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May 31, 2016

To: [redacted]

Re: Potential Risk of Arsenic in a Private Well

The Arizona Department of Health Services (ADHS) received your request to evaluate the potential health risks associated with arsenic levels in your private well. The following summarizes our assessment results.

Background

On April 26, 2016, you submitted lab results to ADHS from Aquatic Consulting & Testing, Inc. which tested for arsenic concentrations in your bathroom tub and wellhead. While you and your husband are not using your private well for drinking, you raised concerns about long-time exposure to arsenic in the water through showering. You explained that your husband has been experiencing numbness and tingling throughout his body, and would like to know if the arsenic levels in your well water could be causing these health effects. In addition to showering, the well water is also being used in your residence for brushing teeth, dish washing, and food preparation. As of March 2016, you had lived in the house for 10 years.

Available Environmental Data

The lab results you submitted from Aquatic Consulting & Testing, Inc. used EPA Method 200.8: Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma – Mass Spectrometry (ICP-MS). They showed the following results for arsenic:

Location	Arsenic Concentration (ppb[1])
Bathroom Tub	150
Well Head	180

[1] ppb: parts per billion

Exposure Pathway Analysis

Identifying exposure pathways is important in a health consultation because adverse health impacts can only happen if people are exposed to contaminants. The presence of a contaminant in the environment does not necessarily mean that people are actually coming into contact with that contaminant. Exposure pathways have been divided into three categories: completed, potential, and eliminated.

There are five elements considered in the evaluation of exposure pathways:

1) a source of contamination
2) a medium such as soil or groundwater through which the contaminant is transported
3) a point of exposure where people can contact the contaminant
4) a route of exposure by which the contaminant enters or contacts the body
5) a receptor population

Completed pathways exist when all five elements are present and indicate that exposure to a contaminant has occurred in the past and/or is occurring presently. In a potential exposure pathway, one or more elements of the pathway cannot be identified, but it is possible that the element might be present or might have been present. In eliminated pathways, at least one of the five elements is or was missing, and will never be present. Completed and potential pathways, however, may be eliminated when they are unlikely to be significant.

For this case, the exposure pathway of concern is through incidental ingestion of the water that may occur during showering, bathing, brushing teeth, dish washing, and food preparation. Since arsenic is not a volatile organic compound, the escape of arsenic from water into the air can be assumed to be negligible. Therefore, inhalation of arsenic is not a pathway of concern for this scenario. Also, if you get arsenic-contaminated water on your skin, only a small amount will go through your skin into your body, so exposure to arsenic through dermal contact is usually not of concern (ATSDR 2007). Therefore, this report will focus on the incidental ingestion exposure pathway for arsenic.

Exposure Pathway Elements					Time Frame	Type of Exposure Pathway
Source	Media	Point of Exposure	Route of Exposure	Estimated Exposed Population		
Private Well	Well Water	Residence tap	Incidental ingestion	Residents	Past	Completed
					Current	Completed
					Future	Potential

Description of Health-based Comparison Values

Health-based comparison values (CVs) are screening tools used to evaluate environmental data relevant to exposure pathways. The comparison values are quite conservative, and usually include uncertainty factors that account for the most sensitive populations. Adverse health effects are not expected to occur if an exposure concentration/dose is below a CV. However, an exposure concentration/dose at or above the CV does not mean adverse effects will occur. Rather, it means that there is a need to conduct a site-specific exposure scenario evaluation. The health risk for an individual depends on individual human factors (e.g. personal habits, occupation, and/or overall health), and site-specific environmental exposure factors (e.g. duration and amount of exposure). Therefore, CVs should not be used to predict the occurrence of adverse health effects without looking at site-specific conditions. CVs are only used to help determine if the contaminant needs to be evaluated in more detail.

The analytical results were compared to the following CVs: chronic Environmental Media Evaluation Guide (chronic EMEG), and Cancer Risk Evaluation Guide (CREG). EMEGs are estimated contaminant concentrations that are not expected to result in adverse noncarcinogenic

health effects based on ATSDR evaluation. CREGs are estimated contaminant concentrations that would be expected to cause no more than one additional cancer in a million persons exposed during their lifetime.

Chemical	Maximum Detected Concentration (ppb)	Comparison Value (ppb)	Source of CV	Is it a Contaminant of Concern?
Arsenic	180	11; 0.023	Adult chronic EMEG; CREG	Yes

Arsenic is selected for further evaluation because its concentration is above its health-based comparison values. However, it should be noted that the comparison values are for drinking water, but the well water is not planned to be used for drinking.

Public Health Implications: *This section will provide general toxicological information and site-specific exposure evaluation.*

Arsenic is a naturally occurring element widely distributed in the earth's crust and can be found in air, water, and soil. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in living organisms combines with carbon and hydrogen to form organic arsenic compounds.

Ingesting very high levels of arsenic can result in death. Exposure through ingestion to lower levels of arsenic can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet. Ingesting low levels of inorganic arsenic for a long period of time can cause a darkening of patches of the skin (known as hyperpigmentation), and the appearance of small "corns" or "warts" on the palms, soles, and torso.

Several studies have linked ingestion of inorganic arsenic to increases in skin cancer and cancer in the liver, bladder, and lungs. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans (ATSDR 2007).

Non-Cancerous Health Effects

To determine potential non-cancerous health risk, the arsenic concentration results were converted to drinking water ingestion doses (see Appendix A for the ingestion equation). While the well water is not used for drinking, incidental ingestion of the water may occur during showering and brushing teeth. For adults, ADHS assumes a daily water intake rate of 10 mL/day due to incidental ingestion that may occur during showering or brushing teeth. This would make the corresponding incidental ingestion dose equal to 2.16×10^{-5} mg/kg/day.

A Minimal Risk Level is an ATSDR estimate of daily human exposure to a substance at or below which that substance is unlikely to pose a measurable risk of adverse noncancerous effects (ATSDR 2016). The oral chronic MRL for arsenic is 3×10^{-4} mg/kg/day. This MRL was determined based on an investigation of the incidence of Blackfoot Disease and dermal lesions (hyperkeratosis and hyperpigmentation) in a large number of poor farmers exposed to high levels of arsenic in well water in Taiwan (ATSDR 2007). Neurological effects have been noted at oral

arsenic doses above 3 x 10^{-2} mg/kg/day. Since the estimated incidental ingestion dose for arsenic is below the MRL, ADHS does not expect to see non-cancerous adverse health effects.

Cancerous Health Effects

ADHS estimated the cancer risk using EPA's cancer slope factor. EPA has calculated an oral cancer slope factor of 1.5 per mg/kg/day for arsenic. Doses are calculated slightly differently for cancer risk estimation than for non-cancer risk estimation due to the consideration of lifetime exposure (78 years) in the development of cancerous health effects. The corresponding incidental water ingestion exposure dose, assuming 30 years of exposure, for cancer risk is 8.30 x 10^{-6} mg/kg/day. This makes the estimated excess lifetime cancer risk equal to 1.24 x 10^{-5}.

Cancer risks are explained in terms of the likelihood that an additional case of cancer will occur in a population. For example, one additional cancer case in 1,000,000 exposed individuals indicates that there is a very low cancer risk. EPA has established a target risk range of between 1 additional cancer risk in 1,000,000 exposed individuals to 1 additional cancer risk in 10,000 exposed individuals (10^{-6} to 10^{-4}) for hazardous sites. Cancer is a complex group of diseases with many possible causes, including genetic factors; lifestyle factors such as tobacco use, diet and physical activity; certain types of infections; and environmental exposures to different types of chemicals and radiation (American Cancer Society 2016).

The estimated excess lifetime cancer risk is within EPA's target risk range of 10^{-6} to 10^{-4}.

Conclusion

ADHS recommends that you do not use the well water for drinking, cooking, or food preparation, as this could lead to significant ingestion of the water. Based on the available information, ADHS does not expect to see noncancerous or cancerous health effects from using the well water for showering, bathing, brushing teeth or dishwashing. However, you may consider using an alternate source of water for brushing your teeth to further reduce exposure.

ADHS also recommends that you find an alternate source of drinking water for your dog. While we do not have specific information on the potential health effects of arsenic on dogs, drinking water with arsenic levels above 20 ppb is not recommended for livestock or poultry (NMSU 2009). The arsenic levels in the well water at your residence are well above 20 ppb.

The most cost-effective method for removing arsenic from a private water supply appears to be reverse osmosis (RO). For more information on RO, please see the following link.

If you have any questions, please contact Kaleb Tsang by e-mail at Kaleb.Tsang@azdhs.gov or call (602) 364-3847.

References:

American Cancer Society (2016). What Causes Cancer?. Available at: http://www.cancer.org/cancer/cancercauses/ Last access: May 10, 2016.

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Oregon Health Authority (2016). Drinking Water Program Fact Sheet: Recommendations for Arsenic Removal from Private Drinking Water Wells in Oregon. Available at: http://public.health.oregon.gov/HealthyEnvironments/DrinkingWater/SourceWater/Documents/gw/arsenicremoval.pdf. Last access: May 31, 2016.

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University of Iowa (2015). Private Well Water: Frequently Asked Questions. Available at: http://www.shl.uiowa.edu/env/privatewell/faq.xml#26. Last access: May 10, 2016.

Appendix A

Water Ingestion Exposure Dose Equation

$$D = \frac{C \ x \ IR \ x \ EF}{BW}$$

D = exposure dose (mg/kg/day)
C = contaminant concentration (mg/L)
IR = intake rate of contaminated water (L/day)
EF[1] = exposure factor (unitless)
BW[2] = body weight (kg)

[1] Exposure factor assumed to be 350 days / 365 days per year for non-cancer risk, 30 yr x 350 days / 78 yr x 365 days for cancer risk
[2] Adult body weight assumed to be 80 kg