Drinking Water Quality: Arsenic Contaminant Levels

Type of EPHT Indicator	Hazard, Exposure
Measures	Level of Contaminant in Finished Water 1. Yearly distribution of number of Community Water Systems (CWS) by maximum arsenic concentration (cut-points: 0-5, >5-10, >10-30, >30 µg/L arsenic). 2. Yearly distribution of number of CWS by mean arsenic concentration (cut-points: 0-5, >5-10, >10-20, >20-30, >30 µg/L arsenic). 3. Average Concentration of Arsenic, by Year. Potential Population Exposure to Contaminants in Finished Water 4. Yearly distribution of population served by Community Water Systems (CWS) by maximum arsenic concentration (cut-points: 0-5, >5-10, >10-30, >30 µg/L arsenic). 5. Yearly distribution of population served by CWS by mean arsenic concentration (cut-points: 0-5, >5-10, >10-20, >20-30, >30 µg/L arsenic).
Derivation of Measures	Arsenic measures will be developed from water system attribute and water quality data stored in state Safe Drinking Water Act (SDWA) databases such as the Safe Drinking Water Information System (SDWIS/State). Data will be cleaned and transformed to a standard format. Analytical results of drinking water samples (usually taken at entry points to the distribution system or representative sampling points after treatment) will be used in conjunction with information about each CWS (such as service population and latitude and longitude of representative location of the CWS service area) to generate the measures.
Units	Concentration of arsenic, µg/L
Geographic Scope	State and Community Water System
Geographic Scale	The finest detail will be approximate point location of the community water distribution system represented by water withdrawal point, water distribution extents, principal county served, or principal city served.
Time Period	2000-Most Recent Year Available
Time Scale	Calendar year
Rationale	**Arsenic and Public Health** Exposures to higher than average levels of arsenic can come from elevated localized soil and ground water concentrations from application and runoff of arsenical pesticides and leachate from coal ash and landfills (ATSDR 2005). Exposure to hundreds of micrograms per liter of arsenic found in drinking water of Taiwan, Chile, Argentina, Mexico, Bangladesh, and India has been associated with many adverse health effects including lung, bladder, liver and skin cancers (NRC, 1999; Rahman et al. 2005; Salazar et al. 2004; Fazal et al., 2001). Arsenic has been identified as a human carcinogen by the International Agency for Research in Cancer (IARC) (IARC, 2004). Other adverse health effects include nausea, cardiovascular disease, (Chen et al., 2007; Chih-Hao et al., 2007; Bunderson et al., 2004), developmental and

	reproductive effects (Hopenhayn et al., 2003; Ahmad et al., 2001)), Diabetes Mellitus (Rahman et al., 1998), and skin keratosis and hyperpigmentation (Kapaj et al., 2006). Measured arsenic concentrations in finished drinking water can be used to understand the distribution of potential arsenic exposure levels for populations served by community water supplies. These measures allow for comparison of potential for arsenic exposures between the populations served by different water systems and water sources over time, and potentially across demographic groups. **Sources of Arsenic** Arsenic compounds (As (III) and As (V)) are found in both ground water and surface waters. The primary sources are geologic formations from which arsenic can be dissolved. Higher levels of arsenic tend to be found in ground water (e.g. aquifers) as compared to surface waters (e.g., lakes, rivers). **Arsenic Regulation and Monitoring** In 2001 EPA reduced the regulatory drinking water standard Maximum Contaminant Level (MCL) to 10 µg/L from 50 µg/L (effective January 23, 2006) on the basis of bladder and lung cancer risks (EPA 2001a). The cancer risks were extrapolated from the Taiwanese (Chen et al. 1985) study to U.S. risks. Lowering the MCL from 50 to 10 ppb statistically reduces bladder and lung cancer mortality and morbidity by 37-56 cancers a year in the U.S. (EPA 2001b). Based on the current understanding of the health impacts from arsenic exposure, the potential for adverse health effects from drinking water exposure to arsenic is very low for most municipal drinking water systems.
Use of Measure	These measures can assist by addressing the following surveillance functions: • Distribution measures provide information on the number of CWS and the number of people potentially exposed to arsenic at different concentrations. • Maximum concentrations provide information on the peak potential exposure to arsenic at the state level. • Mean concentrations at the CWS level provide information on potential exposure at a smaller geographic scale.
Limitations of The Measure	Measures do not account for the variability in sampling, numbers of sampling repeats, and variability within systems. Concentrations in drinking water cannot be directly converted to exposure, because water consumption varies by climate, level of physical activity, and between people (EPA 2004). Due to errors in estimating populations, the measures may overestimate or underestimate the number of affected people.
Data Sources	Iowa Department of Natural Resources
Limitations of Data Sources	Samples are taken once a year (surface sources), once every three years (groundwater sources), or once every nine years (for sources with a waiver).

	Frequency of sampling is based on compliance with the MCL; the lower the measured concentration the fewer samples will be taken and some years there may be no sampling for arsenic. Ground water systems may have multiple wells with different arsenic concentrations that serve different parts of the population. Compliance samples are taken at each entry point to the distribution system. In systems with separate wells serving some branches or sections of the distribution system, the system mean would tend to underestimate the arsenic concentration of people served by wells with higher arsenic concentrations. Exposure may be higher or lower than estimated if data from multiple entry points for water with different arsenic levels are averaged to estimate levels for the PWS.
Related Indicators	Public Water Use
References	1. Ahmad SA, Sayed MH, Barua S, Khan MH, Faruquee MH, Jalil A, Hadi SA, Talukder HK., 2001. Arsenic in drinking water and pregnancy outcomes. Environmental Health Prospectives; 109(6):629-31. 2. ATSDR 2005. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Arsenic. Draft for Public comment. September 2005. Available at http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=22&tid=3 3. Bunderson M, Brooks DM, Walker DL, Rosenfeld ME, Coffin JD, Beall HD., 2004. Arsenic exposure exacerbates atherosclerotic plaque formation and increases nitrotyrosine and leukotriene biosynthesis. Toxicology and Applied Pharmacology 2004 Nov 15;201(1):32-9. 4. Chen C-J, Chuang Y-C, Lin T-M, Wu H-Y. Malignant neoplasms among residents of a blackfoot disease-endemic area in Taiwan: high-arsenic well water and cancers. Cancer Res. 1985;45:5895–5899 5. Chen Y., Factor-Litvak P., Howe GR., Graziano JH., Brandt-Rauf P., Parvez F., van Geen A., Ahsan H., 2007. Arsenic exposure from drinking water, dietary intakes of B vitamins and folate, and risk of high blood pressure in Bangladesh: a population-based, cross-sectional study. American Journal of Epidemiology, Mar 1;165(5):541-52 6. Chih-Hao Wang, Chuhsing Kate Hsiao, Chi-Ling Chen, Lin-I Hsu, Hung-Yi Chiou, Shu- Yuan Chen, Yu-Mei Hsueh, Meei-Maan Wu, Chien-Jen Chen 2007. A review of the epidemiologic literature on the role of environmental arsenic exposure and cardiovascular diseases. Toxicology and Applied Pharmacology 222 (2007) 315–326. 7. Fazal MA, Kawachi T, Ichion E. Extent and severity of groundwater arsenic contamination in Bangladesh. Water International (2001) 26:370–79 8. Hopenhayn C, Ferreccio C, Browning SR, Huang B, Peralta C, Gibb H, Hertz-Picciotto I., 2003. Arsenic exposure from drinking water and birth weight. Epidemiology.;14(5):593-602. 9. IARC 2004. Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 84. Some Drinking Water Disinfectants and

Contaminants, including Arsenic. September Lyon, pp. 39-267. Available at http://monographs.iarc.fr/ENG/Monographs/vol84/volume84.pdf

10. Kaltreider RC, Davis AM, Lariviere JP, Hamilton JW. 2001. Arsenic alters the function of the glucocorticoid receptor as a transcription factor. Environ. Health Perspect 109:245-251.
11. Kapaj S., Peterson H., Liber K., Bhattacharya P., 2006. Human health effects from chronic Arsenic poisoning-A review, Journal of Environmental Science and Health, Part A;41(10):2399-2428.
12. Karagas M, Stukel TA, Tosteson TD. 2002. Assessment of cancer risk and environmental levels of arsenic in New Hampshire. Int. J. Hyg. Environ. Health 205, 85-94.
13. NCI .2003. Ries LAG, Eisner MP, Kosary CL, Hankey BF, Miller BA, Clegg L, Mariotto A, Fay MP, Feuer EJ, Edwards BK (eds). SEER Cancer Statistics Review, 1975-2000, National Cancer Institute (NCI). Bethesda, MD, http://seer.cancer.gov/csr/1975_2000/, 2003. http://seer.cancer.gov/csr/1975_2000/results_single/sect_01_table.01.pdf
14. National Research Council. Arsenic in Drinking Water, National Academy Press. 1999.
15. Rahman M., Tondel M., Ahmad SA., Axelson O., 1998. Diabetes Mellitus associated with Arsenic exposure in Bangladesh. American Journal of Epidemiology, Vol 48, no2, pp 198-203.
16. Rahman MM, Sengupta MK, Ahamed S, et al. Arsenic contamination of groundwater and its health impact on residents in a village in West Bengal, India. Bulletin of the World Health Organization (2005) 83:49–57.
17. Salazar et al. 2004. p53 Expression in circulating lymphocytes of non-melanoma skin cancer patients from an arsenic contaminated region in Mexico. A pilot study. Molecular and Cellular Biochemistry 255:25-31.
18. U.S. EPA 2000a. Arsenic in drinking water proposal, 65 FR 38888 at 38894 and 38897, June 22, 2000, available at http://www.epa.gov/fedrgstr/EPA-WATER/2000/June/Day-22/w13546.htm and http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2000_register&docid=00-13546-filed.pdf
19. U.S. EPA 2000b. Arsenic in Drinking Water Rule Economic Analysis December 2000, available at http://www.epa.gov/safewater/arsenic/history.html
20. U.S. EPA 2001a. Arsenic in drinking water final rule, 66 FR 6976. Available at http://www.epa.gov/fedrgstr/EPA-WATER/2001/January/Day-22/w1668.htm
21. U.S. EPA 2001b. Quick Reference Guide for Arsenic. EPA 816-F-01-004. Available at http://www.epa.gov/safewater/arsenic/pdfs/quickguide.pdf
22. U.S. EPA 2001c. Arsenic in drinking water Technical fact sheet. Available at http://www.epa.gov/ogwdw/arsenic/regulations_techfactsheet.html
23. U.S. EPA 2004. Estimated per Capita Water Ingestion and Body Weight in the United States – an Update. EPA-822-R-00-001. October 2004. Available at http://epa.gov/waterscience/criteria/drinking/percapita/2004.pdf
24. U.S. EPA 2005. Factoids: Drinking Water and Ground Water Statistics for 2004. EPA Office of Water. EPA 816-K-05-001. May

	2005. Available at http://www.epa.gov/safewater/data/pdfs/data_factoids_2004.pdf