LMS/RBL/47241-0.0

Long-Term Surveillance and Maintenance Plan for the Rio Blanco, Colorado, Site

October 2025

U.S. DEPARTMENT OF ENERGY | Legacy Management

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Abbreviations

AEC	U.S. Atomic Energy Commission
AMSL	above mean sea level
bgs	below ground surface
BLM	U.S. Bureau of Land Management
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curies
DOE	U.S. Department of Energy
ECMC	Energy and Carbon Management Commission
EPA	U.S. Environmental Protection Agency
ERDA	U. S. Energy Research and Development Administration
ft	feet
GEMS	Geospatial Environmental Mapping System
IC	institutional control
LM	Office of Legacy Management
LTHMP	Long-Term Hydrologic Monitoring Program
LTS&M Plan	Long-Term Surveillance and Maintenance Plan
MMCF	million cubic feet
QSM	Quality Systems Manual
SGZ	surface ground zero

Executive Summary

The U.S. Department of Energy Office of Legacy Management (LM) prepared this Long-Term Surveillance and Maintenance Plan (LTS&M Plan) for the Rio Blanco, Colorado, Site, which was the location of an underground nuclear test that included three nuclear devices that were detonated nearly simultaneously in a single emplacement well in May 1973. The Rio Blanco site is in the Piceance Basin of northwestern Colorado approximately 52 miles north-northeast of the City of Grand Junction.

Site decommissioning and cleanup activities were initiated in May 1976 and completed in November 1976. A corrective action investigation and risk assessment were completed for the site surface in 2002 and surface remediation was completed 1986 (DOE 1986). Groundwater samples collected in 2002 showed no project related contaminants above the screening levels established by the U. S Environmental Protection Agency. The subsequent report recommended that no corrective actions be required, and no surface use restrictions be placed on the site. The Colorado Department of Public Health and Environment reviewed and approved the report in 2003.

This LTS&M Plan documents LM's operational plan and commitment to long-term stewardship of the site. It summarizes the site's regulatory framework, geologic and hydrogeologic setting, operational and environmental restoration, and provides a surveillance and maintenance plan for future monitoring of the site. The LTS&M Plan is designed to ensure that institutional controls (ICs[1]) provide long-term protectiveness of the site. It includes the plan for monitoring groundwater (radioisotope and hydraulic head), inspecting the site and maintaining the ICs, evaluating and reporting data, and documenting the records and data management processes for the site. Groundwater monitoring and site inspection results will be included in annual groundwater monitoring and inspection reports. These reports and other reports associated with the Rio Blanco site are available on the LM public website at https://www.energy.gov/lm/rio-blanco-colorado-site and copies will be distributed to stakeholders in accordance with the distribution list in Appendix D. Data collected during the monitoring events (analytical and water levels) will continue to be available on the Geospatial Environmental Mapping System (GEMS) website at https://gems.lm.doe.gov/#site=RBL.

[1] ICs are legal, administrative, and physical mechanisms established to ensure the long-term protection of the public and the environment from hazards associated with radioactive or hazardous waste sites after active remediation or disposal activities have ceased.

1.0 Introduction

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) prepared this Long-Term Surveillance and Maintenance Plan (LTS&M Plan) for the Rio Blanco, Colorado, Site. The Rio Blanco site is approximately 52 miles north-northeast of the city of Grand Junction in Rio Blanco County, Colorado (Figure 1). The site was the location of an underground nuclear test that included three nuclear devices that were detonated nearly simultaneously in a single emplacement well. The test was conducted on May 17, 1973, by the U.S. Atomic Energy Commission (AEC), a predecessor to DOE (DOE 2015a). The tests resulted in residual contamination that require long-term oversight. Long-term responsibility for the site was transferred from the DOE National Nuclear Security Administration Nevada Field Office to LM on October 1, 2008. Responsibilities include surveillance, monitoring, and maintenance of institutional controls (ICs) as part of the long-term stewardship of the site. Long-term stewardship is designed to ensure protection of human health and the environment.

AEC acquired the site through a land withdrawal from the U.S. Bureau of Land Management (BLM) in the early 1960s for underground nuclear testing through the Plowshare Program. The Plowshare Program was a research and development initiative started in 1957 to determine the technical and economic feasibility for peaceful applications of nuclear energy. The land was withdrawn as described in Volume 68 *Federal Register* 54739–54740 (68 FR 54739–54740) “Public Land Order No. 7582; Withdrawal of Public Land and Reserved Federal Mineral Interest for the Rio Blanco Project Site; Colorado,” which is provided as Appendix A. The withdrawal contained the original 200 acres of land and 360 acres of mineral rights from the public domain for 50 years. The parcel, where the underground nuclear test occurred, consists of Section 14, Township 3 South, Range 98 West (Appendix B).

1.1 Purpose

This LTS&M Plan documents LM’s operational plan for long-term stewardship of the site. Long-term stewardship refers to the execution of all activities necessary to protect human health and the environment following cleanup, disposal, and stabilization at a site. The objectives of this LTS&M Plan include the following:

- Communicate the operational plan for managing the site to stakeholders, which includes the Colorado Energy and Carbon Management Commission (ECMC), the Colorado Department of Public Health and Environment (CDPHE), BLM, and the private landowner of the surface land surrounding at the Rio Blanco site
- Summarize the underground nuclear testing and status of environmental restoration activities (Section 2.1)
- Document the ICs and land use for the site (Section 2.3)
- Describe the plan for monitoring, completing site inspections, and maintaining the ICs (Sections 3.1 and 3.4)
- Provide the process for evaluating and reporting site-specific information (Section 3.5)
- Inform the public on the process for maintaining site records (Section 3.6)

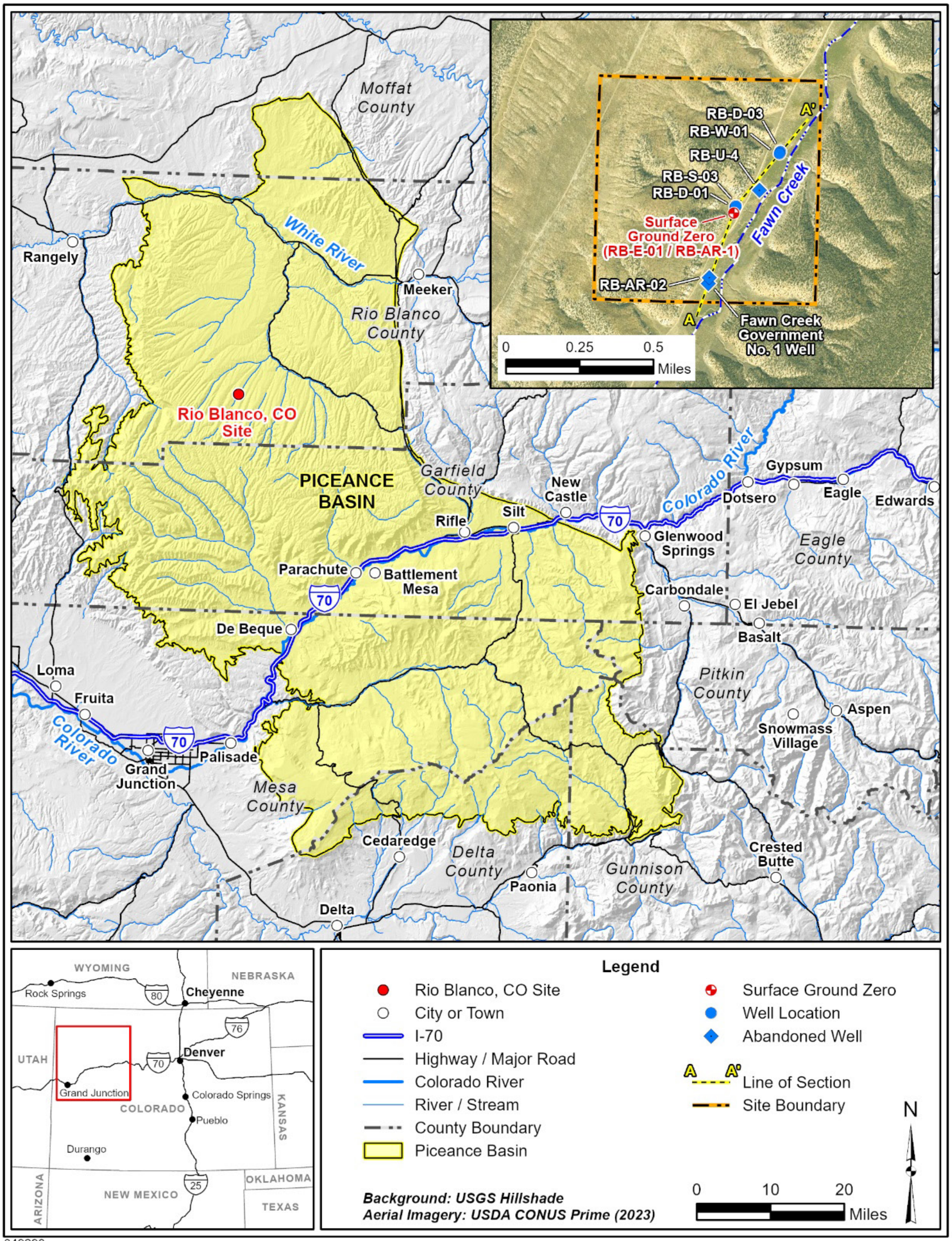

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Figure 1. Location of the Rio Blanco, Colorado, Site

1.2 Regulatory Framework

DOE maintains responsibility for radioactive material at the site under authority of the Atomic Energy Act of 1954, as amended under Title 42 *United States Code* Section 2011 (42 USC 2011). ECMC has decision authority over applications for permits to drill oil and gas wells in Colorado, and CDPHE acts as its consultant on environmental matters. ECMC requires that operators with gas wells within approximately 2 miles of the Rio Blanco site adhere to the ECMC's *Rio Blanco Sampling and Analysis Plan for Operational and Environmental Radiological Monitoring within a Two-Mile Radius of Project Rio Blanco Revision 1* (Williams 2010), hereafter called the Rio Blanco Sampling and Analysis Plan. DOE's monitoring plan outlined in this LTS&M Plan specifies the sampling of producing natural gas wells having a bottom-hole location within 1-mile of the test (identified as surface ground zero [SGZ] in Figure 1). The DOE sampling, in combination with the industry sampling, provides independent confirmation of results and effectively increasing the sampling frequency of natural gas wells near the site.

ECMC notifies DOE of any drilling permit activity within approximately 2 miles of the site. As wells are drilled nearer the site, DOE has adopted the approach outlined in the *Path Forward for Rio Blanco, Colorado* document (DOE 2013b) (Appendix C), hereafter called the Path Forward document, which recommends a conservative, staged approach to gas development near the site. Oil and gas operators are encouraged to drill in areas where there is a lower likelihood of encountering detonation-related contamination (both distance and direction from the detonation zone are factors) and to collect data from these wells prior to drilling nearer to the site. Drilling permit applications submitted for wells within a 0.5-mile of the site require a special hearing before ECMC and before approval (Williams 2010). DOE maintains responsibility for radioactive material at the site under authority of the Atomic Energy Act of 1954, as amended under 42 USC 2011. The recommendations provided in the Path Forward document (DOE 2013b) are maintained in this LTS&M Plan and a copy of the document is provided as Appendix C.

1.3 Geologic Setting

The detonations occurred in the Fort Union Formation and upper part of the Williams Fork Formation (Figure 2). The Williams Fork Formation is the primary gas-producing zone in the Piceance Basin, a northwest-southeast-oriented structure approximately 100 miles long and 40−50 miles wide. More than 20,000 feet (ft) of sedimentary rocks were deposited in this basin. The Colorado River divides the Piceance Basin into northern and southern provinces (Figure 1). The Rio Blanco site is in the northern province; this portion of the Piceance Basin between the Colorado and White Rivers retains basin-like features, with rocks dipping inward from the margins toward the deepest part of the basin at the northern end (MacLachlan 1987).

The Fort Union and Williams Fork Formations are encountered at depths of 5330 and 6160 ft below ground surface (bgs), respectively, at the site (ERDA 1975a). The Williams Fork Formation is composed of low-permeability, discontinuous, interbedded fluvio-deltaic sandstones, and shales. These sandstones vary in clay content; the cleaner sandstones (containing less clay) in the lower two-thirds of the formation are the main targets for natural gas production. Sandstones in the upper third of the Williams Fork are not production targets due to their higher water content that limits the amount of gas that can be produced and results in excessive wastewater production. This increased water content was seen in the gas well production testing data obtained at the Rio Blanco site and it is also supported by the limited number of natural gas wells in production at the detonation interval, near the Rio Blanco site. A more detailed description of natural gas production near the Rio Blanco site is provided in the *Modeling of Flow and Transport Induced by Gas Production Wells near the Project Rio Blanco Site, Piceance Basin, Colorado* (DOE 2013a).

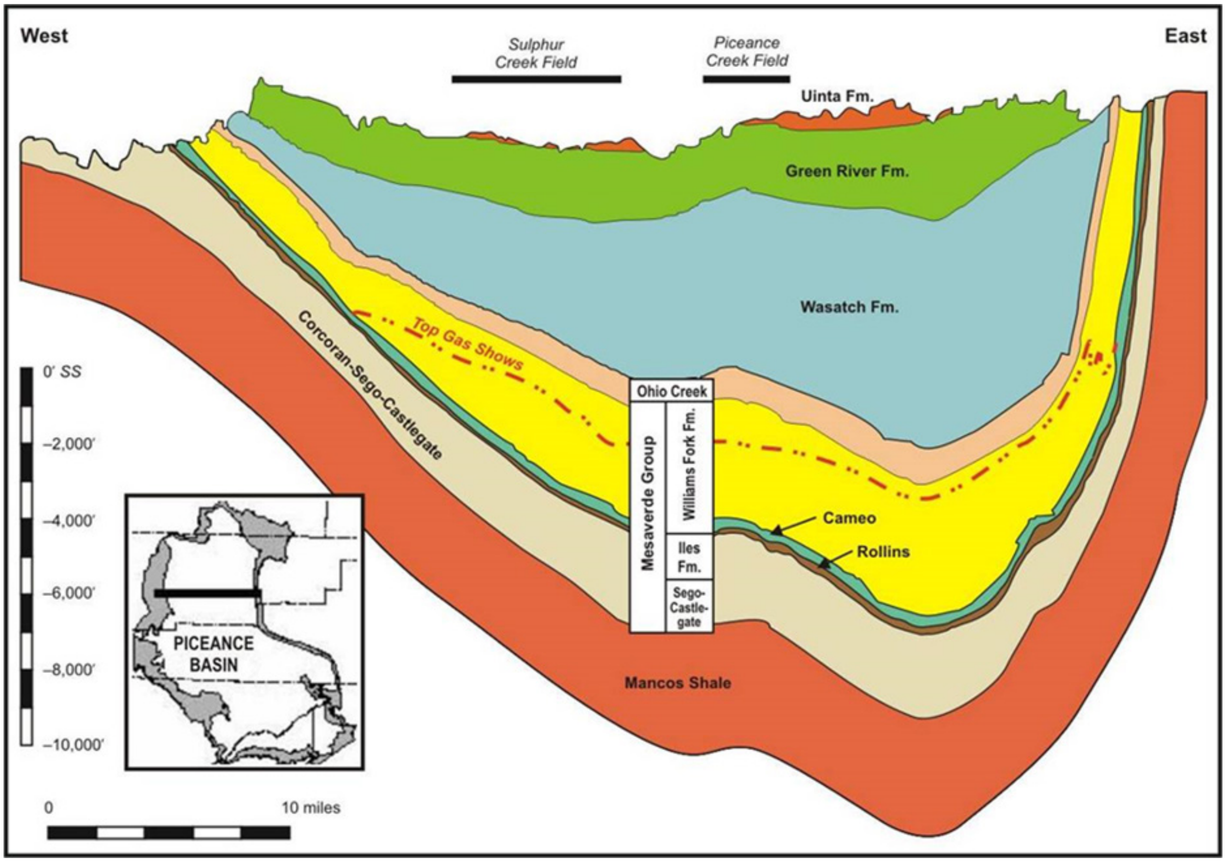

Figure 2. Piceance Basin Cross Section (modified from Yurewicz et al. 2003)

1.4 Natural Gas Development

The gas-bearing sandstone reservoirs are considered unconventional in that the gas is trapped by the low permeability of the formation rather than by a conventional structural trap. The low permeability sandstones must be fractured to release enough gas to be economical (Wolhart et al. 2005). The sandstone bodies vary in size and clay content; the larger sandstone bodies that have less clay are the main targets for hydrofracturing and produce the most natural gas. The elevation of the primary natural gas-producing interval (the lower two-thirds of the Williams Fork Formation) near the Rio Blanco site ranges from roughly −600 ft above mean sea level (AMSL) at the top to −3300 ft AMSL at the bottom (Figure 2). The detonations were above this interval at elevations of 789, 397, and −62 ft AMSL, respectively. A detailed description of the expected hydrofracturing and drainage patterns at the Rio Blanco site is provided in the *Modeling of Flow and Transport Induced by Gas Production Wells near the Project Rio Blanco Site, Piceance Basin, Colorado* (DOE 2013a).

1.5 Site Hydrology

Fawn Creek is the dominant surface water feature on the site (Figure 1). It is a spring-fed perennial stream that receives much of its water from snowmelt and precipitation (USGS 1972). Fawn Creek flows across the site from south to northeast and is approximately 300 ft from SGZ. Fawn Creek discharges into Black Sulphur Creek and then Piceance Creek before it reaches the White River.

Groundwater is encountered at the site in the surficial deposits (shallow alluvium <150 ft thick) and the underlying Green River Formation (approximately 2800 ft thick). The alluvial aquifer is present in the stream valleys and generally consists of sand, gravel, and clay eroded from the Uinta siltstone. The alluvial aquifer is reported as having the highest transmissivity of all rocks in the basin and yields as much as 1500 gallons per minute (USGS 1972). The Green River Formation has two water-bearing zones, an upper aquifer (Zone A or Aquifer A) and a lower zone (Zone B or Aquifer B) (Figure 3). These aquifers are separated by the Mahogany Zone (Figure 3), which acts as an aquitard, separating the upper zone from the lower aquifer zone (USGS 1972). Groundwater flow in the shallow alluvium and the dual A/B aquifer system of the Green River Formation is generally to the east-northeast, which is consistent with the topography in the area. Groundwater in the deeper formations (Wasatch and Fort Union) is too brackish to be considered a usable water source.

The natural gas wells near the site produce some liquids along with natural gas. These liquids consist of produced water and hydrocarbon condensate, which are brought to the surface with the natural gas and mechanically separated at the wellhead. The produced water is a mixture of water vapor in the natural gas that condenses at the surface, formation water, and remnant water from hydrofracturing well development. The produced water is high in total dissolved solids and is not a usable water source.

2.0 Site Information

The following sections summarize the underground nuclear testing (site operational history), decommissioning and environmental restoration activities, and long-term stewardship (ICs and land use) of the site. Table 1 provides a chronology of activities that are considered significant to the Rio Blanco site history.

2.1 Underground Nuclear Testing (Site Operational History)

AEC conducted the underground nuclear test in partnership with Continental Oil Company (Conoco) and CER Geonuclear Corporation, or CER (DOE 1978a). The test was called Project Rio Blanco, and it was conducted under the Plowshare Program, which was a research and development initiative started in 1957 to evaluate the technical and economic feasibility of peaceful applications of nuclear energy. The Rio Blanco test was conducted to evaluate the use of a nuclear detonation to fracture the low-permeability sandstones in the Fort Union and Williams Fork Formations to stimulate natural gas production (Figure 3) (Toman 1974). This was the third natural gas stimulation experiment in the Plowshare Program.

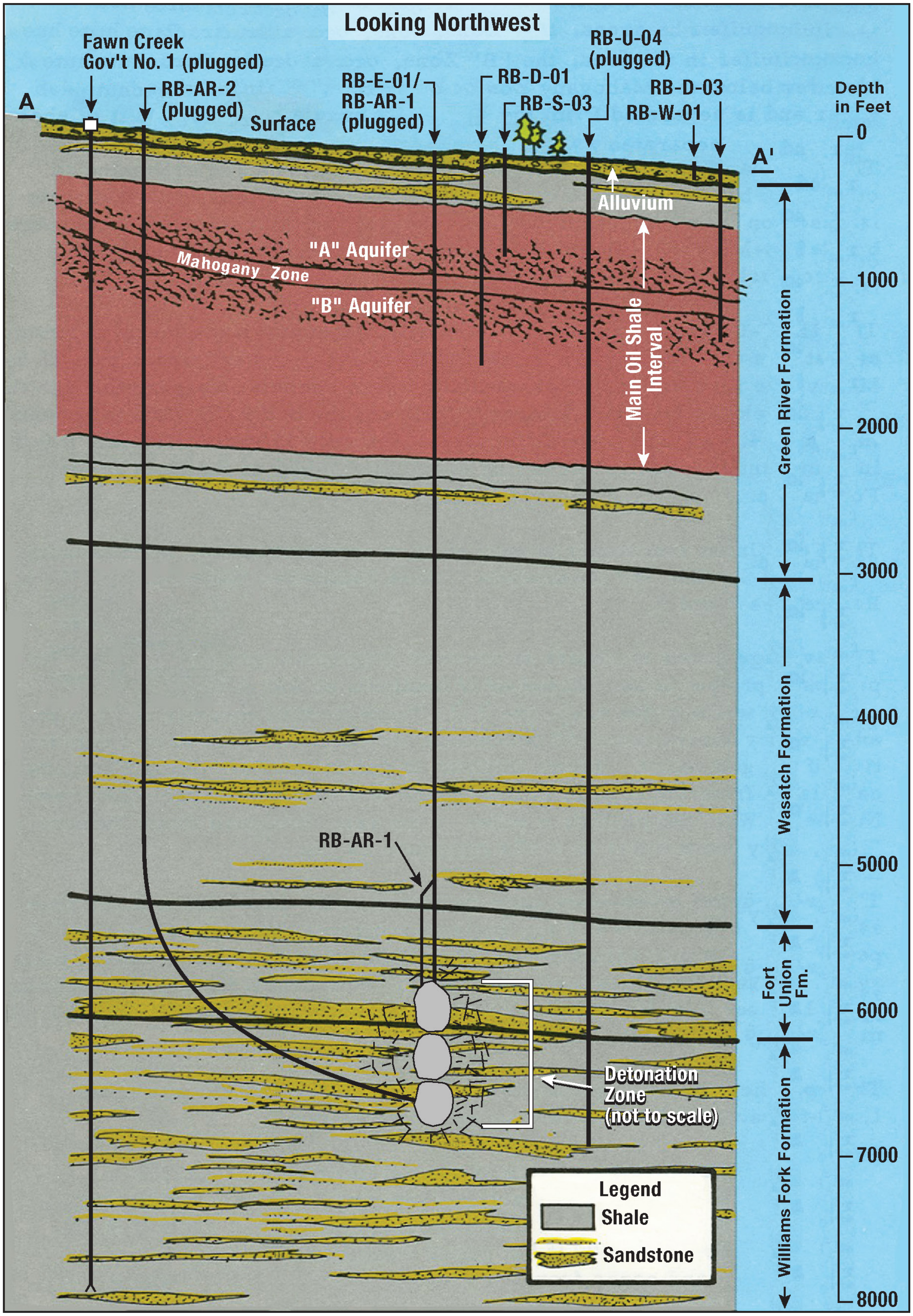

Figure 3. Generalized Cross Section of the Subsurface at the Rio Blanco Site

Table 1. Site Chronology with Document References

Date	Description of Activity	Document Reference
1970	Feasibility and environmental impact studies began for Project Rio Blanco.	CER 1975
1971	Emplacement well RB-E-01 was drilled in preparation for the test.	CER 1972
1973	Three nuclear devices were detonated at the Rio Blanco site in the RB-E-01 emplacement well. The nuclear devices were placed in an emplacement well at depths of 5840, 6230, and 6690 ft.	DOE 2015a
1973	Reentry well, RB-AR-1, was drilled into the uppermost chimney to conduct production testing and analyze for the inert gases used as tracers in the lower detonations.	Toman 1974
1973	Two production tests were conducted on the reentry well to evaluate the efficacy of natural gas stimulation.	DOE 1976
1974	A second reentry well, RB-AR-2, was drilled into the lower chimney.	Toman 1974
1974	Formation evaluation well RB-U-4 was drilled to allow production testing from the Fort Union Formation.	ERDA 1975b
1976	Site decommissioning and cleanup were initiated in July 1976 and included analyzing soil and vegetation samples for radiological contaminants, decontaminating equipment, injecting liquid waste into Fawn Creek Gov't No. 1 well, and removing equipment and material not needed for future gas production activities.	DOE 1978b
1976	RB-E-01, RB-AR-2 wells were plugged and abandoned. Recompletion of Fawn Creek Gov't No. 1 well was finalized.	DOE 1978b
1986	Fawn Creek Gov't No. 1 well was plugged and abandoned.	DOE 1986
1988	A Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) preliminary assessment was conducted to determine CERCLA hazard ranking. The Hazard Ranking System score was not high enough to be included on the National Priorities List.	DOE/NV 1988
1993	An aerial radiation survey was conducted to determine if man-made radiation was present at the earth's surface as a result of an underground nuclear detonation. The survey concluded that no evidence of surface radiation was present at Project Rio Blanco.	DOE 1994
2002	The *Corrective Action Investigation Report for the Rio Blanco Site, Colorado* was submitted to the State of Colorado.	DOE 2002
2003	CDPHE reviewed and approved the *Corrective Action Investigation Report for the Rio Blanco Site, Colorado*.	Stoner 2003
2008	LM assumed responsibility for Rio Blanco site from the DOE Office of Environmental Management and performance of the Long-Term Hydrologic Monitoring Program (LTHMP).	DOE 2007
2010	ECMC (formerly the Colorado Oil and Gas Commission) issued a memorandum requiring that drilling permit applications submitted for wells within a 0.5-mile of the site would require a special hearing before the commission and prior approval.	Williams 2010
2013	Numerical modeling was utilized to make predictions about the subsurface flow system and contamination transport for Rio Blanco.	DOE 2013a
2013	DOE developed the *Path Forward for Rio Blanco, Colorado* document (Appendix C) for the Rio Blanco site. This plan recommends a conservative staged drilling approach that allows natural gas reserves near the Rio Blanco site to be recovered in a manner that reduces the likelihood of encountering contamination.	DOE 2013b
2020	Sampling conducted as part of the LTHMP was reduced to the four wells at the site.	DOE 2021

The underground nuclear test was conducted on May 17, 1973. The test involved the nearly simultaneous detonation of three nuclear devices placed in a single vertical emplacement well (RB-E-01) at depths of 5840, 6230, and 6690 ft bgs (Figure 3) (DOE 2015a). Each detonation had an estimated yield of 33 kilotons, which produced extremely high temperatures that vaporized a volume of rock, temporarily creating a cavity at each depth (DOE 2015a). The fractured rock above each cavity collapsed shortly after the detonation, filling each cavity with rubble, and forming a collapse chimney that extended above each detonation point. Each former cavity and surrounding fractured rock, as well as the collapse chimney are collectively referred to as the detonation zone (Figure 3). It was expected that the three collapse chimneys created by the detonations would connect, allowing improved gas production within the detonation zone (DOE 2015a). To test if the devices created a single, connected chimney, a canister of inert gas (neon, xenon, and krypton) was added to each of the nuclear devices (upper, middle, and lower devices), respectively. This allowed these gases to be analyzed during production testing to help determine if the detonations were connected (DOE 1976).

Following the detonation, a reentry well, RB-AR-1, was drilled into the uppermost chimney to conduct production testing and analyze for the inert gases used as tracers in the detonations (DOE 1978a). Reentry drilling began September 11, 1973, and was completed on October 25, 1973. Two production tests were conducted between November 1973 and February 1974 (DOE 1978b). Analysis of the inert tracer gases and production drawdown pressures indicated that the detonations had not created a single, connected chimney (Toman 1974). Small quantities of the xenon and krypton tracers were detected toward the end of the second drawdown test, although the low concentrations indicated low vertical permeability (Toman 1974).

Drilling of a second reentry well, RB-AR-2, began June 17, 1974, with the initial objective of intersecting the chimney of the middle detonation (DOE 1978b). Due to difficulties in maintaining the correct inclination angle, the lower detonation chimney was targeted instead. Several tests of the gas produced from the lower chimney indicated that the gas was similar to that of the upper chimney. The small volume of gas produced, and the results of the tracer gas analyses indicated no significant connection between the three devices.

Analysis of production data from the reentry wells indicated that the permeability of the Fort Union and Williams Fork Formations at the depth of the detonations was significantly less than predicted before the test, which was approximately 6 to 10 times lower than expected (DOE 1978b). The large differences between predicted and actual production test results led to a decision to drill an additional well, RB-U4, to evaluate the production characteristics of the formations at a distance that would be unaffected by the detonations (Figure 3) (DOE 1978b).

Well RB-U-04 was drilled approximately 600 ft northeast of the emplacement well. Zones of natural gas-bearing sands determined from geophysical logs were perforated, swabbed, and tested for gas production, then hydraulically fractured and tested for gas production (ERDA 1975b). Natural gas production from the four perforated zones in the Mesaverde Group was insufficient to determine permeability due to the relatively high-water saturation that decreases the overall permeability (ERDA 1975b). Flow tests of natural gas-bearing zones in the Fort Union Formation were more successful. Each of the three production tests on well RB-U-4 in the Fort Union Formation yielded flow volumes that were 63% of the effective production from well RB-AR-1, which reentered the upper chimney, though the flow volumes were still far below the volumes predicted for those units before the detonations (ERDA 1975b). Results from well RB-U-04 were mixed, but the significant finding was that the properties of the sands in the various units were considerably different from what was predicted before the detonations (ERDA 1975b). One of the investigators summed up his view of the results: “If we had known in 1972 what we now know about this site, this project would have not been executed there” (Ballou 1976).

2.2 Site Decommissioning and Environmental Restoration Activities

Site cleanup and restoration was initiated in May 1976 (DOE 1978a). Structures used during the test were removed and liquid waste generated during the test was injected into the Fawn Creek Government No. 1 well, hereafter the well is called Fawn Creek Gov't No. 1 well. Liquid waste injected into the Fawn Creek Gov't No. 1 well was pumped through perforations in the well between depths from 5600 to 6100 ft bgs under a subsurface disposal permit (Colorado Department of Health 1974) (Figure 3). The emplacement well (RB-E-01), wells RB-AR-1, RB-AR-2, and RB-U-04, and wells not planned for long-term monitoring were plugged and abandoned during the cleanup that was completed in November 1976 (DOE 1978a). The Fawn Creek Gov't No. 1 well was shut in 1977 and in June 1986 the well was plugged and abandoned.

2.2.1 Surface Cleanup

Surface facilities used during the experiment were located at the emplacement well pad and consisted of a gas production test system and a produced water disposal system. The major items included gas coolers, a gas liquid separator, gas flow monitoring systems, water storage tanks, condensate storage tanks, an injection pump, and filters and associated pipelines (DOE 1978a). Surface equipment that was successfully decontaminated was returned to Conoco. Solid and liquid waste produced consisted of sludge, steam condensate, and other liquids from decontamination operations. Radiological clean combustible waste was disposed of through vaporization. Radiological waste was sent to a waste disposal site in Beatty, Nevada, for processing and disposal (DOE 1978a). The final phase of Project Rio Blanco restoration was land surface restoration. A significant amount of earthwork was moved to reshape the terrain to create more natural contours to fill in excavated drilling and mud pits. Topsoil was redistributed over the well pads and dirt roads. The Fawn Creek dirt road was realigned to its original position. All affected areas were then seeded with wheatgrass and enclosed by a barbed-wire fence (DOE 1978a).

In 1993, DOE commissioned an aerial survey to determine if any surface contamination was present at the Rio Blanco site (DOE 1994). The survey was performed by EG&G Energy Measurements Inc. and took place in June 1993. The goal of the project was to determine if any cesium-137 was detectable over the Project Rio Blanco area. Results of the survey determined that no cesium-137 was detected and that radiation levels at the site were the same as background radiation in the area. Soil samples at the site were also taken to confirm survey findings.

A corrective action investigation and risk assessment were completed in 2002 (DOE 2002). It was concluded in the final investigation report that no corrective actions were required and that no surface use restrictions should be placed onsite (NNSA 2002). CDPHE reviewed and approved the report in 2003 (Stoner 2003).

2.2.2 Surface Water and Shallow Groundwater Monitoring

The U.S. Environmental Protection Agency (EPA) implemented groundwater and surface water monitoring at and near the Rio Blanco test site from 1976 to 2008 as part of its Long-Term Hydrologic Monitoring Program (LTHMP). Surface water and shallow groundwater samples were collected annually at and near the site from 1976 until 2008. In 2008, LM assumed responsibility for the sampling and conducted an evaluation of the monitoring network that consisted of 15 locations (six shallow wells and five surface locations). Seven of the locations (five shallow wells and two surface locations) were onsite and eight of the locations were offsite, with the offsite locations ranging from approximately 2 to 6 miles from SGZ (Figure 4). Samples collected from these locations were analyzed for gamma-emitting radionuclides (using high-resolution gamma spectrometry), strontium-90, and tritium (using conventional and electrolytic enrichment methods). Laboratory analytical results from more than 50 years of monitoring by EPA and LM have shown that radiological contaminants from the Rio Blanco test have not impacted the shallow groundwater or surface water at the sampled locations. Figure 4 shows the 15 sample locations that have been sampled as part of the LTHMP.

DOE reduced the sampling in 2020 to include four shallow groundwater wells on and near the site because no Rio Blanco site-related contaminants have been detected and there is a lack of potential for migration from the detonation zone to the surface or near surface aquifers. Results obtained from the LTHMP have been summarized in annual groundwater monitoring reports prepared by EPA from 1976 through 2008 and by LM from 2009 to the present. These reports and other site documents are maintained on the LM public website (www.energy.gov/lm/rio-blanco-colorado-site).

2.2.3 Deep Subsurface Contamination

Subsurface contamination remains in the detonation zone near the former emplacement well (RB-E-01/RB-AR-1) and Fawn Creek Gov't No. 1 well (Figure 3). The detonation zone includes the former cavities and surrounding fractured rock along with the collapse chimneys (Figure 3). Contamination associated with Fawn Creek Gov't No. 1 well includes liquid waste generated during the test and is contained near the well perforation depths of 5600 to 6100 ft bgs. The nuclear devices used at Project Rio Blanco were designed to significantly decrease the amount of tritium produced by each device relative to previous gas stimulation tests. Tritium is a mobile radionuclide that can migrate with natural gas as it is extracted. The estimated amount of tritium produced from the underground nuclear tests conducted at the Gasbuggy, New Mexico, Site; Rulison, Colorado, Site; and each detonation at the Rio Blanco site was 40,000, 10,000, and less than 1000 curies (Ci), respectively (Toman 1974).

Most of the longer-lived radionuclides produced by the Project Rio Blanco detonations solidified at relatively high temperatures and were entrained within the molten rock as it cooled to form a melt glass at the base of each cavity. The radionuclides incorporated in the melt rock can only be released to groundwater very slowly through dissolution of the melt rock (Tompson et al. 1999; Pawloski et al. 2001). Though dissolution of radionuclides from melt rock could represent a long-term source of subsurface contamination, dissolved-phase transport away from the detonation zone is considered insignificant due to the low permeability of the rock surrounding the detonation zone. The presence of gas in the unsaturated formation further reduces the relative permeability of liquids, making radionuclides that may have dissolved in the detonation zone essentially immobile.

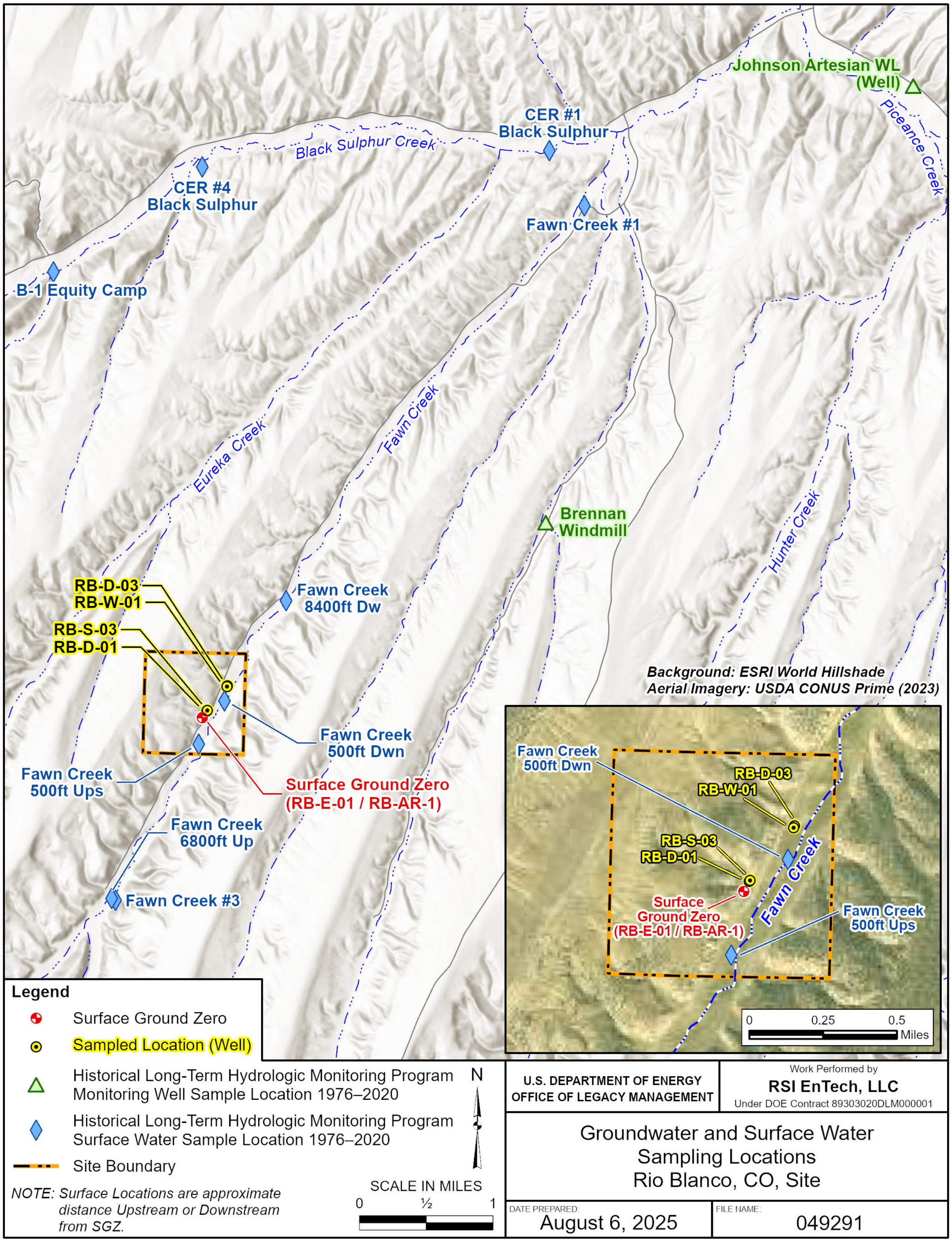

Figure 4. Groundwater and Surface Water Sampling Locations, Rio Blanco, Colorado, Site

The primary contaminants of concern are expected to be radionuclides that can exist in the gas phase because gas is much more mobile than liquids in the gas-producing reservoirs of the Fort Union and Williams Fork Formations. Of the radionuclides that can exist in the gas phase, tritium and krypton-85 are expected to constitute most of the gas-phase radioactivity (Toman 1974). An evaluation of the data obtained from the production testing in 1973 and 1974 indicates that significant quantities of tritium and krypton-85 remain in the detonation zone (DOE 2013a). Tritium is the most abundant and considered the greater risk due to its ability to be incorporated into human tissue, whereas krypton-85 is a noble gas and is not easily retained in the body (ANL 2007). Because tritium is the most mobile, presents the greatest exposure risk, and is the most abundant radionuclide in the detonation zone that can be present in both gas and aqueous phases, it is the primary radionuclide of concern at the Rio Blanco site.

2.3 Long-Term Stewardship (ICs and Land Use)

ICs are instruments (documents) and mechanisms (physical features) that are maintained to ensure long-term protectiveness of a site (DOE 2015b). Surface cleanup activities have been completed, but subsurface contamination remains. The Rio Blanco site's ICs are designed to minimize the potential exposure to any remaining contamination. LM has established ICs with BLM, ECMC, and CDPHE to restrict surface and subsurface access from oil and gas exploration activities and control land use at the Rio Blanco site (Table 2). ECMC has enacted a drilling moratorium within the 600 ft exclusion zone and a 0.5-mile radius from SGZ. ECMC has also limited drilling to a true vertical depth of 6500 ft bgs. This restricts access to the subsurface and reduces the risk of encountering contamination.

As wells are drilled nearer the Rulison and Rio Blanco sites, LM has taken the approach outlined in the Path Forward document (DOE 2013b). The Path Forward document (Appendix C) recommends that drillers adopt a conservative, staged approach to gas development. They are encouraged to drill wells in areas with a low likelihood of encountering contamination (both distance and direction from the detonation zone are factors) and to collect data from these wells before drilling nearer the sites. The Path Forward document relies in part on the results from a numerical modeling effort that indicates contamination has been contained within the IC boundary (Figure 5). The Path Forward document couples the model predictions with the monitoring of natural gas and produced water from the gas wells and the monitoring of shallow groundwater near the site. In coordination with ECMC, DOE reviews applications to drill within 2 miles of the site. Table 2 provides information about the ICs and agreements at the Rio Blanco site.

Surface land use at the Rio Blanco site comprises 360 acres of federally withdrawn land. BLM manages surface interests in a 200-acre parcel (Figure 5). The land is included in the Black Sulphur grazing allotment that is renewed annually. There are no other current surface uses or leases for surface activities on that parcel. With the exception of monitoring wells and the monument installed at ground zero, no improvements remain on the land. For the remaining 160-acre parcel, only the minerals are part of the withdrawal. The surface estate is owned by Fawn Creek, Inc. Fawn Creek, Inc. owns a small hunting cabin onsite (Figure 5). The cabin is used infrequently and is not a permanent residence. The area surrounding the Rio Blanco site has mixed ownership between the BLM and private entities. Some of these parcels have subsurface oil and gas leases (Appendix B).

Table 2. Rio Blanco Site ICs

Type	Instrument or Mechanism	Restriction	Implementation
Administrative	Public Land Order 7582 (federal land withdrawal)	This order withdraws 200 acres of public land from surface entry and mining and 160 acres of reserved federal mineral interest from mining for DOE for a 50-year period to protect the public from subsurface contamination at the Rio Blanco Project Site (Figure 6).	Public Land Order 7582
Physical	Site marker	"No excavation, drilling, and/or removal of subsurface material to a true vertical depth of 1500 feet is permitted with an radius of 100 feet of this surface location, nor any similar excavation, drilling and/or removal of subsurface materials between the true vertical depths of 1,500 feet and 7,500 feet is permitted within a 600 foot radius of this surface location in the NW quarter of the NW quarter, Section 14, Township 3 South, Range 98 West, 6th Principal Meridian, Rio Blanco County Colorado, without U.S. Government permission."	LTS&M Plan, county records, and LM website
	Wellhead locks and monitoring network	Restricts access to the wells and groundwater.	
Informational	ECMC memorandum – policy and notice to operators	Voluntary drilling moratorium within the 600-foot exclusion zone and 0.5-mile radius from SGZ.	Action on Applications for Permits to Drill at locations from 600 ft to 0.5-mile from the Project Rio Blanco blast site
		Limits drilling and gas production within a 600-foot radius of the Fawn Creek #1 well to a true vertical depth of 6500 ft bgs.	
	BLM Resource Management Plan	Limits drilling and gas production within a 600-ft radius of the Fawn Creek #1 well to a true vertical depth of 6500 ft bgs. New leases or interests will require written permission from DOE in the withdrawn area and written permission from DOE to construct permanent structures.	BLM Resource Management Plan
	LM fact sheet and LM public webpage	Document the site restrictions and ICs.	LM public website

3.0 Surveillance and Maintenance Plan

This LTS&M Plan is designed to ensure protection of human health and the environment. It includes the plan for monitoring natural gas wells, surface water, and shallow groundwater wells on and near the site. It also provides the plan for inspecting the site and maintaining the ICs, evaluating and reporting data, and documenting the records and data management process for the site. This plan will be reviewed if site conditions change and will be revised if new data become available that changes the understanding of the site conditions.

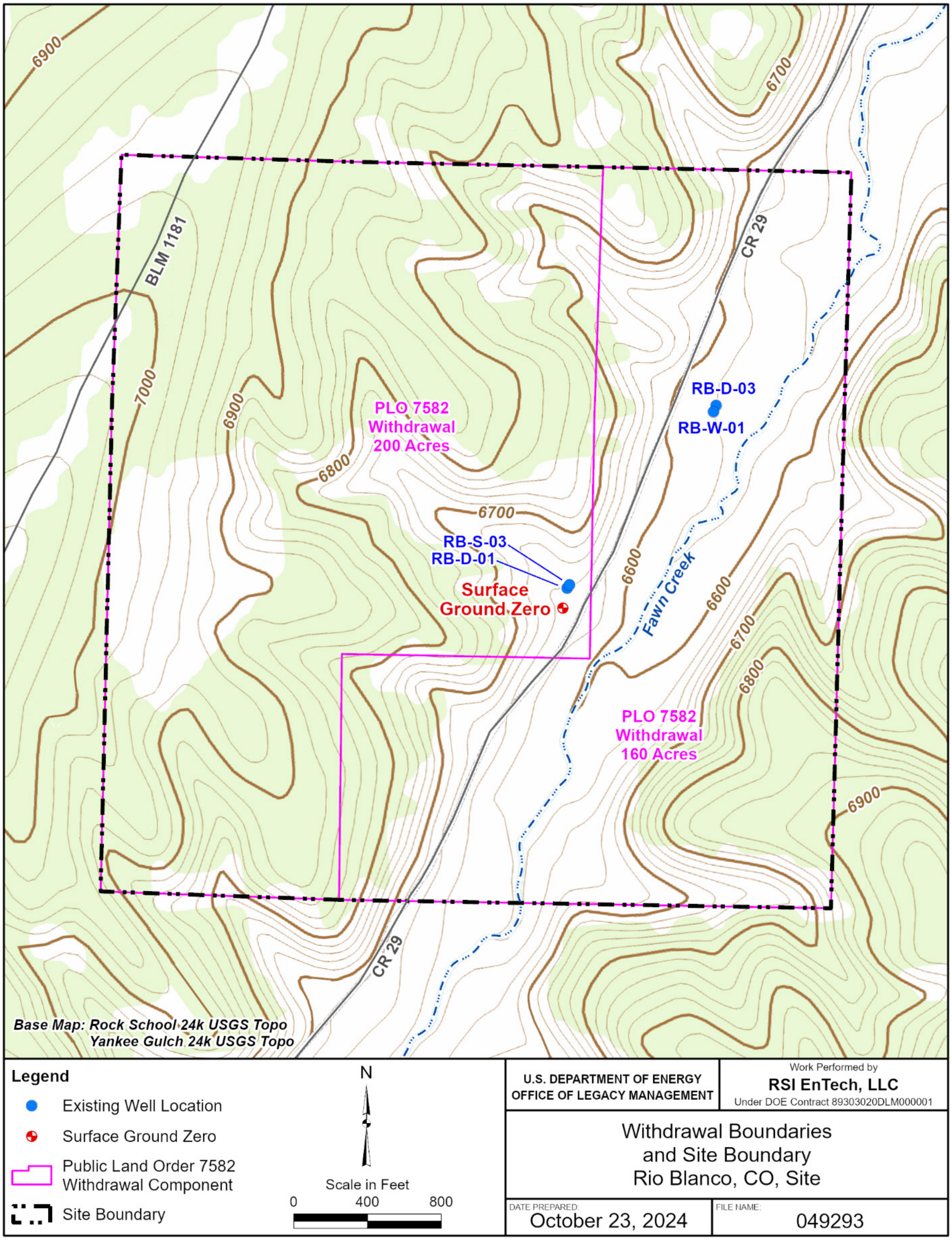

Figure 5. Withdrawal Boundaries and Site Boundary for the Rio Blanco Site

3.1 Monitoring Potential Pathways

The monitoring strategy is designed to monitor the detonation zone, which is the source of contamination at the site. The most likely transport mechanism for this contamination to reach the surface is through migration with natural gas to a producing well having fractures that connect to the detonation zone or the Fawn Creek Gov't No. 1 well perforation depths (5600 to 6100 ft bgs) (DOE 2013a). The monitoring strategy provided herein includes the collection of samples (produced water and natural gas) from producing natural gas wells near the site. It is improbable that contamination from the detonation zone would reach the surface through natural pathways (DOE 2013a). The surface water and shallow groundwater monitoring plan, included in the LTS&M Plan, is designed to confirm protectiveness.

3.1.1 Natural Gas Wells (Produced Water and Natural Gas)

Samples of produced water will be collected from natural gas wells having a bottom-hole location or an estimated drainage area that is within a 1-mile radius of SGZ. Currently, there are no active wells within a 1-mile radius of SGZ and only one producing well within a 2-mile radius of SGZ (Figure 6). If natural gas production increases and new wells are drilled within the 1-mile radius of SGZ, the producing natural gas wells will be added to the monitoring network. There are currently no gas wells within the 0.5-mile radius and any future permits to drill wells in this area will require a hearing with ECMC and approval by the commission prior to drilling. Any changes or enhancements to the sampling strategy for wells within a 0.5-mile radius will be communicated during the permit approval process.

Natural gas wells near the site are being spaced relatively close to each other and are expected to drain a 10-acre area. The wells produce some liquids (produced water and hydrocarbon condensate) along with natural gas. Industry standards require that the natural gas be 95% dry at the time it leaves the wellhead. This requires liquids (produced water and hydrocarbon condensate) brought to the surface with the natural gas to be separated at the wellhead. The produced water is a combination of water vapor in the natural gas that condenses at the surface, formation water, and remnant water from hydrofracturing well development. The primary components of natural gas that can contain tritium are water vapor and methane. Tritium present as tritiated water vapor under gas reservoir conditions can be effectively monitored by analyzing produced water samples. Natural gas will be sampled and analyzed to confirm that no tritiated methane, if present, is migrating from the detonation zone. The samples of produced water and natural gas will be analyzed for tritium, the primary radionuclide of concern at the site.

3.1.2 Groundwater and Surface Water Monitoring

Samples will be collected from the four groundwater wells onsite (RB-D-01, RB-D-03, RB-S-03, and RB-W-01) during the annual monitoring events. A sample may be collected from surface water locations used during the drilling process to assess background conditions. These wells and other offsite wells and surface water locations have been sampled annually as part of the LTHMP since 1976 (Figure 4). DOE reduced the LTHMP sampling because of the limited potential for migration of the subsurface contamination to these locations. DOE continues to monitor the four onsite wells to verify that no Rio Blanco detonation-related contaminants have impacted the groundwater at these locations (Figure 5). Water levels will be measured manually using an electric water level tape prior to sampling the monitoring network wells. The water level data will be converted to groundwater elevations and evaluated with historical data to monitor groundwater at the site.

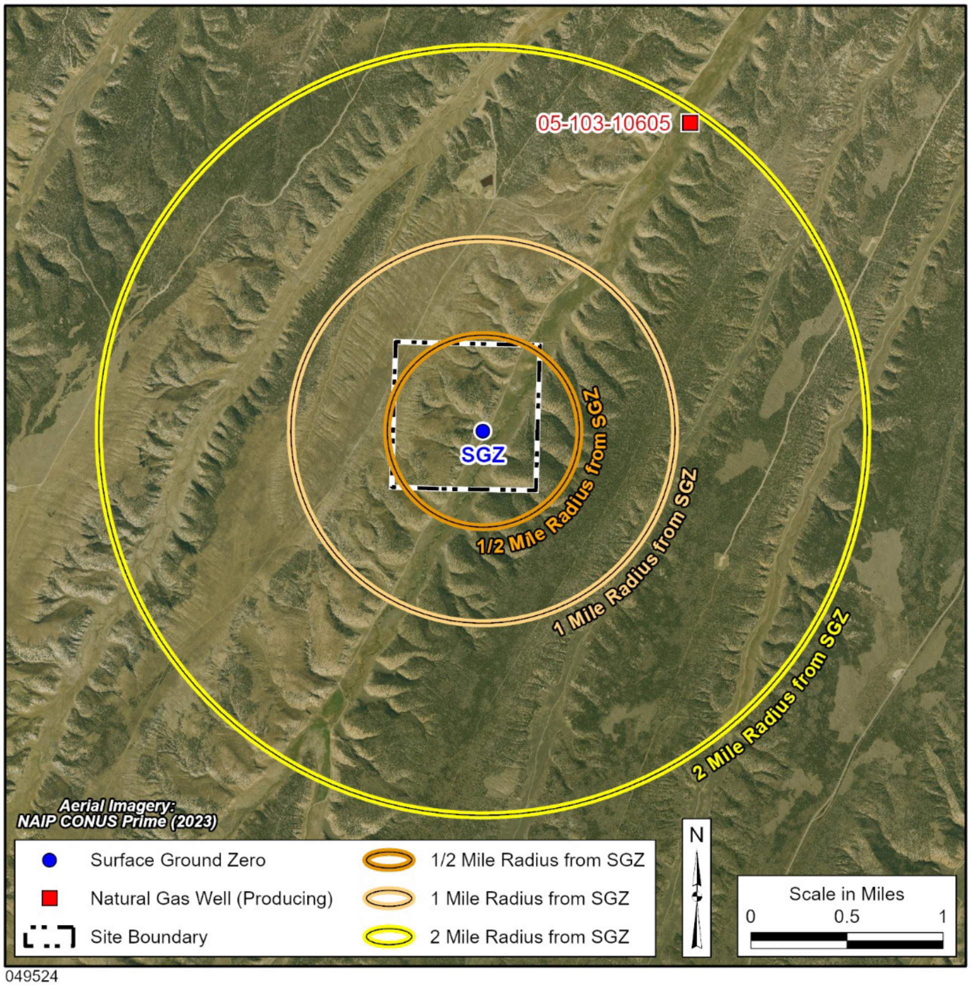

Figure 6. Site and Gas Well IC Boundary Map, Rio Blanco, Colorado, Site

3.1.3 Other Fluids and Solids

The drill cuttings and fluids used during drilling and hydrofracturing are being monitored under the industry Sampling and Analysis Plan (Williams 2010). DOE recognizes the importance of this sampling to document the presence or lack of contaminants at a newly drilled location and to document that fluids introduced during the drilling and completion processes do not contain radionuclides that could give a false indication of test-related contaminants.

3.2 Monitoring Frequency

The shallow groundwater wells are sampled annually. The frequency for sampling the natural gas wells is based on the wells' cumulative natural gas production (COGIS 2025). Production rates are initially high, approximately 50 million cubic feet (MMCF)/month at the start of a well's productive life, declining to approximately 15 MMCF/month by the end of the first year of operation. Production rates typically decline to approximately 5 MMCF/month by the end of the second year. It is conceptualized that natural gas entering the well early in the production cycle is not only from the zone near the well, but also from the more permeable hydrofractures that propagated relatively far from the well along the more permeable preexisting fractures of the natural fracture trend. Production in the latter stages of the well's production cycle is then dominated by gas migrating relatively short distances from the rock matrix to the more permeable preexisting fractures of the natural fracture trend (Mahrer 2011).

The sampling frequency established by DOE provides for more frequent sampling when a well is initially brought online and less frequent sampling later in the production life of the well. This provides more sampling during the period when the area of influence of the well is expanding rapidly and less sampling when the extent of the area of influence has stabilized. Sampling every 50 to 100 MMCF would be roughly equivalent to quarterly sampling during the well's first year of operation, semiannually during the well's second year of operation, and annually during the well's third and fourth years of operation. The frequency would decrease to biannually or longer during the well's remaining years of operation, with adjustments for extended shut-in periods. The recommended sampling frequencies are provided as a guideline to optimize sampling of multiple wells at different times in their production life; actual sampling may be conducted more or less frequently depending on weather conditions, the operational status of the well, number of wells to be sampled, and coordination with industry sampling.

3.3 Laboratory Analyses and Methods and Quality Assurance

Implementation of the monitoring program will include using trained and qualified personnel and following established procedures. Samples will be analyzed for tritium using the conventional method and select samples will also be analyzed for tritium using the enrichment method. The enrichment method allows the laboratory to provide a minimum detectable concentration that is approximately 2 orders of magnitude lower than the conventional method. This allows concentrations to be compared to the worldwide tritium distribution in precipitation and rivers that resulted from aboveground nuclear testing during the 1950s and early 1960s (IAEA 2024). Aboveground tests conducted by the United States and Soviet Union ended with the 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water. The enrichment method has been used during past sampling events and allows for the continued assessment of background tritium concentrations at the site. Laboratory methods, detection limits, and screening levels are detailed in Table 3. Water quality data will be collected in accordance with procedures specified in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (DOE 2024b) which adheres to EPA and ASTM International standards.

Table 3. Rio Blanco Site Laboratory Methods, Detection Limits, Screening Levels, and Action Levels

Analyte	Sample Matrix	Laboratory Method	Laboratory Detection Limit	Screening Level	Action Level[d]
Tritium	Natural gas	Lab Specific	10 TU[a]	100 TU[a]	200 TU[a]
			32 pCi/L	320 pCi/L	640 pCi/L
	Produced water[c]	EPA 906.0	400 pCi/L	1000 pCi/L	15,000 pCi/L[b]
	Surface Water[c]				
	Groundwater[c]				

Notes:
[a] A tritium unit (TU) is equal to 3.19 picocuries per liter (pCi/L) in water at a standard temperature (0° Celsius) and pressure (1 atmosphere).
[b] For reference purposes, the EPA standard for tritium in drinking water is 20,000 pCi/L.
[c] Select samples will also be analyzed for tritium using the enrichment method to allow comparison to background.
[d] Actions may include verification sampling (reanalyzing samples or resampling wells), stakeholder notification, or implementation of protective measures.

Abbreviations:
pCi/L = picocuries per liter

Commercial laboratories provide analytical services in accordance with the *Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, hereafter called the Quality Systems Manual (QSM), to ensure that data are of known, documented quality (DOD and DOE 2019). The QSM provides specific technical requirements, clarifies DOE requirements, and conforms to DOE Order 414.1D*, Quality Assurance*. The QSM is based on Volume 1 of The NELAC Institute standards, which incorporates International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 17025:2005(E), *General Requirements for the Competence of Testing and Calibration Laboratories*. The QSM provides a framework for performing, controlling, documenting, and reporting laboratory analyses. Analytical data will be validated in accordance with the *Environmental Data Validation Procedure* (DOE 2024a), which adheres to EPA and ASTM International standards. The validation results for the annual sampling events will be summarized in a Data Validation Package and made available to the public as specified in Section 3.5.

3.3.1 Screening Levels and Action Levels

Screening and action levels have been developed using information obtained from the *Screening Assessment of Potential Human-Health Risk from Future Natural-Gas Drilling Near Project Rulison in Western Colorado* (DRI 2011). They are concentrations that have been agreed to with ECMC that if exceeded would not necessarily indicate an impact to human health or the environment but would indicate that additional evaluation is necessary or would require a response. Responses may include verification sampling (reanalyzing samples, resampling wells, or both), stakeholder notification, or implementation of protective measures. ECMC provides regulatory guidance and jurisdiction for the natural gas wells in the area as described in Section 1.2. ECMC will be notified if a verified sample result has exceeded a screening level or action level. Any corrective measures will be discussed and agreed to with ECMC prior to implementation. Table 3 provides the laboratory analytical methods and minimum detectable concentrations, with the screening and action levels for the site.

3.3.2 Waste Management and Disposal

Sampling derived waste is managed by the environmental monitoring operations group and is handled in accordance with the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (DOE 2024b).

3.4 Site Surveillance and Maintenance of ICs

Site surveillance and maintenance of ICs consists of visiting the site annually during the groundwater sampling events to assess the condition of the monument at SGZ, and confirm that ICs (Section 2.3; Table 2) remain in place and effective. Inspectors will notify the property owner and DOE of any changes to the site features (monument and groundwater wells) and will photo-document any damage observed during the annual activities. The condition of the site features (monument and groundwater wells) will be documented in the annual LTHMP report (Section 3.5).

Routine site inspections provide a measure of oversight of the effectiveness and site protectiveness of ICs. The following activities will be completed before these inspections or at the frequency specified below:

- Contact the Colorado State Engineer's Office or assess the website on an annual basis to determine if any new groundwater wells have been permitted within 1-mile of the site.
- Contact ECMC or access the website quarterly to verify and determine if any new oil and gas wells have been permitted within 1-mile of the site.
- Maintain involvement with BLM in any land management processes and updates to BLM's Resource Management Plan that may affect the Rio Blanco site.
- Review and maintain public information associated with the Rio Blanco site on the LM website on an annual basis (Section 3.5).

3.5 Data Evaluation and Reporting

Communication among state and federal regulators, stakeholder organizations, elected officials, and members of the general public has benefited the cleanup and plans for long-term management at LM sites. Data collected by DOE and industry sampling plans will be evaluated as they become available (Williams 2010). Results from DOE sampling will be included in gas well monitoring reports and annual LTHMP reports. It will be provided to stakeholders (Appendix D) and maintained on the LM website. Industry sample results are available on the ECMC website. Additional data and information acquired from future wells drilled near the site (e.g., geophysical logs, production histories, or unexpected interactions between wells) will be used to evaluate the current site conceptual model. The reports, along with other reports developed for the site, will be maintained at the following locations:

- The LM website, https://www.energy.gov/lm/rio-blanco-colorado-site, contains specific information about the Rio Blanco site. Information on this webpage includes site records, the fact sheet, and a link to the GEMS website (https://gems.lm.doe.gov/#site=RBL) for the site.

- The ECMC website, https://ecmc.state.co.us/library.html#/areareports, contains sample results from the industry sampling of natural gas wells near the site. These results are available under headings for Piceance Basin and Project Rio Blanco.
- Reports will also be maintained on the Office of Scientific and Technical Information webpage at https://www.osti.gov/scitech/.
- Information about the Rio Blanco site is also available by contacting Legacy Management Support Education, Communication, History, and Outreach personnel at (970) 248-6363 or (970) 248-6000, or by sending an email request to public.affairs@lm.doe.gov.

3.6 Records and Data Management

To support postremediation maintenance of the Rio Blanco site, LM maintains records at the LM Business Center at Morgantown, West Virginia and at the LM Field Support Center at Grand Junction, Colorado. These records contain critical information required to protect human health and the environment, manage land and assets, protect the legal interests of DOE and the public, and mitigate community impacts resulting from the cleanup of legacy waste. Site historical records about the environmental remediation and stewardship are included in these collections. All LM records will be managed in accordance with the following requirements:

- 44 USC 29, "Records Management by the Archivist of the United States," *United States Code*, available at https://www.archives.gov/about/laws/records-management.html
- 44 USC 31, "Records Management by Federal Agencies," *United States Code*, available at https://www.archives.gov/about/laws/fed-agencies.html
- 44 USC 33, "Disposal of Records," *United States Code*, available at https://www.archives.gov/about/laws/disposal-of-records.html
- Title 36 *Code of Federal Regulations* Parts 1220–1239, Chapter 12, Subchapter B, "Records Management," available at https://www.gpo.gov/fdsys/granule/CFR-2011-title36-vol3/CFR-2011-title36-vol3-chapXII-subchapB
- DOE Order 243.1C, *Records Management Program*, U.S. Department of Energy, available at https://www.directives.doe.gov/directives-documents/200-series/0243.1-BOrder-c
- Internal LM records management program procedures and guidelines

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Appendix A

Federal Register Notice for Public Land Order 7582

Federal law only with the concurrence of the Assistant Secretary for Public and Indian Housing or the Assistant Secretary's designee.

Authority: Section 7(d) of the Department of Housing and Urban Development Act, 42 U.S.C. 3535(d).

Dated: September 9, 2003.

Michael Liu,

Assistant Secretary for Public and Indian Housing.

[FR Doc. 03–23882 Filed 9–17–03; 8:45 am]

BILLING CODE 4210–33–P

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[CO–930–1430–ET; COC–59980]

Public Land Order No. 7582; Withdrawal of Public Land and Reserved Federal Mineral Interest for the Rio Blanco Project Site; Colorado

AGENCY: Bureau of Land Management, Interior.

ACTION: Public Land Order.

SUMMARY: This order withdraws 200 acres of public land from surface entry and mining and 160 acres of reserved Federal mineral interest from mining, for the Department of Energy for a 50-year period to protect the public from subsurface contamination at the Rio Blanco Project Site.

EFFECTIVE DATE: September 18, 2003.

FOR FURTHER INFORMATION CONTACT: Doris E. Chelius, BLM Colorado State Office, 2850 Youngfield Street, Lakewood, Colorado 80215–7093, 303–239–3706.

SUPPLEMENTARY INFORMATION: The land will remain open to mineral leasing, subject to approval by the Department of Energy.

Order

By virtue of the authority vested in the Secretary of the Interior by Section 204 of the Federal Land Policy and Management Act of 1976, 43 U.S.C. 1714 (1994), it is ordered as follows:

1. Subject to valid existing rights, the following described land is hereby withdrawn from settlement, sale, location, and entry under the public land laws, including the United States mining laws (30 U.S.C. Ch. 2 (2000)), but not the mineral leasing laws, to protect the public from subsurface contamination at the Department of Energy Rio Blanco Project Site:

Sixth Principal Meridian

T. 3 S., R. 98 W.,
sec. 10, SE¼SE¼;
sec. 11, SW¼SW¼;
sec. 14, NW¼NW¼;
sec. 15, E½NE¼.

The area described contains 200 acres in Rio Blanco County.

2. Subject to valid existing rights, the following described reserved Federal mineral interest is withdrawn from location and entry under the United States mining laws (30 U.S.C. Ch 2 (2000)), but not the mineral leasing laws, to protect the public from subsurface contamination at the Department of Energy Rio Blanco Project Site:

Sixth Principal Meridian

T. 3 S., R. 98 W.,
sec. 11, SE¼SW¼;
sec. 14, E½NW¼ and SW¼NW¼.

The area described contains 160 acres in Rio Blanco County.

3. The Bureau of Land Management will maintain jurisdiction over surface management of the land described in Paragraph 1.

4. This withdrawal will expire 50 years from the effective date of this order, unless, as a result of a review conducted before the expiration date pursuant to Section 204(f) of the Federal Land Policy and Management Act of 1976, 43 U.S.C. 1714(f) (1994), the Secretary determines that the withdrawal shall be extended.

Dated: September 3, 2003.

Rebecca W. Watson,

Assistant Secretary—Land and Minerals Management.

[FR Doc. 03–23827 Filed 9–17–03; 8:45 am]

BILLING CODE 1430–JB–P

DEPARTMENT OF THE INTERIOR

Minerals Management Service

Delegation to States, State of Alaska

ACTION: Solicitation of comments.

SUMMARY: The State of Alaska has requested a delegation of audit and investigation authority from the Minerals Management Service (MMS). This Notice gives the public an opportunity to review and comment on the State's proposal, which is posted on our Web site at *http://www.mrm.mms.gov/Laws_R_D/FRNotices/FRNotices.htm.*

DATES: Submit written comments on or before October 20, 2003.

ADDRESSES: Address your comments and suggestions regarding this proposal to Sharron L. Gebhardt, Regulatory Specialist by one of the following:

- Regular U.S. mail: Center for Excellence, Minerals Revenue Management, Minerals Management Service, P.O. Box 25165, MS 320B2, Denver, Colorado 80225–0165; or
- Overnight mail or courier: Attn: Sharron L. Gebhardt, 303–231–3211, Center for Excellence, Minerals Revenue Management, Minerals Management Service, Building 85, Room A614, Denver Federal Center, Denver, Colorado 80225–0165; or
- Email: *MRM.comments@mms.gov.* Please submit Internet comments as an ASCII file and avoid the use of special characters and any form of encryption. Also, please include "Attn: Delegation to States, State of Alaska; Solicitation of Comments" and your name and return address in your Internet message. If you do not receive a confirmation that we have received your Internet message, call the contact person listed below.

FOR FURTHER INFORMATION, CONTACT: Sharron L. Gebhardt at telephone (303) 231.3211, fax (303) 231.3781, email *sharron.gebhardt@mms.gov,* or P.O. Box 25165, MS320B2, Denver Federal Center, Denver, Colorado 80225–0165.

SUPPLEMENTARY INFORMATION:

Introduction: The Secretary of the U.S. Department of the Interior (DOI) is responsible for collecting royalties from lessees who produce minerals from leased Federal and Indian lands. The Secretary is required by various laws to manage mineral resources production on Federal and Indian lands; collect the royalties due; perform audits, inspections, and investigations related to mineral royalties; and distribute the funds in accordance with those laws. MMS performs the royalty management functions and assists the Secretary in carrying out DOI's Indian trust responsibility.

The Federal Oil and Gas Royalty Management Act of 1982 (FOGRMA), 30 U.S.C. 1701 *et seq.*, and specifically section 205 of FOGRMA, 30 U.S.C. 1735 provide for the delegation of audits, inspections, and investigations to States.

The State of Alaska proposes to conduct audits and investigations for producing Federal oil and gas leases within the State, for producing Federal oil and gas leases in the Outer Continental Shelf subject to revenue sharing under 8(g) of the Outer Continental Shelf Lands Act, 43 U.S.C. 1337 (g), and for other producing solid mineral or geothermal Federal leases within the State. The State requests 100 percent funding of the delegated functions for a 3-year period. We anticipate beginning on October 1, 2003, with an option to extend for an additional 3-year period.

Background: The State of Alaska had a cooperative agreement with MMS

Title 43—Public Lands: Interior

CHAPTER II—BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR

APPENDIX—PUBLIC LAND ORDER

[Colorado 17528]

[Public Land Order 5344]

COLORADO

Withdrawal of Lands for Atomic Energy Commission

By virtue of the authority vested in the President and pursuant to Executive Order No. 10355 of May 26, 1952 (17 FR 4831), it is ordered as follows:

1. Subject to valid existing rights, and the provisions of existing withdrawals, the public lands and the reserved minerals in the patented lands described as follows, which are under the jurisdiction of the Secretary of the Interior, are hereby withdrawn from those forms of disposition under the public lands laws as hereinafter specified, and reserved for use of the Atomic Energy Commission as a site for its Rio Blanco Phase I experiment in connection with the detonation of nuclear explosives to stimulate natural gas production, for the duration of the experiment, but for not more than 10 years:

A. The following described lands are hereby withdrawn from all forms of disposition under the public lands laws, including the U.S. mining laws, 30 U.S.C. Ch. 2, and from leasing under the mineral leasing laws:

SIXTH PRINCIPAL MERIDIAN

T. 3 S., R. 98 W.,
Sec. 10, SE¼SE¼;
Sec. 11, SW¼SW¼
Sec. 14, NW¼NW¼;
Sec. 15, E½NE¼.

The areas described aggregate 200 acres.

B. The minerals reserved to the United States in the following described patented lands are hereby withdrawn from disposition under the U.S. mining laws, 30 U.S.C. Ch. 2, and from leasing under the mineral leasing laws.

SIXTH PRINCIPAL MERIDIAN

T. 3 S., R. 98 W.,
Sec. 11, SE¼SW¼;
Sec. 14, E½NW¼, SW¼NW¼.

The areas described aggregate 160 acres.

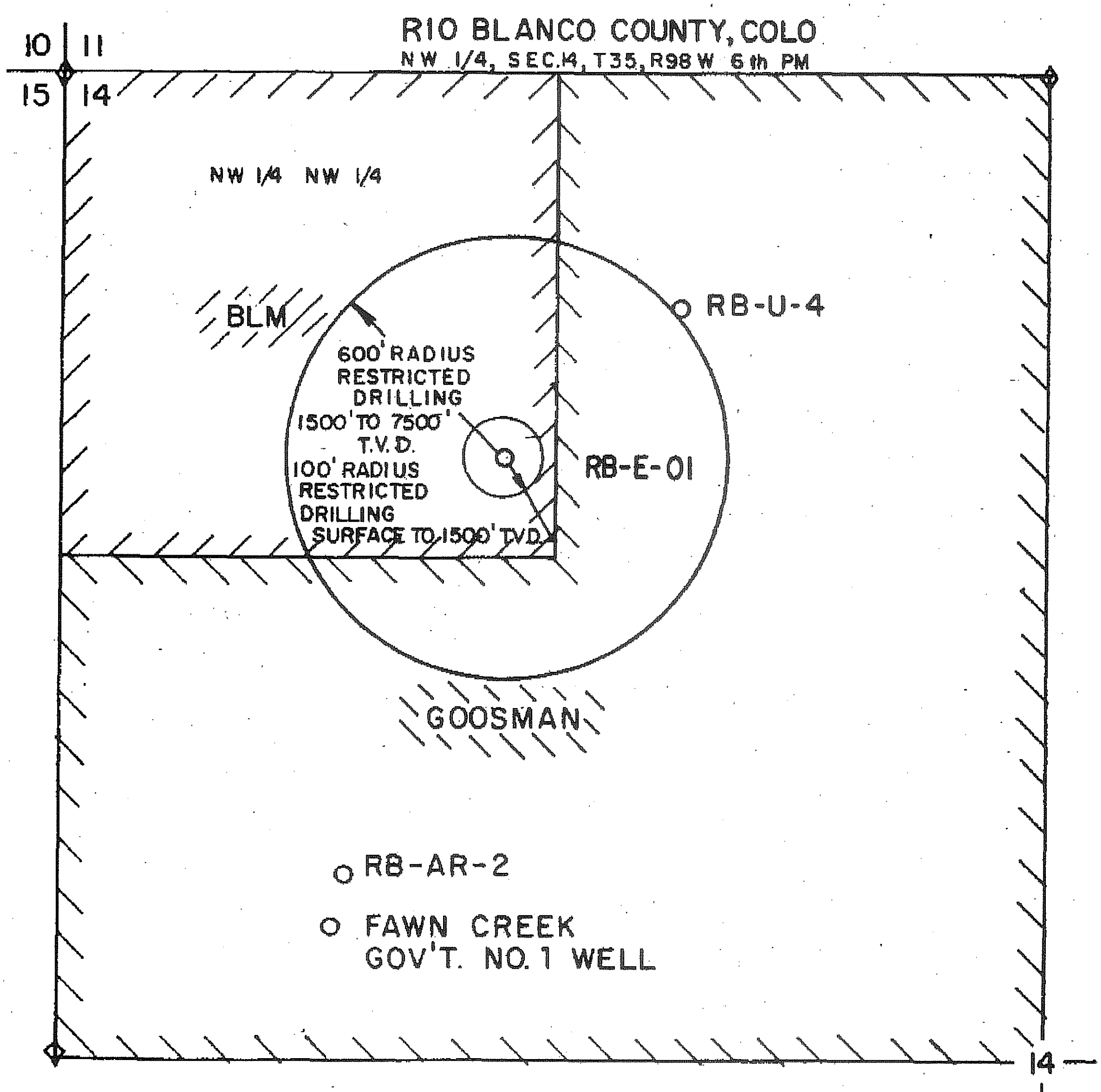
The total of the areas described above aggregates 360 acres in Rio Blanco County.

2. This order supplements but does not otherwise affect the withdrawal of lands for oil shale made by Executive Order No. 5327 of April 15, 1930, and by Public Land Order No. 4522 of September 13, 1968, and modifications thereof. The existing resource management plans will remain in effect or modified as necessary to protect other resources and be followed to the extent it does not interfere with the purpose of this order.

JOHN KYL,
Acting Secretary of the Interior.

APRIL 26, 1973.

[FR Doc.73-8389 Filed 4-26-73;9:57 am]



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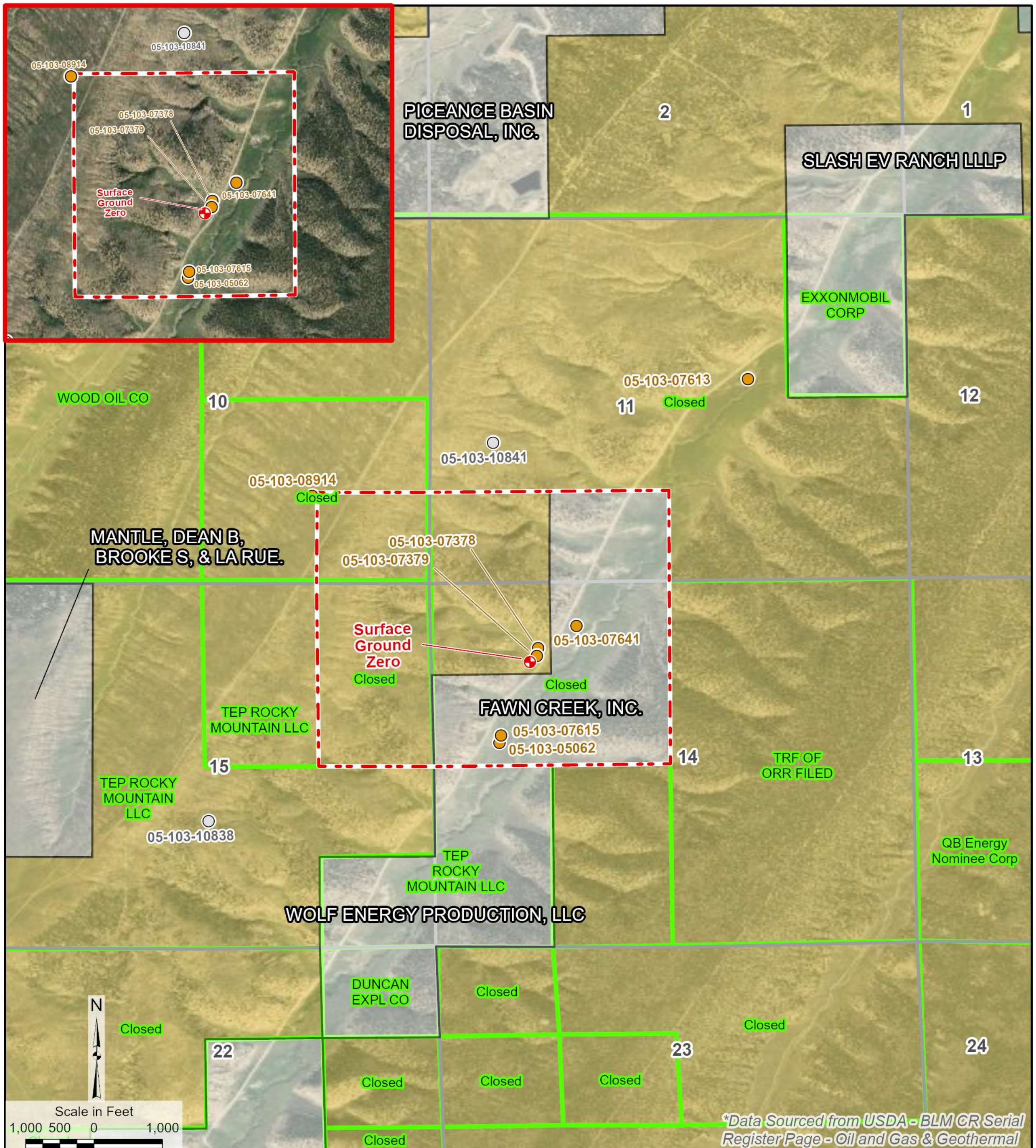
Appendix B

Surface Ownership and Oil and Gas Well Locations, Rio Blanco, Colorado, Site



Abandoned Well Location	Site Boundary	
Plugged and Abandoned Well	Surface Management Agency	
Surface Ground Zero	Bureau of Land Management (BLM)	
Subsurface Oil and Gas Lease	Private	

U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT

Work Performed by
RSI EnTech, LLC
Under DOE Contract 89303020DLM000001

Surface and Subsurface Ownership
Rio Blanco, CO, Site

DATE PREPARED: August 5, 2025

FILE NAME: 051887

A-P 051887

Appendix C

Path Forward for Rio Blanco, Colorado

LMS/RUL/S09791

Path Forward for Rio Blanco, Colorado

April 2013

U.S. DEPARTMENT OF ENERGY | Legacy Management

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LMS/RBL/S09791

Path Forward for

Rio Blanco, Colorado

April 2013

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Abbreviations

BLM	Bureau of Land Management
CDPHE	Colorado Department of Public Health and Environment
COGCC	Colorado Oil and Gas Conservation Commission
DOE	U.S. Department of Energy
IC	institutional control
LM	Office of Legacy Management
RBSAP	Rio Blanco Sampling and Analysis Plan
SGZ	surface ground zero

1.0 Introduction

In response to increased drilling for natural gas reserves near the Project Rio Blanco underground nuclear test site (Rio Blanco site), the U.S. Department of Energy (DOE) Office of Legacy Management (LM) is developing a path forward as a guide for discussion with the Colorado Oil and Gas Conservations Commission (COGCC) and natural gas operators with nearby lease interests.

1.1 Location and Background

The Rio Blanco site is located in Rio Blanco County in western Colorado (Figure 1). The Rio Blanco test was designed to evaluate the use of nuclear detonations to fracture the tight, gas-bearing sandstone reservoirs in the Piceance Basin to enhance natural gas production. The primary participants in the experiment were Continental Oil Company, Houston, Texas; CER-Geonuclear Corporation, Las Vegas, Nevada; the U.S. Atomic Energy Commission Nevada Operations Office; and the University of California Lawrence Livermore Laboratory. The test involved the simultaneous detonation on May 17, 1973, of three nuclear devices placed in a single vertical shaft at depths of 5,838, 6,230, and 6,689 feet (ft) below ground surface in the lower portion of the Fort Union Formation and the upper portion of the Williams Fork Formation of the Mesaverde Group (Figure 2). Each detonation had an estimated yield of 33 kilotons, and together they were designed to create a single, elongate chimney for natural gas extraction. To test if the devices created a single, connected chimney, canisters of inert gas (neon, xenon, and krypton, respectively, in the top, middle, and lower devices) were part of the device package for each vertical location.

Following the detonation, a reentry test well, RB-AR-1, was drilled into the uppermost chimney to conduct production testing and analyze for the inert gases used as tracers in the lower detonations. Reentry drilling began September 11, 1973, and was completed on October 25, 1973. Two production tests were conducted between November 1973 and February 1974. Analysis of the inert tracer gases and production drawdown pressures indicated that the detonations had not created a single, connected chimney. Small quantities of the xenon and krypton tracers were detected toward the end of the second drawdown test, although the low concentrations indicated low vertical permeability (Toman 1974).

Drilling of a second reentry well, RB-AR-2, began June 17, 1974, with the initial objective of intersecting the chimney of the middle detonation. Due to difficulties in maintaining the correct inclination angle, the lower detonation chimney was targeted instead. Several tests of the gas produced from the lower chimney indicated that the gas was similar to that of the upper chimney. The small volume of gas produced and the results of the tracer gas analyses indicated no significant connection between the three devices.

Analysis of production data from the reentry wells indicated that the permeability of the Fort Union and Williams Fork Formations at the depth of the detonations was significantly less than predicted prior to the test, approximately 6 to 10 times lower than expected. The large differences between predicted and actual production test results led to a decision to drill an additional well, RB-U4, to evaluate the production characteristics of the formations at a distance that would be unaffected by the detonations (Figure 3).

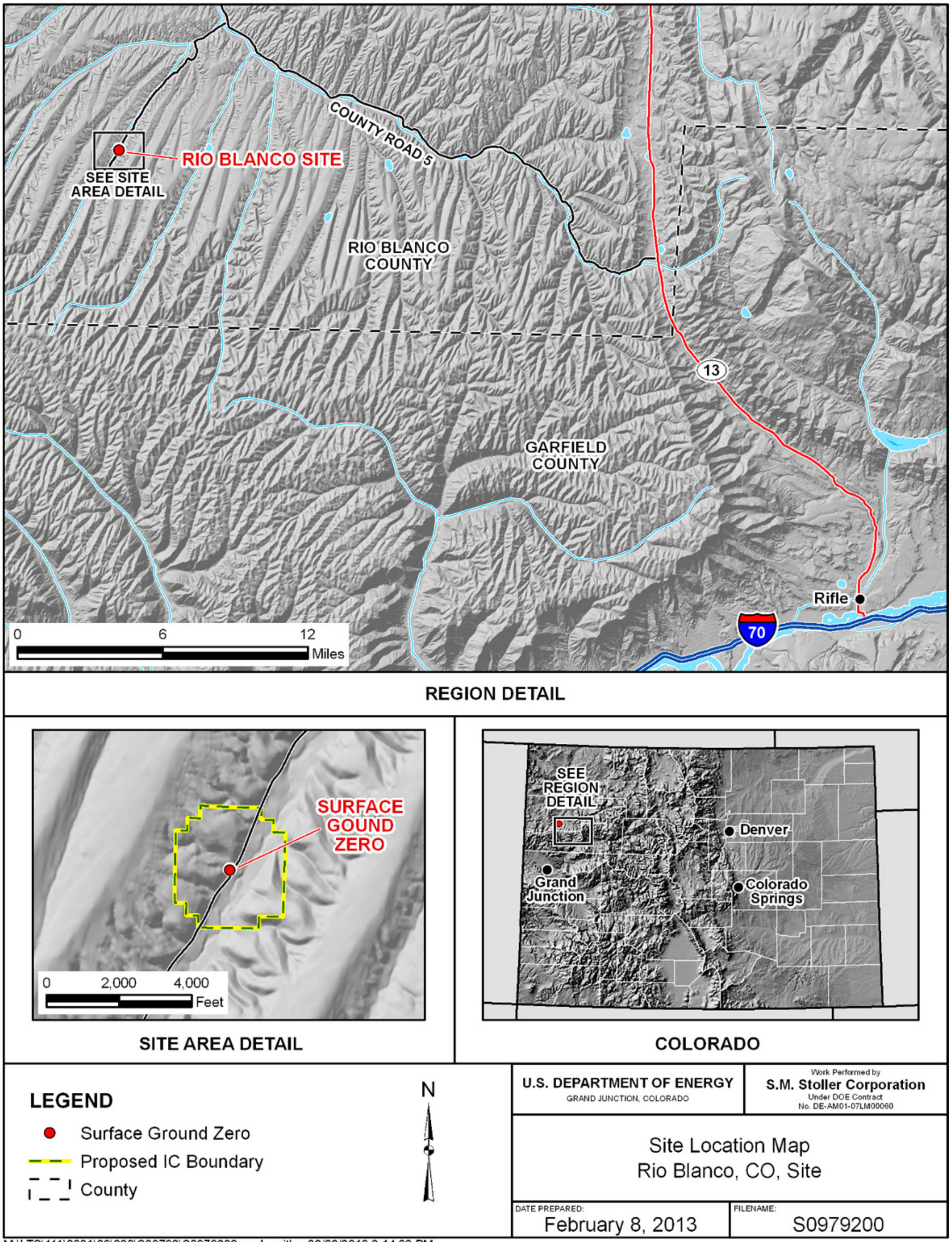

Figure 1. Rio Blanco, Colorado, Site Location Map

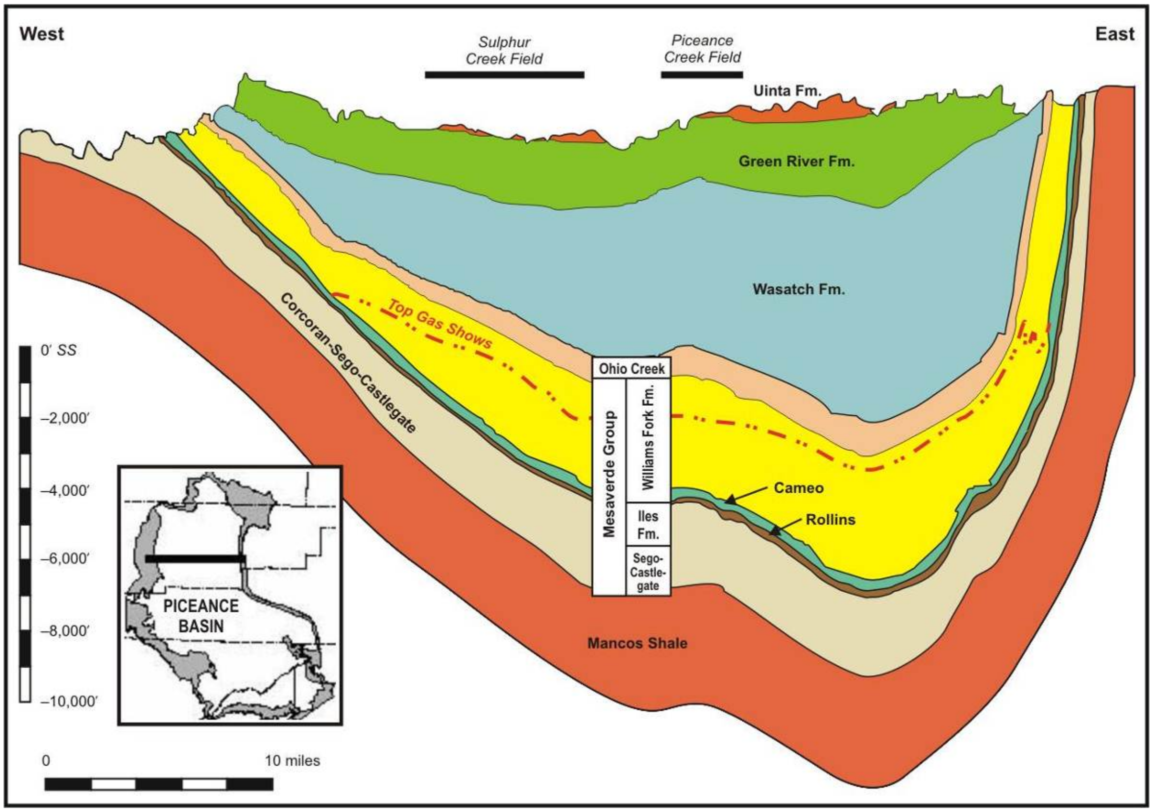

Figure 2. Piceance Basin Cross Section (modified from Yurewicz 2003)

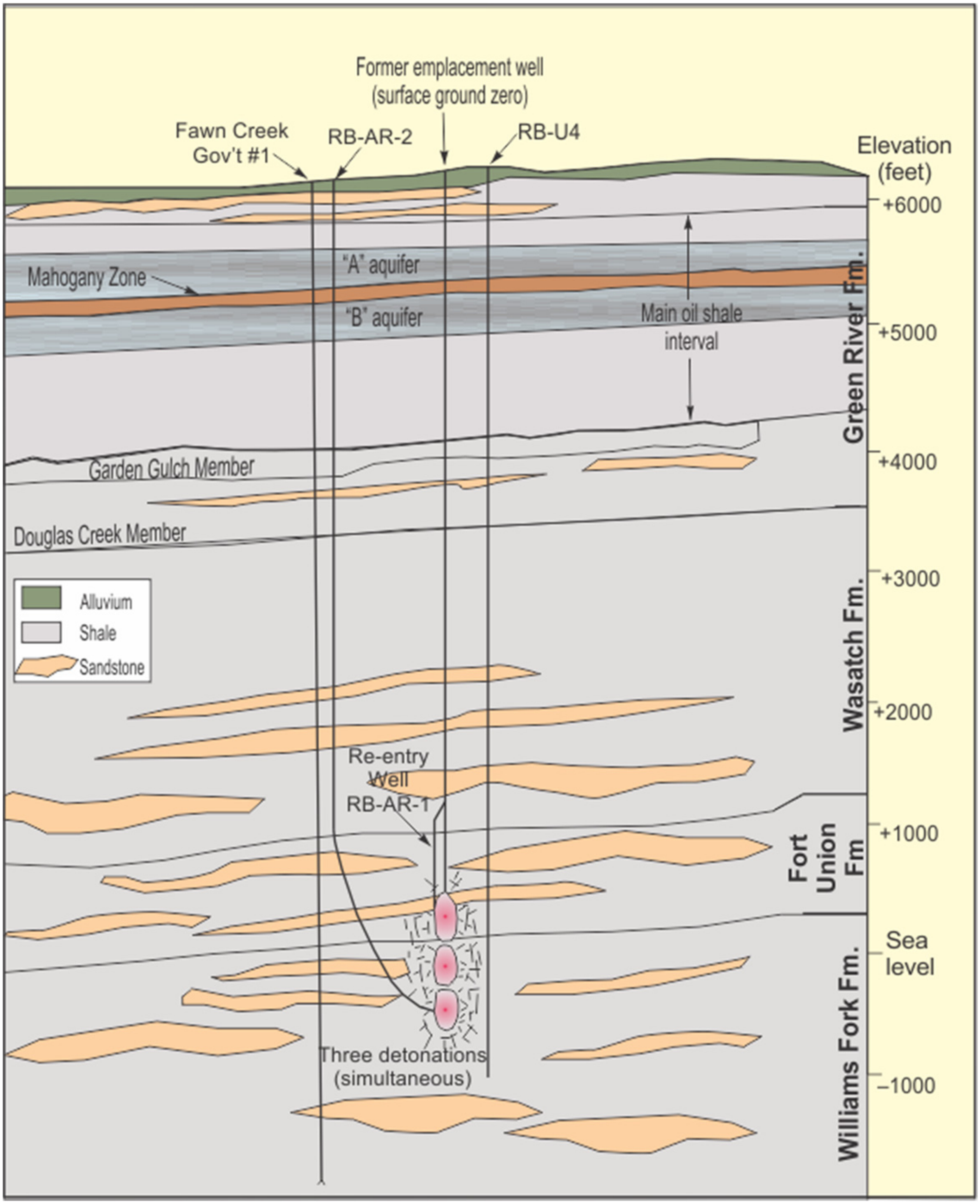

Figure 3. Generalized Cross-section of the Subsurface at the Rio Blanco Site

Well RB-U-04 was drilled approximately 600 ft northeast of the emplacement well. Zones of gas-bearing sands determined from geophysical logs were perforated, swabbed, and tested for gas production, then hydraulically fractured and tested for gas production. Gas production from the four perforated zones in the Mesaverde Group was insufficient to determine permeability due to the relatively high water saturation that decreases the overall permeability. Flow tests of gas-bearing zones in the Fort Union were more successful. Each of the three production tests on well RB-U-4 in the Fort Union yielded flow volumes that were 63 percent of the effective production from well RB-AR-1 which reentered the upper chimney, though the flow volumes were still far below the volumes predicted for those units prior to the detonations. Results from well RB-U-04 were mixed, but the significant finding was that the properties of the sands in the various units were considerably different from what was predicted before the detonations. One of the investigators summed up his view of the results: “If we had known in 1972 what we now know about this site, this project would have not been executed there” (Ballou 1976).

Planning for environmental restoration began in December 1975, and site cleanup activities were conducted from July through November 1976. The following cleanup goals were established (DOE 1978):

- Remove radiological contamination and decontaminate all project-related surface facilities.
- Plug and abandon all wells associated with the project.
- Dispose of all radioactive soil and debris accumulated during the site restoration activities.
- Reshape the terrain to approximate the original contours.
- Revegetate the disturbed areas.

In 2002, DOE’s Nevada Office of Environmental Management submitted to the Colorado Department of Public Health and Environment (CDPHE) a corrective action investigation report for the Rio Blanco site. This report characterized the nature of surface contamination and provided a human health risk assessment. During the site investigation, no gamma-emitting radionuclides were identified above background levels in the soil or groundwater at the site. Contaminants of concern at concentrations above screening levels were detected in the soil and groundwater during the investigation; however, the risk assessment concluded that the contaminants do not pose a risk to human health under current and planned future land use. The report recommended that no corrective actions be required for the site (NNSA/NV 2002). The CDPHE Hazardous Materials and Waste Management Division concurred that no further actions are required to “…assure that this property, when used for the purposes identified in the risk assessment, is protective of existing and proposed uses and does not pose an unacceptable risk to human health or the environment” (Stoner 2003). Surface closure of the Rio Blanco site was completed in fiscal year 2003 (DOE/NV 2005).

Subsurface contamination has been managed through institutional knowledge of restrictions on access to contaminated zones near the detonation point; monitoring of groundwater, natural gas, and production water; and modeling of subsurface transport of contamination.

In April 1973, Public Land Order (PLO) 5344 was granted to the Atomic Energy Commission to withdraw 360 acres of land from the U.S. Bureau of Land Management (BLM) to conduct the detonations. The withdrawal consisted of 160 acres of subsurface mineral rights and 200 acres of surface entry and subsurface mining. PLO 5344 was replaced in 2003 by PLO 7582, which described the same withdrawal area and stipulations for an additional 50 years.

At the Rio Blanco site, a plaque at surface ground zero (SGZ) describes restrictions on drilling within a 100 ft radius of the emplacement borehole from the surface to a depth of 1,500 ft below land surface. The restriction on drilling extends to a radius of 600 ft between 1,500 ft and 7,500 ft below the surface. Although the plaque states restrictions on drilling near the site, the restrictions are not memorialized in procedures for resource exploration or in public records.

In 2012, DOE proposed revisions to the PLO which contain institutional controls (ICs). The revised PLO for the site simplifies the restriction boundary yet provides access to resources below the detonation zone. The ICs restrict penetration, removal, or extraction of any material from the surface to a depth of 7,500 ft within an approximately 1,500 ft radius of SGZ (Figure 4). The revision also allows surface jurisdiction to remain with the BLM to allow any uses that do not conflict with DOE's need for protectiveness of the subsurface down to 7,500 ft in the restricted area.

In June 2009 Williams Production RMT and other companies (EnCana Oil and Gas [USA] Inc. and Whiting Petroleum) submitted the Rio Blanco Sampling and Analysis Plan (RBSAP) (Williams 2010). The RBSAP was revised in July 2010 and serves as a Condition of Approval issued by the Colorado Oil and Gas Conservation Commission (COGCC) for future applications to drill within a 2-mile radius around the Rio Blanco site. As stated in the RBSAP, the companies have voluntarily agreed to a drilling moratorium within a half-mile radius of the site and 600 ft from the Fawn Creek Government No. 1 well to a true vertical depth of 6,500 ft below ground surface. The RBSAP was reviewed and approved by several regulatory agencies, including the COGCC, CDPHE, and BLM. As with the Rulison Sampling and Analysis Plan, the RBSAP contains two tiers of monitoring zones; the Tier II zone regulates wells with bottom-hole locations from 1 mile to the 2-mile boundary. The Tier I zone regulates wells with bottom-hole locations from 1 mile to the half-mile voluntary moratorium area. Any Application to Drill within the half-mile zone will trigger a hearing before the COGCC (Williams 2010).

In July 2010 DOE issued a monitoring plan for the Rulison site (DOE 2010) that is also used at the Rio Blanco site. The DOE monitoring plan differs from the RBSAP in a few key areas. The DOE monitoring plan focuses only on Rio Blanco–related contaminants in production water and natural gas from the wells near the site. The sampling frequency is determined by (1) the distance between the gas well producing interval and the institutional control area, (2) the expected orientation of the well's drainage area given the natural fracture trend of the formation, and (3) the fraction of gas produced relative to the expected lifetime production of the well (DOE 2010).

Recent declining market prices for natural gas have forced the industry to temporarily shut in many wells in the area. Several new natural gas wells near the Rio Blanco site have been planned but not drilled. During this limited-drilling period, the industry has developed extensive infrastructure to support future drilling in the area (Figure 5).

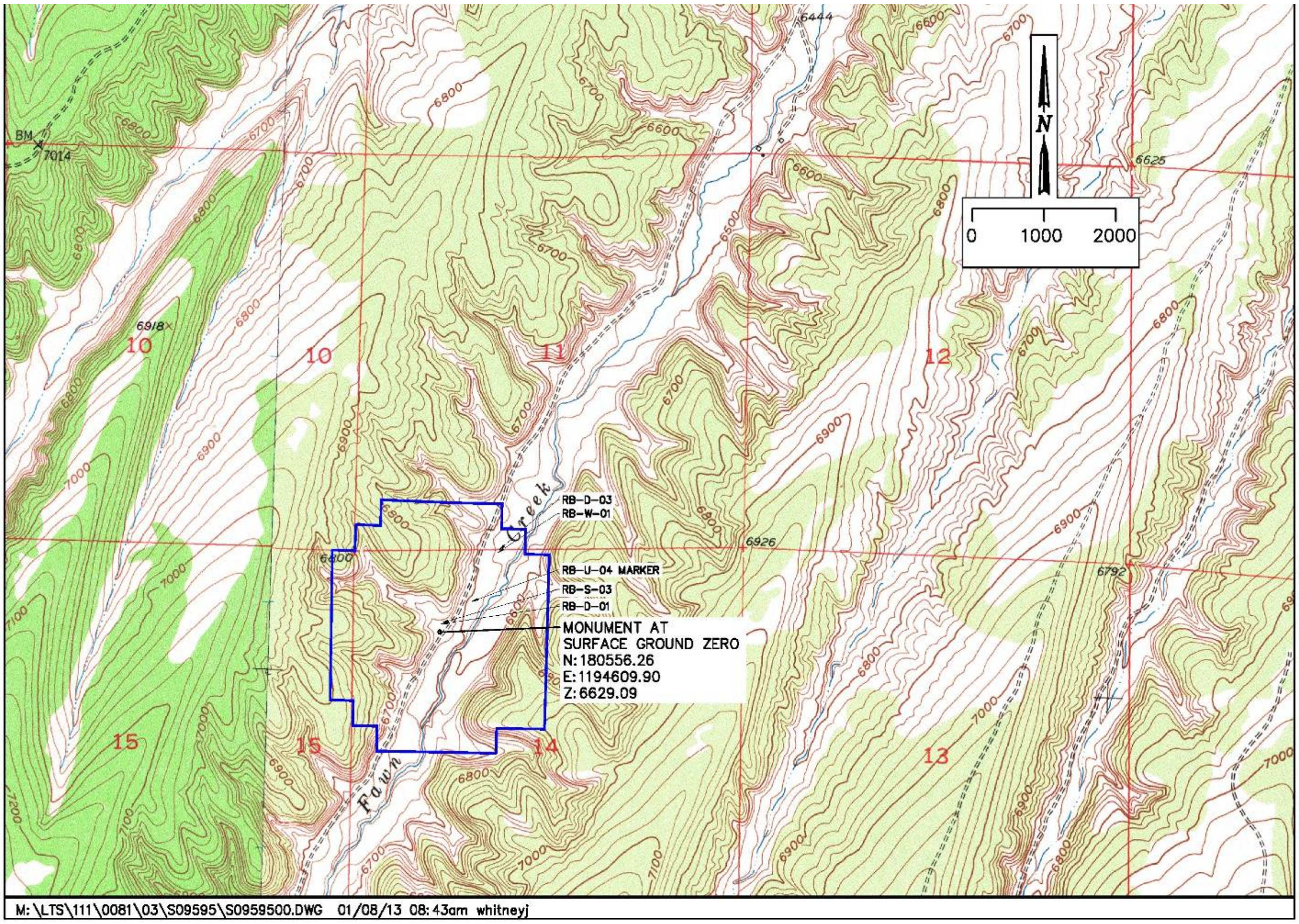

Figure 4. Proposed Institutional Control Boundary

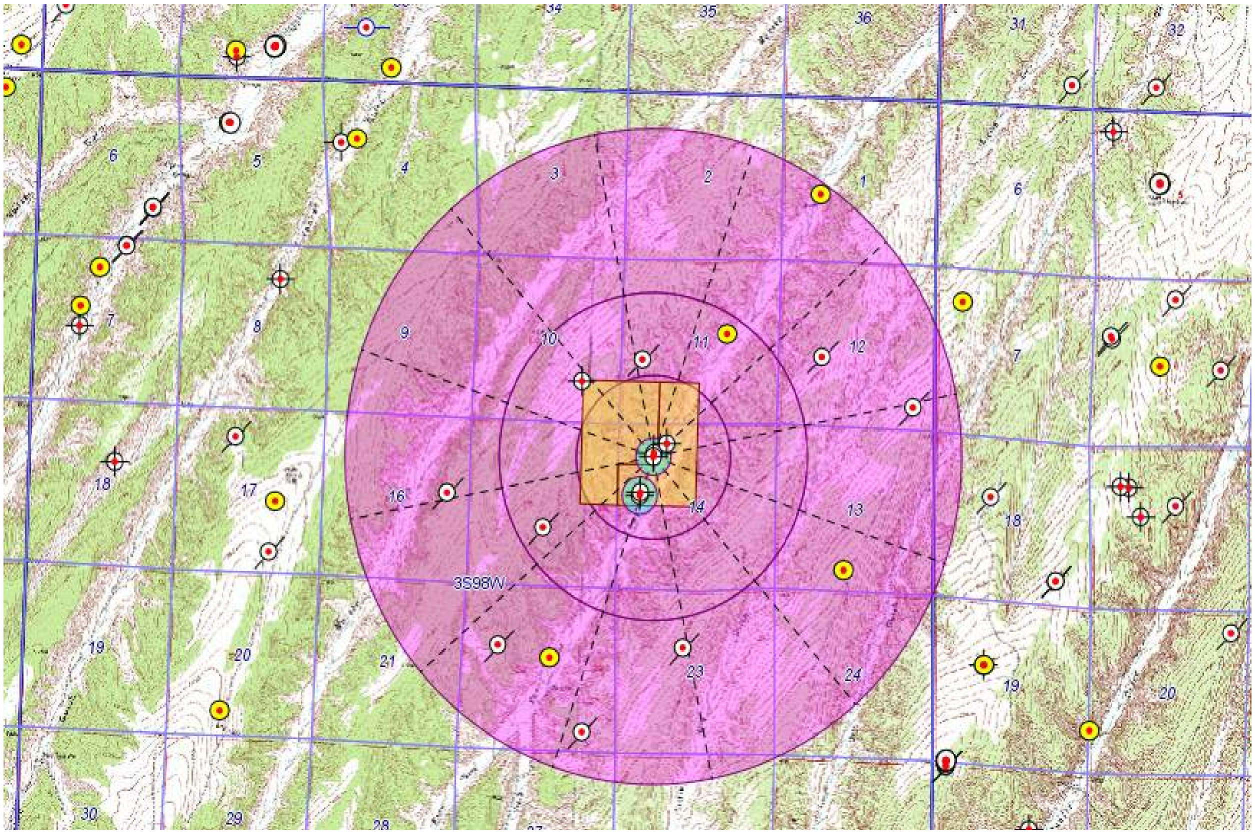

Figure 5. Wells Within COGCC Two Mile Notification Zone, Data from COGCC Online Database
(note) monitoring increases with one mile, voluntary half-mile exclusion zone

1.2 Potential Sources of Contamination

The contaminant source locations at the Rio Blanco site are the detonation cavities and well Fawn Creek Govt #1. The cavities and subsequent collapse chimneys contain the radionuclides produced by the detonations and tritium produced from the reentry well testing was disposed of in well Fawn Creek Govt #1.

The Rio Blanco devices were designed to significantly decrease the amount of tritium produced by each device relative to the previous gas stimulation tests. Tritium is a mobile radionuclide that can migrate with natural gas as it is extracted. The estimated production of tritium for the Gasbuggy, Rulison, and each Rio Blanco explosive were 40,000; 10,000; and less than 1,000 curies (Ci), respectively (Toman 1974).

Most of the longer-lived radionuclides produced by the Rio Blanco detonations solidify at relatively high temperatures and were entrained within the molten rock as it cooled to form a melt glass at the base of each cavity. Transport of these radionuclides any appreciable distance away from the cavity is highly unlikely because of several factors: they must first be released from the solid melt glass by dissolution, the movement of liquid water in the gas-bearing unsaturated formation is limited, and the dissolved radionuclides tend to sorb onto mineral grains or react chemically with the geologic media, slowing their migration relative to moving liquid water.

Several of the longer-lived radionuclides produced by the detonations in quantities large enough to potentially affect public health or the environment (tritium, krypton-85, and carbon-14) do not solidify at formation temperatures and exist in either the liquid or gas phases. When present in the gas phase, these radionuclides are far more mobile than those bound in the solid phase or dissolved in the liquid phase. Tritium (an isotope of hydrogen) is primarily present as tritiated hydrogen gas (HT in place of H_2), tritiated methane (CH_3T in place of CH_4), or tritiated water (THO in place of H_2O). Carbon-14 is primarily present as part of the carbon dioxide molecule ($^{14}CO_2$ in place of $^{12}CO_2$) and to a lesser degree, in the methane molecule ($^{14}CH_4$). Krypton-85 is an inert gas that has a low solubility in water. No reentry well was drilled into the middle detonation zone; therefore, no production testing occurred in that zone. As a result, significant amounts of Krypton-85 remain in the middle detonation zone. Gas production testing on the reentry well to the upper chimney showed that approximately 5 percent of the tritium was contained in the dry gas (48 Ci of the 1,000 Ci produced by the detonations). The Rio Blanco and Rulison tests showed similar behavior in tritium concentrations during their respective production testing. At both sites, initial tritium concentrations (and those of other gas-phase radionuclides) dropped significantly during the production testing as gas-phase contaminants were removed from the detonation zone and replenished by uncontaminated natural gas from the surrounding formation.

Tritiated water occurs both as liquid water and as water vapor, and it migrates readily with either the liquid (formation water that is mobile, limited at the Rio Blanco site) or gas phases (plentiful at the Rio Blanco site). An additional 4 Ci of tritium was produced in the form of water vapor carried in the gas stream during production testing (Toman 1974). Although tritium can also be incorporated into the solidified melt glass, potential migration scenarios maintain a conservative approach by considering all tritium mass to be in the liquid or gas phase.

Upward migration of radionuclides to depths that might pose a risk to public health or the environment solely by way of natural pathways (with fluids moving through pores and fractures in the formation) is extremely unlikely because of the depth of burial (between 5,838 and 6,689 ft below ground surface) and the low permeability of the surrounding formations, which limits fluid movement.

The pores of the tight, poorly connected sandstone reservoirs of the lower Fort Union and upper Williams Fork Formations contain approximately 37–40 percent gas and 60–63 percent formation water (brine) and are isolated within lower-permeability shale. The presence of commercial amounts of gas and the need to use hydraulic fracturing methods to affect even small areas (each well drains roughly a 10-acre area) support the interpretation of essentially no movement of fluids within a time frame that would be of concern for tritium migration. In the absence of wells that penetrate the formations near the detonation zone, there is no realistic pathway for contamination to reach the surface or near-surface. Thus, the most likely tritium transport mechanism at the Rio Blanco site is as tritiated water vapor migrating with natural gas to a nearby producing well.

1.3 How Close to the Detonation Zone Can Natural Gas Be Safely Produced?

The current land withdrawals at the Rio Blanco site consist of two contiguous withdrawal areas. One area encompasses 200 acres and limits surface and subsurface intrusion; the second area encompasses 160 acres and limits only subsurface intrusion until October 2046. In 1976, the Energy Research and Development Administration, a predecessor of agency of DOE, notified the Nevada Operations Office that a permanent withdrawal would be required for the site and that a monument would be placed at the site. The monument would include a plaque inscribed with a brief history of the site and a description of drilling restrictions. The resulting plaque bears the inscription "no subsurface intrusion within a radius of 100 feet from the monument to a true vertical depth of 1,500 feet and no subsurface intrusion with a radius of 600 feet from the monument to a true vertical depth between 1,500 feet and 7,500 feet without permission of the U.S. Government." However, these restrictions cannot be found in any enforceable document with any agency having the authority to control drilling activities (DOE 2007).

The primary factors that are being used to determine a safe distance from the detonations for drilling at the Rio Blanco site are (1) historical data on the extent of detonation-induced fractures, (2) geologic parameters at the detonation zones that control the extent of transport, (3) post-detonation monitoring data, (4) contaminant transport modeling, (5) implementation of institutional controls, and (6) a sequential drilling and monitoring approach.

An important part of the discussion on a minimum safe distance for drilling is the fact that the detonation zones at the Rio Blanco site are not in favorable zones for natural gas production. In fact, a major cause of the overall failure of the test was the stratigraphic location of the detonations (Ballou 1976). The Fort Union and upper Williams Fork Formations, where the detonations took place, both contain significantly more formation water than the lower part of the Williams Fork, where current natural gas extraction occurs. The gas-producing interval of the lower part of the Williams Fork begins approximately 800 ft below the bottom of the lowest detonation at the Rio Blanco site.

The extents of the nuclear detonation zones are thought to be well known from analysis of data from the two wells that reentered the upper and lower chimneys plus the drilling and testing of the RB-U-04 study well. Estimates prior to the detonations, based on geologic parameters and the kiloton yield of each device, predicted that the distance for increased vertical permeability would be a minimum of 446 ft. The upper and middle devices were separated by 392 ft and should have formed a single increased permeability zone. Analysis of production data and the inert gas tracers placed in each device showed that communication between the detonation zones was limited. The data collected from RB-U-04 also indicated that the lateral extent of the gas-bearing sands in that well did not correlate well (especially with the sands in the lower detonation zone) with the gas-bearing sands at the detonation points. The current drilling density of one well every 10 acres in the lower Williams Fork Formation near the Rulison test supports the lack of lateral extent of the gas-bearing sands. Analysis from drill-back data and calculations based on volume of natural gas produced and pressure decline, indicate that the increased permeability extends approximately 246 ft radially from each detonation, and the cavities are approximately 66 ft in radius (Ballou 1976). The average and maximum extents of typical hydrofractures can be estimated from data from the many gas wells in the Piceance Basin. Hydrofractured zones elongate in the direction of the natural fracture trend of the Williams Fork

Formation and allow gas from distances of approximately 600 ft from the well in this direction to be extracted (based on the 10-acre well spacing near Rulison).

The 2012 modeling study of the Rio Blanco site simulated flow and transport from a series of hypothetical gas wells near the site. The top of the gas-producing interval (the Lower Williams Fork) in the model was approximately 500 ft below the lowest detonation zone at the site. This provides a smaller vertical separation between the detonation and gas-producing intervals than would be expected for an actual well near the site. The simulated wells were installed in three sets of eight wells each approaching from the east. The first set of simulated wells began production in the year 2015 and were located approximately 2,200 ft east of SGZ (for the nearest well). The second set of simulated wells were located approximately 900 ft east of SGZ, within the surface footprint of the 160-acre withdrawal area, and began production in the year 2020. The last set of simulated wells were located approximately 450 ft west of SGZ, within the 200-acre withdrawal area and within the 40-acre lot where SGZ is located, and began producing in the year 2035. All wells were produced for a simulated 20-year well-life. The wells were positioned on a 10-acre well spacing as is currently being employed for drilling near the Rulison site. Operators of wells in the vicinity of the Rio Blanco site are currently locating wells on a 40-acre spacing and have not adopted the tighter 10-acre spacing. The tighter spacing was used to maximize the modeled pressure drawdown throughout the formation to increase the potential for transport from the detonation zone.

A tritium source was placed in the detonation zone to simulate transport potential. The model partitions tritiated water between liquid and gas, allowing transport in either phase. Simulation results from the first two well sets showed that production from these wells (completed in the Lower Williams Fork) did not induce a pressure gradient that would connect to the detonation zone in overlying Upper Williams Fork. This was expected, given both the horizontal and vertical separation between the wells and detonation zone. The final set of wells, horizontally near SGZ, induced a slight gradient between the uppermost perforated interval and the lowermost detonation zone. The gradient was insufficient to induce transport of tritium from the contaminated area. The results of the 2012 modeling study provide confidence that wells at the half-mile radius (2,640 ft horizontally from the detonations and farther than the first set of simulated wells) are safe for gas production. Even in the unlikely event that tritium were to reach a natural gas well, there is no reasonable exposure scenario that would result in risk to human health or the environment. Tritium moving through the gas-bearing formation would most likely migrate as tritiated water vapor with the methane gas, and nearly all the tritium would be captured as the entrained water is removed from the gas prior to entering the distribution system (DRI 2012). Appendix B describes the potential exposure pathways associated with natural gas processing and production. The following sections describe and recommend a cautious approach to natural gas development near the Rio Blanco site.

Several revisions to the current drilling restrictions are underway. The new restrictions will be an IC that simplifies the restrictions and provides more confidence in the protection of the site. The new IC will restrict penetration and extraction from a radius of 1,500 ft from the surface to a depth of 7,500 ft. This will add an additional 900 ft of penetration and extraction protection at the detonation zone depths, while allowing penetration and extraction from the lower Williams Fork gas-producing zones. This IC adjustment also adds confidence that wells at the half-mile hearing radius are safe for natural gas production.

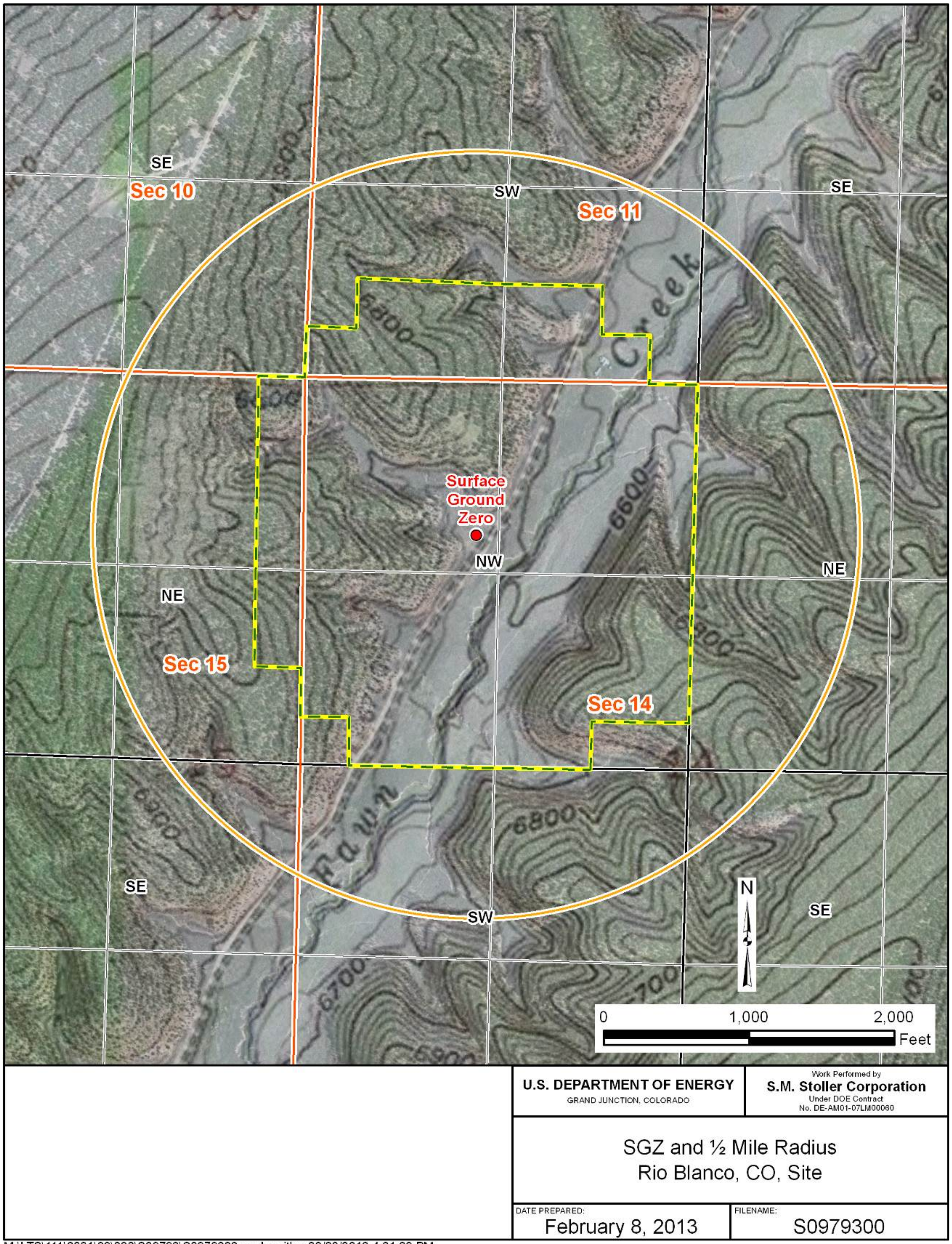

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Figure 6. Half-Mile Radius Within Which Applications to Drill Require a Hearing Before the COGCC (Rio Blanco Sampling and Analysis Plan) with Proposed IC Boundary

1.4 Path Forward Objective

The objective of the DOE path forward is to encourage gas developers to adopt a conservative, staged drilling approach that allows gas reserves near the Rio Blanco site to be recovered in a manner that reduces the likelihood of encountering contamination. Success of the approach will depend on the joint cooperation of companies with lease interests near the Rio Blanco test, the COGCC, BLM, and DOE. Once a comprehensive approach has been adopted, the public would be informed of the changes and kept informed of drilling progress and monitoring results.

2.0 Guidelines for Gas Development near Rio Blanco

A staged approach that initially uses conservative modeling but primarily relies on data collection to determine a safe drilling distance from the Rio Blanco site is recommended. Initially, a new set of model simulations that apply more-conservative transport parameters was used to predict the nearest distance, in the direction of the natural fracture trend, that a hypothetical well can be located to the Rio Blanco site with no simulations exceeding background levels of tritium during the life of the well. The orientation and potential variability of the natural fracture trend in the area should be determined from existing data and integrated into the gas development recommendations. If sampling results from wells with bottom-hole locations of 1 mile from the site indicate no contamination, wells just outside the half-mile hearing boundary can be considered. If possible, it is recommended that the initial half-mile wells be located normal to the natural fracture trend and detonation zone. This well orientation places the initial half-mile wells in the least likely growth direction of the hydrofractures toward the detonation zone, minimizing the likelihood of transport. The wells surrounding the half-mile radius will act as a focused monitoring network in which sampling and analysis of fluids and natural gas from the wells can confirm that no contaminant transport occurs beyond the half-mile radius.

Currently, production wells are completed at depths hundreds to thousands of feet below the detonation horizon. Wells that are planned for completion in sandstone reservoirs in the detonation horizons should be avoided. After sampling and analysis as described in Section 2.2 have confirmed the absence of test-related radionuclides at the wells just outside the half-mile radius, wells inside the half-mile radius may be considered. The initial wells with bottom-hole locations within the half-mile hearing radius should be located normal to the orientation of the natural fracture trend. Confirmation of this natural fracture trend should come from wells completed near the site using the best available technology. Once the natural fracture trend is confirmed, wells in line with the predominant fracture trend within the half-mile radius and outside the IC boundary are discouraged.

The Rio Blanco path forward assumes that the current industry RBSAP (which COGCC enforces) and the DOE Sampling and Analysis Plan for wells inside the 2-mile notification area will be in effect and implemented.

2.1 Natural Fracture Trends near the Site

The Williams Fork Formation of the Piceance Basin has a natural fracture field that generally trends east to west, though the orientation can vary somewhat depending on the location within the basin. The permeability of the formation is greater in the direction of the natural fracture trend, and hydrofractures created by well completion activities tend to elongate in this direction. The orientation of the fracture trend in a given area can be measured using several methods. The dipole sonic log can be used to determine the minimum and maximum principal stress directions within the formation, which can then be used to infer the stress field orientation. Microseismic mapping uses geophones placed in one or more wells near the well being completed to record hydrofracture propagation, which tends to follow the higher-permeability direction of the natural fracture field. The production history and pressure response of closely spaced wells may even be a better indicator. Based on fracture analysis elsewhere in the basin, it will be assumed that an east-west fracture orientation applies to the area surrounding the Rio Blanco site. Considering that the Rio Blanco detonations and gas-producing zone are at different depths, the importance of the natural fracture trend orientation is less important than at Rulison where they are at the same depth.

2.2 Confirmation That the Half-mile Hearing Radius is Safe

It can be confirmed that locations beyond and approaching the half-mile hearing radius are safe for natural gas development by drilling a series of gas wells just outside the radius, producing the wells, and monitoring them for radionuclides associated with the nuclear test. The wells will be drilled by gas operators with lease interests near the site as part of their planned development of gas reserves in the area. These wells would confirm that contamination has not migrated appreciably from the site and could also act as a focused network to monitor potential future contaminant migration.

A conservative approach to this confirmation process is to place the first of the half-mile wells almost directly north and south of the test site (assuming a general east-west natural fracture trend). Subsequent wells would be drilled progressively closer to the linear band aligned with the predominant natural fracture trend and the test site, and wells located within that band would be installed last. The objective of this approach is to create a production and monitoring well network that surrounds the site with the highest-risk wells installed near the end of the drilling program.

The number of sampling events needed to provide confidence that radionuclides have not migrated to the half-mile radius wells is dependent on the total well production as a fraction of total expected production from the well, shut-in pressure of the well, frequency of sampling, and well location. When all samples from a well, including several samples after production reaches one-eighth of expected total production and the shut-in pressure is less than half the original formation pressure, it can be assumed that the next set of wells nearer the site can be drilled.

The probability of encountering radionuclides at any of the half-mile wells is low based on recent modeling of the site and on the test results from well RB-U4. The proposed approach ensures that if test-related contamination were encountered, the concentrations would likely be small. Drilling wells just outside the half-mile radius eliminates the need for COGCC hearings and thereby reduces the potential for decisions made with insufficient data. This approach allows all parties involved to make more-informed decisions regarding the subsequent well installation within the half-mile hearing radius.

2.3 Wells Within the Half-Mile Hearing Radius

Wells inside the half-mile radius would be allowed only if sampling results confirm the absence of test-related radionuclides in wells at the half-mile radius. As with the wells at the half-mile radius, the first wells installed within the half-mile radius should be located almost perpendicular to the site's natural fracture orientation or to the north and south. Subsequent wells could then be installed in a sequence that gradually approaches the higher-risk transport direction, currently believed to roughly east or west of the site. In effect, this approach changes the arbitrary half-mile radius to an oval shape that is elongate in the direction of the natural fracture trend.

As with the gradual approach to developing gas reserves just beyond the half-mile radius, drilling within the half-mile radius and outside the IC boundary should proceed cautiously, using testing and monitoring results from each newly installed well to evaluate successive well locations as to their potential risk. Under no circumstances shall a well be located such that encroachment into or removal of materials from within the IC boundary to a depth of 7,500 below ground surface might occur. This includes hydrofracturing and inducing gradients by way of production near the IC boundary that could induce migration from the IC boundary.

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Appendix D

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