BASELINE

Project Supported By

- Grand Traverse Band of Ottawa and Chippewa Indians
- Leelanau Clean Water
- Glen Lake Association

Project Director: Sarah Litch

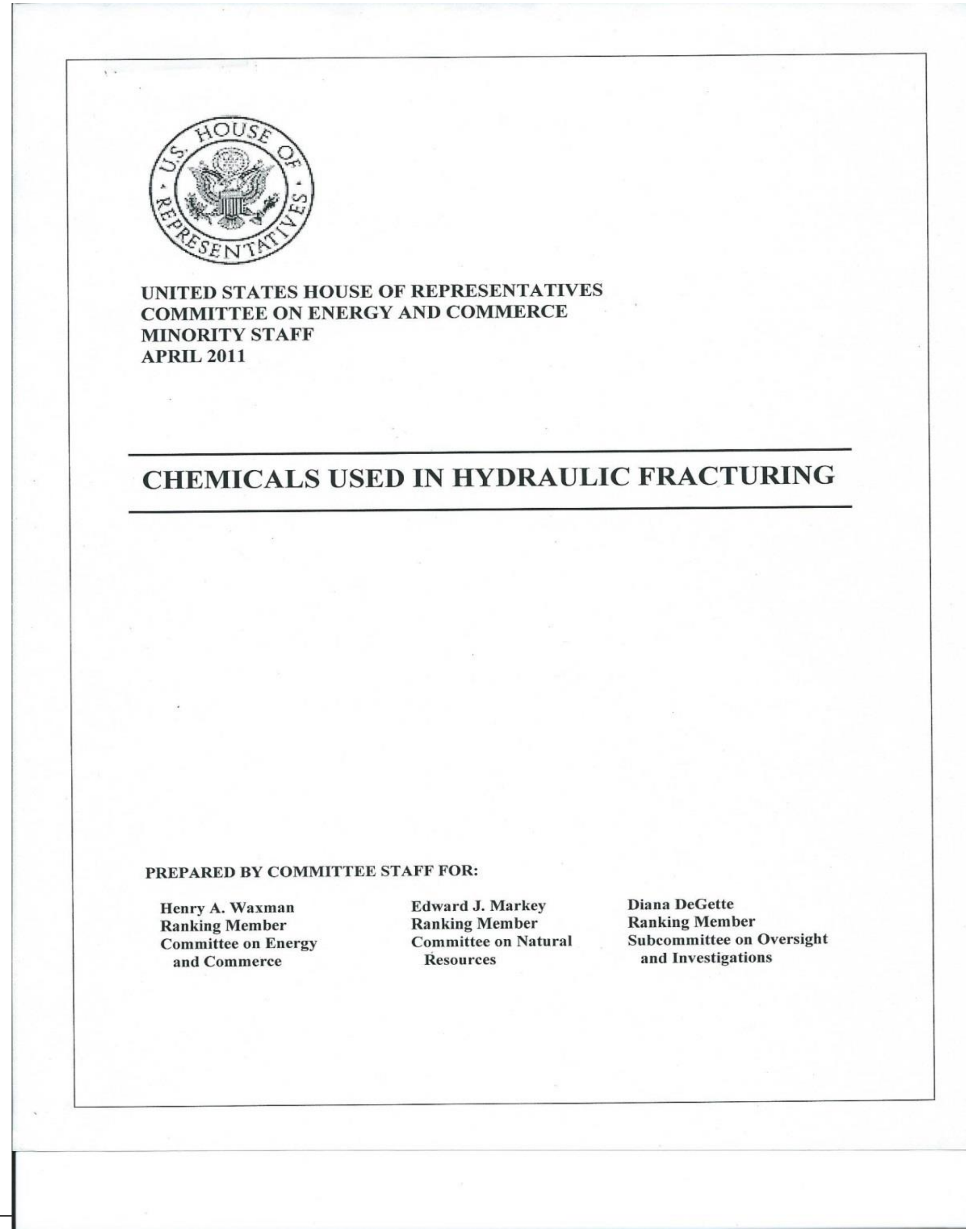
Glen Lake Association Water Quality

Leelanau Clean Water

The Need for Baseline Water Quality Testing Pre Hydraulic Fracturing

Horizontal deep well hydraulic fracturing for methane gas poses considerable risks to pubic health, safety, and the environment. A threat to our county is the contamination of our surface and ground water as well as our lakes, rivers, and streams by the millions of gallons of water used for each fracturing to which has been added a combination of toxic chemical from a pool of 750 chemicals including 29 known carcinogens. Other of these chemicals are neurotransmitter and hormone disrupters, with additional serious health problems implicated with many of these chemicals. Air pollution by methane and toxic chemicals is also at stake.

To 6,000,000 gallons of water are added
600,000 gallons of sand
and
3,000 gallons of chemicals
per full Hydraulic Frack
(15 stages of reloading)



U.S. HOUSE OF REPRESENTATIVES

UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON ENERGY AND COMMERCE
MINORITY STAFF
APRIL 2011

CHEMICALS USED IN HYDRAULIC FRACTURING

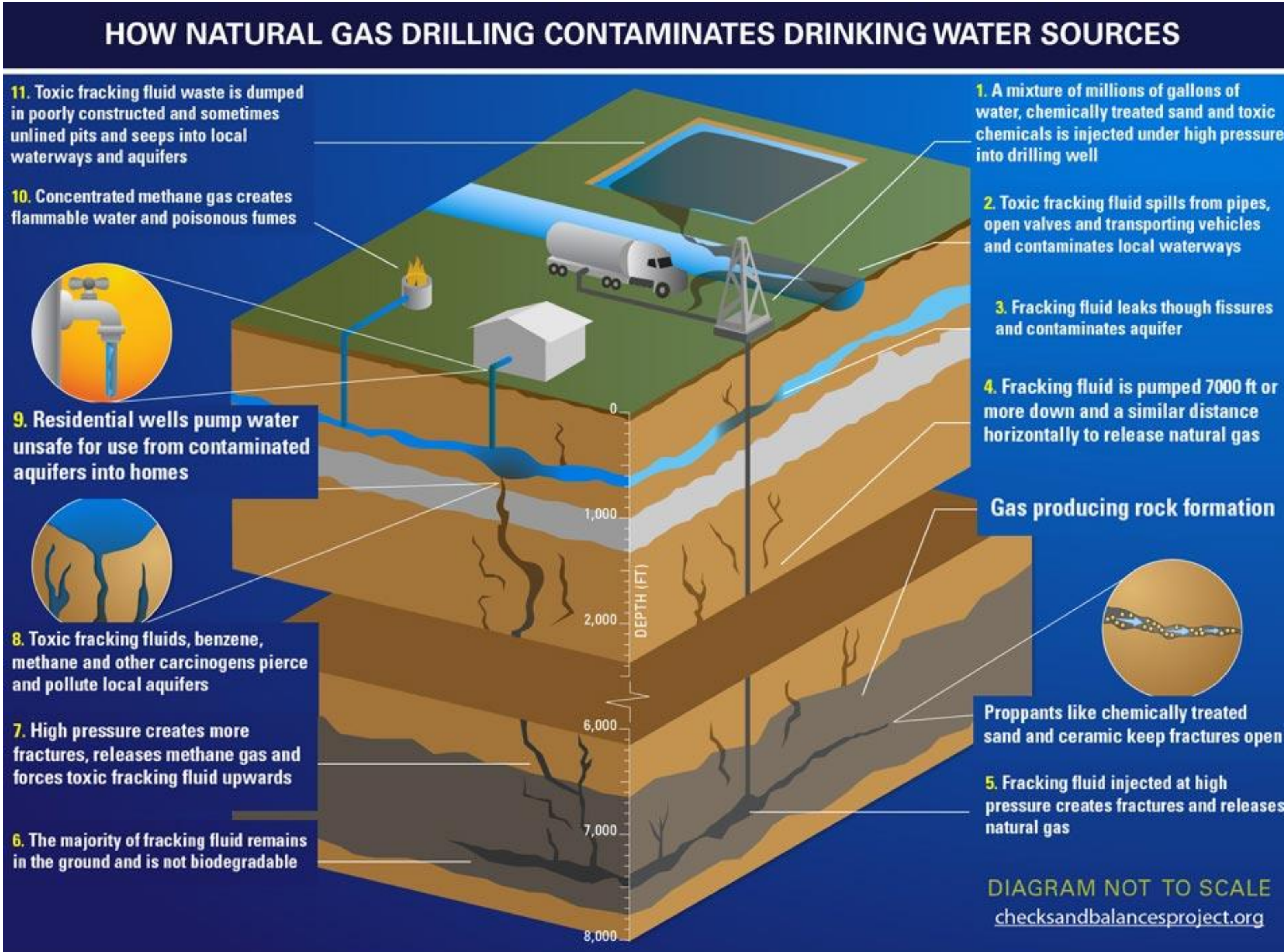
PREPARED BY COMMITTEE STAFF FOR:

Henry A. Waxman
Ranking Member
Committee on Energy and Commerce

Edward J. Markey
Ranking Member
Committee on Natural Resources

Diana DeGette
Ranking Member
Subcommittee on Oversight and Investigations

- This document was written by the U.S. House of Representatives Committee on Energy and Commerce in 2011 and is the most comprehensive national assessment to date of types and volumes of chemicals used in the hydraulic fracturing process. It shows that between 2005 and 2009, the 14 leading hydraulic fracturing companies in the US used over 2,500 hydraulic fracturing products containing 750 compounds.
- More than 650 of these products contain chemicals that are known, or possible human carcinogens, regulated under the Safe Drinking Water Act, or listed as hazardous air pollutants.



HOW NATURAL GAS DRILLING CONTAMINATES DRINKING WATER SOURCES
11. Toxic fracking fluid waste is dumped in poorly constructed and sometimes unlined pits and seeps into local waterways and aquifers
10. Concentrated methane gas creates flammable water and poisonous fumes
9. Residential wells pump water unsafe for use from contaminated aquifers into homes
8. Toxic fracking fluids, benzene, methane and other carcinogens pierce and pollute local aquifers
7. High pressure creates more fractures, releases methane gas and forces toxic fracking fluid upwards
6. The majority of fracking fluid remains in the ground and is not biodegradable
1. A mixture of millions of gallons of water, chemically treated sand and toxic chemicals is injected under high pressure into drilling well
2. Toxic fracking fluid spills from pipes, open valves and transporting vehicles and contaminates local waterways
3. Fracking fluid leaks though fissures and contaminates aquifer
4. Fracking fluid is pumped 7000 ft or more down and a similar distance horizontally to release natural gas
Gas producing rock formation
Proppants like chemically treated sand and ceramic keep fractures open
5. Fracking fluid injected at high pressure creates fractures and releases natural gas
DEPTH (FT)
0
1,000
2,000
6,000
7,000
8,000
DIAGRAM NOT TO SCALE
checksandbalancesproject.org

The purpose of this project is to develop a model baseline testing program

for our county so that tribal lands, farms, vineyards, orchards, residents and tourist businesses will have a form of insurance against the possibility that their air, wells, ponds, streams, lakes, and ground water might be contaminated by nearby shale gas operations. A baseline water quality testing program for signature chemicals and characteristics can provide a basis for holding gas companies accountable to Michigan State regulatory agencies and the courts.

Results of Baseline Water Quality Testing – Pre Hydraulic Fracturing First Year of Two Year Testing Project

SOS Analytical Water and Pace Analytical Water Quality Test Results
2013 First Year

3/25/2013 Sample 1 **8/22/2013 Samples 2-13**

Ground Water (Drinking Water): Sample 1,2,4,5,6,7,8,10,11,12

Surface Water: Sample 3: Hatlem Creek Sample 9: Crystal River

Sampling and Chain of Custody: SOS Analytical , Jack Nowland, Geologist

Analysis : SOS Analytical and Pace Analytical, R. Simmerman/Organic Chemist

Protocol and Rationale: **Community Science Institute Ithaca, NY

Watershed: Glen Lake-Crystal River

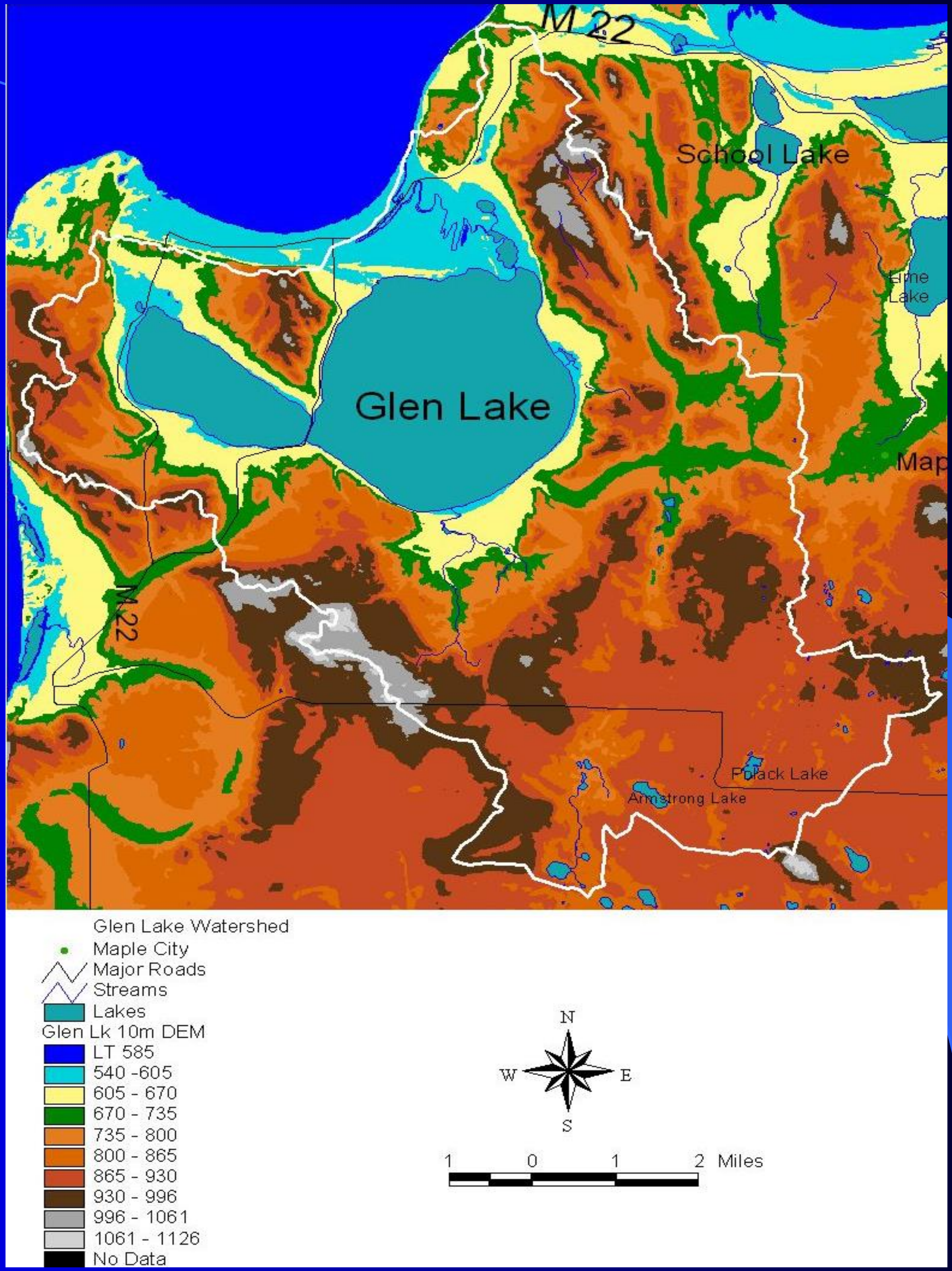
Aquifer: Silurian-Devonian **Shale Play: Antrim**

The Water Quality Test Sites were chosen considering:

- The agricultural and range lands in the Glen Lake-Crystal River Watershed
- The largest surface water input and output to the Glen Lake-Crystal River Watershed
- Riparians who volunteered to have their water tested

Glen Lake - Crystal River Groundwater Watershed

59.7 Sq. Miles



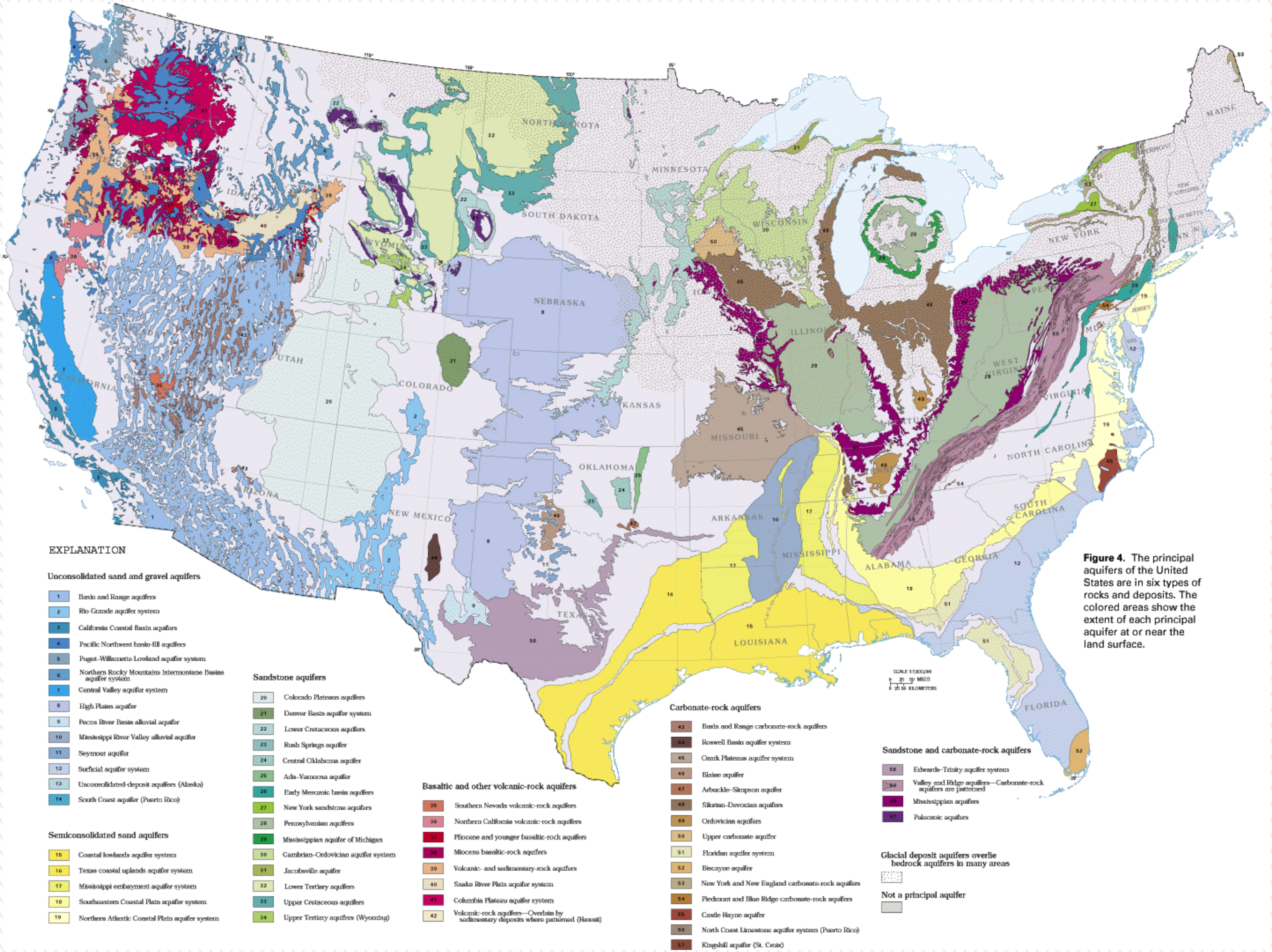
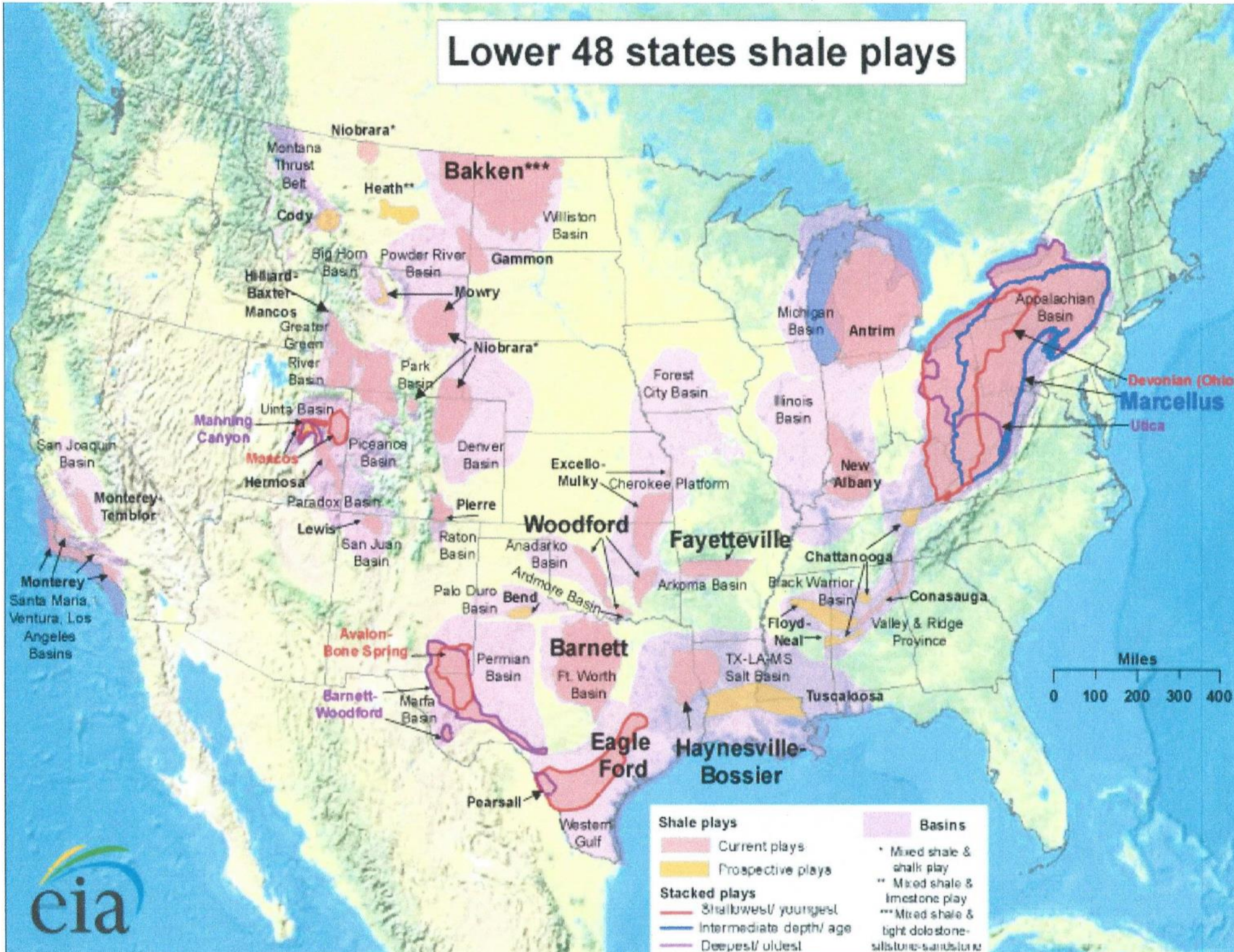


Figure 4. The principal aquifers of the United States are in six types of rocks and deposits. The colored areas show the extent of each principal aquifer at or near the land surface.



Lower 48 states shale plays
Niobrara*
Montana Thrust Belt
Bakken***
Heath**
Cody
Williston Basin
Big Horn Basin
Powder River Basin
Gammon
Hilliard-Baxter-Mancos
Mowry
Greater Green River Basin
Niobrara*
Park Basin
Forest City Basin
Michigan Basin
Antrim
Appalachian Basin
Devonian (Ohio)
Marcellus
Utica
Illinois Basin
Uinta Basin
Manning Canyon
Mancos
Piceance Basin
Denver Basin
Excello-Mulky
Cherokee Platform
New Albany
San Joaquin Basin
Hermosa
Paradox Basin
Monterey-Temblor
Pierre
Lewis
San Juan Basin
Raton Basin
Woodford
Anadarko Basin
Fayetteville
Chattanooga
Ardmore Basin
Arkoma Basin
Black Warrior Basin
Conasauga
Monterey
Santa Maria, Ventura, Los Angeles Basins
Palo Duro Basin
Bend
Floyd-Neal
Valley & Ridge Province
Avalon-Bone Spring
Permian Basin
Barnett
Ft. Worth Basin
TX-LA-MS Salt Basin
Tuscaloosa
Miles
0 100 200 300 400
Barnett-Woodford
Marfa Basin
Eagle Ford
Haynesville-Bossier
Pearsall
Western Gulf
Shale plays
Current plays
Prospective plays
Stacked plays
Shallowest/ youngest
Intermediate depth/ age
Deepest/ oldest
Basins
* Mixed shale & chalk play
** Mixed shale & limestone play
*** Mixed shale & tight dolostone-siltstone-sandstone
eia

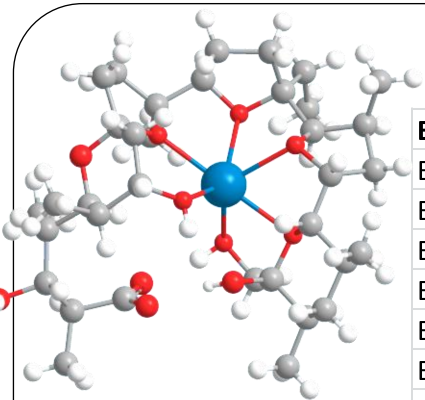

Ground Water, Drinking Water: Sites
1,2,4,5,6,7,8,10,11,12

Surface Water Site 3: Hatlem Creek

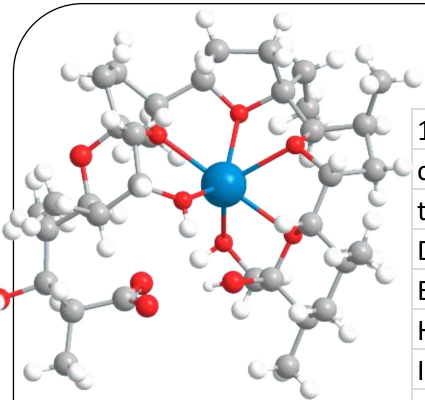
Surface Water Site 9: Crystal River

**Chemical oxygen demand, volatile organic compounds

Organic chemicals including thickeners added to hydraulic fracturing fluid make the water more viscous so it can hold the added sand particles. Petroleum distillates such as diesel may be added to make the water slick. Organic compounds may be released from shale along with the natural gas. The three BTEX chemicals (Benzene, Toluene, and Xylene) are indicators of contamination by hydraulic fracturing. These organic chemicals have sufficiently high volatility and low water solubility to be removed from water samples with purge and trap procedures.

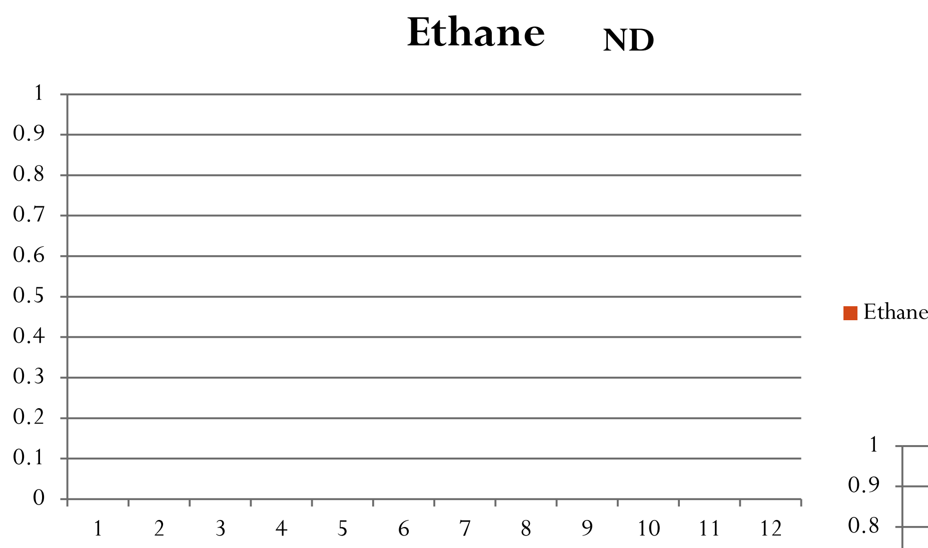


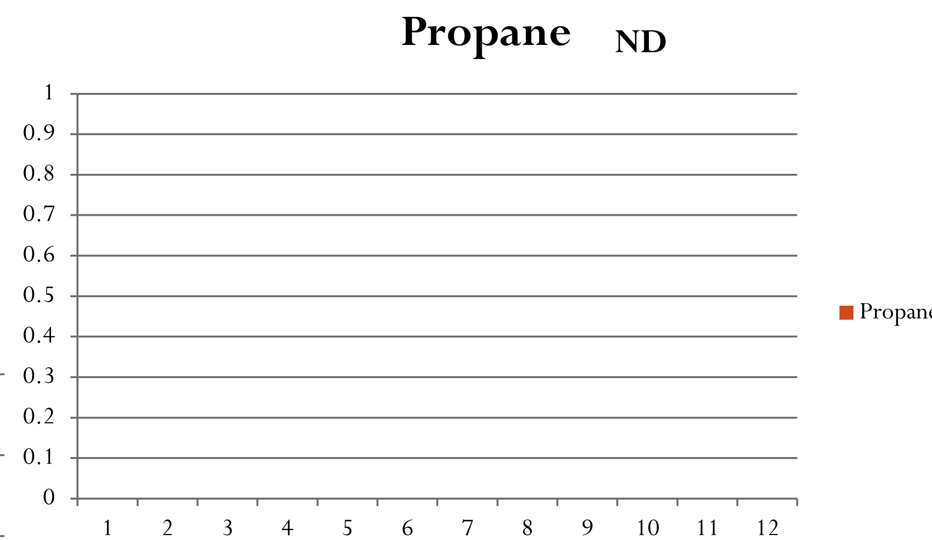
EPA 524.2 PURGEABLE ORGANICS	Limit of Detection LOD (PPM)	Concentration (PPM)
Benzene	0.5	ND
Bromobenzene	0.5	ND
Bromocloromethane	0.5	ND
Bromodichloromethane	0.5	ND
Bromoform	0.5	ND
Bromomethane	0.5	ND
n-Butylbenzene	0.5	ND
s-Butylbenzene	0.5	ND
t-Butylbenzene	0.5	ND
Carbon tetrachloride	0.5	ND
Chlorobenzene	0.5	ND
Chloroform	0.5	ND
Chloroethane	0.5	ND
Chloromethane	0.5	ND
2-Chlorotoluene	0.5	ND
4-Chlorotoluene	0.5	ND
Dibromochloromethane	0.5	ND
Dibromomethane	0.5	ND
1,2-Dichlorobenzene	0.5	ND
1,3-Dichlorobenzene	0.5	ND
1,4-Dichlorobenzene	0.5	ND
Dichlorodifluoromethane	0.5	ND
1,1-Dichloroethane	0.5	ND
1,2-Dichloroethane	0.5	ND
cis-1,2-Dichloroethene	0.5	ND
trans-1,2-Dichloroethene	0.5	ND
1,2-Dichloropropane	0.5	ND
1,3-Dichloropropane	0.5	ND
2,2-Dichloropropane	0.5	ND

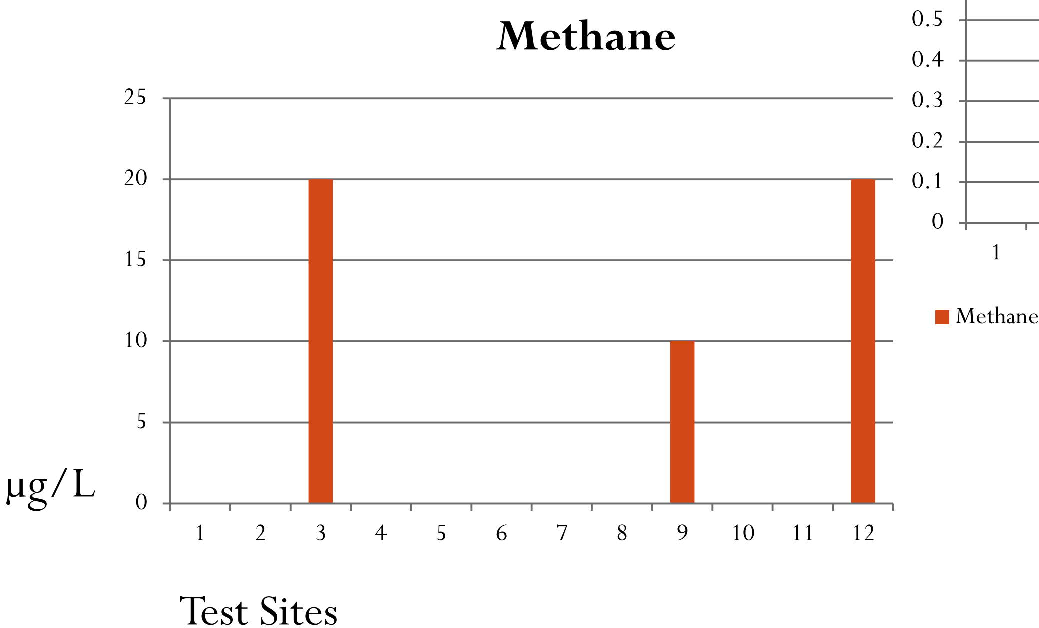


1,1-Dichloropropene	0.5	ND
cis-1,3-Dichlororpropene	0.5	ND
trans-1,2-Dichloroethene	0.5	ND
Diethyl ether	5	ND
Ethylbenzene	0.5	ND
Hexachlorobutadiene	0.5	ND
Isopropylbenzene	0.5	ND
Isopropyltoluene	0.5	ND
Methyl ethyl ketone	2.5	ND
Methyl-1-butyl ether	5	ND
Methylenechloride	5	ND
MIBK	5	ND
Naphthalene	2.5	ND
n-Propylbenzene	0.5	ND
Styrene	0.5	ND
1,1,1,2-Tetrachloroethane	0.5	ND
1,1,2,2-Tetrachloroethane	0.5	ND
Tetrachloroethane	0.5	ND
Toluene	0.5	ND
1,2,3-Trichlorobenzene	0.5	ND
1,2,4-Trichlorobenzene	0.5	ND
1,1,1-Trichloroethane	0.5	ND
1,1,2-Trichloroethane	0.5	ND
Trichloroethene	0.5	ND
Trichlorfluoromethane	0.5	ND
1,2,3-Trichloropropane	0.5	ND
1,2,4-Trimethylbenzene	0.5	ND
1,3,5-Trimethylbenzene	0.5	ND
Vinyl chloride	0.5	ND
Xylene(TOTAL)	1.5	ND

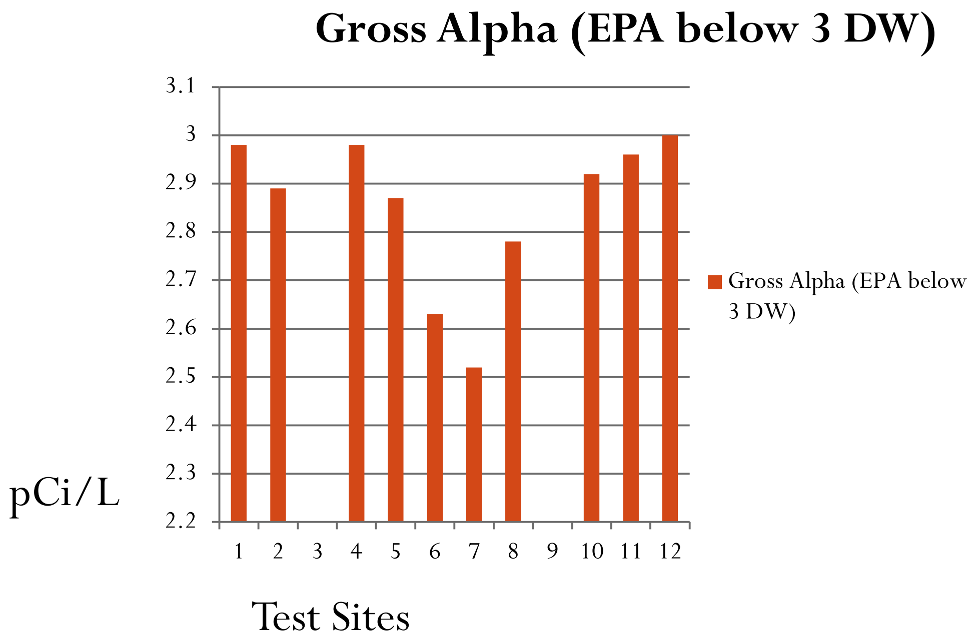
**Natural gas is an indicator of a faulty well casing. It also indicates the possibility of other chemicals being present that are toxic. According to the EPA methane is non-toxic. However, it does pose a risk of explosion when present at concentrations above 10mg/L because it can escape from water and can build up to dangerous levels if the house or the well is not properly ventilated.

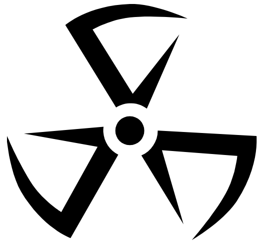

Ethane ND
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 2 3 4 5 6 7 8 9 10 11 12
Ethane

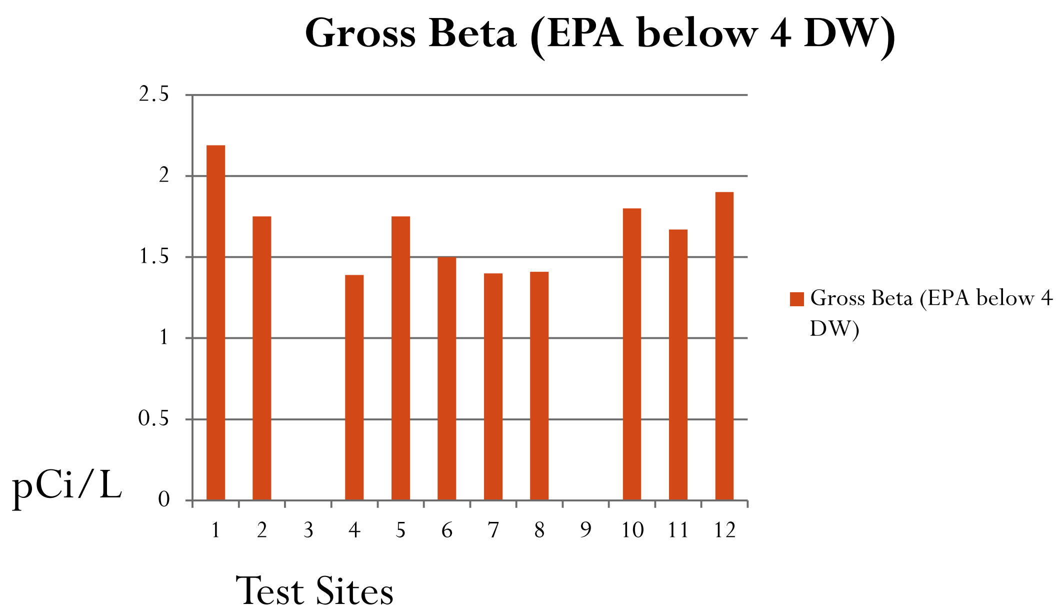

Propane ND
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 2 3 4 5 6 7 8 9 10 11 12
Propane


Methane
25
20
15
10
5
0
µg/L
1 2 3 4 5 6 7 8 9 10 11 12
Test Sites
Methane

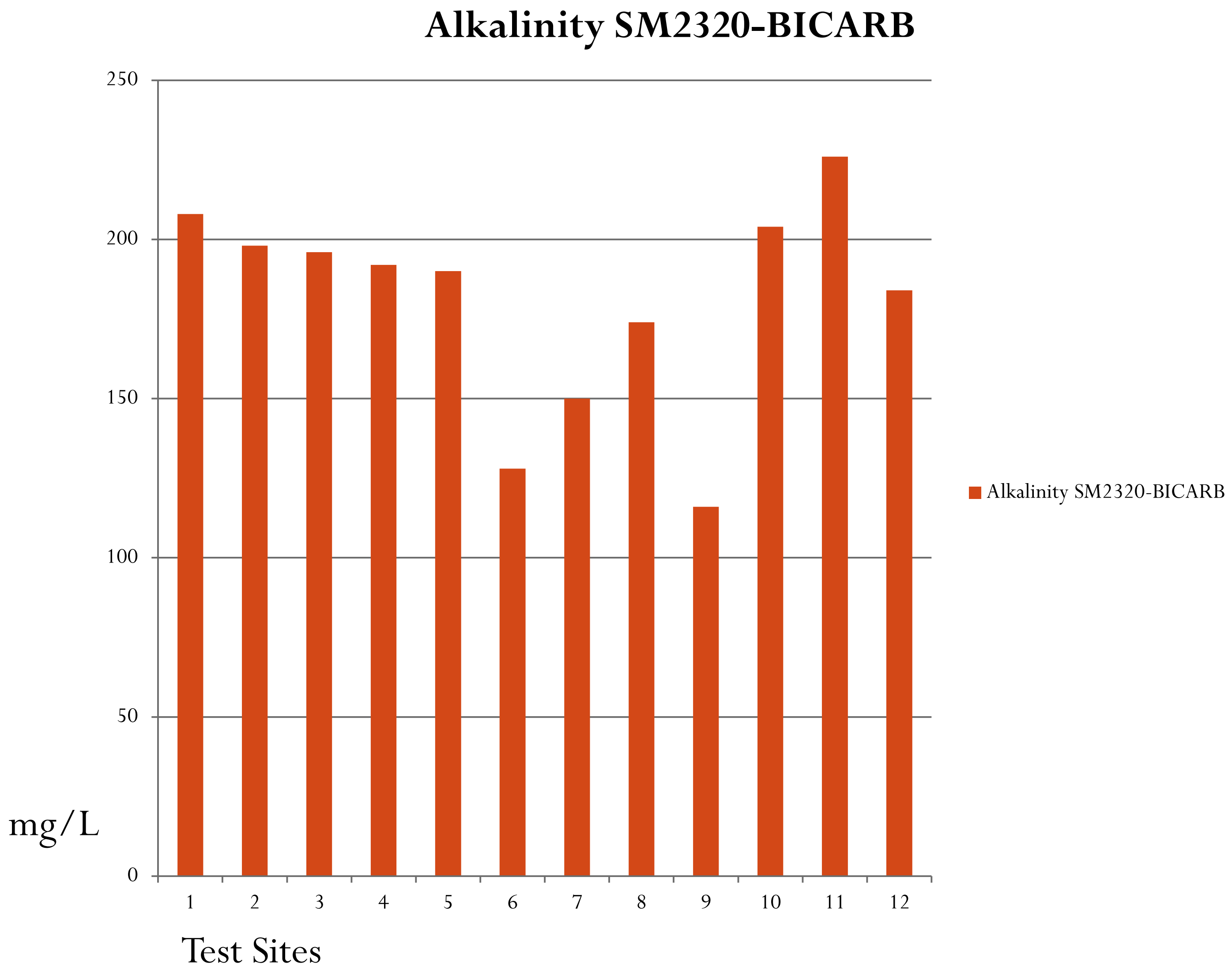
****Gross alpha radioactivity and gross beta radioactivity** are naturally occurring radioactive materials that can leach out of the shale into hydraulic fracturing fluid as it flows back out of the gas wells.


Gross Alpha (EPA below 3 DW)
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
pCi/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Gross Alpha (EPA below 3 DW)

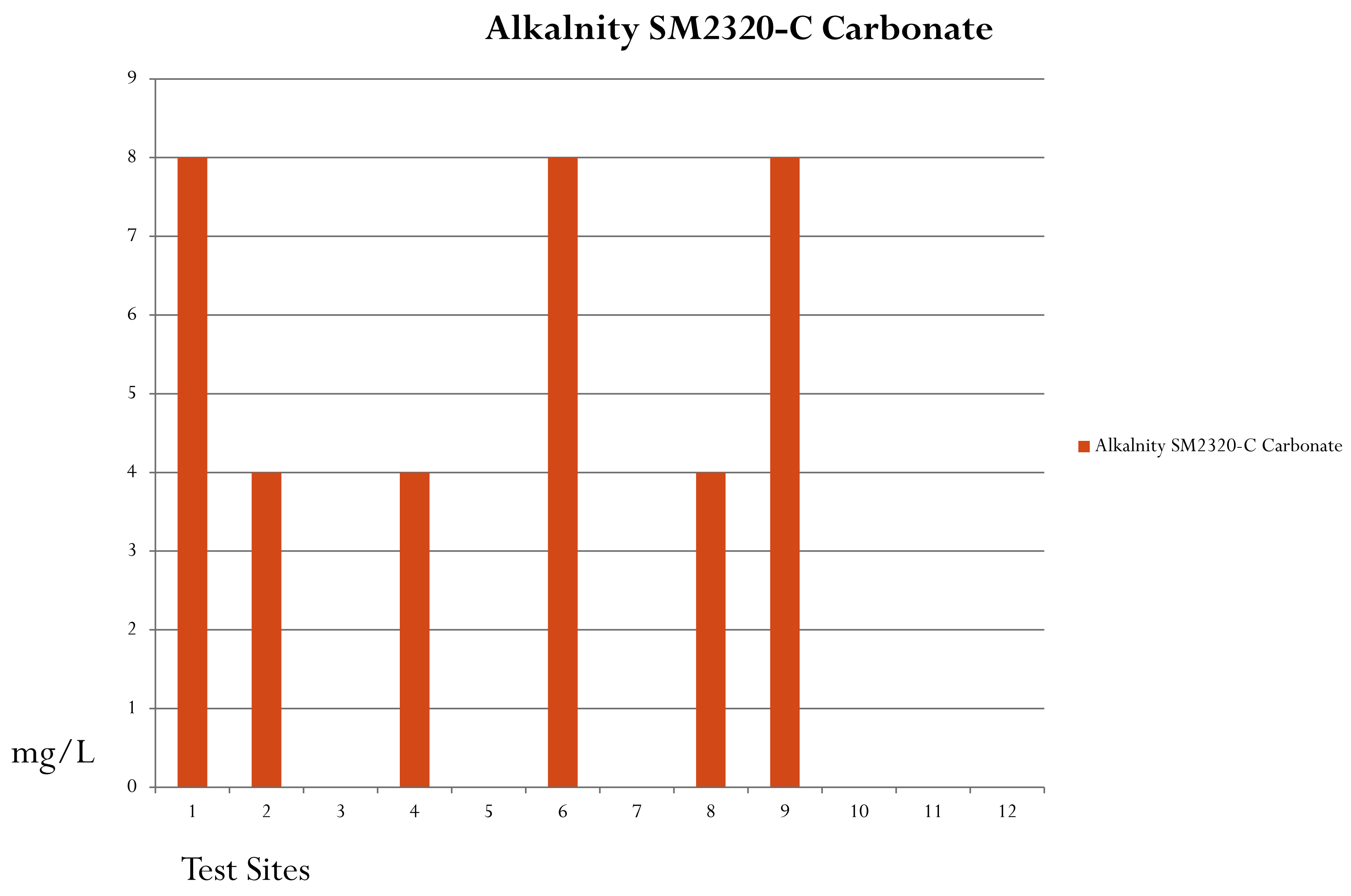



Gross Beta (EPA below 4 DW)
2.5
2
1.5
1
0.5
0
pCi/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Gross Beta (EPA below 4 DW)

**Acid is used in hydraulic fracturing fluid and it can be in the flowback out of the gas well and contaminate ground and surface water. Therefore pH and alkalinity are good signature indicators.

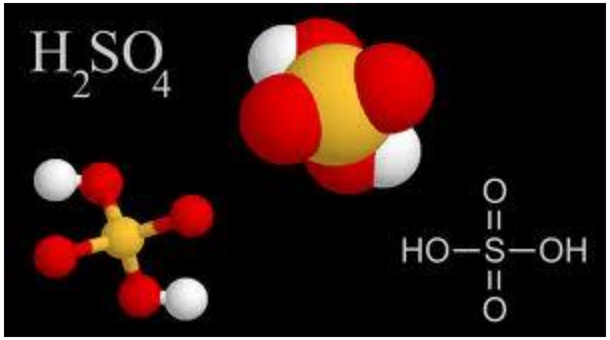


Alkalinity SM2320-BICARB
250
200
150
100
50
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Alkalinity SM2320-BICARB



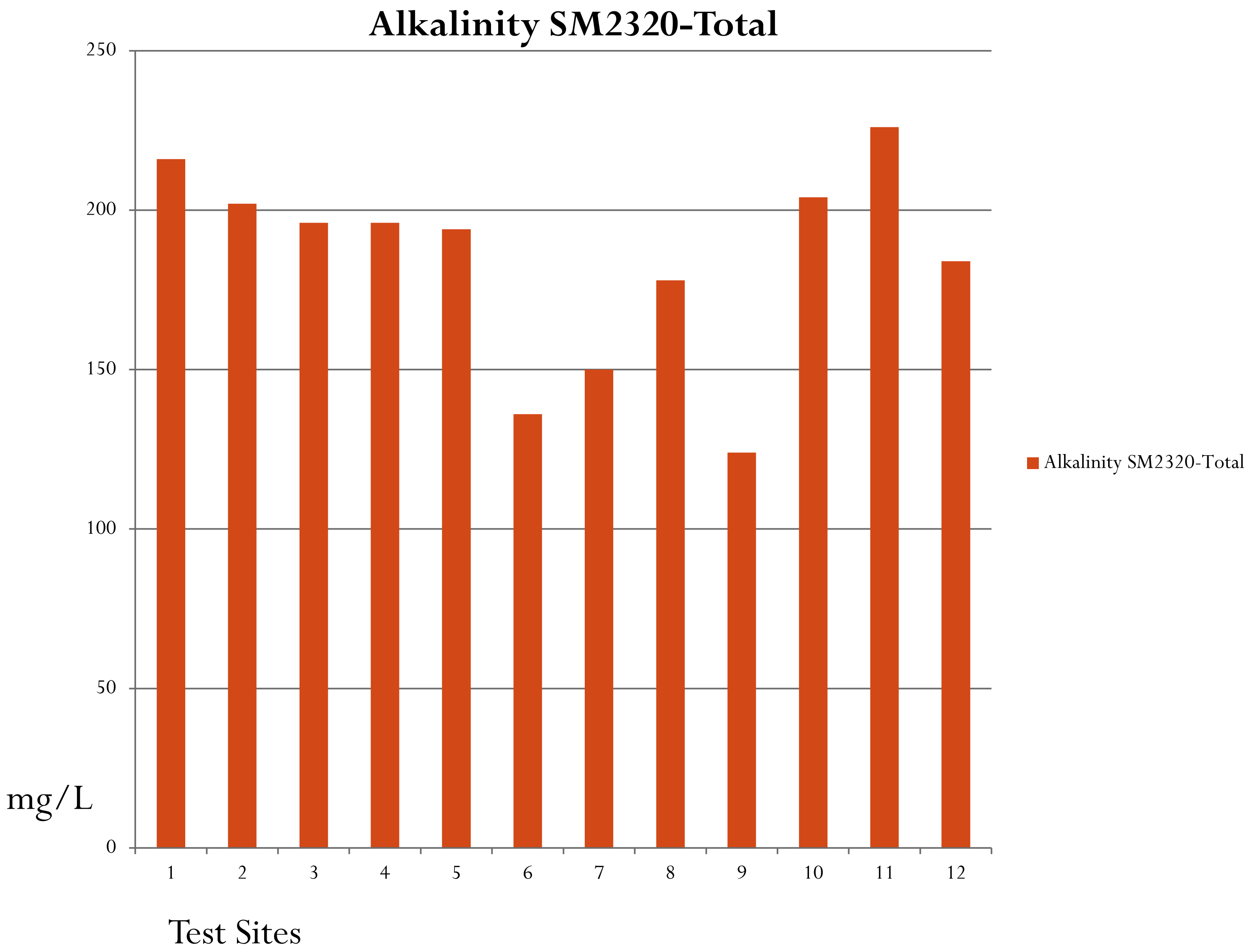
Alkalnity SM2320-C Carbonate
9
8
7
6
5
4
3
2
1
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Alkalnity SM2320-C Carbonate

Alkalinity is determined by measuring the amount of acid (sulfuric acid) needed to bring the water sample to a pH of 4.2.



At this pH all the alkaline compounds in the sample are used up.

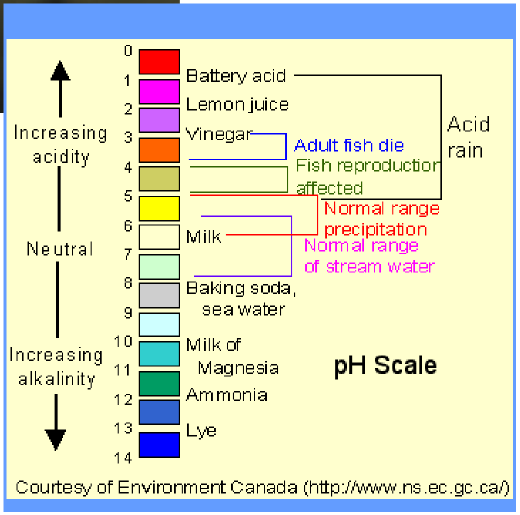
Reported as mg/L of calcium carbonate



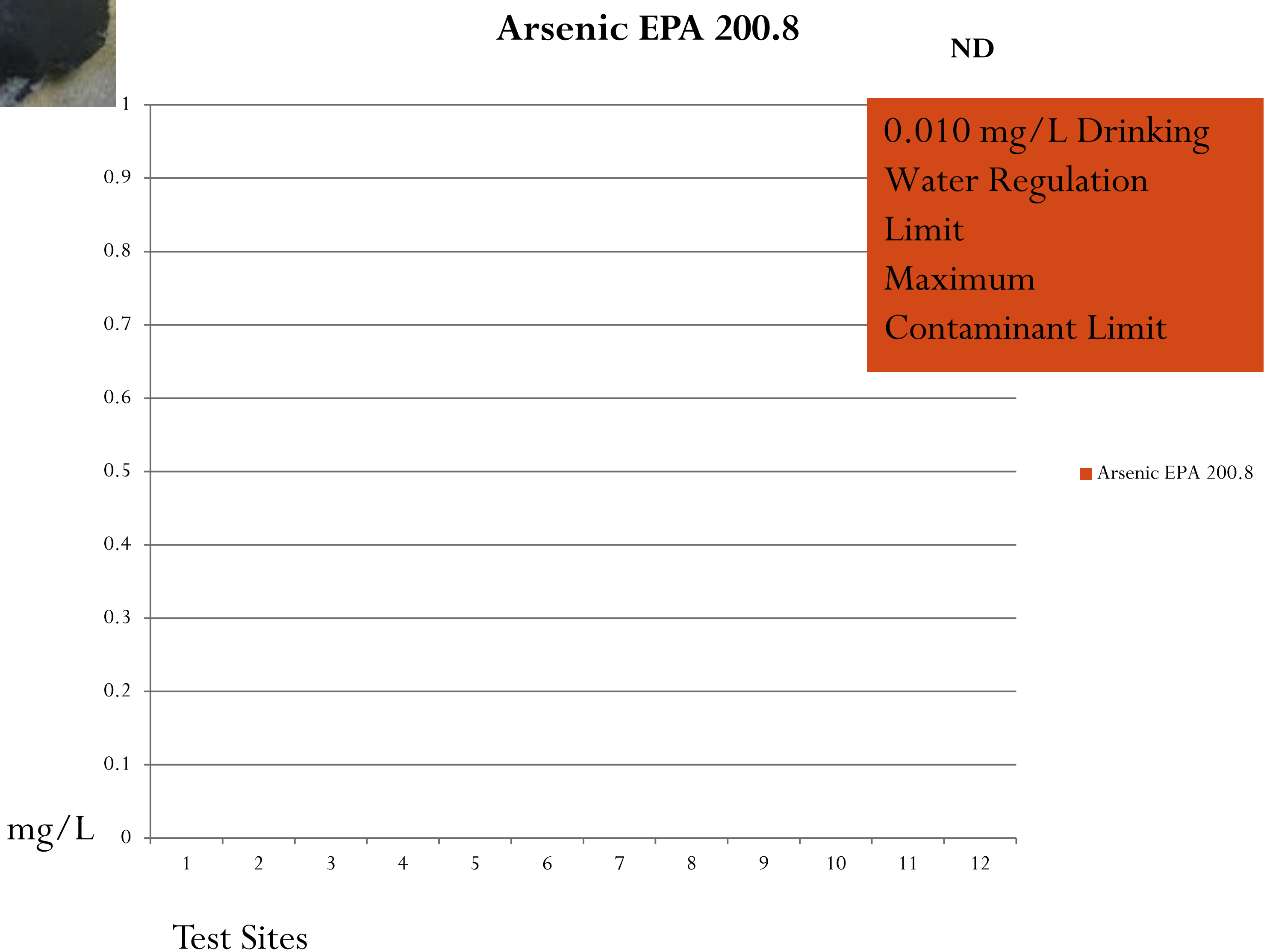
Alkalinity SM2320-Total
250
200
150
100
50
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Alkalinity SM2320-Total

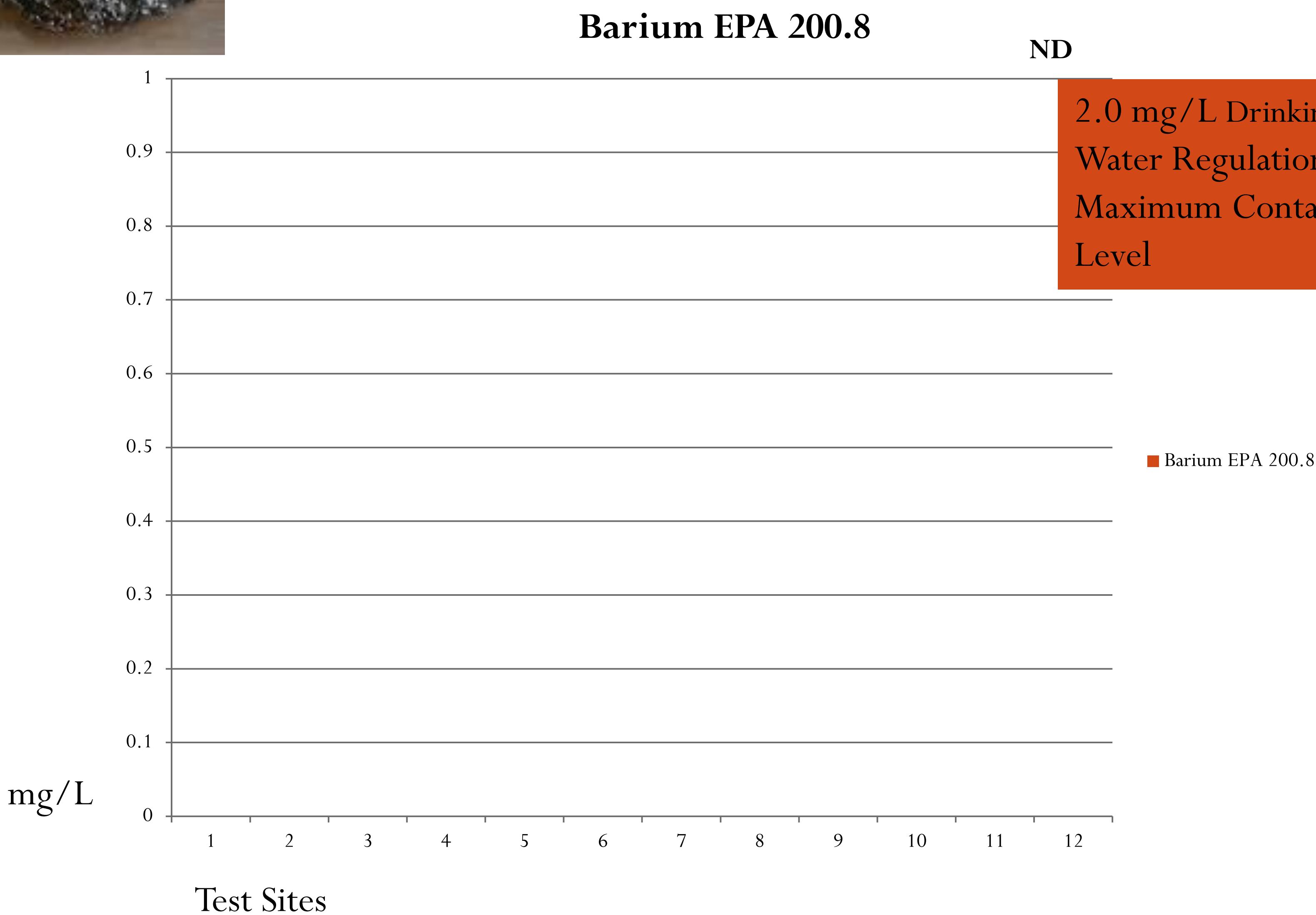
Alkalinity is a measure of the capacity of the **alkaline compounds in water** to neutralize or lower acidity of the water with subsequent increases in the pH.

This is one of the best measures of the sensitivity of a water to acid inputs.

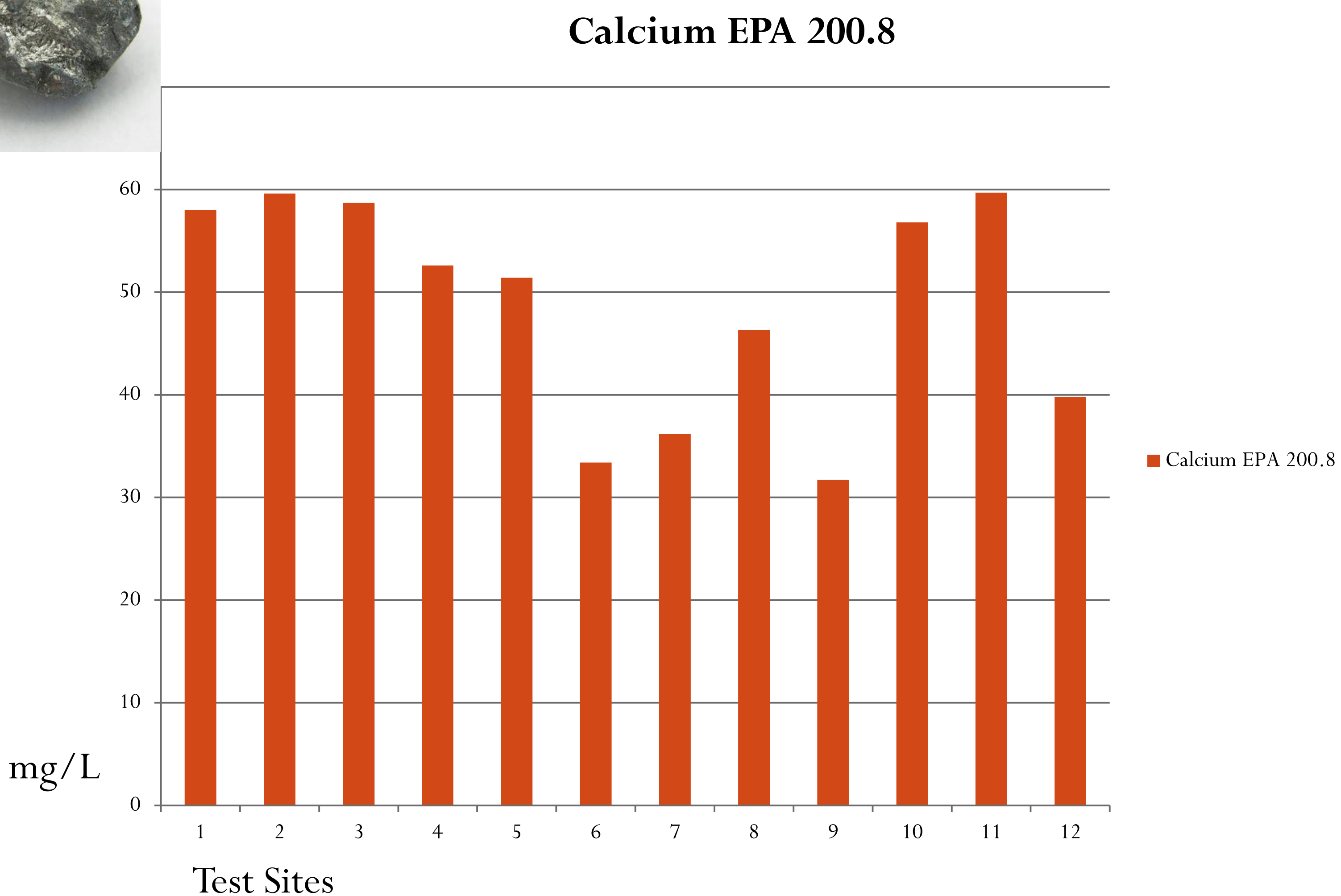


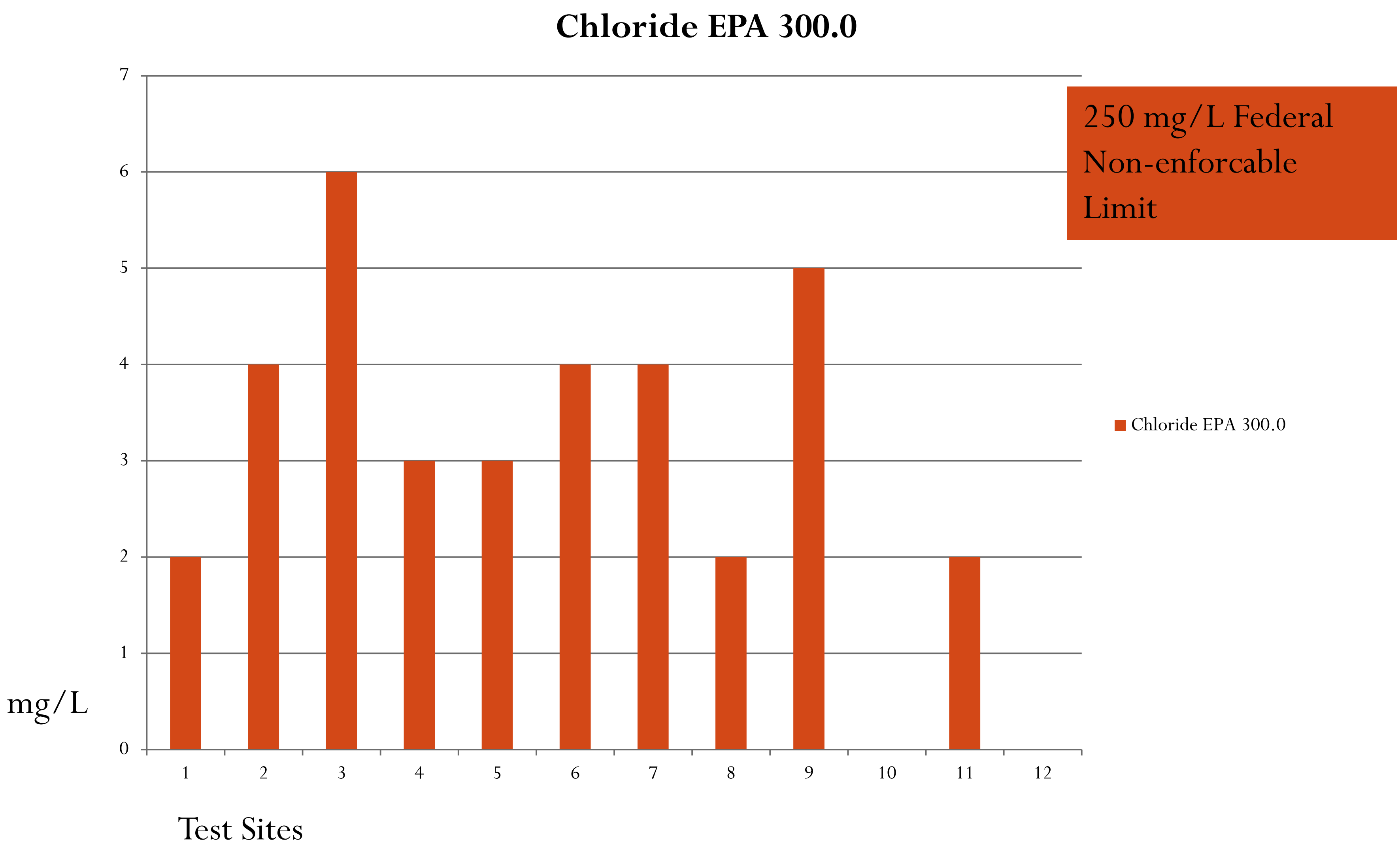
**General and specific tests for total hardness, calcium, barium, strontium, arsenic, manganese, and iron are metals that appear to have the best odds of turning up in gas well waste.


Arsenic EPA 200.8
ND
0.010 mg/L Drinking Water Regulation Limit Maximum Contaminant Limit
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/L
1 2 3 4 5 6 7 8 9 10 11 12
Test Sites
Arsenic EPA 200.8



2.0 mg/L Drinking Water Regulation Maximum Contaminant Level

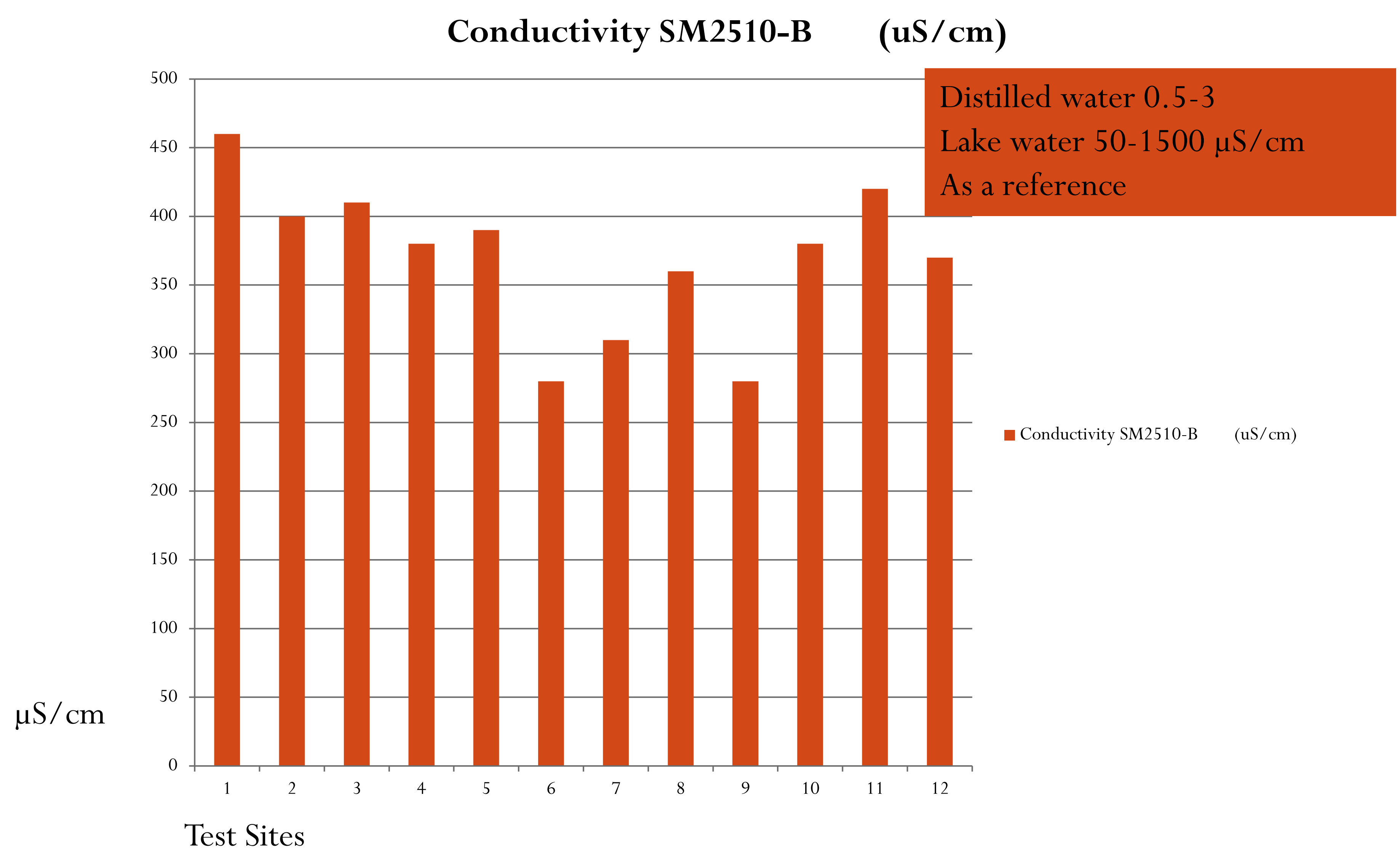

Calcium EPA 200.8
60
50
40
30
20
10
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Calcium EPA 200.8



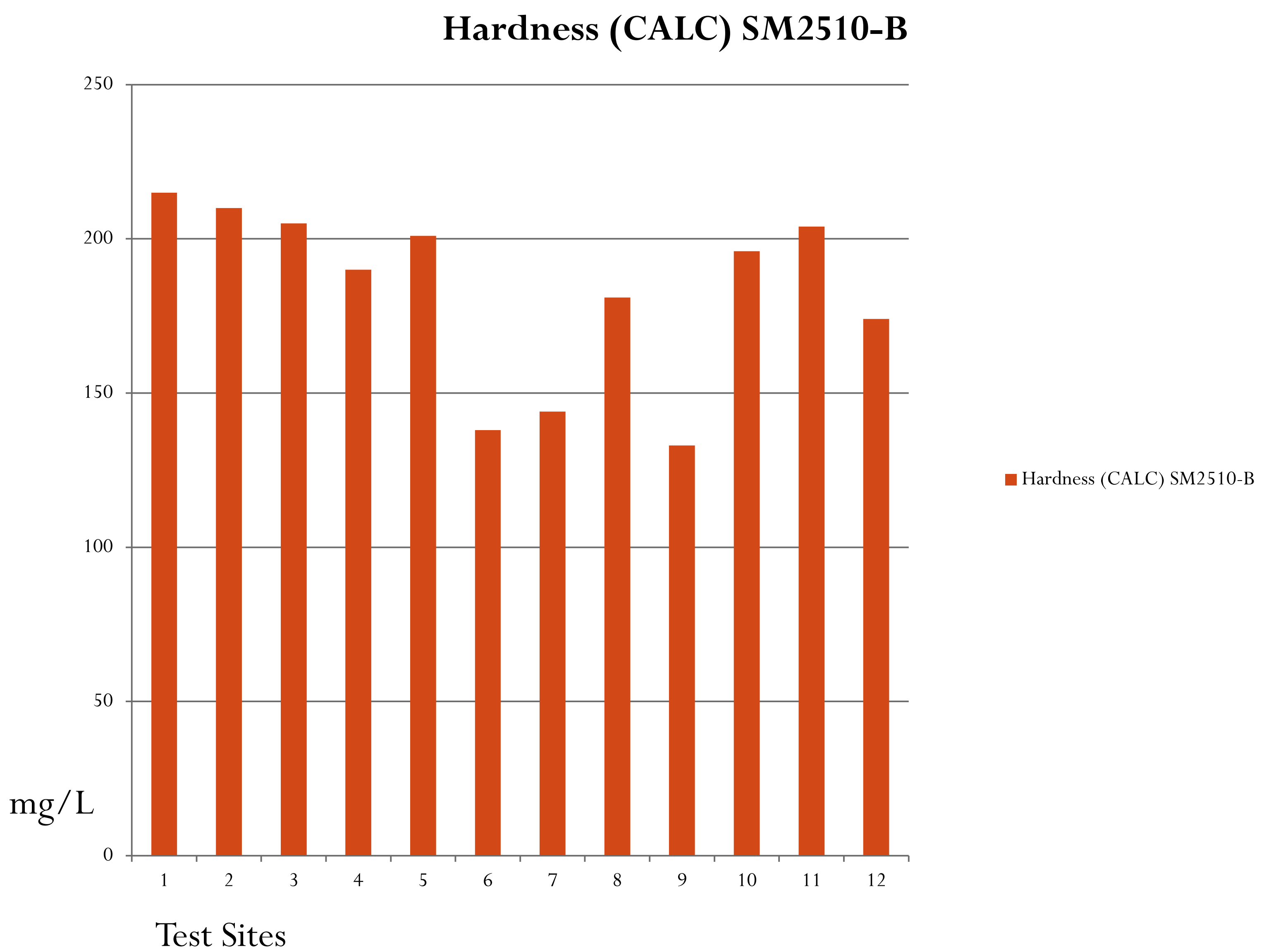
Chloride EPA 300.0
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
mg/L
Test Sites
250 mg/L Federal Non-enforcable Limit
Chloride EPA 300.0

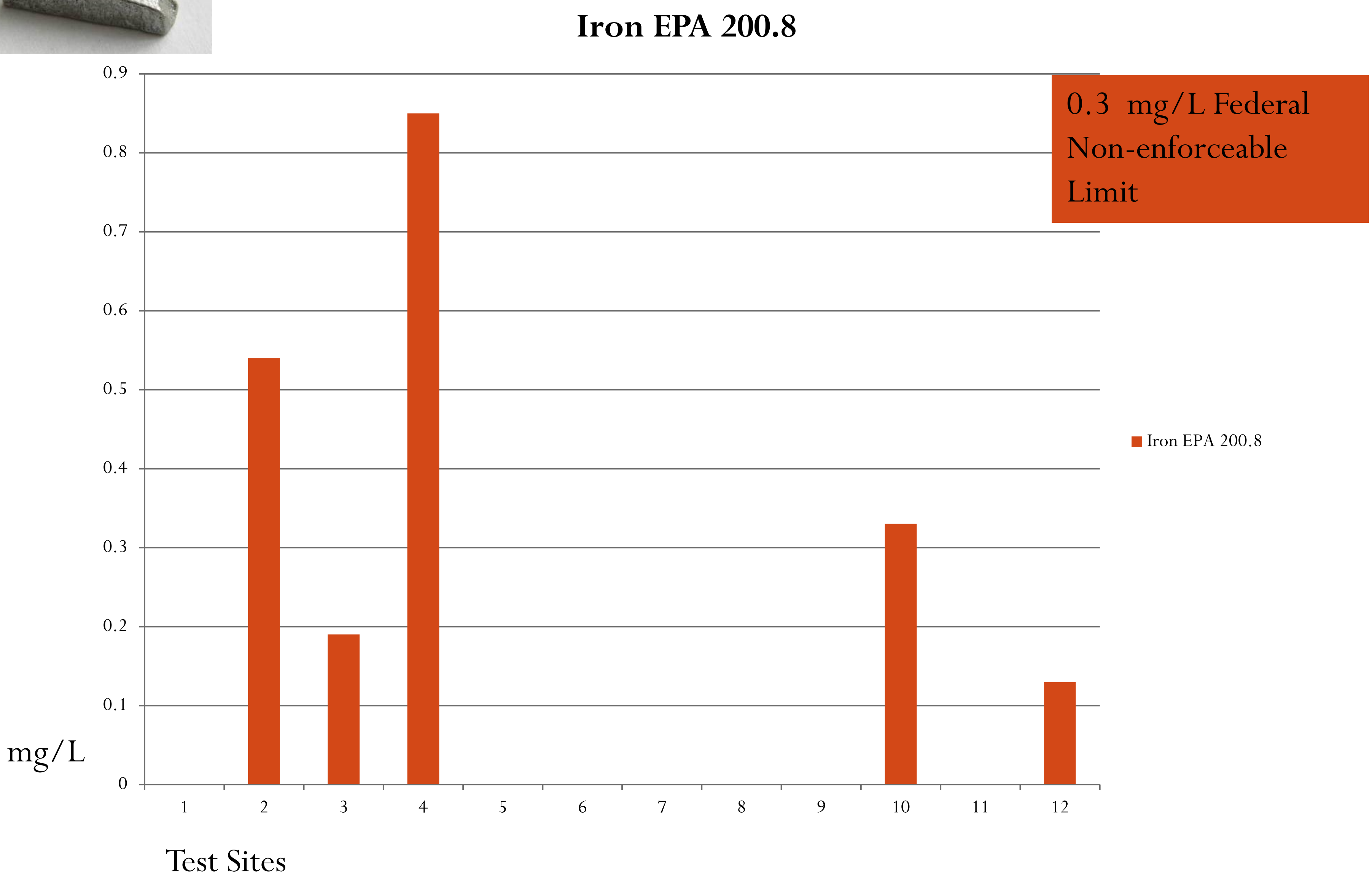
*****What is conductivity and why is it important?***

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) and sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Changes in these values can indicate the presence of fracking fluids in groundwater.



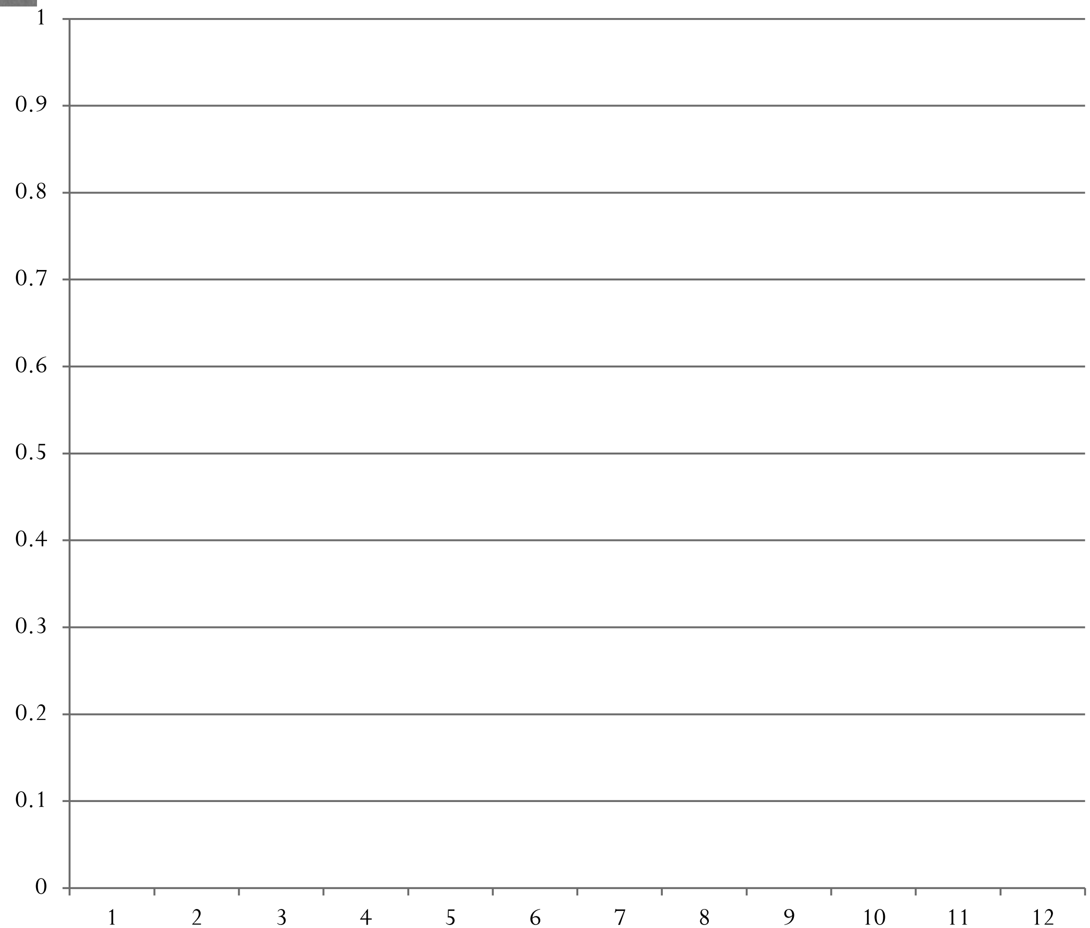
Conductivity SM2510-B (uS/cm)
Distilled water 0.5-3
Lake water 50-1500 µS/cm
As a reference
500
450
400
350
300
250
200
150
100
50
0
µS/cm
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Conductivity SM2510-B (uS/cm)


Hardness (CALC) SM2510-B
250
200
150
100
50
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Hardness (CALC) SM2510-B


Iron EPA 200.8
0.3 mg/L Federal Non-enforceable Limit
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
mg/L
1 2 3 4 5 6 7 8 9 10 11 12
Test Sites
Iron EPA 200.8

Manganese EPA 200.8

ND

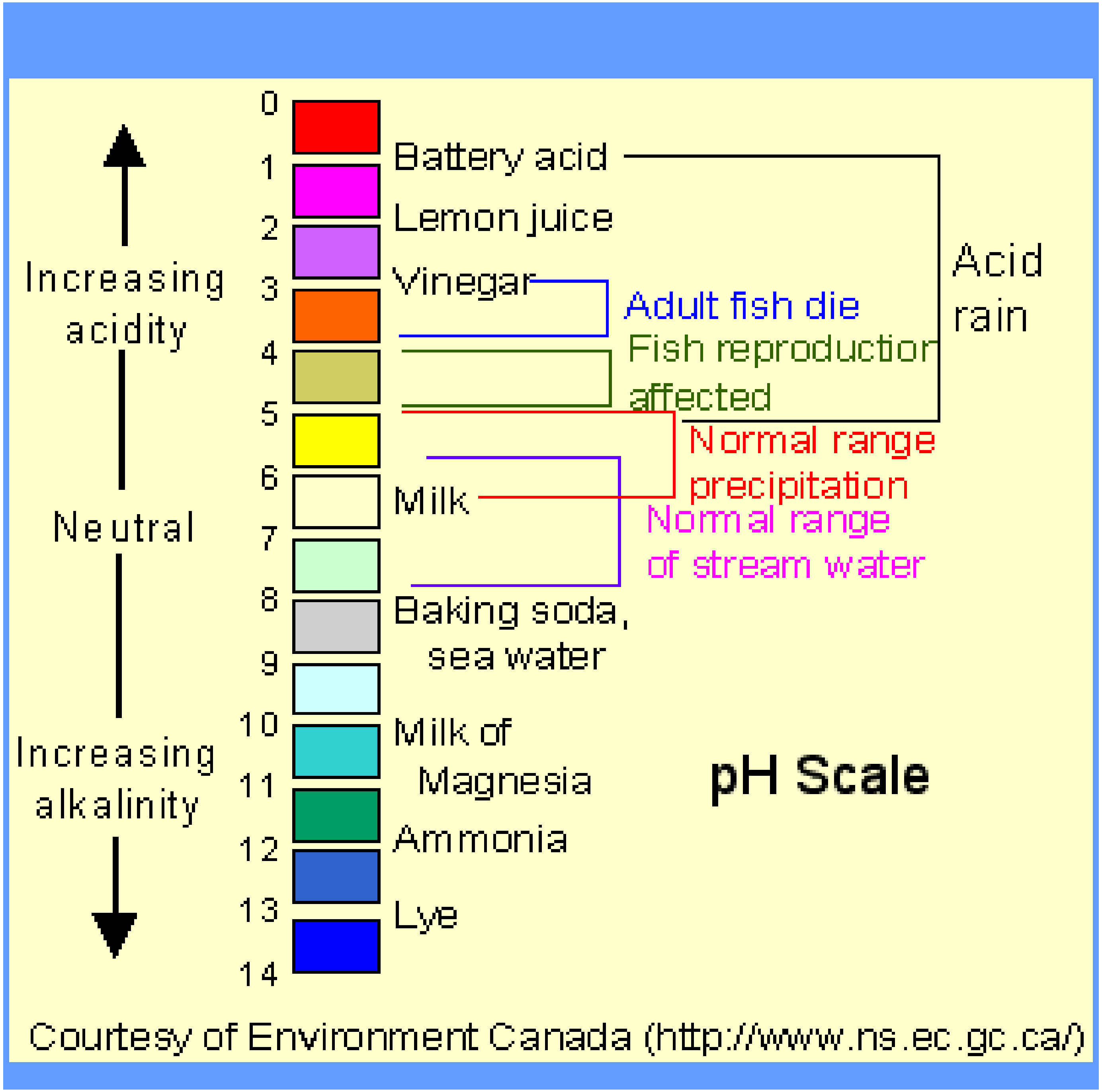


mg/L

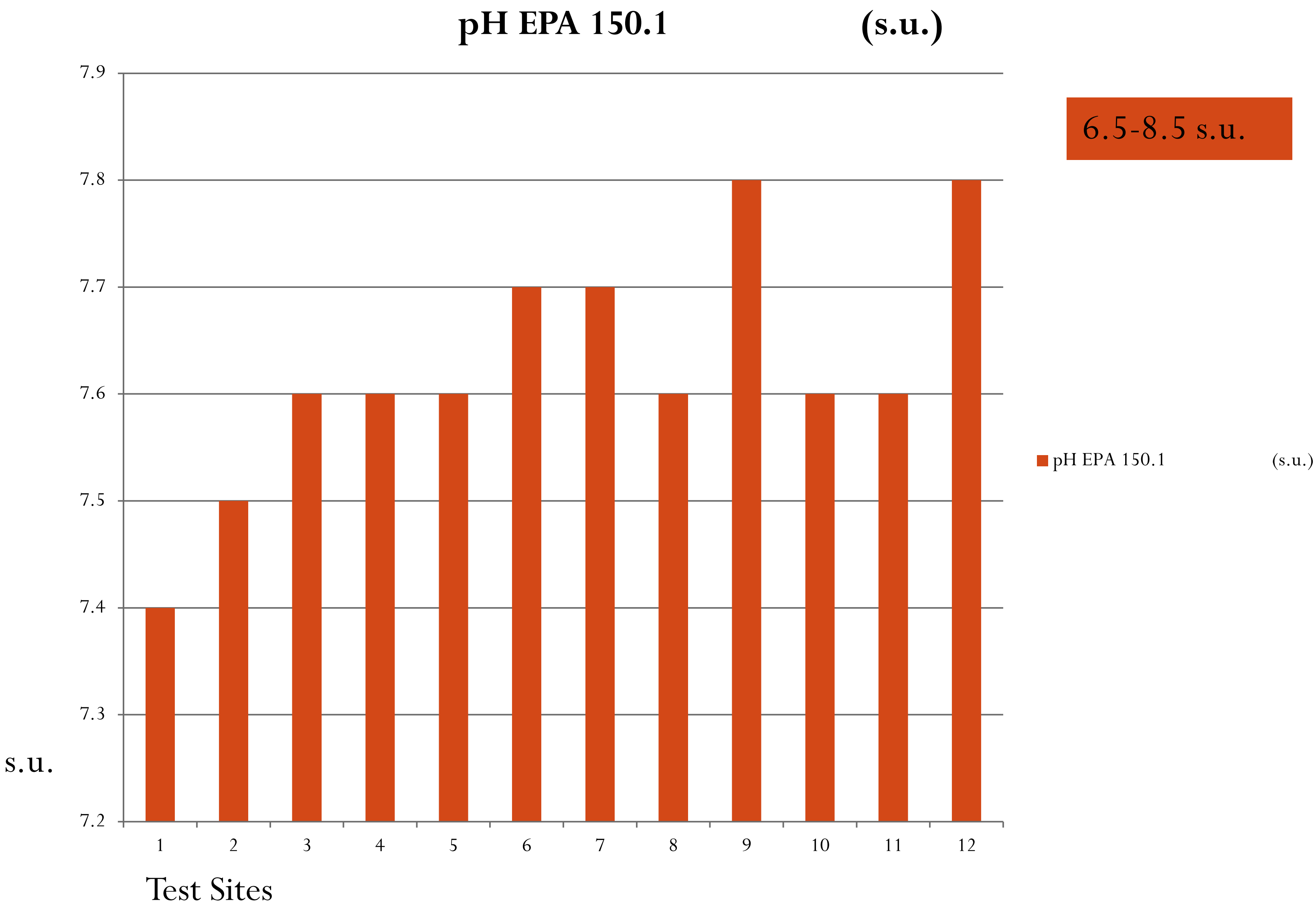
Test Sites

0.05 Maximum
Contaminant Level
Federal
Non-enforceable
Limit

Manganese EPA 200.8

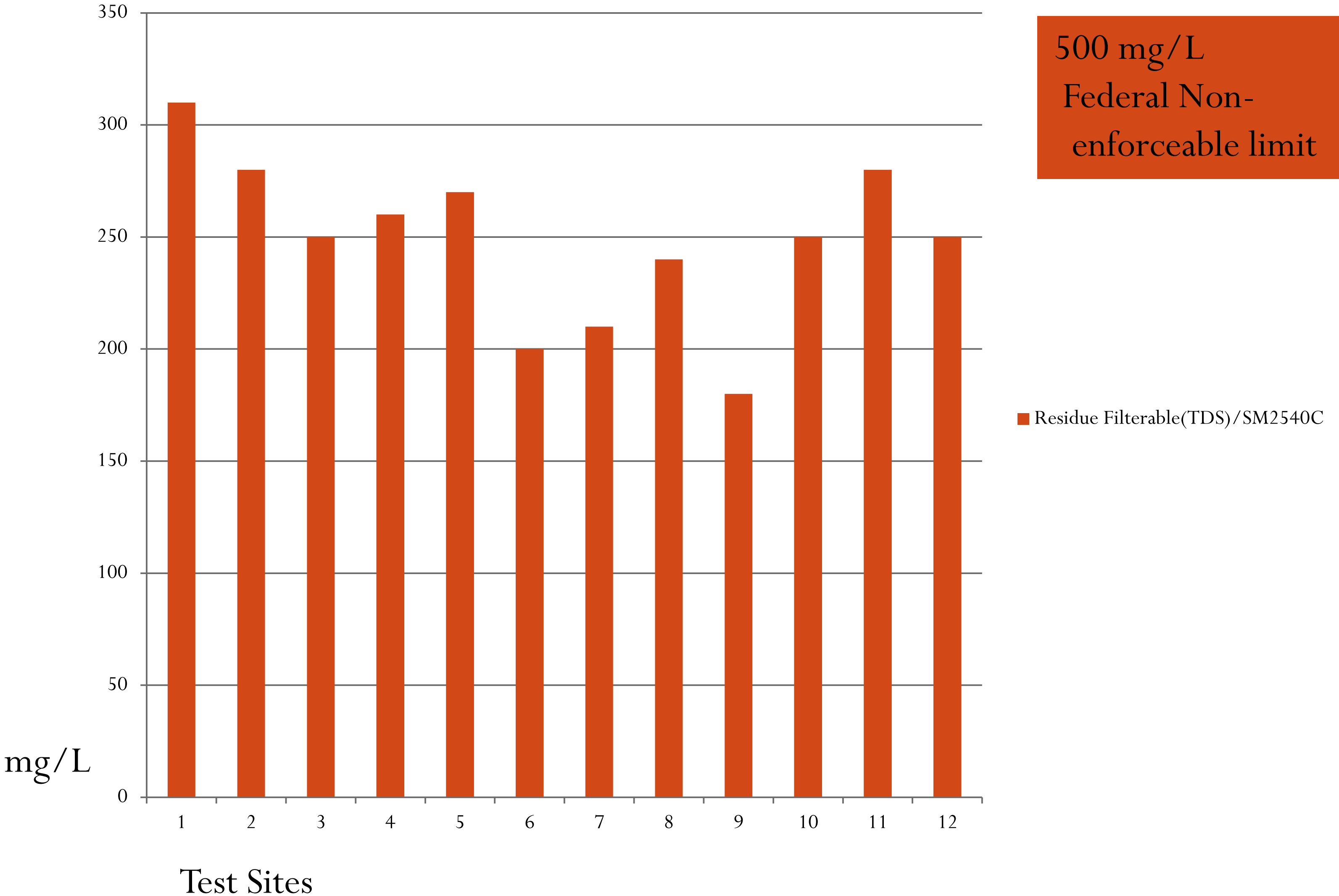


0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Increasing acidity
Neutral
Increasing alkalinity
Battery acid
Lemon juice
Vinegar
Milk
Baking soda, sea water
Milk of Magnesia
Ammonia
Lye
Adult fish die
Fish reproduction affected
Acid rain
Normal range precipitation
Normal range of stream water
pH Scale
Courtesy of Environment Canada (http://www.ns.ec.gc.ca/)

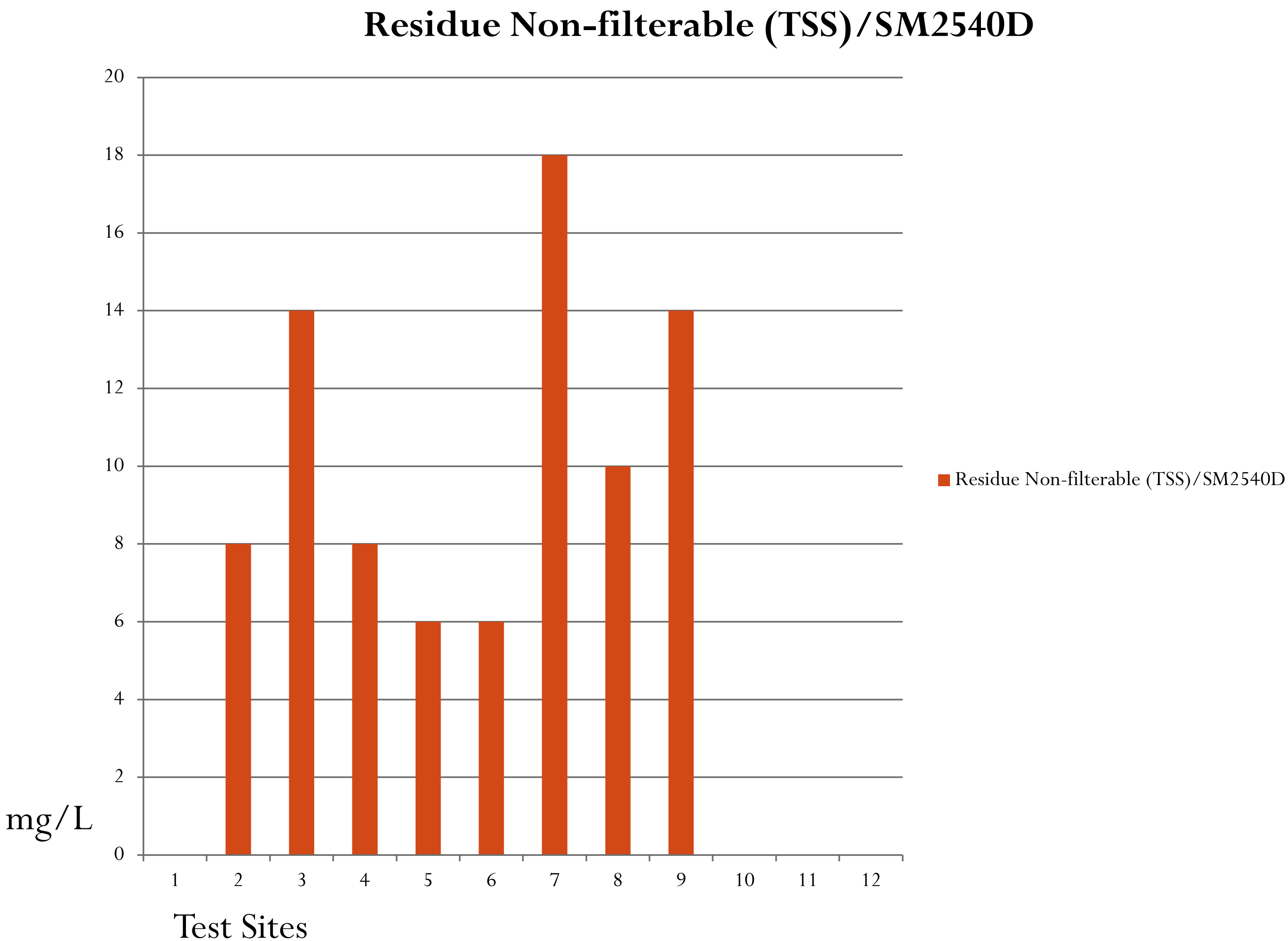


pH EPA 150.1 (s.u.)
6.5-8.5 s.u.
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
s.u.
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
pH EPA 150.1 (s.u.)

Residue Filterable(TDS)/SM2540C

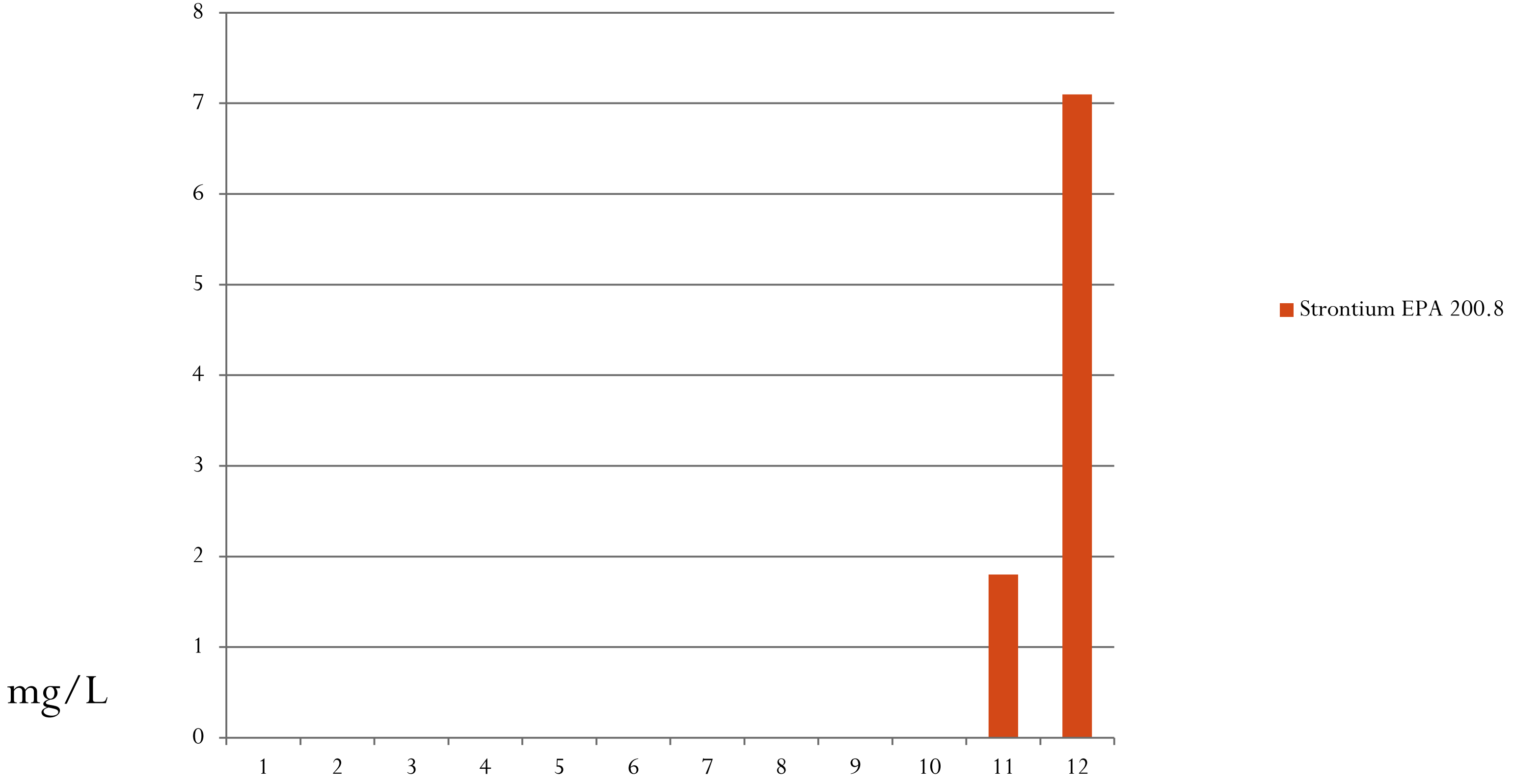


500 mg/L
Federal Non-enforceable limit

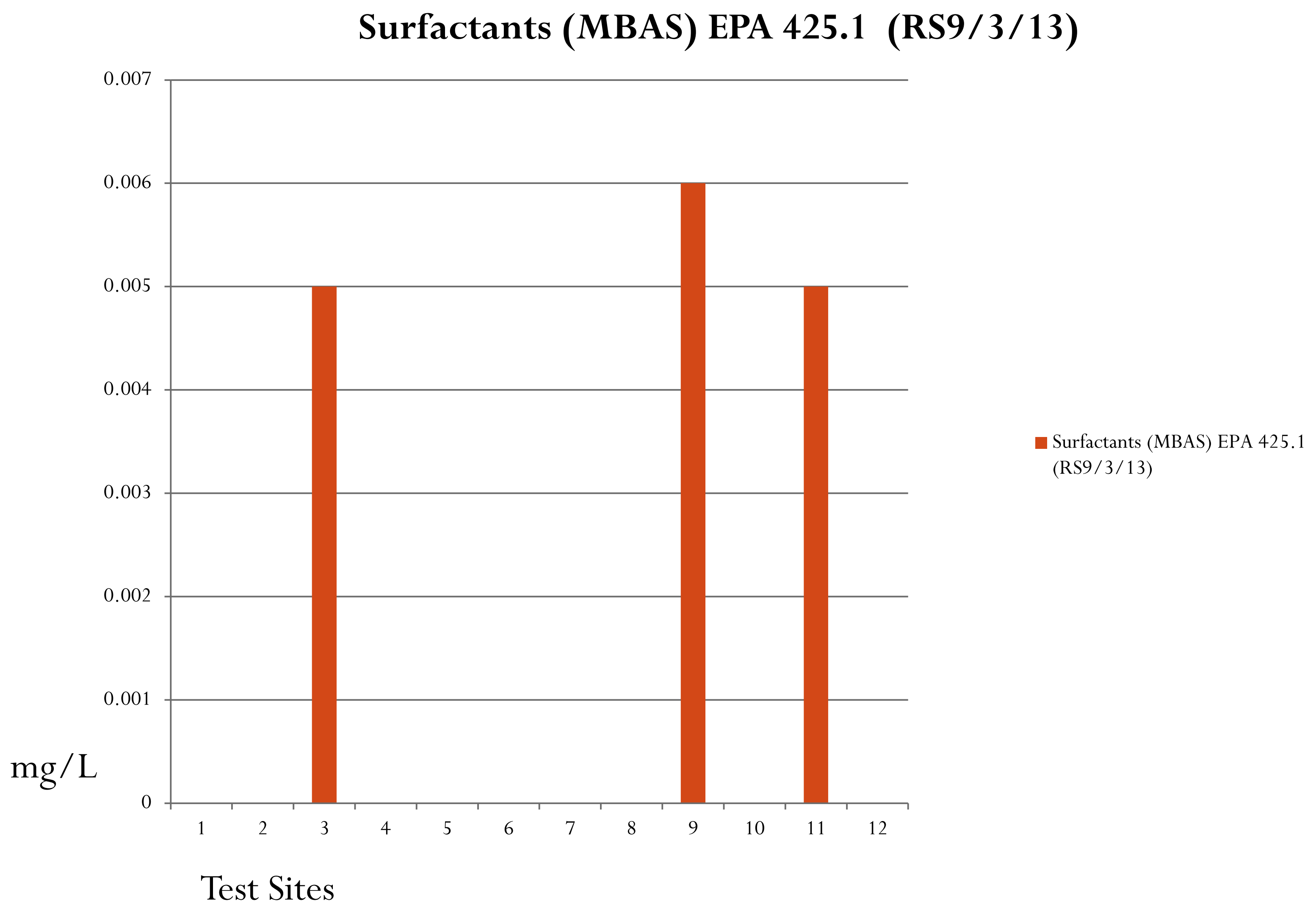


Residue Non-filterable (TSS)/SM2540D
20
18
16
14
12
10
8
6
4
2
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Residue Non-filterable (TSS)/SM2540D

Strontium EPA 200.8



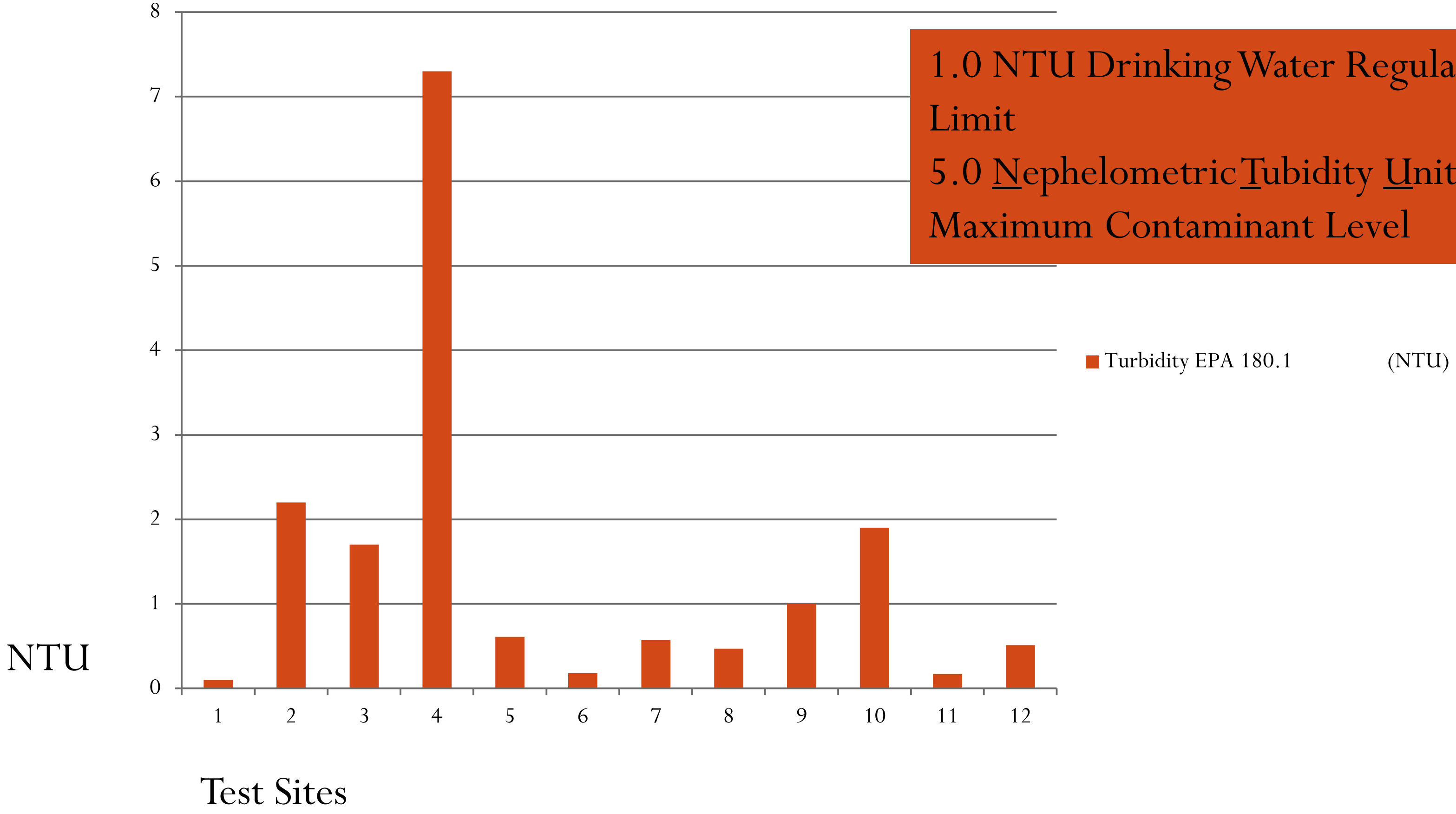
**Detergents are used in hydraulic fracturing fluid to make the water "slick" so it can flow more easily down the well hole and transport sand particles into cracks in the shale.



Surfactants (MBAS) EPA 425.1 (RS9/3/13)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
mg/L
1
2
3
4
5
6
7
8
9
10
11
12
Test Sites
Surfactants (MBAS) EPA 425.1 (RS9/3/13)

****Total suspended solids and the turbidity of the water are indicators that soil and other particles have contaminated aquifers, usually as a result of faulty drilling and cementing practices.**

Turbidity EPA 180.1 (NTU)



1.0 NTU Drinking Water Regulated Limit

5.0 Nephelometric Tubidity Units Maximum Contaminant Level

Two Alternatives for Baseline Water Quality Testing Prior to Hydraulic Fracturing

Costs vary according to number of tests requested and professional collection of the water samples.

1 SOS Analytical, Inc. (Including Pace Analytical) Cost:
4125 Cedar Run R. Suite B **$485 (Individual)**
Traverse City, MI 49684 **$476 (Group Discount)**
231-946-6767
jack@sosanalytical.com
***Includes collection (capture) cost and wide array of tests**

*** Using Community Science Institute Protocol**

2 Michigan Department of Environmental Quality **Cost $236**
Drinking Water Laboratory
3350 North M.L. King Blvd., P.O. Box 30270
Lansing, MI 48909
517-335-8184
***Water must be collected (captured) by third party and is a smaller array of tests**

**Red Flag indicators of water quality for streams and lakes : Community Science Institute of New York recommends monitoring of temperature, pH, dissolved oxygen, conductivity and total hardness.

Temperature, pH, and dissolved oxygen can be impacted by many stressors. Conductivity and total hardness are believed to be good indicators of contamination by hydraulic fracturing.

This monitoring can be done by volunteers.

This project is the beginning of a model strategy to choose signature chemicals and characteristics to identify the contamination of ground and surface water by hydraulic fracturing within watersheds.

We can live without oil as we develop alternative sources of power
but we can’t live without water, air to breath, and healthy land to grow our food.

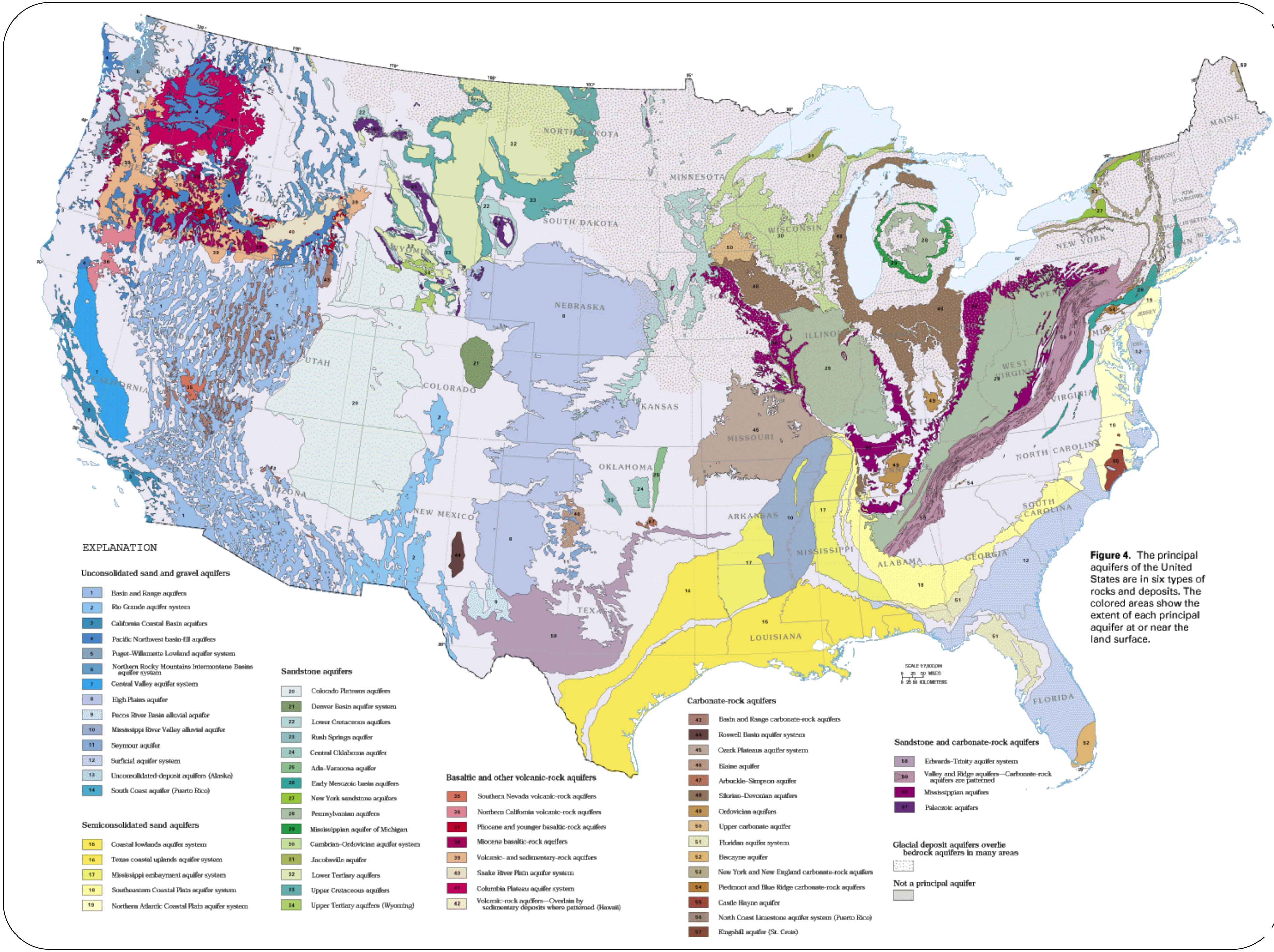


Figure 4. The principal aquifers of the United States are in six types of rocks and deposits. The colored areas show the extent of each principal aquifer at or near the land surface.