Current evidence strongly suggests that older people may be more sensitive to the effects of high manganese in the body. Although the data suggest that children are potentially susceptible to manganese toxicity, the current evidence is not sufficient to allow any assessment for the differing reactions of children. Newborn infants less than a month old retain more manganese in their bodies than older children and adults. This has led several researchers to be concerned about manganese levels in infant formula [15]. The use of water containing manganese for reconstituting formula for infants may result in adverse health effects. This exposure route was not assessed for this health consultation because of reports that this water was not used for drinking.

The EPA chronic oral reference dose (RfD) for manganese is 0.014 mg/kg/day. This value was divided by a modifying factor of three as recommended by EPA when assessing the risk from manganese in water or soil [15]. The exposure dose to manganese from household (non-drinking) ingestion and dermal exposure over the 0.05 mg/kg/day health-based CV was 0.051 mg/kg/day for a child. This dose was found in well water sampled by residents under "blackwater" conditions after a heavy rain.

Exposure dose levels were well under the health-based CV when the water was sampled when the water sampled was not affected by heavy rains. The total exposure to manganese for a child in a household would be a mix of exposures during dry and rainy weather conditions. The mixture of these exposure doses is expected to be below the health-based CV. Therefore, no adverse health effects are expected from exposure to manganese in this private well water used for household (nondrinking) uses.

Sodium – noncarcinogenic effects

Sodium was found in well water up to 189,000 mg/L. The spring water contained 41,300 mg/L sodium. Water treatment systems often use salt, containing sodium, to soften the water. At least part of the sodium in some of the well water likely is from the home water treatment systems. The highest exposure doses to sodium from household (nondrinking) ingestion and dermal exposure were found to be:

- 2.38 mg/kg/day for a child and 0.39 mg/kg/day for an adult from exposure to sodium in University staff-sampled well water.
- 2.45 mg/kg/day for a child and 0.40 mg/kg/day for an adult from exposure to sodium in well water sampled by residents under “blackwater” conditions after a heavy rain.

The exposure dose for people exposed to sodium in the spring water was calculated to be 4.15 mg/kg/day for a child and 1.20 mg/kg/day for an adult on the basis of calculations that assumed the water was used for drinking.

On the basis of the amount of sodium found in these samples, persons on sodium-restricted diets (i.e., a total intake of no more than 500 mg of sodium a day) should restrict using water from local wells or springs for drinking or cooking [16].

Zinc – noncarcinogenic effects

Zinc is a very common element in the earth’s crust. Most drinking water contains zinc. Zinc is found in soil, water, and in all foods. Small amounts of zinc are essential for human health. Too much zinc can be harmful to health. The highest exposure dose to zinc in the well water from household ingestion and dermal exposure was found to be 0.073 mg/kg/day for a child. This dose was found in well water sampled by residents under “blackwater” conditions.

No other exposure doses to zinc were found to be over the health based CV for zinc, 0.03 mg/kg/day [17].

This estimated exposure dose was compared to a study by Yadrick et al. 1989. The study found changes in blood chemistry at a LOAEL of 0.83 mg/kg/day. Applying a safety factor of 3 to the LOAEL to account for human variability results in a value of 0.28 mg/kg/day. This number is greater than the estimated exposure dose for a child exposed to water under “blackwater” conditions. Therefore, no adverse health effects are expected from exposures to zinc in well water using the assumptions outlined in this report.

F. Health Outcome Data

The WVDHHR has no record of an investigation of any child with an elevated blood lead level in this area from 1994 until the present. This indicates that area physicians have not referred any cases to the WVDHHR for the last 10 years.

Consultation with the West Virginia Cancer Registry indicates that the types of cancers in this area are similar to Mingo County as a whole. Cancer rates are age-adjusted to take into account that most cancers become more common in older people. In order to compare populations of different ages, the rates are “age-adjusted.” The incidence rate is the number of newly diagnosed cases per year, averaged from all the cases newly diagnosed over a 5-year period. The 5-year average annual age-adjusted rate of cancers of the lung and bronchus in Mingo County is high compared to the incidence rate in West Virginia and the United States. Other types of cancers for which the West Virginia Cancer Registry publishes average annual age-adjusted rates (female breast, colon and rectum, and prostate) do not show that the rates in Mingo County are significantly higher than those in the United States as a whole [18]. No chemicals tested for in the well water are likely to cause a measurable increase in the lung cancers diagnosed at this site.

No other health outcome data were available for the other possible adverse health outcomes noted in this discussion.

G. Community Health Concerns

Community members are concerned that local well water may be the cause of many cancers, kidney stones, kidney failure, birth defects, breathing problems, arsenic poisoning, Attention Deficit Disorder, Alzheimer’s disease (dementia), typhoid, hepatitis, strep throat, dry skin, rotten tonsils, ulcers, blood in urine and stools, and stomach illness (parasites) in the area.

No evidence indicates that cancers, kidney failure, birth defects, breathing problems, dementia, or Attention-Deficit Disorder are related to the metals tested in the well water in homes in this area.

Arsenic found in the well water was not likely to cause adverse health problems from the household exposures assumed in this report.

Chronic obstructive pulmonary disease (COPD) is a very common disease in Mingo County. COPD causes breathing problems. The Mingo County COPD rate of death, 87.1 people in a population of 100,000, is more than twice the rate for the United States as a whole (40.5 people in a population of 100,000) [19]. Risk factors for this disease are long-term smoking, heredity, exposure to second-hand smoke, and exposure to air pollution. No chemicals tested for in the well water were identified that would link likely exposures at this site to the development of COPD.

The cause of kidney stones is often unknown, although many people have a family history of developing them. People with this family history absorb more calcium from water, food, and supplements that do other people. The calcium is excreted in the urine as calcium oxalate. Sometimes the calcium oxalate makes a kidney stone. In addition, people who have chronic bowel inflammation tend to excrete calcium oxalate in their urine. The best way to avoid the formation of kidney stones is to drink a lot of water.

Several of the community health concerns may be related to bacteria and parasites that are in well water used in the home. Typhoid, rotten tonsils, hepatitis, ulcers, stomach illness (parasites), and blood in urine and stools may be related to infections from bacteria or parasites. Some of these conditions, such as blood in urine or stools may have other causes. This health consultation considered possible adverse health effects from exposure to chemicals, not from infections. These serious health issues are outside the scope of this health consultation. People with these conditions are strongly advised to consult with their personal physicians.

Child Health Considerations

The many differences between children and adults demand special consideration. Children can be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and often use hand-to-mouth behaviors that increase their exposure potential. Children are shorter than adults; they breathe dust, soil, and vapors close to the ground. Children are smaller than adults which results in a greater dose of a substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, access to medical care, and risk identification. This health consultation considered potential health effects to children to assist adults who make decisions regarding their children's health.

Children's exposure doses to the chemicals found in local well and spring water were reviewed. The review found that some of the well water contained lead in amounts that may affect brain and blood functions in children.

Although manganese toxicity for infants has not been confirmed, concern exists about the potential for changes to brain function of newborn babies exposed to levels of manganese at levels that are found in the private well water at this site. Until additional information is available, WVDHHR advises that newborn infants should not be fed formula reconstituted with water from private wells at this site.

Conclusions

The five public health hazard categories used by ATSDR are; no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

The WVDHHR concludes that the Williamson WV Sites pose a **Public Health Hazard for the past, present, and future** because of chronic exposure of the public, especially children, to lead and sodium in on-site private well water when the water is used for cooking (but not drinking) and other household uses. The amount of sodium in the water can potentially lead to adverse health effects to people on sodium-restricted diets who regularly drink water from a local spring. This is consistent with the first health consultation written for this site, which made recommendations about elevated levels of manganese and sulfates based on the previously available data on private well water quality at this site.

The conclusions of this report are based on the data reviewed. The sampling protocol did not follow accepted quality control procedures. This may have affected the final test results. In addition, conclusions are based on a very small sample size, which may not reflect the quality of all the wells in the area. The conclusions based on these data are limited by these factors.

These conclusions are based on the use of private well water in homes for all uses except drinking.

1. Children exposed to lead in the amounts found in the well water may experience changes in blood enzyme activity, changes in muscle function and decreased ability to learn.
2. People on sodium-restricted diets (i.e., an intake of no more than 500 mg of sodium a day) should restrict the use of local well and spring water for drinking and household uses.
3. The theoretical carcinogenic risk from exposure to arsenic in the well water through incidental ingestion and dermal exposures ranged from <1 to 7 in 10,000. This is a low to very low risk of developing cancer from exposure to arsenic in the water.

On the basis of the data reviewed, pathways for the past, present, and future were eliminated for exposures to water drained from the hot water tank, exposures to chemicals from the local spring used for drinking (present exposures only), and for inhalation of chemicals in steam during showering or bathing.

The available data and the University's study design do not allow conclusions to be made regarding

- the effect, if any, of the coal slurry impoundment on the well water quality
- the effect, if any, of changes in groundwater after a lot of rain because of the potential influence of surface water on some wells; or
- the chemical composition of groundwater at this site.

WVDHHR recognizes the extremely poor water well quality in this area, both from the presence of coliform bacteria in many of the wells and the bad taste, smell and color of the water. WVDHHR recognizes the need for quality water for the people living at this site.

Recommendations

1. Avoid using area well water for cooking and drinking if you are on a sodium-restricted diet.
2. The private well water should not be used to reconstitute formula for very young infants because of concern about possible accumulation of harmful amounts of manganese in young infants.
3. People who have a genetic disease called hemochromatosis should avoid using water high in iron for drinking and cooking to assist the treatment of this disease.
4. Public water should be provided to the residents at this site as soon as possible.
5. People should avoid drinking water containing coliform bacteria because of the potential of developing water-borne diseases.

Public Health Action Plan

1. The WVDHHR will provide information to residents and local medical providers about potential health effects of lead and sodium in the water and the need for people with hemochromatosis to avoid using this water for drinking or cooking.
2. The WVDHHR will provide information to residents about the potential health effects from drinking water containing coliform bacteria and ways to avoid illness from bacterial-contaminated water.

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Certification

The West Virginia Department of Health and Human Resources (WVDHHR) prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures in existence at the time the health consultation was initiated.

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The Division of Health Assessment and Consultation of ATSDR has reviewed this health consultation and concurred with its findings.

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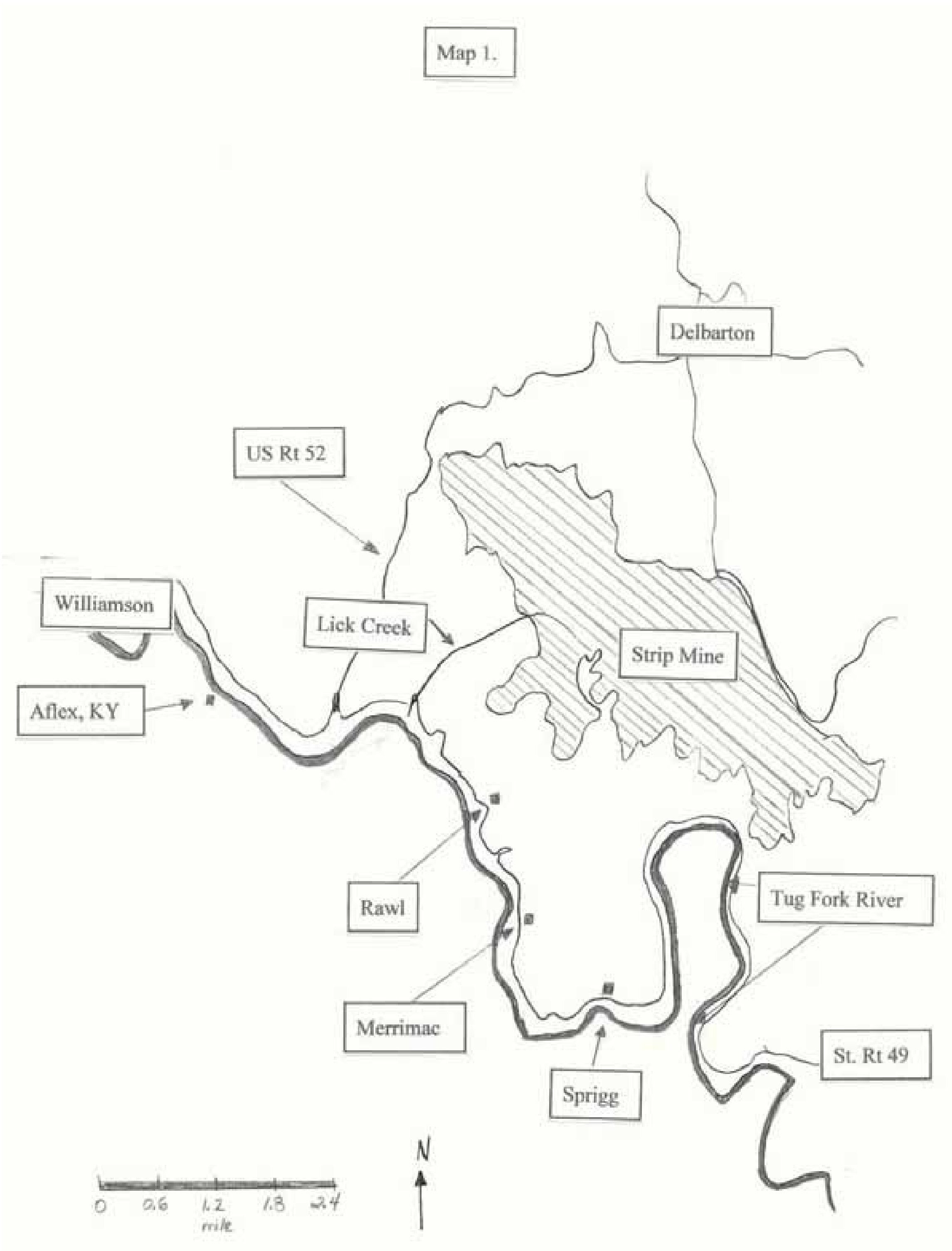
Figure 1. Site Vicinity Map



Appendix A: Tables

Appendix B: Calculation of Exposure Doses

Calculation of exposure factors

The exposure factor is the time period that exposure to a chemical is assumed to occur divided by the total time period during which the exposures occur. For instance, an exposure factor for a person exposed 180 days a year for 30 years out of a lifetime of 70 years would be 0.211. The formula used is:

$$\frac{\text{180 days per year (actual exposure time)} \times \text{30 years (actual exposure time)}}{\text{365 days per year (total days in a year)} \times \text{70 years (years of exposure or years in a lifetime)}}$$

All carcinogenic risks are calculated using a 70-year time period. This averages the risk of exposure over a lifetime. Noncarcinogenic risks use the actual exposure time estimated for this particular site as the years of exposure.

Calculation of Ingestion Exposure Doses

Estimated exposure doses (expressed as milligrams per kilogram per day or mg/kg/day) were calculated using this formula:

$$ed = a \times c \times ef \times abs \times cf / bw, \text{ where}$$

ed = exposure dose; *a* = amount of water ingested in a day *c* = concentration of the chemical in the water; *ef* = exposure factor; *abs* = absorption factor; *cf* = conversion factor, *bw* = body weight

The amount of water ingested in a day (*a*) for nondrinking household uses was assumed to be 0.125 liter or one-half cup a day. This assumption was made to take into account incidental ingestion as well as water used for cooking. People who eat food cooked in this water may ingest metals or elements in the water used in soups or hot cereals, absorbed by pasta products, or foods that have absorbed these chemicals from the water.

The amount of water ingested in a day (*a*) for drinking was assumed to be 1 liter a day for a child and 2 liters a day for an adult.

Arsenic is 80% absorbed (*abs*) when ingested [9]. All other chemicals were assumed to be 100% absorbed.

The conversion factor (*cf*), 0.001, is used to convert the chemical concentration from mg/L to µg/L.

The assumptions used for amount of water ingested, exposure times, and body weight are noted in Table 2**.** The assumptions used for the ingestion pathway require a persistent pattern of ingesting water.

Calculation of Dermal Exposure Doses

Exposure to contaminants through the skin (dermal exposure) is assumed to occur when water comes into contact with the skin, such as during bathing or showering. The absorbed exposure dose formula for dermal exposure to water is:

$$aed = c \times p \times ta \times sa \times ef \times cf / bw, \text{ where}$$

aed = absorbed exposure dose; *c* = concentration of the chemical in water; *p* = permeability coefficient; *ta* = toxicity adjustment; *sa* = exposed body surface area; *ef* = exposure factor; *cf* = conversion factor (1 liter/1,000 cubic meters) *bw* = body weight

The contaminant concentrations used "*c*" are the maximum amounts, expressed as micrograms per liter (µg/L) or parts per billion (ppb), from Table 3. The conversion factor (*cf*), 0.001, is used to convert the chemical concentration from mg/L to µg/L.

The permeability coefficient (*p*) is the rate that the chemical is absorbed through the skin. The larger the number, the faster the chemical is absorbed [20]. Permeability coefficients are expressed as centimeters per hour.

Some chemicals are not absorbed well through the intestinal tract. The toxicity adjustment factor (*ta*) is used for these chemicals t make the comparison from dermal exposure to the oral health-based guidelines more accurate. A toxicity adjustment factor of one means that the chemical is absorbed well through the intestinal tract and no adjustment for dermal uptakes is needed.

One hundred percent (100%) of a person's skin or body surface *(sa)* was assumed to be in contact with the water, when showering, bathing, or at other times when water is in contact with the skin [21].

The time of exposure was assumed to be one hour per day. This is higher than the assumptions used by the EPA for the length of time for a bath or shower (using a median value). However, some children take baths of 1 hour in length (EPA 95% percentile figures). One hour per day is assumed to be as long as, or longer than, any person at this site would be in 100% skin contact with the well water per day [22].

The dermal exposure dose calculations and assumptions are in Table 3.