REVIEW OF THE DRINKING WATER AND GROUNDWATER STANDARDS FOR ARSENIC

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New Hampshire Department of Environmental Services
REVIEW OF THE ARSENIC STANDARD

- Why arsenic
- Current standard (MCL)
- Recent review
- Current status
ARSENIC

- New Hampshire the Arsenic State – “primary domestic source for decades”
- Uses: rodenticide, fungicide, insecticide, embalming, medical
- Exposure from water and food
- Mechanism of low-dose toxicity – possible endocrine disruptor
DRINKING WATER STANDARDS FOR ARSENIC

- USEPA - 50 ppb until 2001
- Proposed 5 ppb in 2000
- Adopted 10 ppb in 2001
  - Health effects
  - Treatment cost

- New Jersey - 2001
  - Health effects
  - Treatment feasibility
  - Proposed 3 ppb
  - Adopted 5 ppb
    - Implemented since 2006

- California
  - Health effects
  - Treatment affordability
  - Adopted 10 ppb

Source: EPA 815-R-00-026
Estimated excess cancer risks per 100,000 people exposed at the MCL

Risks estimated based on cancer potency estimates from IRIS

Source: Craig Steinmaus, MD, MPH; UCSF, UC Berkeley
Figure 1. Estimated cancer risk deaths per 100,000 people exposed at the MCL of each drinking water chemical carcinogen

Risks for arsenic based on NRC 2001 cancer potency estimates

Source: Craig Steinmaus, MD, MPH; UCSF, UC Berkeley
NH 2018 REVIEW OF ARSENIC STANDARD

- 2018 HB 1592 (June): NHDES shall review AGQS & make recommendation
  - Occurrence
  - Ability to detect
  - Ability to treat
  - Public health impact
  - Costs
- USEPA updating Tox Review since 2003 . . .
- Dartmouth Birth Cohort Study
- UNH study: economic value of reduced risk
- NHDES estimates of costs
# DOSE-RESPONSE: MOE SCREENING

<table>
<thead>
<tr>
<th>Health outcome category</th>
<th>All HI studies (Starting point)</th>
<th>Studies set aside in initial screen</th>
<th>Studies set aside in second screen</th>
<th>Studies set aside in final screen</th>
<th>Studies included in MOE modeling</th>
<th>Datasets included in MOE modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder cancer</td>
<td>64</td>
<td>37</td>
<td>3</td>
<td>6</td>
<td>18</td>
<td>73</td>
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<tr>
<td>Diabetes</td>
<td>49</td>
<td>43</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>9</td>
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<td>Diseases of the circulatory system</td>
<td>105</td>
<td>75</td>
<td>4</td>
<td>9</td>
<td>17</td>
<td>73</td>
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<tr>
<td>Immune effects</td>
<td>20</td>
<td>8</td>
<td>3</td>
<td>9</td>
<td>0</td>
<td>0</td>
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<td>Liver cancer</td>
<td>30</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>7</td>
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<tr>
<td>Lung cancer</td>
<td>87</td>
<td>53</td>
<td>8</td>
<td>10</td>
<td>16</td>
<td>37</td>
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<tr>
<td>Nonmalignant respiratory</td>
<td>47</td>
<td>36</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>5</td>
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<tr>
<td>Pregnancy outcomes</td>
<td>39</td>
<td>25</td>
<td>2</td>
<td>9</td>
<td>3</td>
<td>6</td>
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<tr>
<td>Renal cancer</td>
<td>32</td>
<td>19</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td>Skin cancer</td>
<td>38</td>
<td>32</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Skin lesions</td>
<td>72</td>
<td>61</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total Number of Studies or Datasets</strong></td>
<td><strong>415</strong></td>
<td><strong>289</strong></td>
<td><strong>23</strong></td>
<td><strong>47</strong></td>
<td><strong>68</strong></td>
<td><strong>262</strong></td>
</tr>
</tbody>
</table>

*Studies totals do not equal sum of columns due to study overlap across health outcome categories.*

Source: USEPA, ORD, IRIS
### Health Outcomes

<table>
<thead>
<tr>
<th>Health Outcomes</th>
<th>NRC Tier</th>
<th>Characterization of Evidence</th>
<th>Level of Dose-Response</th>
<th>Place in Assessment</th>
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</thead>
<tbody>
<tr>
<td><strong>Cancer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td>1</td>
<td>Robust</td>
<td>Meta-regression</td>
<td>None</td>
</tr>
<tr>
<td>Lung</td>
<td>1</td>
<td>Robust</td>
<td>Meta-regression</td>
<td>None</td>
</tr>
<tr>
<td>Disease of Circulatory Sys.</td>
<td>1</td>
<td>Robust</td>
<td>Meta-regression</td>
<td>Section 1</td>
</tr>
<tr>
<td><strong>Noncancer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adverse Preg. Outcomes(^1)</td>
<td>2 &amp; 3</td>
<td>Robust</td>
<td>Screening and TBD</td>
<td>Section 1</td>
</tr>
<tr>
<td>Diabetes(^1)</td>
<td>2</td>
<td>Robust</td>
<td>Screening and TBD</td>
<td>Section 1</td>
</tr>
<tr>
<td>Neurocognitive effects(^1)</td>
<td>2</td>
<td>Moderate</td>
<td>Screening and TBD</td>
<td>Section 1</td>
</tr>
</tbody>
</table>

Source: USEPA, ORD, IRIS
Arsenic Treatment Options
Arsenic Treatment - Process Selection Guide

Iron - mg/L

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Arsenic - ug/L

0 5 10 15 20 25 30 35 40 45 50

Fe - SMCL

Arsenic Treatment - Process Selection Guide

Iron Removal Process
Optimized for Maximum As Removal

B

Modified Iron Removal Process

C

Media Adsorption
Iron Coag/Filt
Ion Exchange
Iron Removal(M)
RO / NF

20 - 1 Fe/As ratio
or above

PROPOSED NH MCL

Iron Removal Process

As MCL

Iron - mg/L

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 or above

Arsenic - ug/L

0 5 10 15 20 25 30 35 40 45 50
Arsenic Sampling Results (00-05)
CWS and NTNC systems

Number of Detections

Arsenic Concentration (ppb)

Cumulative Frequency

93 Systems
54 Systems
19 Systems

n=459
Adsorptive Media Bedlife Performance

Arsenic filter media longevity varies widely, depending mostly on water pH, but also natural Silica and Phosphorus levels.
Arsenic Breakthrough Curve - Goffstown

Influent - Arsenic (all As-V), pH 7.0

Lead Vessel

19,800 BV

Lag Vessel

52,500 BV

MCL 10 ppb

PROPOSED NH MCL

Bed Volumes Treated (1 BV = 5 CF or 37.4 gal)
Treatment Cost Estimates to Meet 5 ppb As MCL

• Existing Iron-Arsenic systems – no changes
• Existing Ion Exchange systems – no changes
• Existing Adsorption systems
  – Assumed 2x filter media changeout vs. current.

• NEW treatment systems for 5 ppb to 10 ppb, assumed $1,000 per gpm up to ~30 gpm flow, regardless of treatment technology.
## COST ESTIMATES

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Number of Sites</th>
<th>Total Capital Cost ($ M)</th>
<th>Total Additional Annual Cost ($ M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public water systems</td>
<td>195+123= approx. 310</td>
<td>0.95</td>
<td>3.88</td>
</tr>
<tr>
<td>(a few currently treating would add treatment)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewage lagoons and other facilities with groundwater discharge permits</td>
<td>40</td>
<td>2.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Landfills</td>
<td>46</td>
<td>0.46 - 0.76 (0.61 =/ - 25%)</td>
<td>0.19 - 0.32 (.25 +/ - 25%)</td>
</tr>
<tr>
<td><strong>Total of Costs Estimated</strong></td>
<td></td>
<td><strong>3.76</strong></td>
<td><strong>4.63</strong></td>
</tr>
</tbody>
</table>
The Economic Benefits of Lowering the Arsenic Maximum Contaminant Level in New Hampshire Municipal Water Supplies

December 10, 2018

John Halstead
Department of Natural Resources and the Environment
University of New Hampshire

Scott Lemos
Robert Mohr
Robert Woodward
Department of Economics
University of New Hampshire

Prepared for the New Hampshire Department of Environmental Services
UNH STUDY OF BENEFITS

- Literature review
- VSL based on survey of willingness to pay
  - Difference 10 ppb to 3 ppb
  - VSL: $5 million
- Applied to cancer & CVD
- 5.5-point reduction in IQ – impact on lifetime earnings

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Risk Type</th>
<th>Prevalence (per 10,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Heart disease by age 70</td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td>Skin cancer by age 70</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>Automobile accident over 20 years (fatal)</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>Death from opioid overdose over lifetime</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Risk of lung or bladder cancer from drinking water with 10 ppb arsenic on a regular basis for 70 years</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Audited by the IRS per year</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Victim of cybercrime per year</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Death from gun assault over lifetime</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Risk of death from lung or bladder cancer from drinking water 10 ppb arsenic on a regular basis for 70 years</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Risk of lung or bladder cancer from drinking water with 3 ppb arsenic on a regular basis for 70 years</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Death from fire in home over lifetime</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Risk of death from lung or bladder cancer from drinking water 3 ppb arsenic on a regular basis for 70 years</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Death from bicycling accident over lifetime</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Risk of cancer from bromate at current drinking water standard of 10 ppb over 70 years</td>
<td>2</td>
</tr>
<tr>
<td>Low</td>
<td>Risk of cancer from vinyl chloride at current drinking water standards of 2 ppb over 70 years</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Struck by lightning over lifetime</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Death from a plane crash over lifetime</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Summary of benefits

Table 6. Estimated **Bladder and Lung Cancer Deaths** Due to Arsenic Exposure for Lung and Bladder Cancer over a 70-Year Period from New Hampshire Public Water Systems Based on Recent Arsenic Testing Results (2014-2017) and Assuming Specified Maximum Contaminant Levels

<table>
<thead>
<tr>
<th>MCL (µg/L)</th>
<th>Total Cancer Cases from Table 4</th>
<th>Total Deaths</th>
<th>Cancer deaths avoided by lowering MCL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lung</td>
<td>Bladder</td>
</tr>
<tr>
<td>10</td>
<td>33-101</td>
<td>19-37</td>
<td>1-9</td>
</tr>
<tr>
<td>5</td>
<td>27-82</td>
<td>16-30</td>
<td>1-8</td>
</tr>
</tbody>
</table>

Table 7. **Annual willingness to pay ($ Million)** for reduced risk of lung and bladder cancer associated with lowering the arsenic MCL

<table>
<thead>
<tr>
<th>MCL</th>
<th>Lung Cancer Deaths</th>
<th>Bladder Cancer Deaths</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>5</td>
<td>0.216</td>
<td>0.504</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0.072</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reduced IQ (lifetime earnings loss of $150 – 200 million) **$2-3 million per year** (section 5.3)

CVD (not in our report but around 50/year, so $250 million/year)

Lung per D'Ippoliti (7/year or $35 million/year)

**Not quantified:**

Cardiovascular disease
Adverse birth outcomes
Infections in infants
Gestational diabetes
Exposure to levels below 10 ppb increases risk of many diseases

Possible to estimate the magnitude of risk reduction for lung, bladder, skin cancer

Convincing data on other diseases, etc. but not for quantitative estimates: adverse birth outcomes, infant illnesses, CVD deaths

Potential for cognitive effects must be considered

Water treatment feasible down to 5 ppb

5 ppb is the right number

Costs would be substantial

Tangible and intangible benefits warrant the added cost

Costs & benefits of 5 ppb could be addressed with greatest confidence
Review of the Drinking Water Maximum Contaminant Level (MCL) and Ambient Groundwater Quality Standard (AGQS) for Arsenic