Human Health Impacts Associated with Chemicals and Pathways of Exposure from the Development of Shale Gas Plays

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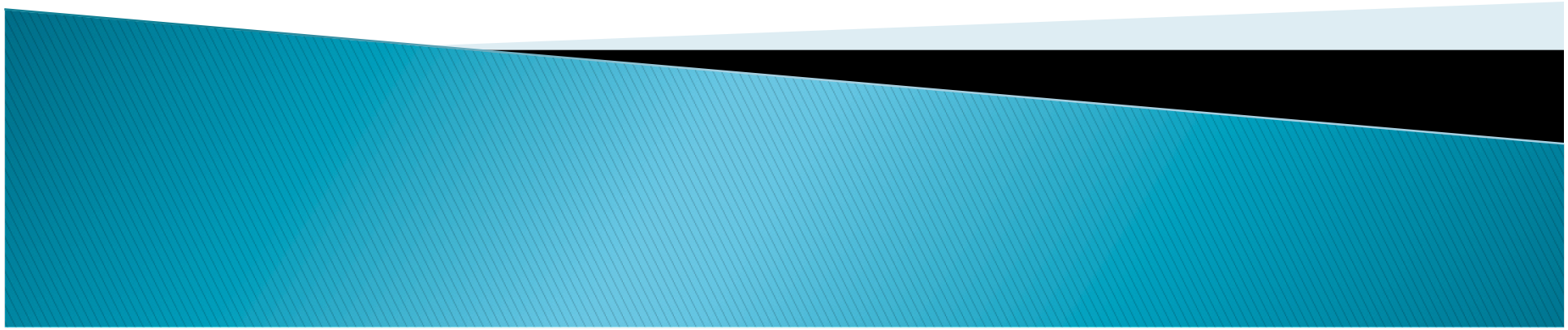
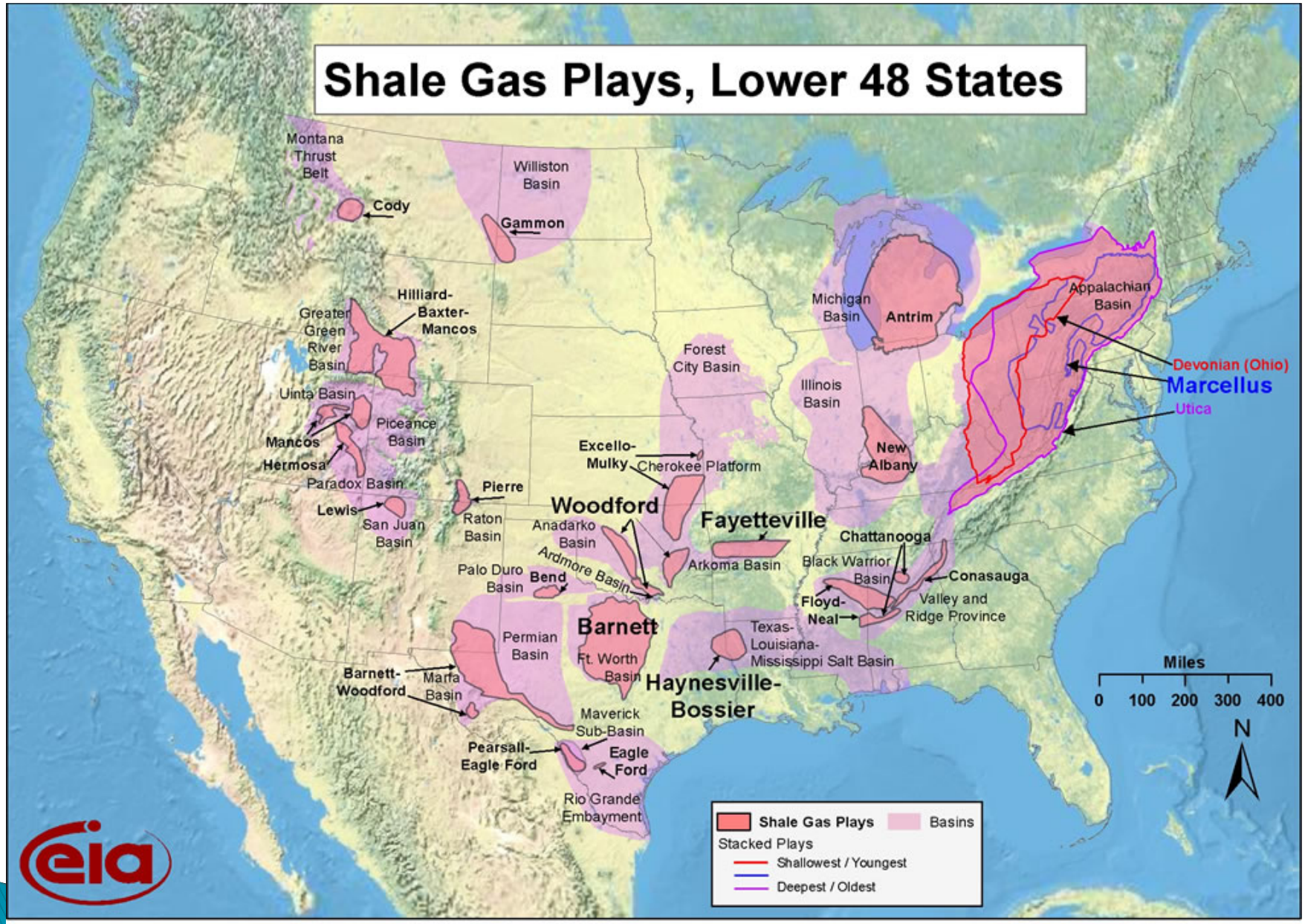
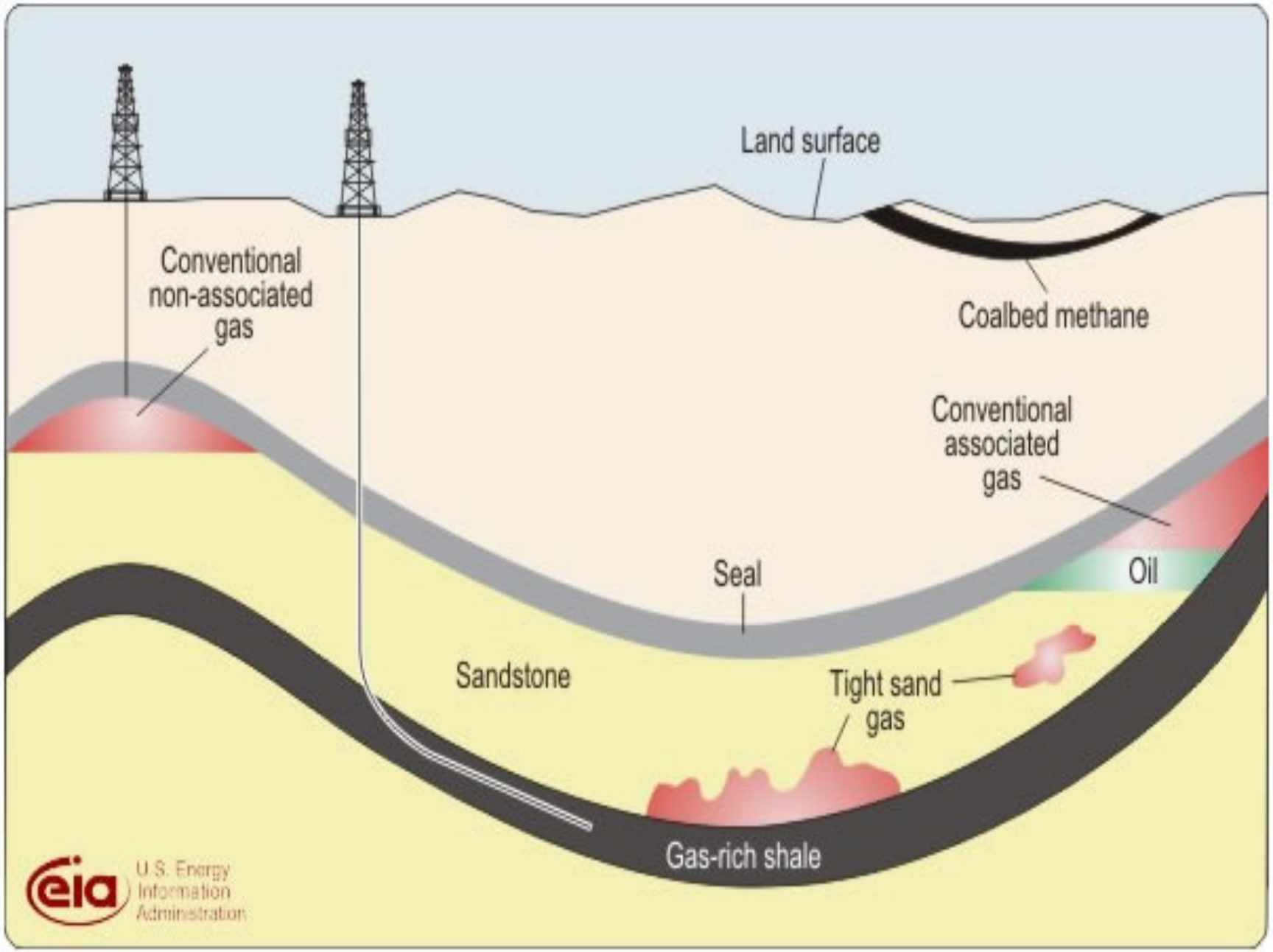
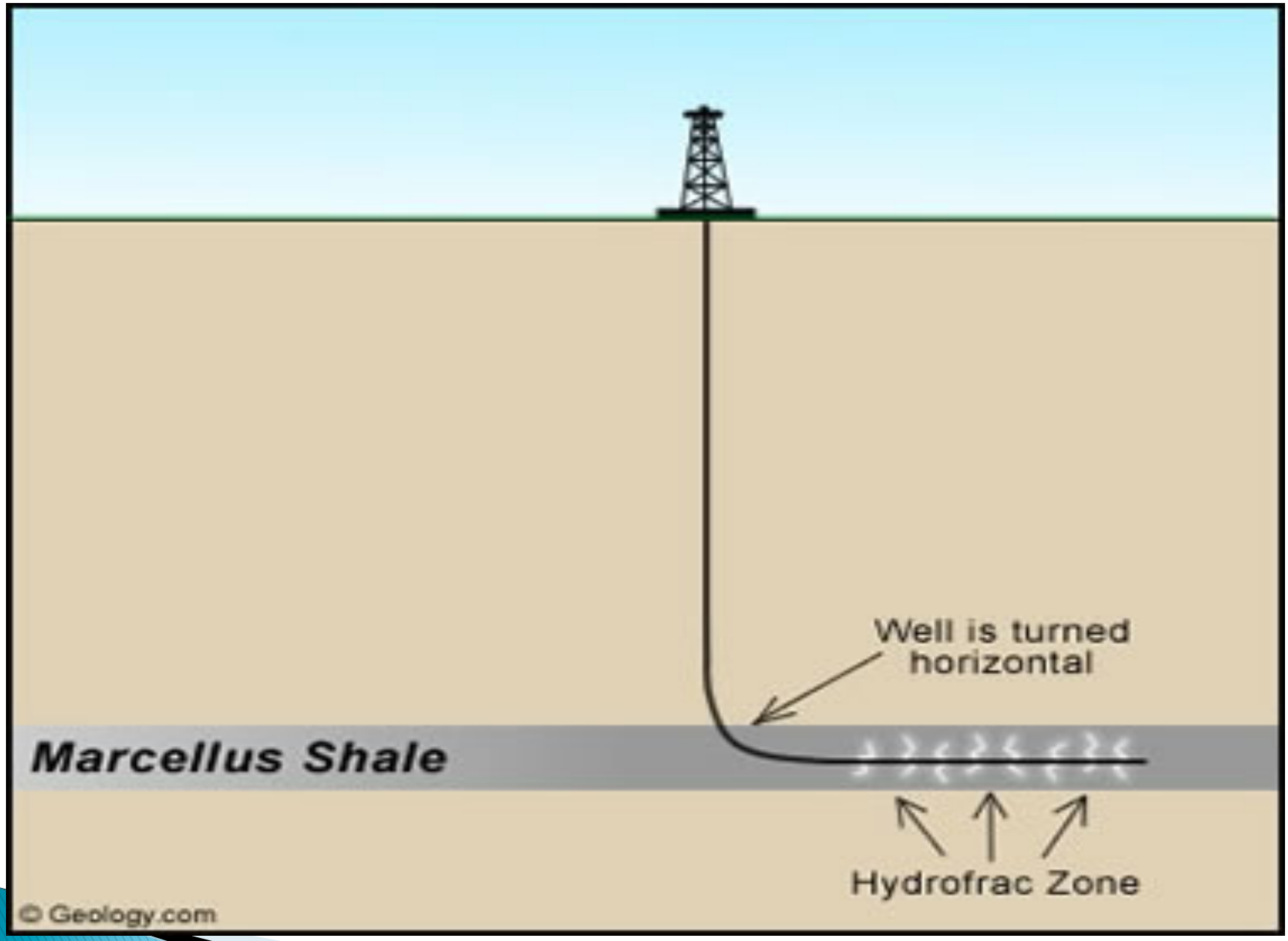




Source: Energy Information Administration based on data from various published studies.
Updated: March 10, 2010


Land surface
Conventional non-associated gas
Coalbed methane
Conventional associated gas
Seal
Oil
Sandstone
Tight sand gas
Gas-rich shale
U.S. Energy Information Administration


Well is turned
horizontal
Marcellus Shale
Hydrofrac Zone
© Geology.com

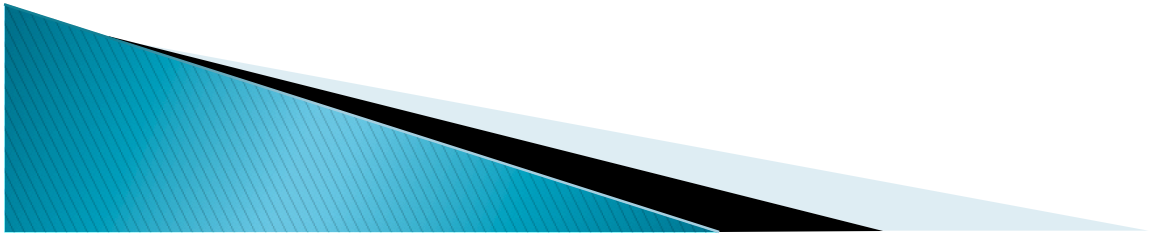
Crude Oil and Natural Gas Drilling and Production

- **Waste---Non-Hazardous**

- Wastes generated by the exploration, development and production of crude oil and natural gas are “exempt” by Federal law from being regulated as hazardous waste.
- Yet 10 to 70% of the large volume waste and 40 to 60% of the toxic associated waste are Hazardous by analysis.

Shale Gas Formations

	Marcellus	Barnett	Eagle Ford
Shale	Gas	Gas	Oil & Gas
Depth	6,750’	7,400’	9,000’
Flowback Remaining Underground	20-30%	20-30%	100%
Fracturing Fluid 3 to 8 Million gallons of water per fracture			

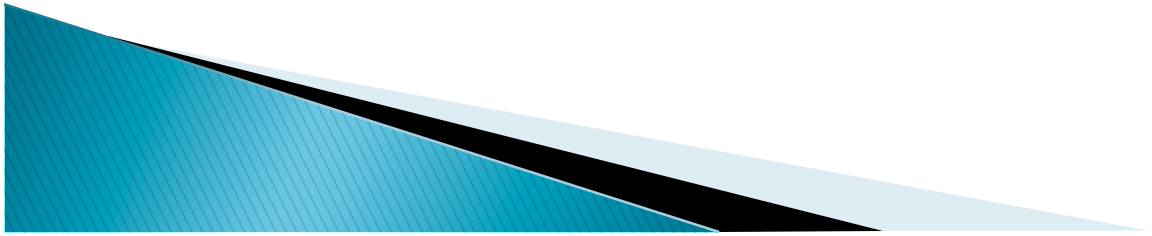


Development of Shale Gas Plays Consist of Horizontal Drilling and Hydraulic Fracturing

- Hydraulic Fracturing Fluids used to Frack each well contain 60 to 160 tons of chemicals such as the following:
  - Surfactants-Laurel Sulfates, reduces interfacial tension in the formation
  - Friction Reducers-Polyacrylamide polymer, reduces surface tension between fluid and pipe surface

Hydraulic Fracturing Fluids used to Frack each well contain 60 to 160 tons of chemicals such as the following: cont'd

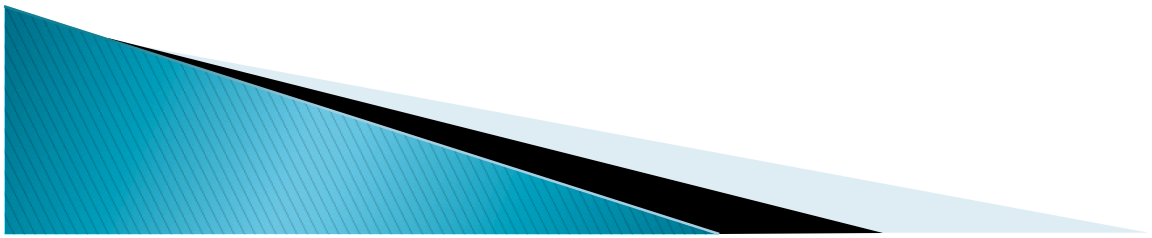
- Biocides-Glutaraldehyde/quaternary ammonia blend, pasteurize not sterilize
- Scale Inhibitors-Solvent based Ethylene Glycol
- Corrosion Inhibitor-n,n-dimethyl formamide, gel-Hydroxyethyl Cellulose
- Iron Control-2-hydroxy-1,2,3-Prapanetricarboxylic Acid
- Breaker-Sodium Chloride
- Plus Propping Agents-Sand-Ceramic Beads



Flowback Water

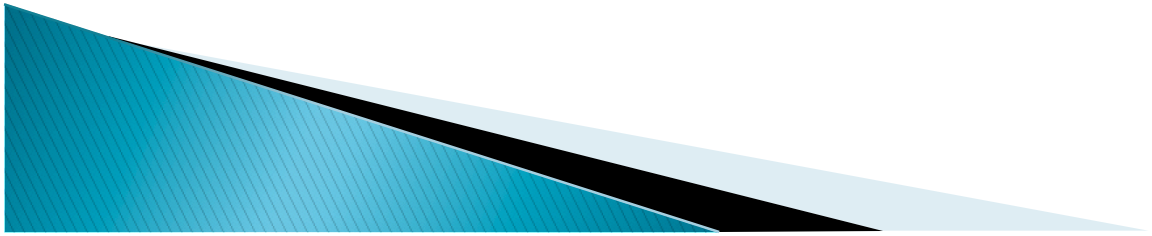
- Flowback Water consists of the used Hydraulic Fracturing Fluids with contaminants from the fractured formation substances including NORM-Radium 226

- 20%-30% (Marcellus and Barnett) to 100% (Eagle Ford) of the flowback water is estimated to remain underground



Produced Water/Formation Water

- Generated as part of the natural gas production process. The Produced water is contaminated with:
  - Volatile Organic Chemicals-Benzene, Ethyl Benzene, Toluene, Xylene
  - Semivolatile Organic Chemicals-Phenol and Pyridine
  - Toxic Heavy Metals-Arsenic, Barium, Cadmium, Chromium, Lead, Mercury and Vanadium



The Produced water is contaminated with: cont'd

- Sulfur containing compounds
- NORM-Radioactive Radium 226, Radium 228 and Uranium 238
- Salt Water Minerals

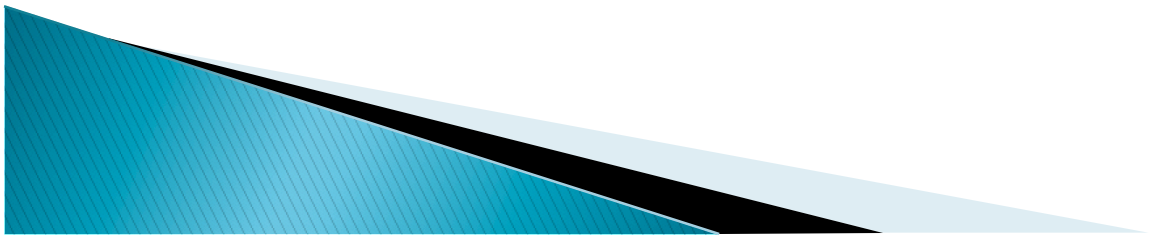
- The Volatile Organic Chemicals and Toxic Heavy Metals are known and possible cancer causing agents and mutagens.

- Radium 226 is a bone seeker and is a known carcinogen associated with lung and bone cancer.

Shale Gas Operators Admit

- Pollution is released into the environment as a result of Shale Gas Drilling, Fracturing/ Stimulation and Production

- Spills and Leaks Contaminate
  - Surface water
  - Ground water resources
  - Soils
  - Air



Shale Gas Operators Admit

- Failure of Cement Around the Casing Contaminated
  - Ground water resources
  - Surface water
  - Soil
  - Air
- Failure of Casing Contaminates
  - Ground water
  - Surface water
  - Soil
  - Air

- The industry stops short of admitting contamination of groundwater as a result of fracturing.

Pathways of Exposure

- Inhalation and Dermal Absorption from Air Emissions
- Natural Gas Production- Methane and associated hydrocarbons and Condensates
- Condensate contains extremely toxic volatile organic chemicals:
  - Benzene known human cancer causing agent
  - Xylene, Toluene, Ethyl Benzene
  - Other probable and possible cancer causing agents
  - Sulfur based compounds
- Chemicals are released into the air during production, separation processes, tank storage and pipeline transportation.

Pathways of Exposure

- Emissions into the air from produced water tanks on the production site release methane, toxic volatile organic chemicals and sulfur compounds into the air.
- Natural gas is frequently vented to the air when a well is completed.
- Compressors and motors on the drilling and production sites, injection well disposal sites and along pipelines release combustion products and volatile organic hydrocarbons into the air and degrade the air quality. These combustion products also combine with the volatile organic chemicals in the presence of heat and sunlight to produce ground level ozone.

Ingestion and Dermal Absorption Pathways of Exposure

- Ground water and surface water resources and soils and sediments are contaminated from:

- Spills and leaks from pits, tanks, rigs, chemical storage containers, drums, flow lines, pipelines, mixing vats, trucks, injection wells, etc.
- Road Spreading and Land Spreading of waste
- Untreated or improperly treated produced water and flowback water discharged from Waste Water Treatment Plants

Acute Health Impacts Experienced by Individuals Living in Close Proximity to Shale Gas Drilling, Fracturing and Production Wells– Air Pathways

- Irritates Skin, Eyes, Nose, Throat and Lungs
- Headaches
- Dizziness, Light Headed
- Nausea, Vomiting
- Skin Rashes
- Fatigue
- Tense and Nervous
- Personality Changes
- Depression, Anxiety, Irritability
- Confusion
- Drowsiness
- Weakness
- Muscle Cramps
- Irregular Heartbeat (arrhythmia)

Chronic Health Impacts Experienced by Individuals Living in Close Proximity to Shale Gas Drilling, Fracturing and Production Wells- Air Pathways

- Damage to Liver and Kidneys
- Damage to Lungs
- Damage to Nervous System Causing Weakness
- Leukemia
- Aplastic Anemia
- Changes in Blood Cells
- Impacts to Blood Clotting Ability

Health Impacts Experienced by Individuals Living in Close Proximity to Shale Gas Drilling, Fracturing and Production Wells–Air and Drinking Water Pathways

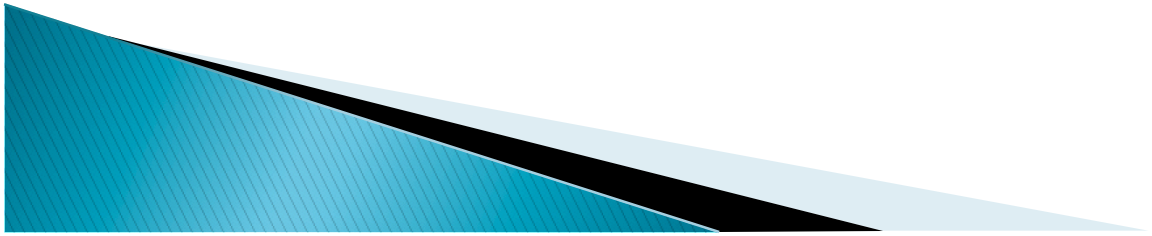
Medical Condition	% of Individuals
Respiratory Impacts	81
Memory Loss	56
Feeling Weak & Tired	50
Throat Irritation	50
Sinus Problems	44
High Blood Pressure	44
Muscle Aches or Pains	44
Forgetfulness	38
Recall Problems	38
Breathing Difficulties	38
Eyes Burning	38
Joint Pain	38
Decrease in Vision	31
Sleep Disorder	31

Health Impacts Experienced by Individuals Living in Close Proximity to Shale Gas Drilling, Fracturing and Production Wells–Air and Drinking Water Pathways

- 25% of the individuals surveyed had the following symptoms:
  - Nasal Irritation
  - Arthritis
  - Persistent Indigestion
  - Increased Fatigue
  - Frequent Urination
  - Extreme Drowsiness

25% of the individuals surveyed had the following symptoms:

- Difficulty in Concentrating
- Inability to Recall Numbers
- Ringing the Ears
- Difficulty in Hearing
- Severe Headaches
- Tingling in Hands
- Reduced Muscle Strength
- Loss of Sexual Drive



Health Impacts Reported by Community Members Living 50 feet to 2 miles from Compressor Stations and Gas Metering Station Along Gas Transmission Pipelines

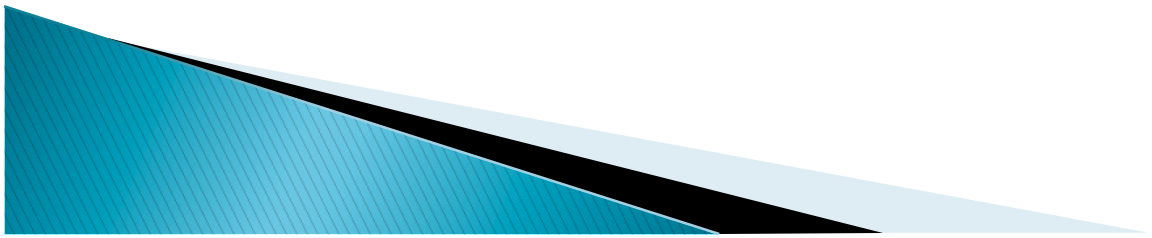
- *61% of Health Impacts Associated with Chemicals present in Excess of Short and Long Term Effects Screening Levels in the air

- Nasal Irritation*
- Throat Irritation*
- Eyes Burning*
- Frequent Nausea*
- Allergies
- Sinus Problems*
- Bronchitis*
- Persistent Cough
- Chronic Eye Irritation*
- Shortness of Breath
- Increased Fatigue*
- Muscle Aches & Pains*
- Severe Headaches*
- Frequent Nose Bleeds
- Sleep Disturbances
- Joint Pain
- Difficulty in Concentrating
- Nervous System Impacts
- Irregular/Rapid Heart Beat*
- Strokes
- Dizziness*
- Forgetfulness
- Easy Bruising

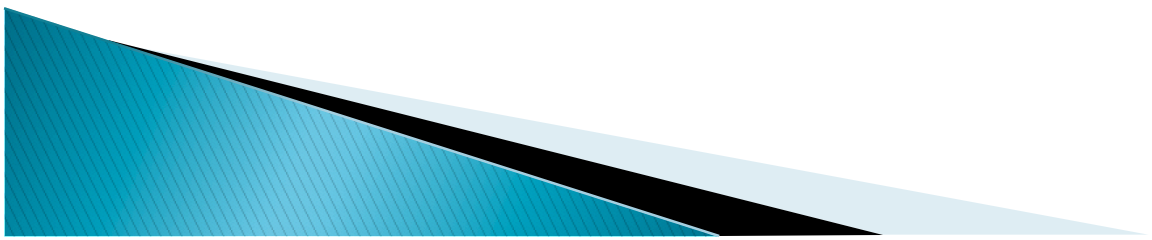
- Weakness* & Tired*
- Ringing in Ears
- Sores & Ulcers in Mouth
- Urinary Infections
- Depression*
- Decreased Motor Skills*
- Falling, Staggering*
- Frequent Irritation*
- Brain disorders*
- Amnesia
- Severe Anxiety*
- Excessive Sweating
- Abnormal EEG*
- Lump in Breast
- Spleen
- Pre-Cancerous Lesions*
- Abnormal Mammogram
- Thyroid Problems
- Endometriosis

Most Prevalent Medical Conditions In Individuals Living in Close Proximity to Compressor Stations and Metering Stations

Medical Conditions	% of Individuals Surveyed
Respiratory Impacts	71
Sinus Problems	58
Throat Irritation	55
Allergies	55
Weakness and Fatigue	55
Eye Irritation	52



Medical Conditions	% of Individuals Surveyed
Nasal Irritation	48
Joint Pain	45
Muscle Aches & Pains	42
Breathing Difficulties	42
Vision Impairment	42
Severe Headaches	39
Sleep Disturbances	39
Swollen & Painful Joints	39
Frequent Irritation	32



Units at Compressor Stations and Gas Metering Stations Releasing Emissions into the Air

- Compressor Engines
- Compressor Blowdowns
- Condensate Tanks
- Storage Tanks
- Truck Loading Racks
- Glycol Dehydration Units
- Amine Units
- Separators
- Fugitive Emission Sources
- 90% of individuals reported experiencing odor events from these facilities

Health Effects Experienced by Community Members Living Near a Natural Gas Storage and Processing Tank Farm

- Acute Health Effects
  - Irritates Skin, Eyes, Nose Mouth, Throat and Lungs
  - Headache
  - Dizziness
  - Light Headed
  - Nausea
  - Vomiting

- Chronic Health Effects
  - Anemia
  - Cancer
  - Leukemia

Single Stage Frac Job in the Barnett Shale in February 2012

- In a residential area. Company assured residents there would be no air emissions.
- Consultant for company detected:

- Flow Back Water
  - Methane 20%
  - Volatile Organic Chemicals (VOC) 8 ppm in emissions
- Open Frac Tank Emission from Open Hatches Released
  - Methane & VOC

Single Stage Frac Job in the Barnett Shale in February 2012

- During Hydro Fracturing Emissions
  - O-Xylene
  - Toluene
  - Ethyl Benzene
  - Nitric Oxide
- During Hydro Fracturing and Flow Back Operations Emissions
  - Benzene
  - Xylene (o,m,p)
  - Toluene
  - Ammonia
  - Nitric Oxide

Single Stage Frac Job in the Barnett Shale in February 2012

- Consultants Recommendations:
  - Need for improved emission capture and removal of VOC emissions during fracturing and flow back operations

Residential Neighbors Collected Their Own Air Samples

- Air sample on day of fracturing from a distance of 1700' from the well:
  - Benzene
  - Ethylbenzene
  - Toluene
  - m,p-Xylene
  - Carbon Disulfide Exceeded TCEQ Short Term (1.97X) and Long Term (20X) Effects Screening Levels
  - Naphthalene Exceeded TCEQ Long Term (7.6X) Effects Screening Level

  - Samples collected on two other days contained similar chemicals in the air samples from two other residences.

Chemicals Detected in Water in Association with Shale Gas Drilling, Production and Distribution

- Groundwater

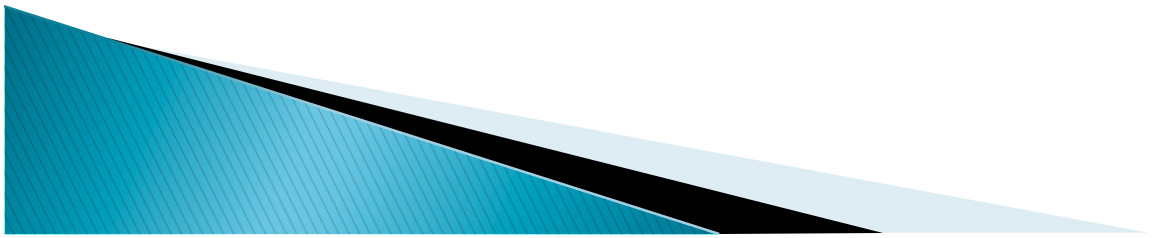
Petroleum Hydrocarbons	Methane
Chlorides	Fluoride
Nitrate	Nitrite
Sulfate	Arsenic
2-Butoxyethanol Phosphate	
Caprolactam	
2,4-bis (1-phenyl)-phenol	Bisphenol A
5-Hydroxymethyl dihydrofuran	Terpineol
Dimethyl Phthalate	Limonene
Bis(2-Ethylehexyl) Phthalate	

Chemicals Detected in the Air in Association with Shale Gas Drilling, Production and Distribution

- Benzene
- 1,3-Butadiene
- n-Butyl Alcohol
- Carbon disulfide
- Carbonyl Sulfide
- Chlorobenzene
- Chloromethane
- 1,2-Dichloroethane
- Diethyl Benzene
- Dimethyl Pyridine
- Dimethyl disulfide
- Ethyl Benzene
- Ethylene
- Ethylene Oxide
- Ethyl-methyl ethyl disulfide
- Formaldehyde
- Methyl-Methyl ethyl Benzene
- Methyl Pyridine
- Naphthalene
- 1,1,1,2-Tetrachloroethane
- Tetramethyl Benzene
- Toluene
- 1,1,2-Trichloroethane
- Trichloroethylene
- Trimethyl Benzene
- 1,2,4-Trimethyl Benzene

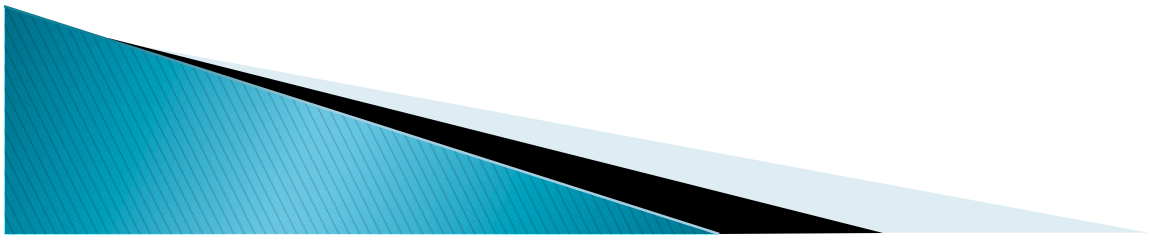
Chemicals Detected in the Air in Association with Shale Gas Drilling, Production and Distribution

- Xylene
- Ethane
- Isobutane
- Methane
- Propane
- Propylene
- Nitrogen Oxide
- Carbon Monoxide
- Sulfur Dioxide



Shale Gas Development has resulted in

- Human Health Impacts to a large number of individuals living and working in the areas of shale development
- Large Quantities of Environmental Damage and Disruption
- State regulatory programs that are not adequate to regulate and control the rapidly developing shale technologies being implemented within the individual states



Shale Gas Development has resulted in

- State regulatory programs that lack sufficient personnel to inspect, monitor and enforce the existing regulations
- Earthworks performed a study of enforcement in Colorado, Texas, Ohio, Pennsylvania, New York and New Mexico. The results demonstrate that enforcement is severely lacking.
- Local governments have the authority to regulate the siting of oil and gas wells, compressor stations, tank batteries, etc. States are attempting to take the local government authority away.