

2011 OUTCROP ZONE REPORT

ARCHULETA COUNTY COLORADO



PRESENTED TO NSJB STAKEHOLDERS – SEPTEMBER 26, 2012



Outcrop Zone Report Overview

- 1) **Summarize Geological, Reservoir, and Hydrogeological Data**
- 2) **Monitoring and Mitigation Program**
- 3) **2011 Monitoring Program Results**
- 4) **Evaluation and Summary of Project Area**
- 5) **Recommendations**

- Report has been submitted for BLM/USFS approval, but has not been approved as of this meeting.
- **First TWG Meeting on 9/18/2012.**
- BLM/USFS COA being prepared based on TWG meeting.

2011 Outcrop Zone Report - Archuleta County
(available at <http://cogcc.state.co.us>)



Overview

Objective:

Evaluate the existing conditions for CBM production of federal minerals based on the BLM Decision Point 5 of the ROD as well as meeting requirements of the Conditions of Approval for the Candelaria 10U #3 issued by COGCC. Outcrop Zone Report to fulfill ROD requirements for all Petrox Fosset Gulch Unit CBM wells.

Purpose:

To ensure the safety of the public and the environment while drilling and producing CBM production wells within the Project Area.



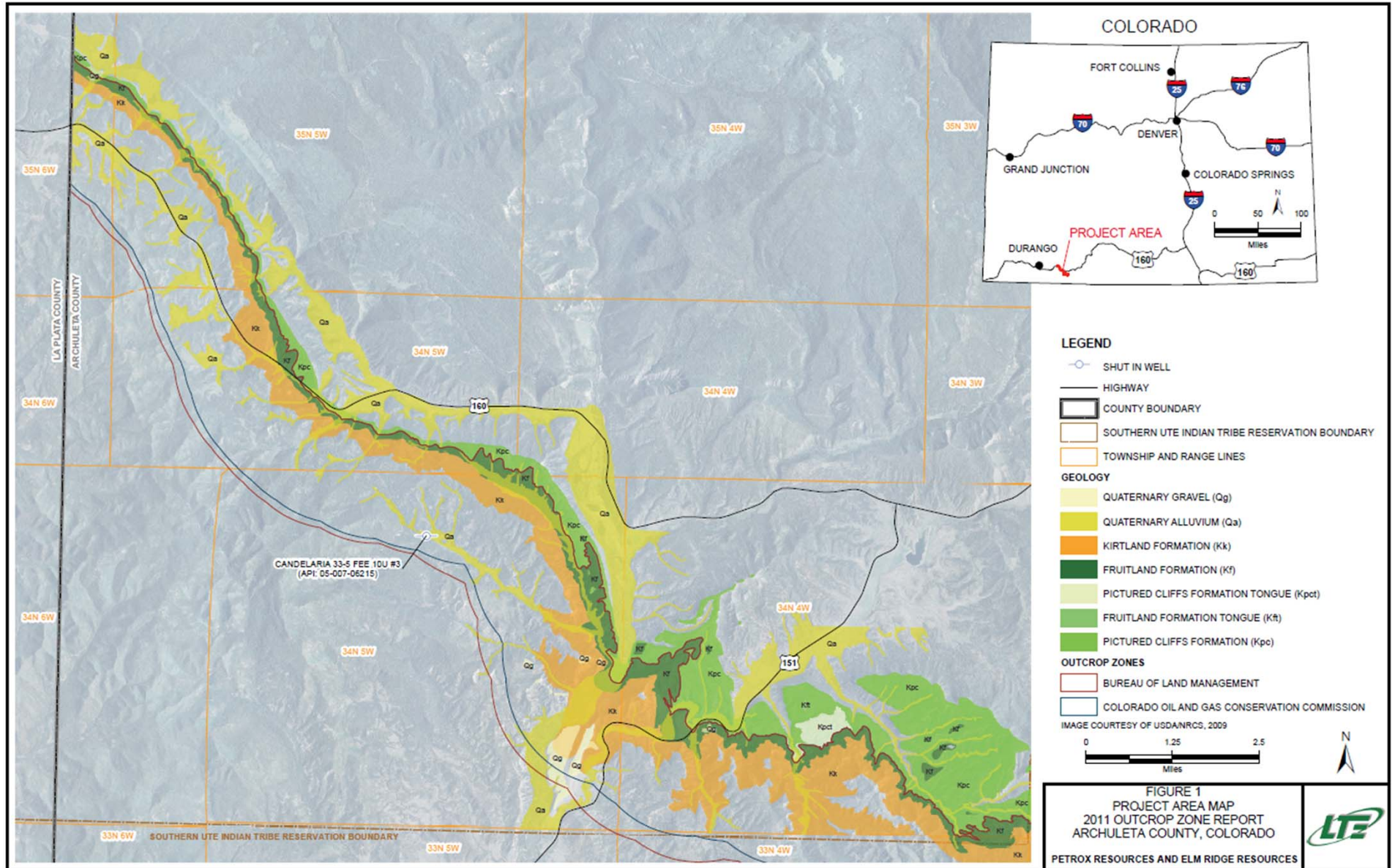
Project Area

The Project Area:

1. Approximately 18 miles of the Kf outcrop starting on the west end at the Archuleta County-La Plata County boundary near Beaver Creek and extends southeast along the Kf outcrop to the SUIT Reservation boundary at Cabezon Canyon.
2. A 1.5-mile outcrop zone defined by the BLM as a 1.5-mile buffer from the Kf-Kk contact.



Archuleta County Kf Outcrop Zone



Geology

- Kf → Upper Cretaceous period, shale, sandstone, coal (20- 40 ft thick)
- Face cleats → Parallel with the strike of the Kf outcrop in the Project Area. Primary pathway for gas flow, inhibits permeability and gas flow towards the Kf outcrop.
- Butt cleats → Perpendicular with strike of Kf outcrop in Project Area and are poorly developed in the Project Area.
- Natural fractures → Poorly developed, resistive, filled or not interconnected, limited ability of free gas to migrate.



Reservoir Characteristics

- Kf coal → 94.489% methane (9U #1A CBM production well), dry gas.
- In situ permeability → 3x to 10x greater in the face cleat direction than the butt cleat directions.
- Permeability → 0.75 md, based on history matching by John Mansoori in 2005.
- Anisotropy ratio → of 2:1 to 4:1.
- Pressure gradient → 0.41 to 0.44 psi/ft. Coals are underpressured, oversaturated (gas) and will not require dewatering to produce.



Reservoir Characteristics (continued)

GEM Model Results Summary – Case 3 and 4 PARALLEL TO THE OUTCROP

Distance to Kk-Kf Outcrop	Development Scenario	Permeability / Anisotropy Ratio	Pressure Drop at Upper Fruitland Outcrop Boundary
6,230 feet	20 Years @ Typical 160 Acre Pattern	0.75 md / 2:1	0%
6,230 feet	20 Years @ Typical 160 Acre Pattern	0.75 md / 4:1	0%
7,210 feet	20 Years Candelaria 10U#3 Lateral	0.75 md / 2:1	0%



Hydrogeology

SURFACE WATERS

9 drainage transects along the Kf outcrop in the Project Area:

- Beaver Creek,
- Squaw Creek,
- Little Squaw Creek,
- Pole Gulch,
- Peterson Gulch,
- Candelaria Ranch,
- Piedra River,
- Stollsteimer Creek, and
- Cabezon Canyon.

NATURAL SPRINGS

There are 27 identified along the Kf outcrop in the Project Area

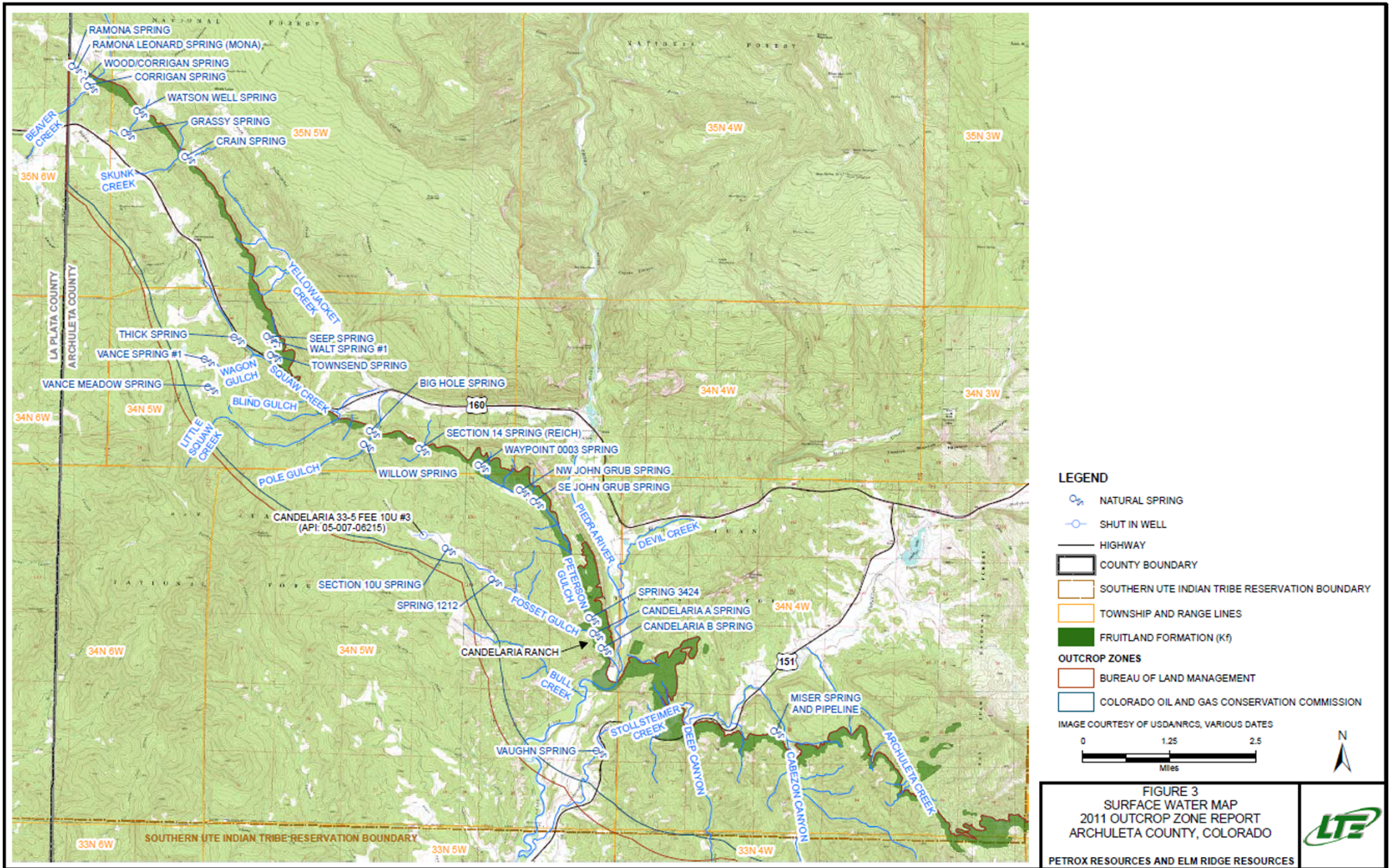
Flow in late spring and run dry during the summer months

Typically calcium bicarbonate waters

SAR < 1.0



Surface Waters and Natural Springs



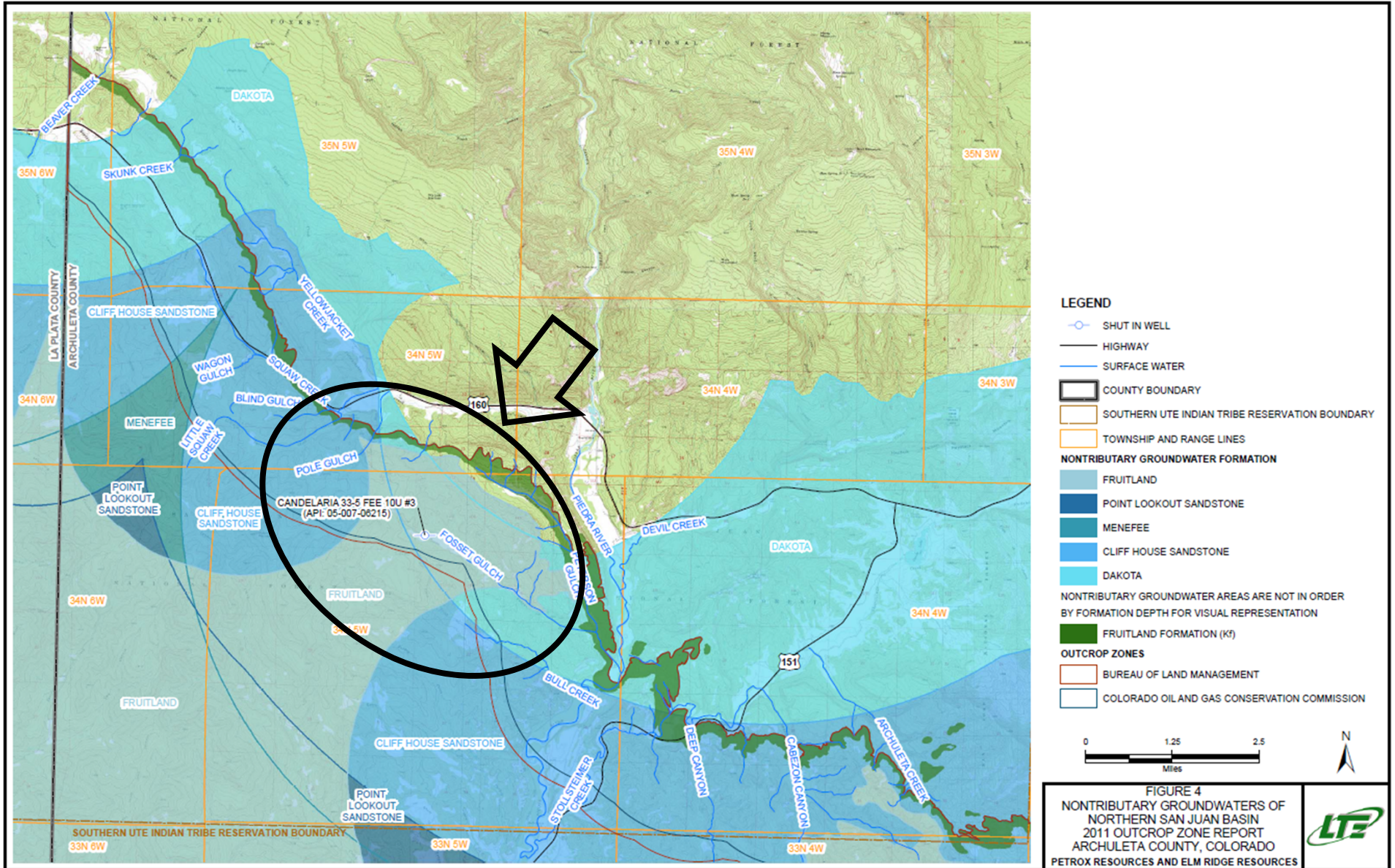
Hydrogeology (continued)

Groundwater and Aquifers

- Water chemistry → Sodium chloride and bicarbonate and depleted in calcium and sulfate resulting in a high SAR.
- Candelaria 10U #3 → Sodium and potassium cations and chloride anions with a SAR of 50.
- Western NSJB = 50 BWPD to 150 BWPD with gas production / Eastern NSJB = 1 BWPD to 15 BWPD when producing gas.
- State Engineer's study → Kf aquifer is nontributary groundwater beneath portions of the Project Area (including Candelaria 10U #3).



Nontributary Groundwater



Monitoring Program

1. Annual detailed mapping w/ flux meter along drainage transects (9 total, 6 mapped in 2011) and Big-Horn Schomburg #1 P&A production well
2. Regional reconnaissance w/ infrared imagery and field verification (3 yr. intervals – conducted in 2011; next IR survey and verification in 2014)
3. Natural Spring Surveys (27 total natural springs along the Kf outcrop,)
4. Abandoned coal mine survey (7 total mines along the Kf outcrop) (new in 2011)
5. COGCC monitoring well data and BLM soil vapor tube (SVT) data evaluation (new in 2011)

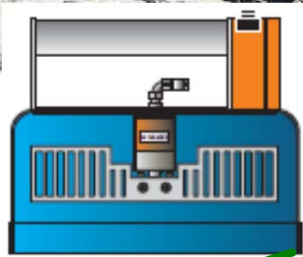


Annual Detailed Mapping Methods

WestSystems, LLC Portable Flux Meter



- Measures flux of methane, hydrogen sulfide, and carbon dioxide at the ground surface
- Flux = Flow Rate per Unit Area



Kettle/chamber



Backpack with detectors



Regional Reconnaissance

Color infrared (CIR) aerial photography imagery from fly-over.

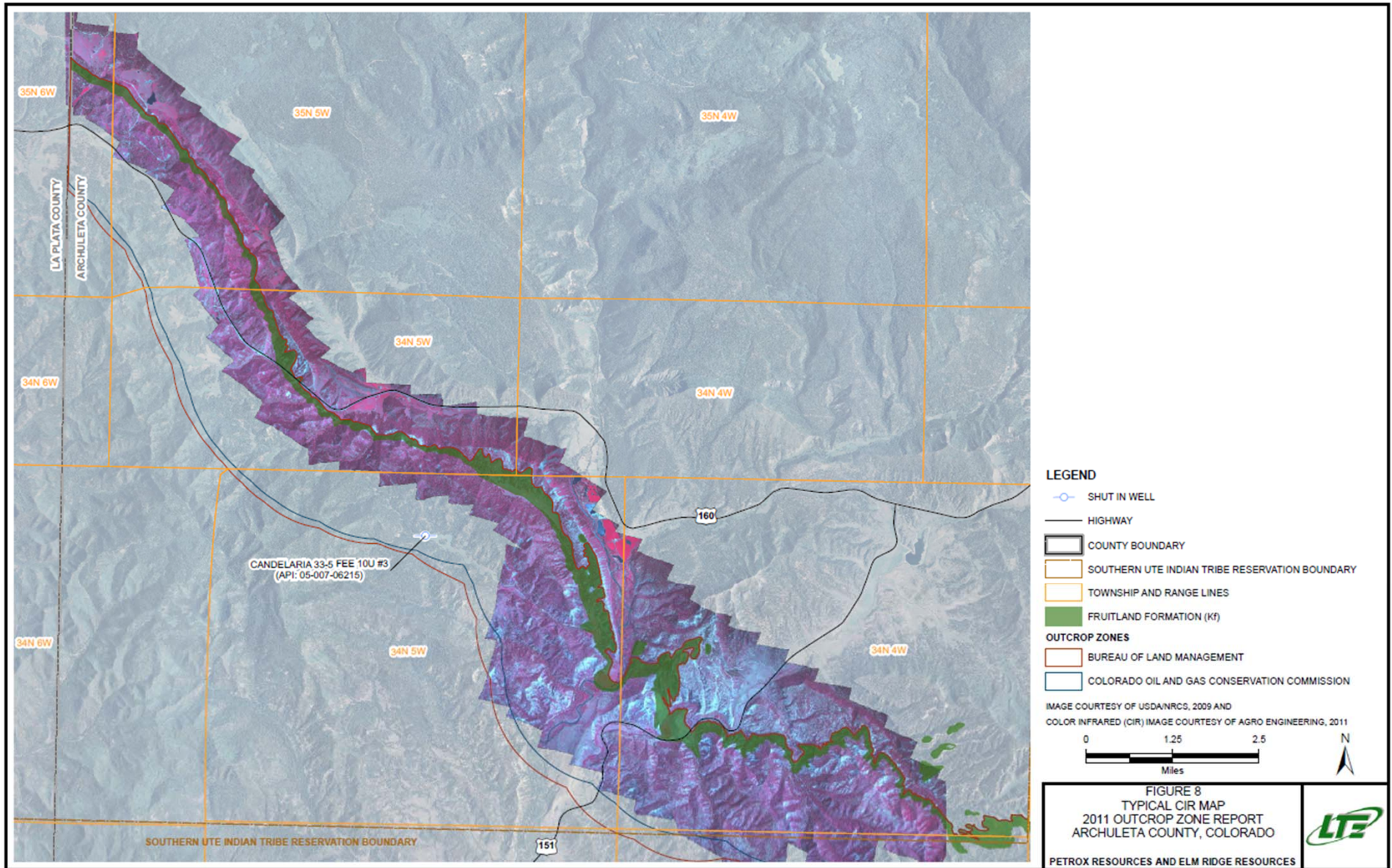
Suspect areas - contain dead and/or stressed vegetation or anomalies.

Field verification conducted using traditional subsurface soil gas survey techniques.

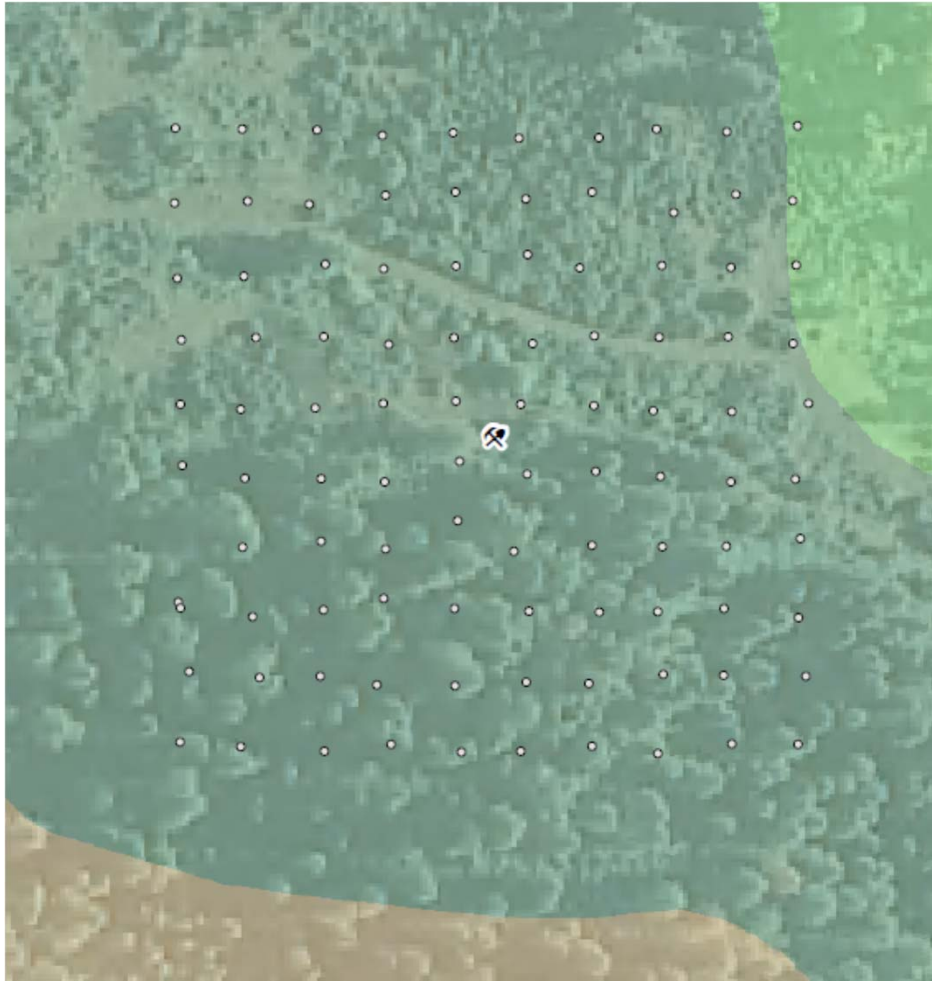
Conducted in 2005, 2008, and 2011.



Regional Reconnaissance – Infrared Imagery



Abandoned Coal Mine Surveys



(Columbine Mine)

Identify abandoned coal mines. Conduct 500-foot radius survey for:

- Methane
- Oxygen,
- Carbon monoxide
- Carbon dioxide
- Hydrogen Sulfide
- Temperature



Natural Spring Survey Methods



GPS, field water quality measurements, flow, and sample for laboratory analysis -

- Major cations
- Alkalinity
- Major anions
- pH
- Specific conductance
- Nitrate/Nitrite as Nitrogen
- Total dissolved solids
- Dissolved methane
- Sodium Absorption Ratio (SAR) (calculated)

COGCC Monitoring wells & BLM Soil Vapor Tubes Evaluations

COGCC Monitoring Wells

There are four monitoring well sites within the Project Area:

- Two wells at Wagon Gulch
- Two wells at Fosset Gulch
- Two wells at Highway 151
- One well at Deep Canyon

LTE evaluated COGCC monitoring well pressure data which is collected by COGCC twice daily with permanently installed pressure transducers and telemetry

BLM Soil Vapor Tubes

There are 67 SVTs in 8 drainage transects along the Kf outcrop in Archuleta County

LTE evaluated BLM SVTs data using the Mann-Kendall test to identify statistical changes in methane concentrations.



Mitigation Program

1. Early detection of methane seepage and/or coal fire by conducting annual monitoring program.
2. Limit water production to 100 bbl/day/well (Petrox typically producing 1-15 bbl/day/well in Archuleta County).
3. Coal fires will be dealt with on a case-by-case basis. Potential for coal fire in Project Area appears low.
4. Mitigation alternatives to be developed based on *Preliminary Evaluation of Methane Seepage Mitigation Alternatives* report (LTE, 2006)

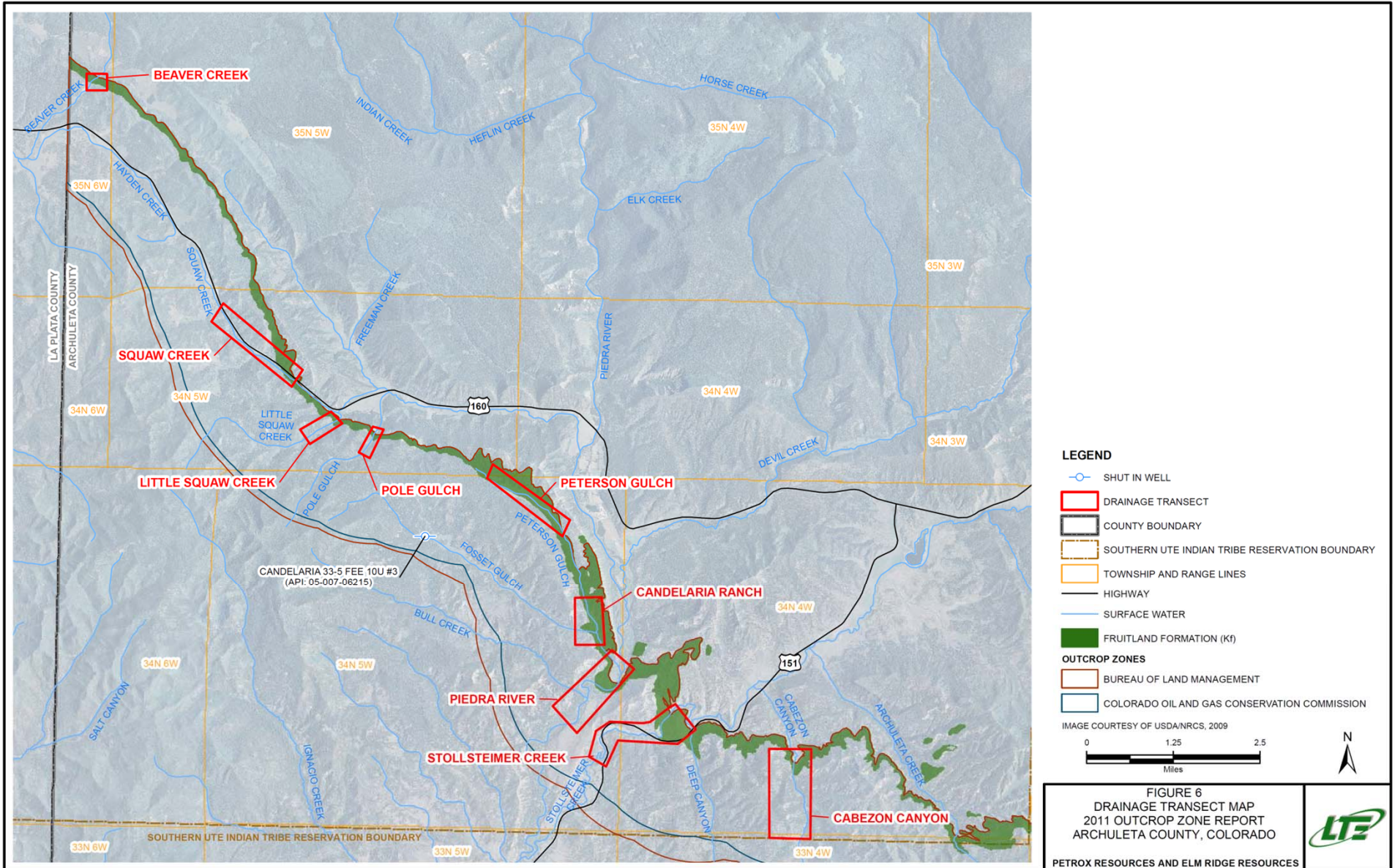


2011 Monitoring Results

1. Drainage transect surveys (May 10 and June 16, 2011)
2. Big Horn-Schomburg #1 survey (June 16, 2011)
3. Regional reconnaissance (Fly-over - June 3, 2011 / Field verification - August 23 to August 31, 2011)
4. Abandoned coal mine surveys (July 27 to August 4, 2011)
5. Natural springs surveys (May 2011)
6. COGCC monitoring well data analysis
7. BLM soil vapor tube data analysis



2011 Drainage Transects



2011 Drainage Transects and P&A Production Well Survey Results

Mapping Area	Number of Sample Points with Methane greater than reporting limit (0.2 mol/m ² -day)					Volumetric Methane Flux (MCFD)			
	2007	2008	2009	2010	2011	2008	2009	2010	2011
Beaver Creek	1	0	0	0	1	0	0	0	NA
Little Squaw Creek	2	2	0	0	0	NA	0	0	0
Yellow Jacket Pass/ Squaw Creek	0	0	0	0	0	0	0	0	0
Pole Gulch	1	0	1	0	0	0	NA	0	0
Peterson Gulch	1	0	0	0	0	0	0	0	0
Stollsteimer Creek	0	3	2	0	1	NA	0.50	0	NA
TOTAL	5	5	3	0	2	NA	NA	0	NA

Abandoned Production Well									
Big Horn-Schomburg #1	1	0	1	0	1	--	--	--	--

(Over 1,000 points in 2011)

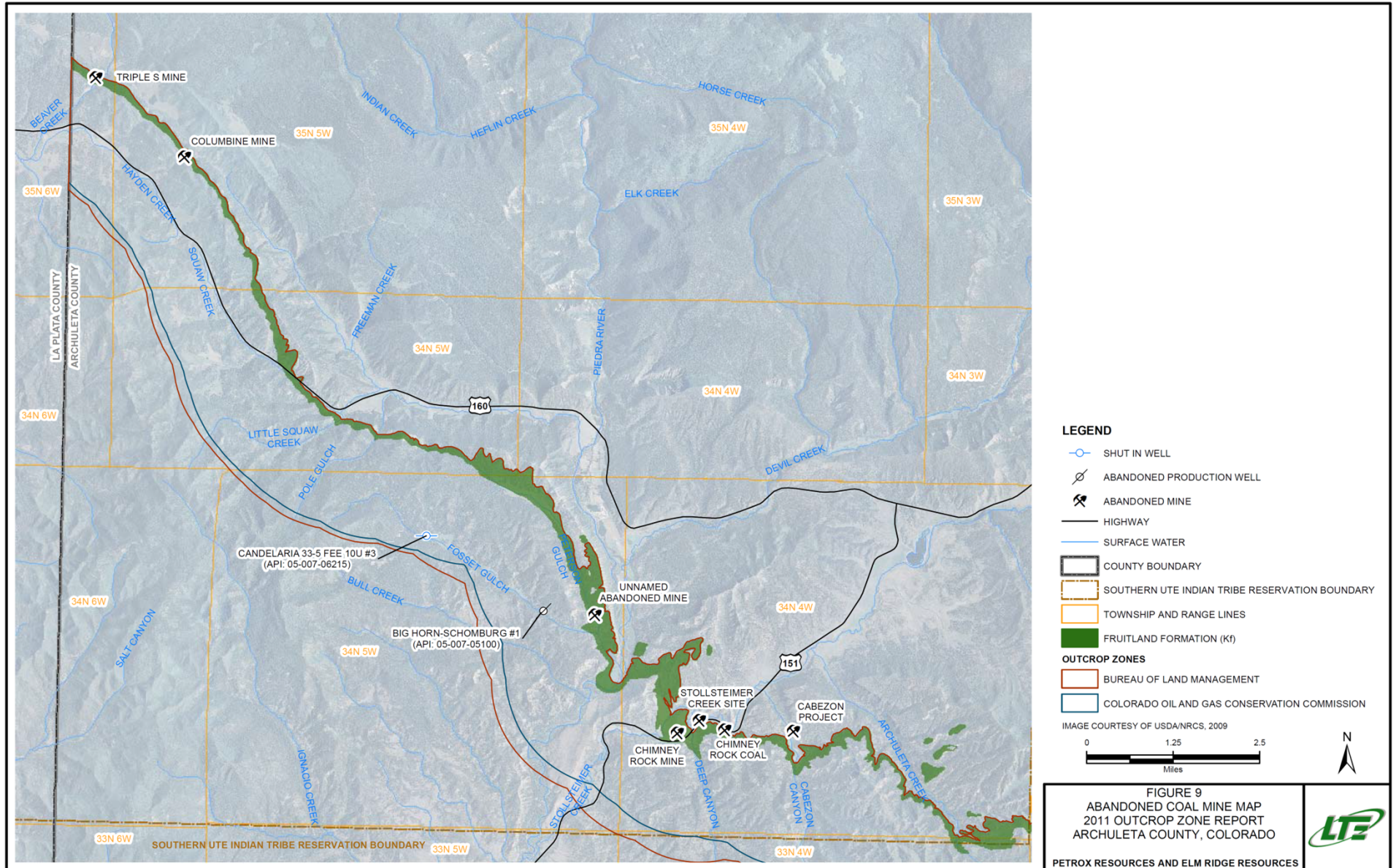


2011 Regional Reconnaissance Results

- 29 of the 34 suspect areas verified (5 had no property access).
- Collected 98 subsurface gas concentration measurements within 29 suspect areas.
- Methane was not detected at the measurement points.
- Generally, poor vegetation health in suspect areas was a function of surface physical conditions, such as poor soil development on coal and rock outcrops and/or steep slopes.



2011 Abandoned Coal Mine Survey Results



2011 Abandoned Coal Mine Survey Results

In 2011, 7 abandoned coal mines along the Kf outcrop, 5 surveyed. No coal fires identified.

- Chimney Rock Mine – CH₄ (48) and CO (1) detected (1 reportable methane flux point at Stollsteimer Creek in 2011)
- Stollsteimer Creek Site – CH₄ (2) and CO (6) detected
- Chimney Rock Coal – CH₄ (2) and No CO detected
- Triple S Mine – No CH₄ or CO detected
- Columbine Mine – No CH₄ or CO detected



2011 Natural Spring Survey Results

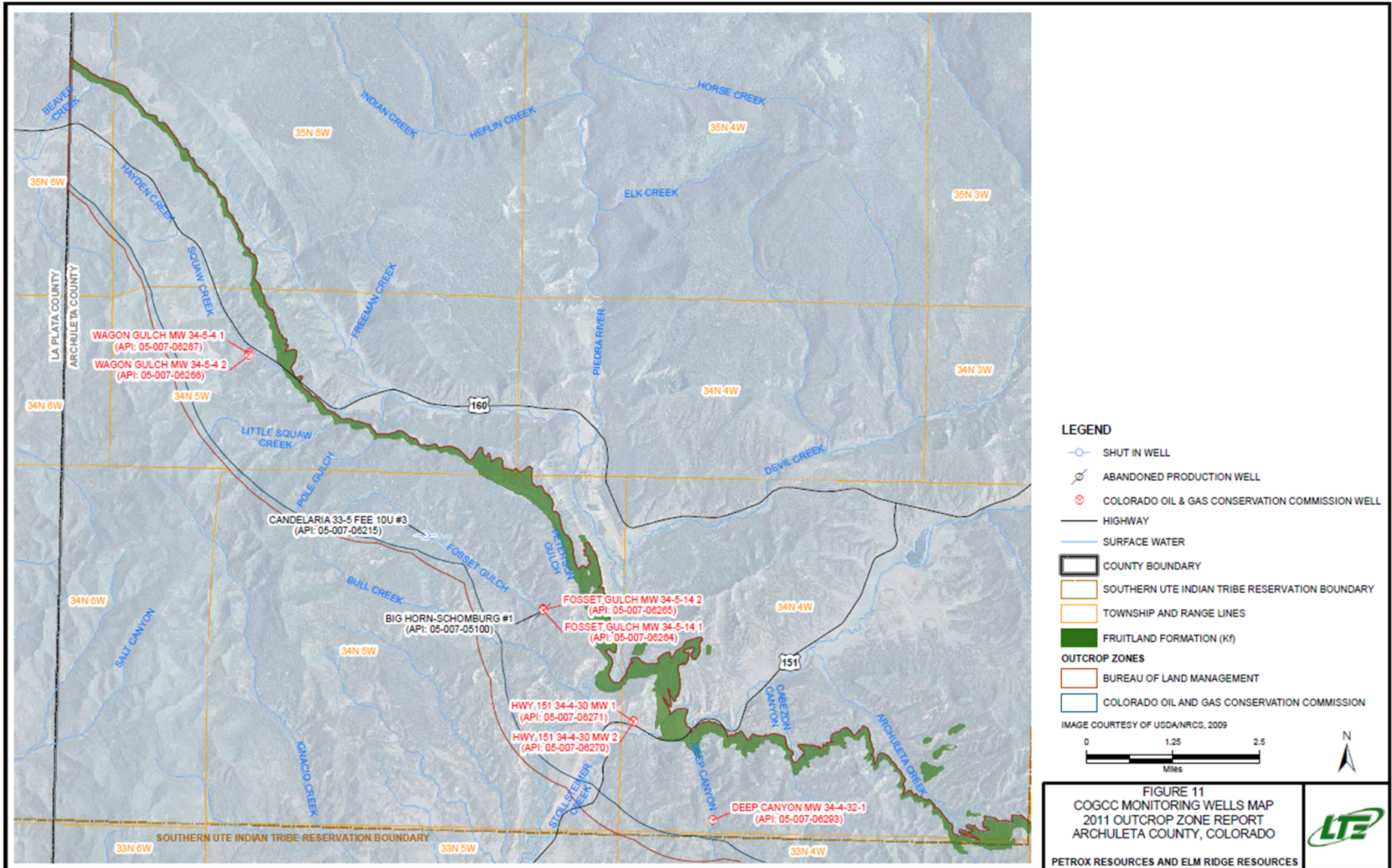
Dissolved Methane

NATURAL SPRING	May 2011
Ramona Leonard Spring	NS
Beaver Creek	NS
Corrigan Spring	<0.02
Watson Well Spring	NS
Grassy Spring	NS
Crain Spring	NS
Walt Spring #1	<0.02
Thick Spring	<0.02
Vance Spring #1	<0.02
Vance Meadow Spring	<0.02
Big Hole Spring	NS
Willow Spring	NS
Section 14 Spring	NS
NW John Grub Spring	0.03
SE John Grub Spring	0.023
Section 10U Spring	NS
Section 12U Spring	NS
Spring 1212	NS
Spring 3424	NS
Townsend Spring	NS
Vaughn Spring	NS

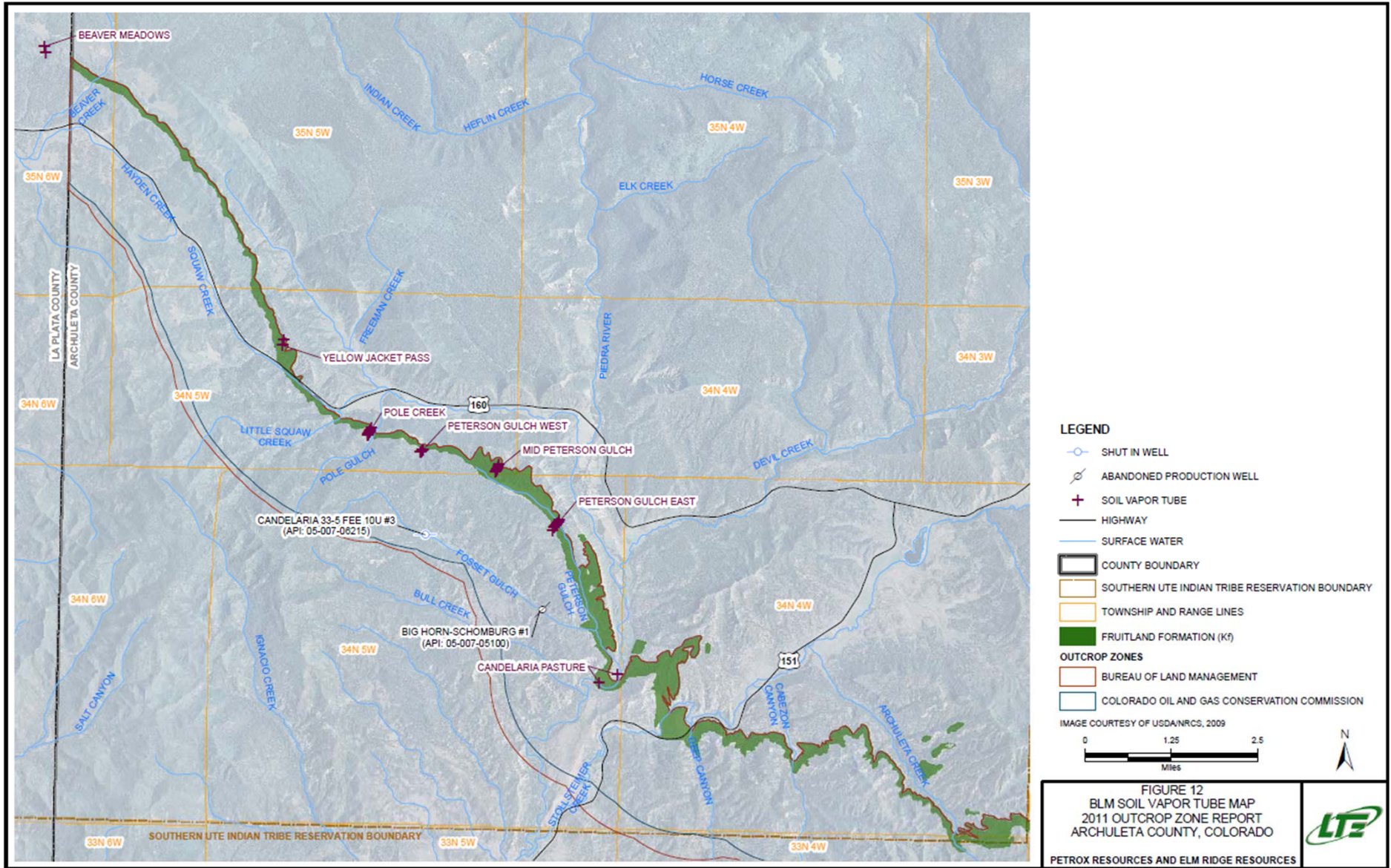
(2 milligram per liter (mg/L) COGCC threshold to identify water for further investigation of the origin of the methane in the water)



2011 COGCC Monitoring Well Data Analysis Results



2011 BLM Soil Vapor Tube Data Analysis Results



2011 COGCC Monitoring Well Data Analysis Results

- In general all monitoring wells show the presence of free gas at the outcrop with no dewatering and resulting in no surface methane seeps.
- Pore pressure approximately 0.41 to 0.44 psi/ft (normal >0.50).

2011 BLM Soil Vapor Tube Data Analysis Results

- Free gas is present in the SVTs at the Kf outcrop; however, it is not migrating to the surface as methane seeps.
- Statistical trends indicate only one SVT with an upward trend.



Evaluation and Summary

- Monitoring since 2004 indicates there are no methane seeps or coal fires existing at the Kf Outcrop within Archuleta County.
- Free gas is present in the reservoir and at the Kf outcrop (gas production in the CBM wells and COGCC Monitoring wells).
- Face cleats, fractures, and joints parallel to the Kf outcrop, inhibiting gas flow to outcrop.
- Free gas available without dewater/lowering pressure.
- Mansoori model of Candelaria 10U#3 suggests no pressure drop at the Kf outcrop after 20 years of production.
- Natural springs/surface water not connected to Kf coal water (water chemistry and SAR values differ).



Recommendations

- Continue annual monitoring as conducted since 2007.
- Monitor abandoned coal mines annually rather than quarterly, unless conditions change.
- Present this outcrop zone report to all interested stake holders at the time of the GORT meeting in 2013.

