Groundwater and Hydrogeology of Luzerne / Columbia County, PA

Flowing Artesian Well
(Well needs no pump)

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Environmental Engineering and Earth Sciences Department
The EEES Department is within the School of Science and Engineering at Wilkes University. The EEES Department offers undergraduate degree programs and continuing education in environmental engineering and in earth and environmental sciences.

http://www.wilkes.edu

Center for Environmental Quality
Non-profit/ equal opportunity employer, is operated and managed within the Department of Environmental Engineering and Earth Sciences at Wilkes University

Outreach Programs
- Environmental and Professional Education and Training
- Applied Research
- Community and Business Outreach Programs

Website: http://www.water-research.net
Columbia and Luzerne Counties were glaciated and they are within the Appalachian Plateau and the Ridge and Valley Provinces.

Source: DCNR - [http://www.dcnr.state.pa.us/topgeo/map13/map13.aspx](http://www.dcnr.state.pa.us/topgeo/map13/map13.aspx)

What Does This Mean?

Wisconsinan (17,000 to 22,000 yrs)
Late-Illinoian (132,000 – 198,000 yrs)
Pre-Illinoian (> 770,000 yrs)

Source: Luzernecounty.org

Source: DCNR - [http://www.dcnr.state.pa.us](http://www.dcnr.state.pa.us)
Appalachian Plateau Province

- Broad to Narrow Valleys
- Rounded Hills and Valleys Associated with Glaciation
- Valleys filled by glacial fluvial material
  - Unconsolidated Material (Un)

Ridge and Valley Province

- Bedrock has been folded into a series of anticline and synclinal structures.

Plunging Anticlines / Synclines

Source: West Virginia University
http://www.geo.wvu.edu

Geology of Columbia and Luzerne County

Anticline – Plunge to NE
Syncline – Plunge to NE
### Geological Sequence

<table>
<thead>
<tr>
<th>Time</th>
<th>Period</th>
<th>Deposit or Rock Type</th>
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<tbody>
<tr>
<td>0 to 1.8 million years</td>
<td>Quaternary – Glaciation</td>
<td>sand, silt, clay, and gravel</td>
</tr>
<tr>
<td>1.8 to 290 million years</td>
<td>Tertiary to Permian</td>
<td>Not present (eroded and weathered)</td>
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<tr>
<td>290 – 320 million years</td>
<td>Pennsylvanian</td>
<td>Llewellyn (coal) and Pottsville (minor coal)</td>
</tr>
<tr>
<td>320 – 354 million years</td>
<td>Mississippian</td>
<td>Mauch Chunk, Pocono and Spechty Kopf</td>
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<tr>
<td>354 - 417 million years</td>
<td>Devonian</td>
<td>Catskill Formation, Trimmers Rock Formation, Marcellus Formation, (Black Shale)- Target, Onondaga Formation, (calcareous sandy shale)</td>
</tr>
<tr>
<td>417 – 443 million years</td>
<td>Silurian</td>
<td></td>
</tr>
</tbody>
</table>

### Ridge and Valley Province – Rt 309

- Llewellyn
- Pottsville
- Mauch Chunk
- Bedding Planes with Seepage

### Mahantango Formation

Source: flickr.com/photos/ (ID –stillriverside)- Site Milford, PA

### Marcellus Shale Photo

Outcrops Along the Southeastern Border of Pike County Along Route 209

Main Fracture Orientation
Groundwater Moves - Slowly

feet per year

Why Test My Water?

A USGS survey found that 70% of private wells were contaminated. This contamination could result in acute or chronic health concerns.

In general, there are no regulations related to well construction, placement, or required testing. It is up to you to determine the safety of your water.

EPA recommends, at minimum, an annual water test for private wells.
Primary Standards (NPDWR)

National Primary Drinking Water Regulations

Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in water. They take the form of Maximum Contaminant Levels or Treatment Techniques.

There are over 100 chemical and biological primary drinking water standards, which include: trace metals, disinfection agents, disinfection by-products, radiological, microbiological agents, and organic chemicals.

Examples: Arsenic, Lead, MTBE, total coliform, Giardia, Trichloromethanes, Asbestos, Copper, Benzene, Trichloromethane, etc.

Secondary Standards

National Secondary Drinking Water Regulations

These standards were established more for cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor or color) in drinking water.

These are not regulated standards, but recommended limits.

The secondary standards include: aluminum, chloride, color, corrosivity, fluoride, foaming agents, iron, manganese, odor, pH, silver, sulfate, total dissolved solids, and zinc.

Groundwater Columbia and Luzerne County

Based on the geology of Columbia and Luzerne County, the common water quality problems are as follows:

- Corrosive Water
- Low pH
- Soft Water (low hardness) to Moderate Hardness
- Iron and Manganese
- Discolored Water – Reddish to Brown Tints
- Total Coliform Bacteria
- Sulfur Odors and Elevated Sulfates
- Methane – Columbia County

Air Quality Issues – Radon In Air!
Unsanitary Well Cap

- Insects, Larvae and Nests / Egg Masses
- Mouse Colonies
- Snakes
- Beehives
- Mud - when casing to close to ground

Types of Contamination - Bacteria, Pathogens, Sediment
Subject to Vandalism, Salts, and Flooding

Source: http://pa.water.usgs.gov

Less Common Problems

These water quality conditions are not common to groundwater in Columbia and Luzerne County.

- Elevated Nitrate- Nitrite Levels
- Radiological (Uranium, Alpha, Beta, and Radium)
- Organic Contamination
- Elevated Trace Metals (except corrosion by-products like Copper, Lead, Aluminum, Zinc)
- Salty or Brackish Water (very deep wells)
- Trihalomethanes
- Pathogenic Organisms

Announcement:
Free Radon in Air Test Program

The American Lung Association of the Mid Atlantic has obtained a supply of radon test kits from a laboratory certified by the Pennsylvania Department of Environmental Protection.

A limited number of tests are available for each region of PA. To determine the availability of a kit go to

http://www.lunginfo.org/freeradonkit
Enter your zip-code

Please allow for four to eight weeks for delivery.
Corrosive Water

- Chemical or Biochemical Reaction between the water and metal surfaces.

- The corrosion process is an oxidation/reduction reaction that returns refined or processed metal to their more stable ore state.

- Corrosion can also be accelerated by:
  1) low pH and high pH;
  2) high flow rate within the piping;
  3) high water temperature;
  4) chemistry of the water; and
  4) presence of suspended solids, such as sand.

- Copper – Typically Blue or Blue-Green Staining
  May also have elevated levels of Lead and Zinc.

pH

- pH < 7 acidic
- pH > 7 basic

Drink Water Standard
6.5 – 8.5

Problems
- Bitter or Sour Taste
- Corrosion
- Scale Formation
- Leaching Metals – Copper, Lead, Zinc, and Aluminum

Source: http://www1.kisr.edu.kw

Coliform Bacteria

- Absent or < 1 colony/100 ml

Testing Purpose
- Used as an Indicator of Sanitary Condition of Water Source

Sources
- Natural Soil Bacteria
- Human and Animal Waste
- Insect Waste

Water Hardness, Iron, Manganese

- The hardness of a water is a measure of the concentration of the multivalent cations (Ca\(^{2+}\), Mg\(^{2+}\), Fe\(^{2+}\), Mn\(^{2+}\), etc) associated with carbonates (HCO\(_3\)\(^-\)).

- Hardness is typically reported as mg/L as CaCO\(_3\) (calcium carbonate).

- Grains per gallon (1 gpg (US) = 17.12 mg CaCO\(_3\)/L).

- Hardness Classification:
  - Soft: 0 to 17 mg CaCO\(_3\)/L.
  - Slightly Hard: 17 to 60 mg/L.
  - Moderately Hard: 60 to 120 mg/L.
  - Hard: 120 to 180 mg/L.
  - Very Hard: > 180 mg/L.

- Iron – 0.30 mg/L (red or black)
- Manganese – 0.05 mg/L (black)

Secondary Drinking Water Standard
- Iron – 0.30 mg/L (red or black)
- Manganese – 0.05 mg/L (black)

Hard to V. Hard Water – Not A Common Problem! Fe, Mn and Low Hardness Common!
Sulfates in Water

Hydrogen sulfide gas also occurs naturally in some groundwater. The gas is formed from decomposition of organic compounds contained within the bedrock.

Problems are typically found in aquifers that are shale, siltstone, peat related, or near surface sources of organic material.

Sulfur-reducing bacteria are primary producers of large quantities of hydrogen sulfide.

Drinking Water Standard is \( \leq 250 \text{ mg/L} \) (Laxative Effect)

Methane in Water

- Methane has been a hidden issue in NEPA. The gas is colorless, tasteless, and odorless and there are no known health effects.
- Potential concerns relate to flammability/explosiveness of gas.
- The Coal regions and deep wells in northern portion of NEPA, and areas associated with the Mahantango/Marcellus Shale.
- No drinking water limit, but Office of Surface Mines recommends monitoring for concentrations from 10 to \(< 28 \text{ mg/L}\) and immediate action for concentrations \(\geq 28 \text{ mg/L}\).
- Primary treatment options would include ventilation or aeration systems and potentially changing the electrical and heating system for the home.

Methane Ventilation, process will also work for Radon and Hydrogen Sulfide

Add Air

Arsenic

- The drinking water MCL is 0.010 mg/L. Locally, total arsenic may be in the range of < 0.005 to up to \(< 0.050 \text{ mg/L}\).
- Arsenic can result in the formation of malignant tumors on skin and lungs and may cause nervous system disorders.
- Observable symptoms of arsenic poisoning are: thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in hands and feet, partial paralysis, and blindness.
- For this particular parameter within Northeastern Pennsylvania (NEPA), it would be advisable to retest the water for dissolved and total arsenic.
- It is also typically bound to iron oxide complexes.
- In many cases, the arsenic has been leached from a colloid or particle during the field preservation of the sample. Therefore, it could be more cost effectively removed by standard filtration.
Announcement

- Wilkes University is working on developing a regional water quality database of surface water and groundwater.
- The only sources of data will be baseline analysis using chain-of-custody. This would include data from individual citizens and potential baseline data collected on behalf of citizens.
- The data will be used for education outreach and not sold or used for a commercial use.
- In the near future, you will be asked, if your water quality data can be used in the database. Your name and address will NOT be in the database, your zip code and GPS position of the well or water source will be used.
- I hope you will participate in this valuable informational tool for our community.
- Want more information, contact Mr. Brian Oram, PG – 570-408-4619
QUESTIONS – Answers are another story!

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Soils Evaluation
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Problems with Sulfates
- Laxative Effect- MCL 250 mg/L
- Form Precipitates on Piping and Fixtures
- Rotten Egg Odors
- Sewage Gas Odors
- Corrosion
- Water Heater Failure/Odors

A Properly Grouted Well
Tremie Pipe
Series of Cement Casings Used in Drilling Process

Taste Problems

- Salty or Brackish Taste
- Sour Taste
- Metallic or Bitter Taste
- High Sodium
- Elevated Hardness or alkalinity
  
  Corrosion, Low pH, high metallic content (Cu, Fe, Mn, Pb, Al, Zn)

Odors

- Rotten Egg / Musty Odor
- Oily
- Methane Like-Smell
- Chemical/ Solvent

Note: Methane gas has no odor.

Sediments and Stains

- Milky or Cloudy
  
  Precipitation of carbonates / sulfates, excessive air, suspended solids, aquifer material

- Bluish Green – Green Precipitates
  
  Copper, hardness, aggressive water and corrosion by-products, nuisance bacteria

- Blackish Tint or Black Slimes
  
  Reactions with manganese and possibly iron, nuisance bacteria

- Yellowish or Reddish Tint or Slimes
  
  Organic material, dissolved or precipitated iron, nuisance bacteria
Earthquakes
Not a major concern- Drilling and Hydrofracturing Technique done in areas with rock under more stress than our local geology (Sid, H). We are in a stable tectonic area and magma is not close to surface.

Possibly a more important concern in NW PA and Ohio and SEPA and NJ Ridge and Valley Province – Rt 309
Llewellyn Pottsville