# 10 THINGS YOU NEED TO KNOW ABOUT ARSENIC POISONING

1. **Arsenic is found in some rat poisons and it can kill you!**


2. **Arsenic can cause cancer (especially bladder and lung cancer) in very small quantities.**

3. **The health impacts of long-term arsenic exposure may not show up for years.**

4. **Arsenic occurs naturally in some regions in the United States and some areas have high amounts in drinking water.**

5. **Old mining areas can concentrate Arsenic in spoil piles. (see satellite photo right)**


6. **Safer limits for Arsenic in public systems for drinking water were only implemented in 2006 after millions of people had already been exposed**

7. **The new Arsenic limits do not protect the millions of people with private wells.**


8. **Have your wells tested for Arsenic or find out the history of your public water system Arsenic exposure.**

9. **If wooden deck or playground equipment was installed before 2004, it should be tested for Arsenic.**

10. **If you suspect Arsenic exposure, tell your doctor and possibly have hair or urine tested.**

# History of Arsenic

- **Arsenic has been used as a poison for centuries and has been suspected in the death or murders of the Medici's, King George III of England, Napoleon and Simon Bolivar to name but a few.**
- **While recognized as a powerful poison, it was not known just how toxic and deadly arsenic could be in minute quantities until this millennium.**
- **After World War II, the global and US consensus for Arsenic in drinking water was believed to be safe below 50 parts per billion.**
- **About 2000, evidence began to mount from Bangladesh, Chile, Taiwan and China that smaller concentrations could cause cancer.**
- **Chronic conditions like skin and bladder cancer were on the rise even in areas where the average arsenic concentrations were between 10 and 50 ppb.**
- **In 2001, the US drinking water standard for Arsenic was lowered from 50 ppb to 10 ppb.**
- **. A 2007 study found that over 137 million people in more than 70 countries are probably affected by arsenic poisoning of drinking water.[1]**

# Arsenic Occurence

## According to the EPA Arsenic:

- **Is a semi-metal element.**
- **It is odorless and tasteless.**
- **It enters drinking water supplies from natural deposits in the earth**
- **It is concentrated by agricultural and industrial practices.**

## Humans increase the level of available arsenic through

- **burning of fossil fuels,**
- **oil sands,**
- **gold and base metal mining,**
- **agricultural pesticides and additives,**
- **burning of waste.**

# Arsenic Regulations

## Maximum Contaminant Level or MCL:

- **The new drinking water standard 0.010 mg/L (milligrams per liter) is the same as:**
  - **0.01 ppm (parts per million) and,**
  - **10 ppb (parts per billion) set in 2001**
  - **10 µg/L (micrograms per liter).**

- **EPA goal is set at 0 ppm.**
  - **This drinking water standard impacted 4,100 public water systems that <u>served 13 million people</u>.**
  -
- **The EPA estimated in 2001 that the 10 ppb standard would prevent approximately 2.3 to 5.5 deaths from bladder cancer and 4.6 to 27.5 deaths from lung cancer each year in the United States.**

# DRINKING WATER SOURCES

## Public Water Systems

- **Given until 2006 to meet the new limit,**
- **Could apply for nine years worth of "compliance extensions"**
- **Could give them until 2015 to incorporate new technology**

## Private Water Wells

- **Used by 40 million Americans**
- **Not protected by the new national standard**
- **May have high levels of arsenic.**

# AN ELEMENTAL CONCERN: ARSENIC IN DRINKING WATER

circle of blue

OVERVIEW | SYSTEM MAP | POPULATION MAP

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Arsenic is a toxic element that is both naturally occurring in Earth's crust and artificially produced during agricultural and industrial processes. Most arsenic compounds have no color, smell, or taste—making the chemical dangerously difficult to recognize. In diverse climates and geographies, arsenic contaminates prominent groundwater sources. Exposure to arsenic, especially in the last few decades, has caused illness and death in societies from the United States to Bangladesh, where one in five deaths can be attributed to arsenic poisoning.

Arsenic can enter the air through rock erosion, mining activity, volcanic eruptions, or forest fires.

The main source of arsenic in drinking water (usually from wells) is arsenic-rich rocks through which the water has been filtered.

When contaminated groundwater is used to irrigate fields, the element accumulates in soil and crops, particularly rice.

Arsenic can enter surface water through runoff from certain agricultural and industrial activities.

In communities where residents cook with and drink from the same contaminated well, arsenic intake multiplies.

## ARSENIC POISONING

Inorganic arsenic has been declared a known human carcinogen by the International Agency for Research on Cancer, the U.S. Environmental Protection Agency, and the Department of Health & Human Services.

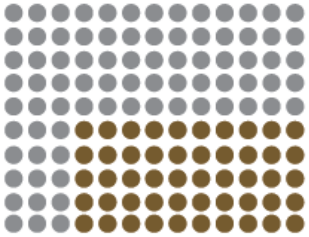
**Early Symptoms:**
Skin discoloration
Skin lesions
Nausea
Vomiting
Diarrhea

**Increased Risk:**
Kidney disease
Heart disease
Liver disease
Lung cancer
Skin cancer
Bladder cancer
Diabetes
Paralysis

## ARSENIC BY THE NUMBERS

### 10 ppb

(Ten parts per billion) – Arsenic standard for drinking water enforced by the EPA and recommended by the World Health Organization. Equivalent to a few drops of ink in an Olympic-sized swimming pool.



### 130 million

People across the world are exposed to levels of arsenic in drinking water that exceed the 10 ppb limit.

### 50 million

People have been exposed to arsenic levels exceeding 50 ppb, or five times the recommended limit.

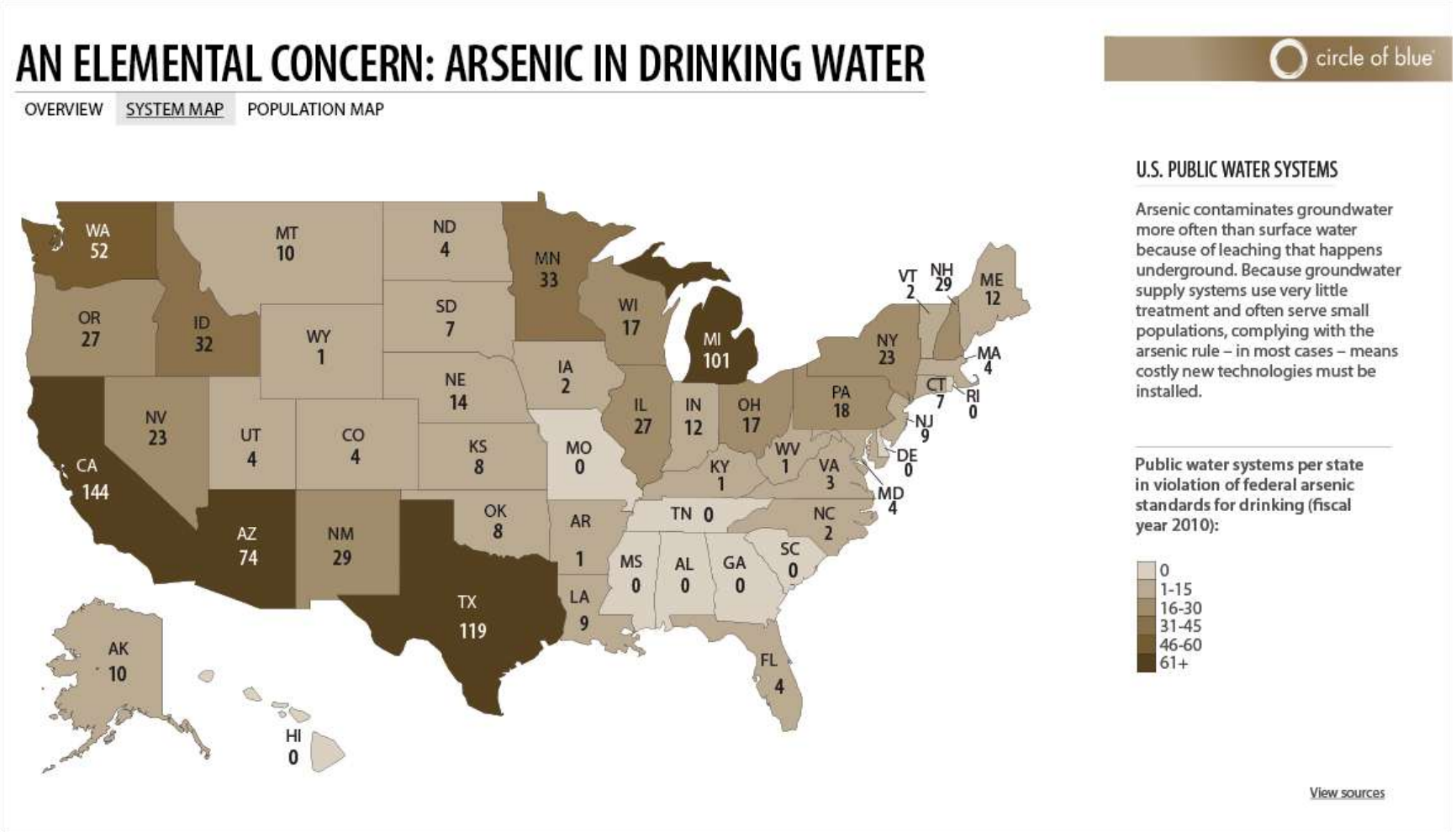
### 1 in 100

Estimated rate of people who routinely drink water containing at least 50 ppb of arsenic who will die from cancers. For each death, many others will live with painful, chronic disease.

### 90%

Amount of those known to have had high water arsenic exposures (>50 ppb) living in Asia.

Many Asians are vulnerable to both poisoning due to malnutrition and overexposure because of their reliance on rice crops.

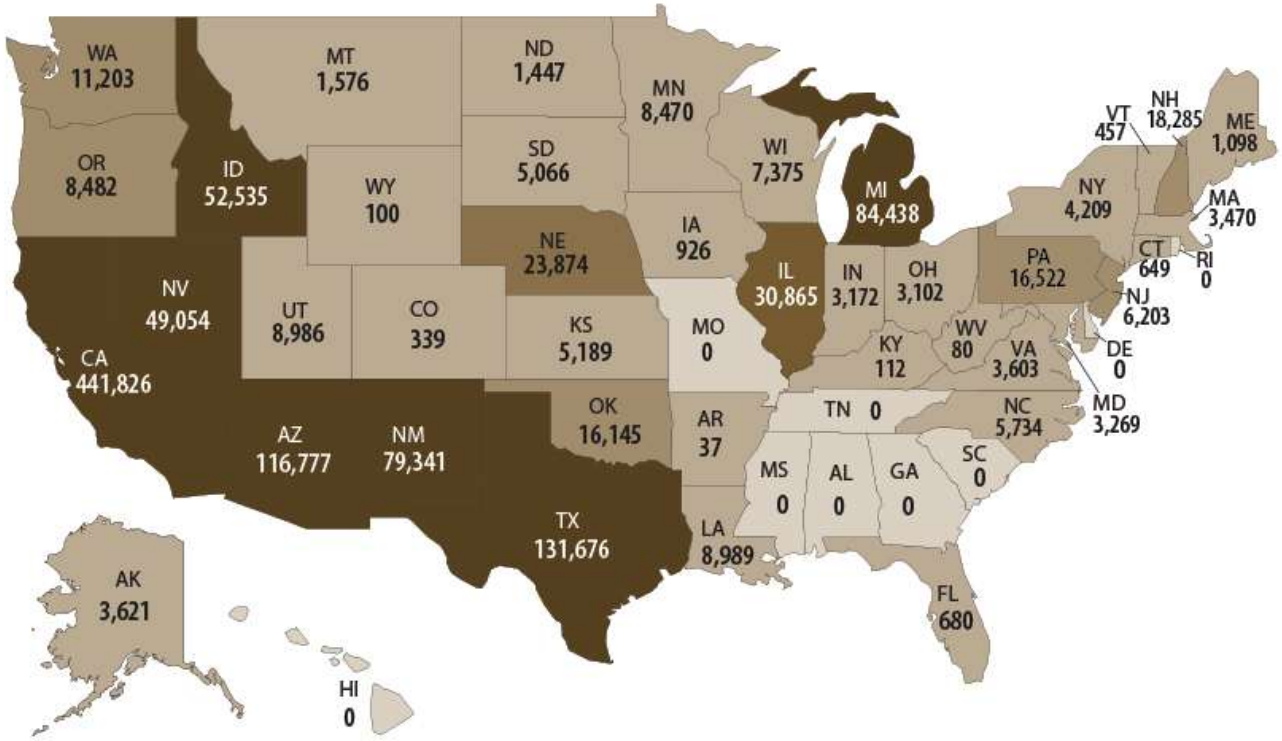



In the US, California, Texas, Michigan, and Arizona top the list of U.S. states with the number of public water systems in violation of the federal standard for arsenic. Joining these states are, New Mexico, Idaho, Nevada, and Illinois at the top of the list of states with more than 30,000 people potentially affected by high arsenic levels.
http://www.circleofblue.org/waternews/2011/world/infographic-an-elemental-concern-arsenic-in-drinking-water/

# AN ELEMENTAL CONCERN: ARSENIC IN DRINKING WATER

circle of blue

OVERVIEW SYSTEM MAP POPULATION MAP




## PEOPLE AFFECTED

When the EPA set the arsenic standard at 10 ppb in 2001, the agency estimated that more than 3,000 public water systems serving 11 million people would be out of compliance. A decade later, 934 systems – nearly all serving fewer than 10,000 people – still violate the rule and some 1.1 million people are affected, according to the EPA's fiscal year 2010 survey.

**People affected per state:**

- 0
- 1-10,000
- 10,001-20,000
- 20,001-30,000
- 30,001-40,000
- 40,001+

View sources

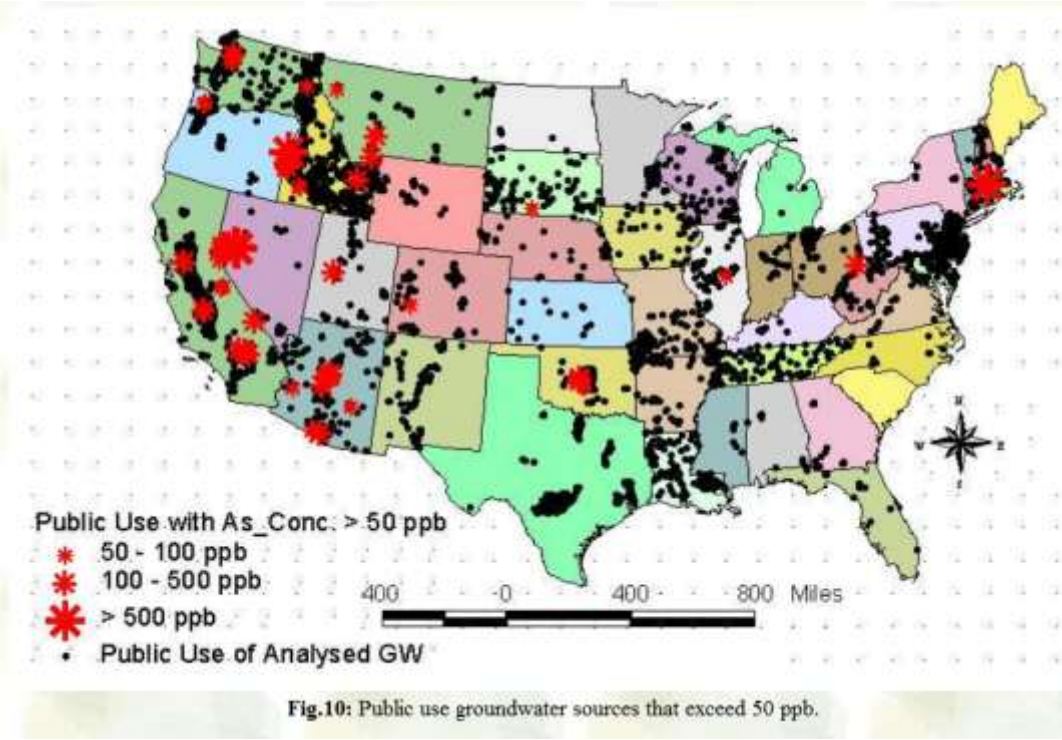



Fig.10: Public use groundwater sources that exceed 50 ppb.

## ARSENIC HOT SPOTS IN US PUBLIC WATER SYSTEMS

**The previous standard for drinking water, established in 1942 was 50 parts per billion but many areas exceeded this limit**. At that level, the National Academy of Sciences found in 1999, **people have a 1-in-100 chance of getting cancer from the arsenic over a lifetime of exposure above 50 ppb.** Arsenic is classified as a "**known human carcinogen"** by the U.S. EPA and the World Health Organization, and **children are at greater risk from arsenic than adults** because they are less able to metabolize the metal (NRC 1999).

# ARSENIC EXPOSURE SYMPTOMS

## Acute Symptoms

**-High dose, short term, exposure to Arsenic will cause coma or death!**

**- Low dose long term exposure to Arsenic in water includes non-cancer effects such as thickening and discoloration of the skin, development of white crescent-moon marks on the fingernails, skin lesions, as well as others listed below:.**

| | |
|---|---|
| **Nausea** | **Vomiting** |
| **Stomach pain** | **Diarrhea** |
| **Kidney damage** | **Diabetes** |
| **Liver damage** | **Abnormal heart rhythm** |
| **Birth defects** | **Spontaneous abortions** |
| **Cardiovascular disease** | **Reproductive problems** |
| **Darkening of the skin** | **Lower IQ levels in children** |

| | |
|---|---|
| **Partial paralysis** | **Blindness** |
| **Low platelet count** | **Numbness of hands and feet** |
| **Damage to blood vessels** | **Decreased red blood cell count** |
| **Decreased white blood cell count** | **"corns" or "warts" on the palms, soles and torso** |
| **Sensation of pins and needles in hands and feet (neuropathy)** | **Thickening, redness, itching, rash or swelling of the skin** |

## Inhalation effects:

- **loss of appetite, nausea, and diarrhea.**
- **'pins and needles' tingling in the palms, or cramps in calf muscles**
- **Heat and irritation in throat and stomach,**
- **a garlic odor on breath, or a metallic taste in the mouth**
- **vomiting, purging**

- **neurological effects including restlessness, chronic headaches, apathy, fainting, dizziness, delirium, somnolence, convulsions or coma.**

## Chronic Symptoms

**Arsenic has been linked to several cancers and has also recently been linked to higher occurrences of Type II diabetes. Arsenic in drinking water may also compromise immune function.**

**Long term arsenic toxicity and arsenic poisoning increases the risk of several cancers including:**

| | | |
|---|---|---|
| **Skin cancer** | **Lung cancer** | **Liver cancer** |
| **Bladder cancer** | **Kidney cancer** | **Nasal passage cancer** |
| **Prostate cancer** | | |

**Chronic arsenic poisoning through ingestion of arsenic-contaminated water is associated with various cardiovascular diseases including:**

| | | |
|---|---|---|
| **Atherosclerosis** | **High blood pressure** | **Stroke and Heart attack** |
| **Impaired electrical conduction in the heart** | **Peripheral vascular disease (aka peripheral artery disease)** | **Impaired small blood vessel circulation** |

# Diagnosis

## Urine

1. **Most reliable simple test for arsenic exposure**
2. **Reliable only for a few days**
3. **Do not eat any fish or seafood for at least 3 days before your test.☐**

## Hair/Finger Nails

1. **Measures exposure to high levels of arsenic over the past 6-12 months.**
2. **Hair samples may give falsely elevated results for years.**
3. **Can determine if you have been exposed to above-average levels of arsenic.**
4. **They cannot predict whether the arsenic levels in your body will affect your health.**

**If needed, your doctor has additional tests that can be performed to check arsenic levels in your body**

- Information excerpted from

  *Toxicological Profile for Arsenic August 2007*
  Agency for Toxic Substances and Disease Registry

# What's New?

**Arsenic Linked to Diabetes - 13 Million Americans Are Exposed to Dangerous Levels of Arsenic Through Drinking Water**

Participants in a Johns Hopkins study with **type 2 diabetes** in 2003-2004 had a **26% higher level of total arsenic in their urine than those without the disease**.

Reported in the 2008 *Journal of the American Medical Association* (2008;300(7):814-822). abstract available at http://jama.ama-assn.org/content/300/7/814.short
http://diabetes.webmd.com/news/20080819/arsenic-linked-to-diabetes

Source -WEBMD- DIABETES

**Arsenic in drinking water may also compromise immune function** "Scientists link influenza A (H1N1) susceptibility to common levels of arsenic exposure". http://www.eurekalert.org/pub_releases/2009-05/mbl-sli052009.php..

# Regional Distribution

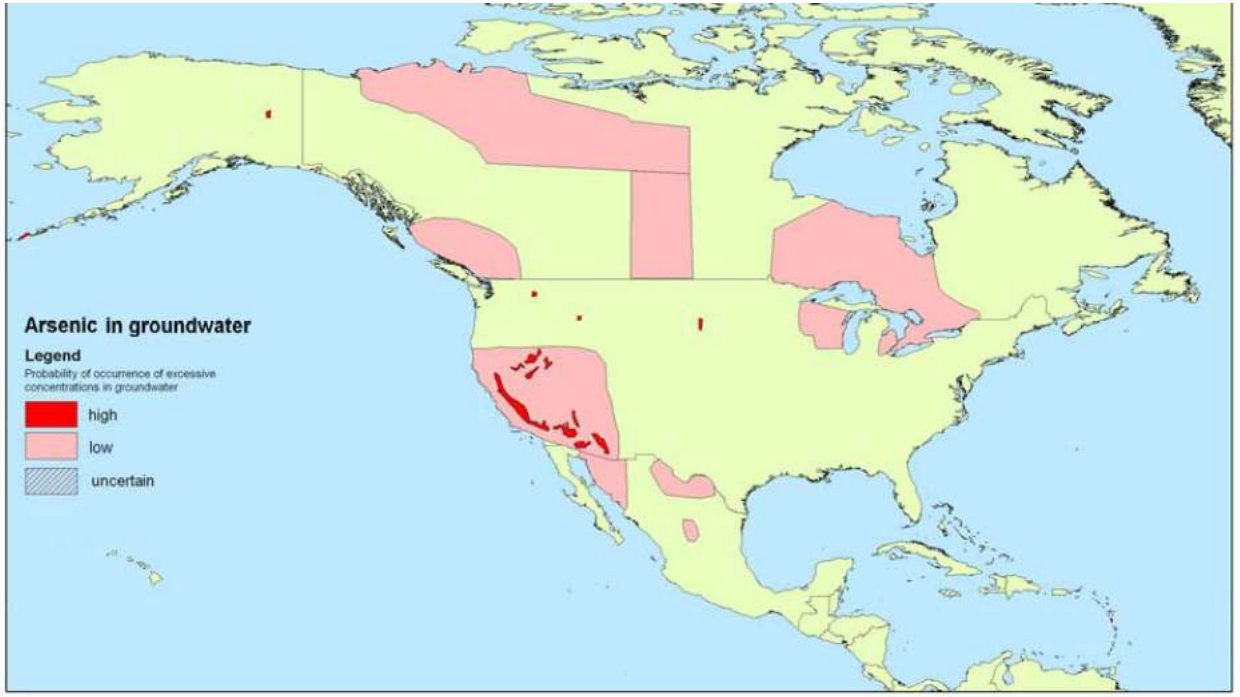
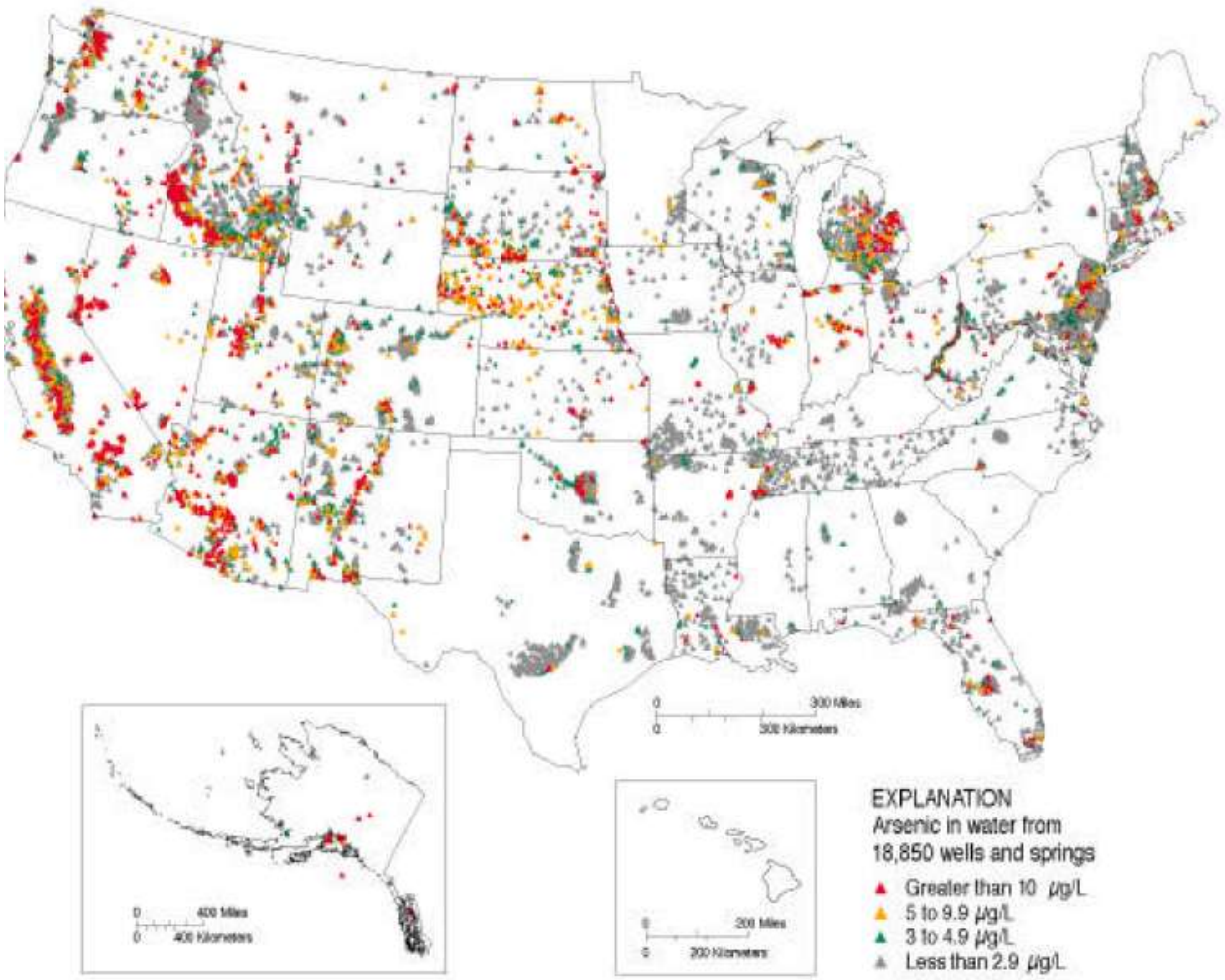



Figure 1 Arsenic in groundwater in North and Central America

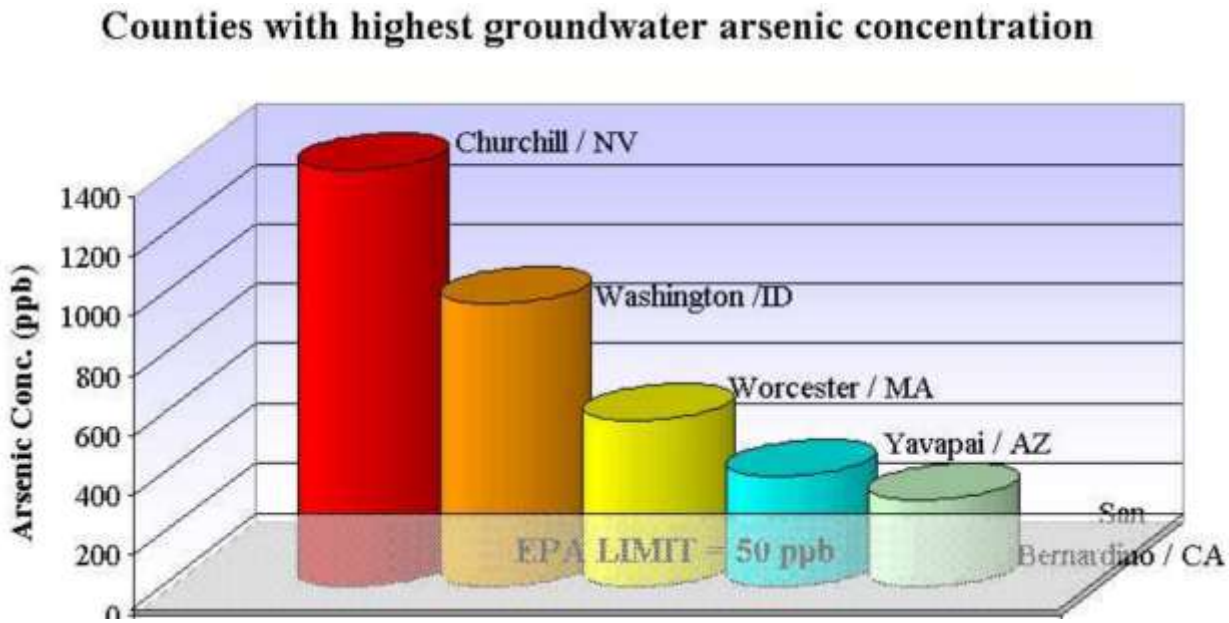
**Generalized map of Groundwater Arsenic in North America**

# Is There Arsenic in Your Water?



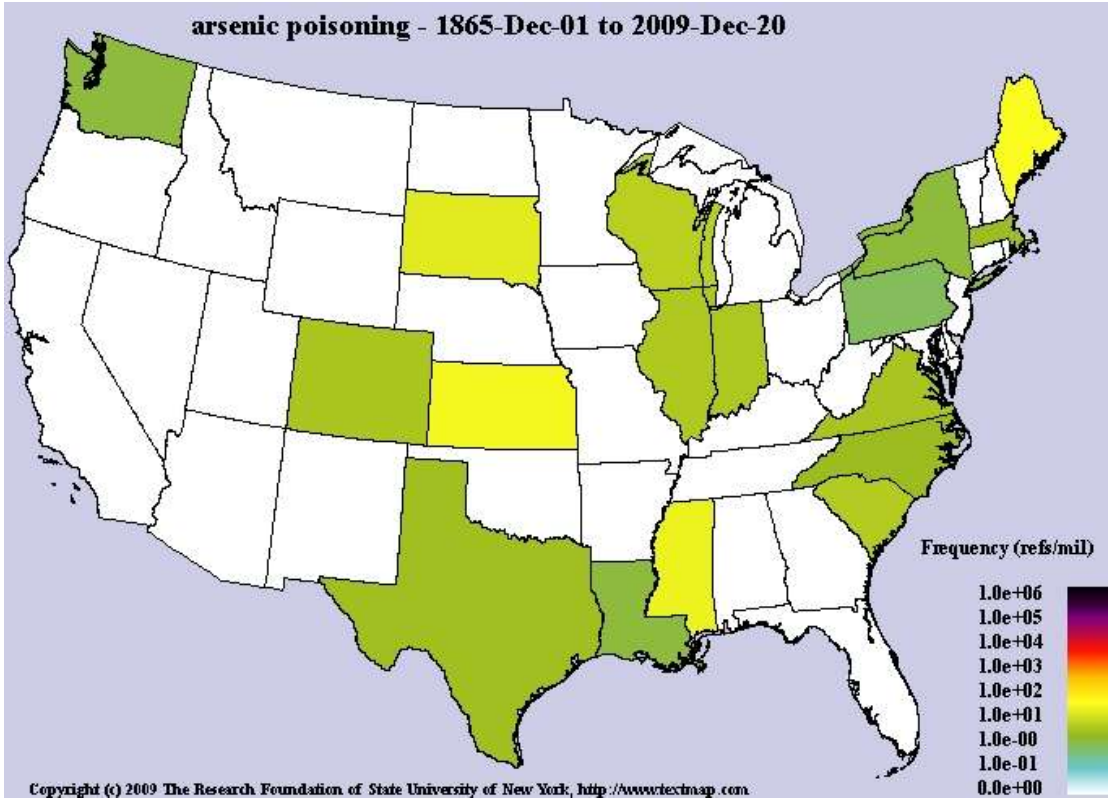
US Map of Arsenic in Wells (red> 10ppb)

The USGS has determined that approximately **10% of the 18,000 samples exceeded the National standard of 10 ppb.**




## Highest Arsenic Levels

- Most places with the highest arsenic levels are in the West,
- Fallon, Nev., tested levels of more than 100 parts per billion.
- In Fallon, the childhood leukemia rate is 40 times the national average,
- Albuquerque New Mexico is said to have the highest arsenic levels of any major American city's drinking water.




- The map above shows that historical, Arsenic poisoning cases by state have tended to mimic the higher concentrations of Arsenic in drinking water.

## FACTS ABOUT BLADDER CANCER

- There is an **undeniable link between bladder cancer and Arsenic exposure**.
- Bladder cancer is the **sixth most common form of cancer in the United States**
- the **fourth most common cancer among men**
- the ninth most common among women
- 4 times more common among men than women
- incidence rate among whites is twice that of blacks in the US
- mortality rates for Hispanics and Asians are about ½ those for whites and blacks
- risk of bladder cancer increases with age.
- incidence rates are highest in industrialized countries (United States, Canada, France, Denmark, Italy and Spain).

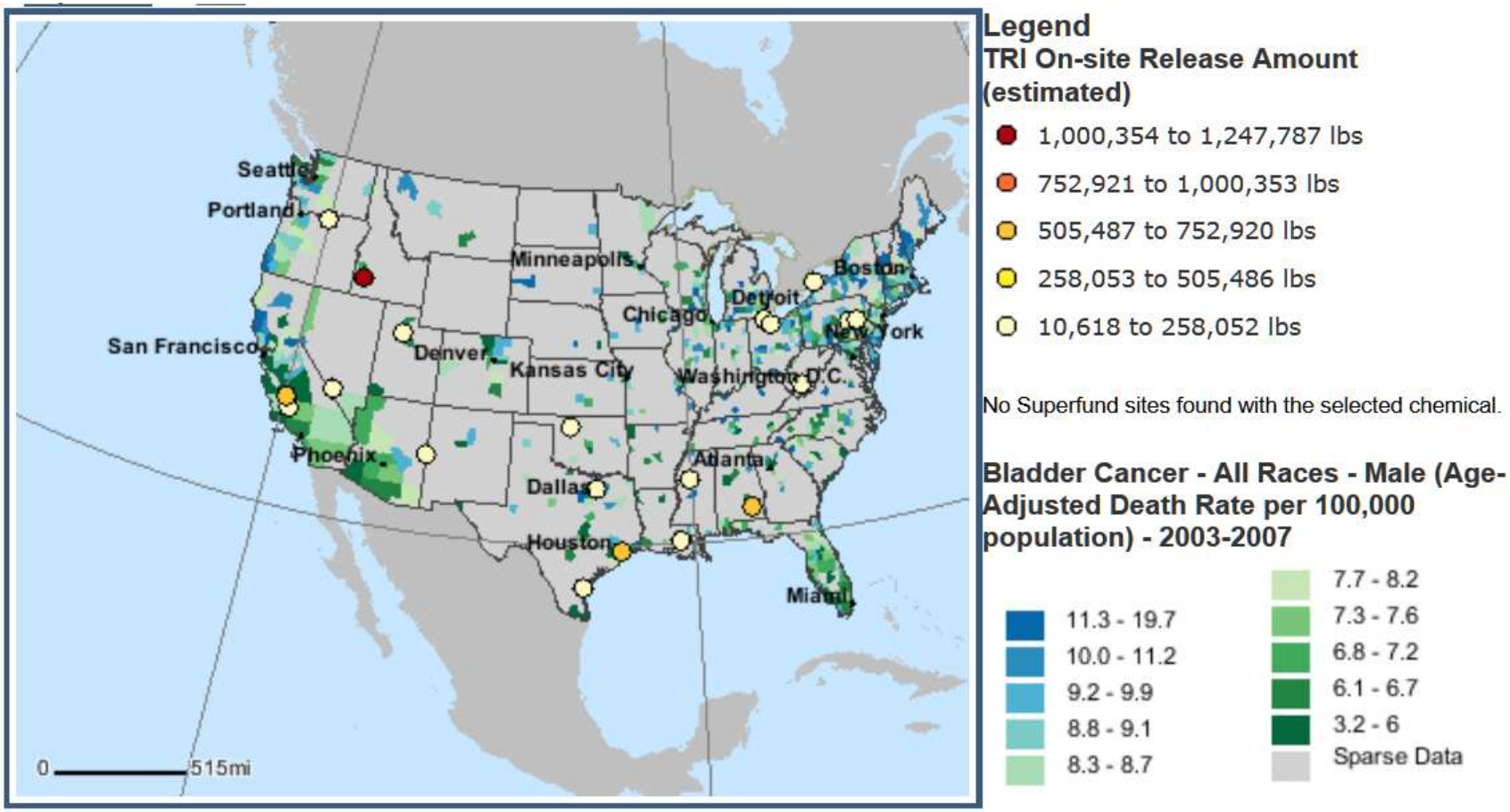
### BLADDER CANCER FACTS

In 2011, the Canadian Cancer Society estimates that 7,200 people in Canada will be diagnosed with bladder cancer, making it the 5th most common cancer in Canada (4th most common among men, with 5,400 cases and 12th most common among women with 1,800 cases).

With a recurrence rate of nearly 80%, bladder cancer is the most expensive cancer to treat on a per patient basis, and the high recurrence rate raises many issues affecting quality of life because of its persistence

What is in dispute is the dose vs. exposure time necessary to trigger the cancer response. Since the evidence indicates that there is generally at least a ten year lag time between exposure and mortality from the disease, precise estimates are difficult. Over a decade many people have moved residences and the sources and concentration of arsenic may have changed. It is for these reasons that we have adopted a regional approach to compare potential sources of arsenic with the known incidence of bladder cancers in males in the US. We hope that this spatial approach will help to fight this slow moving, but relentless scourge.

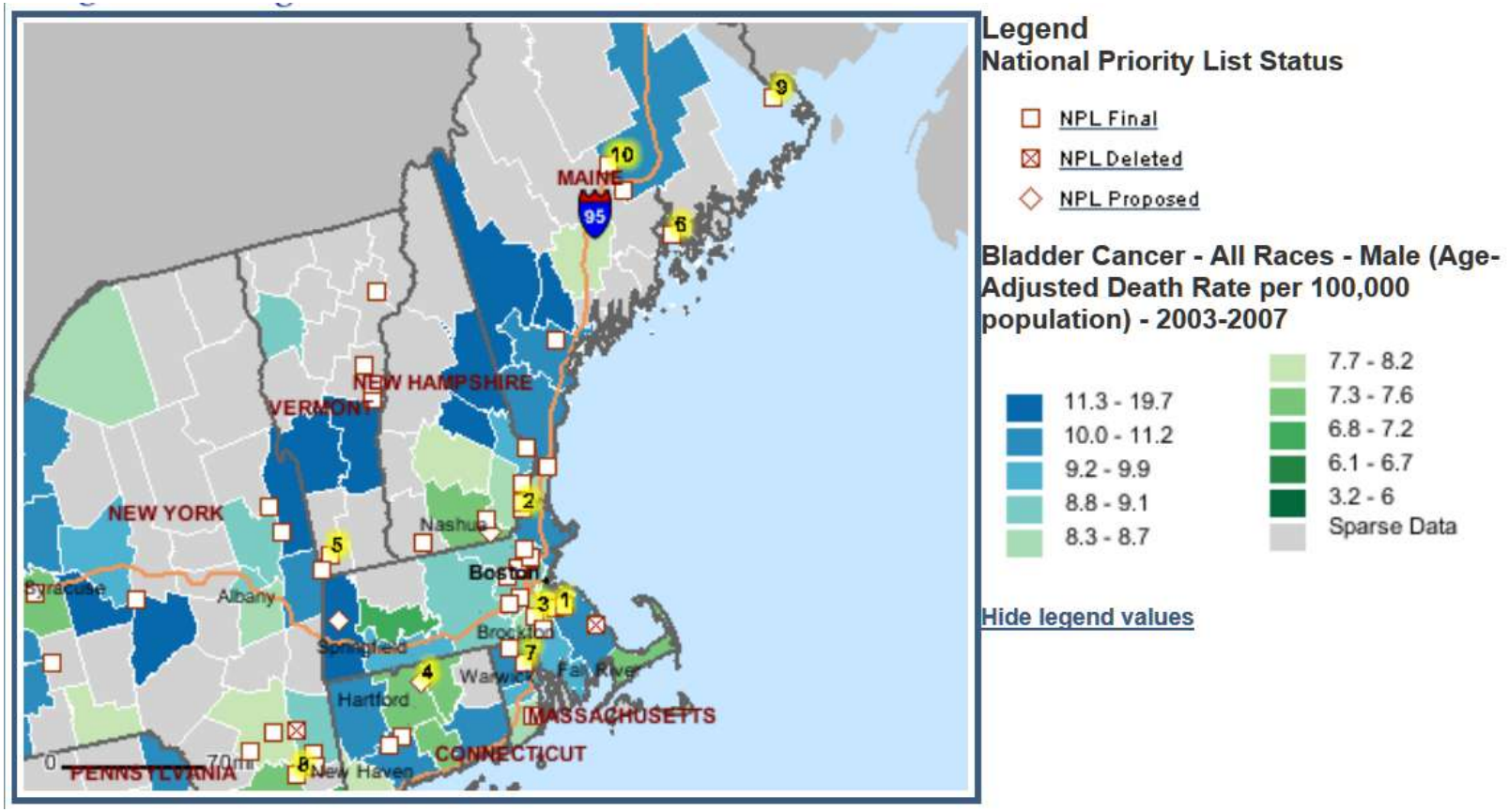
The sources of Arsenic vary greatly by region. Natural sources are strongly influenced by geology and depth of the aquifers. While man-made sources are generally more localized and may come from historical Superfund sites, agricultural and industrial processes or they could be on the Toxic Release Inventory of sites actively reporting to the EPA. For the US, these amount to millions of pounds of potential arsenic in the environment per year. All that is required to exceed the drinking water standard is about one drop of arsenic in an Olympic sized pool.




**US Incidence of Bladder Cancer among males and distribution of major Arsenic Toxic Releases.**

**Note: Correlation does not necessarily imply causation.**

# NEW ENGLAND REGION




**Incidence of Bladder Cancer in males and NE distribution of major Arsenic Superfund Sites.**

Note Correlation does not imply causation.

**In the Northeast, geology and basement rock types seem to define the trends; however the Superfund sites are also common along these same trends. So, it can be difficult to determine with certainty which source is responsible for high arsenic levels in drinking water. It could be virtually impossible to recognize areas where two or more sources are contributing to the total arsenic levels.**

**Many private ground-water wells in New Hampshire and Maine may have arsenic at concentrations close to or above Federal safety standards for public water supplies.**

Private wells supply drinking water for over **40 percent of the population of northern New England (20 percent of all of New England) and are not regulated by state and Federal agencies**. Officials recommend that all private well users test their wells for arsenic.

The current Federal standard for arsenic in public water supplies is 10 micrograms per liter. In New England, **12 percent of the area studied has a greater than 50 percent chance of having wells with arsenic concentrations above 5 micrograms per liter**.

**Nearly one-quarter of the combined area studied in Maine and New Hampshire has a greater than 50 percent chance of having wells with arsenic at or above 5 micrograms per liter.**

# Maine Arsenic Levels

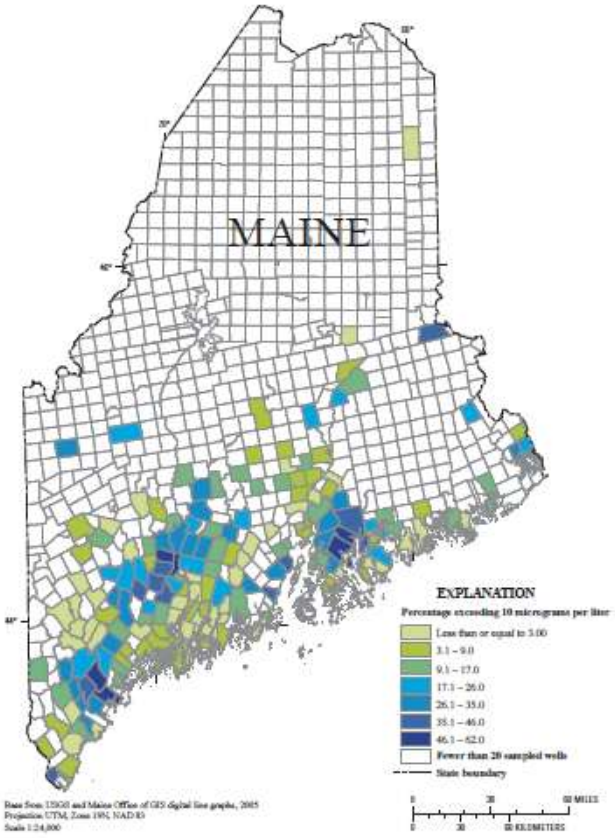



Figure B. Percentage of wells in each town with arsenic concentrations greater than 10 micrograms per liter in Maine, 2005–09. Towns shown have 20 or more wells.

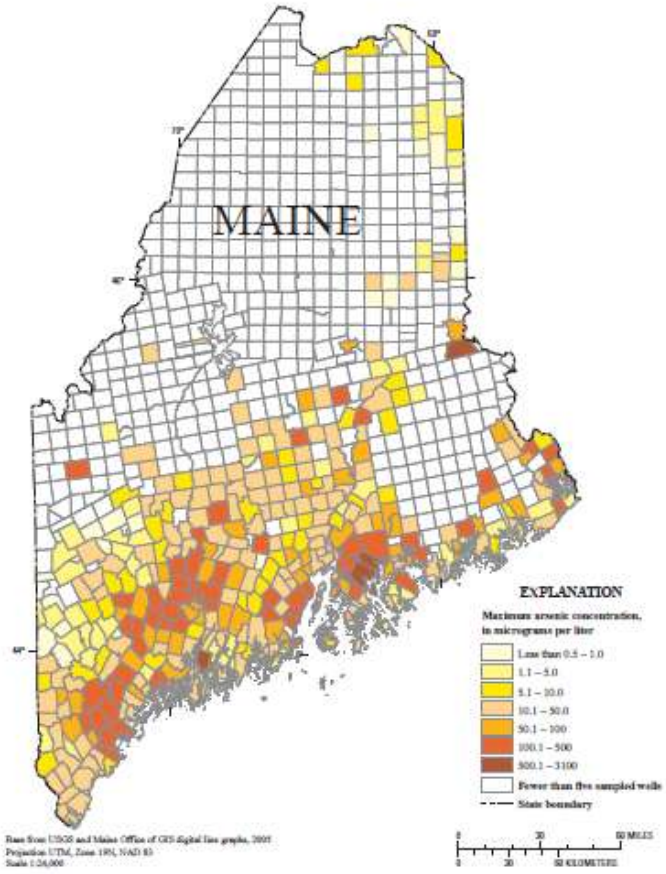



Figure A. Maximum arsenic concentrations for towns with five or more sampled wells in Maine, 2005–09. Concentration is in micrograms per liter.

**% Wells Above 10 ppb (<17% in blue)**

**Max Arsenic Conc.(darker colors >10 ppb)**

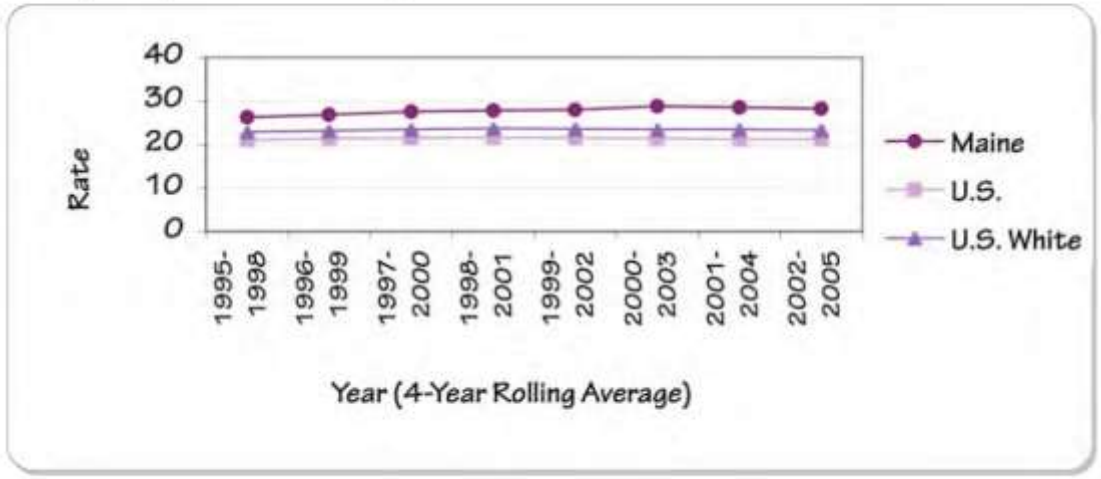
**The maps above show that many counties in Maine exceeded the national standard (10ppb) and some exceeded 500 ppb.**

Data from 1998 – 2002 indicate that **Maine has the highest bladder cancer mortality rate for males and the sixth highest for females in the country. Bladder cancer incidence is also higher in Maine than for the United States** but to a lesser degree.

Roughly **400 Maine residents are diagnosed with bladder cancer annually**, for an age-**adjusted incidence rate of 28 per 100,000**. The incidence rate for bladder cancer has not changed significantly over the past decade.

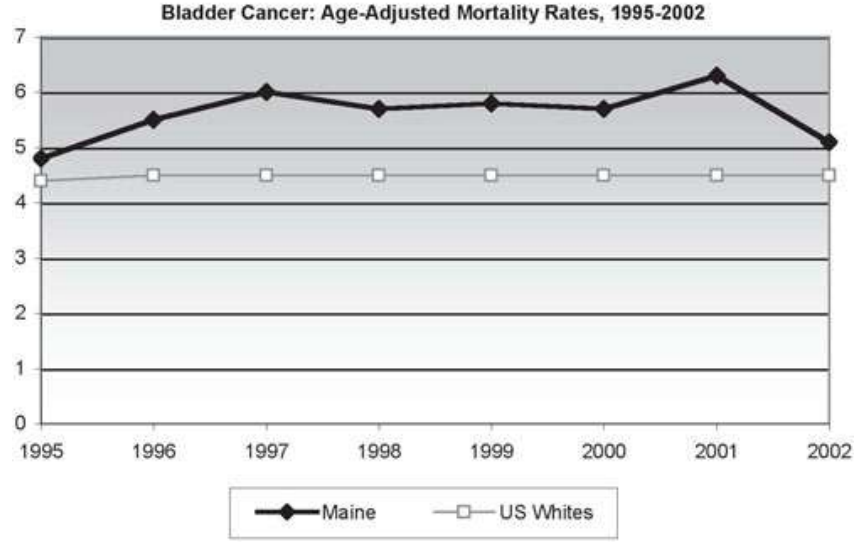
## Bladder Cancer Incidence

**Figure 4.11a. Age-adjusted rates (per 100,000) of bladder cancer incidence for Maine, U.S., and U.S. whites, 1995-2005**




Data source: Maine Cancer Registry and the national Surveillance, Epidemiology, and End Results (SEER) Program.

For the time period 2002-2005, approximately **85 Maine residents died annually from bladder cancer**. For this same time period, Maine's age-adjusted **mortality rate for bladder cancer was six per 100,000** an increase from 2002.




*Source: National Center for Health Statistics*

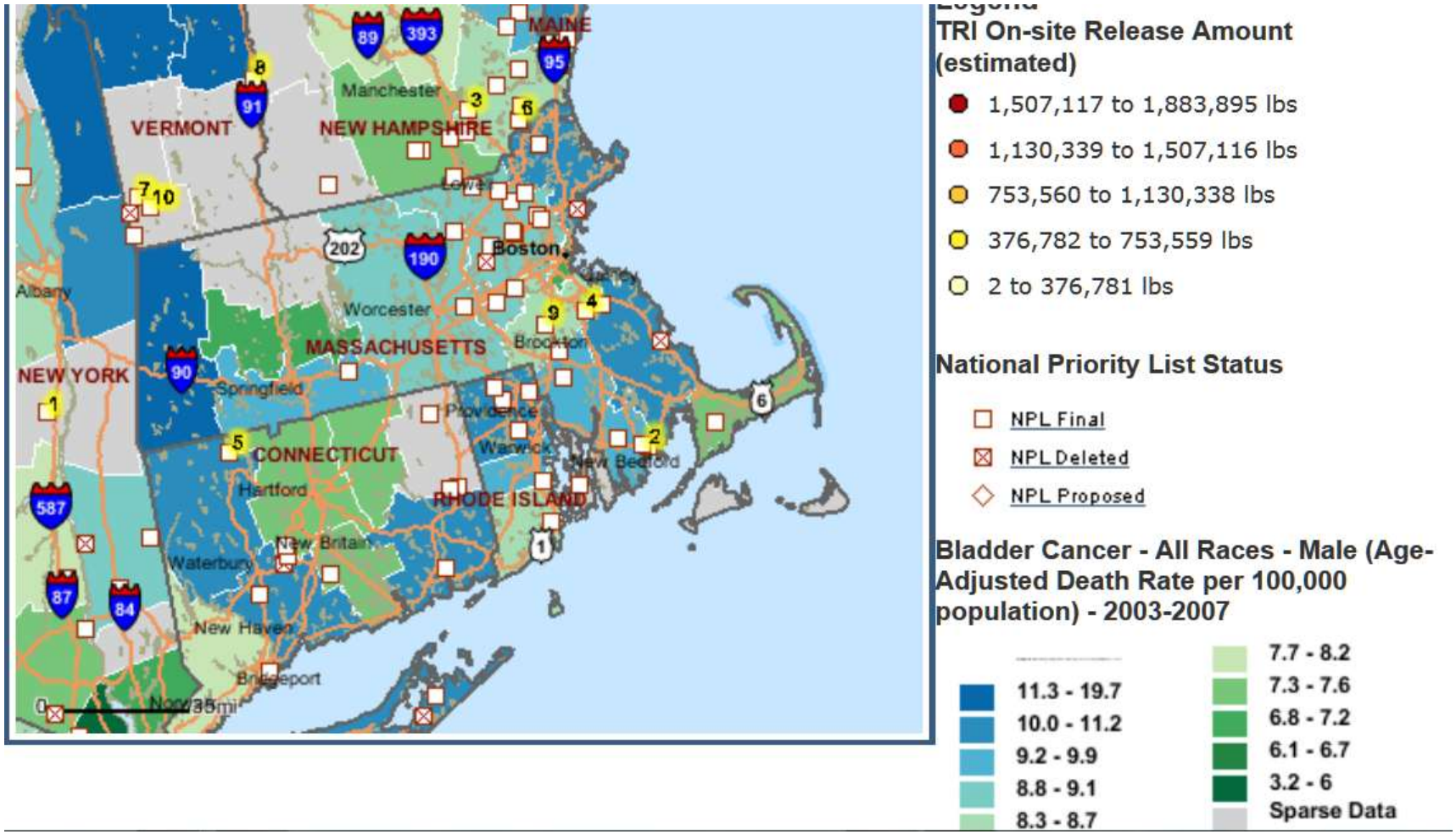
These towns had the highest median concentration of arsenic in tested private wells according to the survey†. The median represents the midpoint of test results. Half the results would be higher than the median figure and half would be lower. The Environmental Protection Agency's safe limit for arsenic in drinking water is 10 micrograms per liter.

| Rank | Town | Total number of samples | Number of sampled wells | Median arsenic concentration* | |
|---|---|---|---|---|---|
| 1 | Camden | 31 | 18 | 22.0 | Above EPA standard |
| 2 | Manchester | 175 | 111 | 15.0 | |
| 3 | Gorham | 287 | 218 | 14.0 | |
| 4 | Blue Hill | 107 | 75 | 14.0 | |
| 5 | Columbia | 22 | 17 | 14.0 | |
| 6 | Otis | 18 | 14 | 12.7 | |
| 7 | Passadumkeag | 9 | 6 | 12.4 | |
| 8 | Surry | 141 | 120 | 11.0 | |

Maine Towns testing Arsenic above EPA standard in 2010

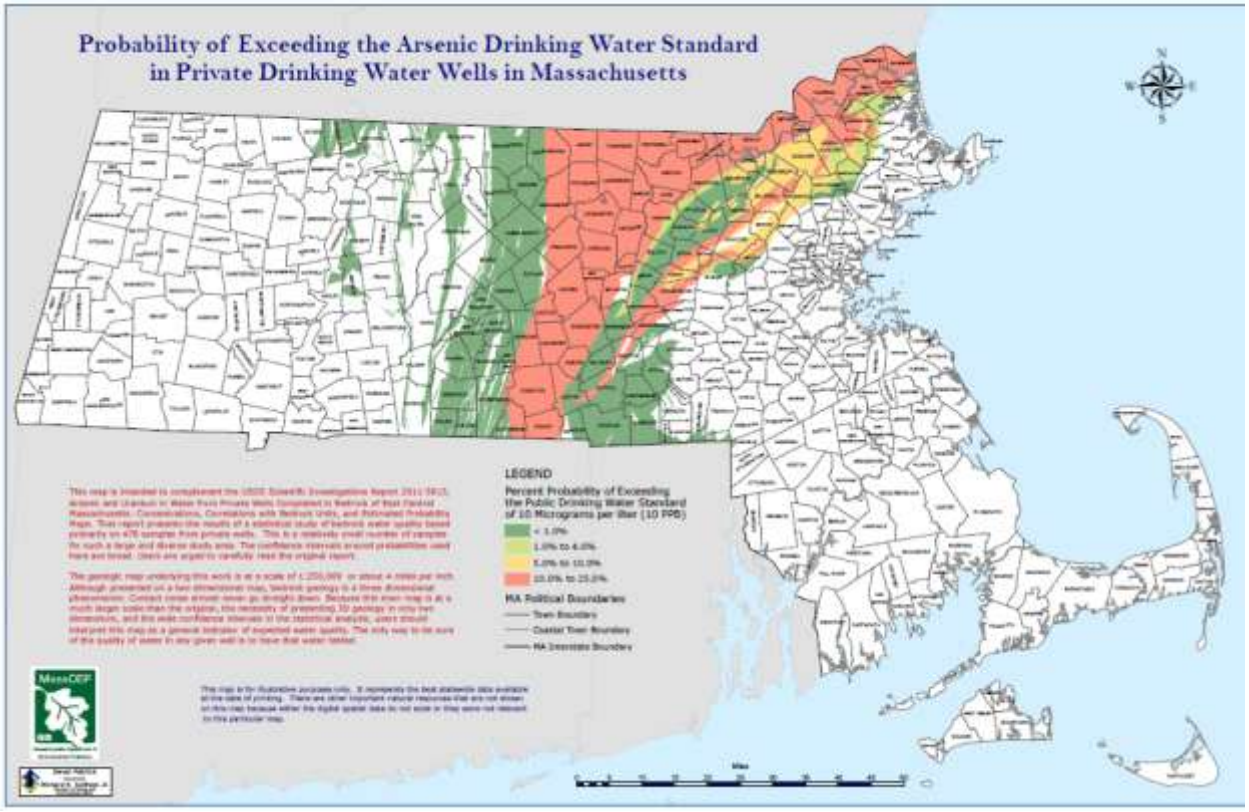
As of 2010, **nearly half of Mainers get drinking water from wells**, but the CDC reports **only 40 percent of wells are tested for arsenic**.

## Massachusetts Arsenic Levels:




**Incidence of Bladder Cancer in males and Massachusetts distribution of major**

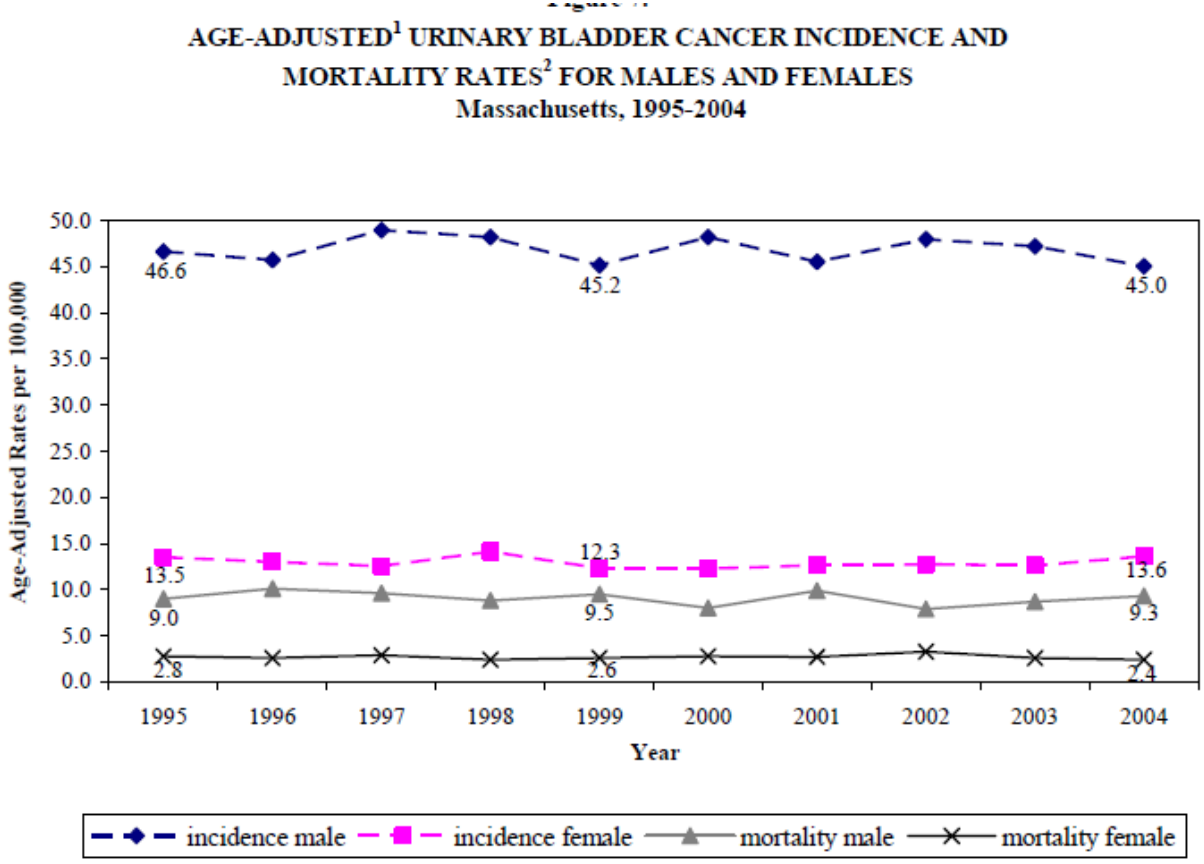
## Arsenic Toxic Release Sites.




% Probability of Exceeding Drinking Water Arsenic Standard (Red >10%)

In March 2011, the Department of Environmental Protection reported that levels of arsenic could exceed federal public drinking water standards in some private wells in more than 25 MetroWest and Milford-area communities. The study by the **U.S. Geological Survey found that 13 percent of 478 private wells tested exceeded arsenic standards**. Researchers **estimated that 5,700 of about 90,000 private**

**wells in the 116 Massachusetts communities in the study area may exceed the arsenic standard** and **approximately 3,800 of these wells are being used without treatment for the removal of arsenic.**



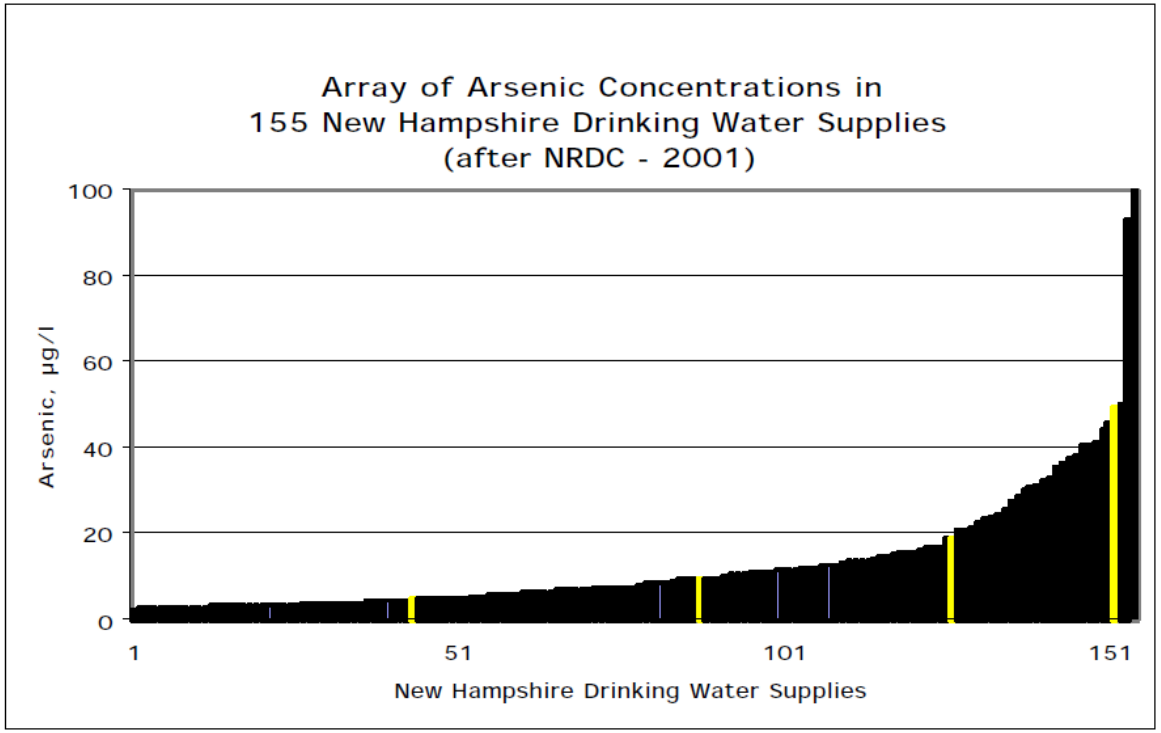

[1]age-adjusted to the 2000 U.S. Standard Population [2]per 100,000
Sources: Massachusetts Cancer Registry

The chart above shows that **the incidence of Bladder Cancer**

**among males in Massachusetts are some of the highest in the country.**

# New Hampshire Arsenic Levels:

**In New Hampshire in 2002, <u>domestic wells served roughly 40% of the population, and about 10% of these contained arsenic concentrations in the controversial range of 10 to 50 micrograms/l. New Hampshire, along with other states in New England, has among the highest bladder cancer mortality rates in the country</u>.**



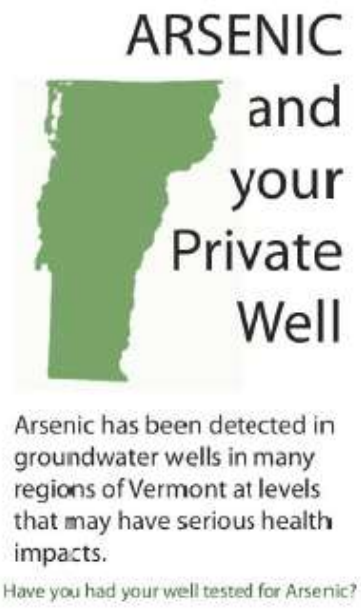
# Vermont Arsenic Levels

In 2010, students at **Middlebury College completed a comprehensive report *Arsenic Contamination in Vermont's Private Wells.* Given the gaps in data in the state water databases there is very little data available. The Vermont Arsenic section below is extracted from their report.**

**"**In Vermont, there are no enforceable EPA standards for private wells, which are common sources of drinking water in rural areas. This is especially a problem in Vermont where the Vermont Department of Health estimates that **40% of state residents use private groundwater wells for their drinking water…**

In the spring of 2005, **arsenic concentrations of 90 and 327 ppb** were found in private bedrock-sourced drinking-water wells in the **Waterbury-Stowe area** of north central Vermont (Bright, 2006). **Several public and private wells in Troy, Newport and Coventry, Vermont produce groundwater with arsenic concentrations that consistently exceed the EPA Maximum Contamination Level and range from 0 to 113 ppb**…

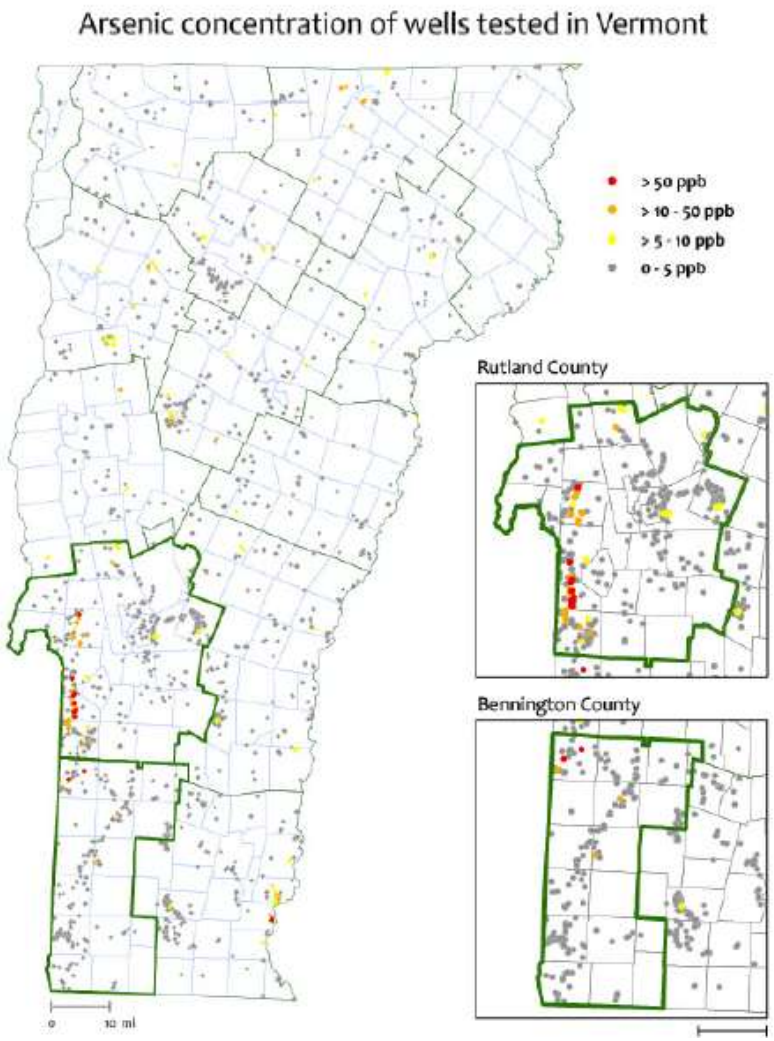
A study conducted in 2010 titled *Elevated Arsenic in Domestic Wells from the Taconic Allochthons in Southern Vermont* found




that **42% of private bedrock wells tested thus far in the town of Castleton, Poultney and Wells contain arsenic levels exceeding 10 ppb with an average concentration of 30 ppb** (Clark et al., 2010). Farther to the south in Pawlet and Rupert, 13% of private wells tested thus far contain levels exceeding 10 ppb arsenic (Mango, 2009)…

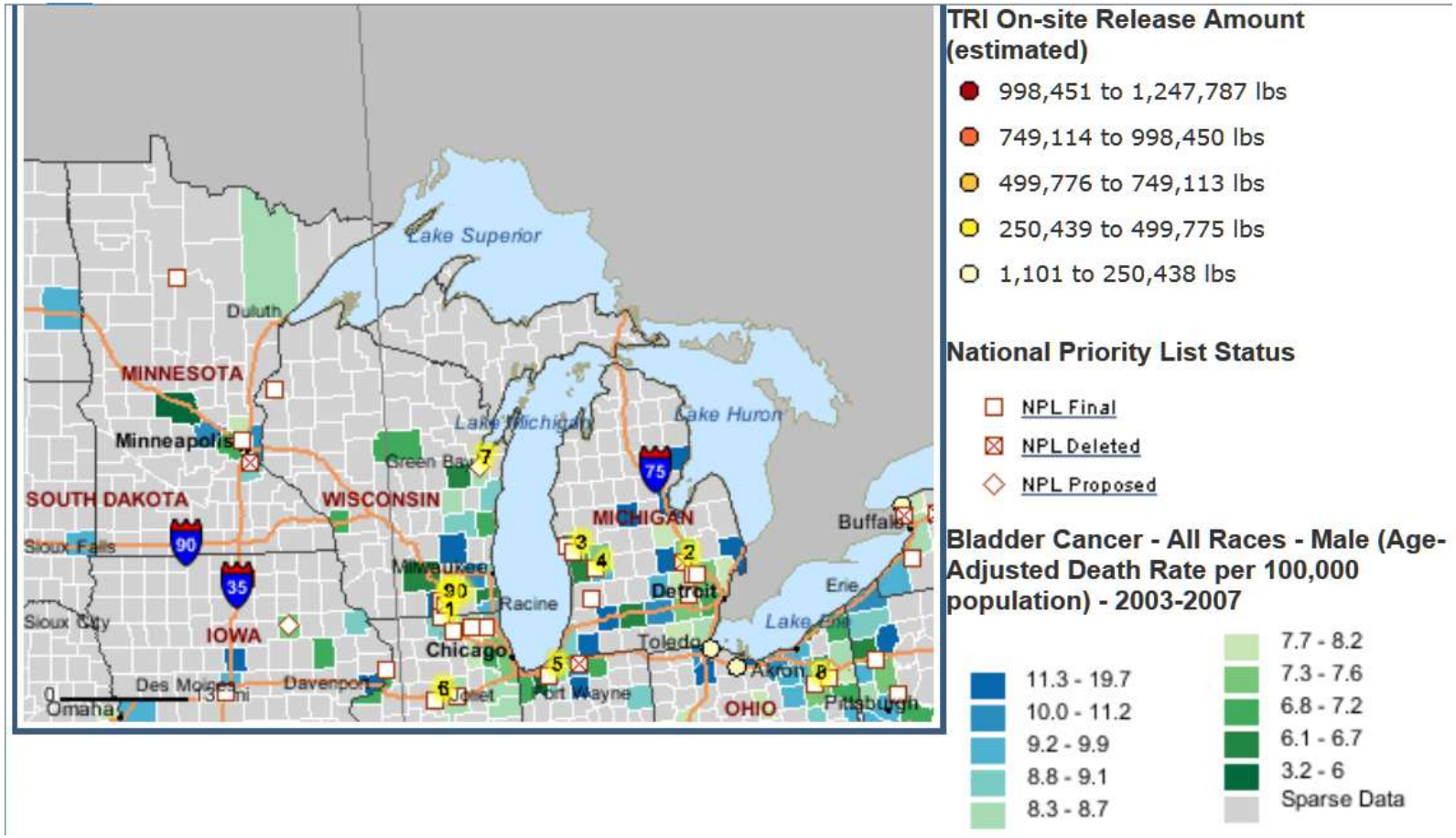
High arsenic levels were found in small pockets throughout the state. The most notable collection of **high arsenic results were in Rutland and Bennington counties**. These two counties had the greatest number of high arsenic results and also the highest test incidence. In addition to Rutland and Bennington counties,

…**”**




**Vermont Arsenic Levels in Wells** (darker colors > 10 ppb)

# Great Lakes Region –



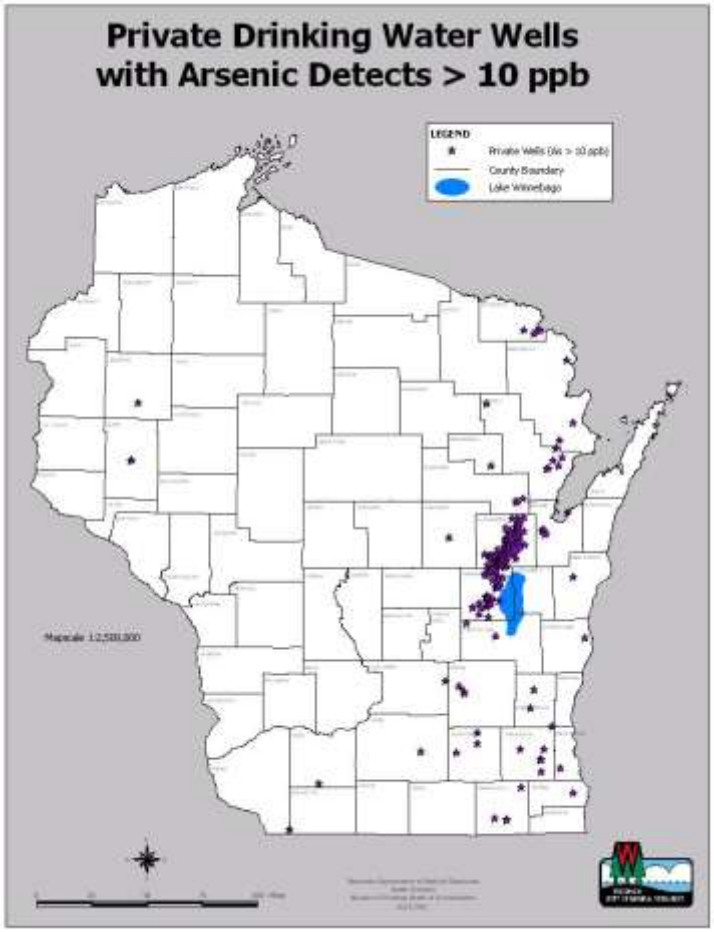

**Incidence of Bladder Cancer in males and Great Lakes distribution of major**

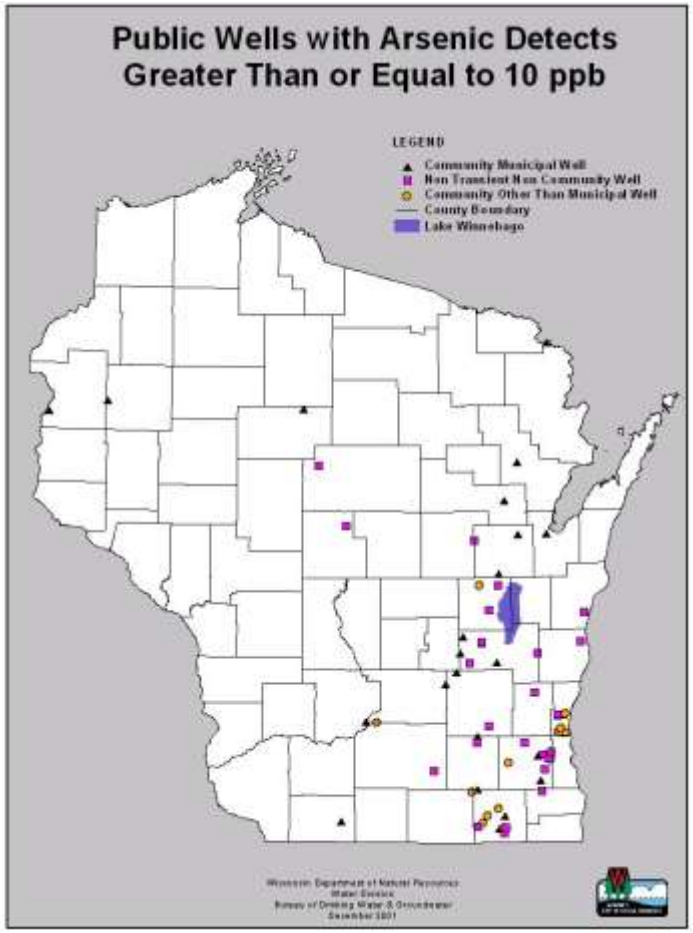
## Arsenic Superfund Sites.

Note Correlation does not imply causation.

**In the Great Lakes region, the arsenic trend is narrow and elongated in line with the geologic formations. Coincidentally the Superfund sites parallel this same trend possibly because the industries utilize the same high arsenic water sources.**

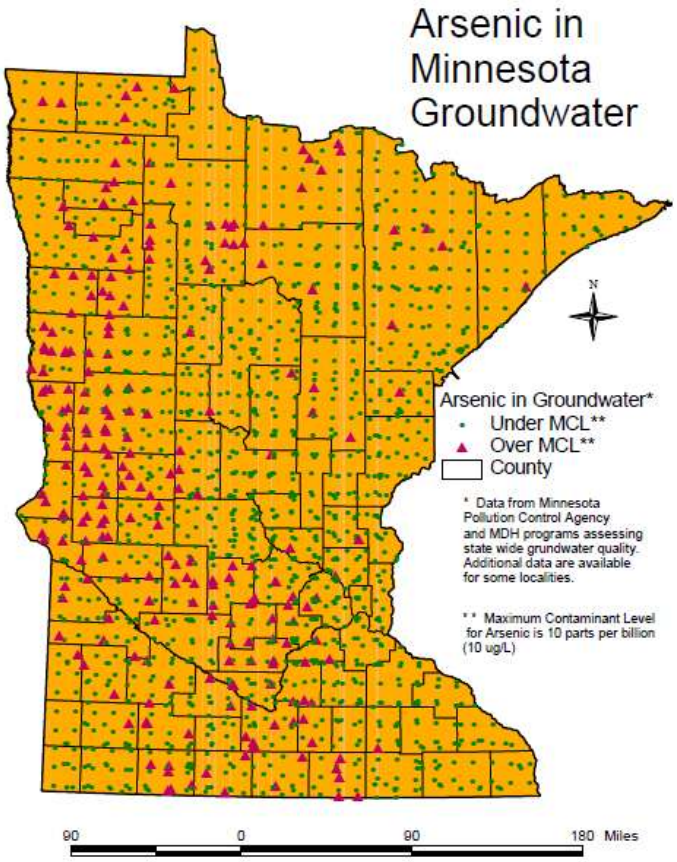
# Wisconsin Arsenic levels



Sampling of 1300 wells in Northeastern Wisconsin revealed that **20% of these wells exceeded the 10 ppb** standard for drinking water quality and **3% exceeded the old standard of 50 ppb**.. (WDNR 2003)

## Minnesota Arsenic levels

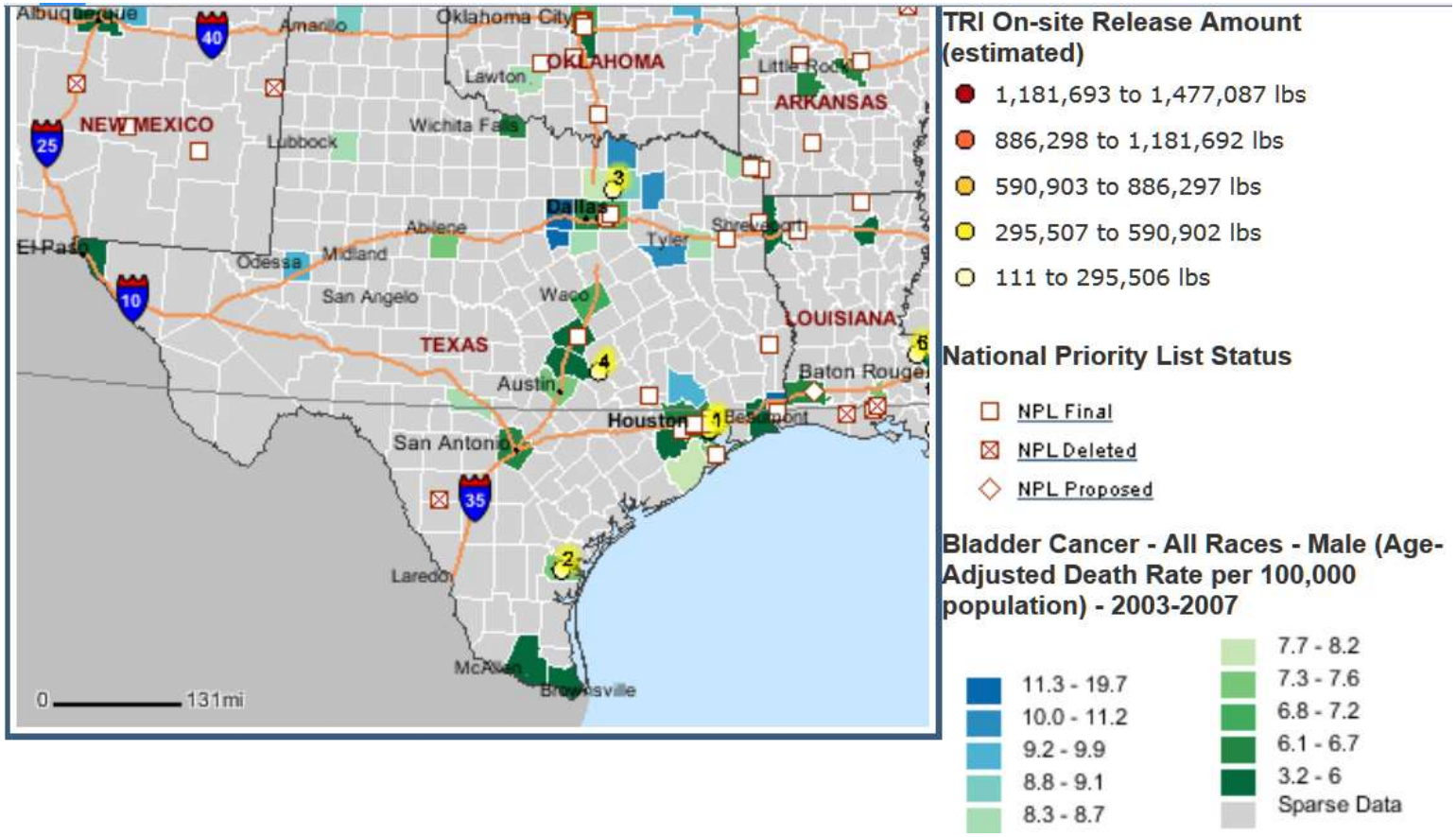


The Minnesota Department of Health has found that

**15% of private wells in Minnesota exceed 10ppb** of Arsenic

(shown in red above)

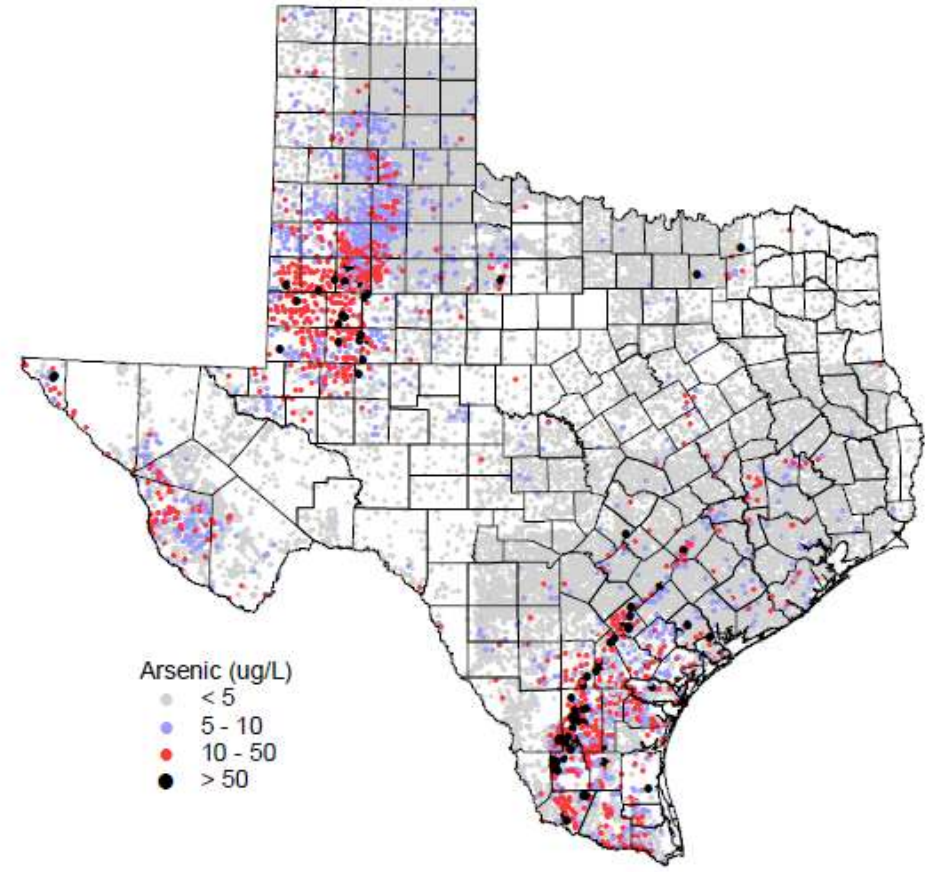
## South Central Region



## Incidence of Bladder Cancer in males and Great Lakes distribution of major Arsenic Toxic Release Sites.

Note Correlation does not imply causation.

The South Central Region arsenic trend is controlled by the aquifers and by the coastal and alluvial volcanics. This pattern is overlain by agricultural developments which were subjected to extensive applications of pesticides some of which contained high arsenic concentrations.




SOURCE : TWDB and NURE databases
Figure 6. Arsenic distribution in groundwater across the state of Texas

**Texas Arsenic Levels (red > 10ppb)**

According to the Texas Water Resources Institute, **27% percent of the nearly 5000 wells sampled were unsafe**. These wells with detectable arsenic levels contained arsenic in excess of 10 micrograms/liter, the new EPA standard. Of the nearly 900

water wells with concentrations exceeding the new primary standard of 10 micrograms/liter, **more than half were used by people for drinking water**. Approximately 30 percent provided water to households, 24 percent to public supply facilities, 18 percent to irrigation wells, 16 percent to stock wells, and 5 percent to other uses, including industrial and commercial facilities; 7 percent of these wells were unused.

High arsenic concentrations that are believed to be naturally occurring have been found in the southern High Plains (Ogallala aquifer), in several West Texas counties (various aquifers) and in south Texas (Gulf Coast aquifer) (Fig. 1). For example, **Harris- Brazoria-Galveston-area public water systems using significant proportions of groundwater report arsenic levels in excess of 10micrograms/**

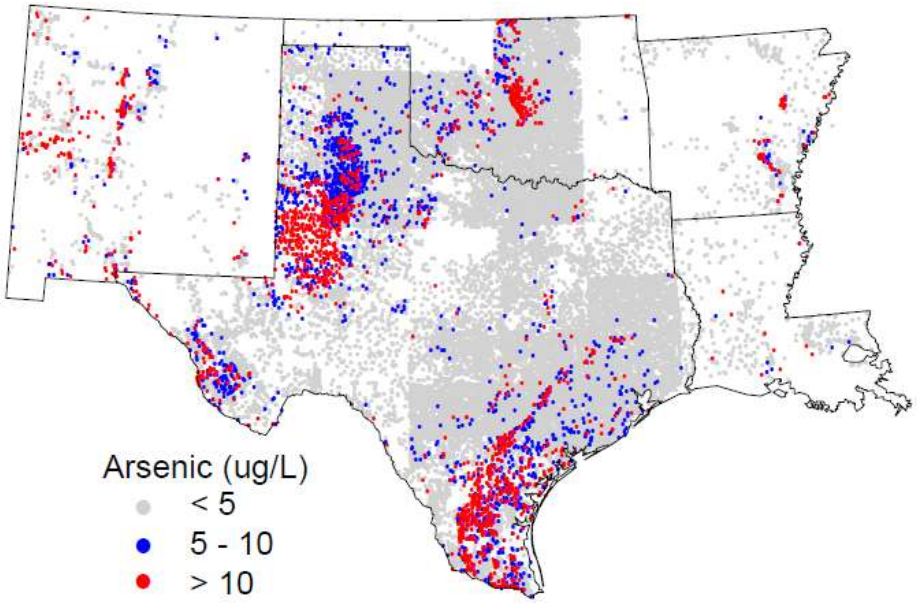
In the Gulf Coast aquifer, arsenic contamination has generally been attributed to abundant volcanic ash fall or reworked volcanic material and possibly the presence of a uranium mining province.

In the High Plains, groundwater arsenic contamination has been attributed to arsenic pesticide application on cotton. The cotton industry has been using arsenic compounds for more than a century. Before DDT and other more efficient organic insecticides were introduced in the late 1940's, the most widespread insecticides were metal arsenates. Calcium arsenate was used in the early fight against boll weevil, while lead arsenate was used in orchards across the United States. Inorganic arsenic compounds were banned from insecticide and herbicide use by EPA in 1988.

Table 5. Arsenical compound use history

| Usage | Start Date | Ban Date | Chemical compound |
|---|---|---|---|
| Animal feed (poultry) | 1930's | N/A | Organic form of As |
| Herbicide<br>- weed killer | 1900's | 1988 | Pb Arsenate,<br>Cu Acetoarsenite<br>("Paris green") |
| - ~specific to cotton | 1977 | N/A | MSMA, DSMA,<br>cacodylic acid |
| Insecticide:<br>- Sheep and cattle dips<br>- Boll weevil (cotton pest)<br>- Orchard pests | <1900 | 1988 | Na Arsenite<br>Ca Arsenate<br>Pb Arsenate |
| Defoliant | First marketed in 1956<br>~1965 | 1992 | Arsenic acid |
| Wood preservatives | ~1900's<br><br>~1975 | N/A | Chromated Copper Arsenate |

SOURCE: Loebenstein (1994);
NOTE: usages not included are lead batteries, metal alloys, semiconductors, glass manufacturing




NOTE: Texas Water Development Board, US Geological Survey, National Uranium Resource Evaluation, New Mexico Bureau of Geology and Mineral Resources, Association of Central Oklahoma Governments, and Arkansas Department of Environmental Quality databases

Figure 4. Arsenic concentrations in groundwater in Texas and surrounding states

**Arsenic Levels in Texas and Surrounding States**

**Arsenic contamination is widespread in surrounding states, particularly New Mexico where 16% of wells exceed the Maximum Contaminant Level or MCL (10 ug/L).** Only 5% of wells in Oklahoma had arsenic levels exceeding the MCL, but these are mainly in Central Oklahoma. Arsenic contamination in Arkansas represented 8% of the wells and is found in alluvial aquifers in eastern Arkansas. Arsenic contamination in Louisiana is limited.

## Arsenic-Containing Pesticides

The organic arsenical pesticides consist of arsenic acid, monosodium methanearsonate (MSMA), disodium methanearsonate (DSMA), calcium acid methanearsonate (CAMA), and cacodylic acid and its sodium salt. They are used as herbicides on cotton and other agricultural crops, in forestry, on residential and other lawns and turf, and in non-crop areas such as rights of way, drainage ditch banks, fence rows, and storage yards.

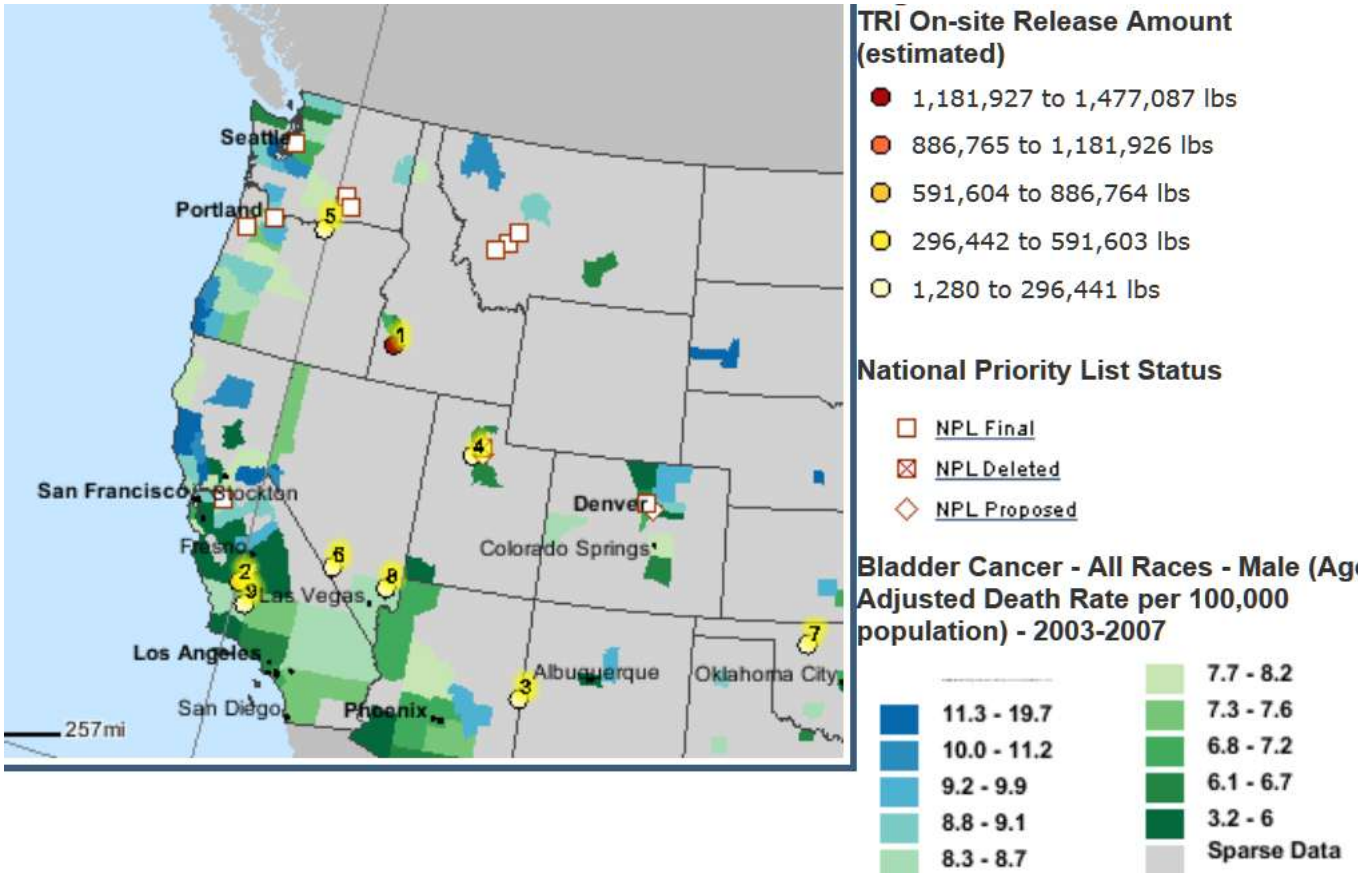
Arsenic-containing pesticides are also among the more toxic pesticides. Arsenic compounds affect the nervous system, liver, kidneys, and other vital body tissues. Poisonings from absorption through the skin are rare. Most victims of arsenic pesticide poisonings have swallowed the chemical.

Symptoms usually appear within one hour after ingestion but may be delayed several hours. One distinctive sign of an arsenic compound poisoning is a garlic odor of the breath of the victim. Other symptoms include inflammation of the mouth and throat. Burning abdominal pain, thirst, vomiting, and diarrhea are common symptoms. Later symptoms include headache, dizziness, muscle weakness, hypothermia, convulsions, and coma. Lethal poisonings usually cause death 1 to 3 days after the exposure.

# Western Region

**The southwestern area is so dry that the availability of water determined development. Many of these developments became Superfund sites. The populations also settled where the water was most available. Much of this water came from geothermal sources rich in Arsenic. Consequently, this region has the highest arsenic levels in the US. Unfortunately, average population density is low and cancer statistics are sparse.**

**In the northwestern area, orchards were planted to take advantage of the abundant rainfall and rich volcanic soils. These orchards were heavily sprayed with pesticides which historically contained arsenic. Both the water runoff and the groundwater locally contained arsenic.**

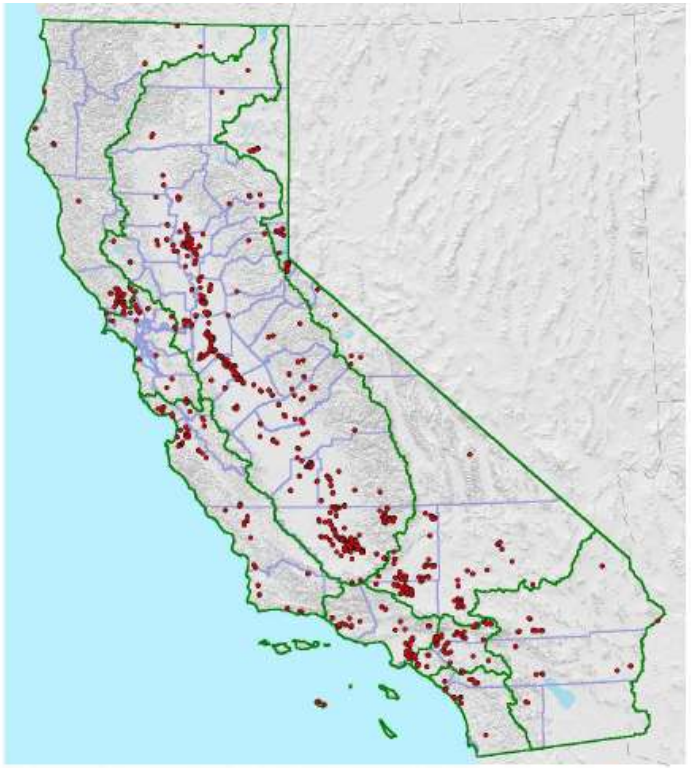



**Incidence of Bladder Cancer in males and Western distribution of major Arsenic Superfund Sites.**

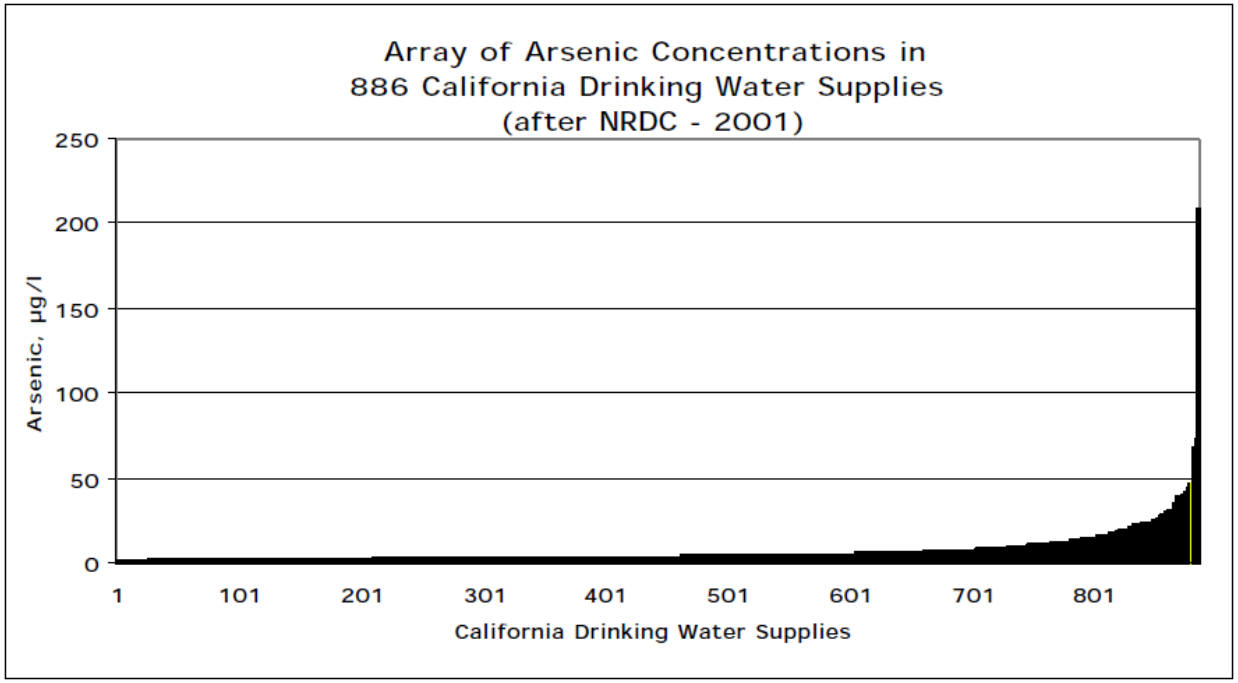
Note Correlation does not imply causation.

# California- Arsenic Levels

Based on Dept. of Health and Safety data through 2000, 1038 of approximately **16,000 public drinking water wells (active and standby status) have had concentrations of arsenic ≥ 10 µg/L,** with most detections occurring in Los Angeles, San Bernardino, and Kern Counties.

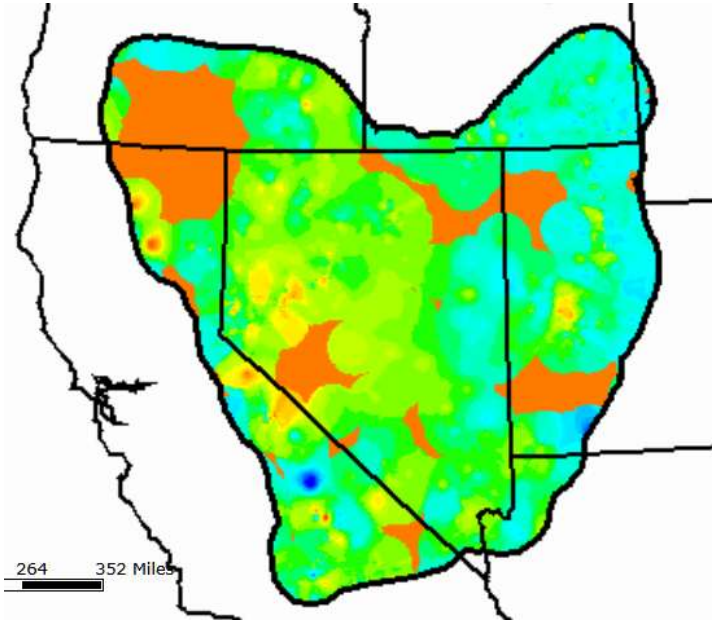



Elevated (**60 ppb) levels of arsenic are present in Crowley Lake**, the first reservoir in the Los Angeles Aqueduct which **provides 75% of the water supply for the 3.2 million residents of Los Angeles**. The arsenic derives from geothermal inputs from Hot Creek, an indirect tributary. As a result of this influx, the arsenic in the **influent to the Sylmar, CA water filtration plant averaged 20 ppb**.



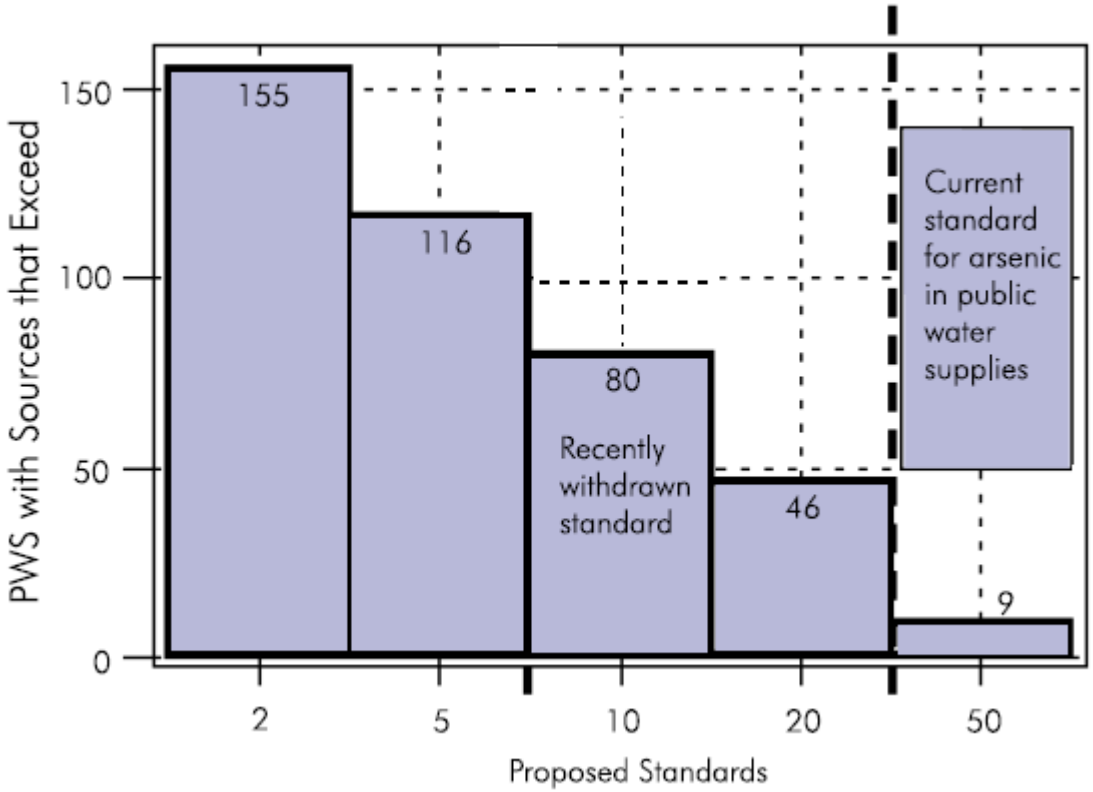

In California, About **26 percent of the samples** in one major-aquifer study (sacrsus1) had **arsenic concentrations greater than the MCL of 10 ppb** and it was estimated that **38 % of water supply wells were out of compliance** with the new standard.

## Nevada Arsenic Levels

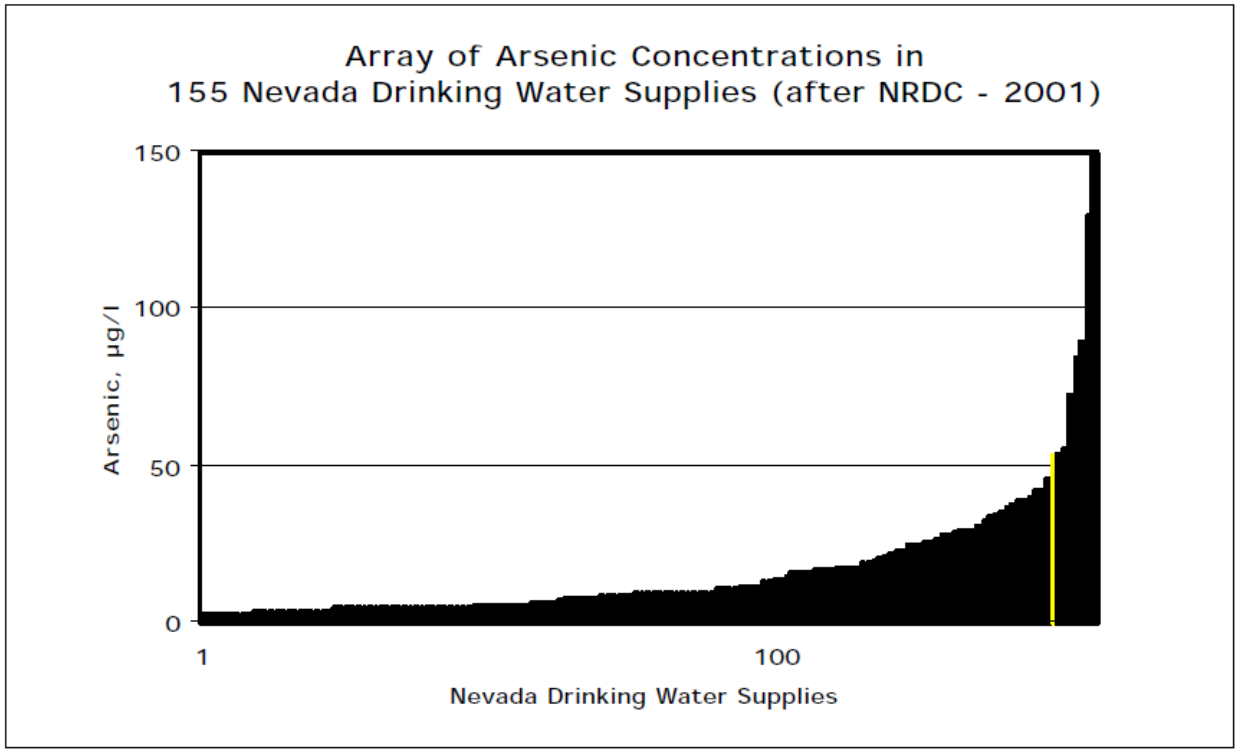



**Great Basins Groundwater Arsenic**

(brown areas are higher arsenic)




**Number of Water Systems in Nevada which exceeded Proposed Drinking Water Standards**




The charts above show that 135 water systems in Nevada exceeded the current standard (10ppb) in 2001. **More than two-thirds of the wells with arsenic concentrations higher than 10 ppb are located in communities with less than 10,000 people**, which are supported by groundwater systems and not surface-water systems. It was estimated that **over 75 percent of the systems in Nevada were affected by the new standard**, and **95 percent of those systems impacted cities with less than 10,000 inhabitants.**


Fallon  Nevada , (Population: 8,300) in Churchill County had arsenic levels in drinking water at 100 ppb and exceeded 50 ppb from 1977 to 2007. **Fallon's water system delivered more arsenic to its customers than any other large system. Residents just outside city limits who rely on private wells where the arsenic frequently reaches 700 ppb and, in some cases, more than 2,000 ppb. Thirty four percent of the residents of Clark County were tested with over 50 ppb** of arsenic in their urine in 2003

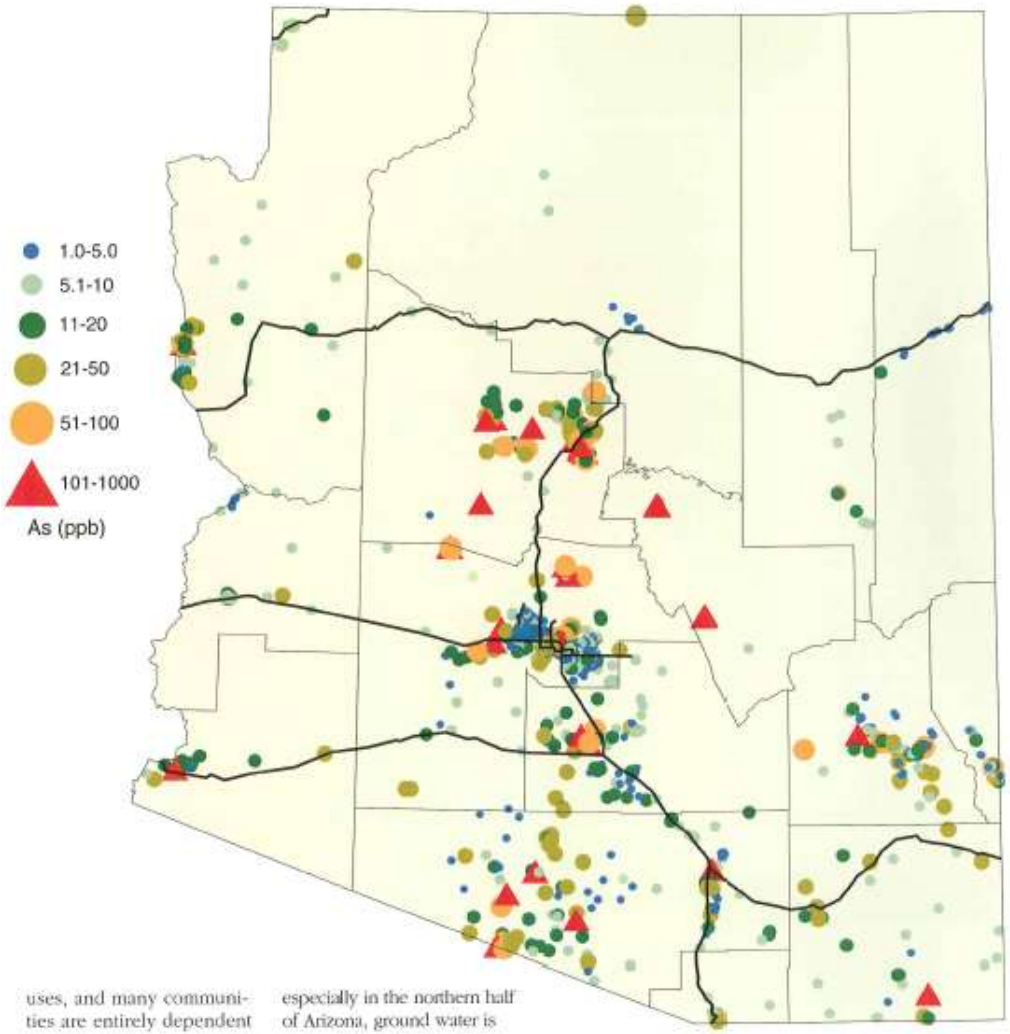
> Although the town has a small **population, 12 children were diagnosed with leukemia over a course of approximately three years**. **The number of childhood leukemia cases here is about 30 times the normal rate in the general population** No other county in Nevada has ever reported more than one

case in a year. According to the American Cancer Society **approximately 1.27 percent of the population (1 in 79) will come down with the disease sometime in their lifetimes.**

**Since leukemia has not previously been linked to arsenic exposure other causes are being investigated. Jet fuel and exhaust fumes containing benzene from the nearby Naval Air Station are one possibility. Pesticides and their metabolites as well as tungsten were also elevated in the urine of residents.**

**The LA Times reported in 2001 that "residents who have been stricken with arsenic poisoning, or have skin cancer that may have been triggered by years of drinking arsenic-laced water, seem resigned."**

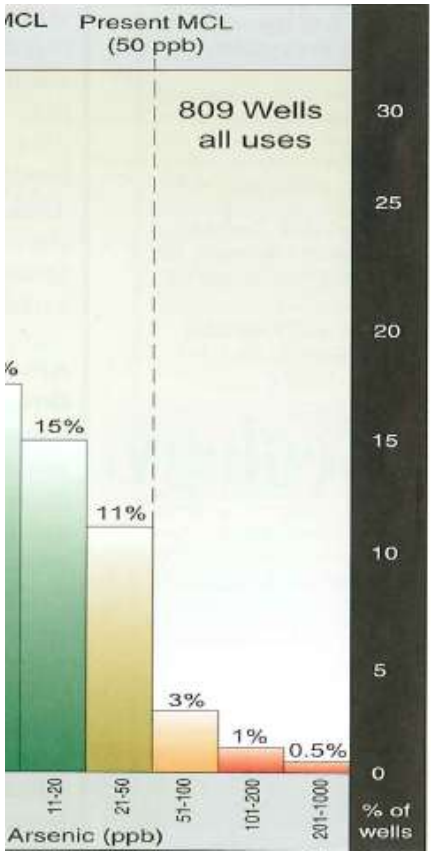
# Arizona Arsenic Levels




uses, and many communities are entirely dependent

especially in the northern half of Arizona, ground water is

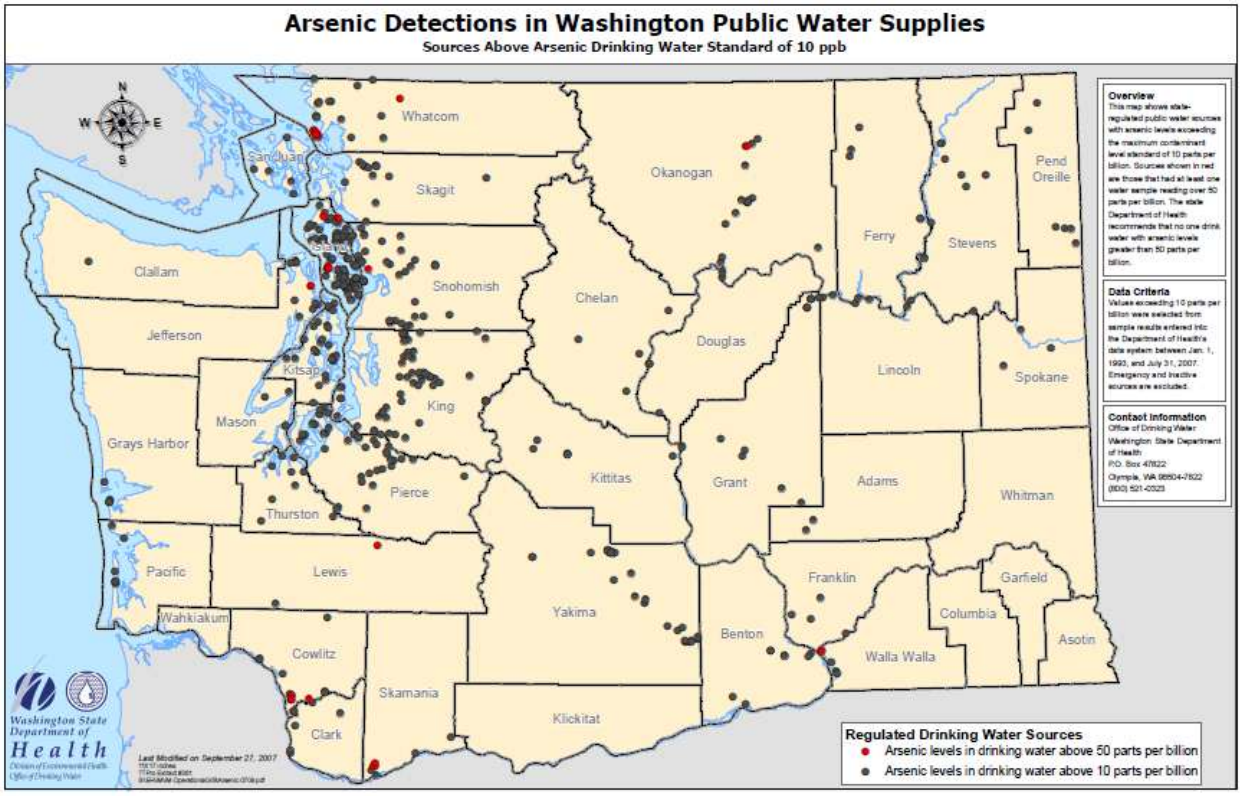
## Map of Arsenic in Arizona Wells




## % Arizona Wells Above Proposed Arsenic Standards

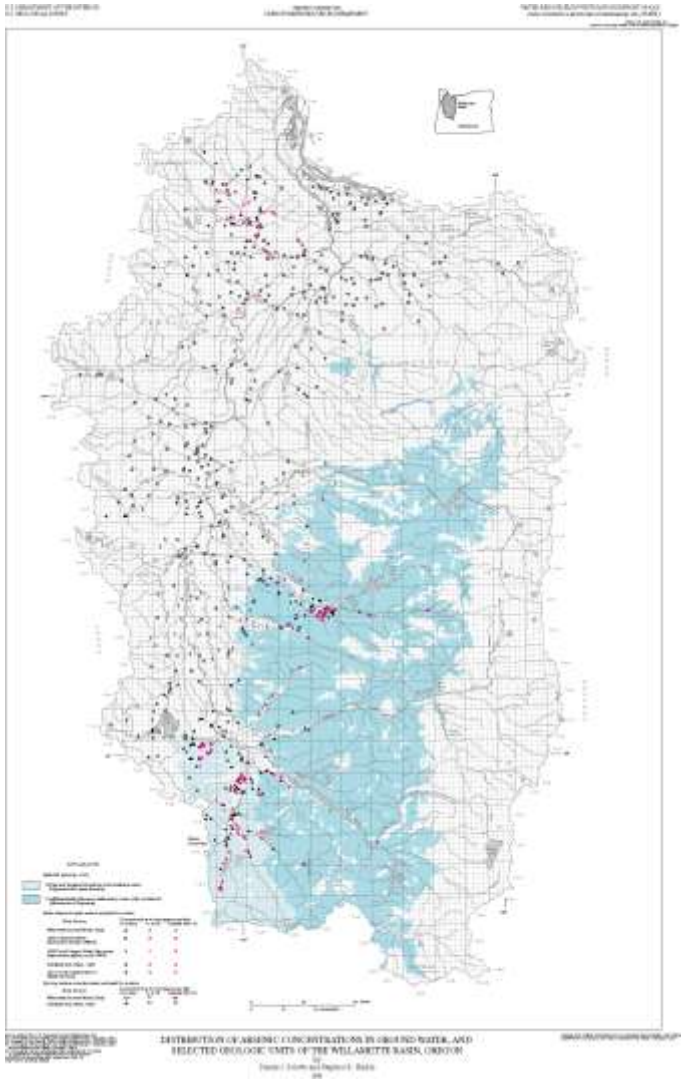
- In Arizona, an **estimated 35 percent of water-supply wells were put out of compliance by the new regulation**. Even some surface waters, such as the **Verde River <u>sometimes</u> exceed 10 ppb arsenic**, especially during low-flow periods when the river flow is dominated by groundwater discharge.

# Washington Arsenic Levels

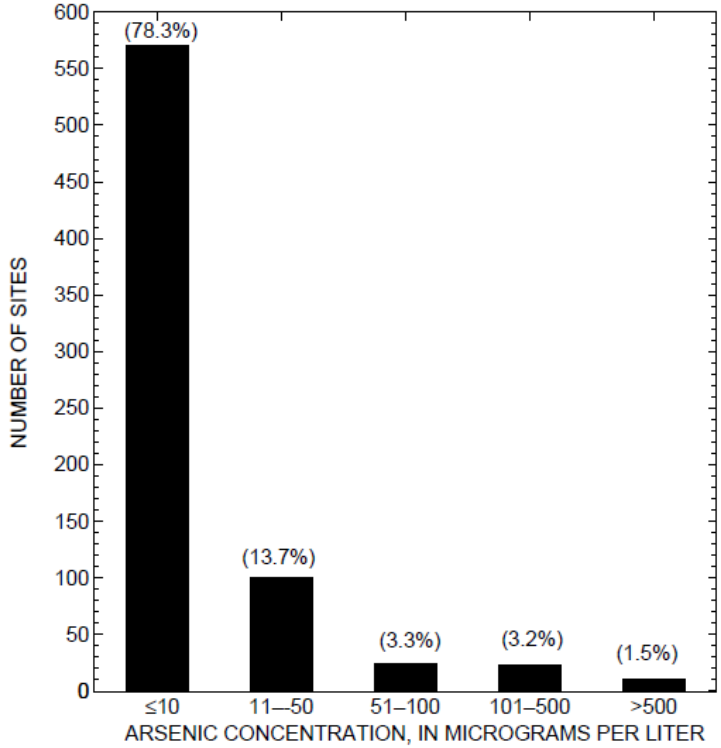



# Water Sources in Washington above Arsenic Standard

# Oregon Arsenic Levels



Oregon Arsenic Concentrations (>10 ppb in red)




**Samples exceeding the 10 ppb arsenic standard are widespread in ground water in the Willamette Basin of Oregon**. Concentrations of arsenic in the 728 spatially distributed **samples ranged from less than 1 to 2,000 ppb**. Of these samples, **22% exceeded the 10 ppb standard** and concentrations in **8% exceeded 50 ppb.**

# Alaska and Yukon

Gold placer deposits have been mined around Nome, Alaska since 1899. The placer separation process concentrates arsenic bearing minerals and generates arsenic and mercury containing dredge tailings. These tailings have been commonly used as foundation and fill for numerous construction projects throughout the Nome area.

Operations from mining and gold extraction in and around Nome, Alaska, may have caused potential health risks to area residents. Preliminary sampling indicates arsenic and mercury contamination of water, sediment, and soil is directly attributable to gold extraction activities. Results of **domestic well samples** taken at three different Nome, Alaska locations revealed a **maximum arsenic level of 24ppb**

## LIST OF PRINCIPAL CONTAMINANTS

**The highest detected levels of contaminants for surface water, groundwater, soil, and sediment samples taken in the Alaska Gold Site area are shown below.**

| Contaminant | Maximum Reported Concentration |
|---|---|
| | |
| **AIR** | |
| | |
| **Mercury (Vapor)** | 0.026 $mg/m^3$ |
| **Mercury (Particulate)** | 0.245 $ug/m^3$ |
| | |
| **SOIL** | |
| | |

| | |
|---|---|
| **Arsenic** | **10,000 ppm** |
| **Mercury** | 85 ppm |
| **Mercury*** | 484,600 ppm |
| | |
| **SURFACE WATER** | |
| | |
| **Arsenic** | **220 ppb** |
| **Mercury*** | 6.6 ppm |
| | |
| **GROUNDWATER** | |
| | |
| **Arsenic** | **24 ppb** |
| **Mercury** | 0.2 ppb |
| | |
| **SEDIMENT** | |
| | |
| **Arsenic** | **120 ppm** |
| **Mercury** | 50 ppb |
| **Mercury*** | 308 ppm |

*Contaminant levels are results from the 1985Alaska Gold Company Site Assessment sampling program.

Steadman Field, a recreational facility located within a residential area, was constructed on the former site of a commercially operated gold extraction facility. This facility is used for a number of recreational purposes, such as teamsports, and also includes an all-terrain vehicle course. Analysis of soil samples collected from Steadman Field revealed **soil arsenic levels as high as 10,000 ppm** and mercury levels up to 85 ppm. Results of soil sampling conducted at other local playgrounds and school facilities revealed arsenic contaminant levels ranging from 20 - 110 ppm and mercury levels from 0.01 - 0.05 ppm. The ATSDR restricted public access to contaminated soils and sediments such as those found in the Steadman Field Recreational area and around gold retort operations

In 1986 the State of Alaska issued the following conclusions in a press release:

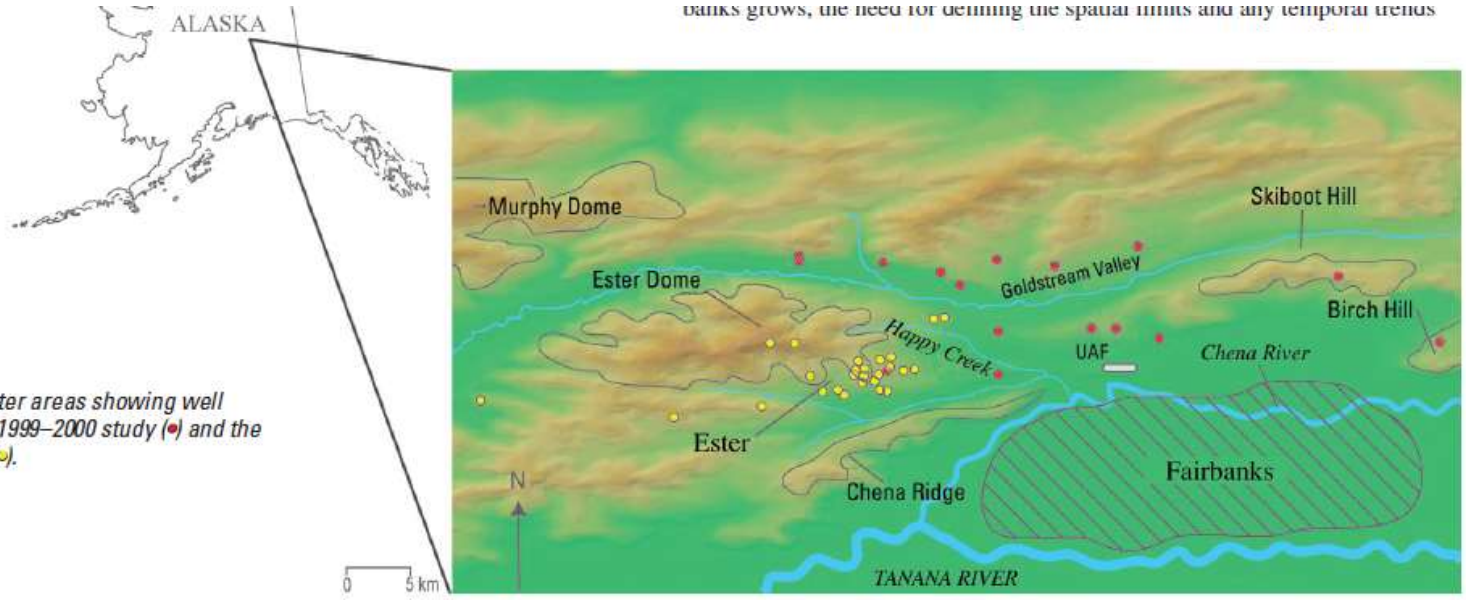
- There is no evidence that children who have played at Steadman Field have, or will have in the future, any adverse health risks from arsenic or mercury.

- There is no risk to individuals from using Steadman Field now because snow and ice will prevent exposure to arsenic and mercury in the soil.

- No restrictions on the use of Steadman Field are needed at this time. The field may be used for any activities, as in past years, safely by the community, at least until after breakup next spring.

> **The ATSDR eventually concluded that "Soil contaminant levels at the Steadman Field Recreational area are sufficiently high to pose a public health risk to those using this facility**. Potential health risks are associated with the ingestion of contaminated soils and the inhalation of fugitive dusts"
>
> Some of the streams affected by **gold-mine drainage near Fairbanks, Alaska**, occasionally contained levels of dissolved arsenic above **50** parts per billion.

The discovery of high concentrations of arsenic **(up to 10,000 µg/liter), among the highest concentrations reported for natural water anywhere in the United States**, in the well water of a residential area near Fairbanks, Alaska prompted an urgent study in 1978. The results showed that mean urine arsenic levels (17.83 µg/100 ml) In persons who drank well water containing ≥100µg arsenic/liter were significantly greater than levels in bottled-water drinkers or in well-water drinkers exposed to <100µg arsenic/liter. Individuals who were exposed to high-arsenic water had elevated arsenic concentrations in their urine, hair, and nails, although no specific health problems were identified.




*Fairbanks and Ester areas showing well locations for the 1999–2000 study (•) and the 2000-2001 study (○).*

Dissolved arsenic in amounts **>50** ppb was present in streams near Fairbanks, whether gold mining was occurring or not. Streams near the gold and silver lode mine at **Ester Dome, Alaska, contained nearly 500 ppb dissolved arsenic**

Water quality data collected from the wells in the Goldstream Valley and Ester Dome areas reveal that arsenic concentrations can range from below detection (<3 µg/L) to **1,670 µg/L**. Most water samples from Ester Dome exceed 10 µg/L, The extreme variations in concentration may occur in wells a few hundred meters apart, many of which may be drawing from the same aquifer.

The Dawson City area of the Yukon is well-known for dredge spoils from its gold mining operations. Some of these are exposed upstream for more than 5 miles. (see satellite photo) Despite the apparent risks of wind-blown and water borne contamination of arsenic and mercury no detailed analysis metal contents or risk assessments have been found. This situation is exacerbated by the fact that Canada does not require annual reporting from toxic release sites as is now required in the US.


GoogleEarth image of gold mine tailings near Dawson City

These scalloped, worm-shaped piles of gravel are tailings left behind from the many gold dredges that worked the Klondike gold fields up to 1966. Some of the old tailings have been reworked again in recent years to recover additional gold.


Clearly, mine tailings can be dangerous. In 2010, the Australian Dept. of Health issued a fact sheet on Arsenic Mine Tailings and Health. It recommends.

- **Reduce your exposure to mine tailing soil and dust.**
- **Do not allow young children to play in or eat mine tailings.**
- **Wash young children's hands and their toys frequently.**
- **Bring in clean soil for vegetable garden beds and ensure all fruit and vegetables are washed before eating.**
- **Do not swim in or eat fish from dams with walls made from mine tailings.**

## Pressure Treated Wood in the US

The most common **wood preservative** used in the United States is chromated copper arsenate (**CCA**), an insecticide that is **22 percent pure arsenic**. The wood in most **playground sets, picnic table, s fences, docks, foundations and decks** contains potentially hazardous levels of this same poison  If it has a greenish tinge, especially if it was built before 2004., there's a good chance it was treated with chromated copper arsenate (CCA), or arsenic, to prevent rot. Numerous laboratory and field studies show definitively that potentially hazardous amounts of **arsenic in CCA leach out of pressure-treated lumber**, where it may be ingested or absorbed by people or animals, or may contaminate water sources or soil beneath the wood. The USGS has reported "**Large amounts of arsenic are becoming widely distributed in the backyards and landfills of the United States as a component of pressure-treated wood…"**

"the estimated total amount of **arsenic used in pressure-treated wood since 1975 exceeds 300,000 tons**... Using the same assumption, **the amount of arsenic contained in discarded CCA pressure-treated wood could nearly triple to 14,400 t in 2010**. Total **decomposition of the wood could take more than 70 years**. When disposed of, CCA **pressure-treated wood is not considered a hazardous waste**, although a portion of this material fails EPA's test for Toxicity Characteristics."

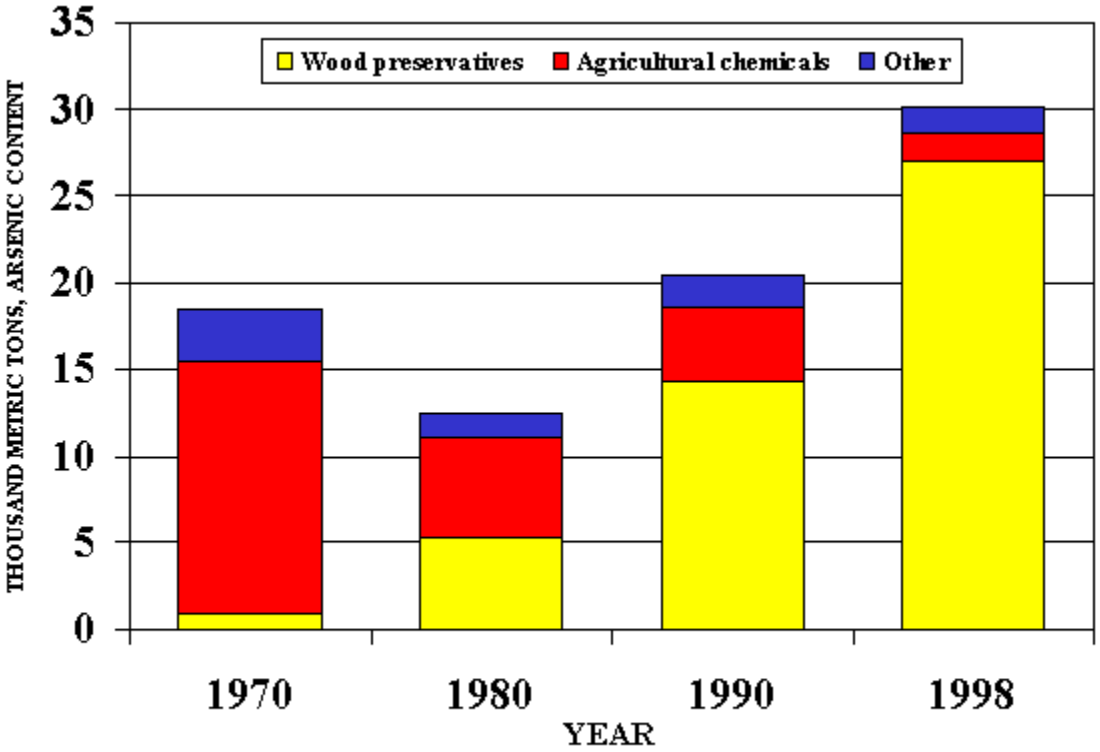



Figure 1. Domestic use of arsenic in selected years. Source of data: Loebenstein, 1994, and Reese, 1999b.

# Bangladesh

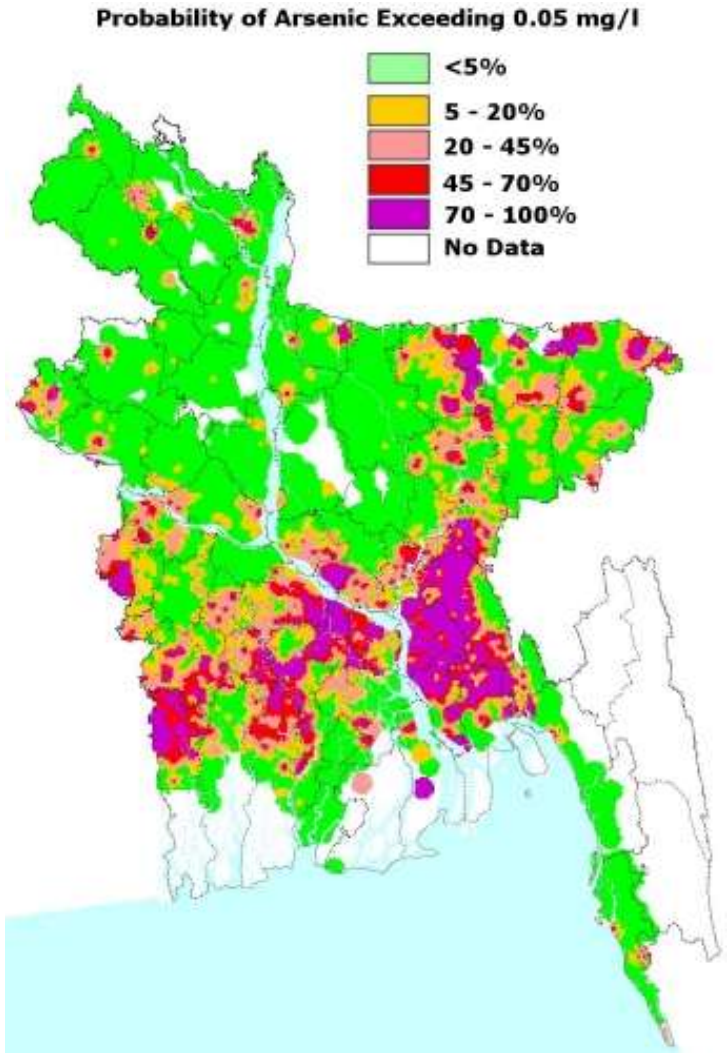
One of the biggest unintentional cases of arsenic poisoning via well water consumption is in Bangladesh and called by the World Health Organization as the "largest mass poisoning of a population in history. UNICEF and the World Bank advocated the use of wells to tap into deeper groundwater for a quick and inexpensive solution to high infant mortality and diarrheal illness. However, with over 8 million wells constructed, it has been found over the last two decades that **approximately one in five of these wells is now contaminated with arsenic above the government's drinking water standard of 50 ppb**. The WHO states:

> " It has been estimated that **35 - 77 million of the total population of 125 million of Bangladesh are at risk of drinking contaminated water** (WHO bulletin, volume 78, (9 ).Approximately 1 in 100 people who drink water containing 0.05 mg arsenic per liter or more for a long period may eventually die from arsenic related cancers. " Studies in other countries where the population has had long-term exposure to arsenic in groundwater indicate that **1 in 10 people who drink water containing 500 mg of arsenic per liter may ultimately die from cancers caused by arsenic**, including lung, bladder and skin cancers.

Skin lesions due to arsenic poisoning


Skin lesions on the feet of a Bangladeshi


Water well in Bangladesh




Map based on several million water wells in Bangladesh drilled since the 1980's

*Picture 1 – Depigmentation.*

*Picture 2 – Keratosis*

A 2011 article in the journal *Social Medicine* concludes arsenic poisoning arsenicosis is linked to poverty, health and nutrition. Furthermore "research suggests **2-9 years as the minimum latency for hyperpigmentation and keratosis**. **Latency for cancers is unknown, but estimated to be of the order of 20 years.**

Carcinoma on the hand of Bangladeshi

# Treatments

Once arsenic has been ingested, the best treatment may be to introduce agents to bind to the arsenic and help prevent its toxic effects. Because arsenic binds strongly to sulfur, sulfur based compounds and chelating agents have shown good success.

Chelating agents such as **"British anti-lewisite" (BAL)** work by binding arsenic tightly in complexes, making it inactive. This can help deactivate arsenic and remove it from a person's body, averting severe toxicity and death. Chemical and synthetic methods are now used to treat arsenic poisoning. Dimercaprol and dimercaptosuccinic acid are chelating agents which sequester the arsenic away from blood proteins and are used in treating acute arsenic poisoning. The most important side effect is hypertension.

By far the preferred treatment is to reduce arsenic exposure immediately through the installation of water filters or removal from the source. Since arsenic body burden is so difficult to reduce after exposure, the best course of action is to prevent arsenic contact in the first place. Only a customized environmental health profile of your present and planned future residences can prevent the need for future treatment.

# Cancer Risks

From a 1988 study in China, the US protection agency quantified the lifetime exposure of arsenic in drinking water at concentrations of 0.0017 mg/L, 0.00017 mg/L, and 0.000017 mg/L are associated with a lifetime skin cancer risk of 1 in 10,000, 1 in 100,000, and 1 in 1,000,000 respectively. The World Health Organization contends that a level of 0.01 mg/L poses a risk of 6 in 10000 chance of lifetime skin cancer risk and contends that this level of risk is acceptable.[15]

In 2001, Exposure to arsenic levels between **10 ppb to 50** ppb in drinking water was estimated to **double urinary cancer risk** compared to the risk in the general population. Risk was roughly **8 times higher** for levels between **50 ppb and 100** ppb and **15 times higher** for people exposed to arsenic levels **exceeding 100 ppb.**

**According to the World Health Organization, approximately 1 in 100 people who drink water containing 0.05 mg arsenic per liter or more for a long period may eventually die from arsenic related cancers. "Studies in other countries where the population has had long-term exposure to arsenic in groundwater indicate that 1 in 10 people who drink water containing 500 mg of arsenic per liter may ultimately die from cancers caused by arsenic, including lung, bladder and skin cancers.**

**Arsenic can cause cancer at levels that are commonly found throughout the United States. In addition to having high levels of arsenic in drinking water along regional trends, we have to be alert to the potential for contamination from toxic sites, waste disposal, pressure treated wood and mining spoils.**

**No one is completely safe from this naturally occurring poison and widespread contaminant. While the overall risk is higher along certain overall regional trends it is imperative that everyone know precisely where your water is coming from and the arsenic variability within that source. If you drink from private wells have your source tested. Consider whether it is necessary to install an in-home arsenic filter. If you drink from public water systems find out the arsenic levels and historical trends. It is not enough to know that your drinking water is below the maximum contaminant level today, you must be aware of your total arsenic exposure in the past or at any residence in the future.**

**Only a personalized environmental health profile showing your specific residences relative to the overall regional arsenic trends along with the nearest potential toxic sites can provide security. If this reveals potential high arsenic exposure or if you develop symptoms consistent with Arsenic poisoning have your body burden tested. Tell your doctors if you have reason to believe that you have been exposed to arsenic over a long period and have them closely monitor early symptoms of arsenic related diseases.**

**In the end, limiting current and future exposures to arsenic is the best strategy. Only early detection and treatment of arsenic-related diseases can significantly lower your chance of developing certain chronic diseases and reduce cancer risk from prolonged arsenic exposure.**