

Pinedale Anticline Ground Water Data Summary

Data collected by the Sublette County Conservation District
January 1, 2011 through December 31, 2011

Annual Report
To
Pinedale Anticline Working Group / Bureau of Land Management, Pinedale Field Office
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Volume 1 of 4



Sublette County Conservation District - www.sublettecountycd.com

Delsa Allen, Ground Water Program Manager • dallen@sublettecd.com
P.O. Box 647 / 1625 W. Pine Street, Pinedale Wyoming

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Introduction

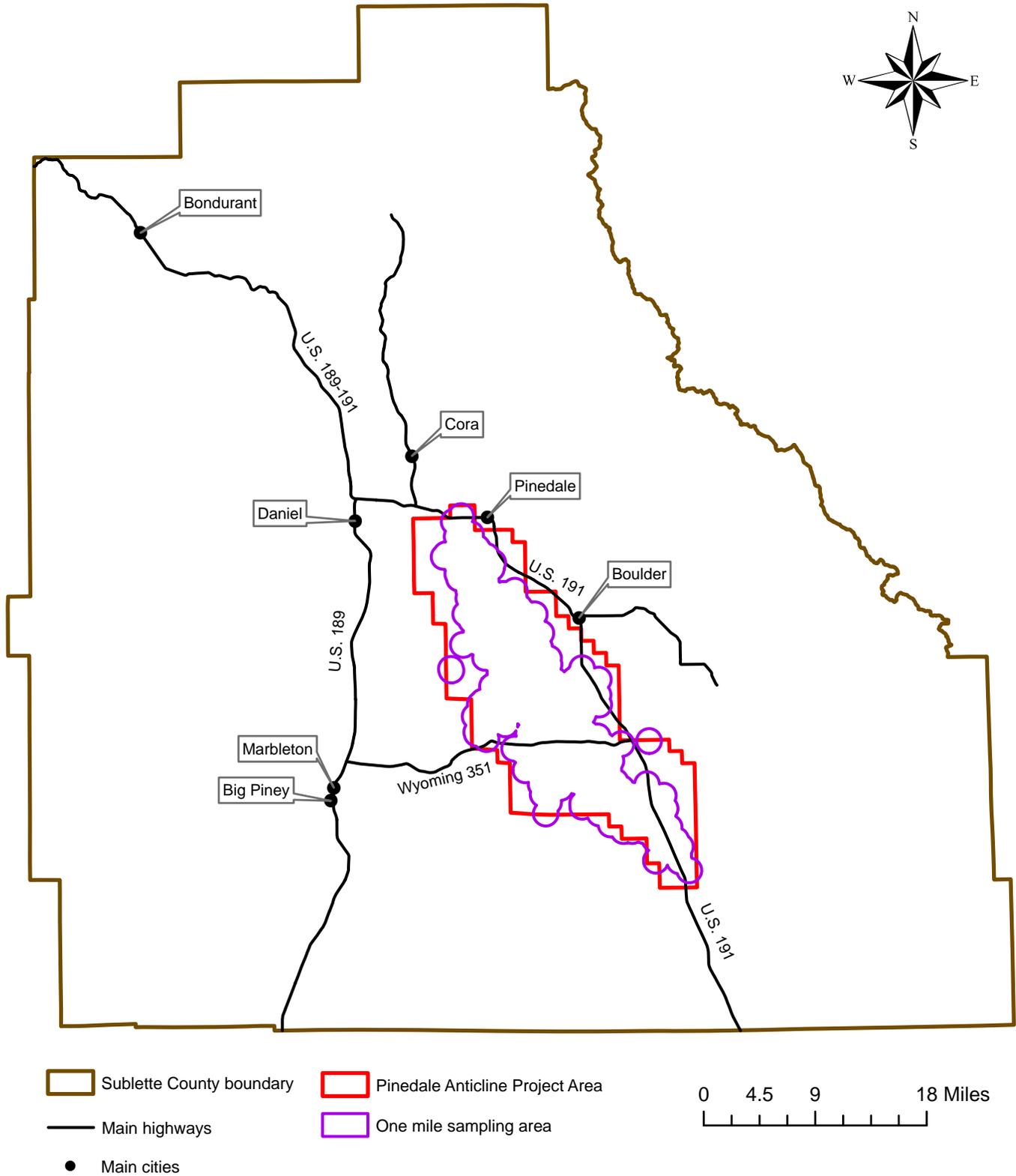
The Pinedale Anticline Project Area (PAPA), which is currently undergoing gas exploration development, is located south of Pinedale, WY and north of the Jonah gas field. It is bordered by the Green River to the west and Highway 191 to the east. The Record of Decision (ROD) for the Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project, Sublette County Wyoming was released in July of 2000. The Conditions of Approval within this ROD states, "...the operators will conduct a survey and a complete water analysis (ex. static water level, alkalinity, salinity, benzene, oil, etc.) of all water wells within a one mile radius of existing and proposed development, and annually monitor and maintain a complete record of water analysis of all new water supply wells drilled in the project area to evaluate the quality of source options in the event some mitigation is required." (section 3, p. 25). See Map 1.

The Sublette County Conservation District (SCCD) was selected to perform the above requirements. The ground water monitoring program was developed in 2001 and ground water sampling began in 2004. As of December 31, 2011, the SCCD has collected 2050 ground water samples from 381 water wells within one mile of an existing or proposed gas well within the PAPA.

Report Objective

The purpose of this report is to provide a summary of the data collection procedures, field data and the lab analysis results from January 1, 2011 through December 31, 2011. See Map 2. Historical results have been included in Appendix A, Table 1 and Table 2, for reference purposes.

Map 1. PAPA Boundary Within Sublette County



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Methods

Water wells that become part of the SCCD ground water monitoring program are monitored annually. The data collected includes water level, GPS coordinates, field parameters and laboratory analysis data. Field parameters are measured just prior to the laboratory bottles being filled. The parameters measured in the field include pH, conductivity, total dissolved solids (TDS) and temperature (reported in Celsius). Water level is also measured when well access is possible and the pump has not been recently active. Field notes are made regarding procedure used to sample, and other field observations.

Sampling procedures are followed in accordance with the Sublette County Conservation District's Ground Water Monitoring Manual and Protocol (March 2010), and the Water Quality Monitoring Sampling and Analysis Plan for the PAPA (March 2008).

Samples are then tested further for alkalinity, calcium, chloride, fluoride, magnesium, potassium, sodium, sulfate and TDS by Energy Laboratories Inc. in Casper, Wyoming. In addition, all samples are tested for hydrocarbon presence using Diesel Range Organics (DRO) and Gasoline Range Organics (GRO), method SW8015B, as indicators. Confirmation samples are collected if DRO and/or GRO is detected, with additional analysis of benzene, ethylbenzene, m+p-Xylenes, o-Xylene and toluene (commonly known as BTEX) using methods SW8021B and SW8260.

The Quality Assurance Program Manual and Performance Evaluations for Energy Laboratories, Inc. is located at the following web address in PDF format:

<http://www.energylab.com/QualityControlList.asp?branch=Casper>

Prior to release, all lab and field data is entered into the Sublette County Conservation District database and quality control measures are taken to ensure credibility.

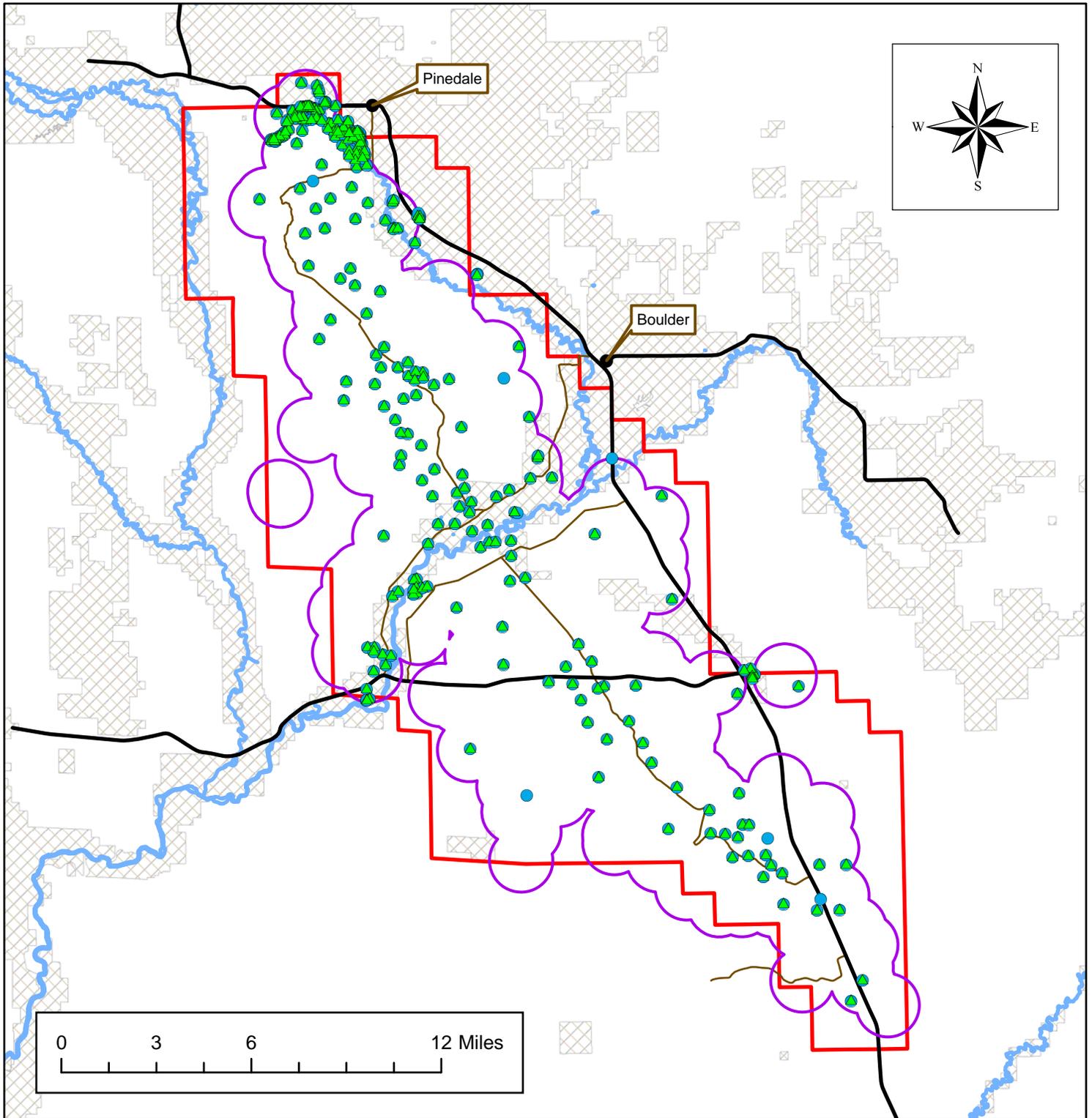
Results

Starting January 1, 2011 through December 31, 2011, 306 field visits took place with 307 samples being collected. Some of these were duplicate samples taken as a quality control measure. Others were second sample sets taken, due to previous DRO and/or GRO detections. See Map 2.

The Wyoming Department of Environmental Quality (WDEQ) and Environmental Protection Agency (EPA) have established drinking water and livestock water quality standards for a handful of parameters. Some of these are analyzed in the SCCD Groundwater Monitoring Program, both in the field and through further lab analysis. The standards for these parameters are given below:

- *Drinking Water Standards:* chloride, 250 mg/L; fluoride, 4 mg/L; sulfate, 250 mg/L; and total dissolved solids, 500 mg/L.
- *Livestock Standards:* chloride, 2000 mg/L; sulfate, 3000 mg/L; and total dissolved solids, 5000 mg/L.

Map 2. Water Wells Visited vs Sampled



- | | | | |
|---------------|-----------------------------|---------------------------------|-----------------------|
| Private lands | Main highways | Pinedale Anticline Project Area | Wells sampled in 2011 |
| Main rivers | Secondary roads within PAPA | One mile sampling area | Wells visited in 2011 |
| Main cities | | | |

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Water Wells Permitted Through the Wyoming State Engineer's Office for Domestic, Stock and Domestic/Stock Use

Field Data

The following results were taken with an Oakton PC 300 multi-parameter field meter and a Ravensgate Sonic Water Level Meter, and represent the range of data collected from the specific well-use group. Multiple readings are taken per well visit for conductivity, TDS, temperature and pH. The last set of recordings per visit was used for the following ranges. Water level is taken only when access into the well is possible or pump has not been recently active.

<i>Field Data Collected</i>	<i>Range</i>
<i>Conductivity (us/cm)</i>	
Domestic	109 to 1844
Domestic/Stock	223 to 868
Stock	351 to 2600
<i>TDS (ppm)</i>	
Domestic	54 to 922
Domestic/Stock	111 to 435
Stock	175 to 1300
<i>Temperature (Celcius)</i>	
Domestic	6.5 to 13.8
Domestic/Stock	7.6 to 11.3
Stock	7.0 to 14.6
<i>pH</i>	
Domestic	6.41 to 9.86
Domestic/Stock	7.28 to 9.61
Stock	7.15 to 9.67
<i>Water Levels (feet)</i>	
Domestic	0 to 102.3
Domestic/Stock	9.3 to 96
Stock	0 to 360.8

When comparing TDS results from field analysis with the standards listed earlier in this summary, 8 domestic wells (AD017, AD057, AD063, AD145, AD194, AD213, AD222 and AD234) exceeded the drinking water standard, 0 domestic/stock wells exceeded the drinking water standard, and 0 stock wells exceeded the livestock standard.

The complete field data, including details regarding sampling methods, is provided in Appendix A, Table 1. Water Well Field Data, 01/01/11 – 12/31/11 Plus Historical Results 01/01/04 – 12/31/11: Wells Permitted for Domestic-use and Stock-use.

Laboratory Data

The following laboratory results are from 167 samples collected from 109 domestic water wells, 17 from domestic/stock wells and 25 from stock wells. They represent the range of data collected from the specific well-use group. "ND" represents non-detectible.

<i>Lab Data</i>	<i>Range</i>
<i>Alkalinity (mg/L)</i>	
Domestic	48 to 419
Domestic/Stock	88 to 221
Stock	65 to 231
<i>Calcium (mg/L)</i>	
Domestic	ND to 101
Domestic/Stock	ND to 54
Stock	ND to 87
<i>Chloride (mg/L)</i>	
Domestic	ND to 87
Domestic/Stock	ND to 84
Stock	2 to 62
<i>Fluoride (mg/L)</i>	
Domestic	ND to 8.6
Domestic/Stock	ND to 4.8
Stock	ND to 8
<i>Magnesium (mg/L)</i>	
Domestic	ND to 20
Domestic/Stock	ND to 10
Stock	ND to 15
<i>Potassium (mg/L)</i>	
Domestic	ND to 4
Domestic/Stock	ND to 2
Stock	ND to 3
<i>Sodium (mg/L)</i>	
Domestic	3 to 375
Domestic/Stock	15 to 241
Stock	8 to 570
<i>Sulfate (mg/L)</i>	
Domestic	1 to 684
Domestic/Stock	3 to 277
Stock	0 to 1060
<i>TDS (mg/L)</i>	
Domestic	65 to 1220
Domestic/Stock	114 to 631
Stock	211 to 1640

When comparing chloride results from lab analysis with the standards listed earlier in this summary, there were no drinking or livestock water exceedences for domestic, domestic/stock or stock water wells.

When comparing fluoride results from lab analysis with the standards listed earlier in this summary, 5 domestic wells (AD020, AD021, AD022, AD197 and AD203) exceeded the drinking water standard and 1 domestic/stock well (ADS004) exceeded the drinking water standard.

When comparing sulfate results from lab analysis with the standards listed earlier in this summary, 10 domestic wells (AD016, AD017, AD018, AD057, AD063, AD145, AD194, AD213, AD222 and AD234) exceeded the drinking water standard, 1 domestic/stock well exceeded the drinking water standard (ADS028), and there were 0 stock wells that exceeded the livestock standard.

When comparing TDS results from lab analysis with the standards listed earlier in this summary, 18 domestic wells (AD009, AD015, AD016, AD017, AD018, AD046, AD057, AD063, AD137, AD145, AD174, AD194, AD213, AD215, AD218, AD222, AD224 and AD234) exceeded the drinking water standard, 1 domestic/stock well exceeded the drinking water standard (ADS028), and there were 0 stock wells that exceeded the livestock standard.

The complete lab analysis data is provided in Appendix A, Table 1. Water Well Field Data, 01/01/11 – 12/31/11 Plus Historical Results 01/01/04 – 12/31/11: Wells Permitted for Domestic-use and Stock-use.

Water Wells Permitted Through the Wyoming State Engineer's Office for Miscellaneous Use

Field Data

Wells permitted for miscellaneous-use may include wells used for industrial purposes within the PAPA.

The following results were taken with an Oakton PC 300 multi-parameter field meter and a Ravensgate Sonic Water Level Meter, and represent the range of data collected from the specific well-use group. Multiple readings are taken per well visit for conductivity, TDS, temperature and pH. The last set of recordings per visit was used for the following ranges. Water level is taken only when access into the well is possible or pump has not been recently active.

<i>Field Data Collected</i>	<i>Range</i>
<i>Conductivity (us/cm)</i>	253 to 2730
<i>TDS (ppm)</i>	127 to 1360
<i>Temperature (Celcius)</i>	5.6 to 26.1
<i>pH</i>	7.16 to 10.08
<i>Water Levels (feet)</i>	0 to 679.3

The complete field data, including details regarding sampling methods, is provided in Appendix A, Table 2. Water Well Field Data, 01/01/11 – 12/31/11 Plus Historical Results 01/01/04 – 12/31/11: Wells Permitted for Miscellaneous-use.

Laboratory Data

The following results are from 140 samples collected from 118 wells. "ND" represents non-detectible.

<i>Lab Data</i>	<i>Range</i>
<i>Alkalinity (mg/L)</i>	72 to 313
<i>Calcium (mg/L)</i>	ND to 75
<i>Chloride (mg/L)</i>	2 to 264
<i>Fluoride (mg/L)</i>	0.1 to 12
<i>Magnesium (mg/L)</i>	ND to 12
<i>Potassium (mg/L)</i>	ND to 4
<i>Sodium (mg/L)</i>	5 to 567
<i>Sulfate (mg/L)</i>	ND to 1010
<i>TDS (mg/L)</i>	145 to 1690

The complete lab analysis data is provided in Appendix A, Table 2. Water Well Field Data, 01/01/11 – 12/31/11 Plus Historical Results 01/01/04 – 12/31/11: Wells Permitted for Miscellaneous-use.

Hydrocarbon Results

To address hydrocarbons in water wells, WDEQ uses a set of ground water clean-up levels to help guide them in determining a point of contamination:

- *Ground Water Cleanup Levels:* DRO, 1.1 mg/L or 10 mg/L; GRO, 7.3 mg/L; benzene, 5 ug/L; ethylbenzene, 700 ug/L; m+p-Xylenes, 10,000 ug/L; o-Xylene, 10,000 ug/L; and toluene, 1,000 ug/L.

The cleanup level for DRO can be either 1.1 mg/L or 10 mg/L depending on the results of other parameters, some of which have not been tested for by SCCD.

Hydrocarbons reported as Diesel Range Organics (DRO), Gasoline Range Organics (GRO) or BTEX have been detected in a total of 11 wells from January 1, 2011 through December 31, 2011. Nine of these water wells are permitted for miscellaneous-use, 1 for domestic use and 1 is a stock-use water well.

The following laboratory results are from samples collected from January 1, 2011 through December 31, 2011. BTEX (benzene, ethylbenzene, m+p-Xylenes, o-Xylene, and toluene) was only tested for when previous results showed hydrocarbon related detections.

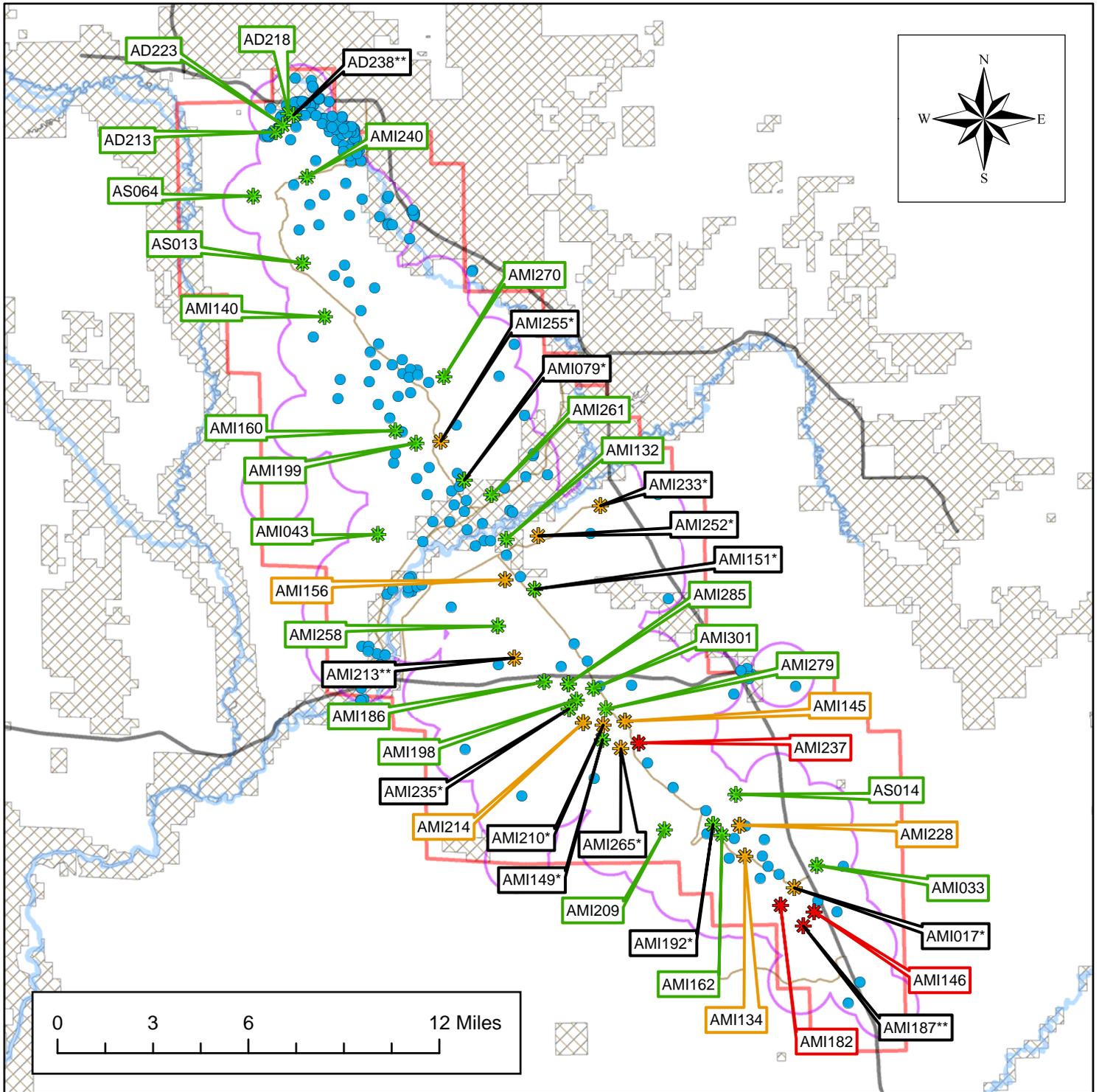
- *DRO* was detected in a total of 4 wells with results ranging from 1.2 mg/L to 9.1 mg/L. Three are miscellaneous-use wells (AMI156, AMI214 and AMI228), and 1 is a stock-use well (AS013).
- *GRO* was detected in a total of 9 wells with results ranging from 0.022 mg/L to 0.64 mg/L. Of those, 8 are miscellaneous-use wells (AMI145, AMI146, AMI156, AMI182, AMI214, AMI228, AMI237 and AMI258). The remaining well is AD218, a domestic well. All levels were under the cleanup level.
- *Benzene using method SW8021B* was detected in a total of 3 wells with results ranging from 5.2 ug/L to 75 ug/L. All are miscellaneous-use wells (AMI146, AMI182 and AMI237) with levels over the cleanup level.
- *Benzene using method SW8260B* was detected in 1 well with results ranging from 54 ug/L to 65 ug/L. This is a miscellaneous-use wells (AMI237) with levels over the cleanup level.
- *Ethylbenzene using method SW8021B* was detected in 1 well with results ranging from 3.8 ug/L to 4.4 ug/L. This is a miscellaneous-use well (AMI237) with levels under the cleanup level.
- *Ethylbenzene using method SW8260B* was detected in 1 well with results ranging from 4.2 ug/L to 4.5 ug/L. this is a miscellaneous-use well (AMI237) with levels under the cleanup level.
- *m+p-Xylenes using method SW8021B* was detected in a total of 2 wells with results ranging from 2.5 ug/L to 33 ug/L. Both are miscellaneous-use wells (AMI134 and AMI237) with levels under the cleanup level.
- *m+p-Xylenes using method SW8260B* was detected in a total of 4 wells with results ranging from 1.2 ug/L to 37 ug/L. All are miscellaneous-use wells

(AMI134, AMI214, AMI237 and AMI258) with levels under the cleanup level.

- *o-Xylene using method SW8021B* was detected in 1 well with results ranging from 3.5 ug/L to 4 ug/L. This is a miscellaneous-use well (AMI237) with levels under the cleanup level.
- *o-Xylene using method SW8260B* was detected in a total of 2 wells with results ranging from 3.5 ug/L to 10 ug/L. Both are miscellaneous-use wells (AMI214 and AMI237) with levels under the cleanup level.
- *Total Xylene using method SW8021B* was detected in a total of 2 wells with results ranging from 2.9 ug/L to 37 ug/L. Both are miscellaneous-use wells (AMI134 and AMI237).
- *Total Xylene using method SW8260B* was detected in a total of 4 wells with results ranging from 1.8 ug/L to 41 ug/L. All are miscellaneous-use wells (AMI134, AMI214, AMI237 and AMI258).
- *Toluene using method SW8021B* was detected in a total of 6 wells with results ranging from 1.4 ug/L to 140 ug/L. All are miscellaneous-use wells (AMI145, AMI156, AMI214, AMI228, AMI237 and AMI258). All levels were under the cleanup level.
- *Toluene using method SW8260B* was detected in a total of 6 wells with results ranging from 1.4 ug/L to 170 ug/L. All are miscellaneous-use wells (AMI145, AMI156, AMI214, AMI228, AMI237 and AMI258). All levels were under the cleanup level.

The complete hydrocarbon analysis data is provided in Appendix B, Table 3. History of Water Wells With Hydrocarbon Detections 01/01/04 – 12/31/11 including additional parameters tested for BTEX method SW8260B.

Map 3. Water Wells With Past Hydrocarbon Detections



- Private lands
- Main rivers
- Main highways
- Secondary roads within PAPA
- Pinedale Anticline Project Area
- One mile sampling area
- Wells visited in 2011

Status of wells (last time sampled by SCCD)

- Hydrocarbon detections over WYDEQ clean-up levels
- Hydrocarbon detections under WYDEQ clean-up levels
- Hydrocarbons non-detectible

* well has been plugged & abandoned ** well is no longer part of SCCD sampling program

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*Details of water wells with new hydrocarbon related detections since last reported
(Pinedale Anticline Ground Water Data Summary, February, 2011).*

AD218 / DC-8 / Emmanuel Baptist Church

This well is a new well that was sampled for the first time 09/09/11 shortly after plumbing was in place with results showing a GRO detection of 0.13 mg/L. According to the plumber, the well was run for 5 to 6 hours, all at once, prior to this sampling event. The well was re-sampled on 12/12/01 after water had been run through the plumbing system for an unknown time and amount. Results from the second sample event showed ND (non-detect) for all hydrocarbon related parameters including BTEX.

AS013 / Mount Airy – 2 #4694 / BLM stock well

This well has been sampled since 2006 with samples collected with polyethylene bailers since 2007. In 2009 SCCD found this well without a cover prior to collecting samples. The water was very foul smelling and once bailers were brought to the surface, SCCD staff discovered what was causing the odor; decaying animal matter was stuck to the outside as well as inside of the bailers. Each year after this event, the smell has lingered as well as remnants of the decaying matter. The 09/13/11 sample showed a DRO detection of 1.2 mg/L. Confirmation samples were collected 10/26/11 with all hydrocarbon related parameters showing ND including BTEX.

AMI145 / Warbonnet 11-10 / Shell

This well has been sampled since 2004. Results from the 09/22/11 samples showed a GRO detections of 0.023 mg/L after 80 barrels of water had been pumped. Confirmation samples were collected on 10/20/11 after 72 barrels had been pumped with results showing a toluene detection of 6.7 ug/L, but no GRO detection. At the request of the operator, another sample was collected after an additional 147 barrels had been pumped with results from that sample showing a toluene detection of 4.5 ug/L.

AMI156 / Riverside 2-24 / Shell

This well has also been sampled since 2004. Results from the 10/12/11 sample showed a GRO detection of 0.076 mg/L after 74 barrels of water had been pumped. Confirmation samples were collected on 11/23/11 after 75 barrels had been pumped. Results from that sample showed a DRO detection of 2.2 mg/L, a GRO detection of 0.022 mg/L and a toluene detection of 8.5 ug/L.

The complete hydrocarbon analysis data is provided in Appendix B, Table 3. History of Water Wells With Hydrocarbon Detections 01/01/04 – 12/31/11 including additional parameters tested for BTEX method SW8260B.

Literature Cited

- The Record of Decision for the Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project, Sublette County, Wyoming, Bureau of Land Management, Pinedale Field Office, July 2000
- Water Quality Rules and Regulations, Chapter 8, Wyoming Department of Environmental Quality, 2003
- Voluntary Remediation Program, Fact Sheet #12, Soil Cleanup Level Look-Up Table, Appendix A: Cleanup Levels for Total Petroleum Hydrocarbons in Soil and Groundwater, Wyoming Department of Environmental Quality, 2008
- Pinedale Anticline Ground Water Data Summary, Sublette County Conservation District, February, 2011
- Sublette County Conservation District's Ground Water Monitoring Manual and Protocol, March 2010
- Water Quality Monitoring Sampling and Analysis Plan for the PAPA, March 2008