Groundwater Environmental Liability Management Using Baseline Sampling Programs*

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Abstract

Traditionally, oil and gas operators have controlled their groundwater environmental liabilities through remedial actions after the groundwater has been impacted with hydrocarbons and salt. In recent years, a handful of US state regulatory agencies have promulgated prescriptive rules to establish baseline conditions in groundwater aquifers in close proximity to planned oil & gas production prior to drilling and then to continue monitoring of the groundwater for a specified period of time following well completion. The intent of the rules is to assure landowners and regulators that drinking water supplies are being protected as oil and gas development occurs. Colorado was the first US state to establish such rules during coal bed methane development in the San Juan Basin in southwest Colorado in 1996. Baseline sampling programs expanded statewide under the Colorado Oil and Gas Conservation Commission (COGCC) and culminated with COGCC Rules 608 and 609 in 2010. Other states adopted similar rules and guidance in areas of oil and gas production. Throughout the development and implementation of these rules, a series of best management practices have been developed and can be employed in voluntary programs worldwide as oil and gas operations continue near valuable groundwater resources. Operators can minimize their environmental liability through voluntary baseline groundwater sampling programs which demonstrate the water quality conditions prior to and post project development, often reducing or eliminating negative publicity, legal actions, or mitigation efforts associated with perceived operational environmental impacts.

Groundwater Environmental Liability Management Using Baseline Sampling Programs

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ICE Conference, September 7, 2016
Cancun, Mexico

LT Environmental, Inc.
COMPLIANCE / ENGINEERING / REMEDIATION

Tom Murphy, Senior Geologist

- B.S. in Geology and Geophysics
- M.S. in Geology
- Exploration Geologist Sohio Petroleum
- Last 30 years Environmental Consulting to O&G in USA
- Founder/Owner of LT Environmental since 1992

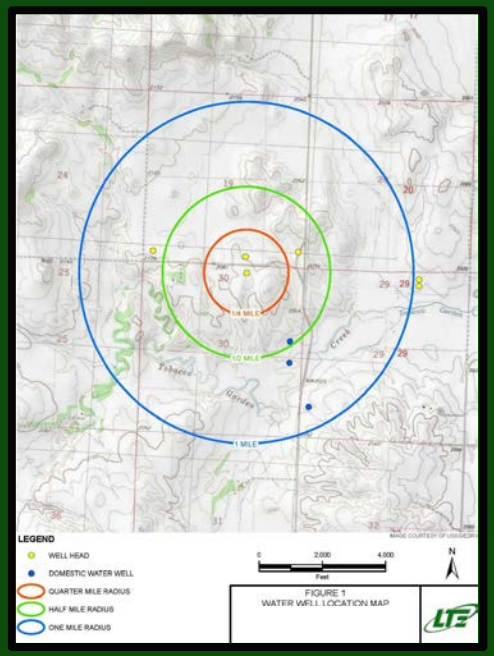
What is Baseline Sampling?

baseline (bās´līn):

a value representing a **normal background level** or an initial level of a measurable quantity and used for comparison with values representing response to an environmental stimulus or intervention.

What is Baseline Sampling?

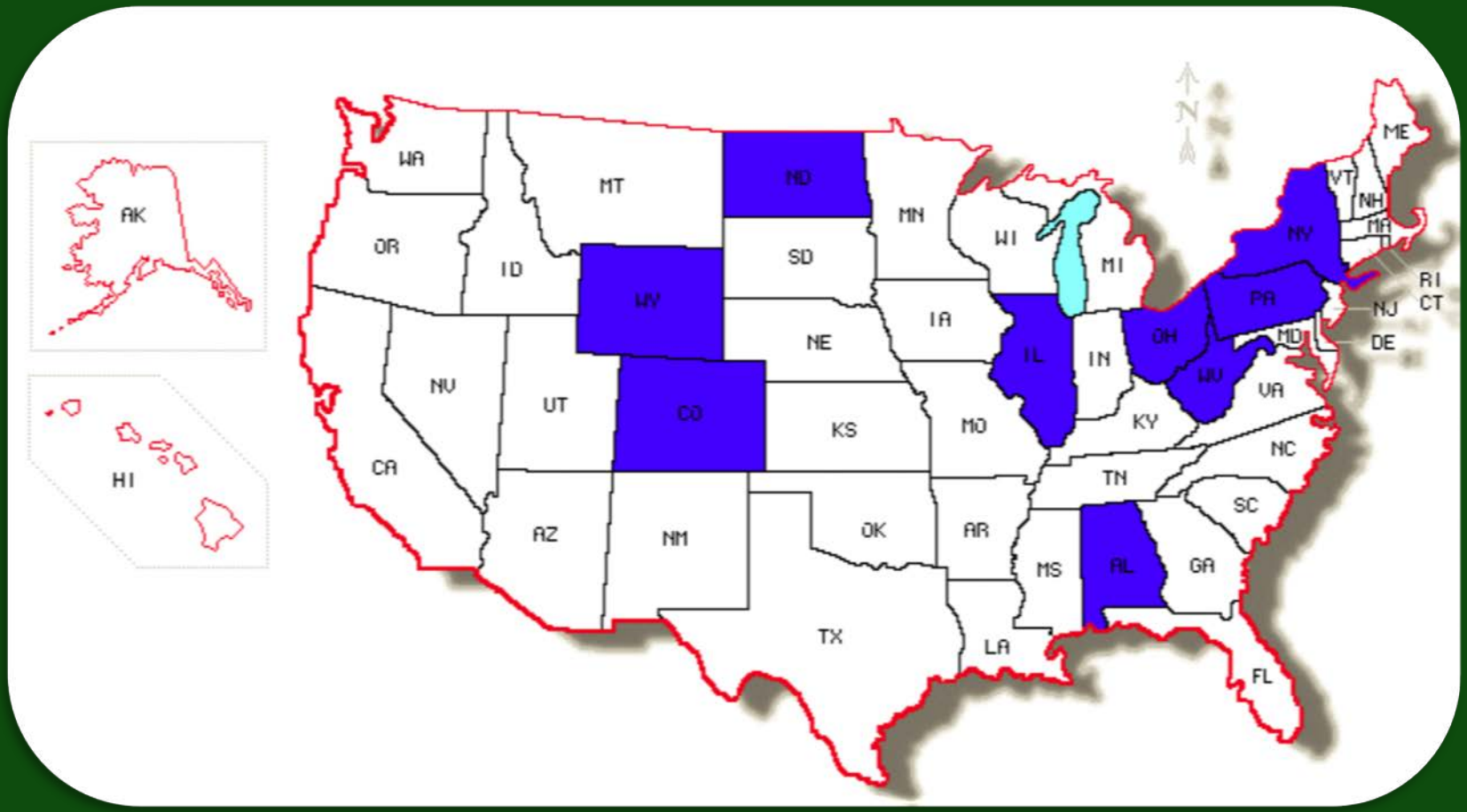
Identify → Sample → Drilling Activity → Re-Sample & Compare



History of Baseline Sampling

- Initiated in San Juan Basin in Colorado, USA
- Shallow Coal Bed Methane (CBM) production from Fruitland Fm. Coal
- Fruitland a gassy domestic use aquifer
- Baseline Sampling Program began in mid 1990's
- Expanded to other basins in Colorado in early 2000's

US States With Regulated Baseline Sampling Programs



Why Is Baseline Sampling Important?

Case Study – Worst Case Scenario

- Well owner filed complaint with state
- State took action:
  - *Water testing of water well*
  - *Engineering review of O&G wells in vicinity*
  - *Water testing in vicinity (localized impact)*
  - *Bradenhead pressure testing, MITs (passed)*
  - *Gas sampling from O&G wells for fingerprinting*
- Unable to identify source of gas
- Local operator voluntarily mitigated
  - *methane dissipated within 1 month*
- Landowner still sued operator
  - *Maintained operator had impacted aquifer and suffering from ill effects*
  - *Methane stimulates bacteria and bacteria thrive even after methane gone*
- Lawsuit settled, but operator purchased property

Constituents of Concern:

TDS, Na, Fe, Mn

CH_4

(Thermogenic or Biogenic)

Bacteria

(Fe-related, SO_4-reducing, slime forming)

Why Is Baseline Sampling Important?

The information or misinformation presented (whether right or wrong) makes today's landowner a different breed. They are more suspicious and more proactive than in the past.

Some states confirm water pollution from drilling
By KEVIN BEGOS AP news
Jan. 5, 2014

The New York Time

A Tainted Water Well, and Concern There May Be More
By IAN URBINA
Published: August 3, 2011

Center for American Progress
RELEASE: San Juan Basin Continues to Be a Hot Spot of Oil and Gas Methane Waste and Pollution
June 20, 2016 Madeline Meth

Advantages

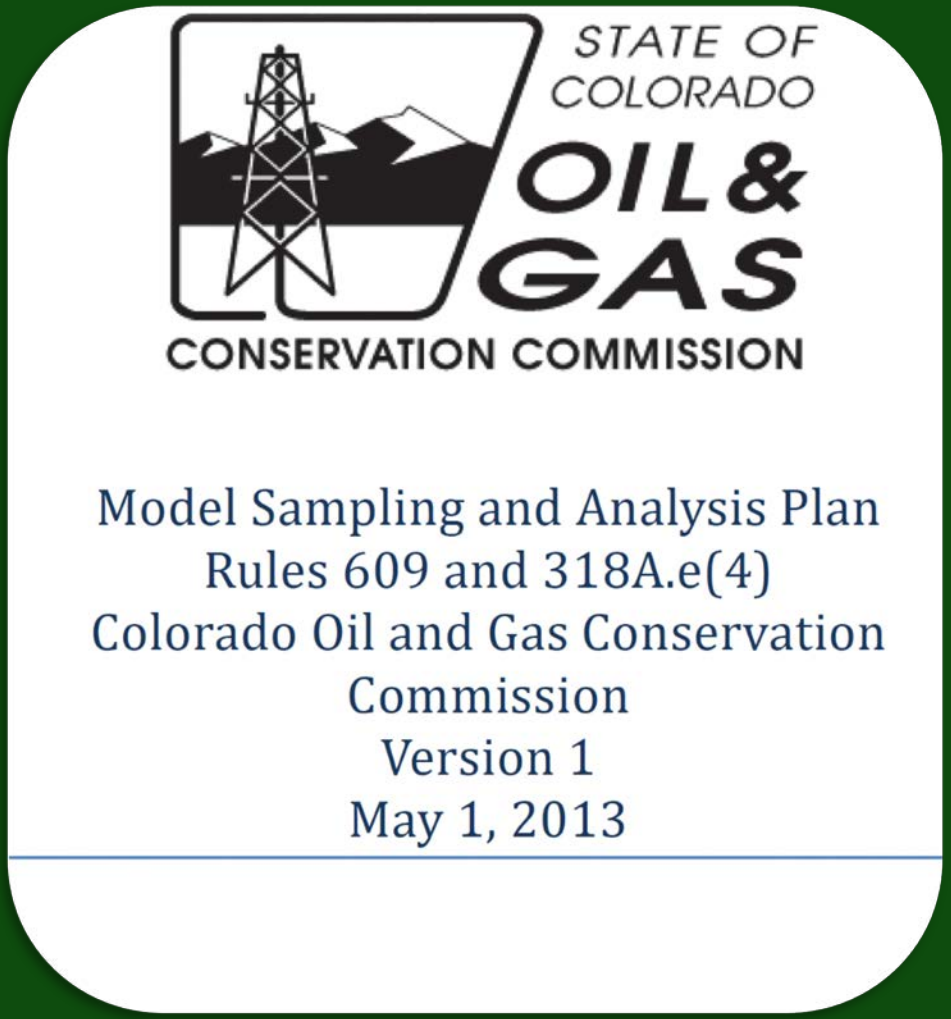
- Liability Management: protection against litigation, claims, and fines
- Demonstrates a systematic program is underway in response to resident concerns
- Identify pre-existing water quality
- Quantitative vs. qualitative
- Subsequent samples can be compared to initial samples to demonstrate no impact has occurred
- If impact is discovered, mitigation is immediate
- Promotes community/landowner relations

"When complaints were lodged with state agencies, there was almost never any pre-drill data to compare to post-drill suspected impacts."

EPA Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water, 2011, R. Puls, PhD, OK Water Survey

Baseline Sampling Procedures

- Conform with industry standard
- COGCC Model Sampling and Analysis Plan
- Available upon request



General Components/BMPs

- Water well identification
- Landowner access agreements (*notice of purging well*)
- Sampling and Analysis Plan
- Initial baseline groundwater samples from wells, seeps, or springs
- Laboratory analyses
- Quality assurance / quality control
- Data management
- Reporting
- Subsequent scheduled sampling

Initial Baseline Sampling

- Consider 3rd party
  - *Increases trust factor*
  - *Experience*
  - *Equipment*
  - *Consistency of sampling procedures*
  - *Liability insurance*
- Complete Questionnaire
- Inspect well or spring prior to sampling
- Document with Photos
- Well samples
  - *Sample at well (preferred) before any treatment/pressure tank*
  - *Do not enter well (potential damage liability)*
- Spring samples
  - *End of pipe, outlet, cistern/water collection*
  - *Grab – mid depth from center of water source*
- Dissolved Gases – under water head

Analytes

- Independent Analytical Labs
  - *Accredited*
  - *Use validated methods*

FIELD PARAMETERS

- pH
- Temperature
- Specific conductivity
- Dissolved oxygen
- Turbidity
- H_2S
- Vapors (LEL/PID)
- Odor

BASIC PARAMETERS

- Dissolved methane
- Major cations & anions
- pH
- Specific conductance
- Alkalinity
- Chloride
- Nitrates & Nitrites
- Sulfate
- TDS
- TPH-GRO/DRO
- BTEX

BASIC PARAMETERS

- Fluoride
- Bromide
- Sodium
- SAR
- Arsenic
- Bacteria
- Strontium
- Trace metals
- Nutrients

COMPREHENSIVE TESTING

- VOCs
- SVOCs
- Dissolved Gases
- Isotopic methane

Analytes - Dissolved Methane Action Level

Colorado:

- If methane >1.0 mg/L:
  - *analyze for gas composition and stable isotopes*
- Notify COGCC immediately:
  - *If thermogenic or thermogenic + biogenic*
  - *If methane increases by more than 5 mg/L*
  - *If methane detected ≥10 mg/L*

Dissolved Gas Analysis

- Chemical composition: determines exact amounts of various hydrocarbon gases, non-hydrocarbon gases, and light hydrocarbon liquids
- Percent composition of key components reveals differences/similarities for fingerprinting
- Multiple lines of evidence can be required (mud gas, geology, hydrology, various isotopes, etc.)
- Not a silver bullet

Measured Values:	Measured ppm	Analyte mol %[a]	HC mol %	$\delta^{13}C$ ‰ VPDB	δD ‰ VSMOW
Nitrogen (N_2)	405349	39.65	-	-	-
Oxygen + Argon (O_2+Ar)	61720	6.04	-	-	-
Carbon Dioxide (CO_2)	1353	0.13	-	-	-
Helium (He)	314883	30.80	-	-	-
Hydrogen (H_2)	nd	nd	-	-	-
Methane (CH_4)	238983	23.38	99.99	-74.6	-279
Ethane (C_2H_6)	23	0.00	0.01	na	na
Propane (C_3H_8)	nd	nd	nd	na	na
iso-Butane (C_4H_{10})	nd	nd	nd	na	na
n-Butane (C_4H_{10})	nd	nd	nd	na	na
iso-Pentane (C_5H_{12})	nd	nd	nd	na	na
n-Pentane (C_5H_{12})	nd	nd	nd	na	na
Hexanes + (C_6H_{14})	nd	nd	nd	na	na

Case Study – Dissolved Gas Analysis

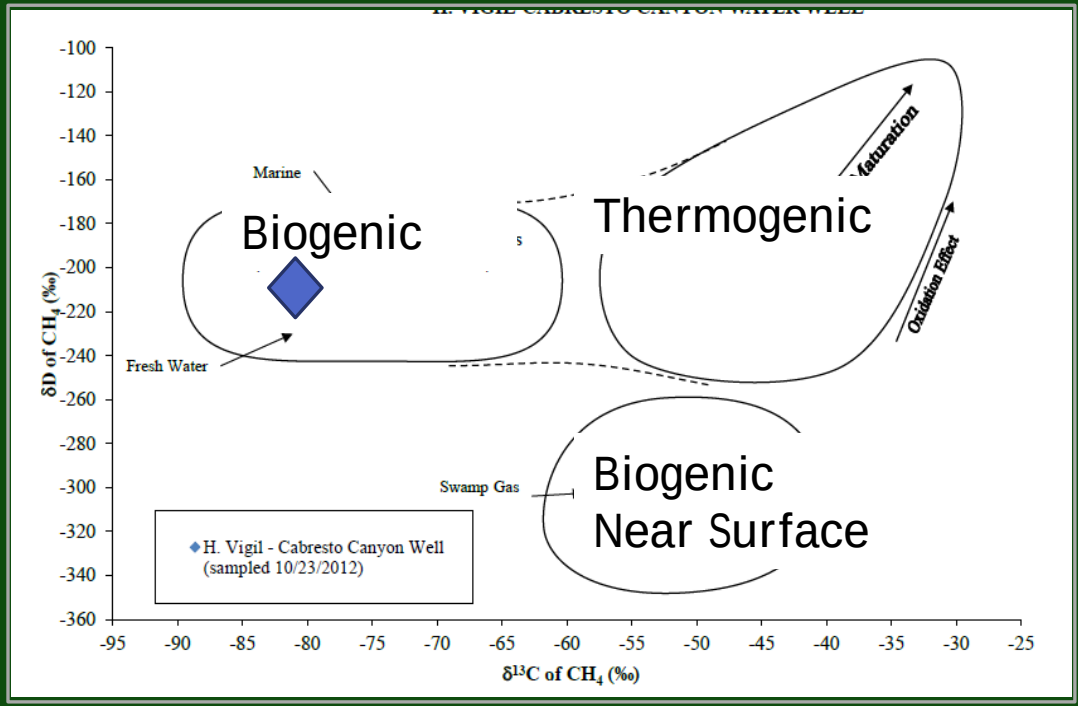
- Well owner complaint to operator about gas bubbles in well
  - *Believed to be impact from nearby recompletion operation*
- Operator collected water sample from domestic well
  - *Observed bubbling in the well*
  - *Combustible gas meter indicated 100% LEL*
  - *Purge water had slight odor and was effervescing*
- Isotopic analysis indicated methane was biogenic
- Operator recommended safety precautions and mitigation system
- Report submitted to state and no impact determined

Constituents of Concern:

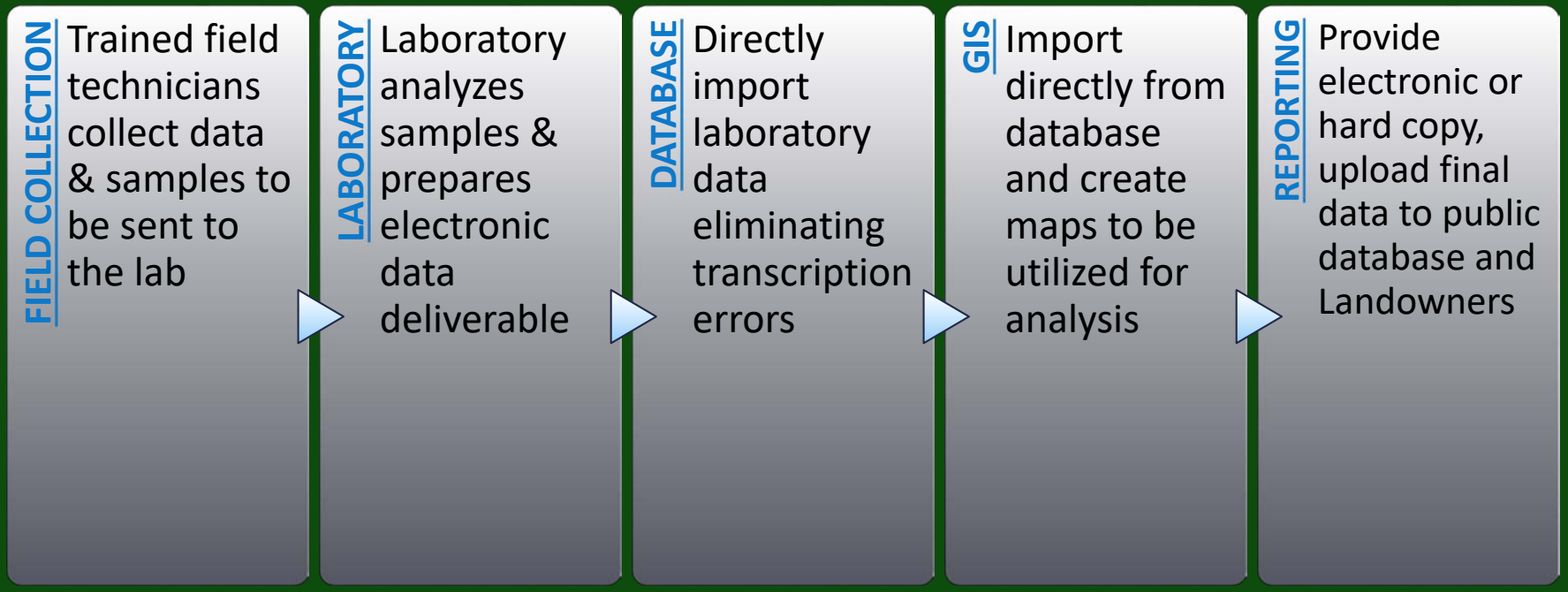
TDS, Na, Fe, Mn

CH_4 (Biogenic)

Bacteria (Fe-related, SO_4-reducing)



Data Management



- Error free data downloads and extractions
- Data merge for reports – faster and more accurate
- Streamlines and automates repetitive tasks
- Automated reporting and calculations

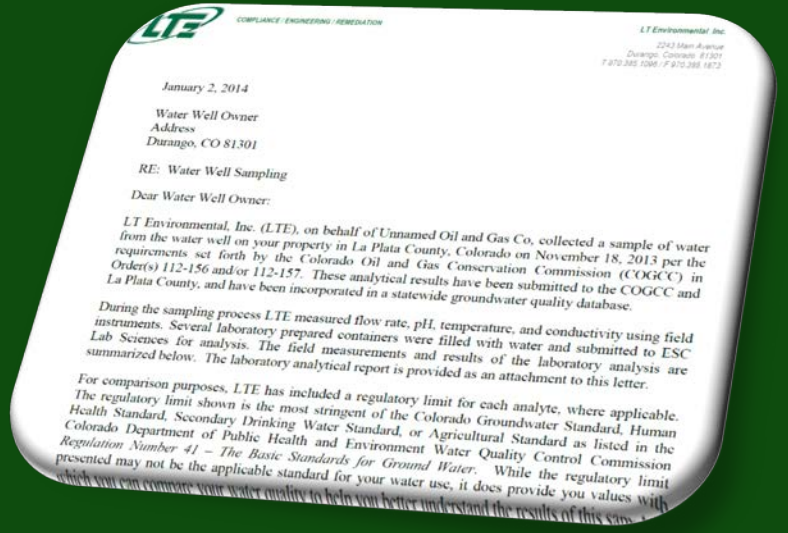
Analysis Case Study – Sheens, Sludges, Crusts, Odors

- Water well owner complained to operator about discolored and foul smelling water
- Operator collected new sample
  - *Sampler observed black crust in piping*
- Results indicated no change from baseline water quality parameters
- Manganese concentration was elevated in historical samples

Iron, sulfate, bacteria, and manganese can create a sheen/ sludge/slime that looks like oil

Reporting

- Summary of water quality
- Comparisons of laboratory analytical results to applicable standards
- Sampling locations
- Sampling methods
- Photographs, if requested
- QA/QC



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LT Environmental, Inc.
2243 Main Avenue
Durango, Colorado 81301
T 970.385.1096 / F 970.385.1673

January 2, 2014

Water Well Owner
Address
Durango, CO 81301

RE: Water Well Sampling

Dear Water Well Owner:

LT Environmental, Inc. (LTE), on behalf of Unnamed Oil and Gas Co, collected a sample of water from the water well on your property in La Plata County, Colorado on November 18, 2013 per the requirements set forth by the Colorado Oil and Gas Conservation Commission (COGCC) in Order(s) 112-156 and/or 112-157. These analytical results have been submitted to the COGCC and La Plata County, and have been incorporated in a statewide groundwater quality database.

During the sampling process LTE measured flow rate, pH, temperature, and conductivity using field instruments. Several laboratory prepared containers were filled with water and submitted to ESC Lab Sciences for analysis. The field measurements and results of the laboratory analysis are summarized below. The laboratory analytical report is provided as an attachment to this letter.

For comparison purposes, LTE has included a regulatory limit for each analyte, where applicable. The regulatory limit shown is the most stringent of the Colorado Groundwater Standard, Human Health Standard, Secondary Drinking Water Standard, or Agricultural Standard as listed in the Colorado Department of Public Health and Environment Water Quality Control Commission *Regulation Number 41 – The Basic Standards for Ground Water*. While the regulatory limit presented may not be the applicable standard for your water use, it does provide you values with

- Landowners receive full analytical report (provide educational fact sheets to assist)
- Client and regulatory agency reporting, as applicable

Subsequent Sampling

- Develop appropriate sampling schedule
- Schedule varies from initial pre drill to 6 to 12 months, 3 years and 6 years post completion
- Consider a reduced list of analytes
- Compare pre- and post-completion water quality data

Case Study – Separate Source Detective Work

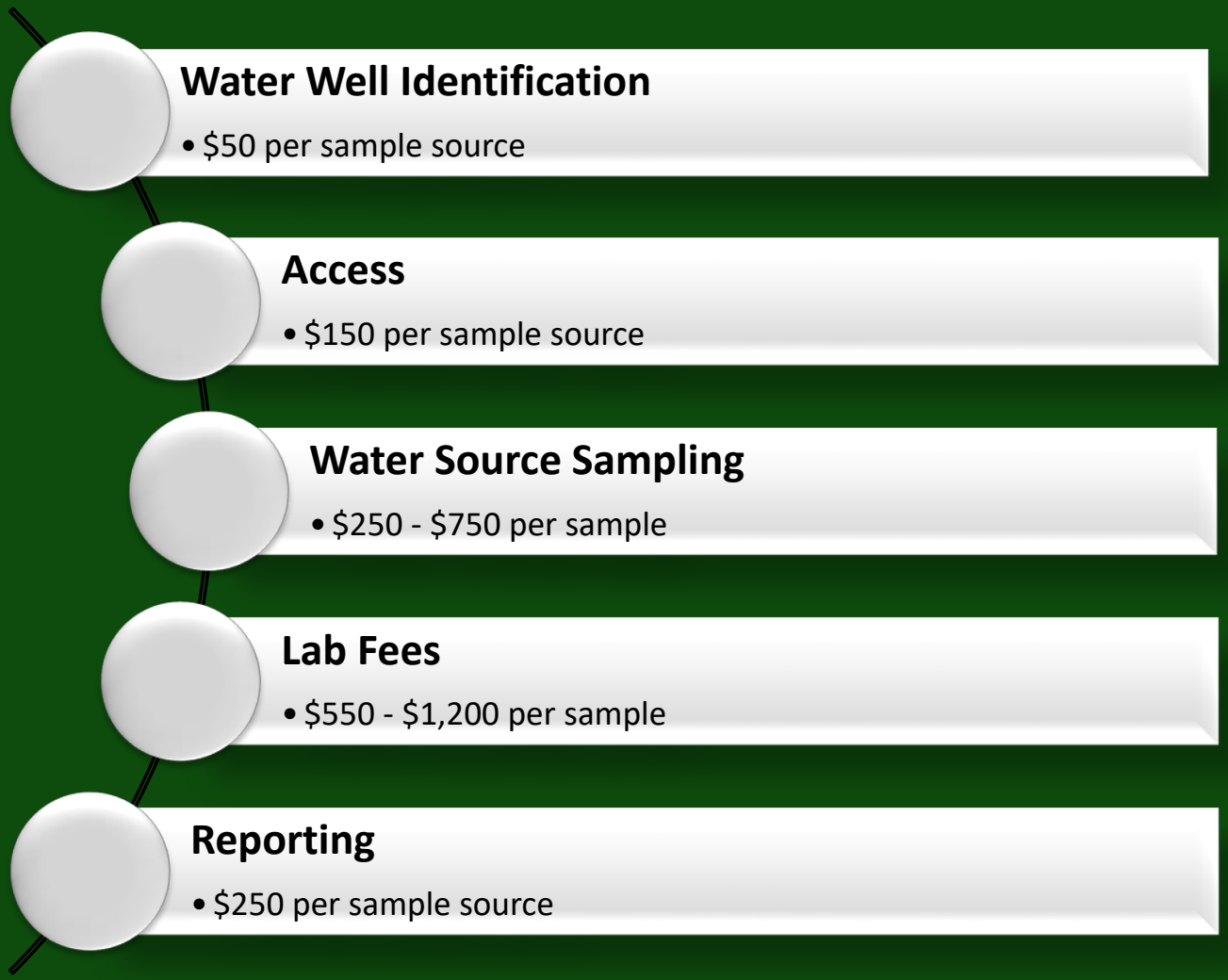
- Landowner repaired well (had collapsed at 300')
- Pulled pump and replaced
- Called operator b/c pump not operating correctly and new odor in well
- Operator sampled well
- Compared to historical baseline results and investigated nearby oil well
- Interview and questionnaire hinted at new installation
- Conclusion: Well owner had used oil to lubricate pump parts

Constituents of Concern:

Toluene

TPH - MRO

Estimated Costs



Bottom Line

$1,200 - $2,000/sample

- **Baseline dataset will reduce environmental liability**
- Reduce or eliminate negative publicity, legal actions, regulatory fines and mitigation efforts associated with perceived operational impacts
- Regardless of regulations, encourage voluntary baseline sampling
  - *Especially in populated areas*
  - *In all areas, consider historical P&A'ed wells*

"Releasing comprehensive information about oil and gas drilling problems is important because the debate is no longer about just science but trust."

- Irina Feygina, a social psychologist who studies environmental policy issues at NYU

THANK YOU!

Thomas Murphy
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303-433-9788

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