

APPENDIX B: NATURAL GAS DEVELOPMENT IN THE PICEANCE BASIN

B1 Geology

This brief summary of the area's geology provides additional context for understanding the potential drilling plan, in particular how the geology of the region relates to proposed drilling methods.

The Battlement Mesa PUD rests on top of a geologic formation known as the Piceance Basin. The Piceance Basin stretches underneath seven Colorado counties, including Garfield County, where Battlement Mesa is located. The Piceance Basin is a part of the larger Uinta-Piceance Province, which is 40,000 square miles in area. Of the larger Uinta-Piceance Province, the Piceance Basin is approximately 100 miles long and 40-50 miles wide. The Axial Uplift forms the Piceance's northeastern border and the White River Uplift forms the eastern border. The Douglas Creek Arch forms the Piceance Basin's western border. The southern border is roughly parallel with and north of the Uncompahgre Uplift axis.

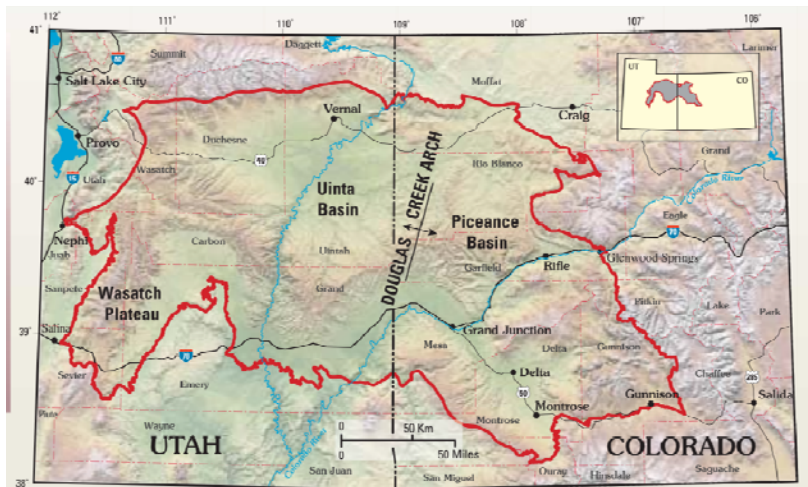


Figure 1. Uinta-Piceance Province located in northwestern Colorado and northeastern Utah. The Douglas Creek arch separates Piceance Basin from Uinta Basin. The Wasatch Plateau is included in this province.

104

The Piceance Basin, however, is not simply an area of land, the Piceance Basin refers to the geology underlying the area previously described. Therefore, it is useful to consider the Basin as

being “deep” as well as “wide.” At its deepest section, the Phanerozoic sedimentary rock* of the Piceance Basin extends 20,000 feet below the Earth’s surface.

The Piceance Basin was formed during a period geologists call the Tertiary Period¹⁰⁵ – which ranges from approximately 65 million years ago to 1.8 million years ago¹⁰⁶. The layers of rock and sediment that comprise the Piceance Basin include significant deposits of petroleum, much of which geologists term “unconventional” petroleum. As opposed to “conventional” reserves of hydrocarbons, that can be accessed using oil well technology from the 1800’s, unconventional reserves such as tight sands, shale gas, coal bed methane and oil shale require more technologically advanced extraction methods. While all of the types of unconventional reserves previously listed are embedded in the Piceance Basin¹⁰⁵, the type of unconventional reserve that relates most directly to Antero’s proposed drilling plan in Battlement Mesa are tight sands.

Tight Sands

Tight sands are deposits of compacted sediment or hard rock that are saturated with natural gas (also known as methane or methane gas). Operators require advanced technologies - particularly hydraulic fracturing and/or acidizing – to access the methane gas permeating tight sand formations.

According to a United States Geological Survey (USGS) assessment of the Uinta-Piceance Province, “Major resources of tight gas are present in the province.”¹⁰⁵ The same USGS assessment highlights two notable tight gas plays in the Piceance Basin. Both tight sands plays are in the Mesaverde Group, and the USGS differentiates them from each other by the quality of the reservoirs, their respective depths and other geological characteristics (i.e. stratigraphy).

Williams Fork Play

Rivers and streams deposited the sediment in the Williams Fork Play. The play’s thickness ranges between 1,500 feet and 4,500 feet. To access methane gas embedded in the Williams Fork Play, natural gas companies need to drill anywhere from 5,500 feet to more than 9,800 feet. The average drill depth for the Williams Fork Play in the Piceance Basin is 7,500 feet.

At the time the USGS assessment was performed, geologists from USGS and industry were “attempting to determine why water is being recovered from horizontal wells; whereas, vertical wells in the same areas do not produce significant amounts of water.” The author hypothesized that the water was from open natural fractures. One implication of the recovered water, noted the assessment’s author, is that “operators may need to attempt to dewater the wells through sustained production.” Although Antero has indicated that their natural gas drilling within the PUD will primarily involve the Williams Fork Play they have also indicated that they are also going to explore the Mancos shale beneath the Williams Fork.

* I.e. sedimentary rock from the Phanerozoic Eon – the current eon of the geologic timescale – which covers the previous 542 million years

Iles Play

The Iles Play lies directly beneath the Williams Fork Play. Sediment in the Iles Play is marine and marginal marine (i.e. deposits from oceans, as opposed to rivers and streams). The Iles Play is approximately 500-1,500 feet thick. To access the Iles Play, natural gas companies would need to drill between 5,800 feet, in excess of 10,000 feet. On average, the drill depth in the Iles Play is 7,700 feet.

*Mancos Shale*¹⁰⁷

In addition to the Williams Fork Play and the Iles Play, it's important to mention a shale formation commonly called the "Mancos Shale" formation. The Mancos Shale is comprised of mudrock (i.e. hardened mud) that was deposited by the Cretaceous Interior seaway between 90 and 85 million years ago. The Mancos Shale is interconnected with the Williams Fork Play and the Iles Play.

B2 Energy Development in the Piceance Basin: Past

The 1973 Organization of the Petroleum Exporting Countries (OPEC) oil embargo and subsequent fluctuations in the price of crude oil created strong financial incentives for the United States to reconsider its dependence on foreign oil. The United States' Government invested in programs, such as the Synthetic Fuels Corporation, to support research and development of alternative fuel sources (such as oil shale and coal gasification)¹⁰⁸. Private energy companies also invested in what seemed to be a growing market for domestically produced fuels. In 1980, the Exxon Corporation announced its Colony Oil Shale Project, which involved developing the oil shale resource within Garfield County. They began building the Battlement Mesa Planned Urban Development (PUD) shortly thereafter. The Battlement Mesa PUD was originally created as a company town for Colony Project workers³. However, when crude oil prices dropped in the early 1980's, the economic viability of oil shale collapsed. On May 2, 1982, the Colony Project was shut down, thereby eliminating 2,200 jobs³. Following the oil shale bust and subsequent exodus of oil shale workers, Exxon marketed the Battlement Mesa PUD as a retirement community until December 1989 when it sold the PUD's surface rights and mineral rights to the Battlement Mesa Company (BMC)³. Though the BMC continues to operate rental properties (primarily town homes and mobile homes) for local workers and their families, the BMC continued to market Battlement Mesa as a retirement community. By 1998, more than two-thirds of Battlement Mesa's residents were retirees¹⁰⁹.

B3 Energy Development in the Piceance Basin: Present

The United States' dependence on fossil fuels has re-emerged as an issue of national political significance. As in the 1970's, policymakers in Federal and State agencies have been considering incentives to promote "alternative" sources of energy (i.e. energy sources that are neither conventional petroleum reserves nor coal reserves). One such energy source, which is

abundantly infused into the geology of Western Colorado's Piceance Basin¹⁰⁵, is methane – commonly referred to as “natural gas.”

In April, 2010, Colorado House Bill 1365, referred to as the “Clean Air – Clean Jobs” initiative, became law. The new law is to provide resources to reduce emissions of air pollutants through retiring, retrofitting, or reprocessing Front Range coal-fired power plants by replacing them with facilities fueled by natural gas or other lower or non-emission sources. This action “will jumpstart our natural gas sector the same way we are driving Colorado’s solar and wind industries, according to Governor Bill Ritter,”¹¹⁰. The Governor went on to say that the “Clean Air-Clean Jobs” law will bring “economic, energy and environmental benefits together in one package.”¹¹⁰ Even before House Bill 1365 was signed into law, though, Colorado’s natural gas industry had been expanding rapidly, in Garfield County, as well as other parts of the state. High oil prices and technological advances such as hydraulic fracturing and directional drilling were making Colorado’s vast “unconventional” natural gas reserves increasingly viable economically. In Garfield County, Colorado, the increased demand for extraction of natural gas was most apparent between 2003 and 2008. As a rapid influx of new workers arrived in Garfield County, some of them bringing families, hotels and motels filled quickly. Temporary housing facilities, commonly referred to as “man camps” were established. The pace of development stressed local infrastructure, creating concerns at the local and state levels of government. In 2009, the Colorado State Legislature implemented revised regulations governing oil and gas development, in part, to minimize development’s impact on public health and the environment¹¹¹. Continued, and possibly accelerated expansion of the natural gas industry within Garfield County is expected with the passage of House Bill 1365.

B4 Antero’s Plan in Battlement Mesa

This section of Appendix B gives a brief overview of what information Antero has shared with the community as to its Plan to drill for natural gas in the PUD. A review of the natural gas drilling process is presented in Appendix A.

In the Spring of 2009, Antero announced plans to purchase surface rights and mineral rights from the BMC. Along with this, Antero indicated its intent to drill for natural gas within the Battlement Mesa PUD. It is important to keep in mind that Antero’s drilling plans have not and will not be determined entirely by Antero. In addition to the federal, state and local regulations, drilling activities in the PUD are subject to three separate Surface Use Agreements (which are legally binding agreements for the parties entering into them). This section briefly summarizes the Surface Use Agreements determining how and where drilling activities will occur in the PUD:

Surface Use Agreement #1: Exxon and BMC – December 12, 1989

This Surface Use Agreement will always be effective as a condition of BMC’s purchase of the PUD. It requires that before mineral resources within the PUD are developed, a formal Surface

Use Agreement must be executed. This initial Surface Use Agreement also established “general” locations for 16 well pads – 15 of which are within the PUD. BMC agreed to accommodate necessary changes to the locations. This Surface Use Agreement also required that in the event that surface development and mineral resource development were in conflict, there needed to be alternate locations for the drill sites.

Surface Use Agreement #2: Barrett Resources and BMC – August 6, 1990

This Surface Use Agreement is only binding for the natural gas operator Williams (which is Barrett Resources’ successor in the Surface Use Agreement). Various restrictive provisions exist within the Surface Use Agreement to dictate how Williams can develop resources in the PUD. Among them is a provision that wells be set back at least two hundred feet from existing structures.

Surface Use Agreement #3: Antero Resources and BMC

According to the Surface Use Agreement (Surface Use Agreement) entered into between Antero and the BMC, the Battlement Mesa PUD development project will utilize horizontal drilling techniques and hydraulic fracturing stimulation to develop approximately 200 gas wells on 10 pads distributed throughout the residential community. The full Surface Use Agreement is included in [Attachment 2].

While the Surface Use Agreement is a worthwhile basis for understanding Antero’s plans, it is not a legally binding agreement with BOCC. Only the Major Land Use Impact Review will represent a contract between BOCC and Antero. The Surface Use Agreement includes provisions (in addition to compliance with existing regulations) that are intended to reduce any potential impacts on the Battlement Mesa community’s health and quality of life.

This is a summary of some, but not all, provisions in the Surface Use Agreement # 3 between Antero and the BMC⁷:

Wellsite Locations

The Surface Use Agreement identifies ten locations where Antero will erect drilling rigs and one site where Antero will build a covered water handling facility.

Access Roads

Access roads Antero builds to and from its well pads must be 20 feet wide and gated. Antero agreed to keep the access roads clean and suppress dust generated on the access roads.

Pipelines

The pipelines that gather gas must be at least 48 inches deep except where BMC and Antero agree that the pipelines need to accommodate existing infrastructure (in particular, gravity-dependent facilities including but not limited to sewer lines). Antero was granted 25 foot easements to install, operate maintain and repair permanent pipelines. They were also granted 50 foot easements for pipelines during construction.

Power/Telephone/Transformers

The only situation in which power lines, transformers and data transmission lines can be installed at a pre-identified well location is when they are necessary for the operation of production equipment.

Hours of Operation

BMC does not restrict the times of day when Antero can be engaged in drilling, completing, re-completing, well workover or reservoir stimulation operations. For routine maintenance, development and production, the Surface Use Agreement requires Antero to work between 7 AM and 8 PM, except in the event of an emergency.

Noise Abatement

Antero needs to be in compliance with COGCC standards that relate to noise (e.g. COGCC Series 802 Noise Abatement Rule⁴⁸). There will be no centralized compression stations, which could be sources of constant noise, in the PUD. Hospital-grade mufflers will be installed on high noise output machinery.

Lighting Abatement

Rigs will be oriented to direct light away from closest homes. Antero “shall use appropriate technology to minimize light pollution emanating from the Property, including, but not limited to, utilization of low density sodium vapor lighting.”

Air Emissions and Odor Abatement

Antero will use mats, soil tack and/or liquid dust suppressants as necessary to suppress dust. Antero can not flare wells within 2,000 feet of an occupied dwelling, unless they take the measures specified in the COGCC rules to contain the flare or unless there is an emergency. Antero will comply with Colorado Department of Public Health and Environment (CDPHE) Air Quality Control Commission Regulations. At the “F” pad, there will be a centralized water handling facility that will be lined and covered.

Noxious Weed Management

Antero will implement a noxious weed management plan in accordance with Garfield County and COGCC requirements. While it is expected the weed management plan will be similar to weed management plans currently in place within the PUD, the plan was not available for review at the time of this HIA report.

Visual Impact Mitigation and Reclamation of Wellsite Locations

Antero will construct well pads that mitigate the visual impact using berms and trees to shield the pad from view. Some drill rigs will be shrouded.

Environment and Safety

Antero will comply with all applicable COGCC, CDPHE, United States Environmental Protection Agency (EPA), Comprehensive Environmental Response Compensation and Liability Act (also known as CERCLA), Resource Conservation and Recovery Act (also known as RCRA), Oil Pollution Act, and Clean Water Act regulations. These include, but are not limited to, stipulations pertaining to sanitary facilities; refuse, trash and solid waste disposal; hazardous materials; spills of oil, gas and other hazardous chemicals; spill prevention and control plans; employee training; and employee housing.

Emergency Communications

Antero will comply with local, state and federal reporting requirements in all emergency situations.

Operator's Sole Risk: Insurance

Antero assumes all risk and liability of "any natural incident to, occasioned by or resulting in any manner, directly or indirectly, from (Antero's) operations hereunder."

Owners' Utilities

If Antero requires any utility lines to service any of the well site locations, Antero will pay to locate the lines underground.

The Surface Use Agreement does not address environmental monitoring.

Antero has described a three-phase development plan for the Battlement Mesa project. (Battlement Mesa Website)

- Phase 1 will develop the Stierberger Pad, Pad E, Pad G and the water storage facility (Pad F) on the south side of the PUD.
- Phase 2 will develop the Parks and Rec Pad, Pad A, Pad B and Pad D on the north side of the PUD.
- Phase 3 will develop the L and M pads on the northeast side of the PUD.

Each phase will involve access road, pad and pipeline construction needed to develop the wells and tie them to the water movement system and the gas gathering lines at the eastern edge of the PUD. At this time, Antero anticipates that all three phases will be completed in five years. A slower development scenario is possible and could depend upon the natural gas economy, internal Antero priorities, regulatory impacts, etc. This HIA is based upon the five-year development concept currently favored by Antero.