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Groundwater and Hydrogeology of Luzerne / Columbia County, PA

Llewellyn and **Pottsville** Formation Contact

Flowing Artesian Well (Well needs no pump)

Presented by:

Mr. Brian Oram, Professional Geologist (PG),
Soil Scientist, Licensed Well Driller

Lab Manager, Center for Environmental Quality

Wilkes University

Environmental Engineering and Earth Sciences

Wilkes-Barre, PA 18766

http://www.water-research.net

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

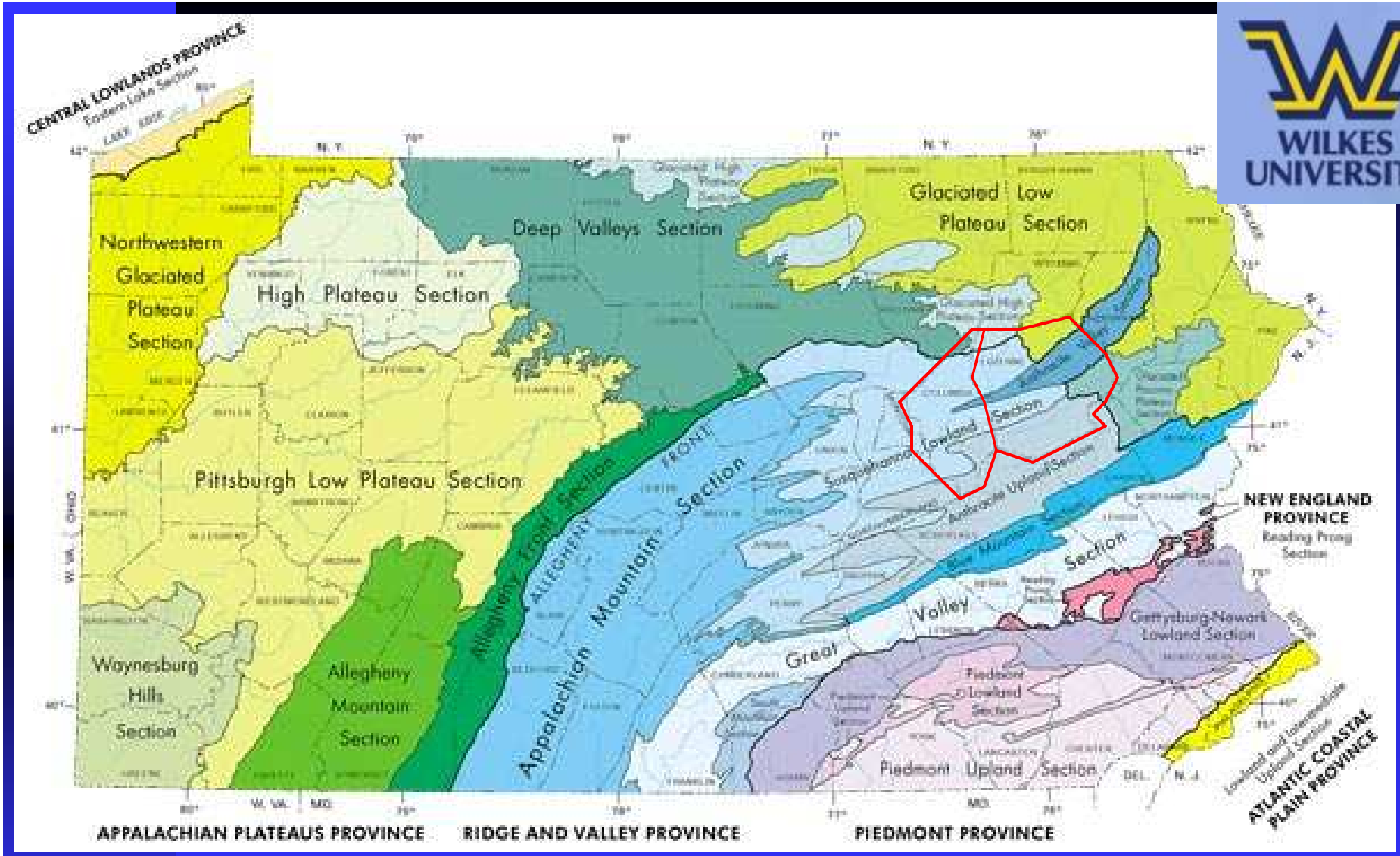
Outreach Programs

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

Website: http://www.water-research.net

Information Compiled by:

- Dr. Dale Bruns – Wilkes University
- Dr. Sid Halsor, PG – Wilkes University
- Mr. Brian Oram, PG – Wilkes University
- Dr. Brian Redmond, PG – Wilkes University
- LuzerneCounty. Org
- Carbon County Groundwater Guardians – Master Well Owner Program



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/topogeo/map13/map13.aspx

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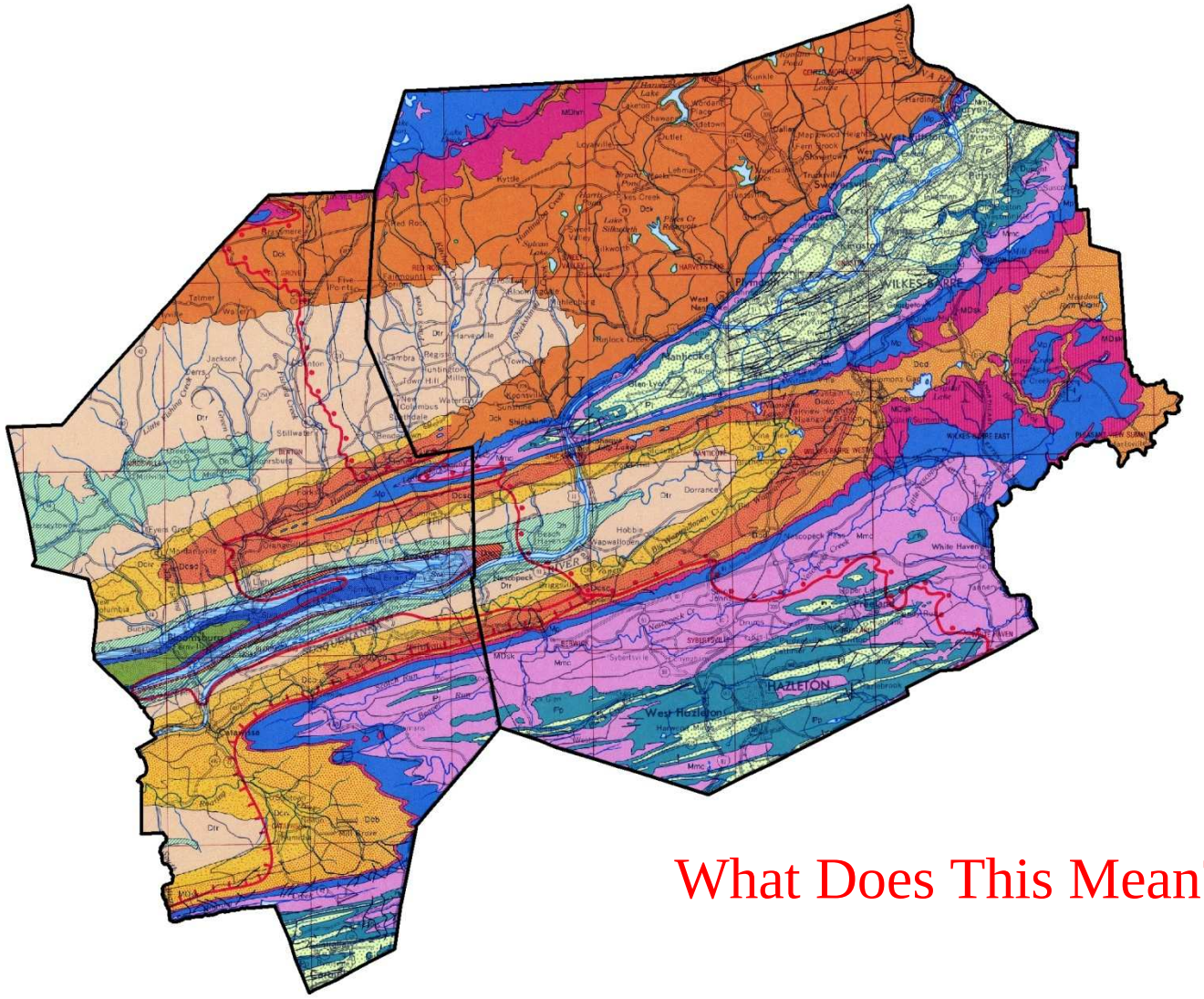
GEOLOGY



What Does This Mean?

Source: Luzernecounty.org

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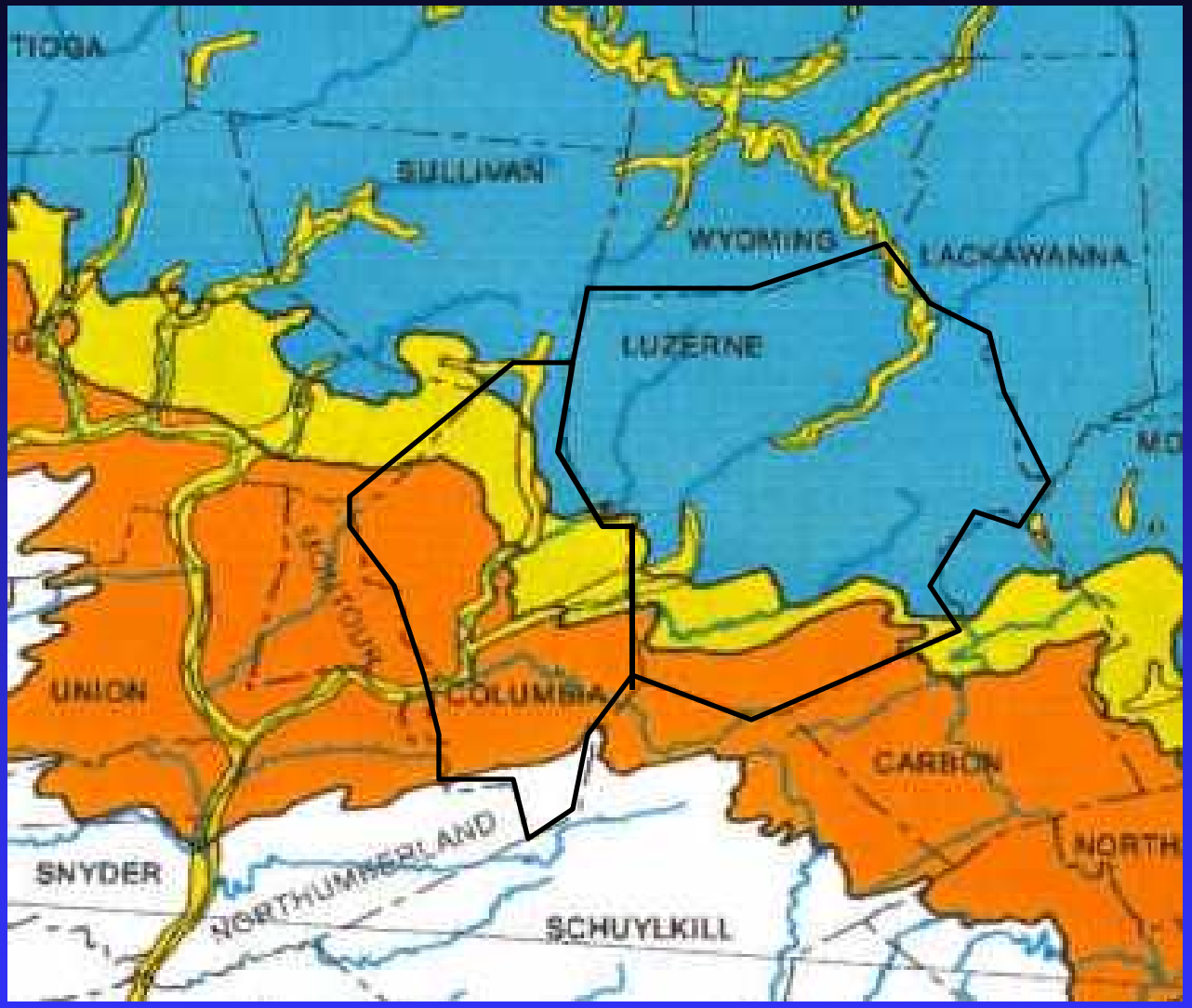
GLACIATION



Wisconsinan (17,000 to 22,000 yrs)

Late-Illinoian (132,000 – 198,000 yrs)

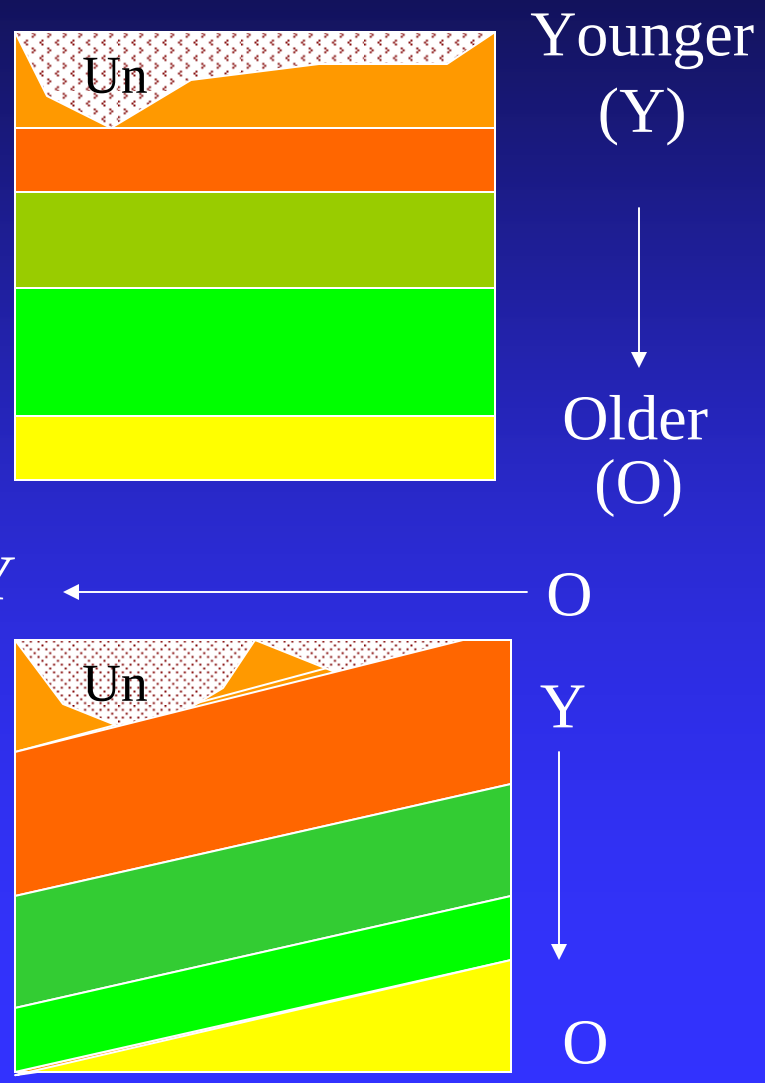
Pre-Illinoian (> 770,00 yrs)

Source: DCNR - http://www.dcnr.state.pa.us

Appalachian Plateau Province

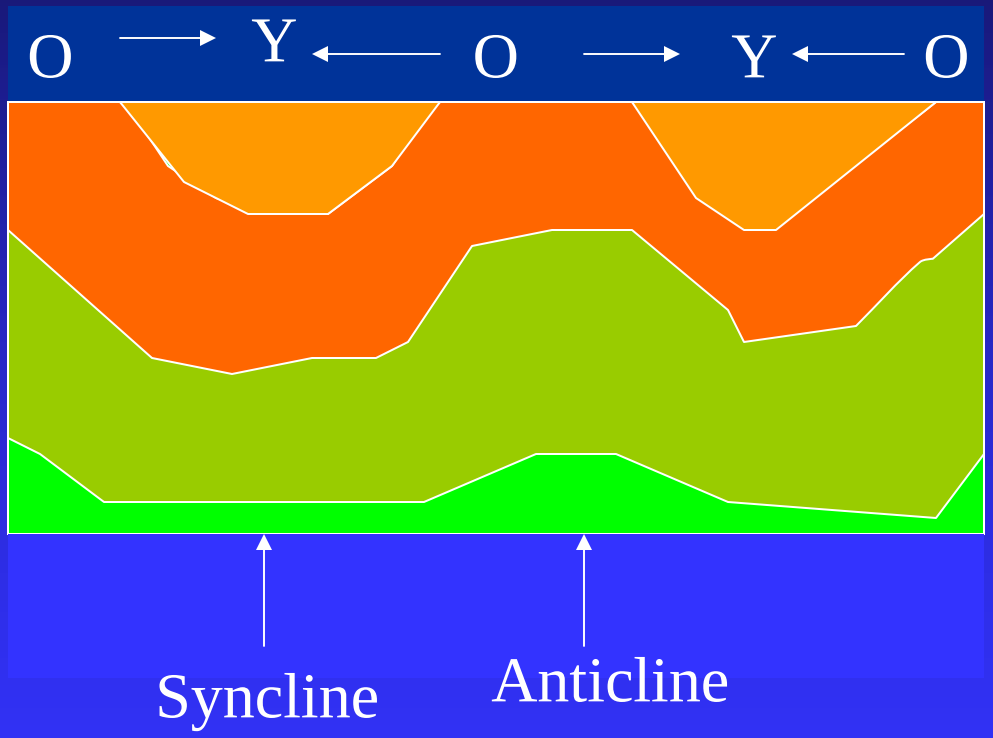
- Broad to Narrow Valleys
- Rounded Hills and Valleys Associated with Glaciation
- Valleys filled by glacial fluvial material

Unconsolidated Material (Un)

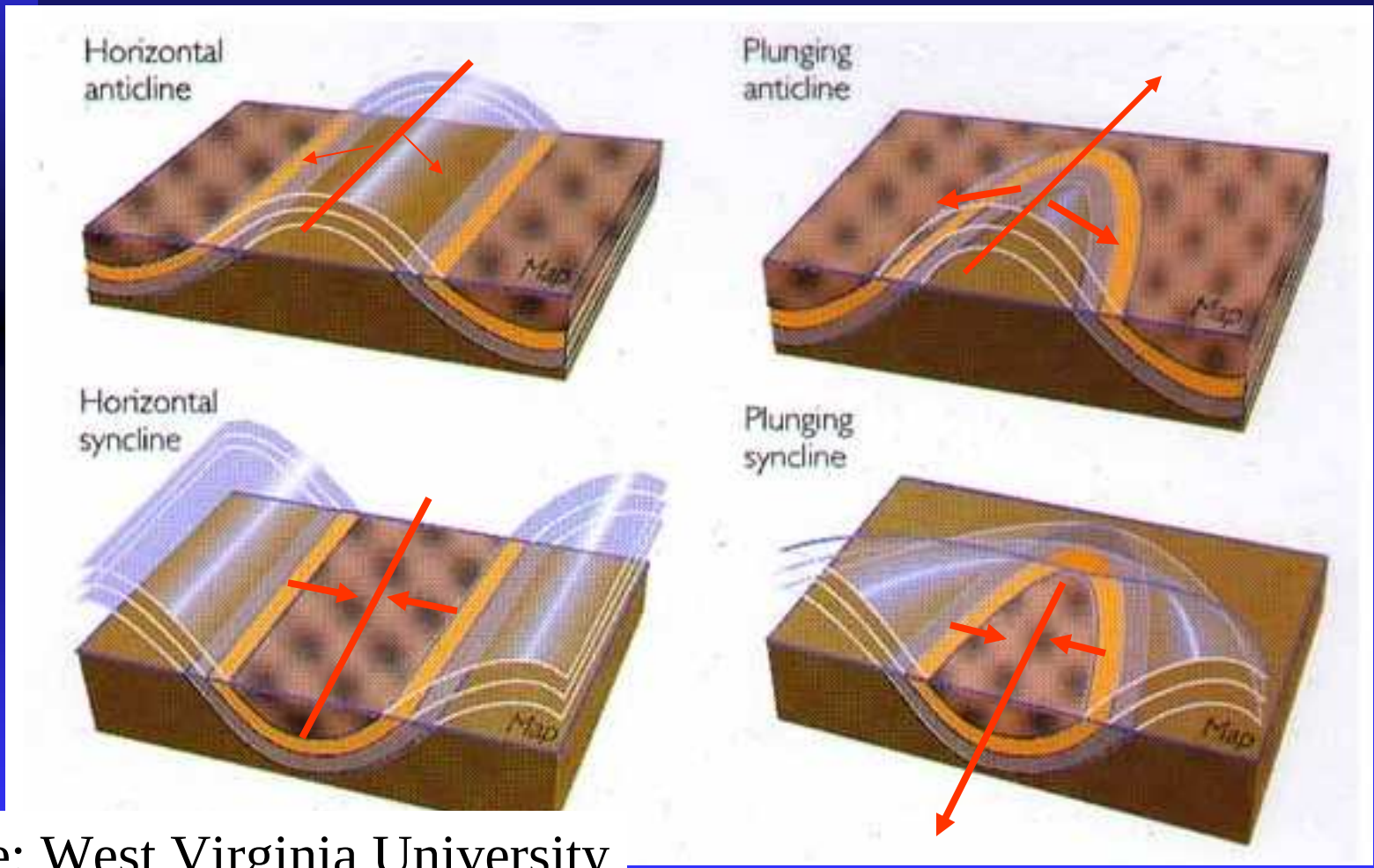


Ridge and Valley Province

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



Plunging Anticlines / Synclines



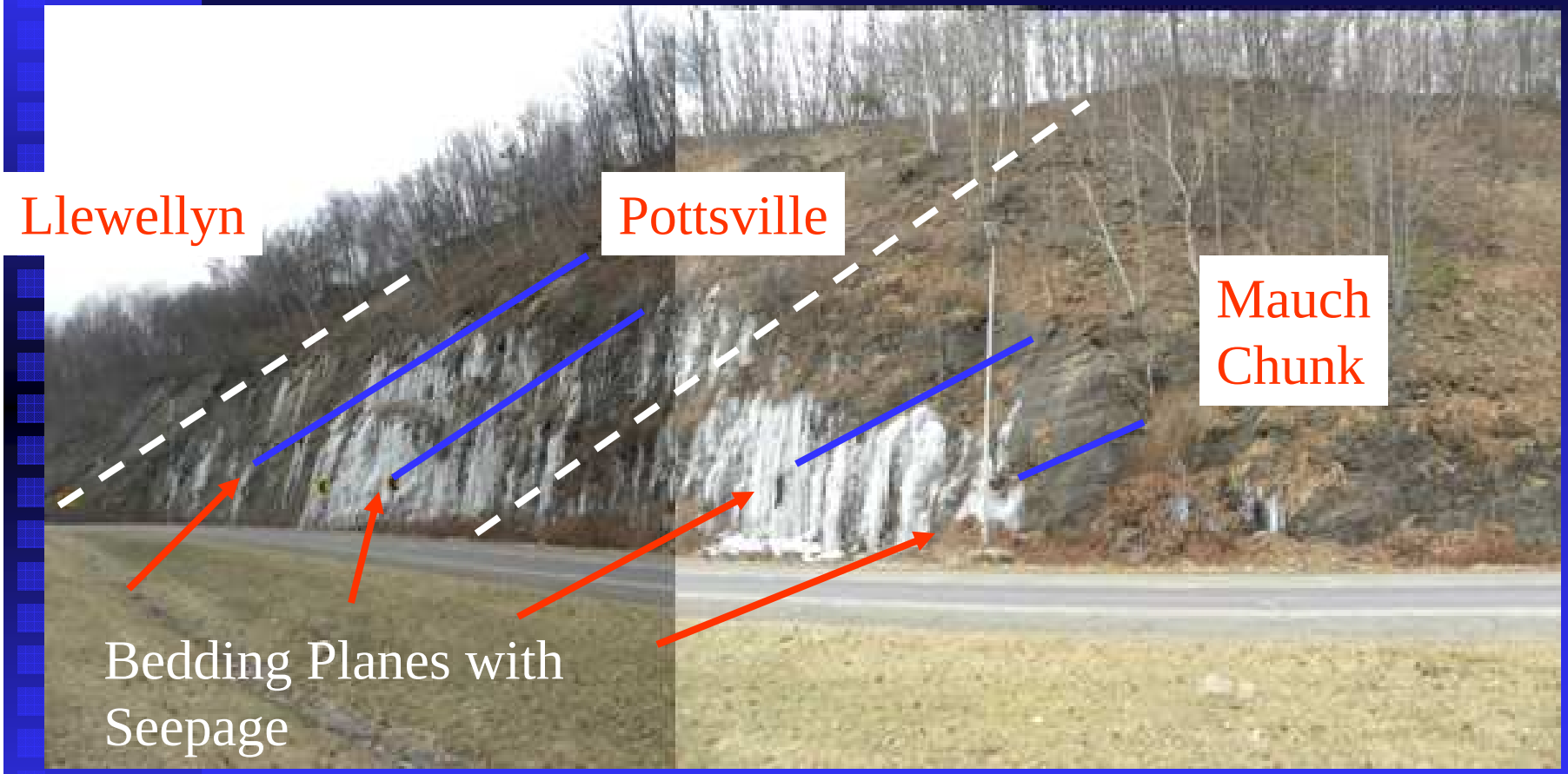
Source: West Virginia University
http://www.geo.wvu.edu

Geological Sequence

OLDER

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

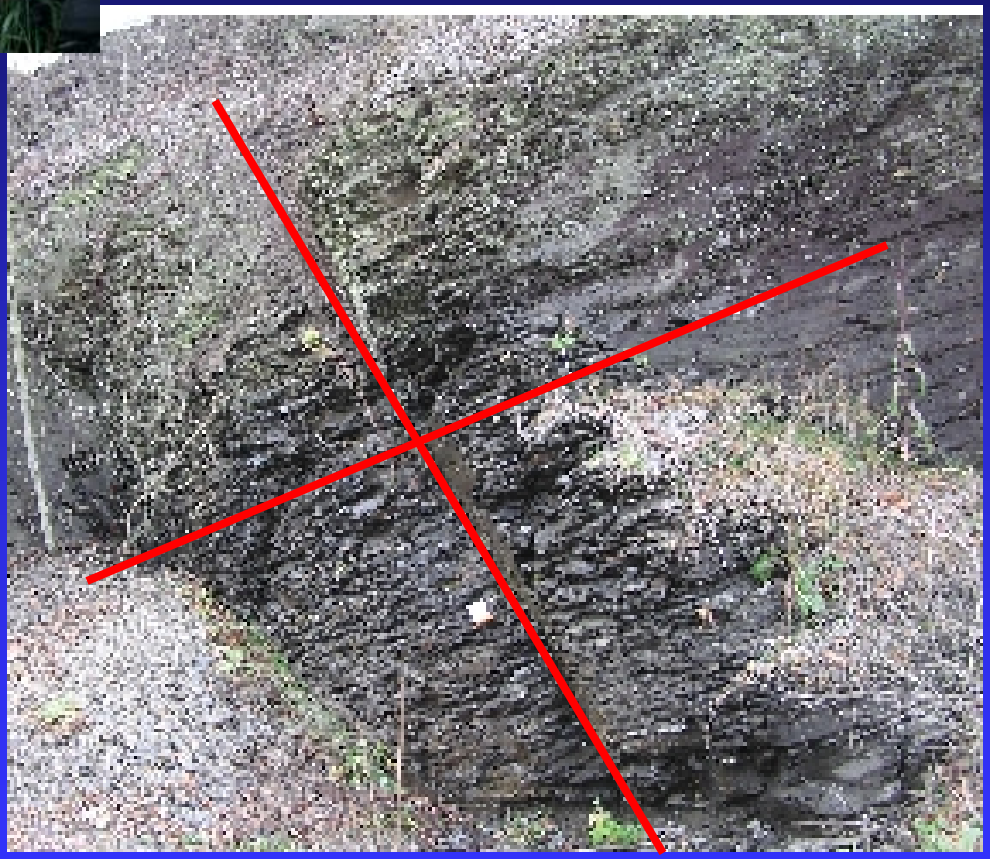
Ridge and Valley Province – Rt 309



Mahantango Formation

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

Marcellus Shale Photo

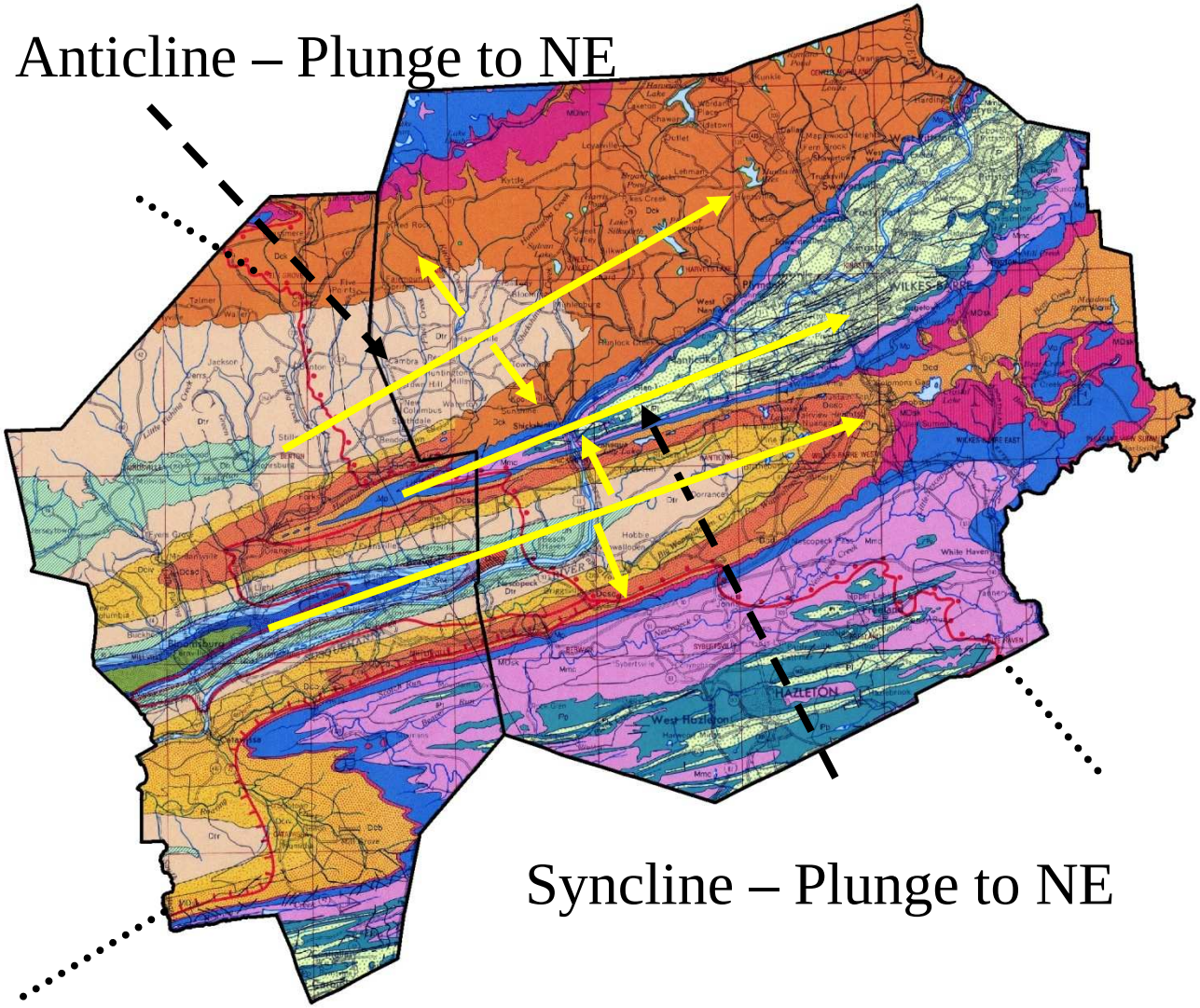


Main Fracture Orientation

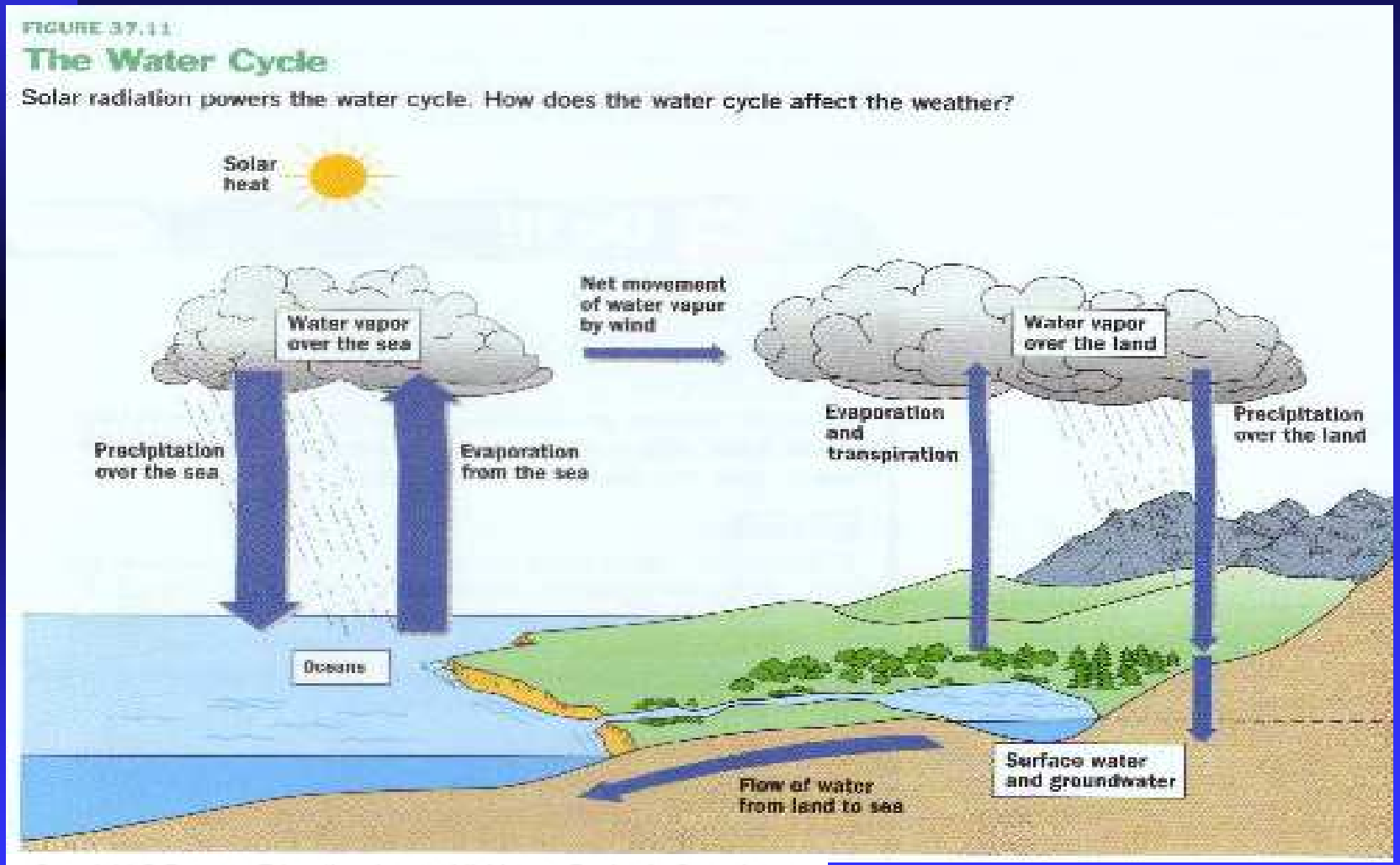
Outcrops Along the Southeastern Border of Pike County Along Route 209

Source: Oram, 2009

Geology of Columbia and Luzerne County



The Water Cycle
Powered by the Sun: Solar Power



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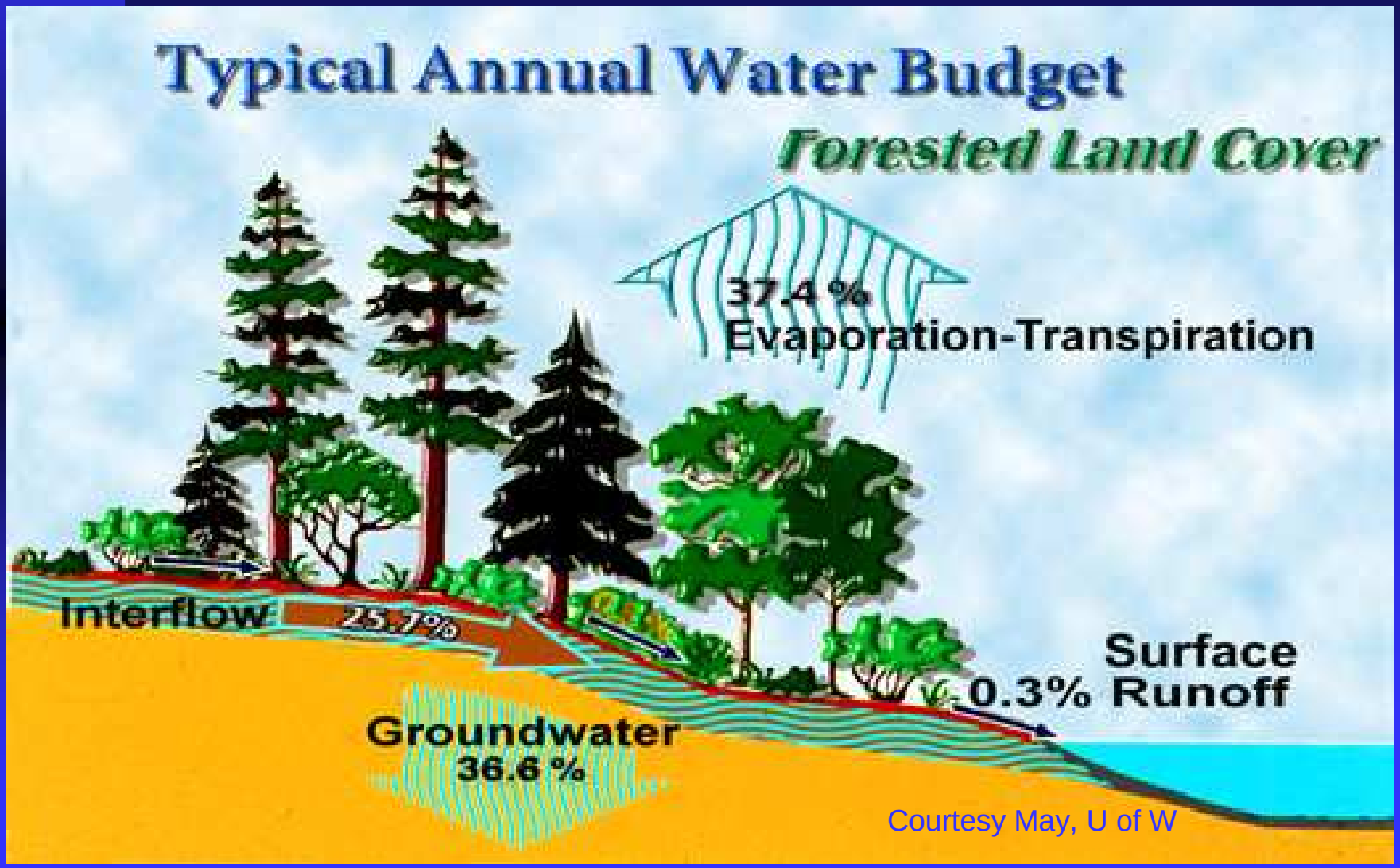
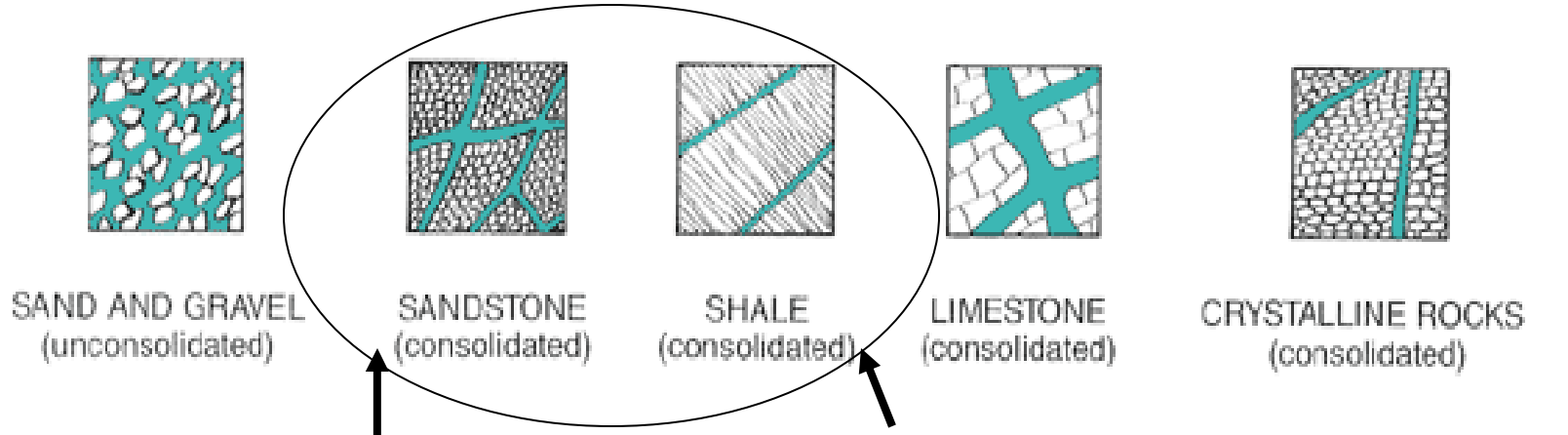
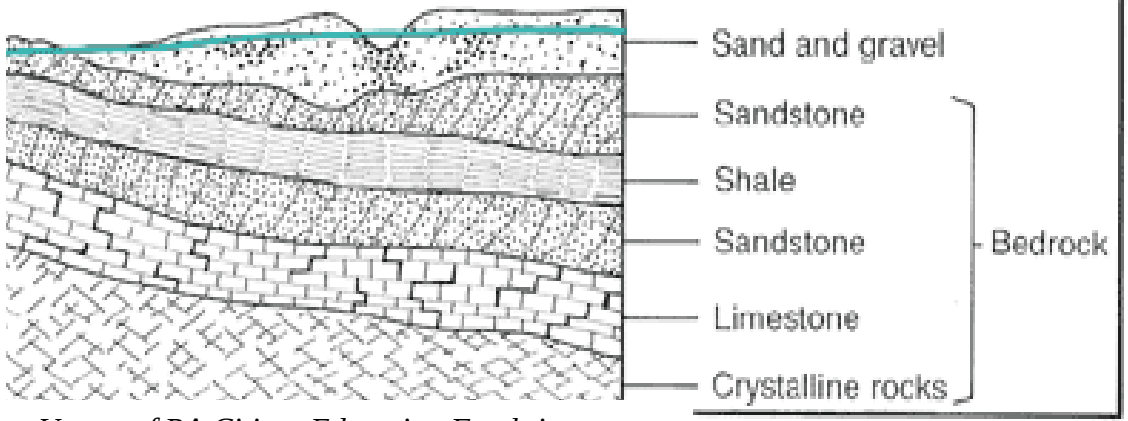
Hydrology Under Natural Conditions



Primary Aquifers in PA



Most Common Aquifers



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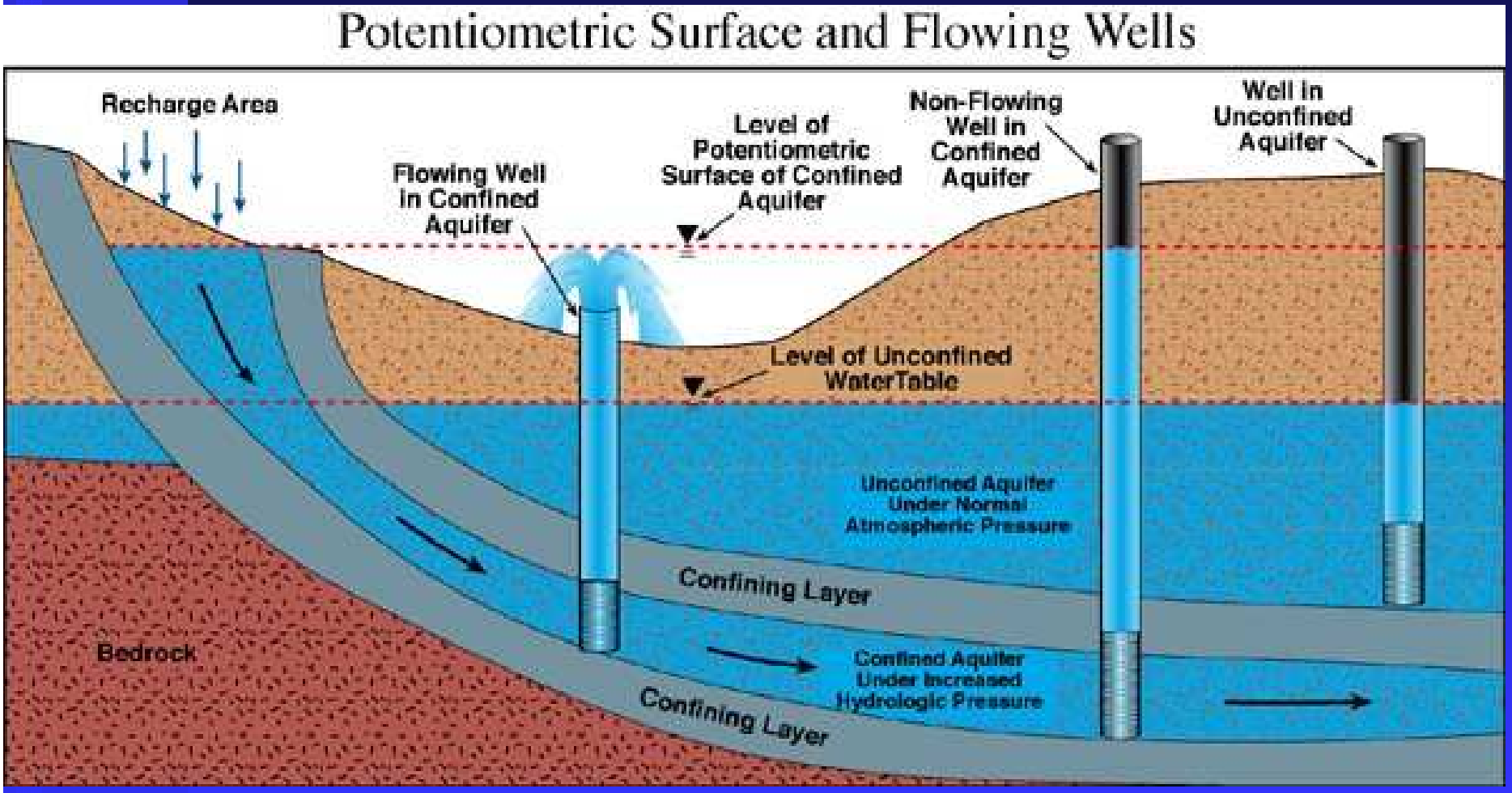
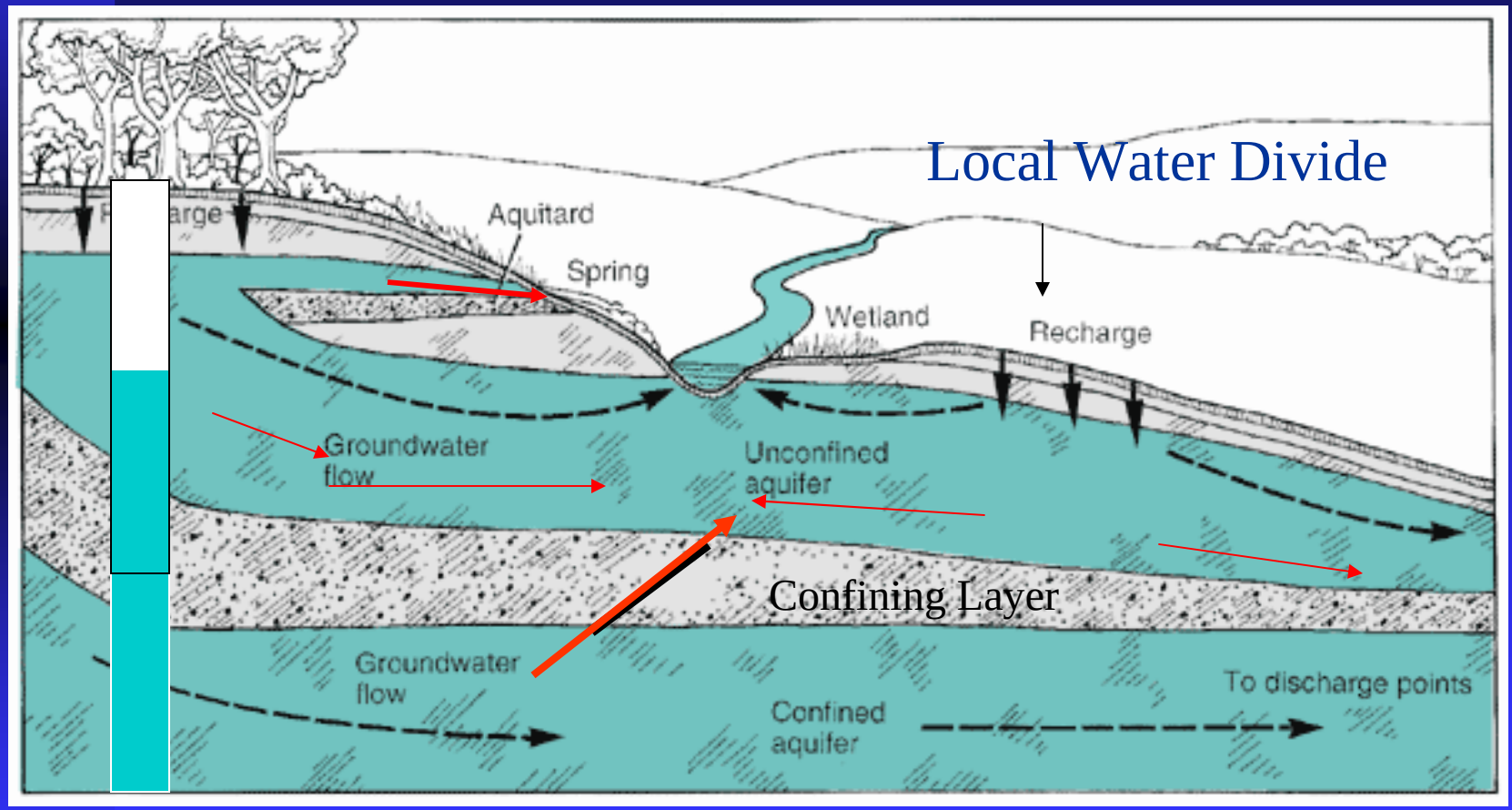
Well Geology (Unconsolidated)



Source: Water Watch Alliance

Surfacewater & Groundwater
They Are Related and Connected !



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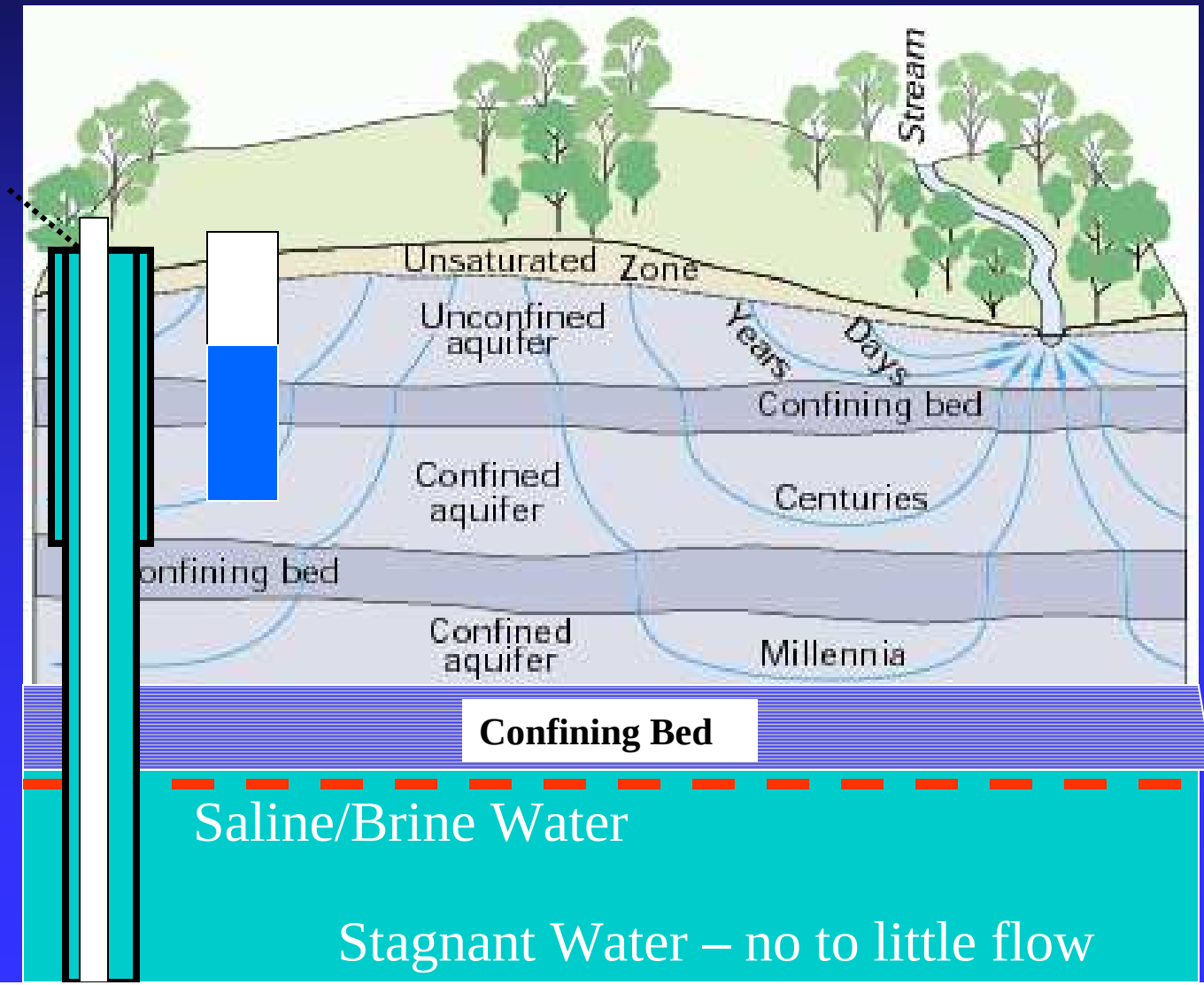
Groundwater Moves - Slowly feet per year



Why Test My Water ?

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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*, Trihalomethanes, Asbestos, Copper, Benzene, Trichloroethane, etc.

Secondary Standards

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National Secondary Drinking Water Regulations

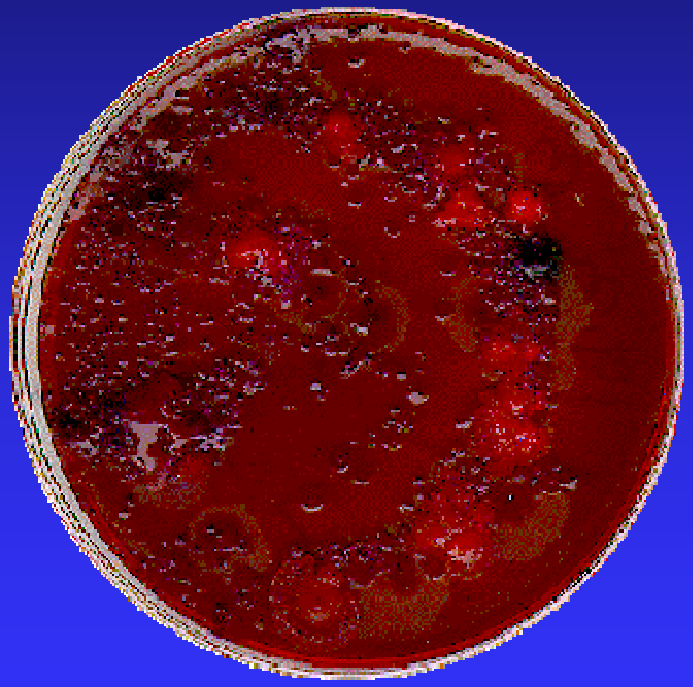
These standards were established more for cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor or color) in drinking water.

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

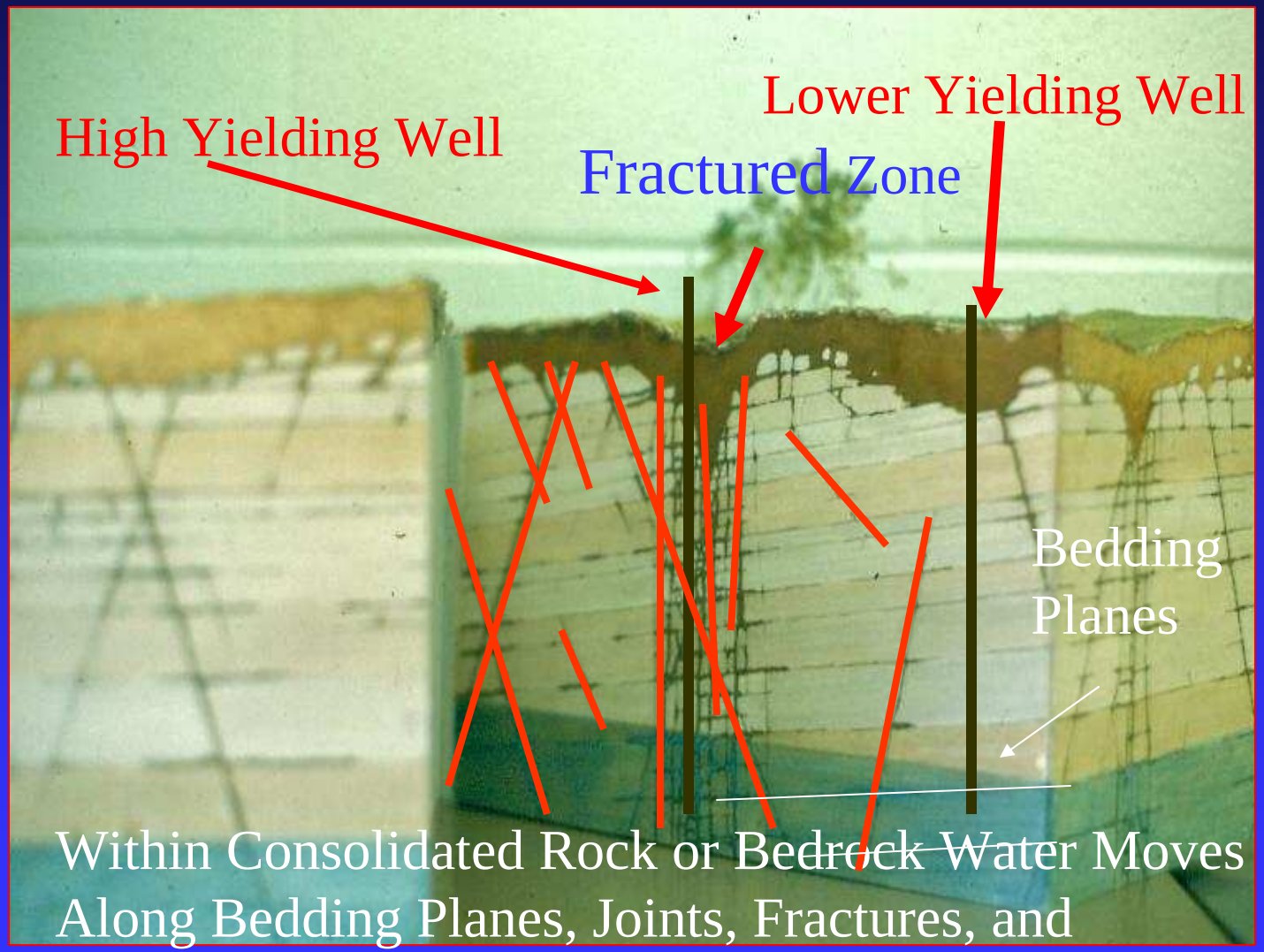
Total Coliform Bacteria

Sulfur Odors and Elevated Sulfates

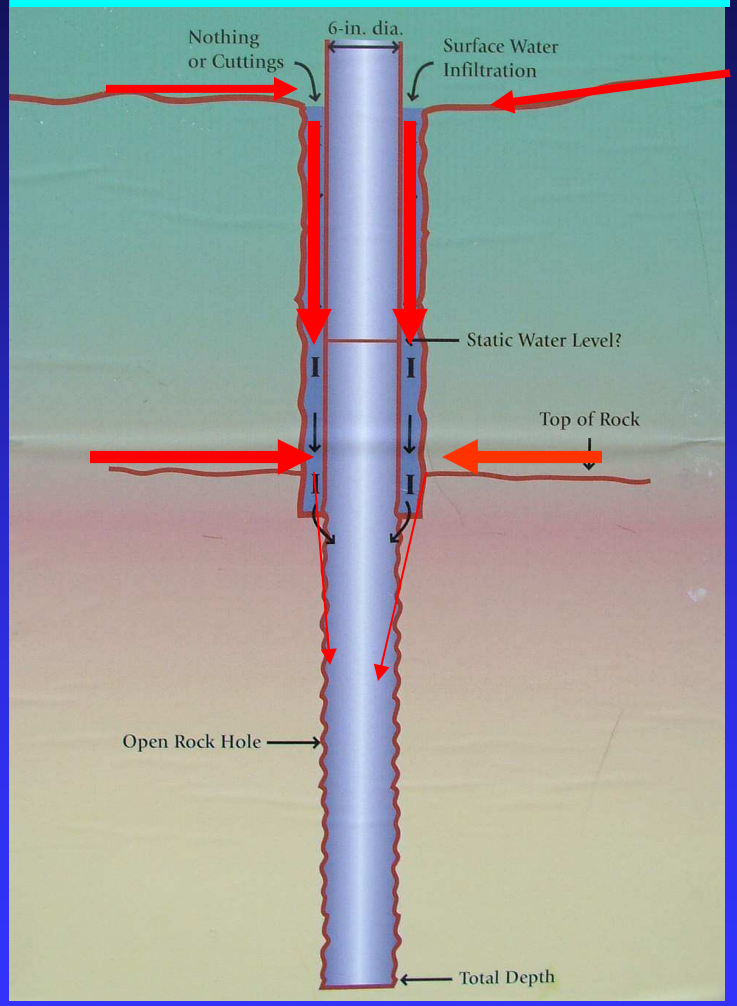
Methane – Columbia County

Air Quality Issues – Radon In Air !

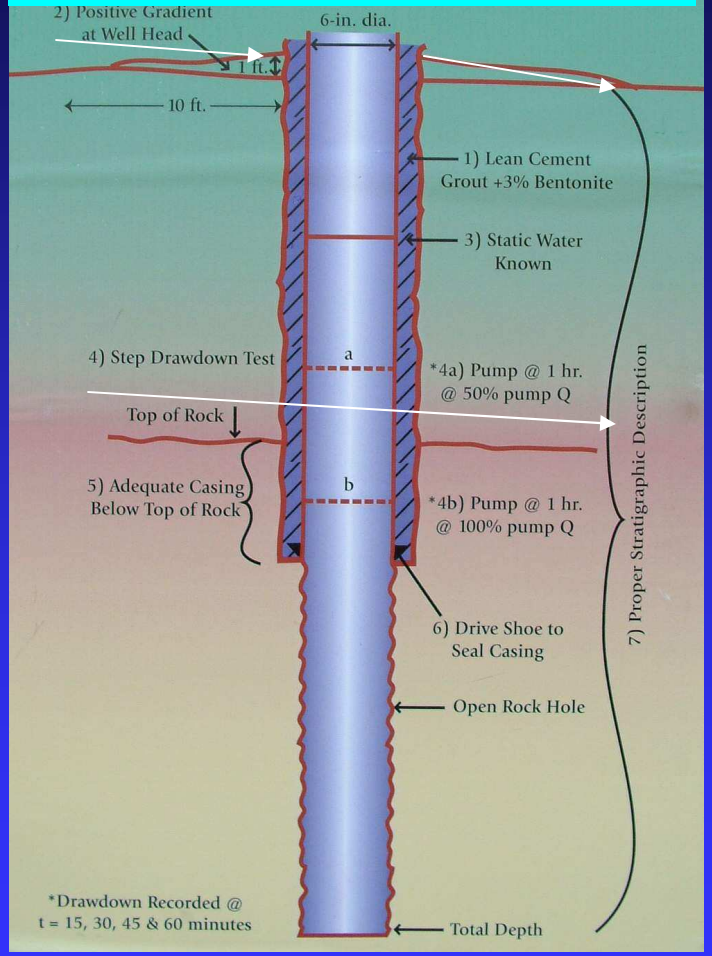
Bedrock Fractures and Fractured Zones



An Ungrouted Residential Well



A Properly Grouted Well



Source: Pennsylvania State University – Master Well Owner
Carbon County Groundwater Guardians (edited by Mr. Brian Oram)

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)
Arsenic (local issues)

Organic Contamination
Elevated Trace Metals
(except corrosion by-products like Copper, Lead, Aluminum, Zinc)

Salty or Brackish Water (very deep wells)
Trihalomethanes
Pathogenic Organisms

Radon (In Air)- PA

Columbia and Luzerne County in the Red Zone – Suggests indoor air radon levels greater than 4 pCi/L

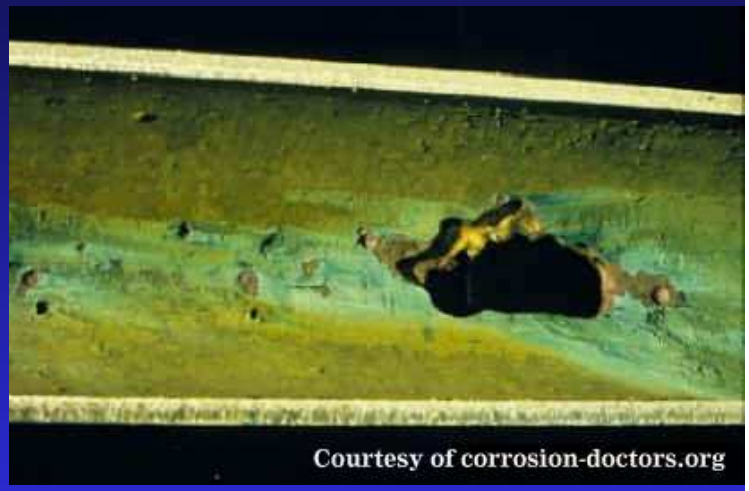
Zip Code	Number of Tests	Minimum Result pCiL	Maximum Result pCiL	Average Result pCiL
18612	1620	0.1	173	5.1

Zip Code	Number of Tests	Minimum Result pCiL	Maximum Result pCiL	Average Result pCiL
17814	153	0.1	865.4	39.8

http://www.dep.state.pa.us/RadiationProtection_Apps/Radon/

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.**


Courtesy of corrosion-doctors.org

Copper – Typically Blue or Blue-Green Staining

May also have elevated levels of Lead and Zinc.

pH

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

pH < 7 acidic

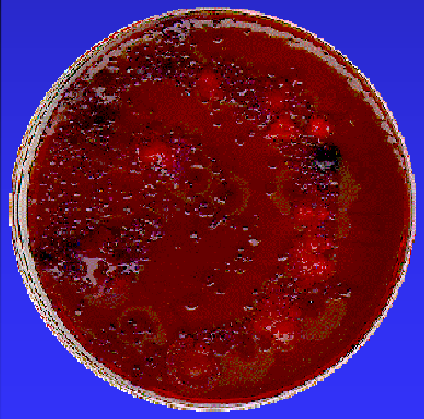
pH > 7 basic

Drink Water Standard
6.5 – 8.5

Problems

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

Coliform Bacteria



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**

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

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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.

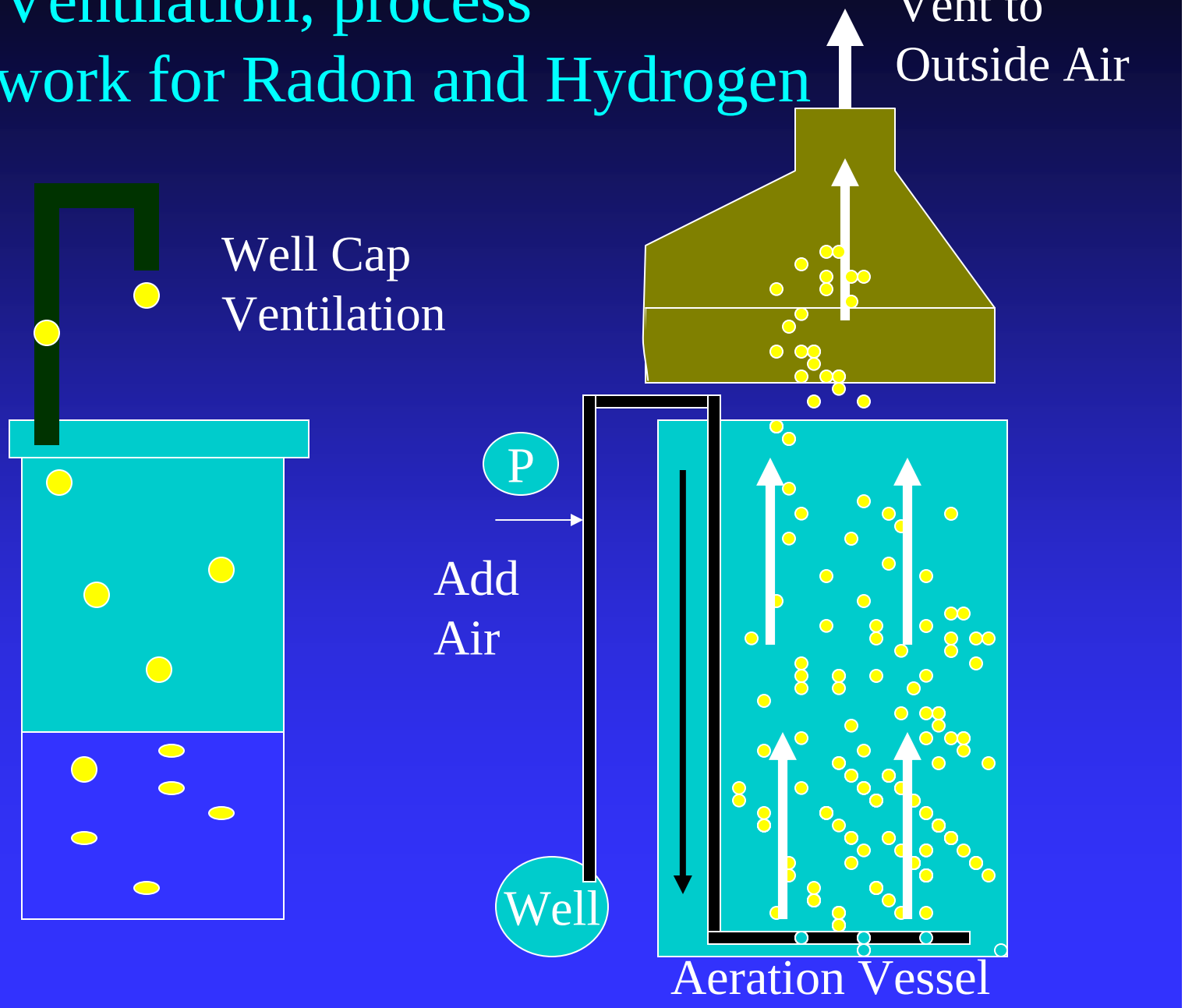
Sulfur-reducing bacteria are primary producers of large quantities of hydrogen sulfide.

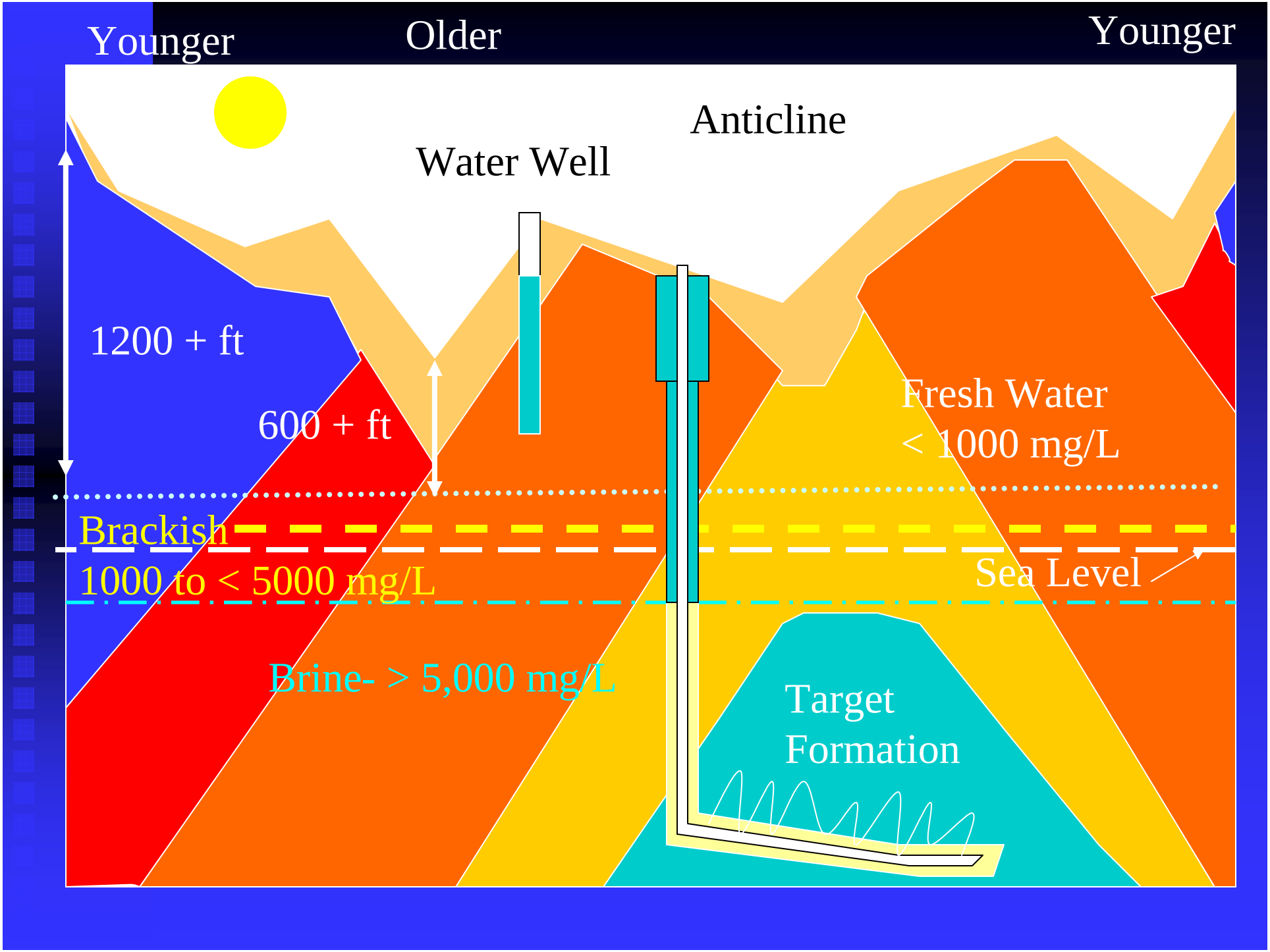
Drinking Water Standard is $\leq$ 250 mg/L (Laxative Effect)

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 northern portion of NEPA, and areas associated with the Mahantango / Marcellus Shale may have elevated levels of methane.
- No drinking water limit, but Office of Surface Mines recommends monitoring for concentrations from 10 to < 28 mg/L and immediate action for concentrations > 28 mg/L
- Primary treatment options would include ventilation or aeration systems.

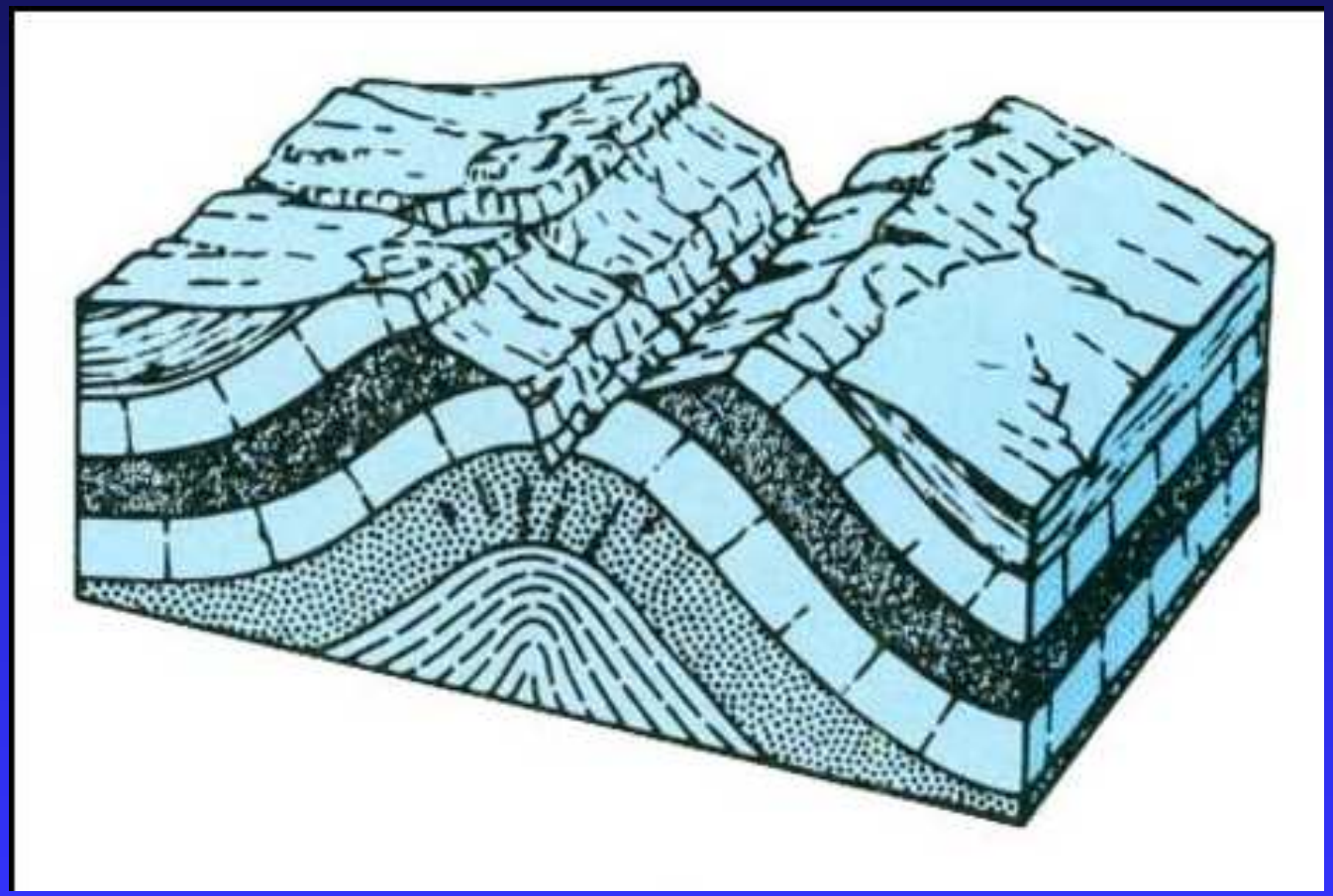
Methane Ventilation, process will also work for Radon and Hydrogen Sulfide




Younger
Older
Younger
Anticline
Water Well
1200 + ft
600 + ft
Fresh Water
< 1000 mg/L
Brackish
1000 to < 5000 mg/L
Sea Level
Brine- > 5,000 mg/L
Target
Formation

QUESTIONS – Answers are another story!

Common Structure in NEPA – Anticline with Valley Surface Topography



Source: http://www.nps.gov

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Groundwater and Hydrogeology of Luzerne / Columbia County, PA

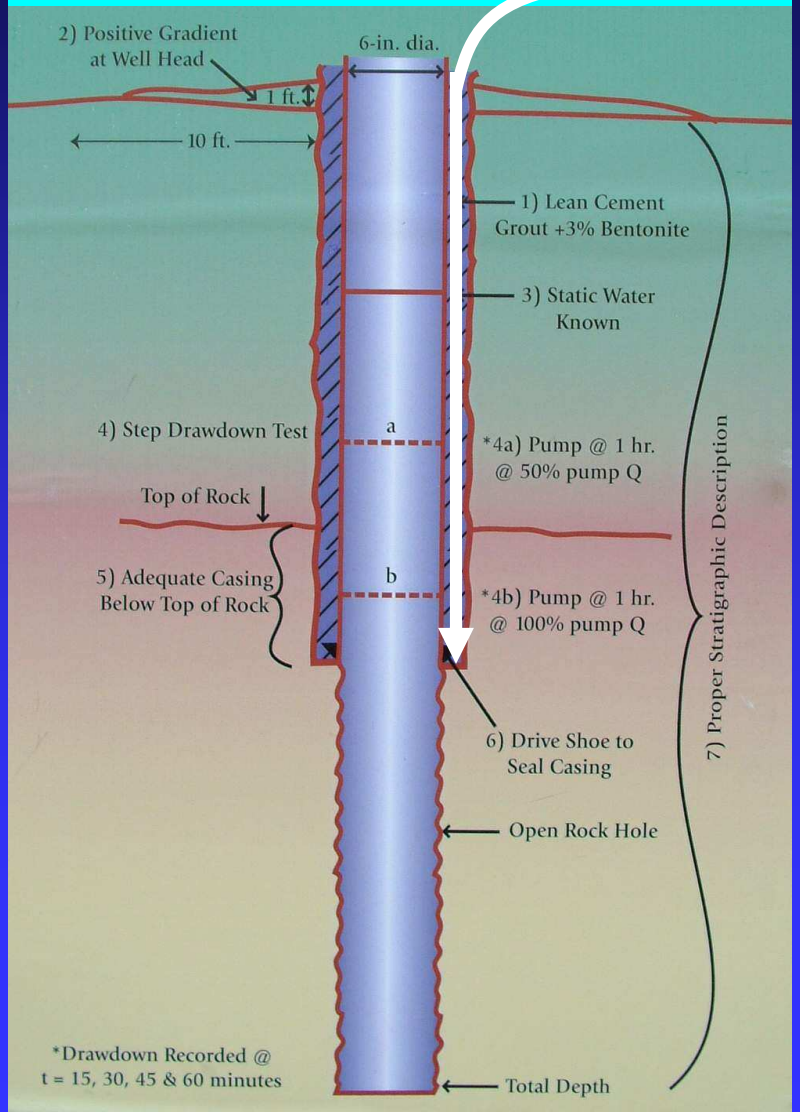
Soils Evaluation

Hydrogeological Assessments

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



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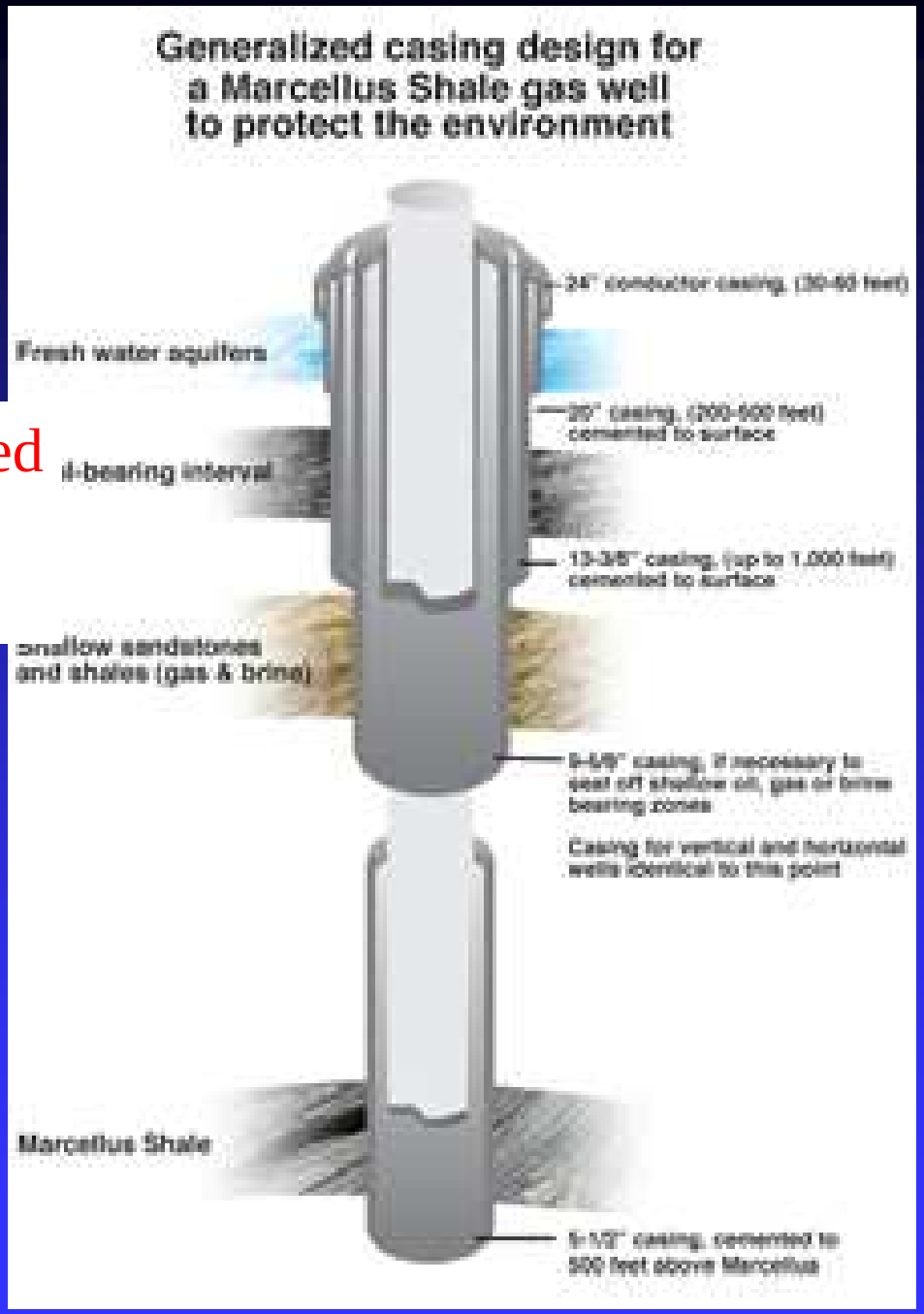
Series of Cemented Casings Used in Drilling Process



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

- Sulfate, Sulfur, Nuisance Bacteria
- Gasoline, Oil Contamination or Nuisance Bacteria
- Organic Material or Gas Additives (mercaptones) – this is not present in natural gas
- Industrial Chemicals

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

Ridge and Valley Province – Rt 309