Groundwater Wells Under the Influence of Surface Water as Determined by Microscopic Particulate Analysis Sampling Predicated on Near Real-Time Geochemical Data

By Christopher Lee Braun

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Background

- Ground-water resources that are under the influence of surface water are particularly vulnerable to contamination.
- Surface-water influence might be brief and relatively infrequent, but knowledge of the duration and timing of surface-water influence is vital to drinking water suppliers.
- Indicators (or tracers) that might be indicative of surface-water influence on ground water:
  - Specific conductance
  - Temperature
  - Turbidity
  - Microscopic particulates characteristic of surface water

Purpose

The U.S. Geological Survey conducted a study, in cooperation with the Texas Commission on Environmental Quality, to optimize the collection-times for large-volume filtered samples (referred to as MPA samples) that are to be analyzed for microscopic particulates characteristic of surface water using EPA Consensus Method 1623.

Scope of Work

- Two continuous monitoring sites were established at two public water-supply system wells to determine if there was a geochemical variation in response to surface-water inflow.
- Temperature and specific conductance were continuously monitored at 15-minute intervals for 5 months starting on 4/6/2006.
Microscopic Particulates Analyzed (EPA Consensus Method)

- Amorphous debris
- Vegetative debris
  - with chlorophyll
  - without chlorophyll
- Diatoms
  - with chlorophyll
  - without chlorophyll
- Other algae
- Rotifers
- Rotifer eggs
- Spores
- Pollen
- Iron bacteria
- Crustaceans
- Crustacean parts
- Crustacean eggs
- Water mites
- Gastrotrichs
- Tardigrades
- Nematomes
- Nematomes eggs
- Invertebrate eggs
- Annelids
- Amoebae
- Protozoa
- Insect/larvae
- Giardia
- Cryptosporidium

Microscopic Particulate Analysis Risk Rating (EPA Consensus Method)

- Risk rating tables were developed by the EPA in the early 1990s as a tool to aid with the interpretation of MPA data.
- Risk rates are based on the number of surface water bioindicators present per 100 gallons of water.
- Different risk weights are assigned to various bioindicators.

To use the risk rating tables, the concentration of each bioindicator is entered into Table 1 (below) and the corresponding qualitative ranking is recorded.

Table 1. Numerical range of each primary bioindicator (particulate) counted per 100 gallons of water

<table>
<thead>
<tr>
<th>Bioindicators</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giardia</td>
<td>&gt;30</td>
<td>16-30</td>
<td>6-15</td>
<td>1-5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Giardia</td>
<td>&gt;30</td>
<td>16-30</td>
<td>6-15</td>
<td>1-5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Diatoms</td>
<td>&gt;100</td>
<td>65-140</td>
<td>11-40</td>
<td>1-5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other Algae</td>
<td>&gt;100</td>
<td>96-230</td>
<td>21-68</td>
<td>1-5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Insecto/Larvae</td>
<td>&gt;100</td>
<td>11-500</td>
<td>16-30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nematodes</td>
<td>&gt;100</td>
<td>65-140</td>
<td>71-60</td>
<td>1-5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Plant Flora</td>
<td>&gt;100</td>
<td>25-200</td>
<td>25-80</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The qualitative ranking for each surface water indicator is then cross-checked using Table 2 (below) to obtain a numerical score for each.

Table 2. Relative surface water risk factors associated with scoring of primary bioindicators (particulates)

<table>
<thead>
<tr>
<th>Bioindicators</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giardia</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Giardia</td>
<td>29</td>
<td>15</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Diatoms</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other Algae</td>
<td>12</td>
<td>9</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Insecto/Larvae</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nematodes</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Plant Flora</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The sum of the scores for all bioindicators is then used to determine the relative risk rating for the sample in question.

Risk of surface water contamination:
- > 20 – high risk
- 10-19 – moderate risk
- < 9 – low risk
Selected Wells – Phase I

Karst well
- Site ID: 30020097423601
- Station name: YD-58-27-931
- Location: Round Rock, Tex.
- Name: City of Round Rock well 1

Alluvial well
- Site ID: 301151097342901
- Station name: YD-58-52-500
- Location: Garfield, Tex.
- Name: Garfield Water Supply Company well 2

City of Round Rock well 1
- Primary aquifer: Edwards
- Aquifer type: Unconfined single
- Well depth: 222 ft

City of Round Rock well 1
- Hydrolab and filtration apparatus inside the shelter.

City of Round Rock well 1
- Removing shelter from the truck.

City of Round Rock well 1 - sample collected 4/19/06

Garfield WSC well 2
- Primary aquifer: Alluvial
- Aquifer type: Unconfined single
- Well depth: 48 ft
Garfield WSC well 2

Shelter showing inlet line coming from the well

Hydrolab and data logger inside the shelter

Garfield WSC well 2

Observations of Near Real-Time Monitoring Results

Original intent of the project was to use the near real-time monitoring results to schedule sample collection.

These results may also prove useful as a mechanism for determining the likelihood that a well is a GUI in the absence of MPA data.

Phase I monitoring results revealed numerous lines of evidence that suggest that City of Round Rock well 1 is more likely to be influenced by surface water than Garfield WSC well 2.

Relation between ground-water temperature and ambient air temperature

Comparison of ranges in temperature and specific conductance data
Observations of Near Real-Time Monitoring Results...

Conclusions/Lessons Learned
- Temperature and specific conductance data proved to be useful for scheduling sample collection times particularly at the Round Rock well.
- These results may also prove useful as a mechanism for determining the likelihood that a well is a GUI in the absence of MPA data.
- Realized the need for a precipitation gauge at each of the wells being continuously monitored (something we’ve added for the second phase of the study).

Conclusions/Lessons Learned
- Should be aware of the potential for changes to the natural environment in the proximity of the well and what effects those changes might have on the microbiology and geochemistry at the well.

Phase II
- A decision support scoring system was developed to rank public water supply sites based on their potential as ground-water resources under the influences of surface water (GUIs).
- Baseline samples were collected at each of the wells to determine which will be selected for continuous monitoring.
- Continuous monitoring equipment will only be installed at those wells classified as a low risk from the baseline sample.

Phase II
- Collection of duplicate sample at Double Horn WSC
- Well housing and sample collection box at Barkodale WSC