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Natural Gas Development and Watershed Management

Colorado Watershed Assembly Oct. 6, 2010

NYSE: PXD
www.pxd.com




Natural Gas Development and Watersheds

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What are some of the investments Pioneer and the natural gas industry have made to protect water resources and watersheds?

- **Depletion**
- **Water treatment and conservation**
- **Domestic water wells**

- **FOCUS: Watershed monitoring**

Water Depletion

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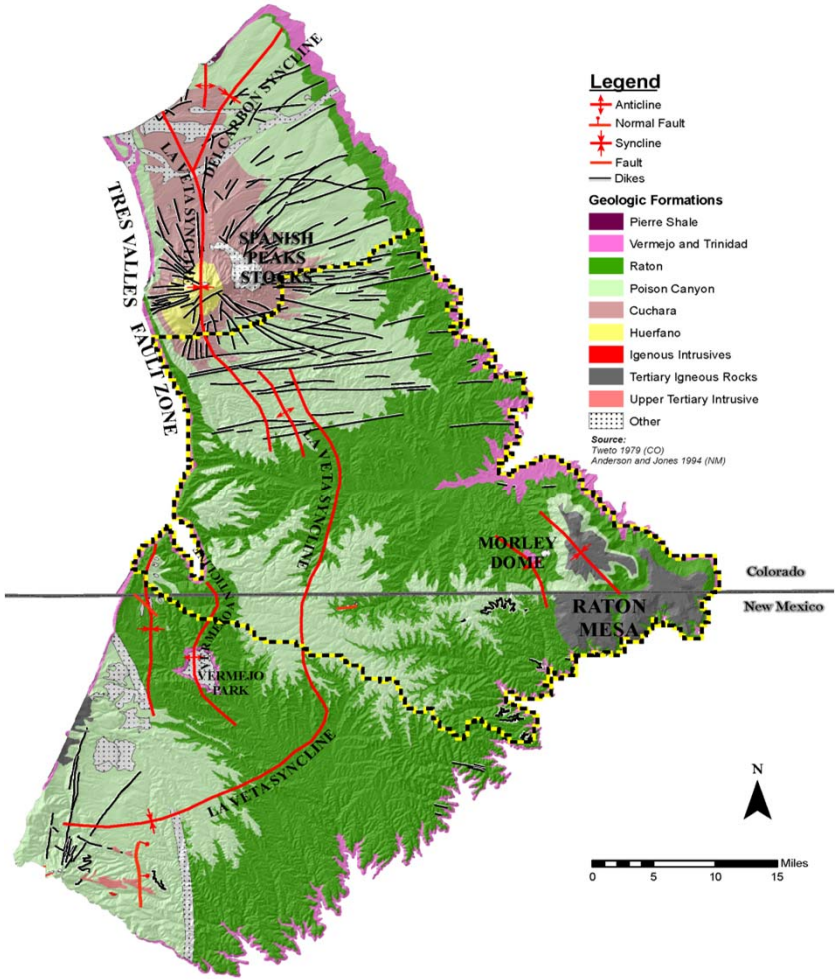
Concern: Production of large amounts of water

A Pro-Active Investment by Producers:

- **Geo-hydrologic company (Norwest) develops models needed to assess CBM pumping and depletion**
- **Six year inter-company effort**
- **Included peer review with Colorado School of Mines**
- **Added review by outside experts**
- **Results presented to SEO**



Identified where depletion impacts occur

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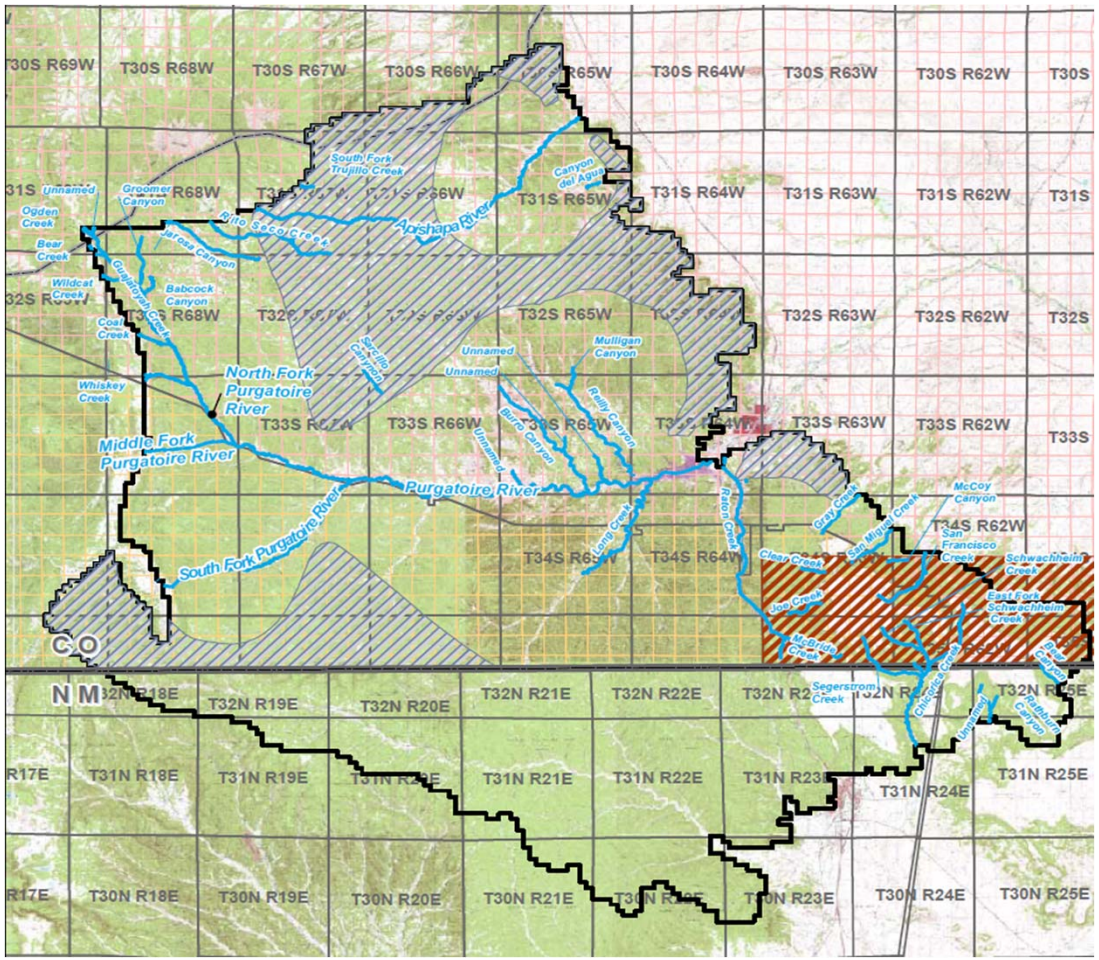
Used the latest USGS MODFLOW code and supporting software.

Set tributary & non-tributary boundary and estimated depletion impacts.

Result: Approximately 4 acre-ft/yr depletion (less than 2 acres of alfalfa) in 2010 and a maximum of approx. 20 acre-ft/yr.



<u>SEO now has a tool to manage water in the Basin.</u>

CBM Produced Water – a resource?

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CBM producers bring thousands of acre-feet of "deep" water to the surface.

Uses include:

- **Livestock**
- **Wildlife**
- **Wetlands enhancement**
- **Dust control**

Industry is investing in research at the Colorado School of Mines on produced water treatment technologies.

~ work that someday could expand possible uses of produced water

Assessing domestic water wells

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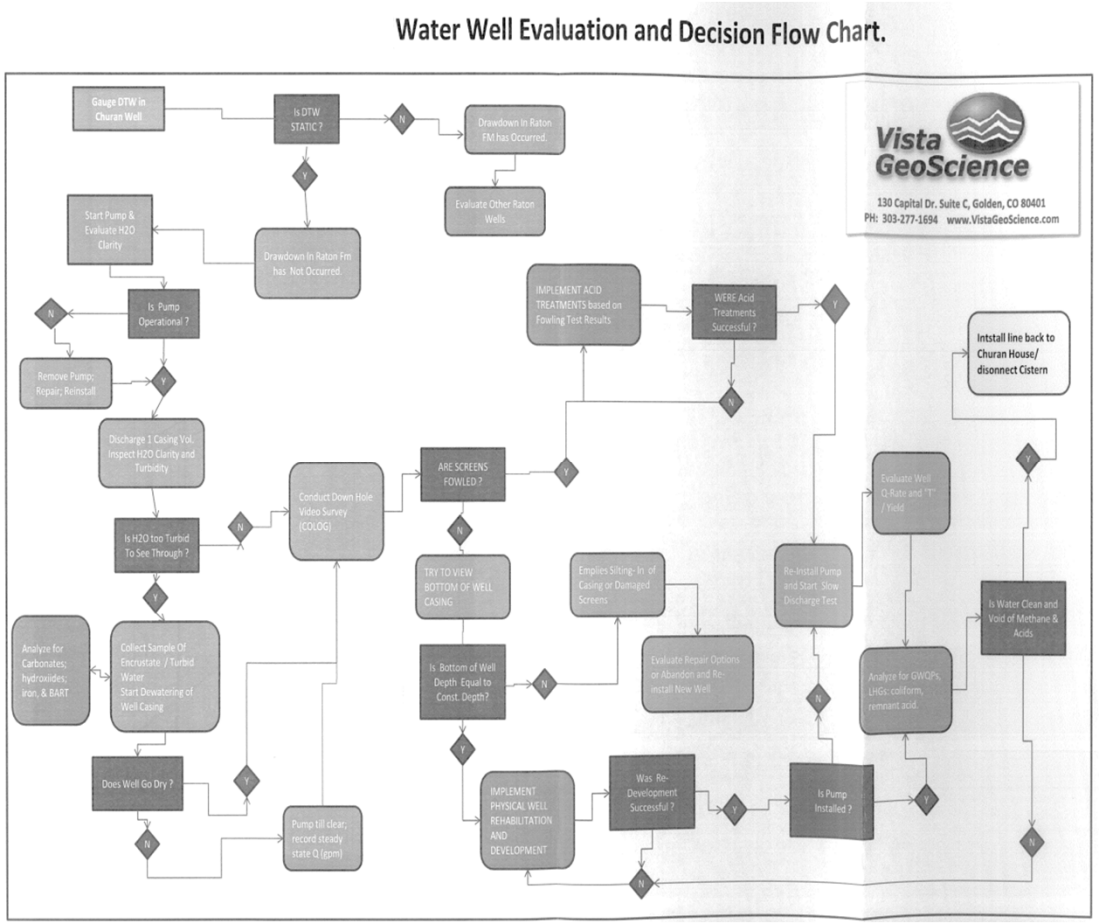
Concern: Natural gas development , especially coalbed methane, raises public concerns about contamination and/or water production impacts.

<u>Investment</u>:

Needed a systematic water well investigation and evaluation process

Developed by firm of water well engineers and groundwater hydrologists

Comprehensive, using wide range of technologies



Water well assessment

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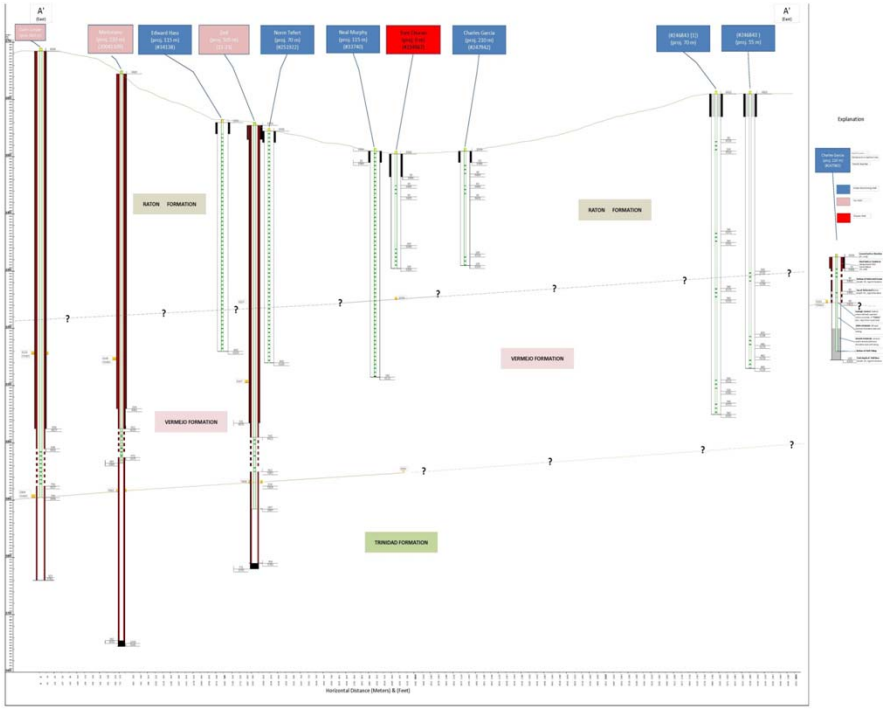
- **Process includes review of well construction documents and evaluation of well drilling and construction methods**
- **Building geologic cross-sections**



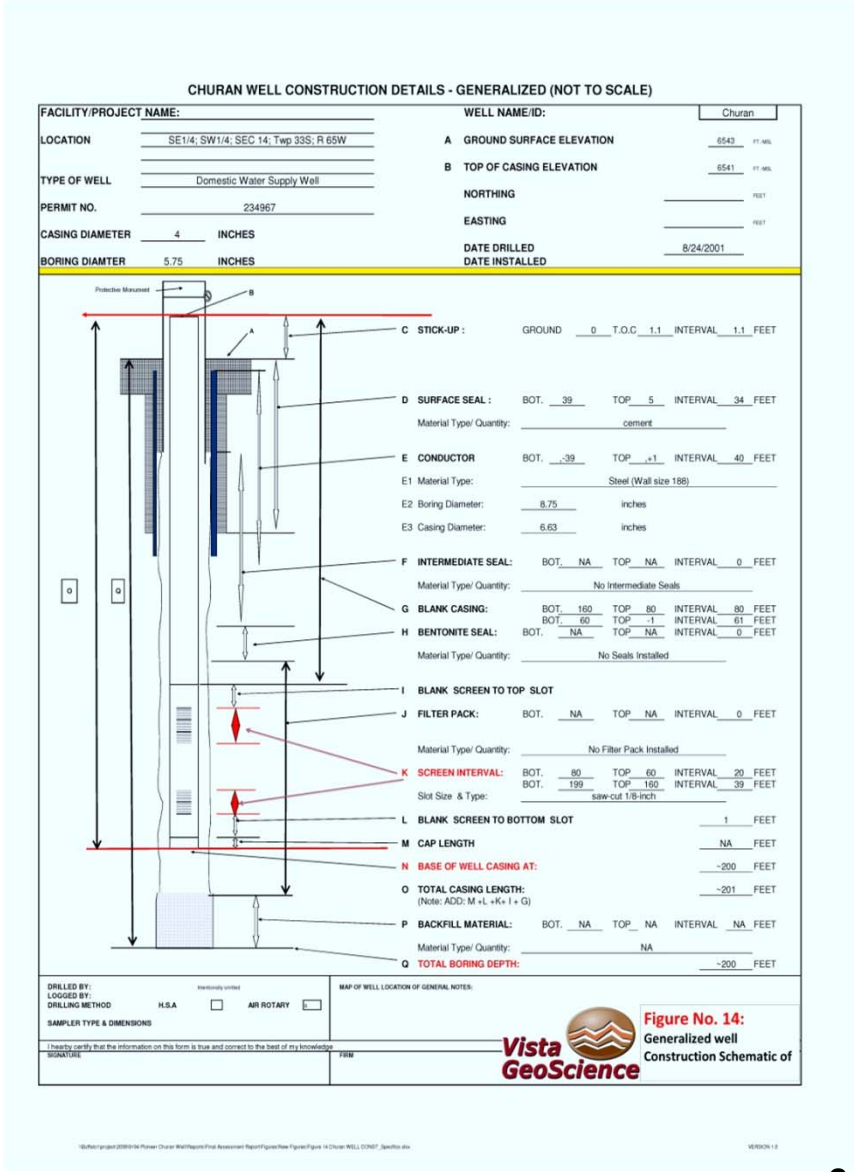


Figure No. 14: Generalized well Construction Schematic of

Water quality and/or production assessments

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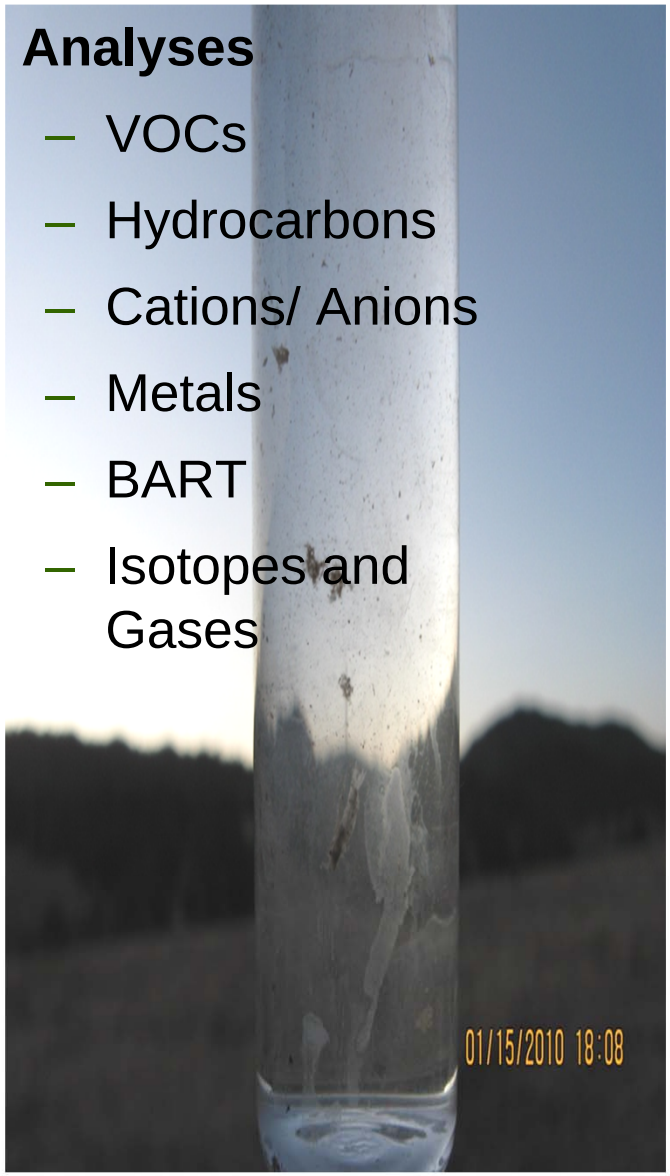
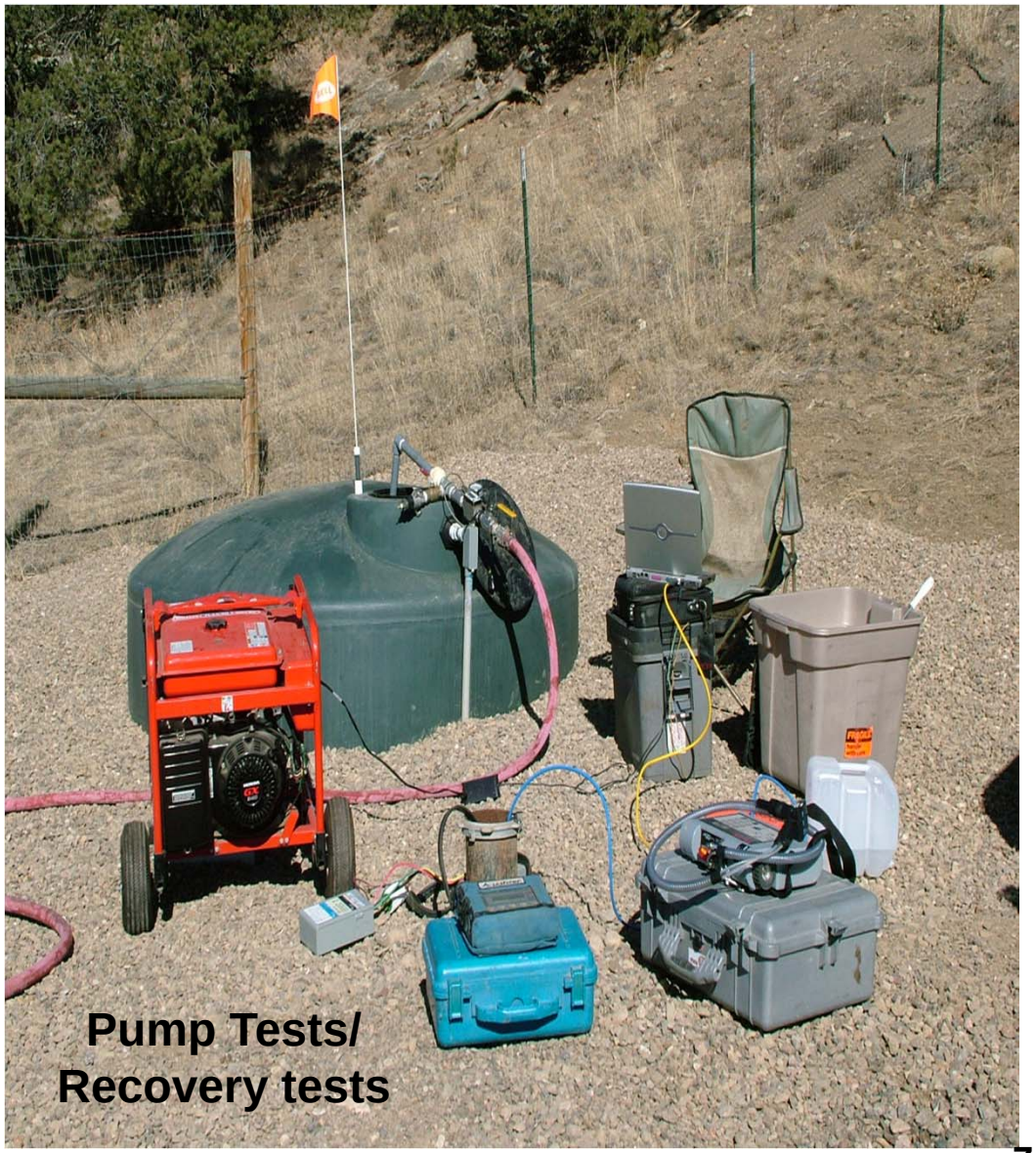
- **Analyses**
  - VOCs
  - Hydrocarbons
  - Cations/ Anions
  - Metals
  - BART
  - Isotopes and Gases





Pump Tests/ Recovery tests

Down-Hole Video Logging

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Side looking camera

Bottom looking camera

Help landowners understand their well

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Systematic process to provide factual information on potential problems and/or impacts

Some examples of problems we've found:

- Poor screening and construction reduces water volumes
- Bacterial contamination (slime) blocking well screens
- Bacteria-producing methane
- Inaccurate drilling formation on water well report: "black shale" vs. coal
- Water wells are "open hole" – minimal surface casing, no cement
- "Open hole" water wells are a potential conduit
- Potential for gas to travel up hole to shallower aquifers and the surface

Addressing water well problems -- solutions

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Investing in solutions:

- **San Juan Basin natural gas operator supported a "know your water well" booklet**
- **Goal to provide understanding and solutions**
- **Recommendations from well engineers on water well maintenance**
- **The basis for web-site information and community outreach**
- **A collaborative effort between industry and community groups**

Investing in a Watershed Monitoring System

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- **Watershed-based monitoring – the scientific basis for understanding water quality**
- **Data from historical grab samples**
- **Tetra-Tech hired to design, install and manage a watershed monitoring station system to provide continuous, real-time flow and water quality monitoring data**
- **Only one USGS station (flow) – no systematic monitoring of the watershed**

Installation of Nine Monitoring Stations

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Project initiated in January 2010.

Stations operational by May 2010.

Finished Monitoring Station

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Installed on tributary to Purgatoire River in the Raton Basin

Continuous Monitoring of Purgatoire River & Key Tributaries

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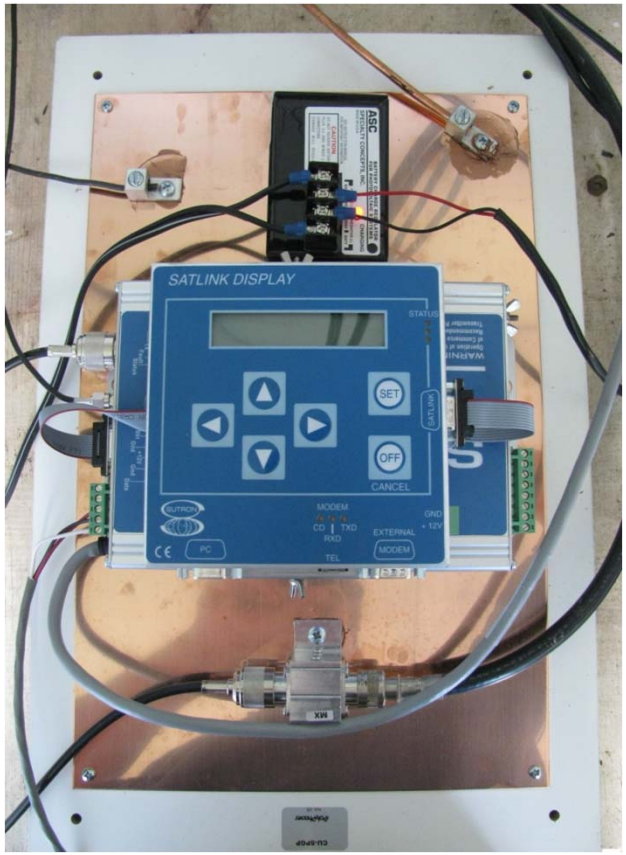
Monitoring station funded by natural gas operators "piggy-backs" on the lone USGS station in the watershed

Data collected every 15 minutes: Flow, pH, EC, Chloride, and Temperature



Continuous monitoring supported by field sampling

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Monthly Water Quality Sampling Conducted at 25 Sites in Watershed

- Used to calibrate and verify monitoring station data
- Used to establish correlations between continuously monitored constituents (chloride, EC) and other water quality parameters
- Used to assess quality parameters and suitability for uses (e.g. irrigation)

Advantages of This Watershed Approach

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- **Continuous data to assess effectiveness of discharge permit limits**
- **Real-time “warning” on changes in flow and water quality**
- **Multiple points of flow data useful to the state and downstream users**
- **Data on baseline conditions and the contributing sources of pollutants in the watershed**

Monitoring Data Transmitted Via Satellite to Website

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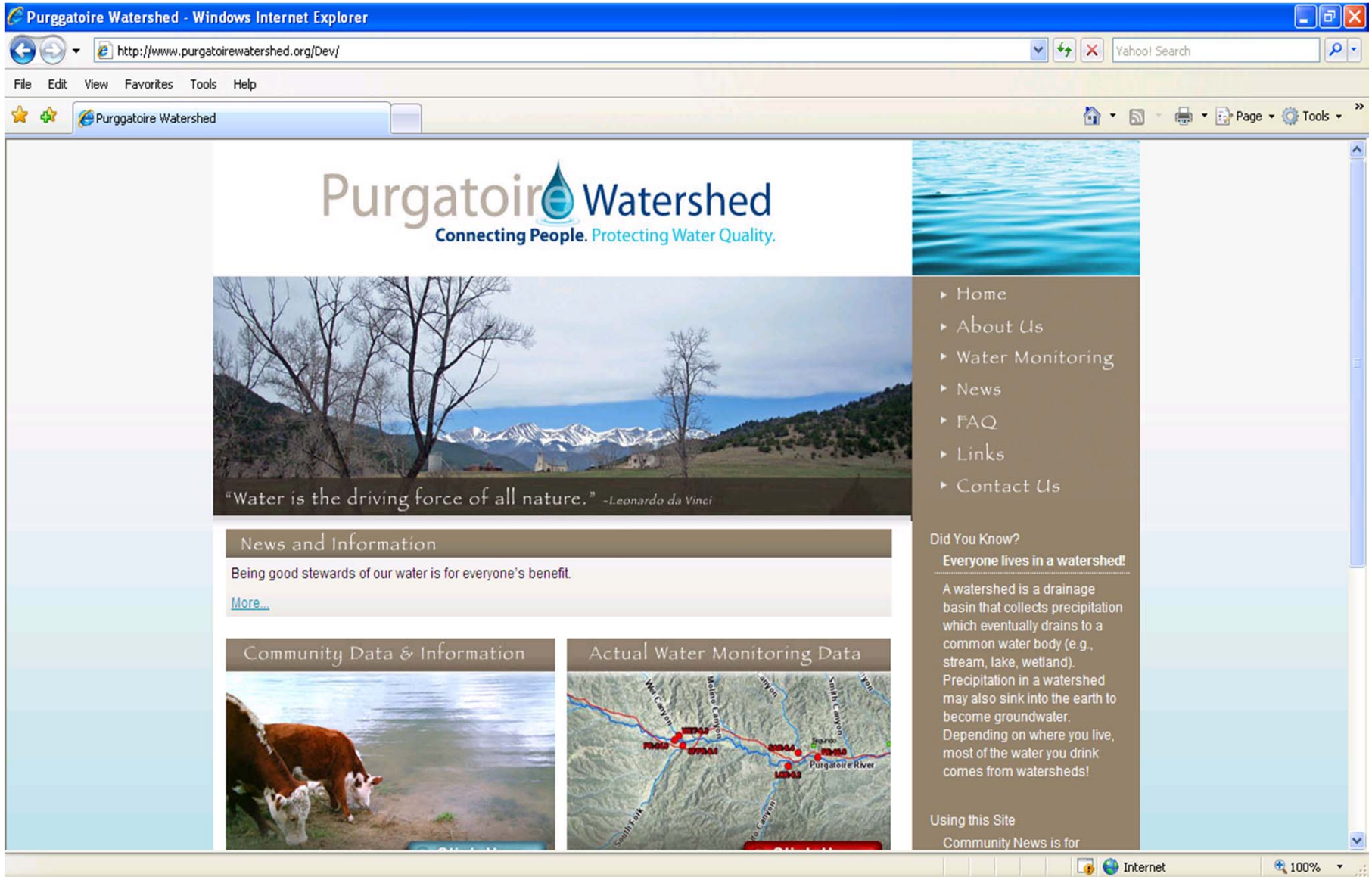

Data Transparency and Communication

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www.purgatoirewatershed.org

- **Point and click -- public access to data from each station**
- **The first? One of the few? watershed-based, real-time water monitoring systems in a coalbed methane or natural gas field.**

Data transmitted via satellite link to website

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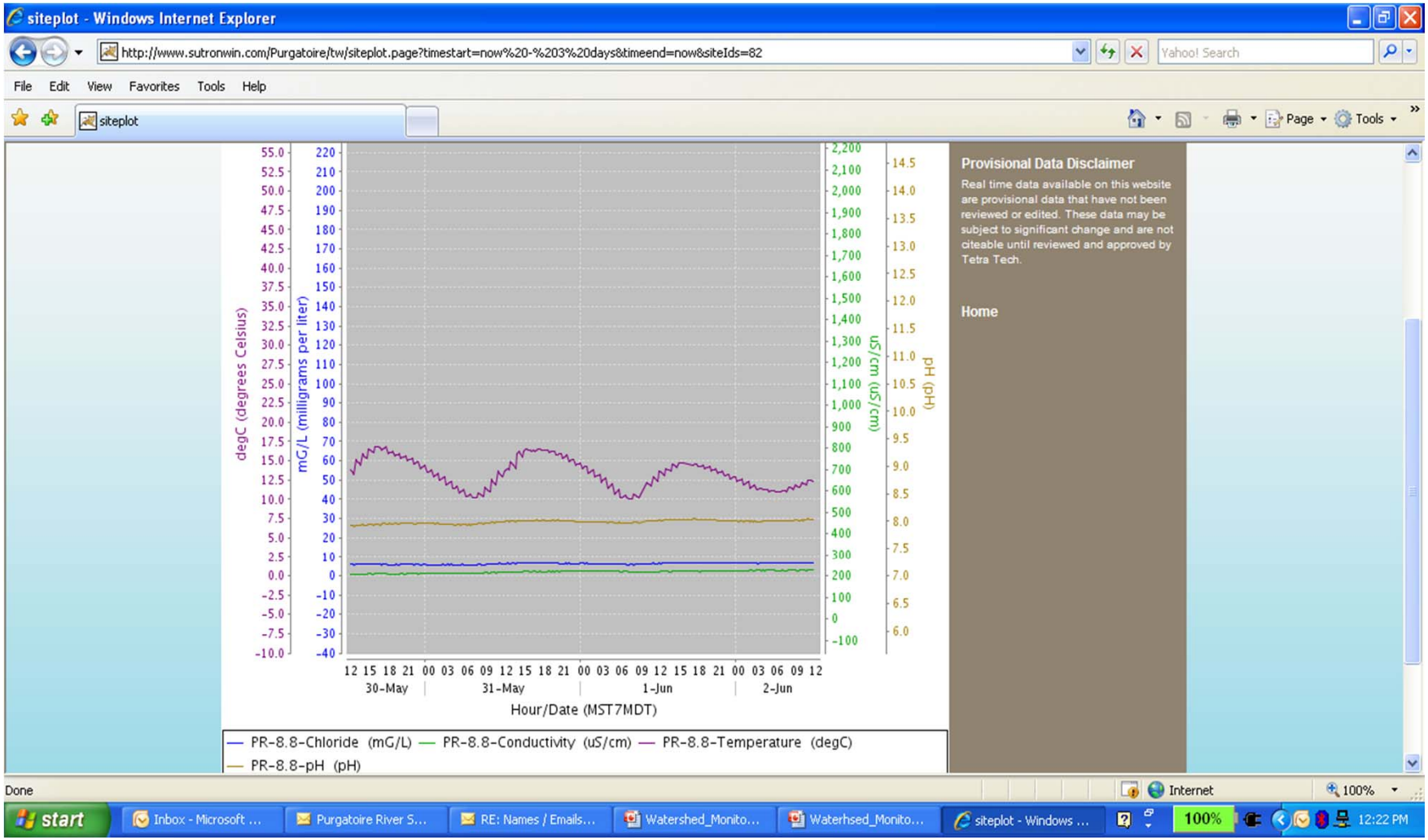
Daily, weekly, monthly data reports in graphical formats



Purgatoire River at Madrid, Colorado

Expandable to include new information

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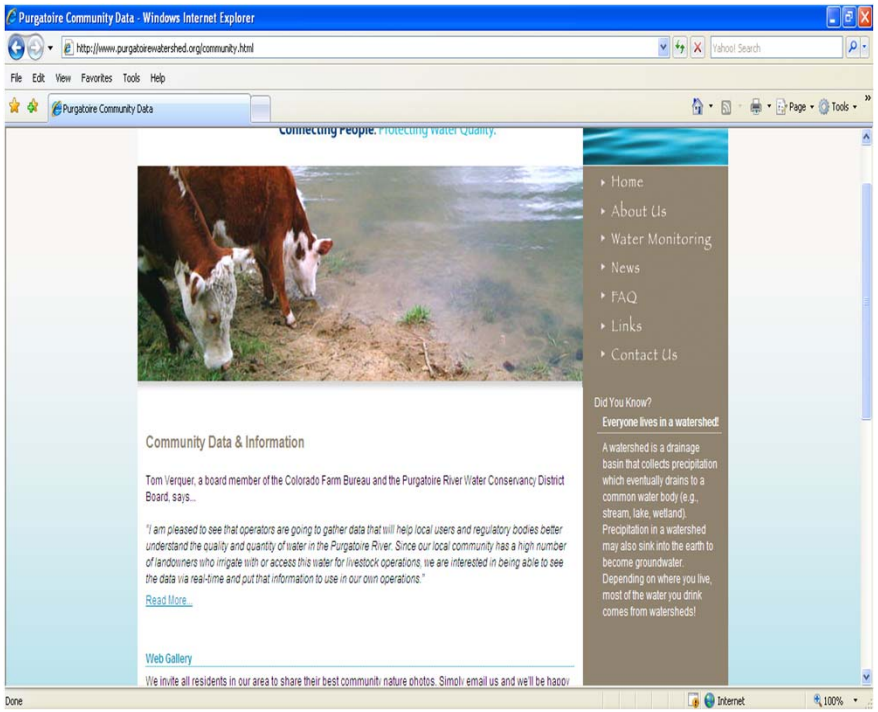
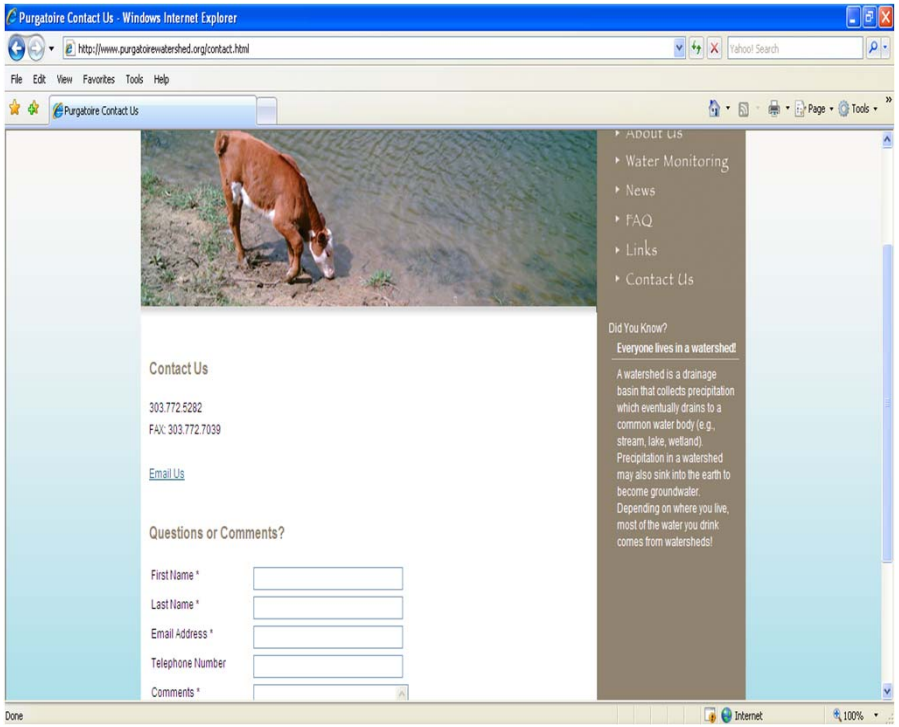
Community news

Place holder for other sources of water data and information



Point of e-mail contact with watershed experts at Tetra-Tech – suggestions for the site and questions



Where do we go from here…

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In the Purgatoire watershed, natural gas producers invested in:

- **Technical expertise**
- **Landowner access**
- **Monitoring station equipment**
- **Laboratory testing and calibration**
- **Satellite links**
- **Web-site reporting**

But there are additional opportunities to make this more of a community-based program:

- Local college – environmental program
- Chamber of Commerce members
- Watershed groups such as Purgatoire River Anglers chapter of TU