Pinedale Anticline
Ground Water Data Summary

Heather Cole, Ground Water Quality Specialist
Sublette County Conservation District
1625 Pine Street, PO Box 36
Pinedale, WY 82941
(307)367-2257 ext. 120
August 25, 2008

INTRODUCTION

The Pinedale Anticline Project Area (PAPA) 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. This area is currently undergoing gas exploration development. 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 the 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. 20)

The Sublette County Conservation District (SCCD) was chosen to fulfill the above requirements. The SCCD developed a ground water monitoring program in 2001 and began ground water sampling August 23, 2004. The fall 2007 sampling season and spring 2008 sampling season concluded the 4th year of monitoring. The fall 2007 season ran from July, 2007 through December, 2007 and the spring 2008 sampling season ran from April, 2008 through June, 2008.

REPORT OBJECTIVE

The purpose of this report is to provide a summary of the data collection procedures and the lab analysis results from July 2007 through the most current data possible. This includes one complete year of sampling plus one month, and excludes July 30th, 2008 lab data, as it has not been released from the lab as of 8/23/08. During this time frame, 257 total samples were collected. Of these, 183 were collected in the fall 2007 season, 60 were collected in the spring 2008 season, and the remaining 14 were collected in the fall 2008 season. The information collected from the water wells provides baseline data.

METHODS

The SCCD ground water monitoring program began sampling in 2004 and has since collected 856 ground water samples from 260 water wells within one mile of an existing or proposed gas well within the PAPA. The data collected includes water level, GPS coordinates, field parameters and laboratory analysis data. Field parameters are measured at the same time the laboratory bottles are filled. The parameters measured in the field include pH, conductivity, total dissolved solids (TDS) and temperature. Field notes are made regarding procedure used to sample, activity on location, potential contamination and other field information.

Prior to 2008, new wells and 10 percent of the re-sampled wells were tested for total petroleum hydrocarbons (TPH) using method 1664A. Beginning with the spring

2008 sample season, all wells have been tested for TPH. The TPH analytical method has also been changed to the 8015 method as it is more sensitive to light range hydrocarbons. This TPH method tests for Diesel Range Organics (DRO) and Gasoline Range Organics (GRO). Samples in which DRO or GRO were detected have been sampled a second time and also analyzed for benzene, ethylbenzene, m+p-xylenes, o-xylene and toluene (BTEX). All lab and field data has been entered into the Sublette County Conservation District database and quality control measures are taken prior to release.

In each incident of detected TPH, the relevant operator contact was notified immediately and lab reports were sent to the operator and SCCD Board of Supervisors. A second sample was taken from each of these wells to confirm the first analysis, unless the SCCD had a previous TPH detection in that well. BTEX was also analyzed on the second set of samples.

The specific procedures used to take samples and to measure water level per water well are given in *Appendix I, Table 1*. Ground Water Sampling Procedures 07/01/07 through 7/31/08 and *Table 2.* Water Level Data 07/01/07 through 7/31/08. The SCCD used the following protocols for sampling procedures: Ground Water Monitoring Protocol Manual, Pinedale Anticline Project dated October 2004 by HydroGeo, Inc. and ASTM Standard D4448-01, Standard Guide for Samlping Groundwater Monitoring Wells, 1985.

The locations of all water wells that have had GPS data collected from July 2007 through July 2008 are listed in attached *Appendix I, Table* 3. Locations of Water Wells Visited 07/01/07 through 7/31/08. *Appendix I, Table 7*. Water Well Ownership, provides the corresponding well name, and owner to each well ID. These wells may or may not have been sampled depending on their current status.

RESULTS

There were a total of 257 samples taken on 220 wells. 183 of these samples were taken in 2007 and 74 were taken in 2008. Some of these were duplicates and some were second sample sets taken when a TPH detection was found.

Field Parameters:

The field pH values ranged from 6.43 to 10.7. Domestic wells averaged 8.25 while the miscellaneous industrial wells averaged a pH of 9.15 and stock wells averaged 8.4. Field TDS values ranged from 78 us/cm to 2000 us/cm. Water levels ranged from 0 ft. to 111.95 ft. for domestic wells, 4.82 ft. to 368.35 ft. for stock wells and 0 ft. to 694.72 ft. for industrial wells. The complete field parameter data set is provided in *Appendix I, Table 5*. Water Well Field Parameter Data 07/01/07 through 07/31/08. The complete water level data set is provided in *Appendix I, Table 2*. Water Level Data 07/01/07 through 07/31/08.

Laboratory Data:

Collected chemical data is provided in *Appendix I, Table 4*. Available Laboratory Analysis Data Report 07/01/07 through 07/31/08. The Wyoming Department of Environmental Quality (DEQ) and Environmental Protection Agency (EPA) has established drinking water and livestock water quality standards. Some of these overlap with parameters analyzed in the SCCD Groundwater Monitoring Project. The standards for these parameters are given below:

- *Drinking Water Standards*: Chloride (250 mg/L); Fluoride (4 mg/L); Oil and Grease (virtually free); Sulfate (250 mg/L); and Total Dissolved Solids (500 mg/L).
- *Livestock Standards*: Chloride (2000 mg/L); Oil and Grease (10.0 mg/L); Sulfate (3000 mg/L); and Total Dissolved Solids (5000 mg/L).

The following are the results of the parameters compared to the above standards:

- *Chloride* - Values ranged from non-detect to 326 mg/L.
  - Non-detects were mainly domestic wells.
  - Two industrial wells exceeded the drinking water standard.

- *Fluoride* - Values ranged from non-detect to 16.2 mg/L.
  - All wells passed the livestock standards.
  - 50 water wells exceeded the drinking water standard.
    - 8 of these were domestic and 2 were stock wells.

- *Sulfate* - Values ranged from non-detect to 1620 mg/L.
  - There were 36 wells that exceeded the drinking water standards.
    - five were stock wells and seven were domestic wells.
  - No wells exceeded the livestock standard.

- *Total Dissolved Solids (TDS)* - Values ranged from 92 mg/L to 2610 mg/L.
  - 48 wells exceeded the drinking water standard.
    - Five of these were stock and eight were domestic wells.
  - The livestock standard was not exceeded.

Many parameters were measured that do not have DEQ or EPA standards. These parameters include alkalinity, calcium, magnesium, potassium, sodium, conductivity, calcium SAR, magnesium SAR, anion/cation balance and TDS balance.

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

TPH results:

Total petroleum hydrocarbons reported as diesel range organics (DRO), gasoline range organics (GRO) or BTEX have been detected in a total of 15 wells. Fourteen of these are industrial wells and one is a stock well. The data for all wells with detectable hydrocarbons is provided in Appendix I, Table 6. Laboratory Analysis for Wells with Detectable Hydrocarbons**.**

- *Diesel Range Organics (DRO)* – Values ranged from non-detect to 380 mg/L.
  - Analyzed in 74 samples on 60 wells.
  - Detected in three wells, with the reporting limit at 1mg/L
    - All wells were industrial, one of these wells was over standard.

- *Gasoline Range Organics (GRO)* ─ Values ranged from non-detect to 241 mg/L.
  - Analyzed in 89 samples on 67 wells
  - Detected in 11 wells, with the reporting limit at 0.04 mg/L.
    - All wells were industrial, one of these wells was over standard.

- *BTEX* - benzene, ethylbenzene, m+p-xylenes, o-xylene and toluene
  - Analyzed in 28 samples on 17 wells.
  - Detected in 12 wells.
    - 11 industrial and one stock well.
    - Three industrial wells exceeded the MCL for at least one of the BTEX components.

- Total Petroleum Hydrocarbons (method 1664A)
  - Analyzed only in fall 2007 samples.
  - 59 total samples with zero detections

The wells that were under TPH standards include AS014, AMI140, AMI160, AMI162, AMI186, AMI285, AMI198, AMI199, AMI209, AMI210, AMI233 and AMI252. The wells that were higher than the standard are the AMI132 (Riverside 15-12), AMI237 (Warbonnet 7-15D) and the AMI149 (Blue Rim State #2).

AS014 refers to the N.W. Squaretop stock well owned by the BLM. It is the first and only stock well to show any amount of TPH and only the third to have BTEX, GRO and DRO analyzed. This well was sampled for the first time on June 29, 2007 with a bailer and tested for TPH (1664A). No TPH was detected in this sample. The well was sampled again on July 1, 2008 after running a pump for 15 mintues. GRO and DRO bottles were filled and sent to Energy Labs as usual. The lab then inadvertently ran BTEX in addition to GRO (the same bottles can be used for the two tests). The results showed 13ug/L of toluene and non-detect for all other hydrocarbons. The well was sampled a second time on July 31, 2008 after pumping it for another 15 minutes.

Duplicate samples were also filled. Both of these samples had less than one ug/L toluene and were non-detect for all other hydrocarbons.

The AMI132 (Riverside 15-12) has been sampled each year since 2004 but was tested for TPH only once prior to 2008. There has been no color or odor recorded for this well prior to 2008. This well was sampled using a bailer on 7/2/08 and the well cap was locked. As the bailer was being reeled back out of the well, field personnel noticed a strong odor to the water, although it was fairly clear. Further observation revealed a sheen on the water. A duplicate sample was taken. The lab results showed all under standard amounts of BTEX, GRO and DRO. A second sample was taken on 7/23/08 to verify the previous results. A sample was taken from 25ft, just below the water level, and from the usual sample depth of 300ft. These samples were bailed using a rope. The water from these samples, taken only three weeks later, was a dark brown or tan color and had a strong odor. Lab results for both samples showed above standard levels of BTEX, GRO and DRO and were the highest TPH levels to date.

AMI237 (Warbonnet 7-15D) was first sampled in 2006. It showed above standard benzene in 2007 along with less than 1mg/L GRO. The 2008 sample showed .716 mg/L GRO and non-detect for DRO. Benzene was not analyzed in the 2008 sample.

AMI149 (Blue Rim State #2) was sampled in 2005 for TPH (1664A) and showed non-detect. The 2006 sample was not analyzed for TPH. The 2007 sample was analyzed for BTEX, TPH (1664A), GRO and DRO due to the color and odor of the water being pumped. This sample was taken on 10/9/07. Two sample sets were later taken on 11/5/07. One was taken after running the pump for 15 minutes and one was taken after running the pump for 3 hours. Benzene went from 5.2ug/L to 4.8ug/L after 3 hours, however toluene stayed at 13ug/L for both samples and GRO went from .051ug/L to .052 ug/L after 3 hours.

The data for all wells with detectable hydrocarbons or BTEX is provided in *Appendix I, Table 6*. Laboratory Analysis for Wells with Detectable Hydrocarbons.

Upon arrival at a sampling location, a Gas Alert Micro is used to determine if there are unsafe levels of gas in the water well. This is done only for wells that are bailed. There were 9 wells that caused a lower explosive limit (LEL) alarm and therefore could not be sampled. One of these wells, the Antelope 1-16, (AMI187), has been contaminated in the past. This well has had a pump in past years and therefore has been sampled without checking for gas. The June 2007 results showed 25 ug/L of benzene, where the maximum contaminant level (MCL) is 5ug/L. In 2008, the well was bailed and therefore was checked with the gas meter before sampling and caused an alarm.

There were seven wells that had been previously sampled and are now plugged. These wells are as follows: AMI083, AMI123, AMI130, AMI197, AMI206, AMI247 and AMI252. The AMI252 is the only on that has record of past TPH contamination.

CONCLUSION

The SCCD has been conducting the groundwater monitoring program to fulfill the requirements of the ROD since 2001. Sampling has been ongoing since 2004 and the SCCD is currently working on the fifth year. The project will continue to incorporate additional water wells based on their proximity to the growing number of gas production

wells. These water wells may consist of newly drilled wells or preexisting wells. Wells may also be taken off the sampling list as some are scheduled to be plugged. The SCCD will continue to work with the operators as well as the Wyoming State Engineer's Office to determine the current status and the locations of the water wells within the PAPA.

Literature Cited

Groundwater Monitoring Protocol Manual, Pinedale Anticline Project dated October 2004, HydroGeo, Inc.

ASTM Standard D4448-01, Standard Guide for Sampling Groundwater Monitoring Wells, 1985.

Ground Water Monitoring Plan Pinedale Anticline Project Area, May 2, 2003.

The Record of Decision for the Environmental Impact Sataement for the Pinedale Anticline Oil and Gas Exploration and Development Project, Sublette County, Wyoming July 2000.

Water Quality Rules and Regulations, Wyoming Department of Environmental Quality, Chapter 8, 2003.

Appendix I

(see tables 1 through 7)