Review of the Draft Environmental Assessment

August 2011 Competitive Oil and Gas Lease Sale
U.S. Department of the Interior
Bureau of Land Management
Kremmling Field Office
Colorado

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Background

The BLM Kremmling Field Office plans to offer subsurface federal mineral parcels for competitive oil and gas leasing. The parcels recommended for leasing total approximately 3000 acres of Federal mineral estate administered by the Kremmling Field Office. Four parcels acres are in Grand County and two parcels, totaling 160 acres, are in Jackson County. All of the parcels in Grand County are on privately owned surface with Federal minerals, known as 'split estate lands' where the surface owner does not own the subsurface mineral rights. BLM asserts that the proposed action conforms to the Kremmling Resource Management Plan (RMP) and Environmental Impact Statement approved in 1984, updated 1999. BLM had prepared this broad planning document to comply with the provisions of the National Environmental Policy Act (NEPA). BLM states that the current "...Proposed Action is in conformance with their prior RMP and EIS, *even though it is not specifically provided for,* because it is consistent with their finding in that RMP that federal mineral estates will remain open" to oil and gas leasing under the 1920 Mineral Leasing Act. (emphasis added)

Since 2007, the BLM Kremmling Field Office has been in the process of preparing another revised Resource Management Plan/EIS that will evaluate all the federal surface and mineral estate managed by BLM within the field office boundary. This updated RMP/EIS is expected to be released in late spring 2011.

Summary of author's findings

The August 2011 Competitive Oil and Gas Lease Sale EA fails to meet the requirements of NEPA because neither this EA nor the proceeding RMP/EIS nor the Statewide Oil and Gas EIS of 1991 evaluated modern shale oil or shale gas technology. Not until this decade did the industry master the techniques needed to release oil from shales. This is an unstudied and untested new technology not previously analyzed by the BLM in its prior NEPA documents.

It is likely that the parties that nominated leasing of these federal minerals are seeking to hydrocarbon targets in Upper and Lower Cretaceous section including the Sundance, Entrada, Frontier, and the Niobrara Shale Formations. Last year, the Niobrara Formation in Weld County, Colorado and Laramie County, Wyoming produced large volumes of oil and minor amounts of natural gas using the modern and unevaluated techniques of

horizontal drilling combined with hydraulic fracturing using gelled fracking agents.

Developing industrial shale gas and shale oil projects in Grand County using current practices is likely to degrade surface water and groundwater quality, to harm humans, and to negatively impact aquatic ecosystems.

Approximately 1 of 50 natural gas or oil wells could impact local groundwater during development. The probability that shale gas and shale oil wells will degrade local water quality over a fifty-year period is high.

Some chemicals used for drilling muds, hydraulic fracturing, and flow-back waters associated with shale gas and shale oil drilling constitute human health and environmental hazards even when the chemicals are extremely diluted.

Recommended corrections to the BLM needed to fully disclose the impacts in order to meet their obligations under NEPA and to evaluate means to reduce these environmental and human health risks.

1. BLM should withdraw this EA pending completion of its updated RMP. BLM should not take this irretrievable action which would limit the choice of alternatives. A revised NEPA analysis should evaluate alternative lease stipulations to be applied to these parcels to reduce potential environmental damage that might occur using standard leasing stipulations.

2. The updated RMP must thoroughly analyze the emerging modern technology of developing shale oil in the Niobrara Formation using horizontal drilling combined with high volume hydraulic fracturing.

3. The revised EA should be coordinated with the Colorado Oil and Gas Conservation Commission (COGCC) to determine if COGCC intends to define the area as a 'sensitive use determination'. Such a designation by the COGCC requires the use of 'green completion' technologies which involves the use of enclosed tanks to contain all drilling fluids and limits the time period when fracking fluids can be retained in any pit.

4. The revised EA, once it has been tiered to a properly completed and updated RMP/EIS, should evaluate whether to require 'green completion' technology as a discretionary performance-based lease stipulation. BLM should expand upon this concept to include the possible use of 'green' or less toxic hydraulic fracturing fluids.

5. The BLM should consider a discretionary performance-based lease stipulation to require three ground water monitoring wells near production wells or well pads; one up-gradient and two monitoring wells down-gradient in the uppermost useable aquifers.

Recommendations to improve the analysis in the BLM EA and to evaluate leasing stipulations to reduce these risks.

Recommendation 1: BLM should withdraw this EA pending completion of its updated RMP. BLM should not take this irretrievable action which would limit the choice of alternatives. A revised NEPA analysis should evaluate alternative lease stipulations that might be applied to these parcels to reduce potential environmental damage that might occur using standard leasing stipulations.

Despite the claim in the EA that federal and state restrictions on oil and gas development reduce the risks to the natural environment, natural gas and oil exploration and production impose near certainty of environmental harm. Data from Colorado indicated that 1549 spill incidents related to natural gas extraction activities occurred in a five year period between January 2003 and March 2008. The Congressional Sportsmen's Foundation estimated that 20% of these impacted groundwater. The New Mexico Oil Conservation Division recorded 705 groundwater-contaminating incidents between 1990 and 2005 by the oil and gas industry. And the Pennsylvania Land Trust reported 1610 violations in Pennsylvania between January 2008 and August 2010, 1052 of them likely to have impacted the environment. Compared with totals for producing gas wells of 25,716, 40,157 and 55,631 in Colorado, New Mexico and Pennsylvania, respectively, these data suggest that natural gas development degrades groundwater quality at a rate of 1.2 to 1.9 incidents per 100 gas wells.

Immediate damage from spills and improperly constructed wells create short-term environmental risks. Over a longer time period, other risks will develop. In 1992, the EPA estimated that of 1.2 million abandoned oil and gas wells in the United States, 200,000 were leaking. Canadian research has shown that concrete shrinkage leads to well casing fissures nearly impossible to avoid after fifty years. This can provide a pathway for formation gases and other fluids to re-pressurize the deteriorating wells. Natural gas well casings will fail over time, especially longer than fifty years.

A complex array of chemicals are used for natural gas and oil development in 'non-conventional' formations. First, combinations of chemicals are added to the drilling muds used to drill the bore hole. Chemicals are added to

increase the density of the fluids to facilitate boring, to reduce friction, and to facilitate the return of drilling debris to the surface. After drilling, hydraulic fracturing is done to break up the rock matrix to allow the methane or oil to escape, increasing well productivity.

The hydraulic fracturing fluids are approximately 99 to 99.5 percent water and sand, and typically contain chemical additives that are needed to increase viscosity, act as biocides, clay inhibitors, scaling inhibitors, acidifiers, breaking agents and corrosion prevention. In Niobrara producing wells in Weld County, Colorado, approximately 1.0 million or more gallons of fluid containing toxic chemicals are injected underground during each fracking operation. The total chemical portion of the fracking fluid at one-half of one percent means that approximately 5000 gallons of chemical additives are included in each fracking event that uses 1.0 million gallons of fracking fluid. Niobrara wells in Weld County have been hydraulically fractured using ten fracturing stages per well. An estimated one half to two-thirds of the fracking fluid is returned to the surface during well completion and subsequent production bringing with it toxic gasses, liquids, and solid material naturally present in underground oil and gas deposits.

As of May, 2010 researchers at The Endocrine Disruptor Exchange (TEDX) identified 944 products used in natural gas operations in the U.S. However, little was known about 43 percent of these products, since less than one percent of the total product composition was available. For those 407 products, only the name of the product with no identifiable chemical name or percent composition was reported. These researchers were able to locate CAS numbers for 353 products. (Note: CAS numbers refers to a unique identifier assigned to known substances by the Chemical Abstracts Service Registry.)

Using the health effect information for the 353 chemicals with CAS numbers, the TEDX researchers created a profile of possible health effects that depicts the percentage of chemicals associated with each of the twelve health effect categories. Three fourths of the chemicals on the list affect the skin, eyes, and other sensory organs, the respiratory system, the gastrointestinal system and the liver. Over half the chemicals show effects in the brain and nervous system. More than one quarter of the chemicals can cause cancer and mutations. Notably, 37% of the chemicals can affect the endocrine system that encompasses multiple organ systems including those critical for normal reproduction and development.

Many chemical products are used in the development of a gas or oil well. Some examples, along with their most common applications, are shown in Table 1.

Table 1. Examples of Additive Functions in Shale Gas Extraction

Additives	Examples	Purpose
Friction reducers	heavy naphtha	penetrate fissures
Biocides	glutaraldehyde, DBNPA	prevent biofilms
Scale inhibitor	ethylene glycol	prevents chemical scaling
Corrosion inhibitor	propargyl alcohol	prevent corrosion of piping
Surfactant	2-butoxyethanal (2-BE)	promote fracturing
Breaker	ammonium persulfate	alters viscosity to promote flow-back
Cleaners	hydrochloric acid	dissolves formation debris
Processors	propylene glycol	strips impurities from produced gas

These drilling additives including ammonia, methanol, ethanol, 2- propanol, 1-butanol, thioglycolic acid, sodium perborate tetrahydrate, diammonium peroxydisulfate and hydrochloric acid, are moderately or acutely toxic to humans or aquatic organisms when encountered in concentrated forms. Significant issues with these chemicals would be anticipated from storage sites, trucking accidents while they are being transported to remote well sites via rural roads, and staging at well sites.

However, the majority of chemical products used by the gas industry for hydraulic fracturing have not been fully tested for human or environmental toxicity. Of those which have, a minority (e.g., bentonite, guar gum, hemicellulase, citric acid, acetic acid, potassium carbonate, sodium chloride, limonene, polyethylene glycol and mineral oil) pose no significant hazards to humans or other organisms as utilized in gas extraction processes.

A few chemical products in widespread use in the industry pose significant hazards to humans or other organisms, because they cause adverse health effects even at concentrations near or below their chemical detection limits. These include the biocides glutaraldehyde, 2,2-dibromo-3-nitrilopropionamide (DBNPA) and 2,2- dibromoacetonitrile (DBAN), the

corrosion inhibitor propargyl alcohol, the surfactant 2- butoxyethanol (2-BE), and lubricants containing heavy naphtha. Glutaraldehyde (CAS No. 111-30-8) is a biocide used widely in drilling and fracturing fluids. 2,2-Dibromo-3-nitrilopropionamide (DBNPA) (CAS No. 10222-01-2) is a biocide used in drilling and fracturing fluids. In the environment, it is very toxic to a wide variety of freshwater, estuarine and marine organisms. In particular, it is lethal to "water fleas" (*Daphnia magna*) and rainbow trout at low (40 to 50 ppb) concentrations.

In order to complete the requirements of NEPA, the BLM should withdraw the EA and and issue a revised or updated RMP prior to offering these parcels for lease sale. The Draft EA fails to fully develop an adequate range of lease stipulations for the proposed action. For the reasons cited here, the BLM cannot conclude this action has 'no significant impact' and thus the EA should be withdrawn.

Recommendation 2: The updated RMP must thoroughly analyze the emerging modern technology of developing shale oil in the Niobrara Formation using horizontal drilling combined with high volume hydraulic fracturing.

The apparent primary targeted formation of these lease sales is the Niobrara Formation. The EA does not disclose the targeted formations. According to Edward O'Mara, geologist with the BLM Little Snake Field Office, the BLM staff "...have no idea what the targeted formations may include." (Personal Communication, March 10, 2011).

The 1991 BLM statewide EIS indicates that exploration drilling in the Middle Park Basin resulted in no commercial production to that date. (EIS Appendix B, page B-20). In 1991, BLM concluded then with a 95% probability level that only negligible amounts of oil and and 10 MCFG of natural gas were recoverable from the Middle Park Basin. Modern shale gas and shale oil techniques render this two-decade old conclusion no longer pertinent to today's potential to produce recoverable amounts of oil and gas from the Niobrara Formation. This has not be assessed by the BLM nor could it have been twenty years ago as the advent of this technology to the Niobrara Formation has occurred only during the last two years in Colorado.

Natural gas and oil production from 'unconventional' shale formations has been rapidly expanding during this century. Natural gas and oil in what the U.S. Geological Survey defines as 'non-conventional' formations contain natural gas within the rock matrix where the hydrocarbons were originally deposited. Such formations have not released their hydrocarbon content due to low permeability or lack of fracture release. Two technologies have

made it economically feasible to extract natural gas and oil from 'non-conventional' shale deposits: 1) horizontal drilling of multiple wells from a single pad and 2) hydraulic fracturing. Hydraulic fracturing opens new fractures in the shale increasing permeability which allows the natural gas or oil to flow to the production well.

While the 1991 EIS discusses the potential for drilling horizontally to produce hydrocarbons, it does not address the technology for recovering oil and gas using high volume hydraulic fracturing.

Unconventional-oil plays in the Western U.S. have garnered increased attention as production results have improved. A key new formation that oil and gas exploration companies are nominating to be opened for leasing by the BLM and the States of Colorado and Wyoming is the Cretaceous Niobrara Shale.

It was established prior to the 1950s that the Niobrara Shale has adequate thickness throughout, is high in total organic content, and is thermally mature. While oil has flowed from the Niobrara since initial discoveries in the Florence Field, near Canon City, Colorado, in 1876 near an oil seep, the formation is now being exploited even where the oil in the Niobrara remains in place using fracking to release the oil in horizontal wells.

Currently companies are pursuing the Niobrara Formation with increased interest including nominating these parcels in Grand County previously thought to have low potential to produce hydrocarbons. For example, EOG Resources' Jake well, a horizontally-drilled Niobrara discovery in Weld County, is in the northern Denver-Julesburg Basin. According to state records, the well flowed an average 1,750 bbl. of oil and 360,000 cu. ft. of gas per day for its first eight days on production in October 2009. The next month, it made an average of 680 bbl. per day for 30 days.

In addition to the Denver-Julesburg Basin, active exploration in the Niobrara is ongoing in the southern Powder River Basin in Wyoming, and in Colorado's North Park and South Park basins.

There are plenty of places to prospect for Niobrara, as the shale occurs across a vast, tectonically active area. It can be anywhere from 150 to 1,500 feet thick, and its total organic content (TOC) ranges up to around five percent. It contains Type II kerogen. Additionally, the Niobrara contains a high proportion of carbonates, including brittle, calcareous chalk benches. The chalk benches enhance porosity and its ability to be fractured. These factors mean that few Niobrara wells fail to produce since the high TOC persists and horizontal drilling combined with gelling agents capable of

carrying the proppant through the viscous oil have consistently proven successful.

Recommendation 3: The revised EA should be coordinated with the Colorado Oil and Gas Conservation Commission (COGCC) to determine if COGCC intends to define the area as a 'sensitive area'. Such a designation by the COGCC requires the use of certain 'green completion' technologies which involve the use of enclosed tanks to contain all drilling fluids and limits the time period when fracking fluids can be retained in any pit.

The Colorado Oil and Gas Conservation Commission (COGCC) has provisions to declare any potential development area as a 'sensitive area' determination. The proposed parcels and surrounding area may qualify for a sensitive area determination by the COGCC due to the big game habitat, recreational values and presence of sage grouse near the proposed lease parcels. When the COGCC makes a 'sensitive area determination' then certain 'green completion' drilling techniques apply. The principle component of 'green completions' is to eliminate the use of open pits and require flow-back fluids be stored in tanks with controlled valves. To define precisely when an operator must separate flow-back from natural gas product, the State of Colorado has regulatory provisions to minimize, but not preclude, the initial use of pits to contain production and fracking fluids. In Colorado, green completion practices, when required, are imposed on gas wells whenever the reservoir pressure is capable of yielding economic quantities of natural gas. This is defined as when the gas well is capable of naturally flowing hydrocarbon gas at a stabilized rate in excess of 500 thousand cubic feet per day to the surface against an induced surface back pressure of 500 pounds per square inch. (Colorado's 'green completion' definition is for natural gas wells. A modified definition would be needed to apply 'green completion' criteria for those wells that produce oil from shale.)

In Colorado, these green completion practices include the following emission reduction measures:

1. The operator must employ sand traps, surge vessels, separators, and closed top tanks as soon as practicable during flow-back and clean-out operations to maximize resource recovery and minimize releases to the environment.

2. Well effluent during flow-back and clean-out operations prior to encountering hydrocarbon gas of salable quality or significant volumes of condensate can be directed to open top tanks or pits. But if these fluids are returned to a pit, then the oil or condensate are not

allowed to accumulate in excess of ten barrels and must be removed within twenty-four hours. The gaseous phase of inflammable effluent should also be directed to a flare pit for safety purposes until flammable gas is encountered.

3. Well effluent containing more than ten barrels per day of condensate or within two hours after first encountering hydrocarbon gas of salable quality must also be directed to a combination of sand traps, separators, surge vessels, and closed top tanks or other equipment as needed to ensure that non-salable products are disposed of in a safe and environmentally responsible manner.

4. All liquids coming from the gas separators must be dumped to closed top tanks with a vapor gathering system. Flammable vapors and gas evolving from well effluent directed to closed top tanks shall be gathered and directed to a combustion device capable of 95 percent destruction efficiency.

5. Closed top tanks must utilize back pressure systems that exert a minimum of four ounces of back pressure and a maximum that does not exceed the pressure rating of the tank to facilitate gathering and combustion of tank vapors. Vent and back-pressure valves, the combustor, lines to the combustor, and knock-outs must be sized and maintained so as to safely accommodate any surges the system encounters.

Recommendation 4: The revised EA, once it has been tiered to a properly completed and updated RMP/EIS, should evaluate whether to require 'green completion' technology as a discretionary performance-based lease stipulation. BLM should expand upon this concept to include the possible use of 'green' or less toxic hydraulic fracturing fluids.

The Colorado requirements for 'green completions' should be considered by the BLM and possibly imposed as a discretionary performance standard lease stipulation. This or a similar definition of when separation of produced water is required and how long that fluid can remain in a pit should be evaluated in the upcoming RMP revision. This recommendation differs from the prior recommendation only by what government entity imposes 'green completion' technology. The author is recommending that BLM should impose green completion technologies even if the COGCC does not determine the Middle Park area to be a 'sensitive area.'

The use of less toxic, or 'green fracturing compounds' should be evaluated and possibly obligated to be used depending upon their efficacy in natural

gas recovery. Regardless of the discretionary lease stipulation imposed by the BLM, there will still be the likelihood of industrial accidents. Accidents that involve the release of chemical additives in their undiluted form pose a significant risk to the ecosystem. Industrial accidents include failure to install back flow valves, and numerous operator errors such as failure to shut off valves, improper construction of tanks and pit liners, and highway collisions involving fracking chemical transport.

Less toxic fracking fluids are being developed by the industry that remove the chlorinated hydrocarbons from the process and substitute chemicals that are water based. Less toxic fracking fluids contain guar gums and starch based chemicals that are biodegradable and do not bio-accumulate in an ecosystem. A non-toxic fluid should be free of synthetic polymers that are not biodegradable and lack the typically-used chlorinated biocides frequently used by the industry. The updated RMP should evaluate the use of less toxic fracking fluids and determined if obligating as a condition of a lease, that an operator use such fluids would not significantly impair the recovery of the natural gas or oil resource.

Production wells must be sealed from allowing any fluids to migrate up along the well annulus into a useable aquifer. In Colorado, the Oil and Gas Conservation Commission defines that the production tubing must be sealed to 50 feet below the nearest domestic well, which in intended to provide aquifer protection. A better procedure is to cement through the uppermost aquifer and approximately 50 feet into the zone below the aquifer to assure that fluids do not rise in a production well and migrate laterally along an un-cemented portion of the well.

It was also noted that the soils in the area have naturally occurring salts and selenium that are flushed from the soil during runoff and from applied irrigation water. (EA, page 13.) Such conditions may also require discretionary lease stipulations to assure that selenium is not flushed from the soils and allowed to enter streams. Consideration for example of the use of wooden well pads that reduce soil disturbance would ameliorate the mobility of selenium during well pad and pit construction and use.

Recommendation 5: The BLM should require a discretionary performance-based lease stipulation to drill and operate three ground water monitoring wells near each production well or well pad; one up-gradient and two monitoring wells down-gradient in the uppermost useable aquifers.

Several states and federal agencies have or are currently considering regulations that would require ground water monitoring wells for every non-

conventional oil and gas well that uses modern hydraulic fracturing techniques.

In Colorado, regulations adopted by the Colorado Oil and Gas Conservation Commission require ground water monitoring for centralized exploration and production waste management facilities. COGCC 2CCR 404-1 Final Rule Section 908(b)(9) defines the ground water monitoring for these centralized facilities:

> Ground water monitoring.
> A. Water wells.
> Water samples shall be collected from water wells within a 1-mile radius of the proposed facility and shall be analyzed to establish baseline water quality. Analytical parameters shall be selected based upon the proposed waste stream and shall include, at a minimum, all major cations and anions, total dissolved solids, iron and manganese, nutrients (nitrates, nitrites, selenium), benzene, toluene, ethylbenzene, xylenes, pH, and specific conductance.
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> B. Site-specific monitoring wells.
> i. The Director shall require ground water monitoring to ensure compliance with the allowable concentrations and levels in Table 910-1 and, with consideration to WQCC standards and classifications by establishing points of compliance. All monitoring well construction must be completed in accordance with the State Engineer's regulations on well construction, 'Water Well Construction Rules' (2 CCR 402-2).
> ii. *Where monitoring is required, the direction of flow, ground water gradient and quality of water shall be established by the installation of a minimum of three (3) monitor wells, including an up-gradient well and two (2) down-gradient wells* that will serve as points of compliance, or other methods authorized by the Director. (emphasis added)

The Delaware River Basin Commission (DRBC) is considering a rule that would require ground water monitoring at every production well. The DRBCC is proposing a new Article 7 of its Water Quality Regulations to protect water resources during the construction and operation of natural gas operations. In that Basin, the principle natural gas development occurs in the vast Marcellus Shale, also an 'unconventional formation' that relies upon horizontal drillings and high-volume slick water hydraulic fracturing. In Section 7.5 2(I)(A) of the draft DRBC rules ground, the ground water monitoring obligations of an operator are defined:

"Well pad project sponsors must submit ... a pre-alteration groundwater and surface water monitoring study report as part of the well pad application. The pre-alteration report must include an inventory and the mapped locations of any artificial penetrations including groundwater wells within 2,000 ft of the project well pad. The report must also include the results of groundwater sampling and laboratory analysis of a representative number of groundwater wells within 1,000 ft of the well pad. If the project sponsor or the Executive Director concludes that an insufficient number of existing wells are identified within this distance to adequately characterize the groundwater, the sampling distance must be extended up to 2,000 ft from the gas well pad. If there are no existing groundwater wells or the project sponsor is unable to gain access to any existing groundwater wells within 2,000 ft of the project well pad, *the project sponsor will be required to install a monitoring well or wells within 1,000 ft of the project well pad."* (emphasis added)

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Weston Wilson's education, work experience, and awards.

Educational background

Bachelors of Science Degree in Geological Engineering in 1969, University of Arizona, 1969.

Masters of Science Degree in Water Resources Administration, University of Arizona, 1973.

Work Experience:

US Army Corp of Engineers -- I was the second officer in the US Army to become a conscientious objector and was assigned a non-combatant function in the Republic of Vietnam. Honorably discharged in 1974.

Employed by EPA in Denver since 1974. Retired from federal civil service in January 2010. My work has included assisting Estonia, Ukraine, and the West African nation of Mali to develop their own environmental protection agencies. In this work, I have stressed the importance of scientific objectivity, lack of conflicts-of-interest, and the need for independence by a nation's environmental regulatory authority from its privately-owned and governmental industrial endeavors.

Awards from EPA and others:

1978 – EPA Bronze Medal for leading a team of experts at EPA to prepare the environmental analysis of the Northglenn, Colorado, sewage treatment system.

1990 – EPA Bronze Medal for participating in a team of experts that prepared the EPA decision to veto the building of Two Forks Dam by the Denver Water Board.

1994 – EPA Bronze Medal for leading a team of experts at EPA in analyzing the environmental risks of the proposed New World Gold Mine near Yellowstone National Park.

2002 – EPA Bronze Medal for assisting a team of experts to conduct an analysis of the impacts to streams associated with coal bed methane production in Montana and Wyoming.

2003 – Department of the Interior "Four C's Award" from Kathleen Clark, Director of the Bureau of Land Management, for analysis of the surface water quality impacts associated with coal bed methane development in Montana and Wyoming. The 'Four C's Award' is awarded to federal employees for their "consultation, cooperation, (and) communication, (for) conservation.