The Wilderness Society * Wyoming Outdoor Council * National Audubon Society

BLM Wyoming State Office
5353 Yellowstone Road
P.O. Box 1828
Cheyenne, Wyoming 82003

Via Federal Express

December 29, 2017

Re: Protest of the March 21-22, 2018 Competitive Oil and Natural Gas Lease Sale for the BLM Wyoming High Plains District

To whom it may concern:

Please accept this protest of the above oil and gas lease sale that is filed by The Wilderness Society, Wyoming Outdoor Council, and the National Audubon Society. This protest is filed pursuant to the provisions at 43 C.F.R. § 3120.1-3. In this lease sale, the Bureau of Land Management (BLM) is proposing to sell 81 parcels that would cover 45,003 acres of public minerals and 4,077 acres of federal surface estate.

Founded in 1935, The Wilderness Society's mission is to protect wilderness and inspire Americans to care for our wild places. The National Audubon Society's mission is to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the earth's biological diversity. Founded in 1967, the Wyoming Outdoor Council is the state's oldest and largest independent conservation organization. Its mission is to protect Wyoming's environment and quality of life for future generations.

I. INTERESTS OF THE PARTIES

The Wilderness Society, Wyoming Outdoor Council and National Audubon Society have a long-standing interest in the management of BLM lands in Wyoming and we engage frequently in the decision-making processes for land use planning and project proposals that could potentially affect our public lands and mineral estate, including the oil and natural gas leasing process and lease sales. Our members and staff enjoy a myriad of recreational, scientific and other opportunities on BLM-managed public lands, including hiking, biking, nature-viewing, photography, and quiet contemplation in the solitude offered by wild places. As indicated, our missions are to work for the protection and enjoyment of the public lands for and by our members and the public.

II. AUTHORIZATION TO FILE THIS PROTEST

As an attorney and Litigation and Energy Policy Specialist for The Wilderness Society, I am authorized to file this protest on behalf of The Wilderness Society and its members and supporters, and I have like authority to file this protest on behalf of the Wyoming Outdoor Council and National Audubon Society.

III. STATEMENT OF REASONS

We protest the potential sale of all 81 parcels that are proposed to be offered in this lease sale. These 81 parcels are the parcels listed in Appendix C of the "High Plains District Portion of the First Quarter 2018 Competitive Oil and Gas Lease Sale" Environmental Assessment (EA). DOI-BLM-WY-P000-2017-0002-EA (hereinafter March EA) (presenting the lease parcels proposed to be offered for sale at the March, 2018 lease sale, and which we protest). *See also* Notice of Competitive Oil and Gas Lease Sale March 21-22, 2018 (presenting the 81 Lease sale parcels in the Casper, Buffalo, and Newcastle Field Offices of the High Plains District, which we protest). This protest is based on the comments on the draft March EA that were filed separately by The Wilderness Society and the Wyoming Outdoor Council.

In this protest, we will address several issues of concern to us. The BLM's proposed lease sale and the analysis in the March EA would violate the National Environmental Policy Act (NEPA). It would do so because BLM has failed to consider a reasonable range of alternatives in the March EA, it has failed to adequately consider the cumulative environmental impacts of leasing, and the March EA underestimates impacts to groundwater. This lease sale and the March EA would also violate provisions in the Federal Land Policy and Management Act (FLPMA). BLM is not adhering to the multiple use mission and requirement that was established by FLPMA and it has not prioritized leasing outside of Greater sage-grouse habitats as required under resource management plan (RMP) amendments and revisions that BLM has adopted. And last, BLM would not meet the obligation under the Mineral Leasing Act (MLA) to ensure that waste of natural gas (methane) is prevented at the leasing stage.

A. BLM has not Complied with the National Environmental Policy Act.

1. BLM has Failed to Consider a Reasonable Range of Alternatives in the March EA.

NEPA requires that BLM analyze in detail "all reasonable alternatives." 40 C.F.R. § 1502.14(a). The range of alternatives is the heart of a NEPA document because "[w]ithout substantive, comparative environmental impact information regarding other possible courses of action, the ability of [a NEPA analysis] to inform agency deliberation and facilitate public involvement would be greatly degraded." *New Mexico v. Bureau of Land Management,* 565 F.3d 683, 708 (10th Cir. 2009). This requirement applies equally to EAs. *See* 42 U.S.C. §§ 4332(2)(C)(iii) and (2)(E); 40 C.F.R. § 1508.9(b); *see also Bob Marshall Alliance v. Hodel,* 852 F.2d 1223, 1228-29 (9th Cir. 1988). That analysis must cover a reasonable range of alternatives so that an agency can make an informed choice from the spectrum of reasonable options.

The March EA for the lease sale in the Casper, Buffalo, and Newcastle Field Offices fails to meet this requirement. It only analyzes two alternatives:

1. The No Action alternative, which would not offer any lease parcels at this sale; and

2. The Proposed Action where 81 lease parcels covering approximately 45,003 acres of public mineral and 4,077 acres of federal surface estate would be offered for sale (we will refer to this as the Lease Everything Alternative).

March EA at 14.

An EA offering a choice between leasing nearly every parcel nominated, and leasing nothing at all does not present a reasonable range of alternatives. At a minimum, the 14 parcels located in sage-grouse priority habitat management areas (PHMA) and the 23 parcels located in sage-grouse general habitat management areas (GHMA) could be deferred from leasing, creating a middle ground between the no action alternative and the Lease Everything Alternative. *See* March EA at 48-49 (presenting the PHMA and GHMA parcels). *See also id.* at Appendix A (noting the no surface occupancy, controlled surface use, and timing limitation stipulations for these parcels). This issue will be discussed in more detail in the lease parcel prioritization section below. So, it is clear there are options available besides the Lease Everything Alternative that is the only alternative actually considered in this sale.

BLM must consider reasonable alternatives that fall between the two extremes. Again, at a minimum, the agency should analyze one or more alternatives for prioritizing leasing outside of high-quality sage-grouse habitat. At a minimum, these parcels could be deferred from leasing, especially if they contain nesting habitat, leks, or winter concentration areas. Failing to analyze such a middle-ground option violates NEPA. *See The Wilderness Society v. Wisely,* 524 F. Supp. 2d 1285, 1312 (D. Colo. 2007) (finding BLM violated NEPA by failing to consider "middle-ground compromise between the absolutism of the outright leasing and no action alternatives"); *Muckleshoot Indian Tribe v. U.S. Forest Serv.*, 177 F.3d 800, 813 (9th Cir. 1999) (finding NEPA analysis failed to consider reasonable range of alternatives where it "considered only a no action alternative along with two virtually identical alternatives").

In this EA, the BLM did not even consider any other alternatives before deciding whether to fully analyze them. March EA at 14 ("No other action alternatives were considered by the three field office ID teams or the HPD."). Only the no action and Lease Everything Alternative were considered, which is not a reasonable range of alternatives.

In choosing alternatives to consider in a NEPA document, BLM is to ensure it can make a "reasoned choice." BLM NEPA Handbook H-1790-1 at 49. "In determining the alternatives to be considered, the emphasis is on what is "reasonable" rather than on whether the proponent or applicant likes or is itself capable of implementing an alternative. "Reasonable alternatives include those that are *practical or feasible* from the technical and economic standpoint and using common sense, rather than simply *desirable* from the standpoint of the applicant."" *Id.* at 50 (citing the Council on Environmental Quality (CEQ) Forty Most Asked Questions Concerning CEQ's NEPA Regulations). Moreover, "[y]ou must consider alternatives if there are unresolved conflicts concerning alternative uses of available resources." *Id.* at 79 (citing 40 C.F.R. § 1508.9(b)).

Under its own guidance, BLM needed to consider more than just the lease nothing or Lase Everything Alternative. It would certainly have been reasonable, practical, and feasible to have considered an alternative that deferred leasing parcels in important sage-grouse habitats.

At a minimum, given its obligations under the sage-grouse plan amendments, BLM needed to consider one or more deferral alternatives in sage-grouse PHMA and GHMA. Further, other alternatives that focused on protecting other resources could have been considered. As the March EA recognizes and analyzes, other important resources in the High Plains District include air quality and climate change issues, soil resources, water resources, and cultural resources, among others. Certainly at least one alternative focused on protecting some of these resources could have been considered. And to do so would not have prevented a substantial number of parcels having been identified for possible sale, an issue and concern that pervades all BLM leasing considerations.

The Wilderness Society raised this issue in our comments on the draft March EA. In responding to this concern the BLM categorically rejected it. March EA at Appendix F page 5. The BLM offered three reasons for dismissing our concerns. These were:

1. The impacts of considering not leasing in sage-grouse habitats are "imbedded" in the no action alternative and considered there;
2. The Casper, Buffalo, and Newcastle Resource Management Plans (RMP) do not close PHMA to leasing; and
3. Stipulations (and required design features and best management practices) for the protection of sage-grouse are attached to the leases, as provided for in the RMPs.

Id. These are insufficient reasons to not have at least considered deferring the parcels in the PHMA and GHMA.

The no action alternative is not a sufficient consideration of a "middle ground" alternative as we are asking for. In the March EA, the BLM has this to say about the no action alternative:

> . . . the No Action Alternative generally means that the proposed action would not take place. In the case of a lease sale, this would mean that an EOI to lease (parcel nomination) would be deleted. The No Action alternative would delete all 81 parcels from the HPD portion of the First Quarter 2018 Competitive Oil and Gas Lease Sale.

March EA at 13. The no action alternative "does not respond to the purpose and need for the action." BLM NEPA Handbook H-1790-1 at 51. We are not asking that the action not take place, we asking that the deferral of leasing be considered. This is not the same as the no action alternative, as BLM claims.

That the RMPs do not close PHMAs to leasing also does not meet BLM's obligation to consider a reasonable range of alternatives. We are not asking that the PHMAs be closed to leasing. We are asking that BLM consider exercising its authority under the RMPs to defer

leasing parcels in GHMAs and PHMAs, which is wholly consistent with the sage grouse provisions in BLM's RMPs, as will be discussed in more detail below. Under the sage-grouse RMPs, deferral of leasing in GHMAs and PHMAs is clearly a reasonable consideration that must be considered at the leasing stage. BLM's RMPs so provide.

Moreover, consideration of alternatives at the RMP stage does not absolve BLM from considering a full range of alternatives at the leasing stage. By definition an RMP does not prescribe any particular action, it only provides general guidance. The purpose of an RMP is to establish goals and objectives for resource management, it does not constitute project level decision-making.[1] While the RMPs may have made the areas under consideration here available for leasing, they did not preclude consideration of deferral as an action at the leasing stage.

And as for the stipulations that have been attached to these leases, they do not completely fulfill BLM's obligations relative to consideration of alternatives for sage-grouse conservation. As will be discussed below, BLM's sage-grouse RMPs mandate that BLM consider the option of deferring lease parcels in GHMAs and PHMAs at the leasing stage of decision-making.

Given that BLM's responses to our comments are unavailing, we renew our objections to the March EA for this oil and gas lease sale in this protest due to consideration of an unreasonable range of alternatives. This concern, and protest, applies to all 81 parcels that are proposed for leasing but especially the 14 parcels in PHMA and the 23 parcels in GHMA.

A summary treatment of alternatives, as has occurred here, "must be measured against the standards in 42 U.S.C. § 4332(2)(E) and 40 C.F.R. 1508.9(b)." *Davis v. Mineta,* 302 F.3d 1104, 1120 (10th Cir. 2002) (noting these provisions require an agency to study, develop and discuss appropriate alternatives and to briefly describe those alternatives). An agency's rejection of alternatives will be deemed illegal if the consideration is "so vague and unspecific as to be little more than platitudes." *Id.* at 1121. In a case where "[a]lternatives were dismissed in a conclusory and perfunctory manner that do not support a conclusion that is was unreasonable to consider them as viable alternatives in the EA" the agency's action will be rejected. *Id.* at 1122. As here, *Davis* involved a situation where the agency only considered two alternatives in its EA, the no action alternative and the preferred highway construction alternative, which the court deemed illegal.

Here we have nothing more than platitudes being used to reject consideration of additional alternatives in the March EA. We have BLM's bare assertion that it met its obligation to consider a reasonable range of alternatives, but nothing more. March EA at Appendix F page 5. This does not meet the requirements of NEPA.

2. *BLM has failed to consider the impacts of its leasing decision and its Finding of No Significant Impact is invalid.*

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[1] *See* https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&currentPageId=48299 (Buffalo Field Office RMP page).

The March EA provides no meaningful analysis of what the impacts on these parcels will be if the leases do get developed. The March EA states that it cannot predict the impacts from development at the leasing stage. March EA at 8, 9, 44. BLM's position illustrates why options that defer at least some of these parcels should have been considered. BLM has not completed the analysis to determine what impacts are likely under the stipulations proposed for these leases, and whether those stipulations will be adequate to prevent significant adverse impacts to sage-grouse and other resources such as water supplies and public health. Nor can BLM conclude that the potential economic benefits of leasing these parcels outweigh the environmental and economic harms to the local community and other resources. But by leasing these lands now, BLM will make an irreversible commitment of resources limiting the government's options if and when companies seek to drill for oil and gas. If leases are issued now, it becomes difficult or impossible for BLM to change course later.

Unfortunately, the March EA takes exactly the wrong approach and does not adequately evaluate impacts. BLM expressly defers a site-specific analysis on key resource values, including wildlife, recreation, visual resources, and useable water resources. This approach violates NEPA, and BLM must take the site-specific impacts of leasing into account at this leasing stage.

BLM cannot hide behind its "leasing is a paper transaction" claims in order to avoid analyzing the indirect effects of leasing. NEPA requires an analysis of both the direct and indirect effects of a proposal.
BLM, however, has not considered the indirect effects of its leasing decision. The record shows there will be reasonably foreseeable indirect effects of leasing from development on many of these parcels, including impacts on wildlife resources such as sage-grouse and water resources, among others.

As stated by the Tenth Circuit Court of Appeals,

> . . . we first ask whether the lease constitutes an irretrievable commitment of resources. Just as we did in *Pennaco Energy,* 377 F.3d at 1160 and the D.C. Circuit did in *Peterson,* 717 F.2d at 1412, 1414, we concluded that issuing an oil and gas leases without an NSO stipulation constitutes such a commitment.

New Mexico v. Bureau of Land Management, 565 F.3d 683, 718 (10th Cir. 2009). Thus, it is clear that in order to comply with NEPA at the leasing stage, BLM must analyze all reasonably foreseeable impacts..

The Finding of No Significant Impact (FONSI) proposed for this lease sale also does not meet the NEPA standards required to issue a FONSI. The CEQ NEPA regulations only allow a FONSI if an agency validly concludes its project "will not" significantly affect the human environment. 40 C.F.R. § 1508.3. In reaching this conclusion the BLM considered the context of the project and the ten "intensity" factors specified in the CEQ regulations. *Id.* § 1508.27. The BLM's conclusion that there will not be significant impacts to the human environment is misplaced.

The analysis of the context factor in the proposed FONSI misses the mark as defined by regulations at 40 C.F.R. § 1508.27(a). All the BLM does in the FONSI is state that any impacts are local and have been previously considered in the RMPs for these Field Offices. But the FONSI does not consider the impacts of the leasing on society as a whole, the affected region, or the affected interests, as the CEQ regulations require. *See* FONSI at unnumbered page 2. Short- and long-term effects are not considered. Yet as much as 49,080 acres (nearly 77 square miles) could be irreversibly and irretrievably leased. This is clearly a significant context. And as will be discussed below in the cumulative impacts section, the BLM has also ignored the vast number and acreage of other leases it is issuing throughout the west.

And as to the ten intensity factors at 40 C.F.R. 1508.27(b), generally all BLM can say is that leasing produces no environmental impacts and any impacts were previously considered in the respective RMPs. But as we have discussed, leasing represents an irreversible and irretrievable commitment of resources, so these analyses are misplaced. Irreversibly and irretrievably committing resources on nearly 77 square miles of public lands and minerals clearly could have intense environmental impacts. And again, the large number of other leases being issued that will be discussed in the cumulative impacts section emphasizes the potential intensity of impacts.

In addition, factor three, the uniqueness of the area, also misses the point because it does not consider the fact many of these parcels are in sage-grouse PHMA and GHMA, which are clearly an important, unique resource, as recognized in many BLM documents, including the RMPs. Likewise, as we will discuss, BLM's analysis of factor nine, the BLM sensitive species issue, is off the mark because it does not consider the sage-grouse prioritization factors as required under BLM's RMPs. The consideration of cumulative impacts is also misplaced because the BLM does not reconcile the leasing of these 81 parcels with the large number of existing, producing wells in the area. *See* March EA at 63 (noting there are 39,000 producing wells in the High Plains District with over 18,000 of those being federal).

All-in-all it is clear this FONSI is invalid, and therefore an environmental impact statement (EIS) should be developed for this lease sale. An EIS is needed to comply with the requirements of NEPA.

3. BLM has Failed to Consider the Cumulative Impacts of Leasing.

NEPA requires BLM to evaluate the cumulative impacts of this lease sale "resulting from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions." 40 C.F.R. § 1508.27(b)(7); *Kern v. Bureau of Land Management*, 282 F.3d 1062, 1075-77 (9th Cir. 2002). To satisfy this requirement, BLM's NEPA analysis must consider the cumulative impact of all the recent and currently-planned auctions in which BLM has offered hundreds of leases affecting sage grouse habitat protected under the RMPs. These sales include, but are not limited to:

- The companion to this lease sale, the March, 2018 sale in the Wind River/Bighorn Basin District where BLM proposes to sell 89 parcels and 96 percent of the parcels to be offered are located in sage-grouse habitat.[2]

- The December 2017 Montana sale: 187 out of 204 parcels are offered.[3]

- The December 2017 Wyoming sale: of 45 parcels to be offered, 26 parcels are partly or entirely in PHMA, and 24 parcels are partly or entirely in GHMA.[4]

- The December 2017 Utah sale: 30,371 acres of GHMA and 952 acres of PHMA.[5]

These are only a few examples. Other recent BLM sales have already occurred in western states that leased other sage grouse-protected areas. Many of these sales also, as discussed in more detail below, violate the prioritization requirements of the 2015 sage-grouse plans.

BLM must analyze and disclose the cumulative impacts of this wave of leasing on the Greater sage-grouse and its habitat. BLM (in the Rocky Mountain Region Record of Decision and other sage-grouse plan amendments) and numerous authorities have recognized the importance of addressing sage-grouse conservation on a comprehensive range-wide basis, and accounting for connectivity between state and regional populations and habitats, habitat fragmentation, and other impacts. As stated in the Rocky Mountain Record of Decision (ROD): "The cumulative effect of these measures is to conserve, enhance, and restore GRSG habitat across the species' remaining range in the Rocky Mountain Region and to provide greater certainty that BLM resource management plan decisions in GRSG habitat in the Rocky Mountain Region can lead to conservation of the GRSG and other sagebrush-steppe-associated species in the region." Rocky Mountain ROD, p. S-2.

Under NEPA, BLM cannot lease hundreds of parcels covering many thousands of acres in Montana, Wyoming and other states without considering the cumulative and trans-boundary

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[2] Draft EA for BLM Wind River/Bighorn Basin District First Quarter 2018 Lease Sale at 3-44, DOI-BLM-WY- R000-2017-0002-EA, available at: https://eplanning.blm.gov/epl-front office/projects/nepa/85072/114136/139365/181Q_WRBBD_EA_ver.1.pdf.

[3] EA for BLM Montana December 2017 sale at 27-28, DOI-BLM-MT-C020-2017-0051-EA, available at: https://eplanning.blm.gov/epl-frontoffice/projects/nepa/78400/120092/146548/MCFO_EA_December_2017_Sale_Post_with_Sale_List.pdf.

[4] EA for BLM Wyoming December 2017 sale at 52, D OI-BLM-WY-D000-2017-0003-EA, available at: https://eplanning.blm.gov/epl-front office/projects/nepa/65707/115166/140613/20170721.HDD_EA_for_December_2017_Lease_Sale_v.2.mg.pdf.

[5] Final Environmental Assessment for BLM Utah December 2017 Competitive Oil and Gas Lease Sale at 69, DOI-BLM-UT-G010-2017-0028-EA, available at: https://eplanning.blm.gov/epl-frontoffice/ projects/nepa/80165/119135/145398/FEA.pdf .

impacts to the greater sage-grouse and other resources. It has failed to do so in the March EA, and thus we protest the proposed sale of the 81 parcels included in this lease sale.

4. The March EA Underestimates Impacts to Groundwater Resources by Incorrectly Assuming that Useable Water Sources will be Protected.

Section 4.2.8 of the March EA summarizes some of the protections that would be applied to water resources. It says,

> Parcels that contain stipulations requiring restriction and prohibition of operator surface use until approval of an acceptable plan for mitigation of anticipated impacts, [are found in Appendices A and C]. This ensures protection of surface waters and associated riparian habitats by meeting the standards outlined in Chapter 6 of the BLM's Oil and Gas Gold Book, as revised, and the respective RMPs.

March EA at 48. That said, only about half of the 81 parcels have water protection stipulations. *See id.* at Appendix A, column X. It is not clear that the provision at 43 C.F.R. § 3162.5-2(d) would be complied with—dissolved solid limits could be exceeded. These provisions seem to address potential impacts to surface waters, not groundwater.

Unfortunately, the reality is that useable water zones are typically not protected. Since 1988, BLM's Onshore Order No. 2 has required operators to construct wells to isolate and protect aquifers containing "usable water," defined as having up to 10,000 ppm total dissolved solids (TDS). 53 Fed. Reg. 46,798, 46,801, 46,805 (Nov. 18, 1988). BLM adopted the 10,000 ppm standard because it matched the definition of "underground source of drinking water" used by the Environmental Protection Agency (EPA) in administering the Safe Drinking Water Act (SDWA). *See id.* at 46,798 (citing 40 C.F.R. § 144.3). When BLM issued its 2015 hydraulic fracturing rule, it made a housekeeping change amending the applicable provision in the Code of Federal Regulations at 43 C.F.R. § 3162.5-2(d) to conform with the Onshore Order No. 2 usable water requirement. 80 Fed. Reg. 16,128, 16,141–42 (Mar. 26, 2015).

But in opposing the hydraulic fracturing rule, several industry trade associations and states informed the court that there has been widespread non-compliance with the 10,000 ppm standard, despite the fact that Onshore Order No. 2 is a legally-binding regulation promulgated by notice-and comment rulemaking. *See* 53 Fed. Reg. at 46,798; 43 C.F.R. § 3164.1(b).

Based in part on concern that the hydraulic fracturing rule would require companies to change their practices, the U.S. District Court for Wyoming enjoined the rule in 2015. Order on Motions for Preliminary Injunction at 30-33, 53-54, ECF No. 130, *Wyoming v. Jewell,* 2:15-cv-00043-SWS (D. Wyo. Sept. 30, 2015) (*Wyoming v. Jewell*). Since then, industry trade associations have continued to highlight that there is a widespread industry practice of failing to protect underground sources of drinking water.

For example, in their September 25, 2017 comments supporting BLM's proposed rescission of the hydraulic fracturing rule, Western Energy Alliance and the Independent

Petroleum Association of America (collectively, WEA), told the agency that the 10,000 ppm standard is inconsistent with "existing practice for locating and protecting usable water." Sept. 25, 2017 WEA comments at 59 (WEA comments).[6] Instead, companies in Wyoming typically set well casing to a depth of only "100 feet below the deepest water well within a one mile radius of [the] oil or gas well"—usually 1,000 feet below ground or less. *Id.* at 84. And in Montana and North Dakota, WEA states that companies only install protective casing for the Pierre Shale formation, regardless of whether underground sources of drinking water may exist below that formation. *Id.* WEA has explained that requiring companies to protect all underground sources of drinking water would result in substantial additional costs for "casing and cementing associated with isolating formations that meet the numerical definition of usable water under the [Onshore Order No. 2 standard], but which are located at depths deeper than the zones that state agencies and BLM field offices have previously designated as requiring isolation." WEA comments at 84. WEA predicted that complying with the 10,000 ppm standard would cost industry nearly $174 million per year in additional well casing expenses. *Id.* at 84-85. Industry's admissions raise a significant environmental concern that BLM must address before issuing new leases.

Accepting WEA's statements as true, BLM and energy companies have been putting numerous underground sources of drinking water at risk. In its 2016 hydraulic fracturing study, the EPA noted that, "the depth of the surface casing relative to the base of the drinking water resource to be protected is an important factor in protecting the drinking water resource."[7] While water with salinity approaching 10,000 ppm TDS is considered "brackish," such aquifers are increasingly being used for drinking water. In fact, EPA adopted the 10,000 ppm standard based on the 1974 legislative history of the SDWA, which explained that Congress intended the SDWA to "protect not only currently-used sources of drinking water, but also potential drinking water sources for the future." H.R. Rep. No. 93-1185 (1974), 1974 U.S.C.C.A.N. 6454, 6484.

Similarly, BLM explained in 2015 that "[g]iven the increasing water scarcity [in much of the United States] and technological improvements in water treatment equipment, it is not unreasonable to assume [these] aquifers . . . are usable now or will be usable in the future." 80 Fed. Reg. 16,128, 16,142 (Mar. 26, 2015). The agency noted that even "if we're not using that water today we may be using it ten years [or] a hundred years from now. So we don't want to contaminate it now so it's unusable in the future." *Wyoming v. Jewell* admin. record at DOIAR0009703, attached as Exhibit 1 to these comments. Comments from EPA and the Association of Metropolitan Water Agencies (AMWA) supported this conclusion. *Id.* at DOIAR0038117. AMWA reported that brackish groundwater is *already* being used for drinking in some parts of the country. *See id.* at DOIAR0038118 (pumping 8,000 ppm TDS groundwater in Florida); *id.* at DOIAR0068337 (desalination already being used for municipal water treatment in some areas). AMWA explained that because of "challenges resulting from climactic changes, population growth and land development, many utilities are turning to more challenging groundwater sources such as those that are very deep or have high salinity concentrations . . .

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[6] A complete copy of WEA's comments is available at: https://www.regulations.gov/ document?D=BLM-2017-0001-0412 .

[7] EPA, Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States at 6-19 (2016) (EPA Study), available at: https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990.

given the lack of sufficient water elsewhere." *Id.* at DOIAR0038118. Higher salinity water is also being used today for some industrial purposes. *See, e.g., id.* at DOIAR0075763 (power plant cooling).

Our concerns are underscored by recent research showing that it is very common in this region for hydraulic fracturing and oil and gas production to occur in shallow formations that have only limited vertical separation from underground sources of drinking water. Fracturing and production also sometimes occur *within* an aquifer that represents an underground source of drinking water. For example, EPA's 2016 report found that "hydraulic fracturing within a drinking water resource" is "concentrated in some areas in the western United States" that include "the Wind River Basin near Pavillion, Wyoming, and the Powder River Basin of Montana and Wyoming."[8] Where that occurs, EPA explained that:

> . . . hydraulic fracturing within drinking water resources introduces hydraulic fracturing fluid into formations that may currently serve, or in the future could serve, as a drinking water source for public or private use. This is of concern in the short-term if people are currently using these formations as a drinking water supply. It is also of concern in the long term, because drought or other conditions may necessitate the future use of these formations for drinking water.

Id.

Other recent studies have made similar findings. Researchers investigating the oil and gas-related contamination in Pavillion, Wyoming reported that shallow fracturing also occurs in New Mexico, Colorado, Utah and Montana. Gayathri Vaidyanathan, *Fracking Can Contaminate Drinking Water* at 8, Sci. Am. (Apr. 4, 2016) (Sci. Am. Article), attached as Exhibit 2 to these comments. The researchers concluded that "it is unlikely that impact to [underground sources of drinking water] is limited to the Pavillion Field . . . ." Dominic C. DiGiulio & Robert A. Jackson, *Impact to Underground Sources of Drinking Water and Domestic Wells from Production Well Stimulation and Completion Practices in the Pavillion, Wyoming Field,* 50 Am. Chem. Society, Envtl. Sci. & Tech. 4524, 4532 (Mar. 29, 2016), attached as Exhibit 3 to these comments. Another study found that approximately three quarters of all hydraulic fracturing in California occur in shallow wells less than 2,000 feet deep.[9]

WEA's description of widespread non-compliance with Onshore Order No. 2, and the evidence of shallow production and fracturing, raise a significant environmental issue that must be addressed as a reasonably foreseeable effect of the lease sale. *See Baltimore Gas & Elec. Co. v. NRDC*, 462 U.S. 87, 97 (1983) (an agency must "consider every significant aspect of the environmental impact of a proposed action"); *see also Davis v. Mineta*, 302 F.3d 1104, 1123 (10th Cir. 2002). Moreover, BLM's analysis must "state how alternatives considered in it and

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[8] EPA Study at ES-27; *see also id.* at 6-44 to 6-50.

[9] California Council on Science and Technology, An Independent Scientific Assessment of Well Stimulation in California at Executive Summary 10 (2015), http://ccst.us/publications/2015/2015SB4-v2ES.pdf ; *see also* Sci. Am. Article at 8 (similar finding about California).

decisions based on it will or will not achieve the requirements of [NEPA] and other environmental laws and policies." 40 C.F.R. § 1502.2(d); *League of Wilderness Defenders v. USFS,* 585 Fed. Appx. 613, 614 (9th Cir. 2014); *Montana Wilderness Association v. McAllister,* 658 F. Supp. 2d 1249, 1255-56 (D. Mont. 2009). The CEQ regulations also require a discussion of possible conflicts with the objectives of state, local and federal land use plans, policies and controls for the area concerned. 40 C.F.R. § 1502.16(c).

Ignoring evidence of widespread noncompliance with BLM's standards for protecting underground sources of drinking violates NEPA. To make an informed decision on whether to lease these lands BLM needs to know whether doing so will put underground sources of drinking water at risk, and what additional stipulations or other steps are needed to prevent such contamination. The March EA provides no such analysis. The information necessary to make such an assessment is readily available in BLM's own permitting files for existing oil and gas wells, from produced water records on existing wells, and from other sources such as U.S. Geological Survey reports. 80 Fed. Reg. at 16,151–52. Moreover, to the extent any information gaps exist, it is incumbent on BLM to obtain that additional information before making an irreversible commitment of resources by issuing the leases. 40 C.F.R. § 1502.22(a). Additional data on, for example, aquifer quality or well construction practices is "essential to a reasoned choice among alternatives" and can be collected at a cost that is not "exorbitant." *See id.* § 1502.22. As described in the attached report from Greg Oberley and Dominic DiGiulio (Exhibit 4), the information necessary to analyze this issue prior to deciding whether to offer the leases is readily available. Because of these gaps in the March EA analysis we protest the sale of the 81 lease parcels proposed for sale at the March, 2018 lease sale.

B. The BLM is Violating the Federal Land Policy and Management Act.

1. BLM is Not Meeting the Multiple Use Requirements of FLPMA.

In The Wilderness Society's August 23 comments on the draft March EA we pointed out that BLM cannot adopt a policy of dominance for energy development on the public lands at the expense of other resources and public land values. BLM's proposal to attempt to lease all 81 parcels represents a rejection of the multiple use mandate. This is prohibited under the terms of FLPMA. *See, e.g.,* 43 U.S.C. §§ 1701(a)(8), 1702(c), 1702(l), 1732(a), and 1732(b).

BLM rejected these concerns. March EA at Appendix F pages 5-6. BLM had this to say about our concerns:

1. Multiple use is carried out through RMPs and leasing is in conformance with the governing RMPs.
2. BLM then claimed it need not adopt the practices best suited for protecting wildlife "but instead [ ] balance the protection of wildlife with the nation's immediate and long -term need for energy resources." *Citing Theodore Roosevelt Conservation Partnership. v. Salazar,* 616 F.3d 497 (D.C. Cir. 2010).

3. BLM then invoked a provision of FLPMA that only relates to not amending or impairing rights under the hard rock mining law[10] (not the MLA), but it did recognize that it has a duty to prevent the unnecessary or undue degradation of the public lands. 43 U.S.C. § 1732(b).
4. Then the BLM mentions the MLA stating, the "BLM works to ensure that mineral resources are developed in an environmentally responsible manner."
5. And last the BLM questioned our concerns about not abiding by the multiple use mandate by stating that its MLA regulations open areas to oil and gas leasing and that BLM has attached stipulations based on the RMPs "to mitigate for resource impacts, as appropriate."

Id.

These bare assertions do not bring into question our concerns about BLM not meeting its multiple use mandate. As to BLM' first claim, BLM is not abiding by its governing RMPs, specifically the sage-grouse amendment RMPs. This issue will be discussed in more detail below. As to BLM's second point, we are not saying that BLM has to maximize wildlife protection in all cases, only that it has to fully consider all management issues and adopt procedures that recognize that there are more interests in play on these lands than just maximizing oil and gas development. If BLM were to defer the 37 parcels in priority sage-grouse habitat, 44 parcels would remain available for leasing, certainly allowing it to "balance the protection of wildlife with the nation's immediate and long -term need for energy resources." We have no idea why BLM invoked the hard rock mining law, which has nothing to do with the concerns we expressed. We appreciate that BLM is seeking to lease oil and gas in an "environmentally responsible manner," but our concern remains: this cannot be achieved when BLM is adopting the Lease Everything Alternative. Environmentally responsible leasing would not open all lands up to leasing that industry desires—this is energy dominance not multiple use. As we mentioned above, BLM's NEPA handbook prohibits it from only considering alternatives that an industry proponent of a project desires. BLM NEPA Handbook H-1790-1 at 49-50. And last, as we will discuss below in the lease prioritization section, the stipulations that BLM has attached to the 37 parcels in sage-grouse habitat do not meet BLM's obligations under the RMPs to defer leasing in priority sage-grouse habitats.

The fact is BLM is giving overwhelming priority to oil and gas development on the public lands and mineral estate at the expense of all other values. As noted above, leasing represents an irreversible and irretrievable commitment of resources to allow oil and gas drilling. As we noted in our August 23 comments, "energy development is an allowable use that must be carefully balanced with other uses." Leasing all 81 parcels represents an attempt to give dominance to oil and gas development, not balance, which is not permitted under FLPMA. Consequently, we protest the plan to offer all 81 parcels at the March, 2018 lease sale.

Even if the applicable RMPs permit leasing of these lands, leasing is not mandated. "Under applicable laws and policies, there is no presumed preference for oil and gas development over other uses." Instruction Memorandum (IM) 2010-117 at 2. And as will be discussed in more detail below, under BLM's sage-grouse conservation guidance, leasing many of these lands is not in conformance with the multiple use mandate. If BLM were giving balance

[10] The Mining Law of 1872.

to oil and gas development, as it is required to do under the FLPMA multiple use mandate, it would not seek to lease all 81 of these parcels at the same time—at a minimum there would be consideration of deferral of the parcels in PHMA and GHMA.

While this administration has expressed a commitment to "energy dominance" and an executive order stating this position has been issued, that approach has no legal basis and is rejected by FLPMA. Similarly, the policy direction stated by the Department of the Interior and incorporated in various Secretarial Orders cannot override the fundamental laws governing BLM's management of public lands and minerals.

None of these administrative directives can override the statutory directives in FLPMA. It is the policy of the United States to protect natural resources on the public lands. 43 U.S.C. § 1701(a)(8). Multiple use means "the use of some of the land for less than all of the resources" as well as the "harmonious and coordinated management" of the resources "without permanent impairment of the productivity of the land and the quality of the environment with consideration being given to the relative values of the resources . . ." *Id.* § 1702(c). Managing in compliance with the definition of multiple use is mandated, and this management must "prevent unnecessary or undue degradation of the lands." *Id.* §§ 1732(a) and (b).

Thus, as we noted in our August 23 comments,

> Federal courts have consistently rejected efforts to affirmatively elevate energy development over other uses of public lands. In the seminal case, *New Mexico ex rel. Richardson v. BLM*, the Tenth Circuit put to rest the notion that BLM can manage chiefly for energy development, declaring that "[i]t is past doubt that the principle of multiple use does not require BLM to prioritize development over other uses." 565 F.3d 683, 710 (10th Cir. 2009); *see also S. Utah Wilderness Alliance v. Norton*, 542 U.S. 52, 58 (2004) (defining "multiple use management" as "striking a balance among the many competing uses to which land can be put"). Other federal courts have agreed. *See, e.g., Colo. Envtl. Coalition v. Salazar*, 875 F. Supp. 2d 1233, 1249 (D. Colo. 2012) (rejecting oil and gas leasing plan that failed to adequately consider other uses of public lands).

IM 2010-117 reiterates the need to consider multiple use values in leasing decisions.

Although BLM seeks to implement these policies in its approach to oil and gas leasing, seeking to lease all 81 parcels that have been proposed for sale at the March, 2018 lease sale would violate BLM's multiple use mandate as part of promoting a policy of "energy dominance" on the public lands. But this is not permitted under FLPMA. We therefore protest the potential sale of these 81 parcels.

2. *BLM Failed to Prioritize Leasing Outside of Greater Sage-Grouse Habitats.*

BLM has not prioritized leasing outside of sage-grouse habitat, as required by the Record of Decision [ROD] and Approved Resource Management Plan Amendments [ARMPA] for the Rocky Mountain Region, Buffalo Field Office ARMP/ROD, Wyoming 9-Plan ARMPA, and IM 2016-143. Under the Rocky Mountain ARMPA ROD:

> . . . the ARMPs and ARMPAs prioritize oil and gas leasing and development outside of identified PHMAs and GHMAs. This is to further limit future surface disturbance and encourage new development in areas that would not conflict with GRSG. This objective is intended to guide development to lower conflict areas and as such protect important habitat and reduce the time and cost associated with oil and gas leasing development by avoiding sensitive areas, reducing the complexity of environmental review and analysis of potential impacts on sensitive species, and decreasing the need for compensatory mitigation.

Rocky Mountain ARMPA ROD at 1-25.

The Buffalo Field Office ARMP/ROD and Wyoming 9-Plan ARMPA echo this directive, including the following objective:

> Priority will be given to leasing and development of fluid mineral resources, including geothermal, outside of Greater Sage-Grouse habitat. When analyzing leasing and authorizing development of fluid mineral resources, including geothermal, in priority habitat (core population areas and core population connectivity corridors) and general habitat, and subject to applicable stipulations for the conservation of Greater Sage-Grouse, priority will be given to development in non-habitat areas first and then in the least suitable habitat for Greater Sage-Grouse

See Wyoming 9-Plan ARMPA at 24 (emphasis added); Buffalo Field Office ARMP/ROD at 50 (same).

Further, in IM 2016-143, BLM has issued guidance elaborating on the way agency staff are to comply with the requirement to prioritize leasing and development outside of sage-grouse habitat:

> Lands within GHMAs: BLM State Offices will consider EOIs for lands within GHMAs, after considering lands outside of both GHMAs and PHMAs. When considering the GHMA lands for leasing, the BLM State Office will ensure that a decision to lease those lands would conform to the conservation objectives and provisions in the GRSG Plans (e.g., Stipulations).
>
> Lands within PHMA: BLM state offices will consider EOIs for lands within PHMAs after lands outside of GHMAs and PHMAs have been considered, and EOIs for lands within GHMA have been considered. When considering the PHMA lands for leasing, the BLM State Offices will ensure that a decision to lease those lands would conform to the conservation objectives and provisions in the GRSG Plans (e.g., Stipulations) including special consideration of any identified [Sagebrush Focal Areas].

IM 2016-143 at 4.

Importantly, the IM also sets out factors to consider (i.e., parcel-specific factors) after applying this prioritization sequence:

- Parcels immediately adjacent or proximate to existing oil and gas leases and development operations or other land use development should be more appropriate for consideration before parcels that are not near existing operations. This is the most important factor to

consider, as the objective is to minimize disturbance footprints and preserve the integrity of habitat for conservation.

- Parcels that are within existing Federal oil and gas units should be more appropriate for consideration than parcels not within existing Federal oil and gas units.
- Parcels in areas with higher potential for development (for example, considering the oil and gas potential maps developed by the BLM for the GRSG Plans) are more appropriate for consideration than parcels with lower potential for development. The Authorized Officer may conclude that an area has "higher potential" based on all pertinent information, and is not limited to the Reasonable Foreseeable Development (RFD) potential maps from Plans analysis.
- Parcels in areas of lower-value sage-grouse habitat or further away from important life-history habitat features (for example, distance from any active sage-grouse leks) are more appropriate for consideration than parcels in higher-value habitat or closer to important life-history habitat features (i.e. lek, nesting, winter range areas). At the time the leasing priority is determined, when leasing within GHMA or PHMA is considered, BLM should consider, first, areas determined to be non-sage-grouse habitat and then consider areas of lower value habitat.
- Parcels within areas having completed field-development Environmental Impact Statements or Master Leasing Plans that allow for adequate site-specific mitigation and are in conformance with the objectives and provisions in the GRSG Plans may be more appropriate for consideration than parcels that have not been evaluated by the BLM in this manner.
- Parcels within areas where law or regulation indicates that offering the lands for leasing is in the government's interest (such as in instances where there is drainage of Federal minerals, 43 CFR § 3162.2-2, or trespass drilling on unleased lands) will generally be considered more appropriate for leasing, but lease terms will include all appropriate conservation objectives and provisions from the GRSG Plans.
- As appropriate, use the BLM's Surface Disturbance Analysis and Reclamation Tracking Tool (SDARTT) to check EOI parcels in PHMA, to ensure that existing surface disturbance does not exceed the disturbance and density caps and that development of valid existing rights (Solid Minerals, ROW) for approved-but-not-yet-constructed surface disturbing activities would not exceed the caps.

IM 2016-143 at 4-5.

These prioritization requirements apply to this sale. The March EA acknowledges that 14 parcels overlap PHMA and another 23 parcels overlap GHMA. March EA at 48-49. FLPMA requires that lease sale decisions comply with their governing land use plans. *See* FLPMA § 302(a), 43 U.S.C. § 1732(a) ("The Secretary shall manage public lands...in accordance with land use plans developed by him under section 1712 of this title..."); *see also* 43 C.F.R. § 1610.5-3(a) (48 Fed. Reg. 20,368 (May 5, 1983)) ("All future resource management authorizations and actions...shall conform to the approved plan.").

Yet, the March EA does not reference the prioritization requirement or explore the parcel-specific factors that are supposed to guide leasing in GRSG habitat. Rather than prioritizing leasing outside of habitat, the proposed action would offer every nominated parcel in

PHMA and GHMA for leasing (all 14 EOIs in PHMA and all 23 EOIs in GHMA). March EA at 48-49, Appendix A. As to the requirements outlined in IM 2016-143, the EA only states:

> One parcel in Greater Sage-grouse core area, WY-181Q-054, was recommended for deferral by the Buffalo Field Office ID team in accordance with Instruction Memorandum No. 2016-143... It is the position of the HPD and the State of Wyoming that the stipulations applied to Parcel WY-181Q-054 would be sufficient to conserve sage-grouse and their habitats, and therefore this parcel will be offered in the First Quarter 2018 Competitive Oil & Gas Lease Sale.

March EA at 4. BLM declined to adopt the direct recommendation of Field Office resource specialists under IM 2016-143 and the EA fails to explore any of the parcel-specific factors from the IM relative to other parcels. The EA does not analyze or consider whether the parcels are near existing leases and development; overlap unitized areas; fall on lands with high or low development potential; or contain important habitat features, like leks, nesting, and winter range areas, as IM 2016-143 requires.

This lack of analysis fails to comply with the provision cited above from the Rocky Mountain ARMPA/ROD, Buffalo Field Office ARMP/ROD, Wyoming 9-Plan ARMPA, and IM 2016-143. In fact, these guiding documents, which BLM is bound to honor in its decision-making are not even mentioned in the March EA except for the one mention of IM 2016-143 shown above and two mentions of the ARMPAs relative to sage-grouse, but with no analysis. March EA at 2, 41. All BLM can say is that "[t]hese RMP amendments and portions of the Buffalo Approved Resource Management Plan (ARMP) have been developed to provide additional protections for PHMAs and further limit degradation and fragmentation from human activity in sage-grouse habitat." But this does not meet the requirement that "[p]riority will be given to leasing and development of fluid mineral resources . . . outside of Greater Sage-Grouse habitat."

With these comments, we are submitting and incorporating by reference a report from Dr. Matt Holloran addressing the importance of prioritization of leasing and development outside sage-grouse habitat. Attached as Exhibit 5 to these comments. Dr. Holloran's report looks to the manner in which the ARMPAs require prioritizing leasing and development outside PHMAs and GHMAs, in addition to protective stipulations for leases that are offered. Dr. Holloran's report further concludes that by disregarding the prioritization requirement, BLM is failing to protect sage grouse habitat at the landscape level as required by the ARMPAs. As Dr. Holloran explains, BLM also is failing to analyze the reasonably foreseeable impacts of leasing these parcels, as required by NEPA.

In addition, the attached report from geo-scientist Ken Kreckel, attached as Exhibit 6, illustrates the importance of applying the prioritization requirement. Mr. Kreckel's report shows that most of the proposed parcels should be low priorities for leasing because they are located in high value sage-grouse habitat, while also lying outside of areas with existing development.

BLM clearly must apply the prioritization guidance from the RMPs to this lease sale when parcels are proposed in or near PHMA and GHMA and BLM must apply the prioritization sequence and weigh the parcel-specific factors in reaching a leasing decision. *See* IM 2016-143 ("This guidance is also intended to ensure careful consideration of the factors identified below

when making any leasing and development decisions.") (emphasis added). Yet BLM has not done this. Even if the BLM is not required to defer the sale of all parcels in PHMA and GHMA, it is impossible to see how some of these parcels would not be deferred, if the RMPs and IM 2016-143 were faithfully applied and complied with. "Priority" for leasing of fluid minerals outside of PHMA and GHMA would be demonstrated by deferring the sale of at least some lease parcels in these areas.

As we discussed above, leasing constitutes an irreversible and irretrievable commitment of resources, and in addition a lease gives a lessee the right to develop oil and gas. Form 3100-11 and 43 C.F.R. § 3101.1-2. Thus, it is clear that leasing has tangible aspects that cannot be ignored if BLM is to meet the commitment to prioritize leasing outside of sage-grouse habitats. BLM mentions the stipulations that will be applied to the GHMA and PHMA parcels in Appendix A of the March EA and the stipulations are listed in Appendix C and in the Notice of Competitive Lease sale, but there is no analysis whatsoever of how BLM is complying with the sage-grouse RMPs. BLM is assuming that the stipulations meet its obligations to protect sage-grouse.

But stipulation limits are additional mitigation measures required by the RMPs that are supplemental to and in addition to the requirement to give priority to leasing outside of sage-grouse habitats. These stipulations do not show that BLM has given priority to leasing outside of sage-grouse habitats, as the RMPs require. As we noted above, the Wyoming 9-Plan AMRPA and the Buffalo Field Office ARMPA/ROD provide that:

> Priority will be given to leasing and development of fluid mineral resources . . . outside of Greater Sage-Grouse habitat. When analyzing leasing . . . in priority habitat . . . and general habitat, and subject to applicable stipulations for the conservation of Greater Sage-Grouse, priority will be given to development in non-habitat areas first and then in the least suitable habitat for Greater Sage-Grouse.

Thus it is clear the stipulations standing alone do not meet BLM's obligation to pursue leasing outside of sage-grouse habitats. The stipulations are a supplement to the additional requirement to give priority to "development in non-habitat areas first and then in the least suitable habitat for Greater Sage-Grouse."

Even if the RMPs have not closed these areas to leasing it is also true that they establish a policy that leasing will be prioritized outside of sage-grouse habitats. The BLM has not shown compliance with that requirement. The priority for leasing is clearly to be outside of PHMA and GHMA areas, yet BLM is ignoring this direction and doing exactly the opposite: it is prioritizing leasing inside of PHMA and GHMA. This does not comply with the ARMPAs, and thus violates the provisions in section 302(a) of FLPMA and BLM's land use planning regulations, as we argued in our comments on the draft EA.

Under FLPMA, when an RMP is developed, the Secretary of the Interior must manage the public lands "in accordance" with the RMP. 43 U.S.C. § 1732(a). And under BLM's land use planning regulations, BLM must make resource management authorizations and take management actions in a way that "shall conform to the approved plan." 43 C.F.R. § 1610.5-2033 (48 Fed. Reg. 20368 (May 5, 1983)). Commenting on these provisions, the Supreme Court said,

> The statutory directive that BLM manage "in accordance with" land use plans, and the regulatory requirement that authorizations and actions "conform to" those plans, prevent BLM from taking actions inconsistent with the provisions of a land use plan.

Norton v. Southern Utah Wilderness Alliance, 542 U.S. 55, 68 (2004). Thus, it is clear that that the BLM must abide by the sage-grouse RMPs in this lease sale. BLM's leasing decisions, not just its development decisions, must comply with the ARMPAs ("Priority will be given to leasing . . . of fluid mineral resources . . . outside of PHMA and GHMA.").

In rejecting these concerns, BLM essentially offered two arguments for why it was complying with the sage-grouse lease prioritization requirements. March EA at Appendix F pages 7-8. BLM claimed:

1. Offering these parcels for leasing is in conformance with the applicable land use plans.
2. And the referenced sage-grouse stipulations were attached to the proposed leases.

Id.

Essentially BLM's claims are that it is abiding by the Casper, Buffalo, and Newcastle RMPs, including the sage-grouse amendments, and that by placing the stipulations shown in Appendices A and C on the leases the BLM has met all of its obligations. But as we have discussed above, this is far too narrow a view of BLM's prioritization obligations under the RMPs and FLPMA, which require it to fully abide by all provisions in its RMPs, including the requirement to pursue leasing outside of sage-grouse habitats, a requirement that BLM completely ignores in the March EA and in the Notice of Competitive Lease Sale. We therefore renew our protest of the 37 lease parcels that are in PHMA and GHMA.

C. BLM is not Meeting the Mineral Leasing Act Requirement to Prevent Waste of Natural Gas.

The last issue that we raised with BLM in our August 23 comments on the draft March EA was the need for BLM to reduce methane waste releases that could result from oil and gas development in order to comply with the MLA. The MLA first provides that each lease shall contain provisions to ensure the exercise of "reasonable diligence, skill, and care" in the operation of the lease, and then provides that leases will contain a provision allowing rules "for the prevention of undue waste" that can be prescribed by the Secretary and which "shall be observed." 30 U.S.C. § 187. Next the MLA provides that all oil and gas leases "shall be subject to the condition that the lessee will . . . use all reasonable precautions to prevent waste of oil or gas developed in the land . . ." *Id.* § 225 (emphasis added).

Clearly under the MLA the BLM must take steps to reduce methane waste at the leasing stage. Actually, BLM is required to "prevent" the waste of oil and gas. While section 4 of BLM's standard oil and gas lease form (Form 3100-11) provides that lessees must prevent unnecessary waste of the leased resource, this does not fully encompass what the MLA says. This provision does not say that BLM can prescribe rules for the prevention of undue waste, as section 187 provides for. It also does not say that all reasonable precautions to prevent waste will be required, as section 225 provides for. And in the stipulations that BLM has put in place for leases proposed for sale in March, 2018 there is no mention of waste or the duty to prevent waste.

As we argued in our August 23 comments, BLM is required to put in place provisions on these leases that will prevent waste. It has not done so. This must be corrected. In response to and in rejecting these concerns, BLM had this to say:

1. This concern is "[b]eyond the scope of this document."
2. BLM requires submittal of a waste management plan and in any event Wyoming state regulations provide for waste management.
3. Leasing does not result in land disturbance immediately, this leasing proposal is in conformance with the RMPs, and site specific NEPA compliance will occur if well drilling proposals are made.
4. Stipulations on these leases conform to the RMPs and any changes to them would require land use plan amendment.

March EA at Appendix F pages 8-9.

Clearly given the provisions in sections 187 and 225 of the MLA, addressing the issue we have raised is not beyond the scope of this EA and the related leasing decisions. As mentioned above, any plans that BLM requires do not ensure that all provisions to prevent waste have been put in place, and the state of Wyoming's regulations cannot substitute for BLM's obligation under the MLA to prevent waste. The MLA is explicit, efforts to prevent waste must be taken by BLM at the leasing stage, in the leases. RMP planning efforts are not sufficient; the MLA requires regulation at the leasing stage. All "reasonable precautions" to prevent waste must be put in place in leases. This is not something that can be put off until there is future site-specific NEPA analysis if a well is proposed. The BLM seems to think that it has complied with the applicable RMPs and this takes care of any waste issues. But if the RMPs do not require what the MLA requires (rules to prevent waste and all reasonable precautions to prevent waste), and they do not, then this assertion does not save the BLM.

In our August 23 comments we noted several means that BLM might consider to reduce waste which have been used in other Districts and Field Offices. BLM ignored these suggestions in its response to our comments. But even if BLM does not feel these suggestions have merit, it nevertheless still has an obligation under the MLA to put in place rules to prevent waste and to ensure all reasonable precautions are used to prevent waste. And these provisions must be made in the lease. Again, BLM has not done this, which is impermissible.

We are well aware that BLM has issued a final rule that would suspend requirements in its 2015 Waste Prevention, Production Subject to Royalties, and Resource Conservation rule. 82 Fed. Reg. 58050 (Dec. 8, 2017). A lawsuit challenging this weakening of the 2015 rule has been filed. *Complaint for Declaratory and Injunctive Relief,* filed in the United States District Court for the Northern District of California, December 19, 2017. But regardless of the status of the 2015 waste rule, the BLM must still meet the requirements of the MLA. And that statute clearly requires BLM to prevent waste of natural gas at the leasing stage. Since BLM has failed to meet this obligation we again protest the proposed sale of all 81 parcels at the March, 2018 High Plains District lease sale.

IV. CONCLUSION

Thank you for considering this protest of the March 21-22, 2018 competitive oil and gas lease sale proposed in the BLM's Casper, Buffalo, and Newcastle, Wyoming Field Offices.

Sincerely,

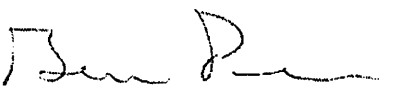

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Exhibit 1

HYDRAULIC FRACTURING ON PUBLIC LANDS

TRIBAL CONSULTATION SESSION

JANUARY 10, 2012

HYATT HOTEL

TULSA, OKLAHOMA

STEVE TRYON, Bureau of Land Management, Tulsa, OK, Meeting Facilitator

STEVEN WELLS, Bureau of Land Management, Washington, DC

MIKE WORDEN, Bureau of Land Management, Washington, DC

JIM STOCKBRIDGE, Bureau of Land Management, Colorado

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JANUARY 10, 2012

MORNING SESSION

STEVE TRYON: I feel like I'm at church today, where everybody started at the back pews and filled in, so I'm going to come a little forward.

UNIDENTIFIED SPEAKER: Pass the offering plate.

STEVE TRYON: My name is Steve Tryon. I am the Field Manager for the Bureau of Land Management in Oklahoma. My office is based here in Tulsa. We also have a handful of people representing our Moore, Oklahoma, field station. And I look around and I see familiar faces from the Bureau of Indian Affairs, but also primarily from the tribes in Oklahoma.

Our office in Tulsa actually represents federal and Indian minerals in a three-state area. So that includes Kansas, Oklahoma, and Texas. And we have staff who really wander the earth that go as far south as the border with Mexico and on up to the northern stretches of Kansas.

It's an honor to be able to host the first of four listening sessions and tribal consultations on the subject of hydraulic fracturing. Most of you know that hydraulic fracturing, or completion, or stimulation, or any of the things that you may see as shorthand, or

we can do that. We try. And stay tuned on this one. As you know, it's an election year, so anything can happen.

STEVE TRYON: So after lunch, Jim Stockbridge is going to walk us through the schedule that would lead to a draft rule-making and a final rule-making, which, of course, is a public process and everybody in this room has a chance to participate again. I think that would be a chance, when he's doing that presentation, is, does that schedule somehow need something special for Indian tribes in addition to the public outreach that all of you are going to be invited to. So that's a chance to come back on this subject.

If people can hang in there with us, what we had intended to do till about the top of the hour was to talk about water quality and EPA's designs on protecting water quality. If we can do that before we break, that keeps Mike Worden from our Washington office from having to do back-to-back presentations, which I promised him. And then before we break today, we're going to kind of do this all over again about putting your questions and thoughts out there. So give us a chance to get it out first and then come back and revisit it.

So if we can move to Mr. Worden.

MIKE WORDEN: Thank you, Steve.

As Steve said, my name is Mike Worden. I'm a petroleum engineer with our Washington office, I've been there for a year and a half, and I'm the team lead on our hydraulic fracturing attempts at regulation, or thoughts on regulation.

11:26:08AM

This basically started about the time I arrived in Washington. November 30th of 2010, Secretary Salazar held a public forum in Washington, DC on hydraulic fracturing. The BLM subsequently went out in April to Bismark, North Dakota, Little Rock, Arkansas, and Boulder, Colorado, for public listening sessions on what people of the nation felt about hydraulic fracturing. And three of the major points that came out of that were, people wanted to see disclosure -- I think we've seen a lot of that in the newspaper -- of components that are used in hydraulic fracturing fluids. Part of these forums, we had a panel that was -- the public was represented, industry was represented, and in some cases there was tribal representation where there was, particularly in Bismark, where that was -- they were invited and they accepted. So there was a number of different stakeholders involved on the panel.

11:26:30AM

11:26:46AM

11:27:06AM

And, in addition to disclosure, one of the issues was protection of trade secrets. And so we're trying to be -- strike that balance.

:27:26AM

The other major, second major topic would be wellbore integrity. As Galen pointed out in his presentation, about how we can protect the resources using proper wellbore construction.

11:27:42AM And, finally, one of the big issues, third big issue was water quality. So we made an attempt to address this here today, or are going to make an attempt. I asked EPA to put together a presentation, and up until last night they were going to come and

11:28:02AM present this. So bear with me. I'm not a water quality expert. Like I said, I'm a petroleum engineer. But I'm going to do my best to present the presentation that EPA put together. And when we get on to the rule later on, my actual talk, hopefully, I'll be a little bit better

11:28:20AM at it.

What is water quality? It's the suitability of water for a particular use based upon the physical, chemical and biological characteristics, such as taste, temperature, dissolved mineral content, purity.

11:28:38AM There are several sources of drinking water. There's surface water, rainwater, desalinized seawater if you live close to the ocean, reclaimed wastewater, and of particular interest when we're talking about drilling wells is groundwater.

:28:56AM How do you measure groundwater quality? What are

we looking at? Or what are they looking at when they measure groundwater quality? It's measured at the source. You look at the temperature. You look at the pH, the acid, whether it's alkaline. Dissolved oxygen. Total dissolved solids, which is going to come up again and again in this presentation. Other things you look at in the laboratory, whether it has organic pesticides or benzene or toluene.

One of the main points we're looking at is this total dissolved solids, which is basically a measure of how water tastes, where it's used, what's available for drinking, for livestock, for agriculture. So TDS, you'll hear that term used. It's total dissolved solids, is the measurement of the total salts and compounds dissolved. So you can't see it in the water. It's dissolved into the water.

It can be any mineral, salts, metals, cations, anions. It can also be inorganic salts. A number of things that, as not a chemist, I'd prefer not to talk about.

And we'll get to the next slide, which is some ranges of total dissolved solids. We think about freshwater. EPA has standards that drinking water has to be less than 500 parts per million -- that's less than 500 grams per liter of water -- for it to be

considered drinking water. For agricultural uses, we're looking at in the -- they look in the range up to 2,000 parts per million. You can see down there, saltwater is 30,000 to 50,000 parts per million.

11:31:04AM I remember as a child going swimming in the ocean, you certainly didn't want to be drinking that. And if you're like me, and like raw oysters, you try not to get too much of that in your system.

So that gives us a -- what I had wanted the EPA 11:31:20AM to present was a basis for us to talk on this. What is freshwater? What is drinkable water? What are waters that our rule is going to look to protect, or should be looking to protect? So I wanted to establish this background with this, where we're looking at the 11:31:36AM drinking water is 500 parts per millions and agricultural uses usually start at 2,000 parts per million.

Next slide, please. We'll get into that a little bit more, but all of this is defined in the Safe 11:31:52AM Drinking Water Act, and they define underground sources of drinking water. And it's codified in -- here's some legalese -- 40 CFR 104(b)(6.3), which is of a section of the Safe Drinking Water Act that was passed in 1974. It defines an underground source of drinking water, the :32:20AM definition: Assures that the potential resources of

drinking water are protected as stringently as those sources currently used for drinking water.

So we're looking at potential sources of drinking water, not just those that are being used today. So they're protected the same. They need to be protected the same.

We heard earlier that we want to protect water for our future generations. So if we're not using that water today, we may be using it ten years, a hundred years from now. So we don't want to contaminate it now so it's unusable in the future.

It talks about, the Safe Drinking Water Act talks about aquifers. Definition of an aquifer is a formation capable of yielding a significant amount of water to a well. Does not mandate that the formation currently be used as a producing source, which is what I said earlier, and does not have to be drinking water well -- does not have to have drinking water wells completed into it. But we're trying to protect potential sources that could be used, or the EPA is, under the Safe Drinking Water Act. The EPA is the one authorized to protect drinking water under the Safe Drinking Water Act. The Department of Interior has no authorities under the Safe Drinking Water Act.

This is a nice drawing. It kind of puts it maybe

in a visual perspective of where drinking water would be the, quote/unquote, usable quality of water, and then this brackish and saltwater that it's highly unlikely it's approaching seawater concentrations. And it very much moves from close in surface the deeper you go.

11:34:04AM

It's important to note that it's not the same around the country. So region to region, this same general dynamic follows, but in some areas we're hitting the only usable water at 600 feet. In other areas it's at 2,000 feet, which is important that when the Bureau, BLM, is reviewing permits to drill, that we're looking at where the usable water is and protecting it. That's why we have regional offices or field offices where we've got geologists and petroleum engineers reviewing this for that area. This isn't regulation -- we're not looking to have regulation from on high in Washington saying this is where it's going to cut off. We need that local input. And when the proponent proposes where they're going to set their casings at and where they're going to cement to, this information is being reviewed by the local office to see that these usable sources of water are being protected.

11:34:26AM

11:34:44AM

11:35:02AM

One of the ways we -- next slide, please. Several of the ways you protect groundwater quality, you can see the one that's highlighted. That's the one

we're going to talk about next. Watershed level controls, environmental controls, source water controls, drinking water system controls, groundwater quality standards, and then the Underground Injection Control Program. That's -- under the Safe Drinking Water Act, EPA regulates or gives primacy to states or tribes to regulate disposal wells.

Next slide. The way that -- what they use to regulate these are set out in the law and any further regulation that EPA did after the law was passed in '74.

What the Safe Drinking Water Act is, it gives EPA the authority to set drinking water standards. Required water systems to be monitored to ensure compliance. They created this Underground Injection Control Program to protect drinking water resources from contamination through underground injection. It defined what underground injection is. Defined endangering drinking water sources. These are all in the law itself.

It recommended -- it has recommended compliance of contaminant levels and recommended maximum contaminant levels as specified in the law. And for -- and it also provides treatment techniques for those chemicals that don't -- that don't have maximum contaminant levels.

Next slide, please. It required the EPA to draft

regulations to protect drinking water, which I said earlier. But these regulations, they can -- through the law, it allows states -- and I'm trying to think. I don't know all my states that well, but I believe Oklahoma is one that does have primacy, and some tribes in this room may have primacy of regulating their Underground Injection Control Program. But it's -- EPA sets the standard and then states and tribes can apply to demonstrate that they can meet those standards or that their standards are more stringent, and then they have primacy over the program.

But what the program does is it sets a threshold for the amount of total dissolved solids, one of the things that's in there, that can be of waters that need to be protected. So it -- maybe we should go back to the slide on page 8.

The standard of the Safe Drinking Water Act is this 10,000 parts per million TDS. Any waters above that need to be protected under the Underground Injection Control Program, with one caveat, if they're exempted and the agency with primacy can exempt them. But typically all those waters need to be protected.

Current BLM regulations, our Onshore Order II which deals with drilling uses that same value. It was specifically, when the regulation was written in 1988,

it was decided that this is good for the Underground Injection Control Program. We're another federal agency. That number is a good number. So that is the number that is currently in Onshore Order II, with a little caveat here, getting into my later talk, that we also have regulation that talks about 5,000 TDS being the number, and that was published prior to Onshore Order II. So Onshore Order II actually is the precedent because it came out after. The lawyers tell me that the law that's passed, or regulation that's passed the latest is the one that takes precedence.

So, in theory, or in actuality, we've been using this 10,000 TDS whenever an Application for Permit to Drill is filed, to protect all those waters, to isolate them. As Galen showed earlier, surface casings run through them, cement is circulated back, covering the entire zone, so those zones are protected.

One of the things that we'll talk about this afternoon in the proposed regulation is to rewrite that section in our regs that say 5,000. I just wanted to point that out, that when we change that, it really hasn't changed anything, but it's more of an administrative act because we've already been using this 10,000. But it's very unclear when you look at the BLM's regulations that this is what it is. So we're

trying to basically use this opportunity to clean up that part of our regulations. And I'll discuss that a little bit more this afternoon.

But that's everything I know about water quality, unless you ask me a question and I know more. Are there any questions?

ANDREW YATES: Andrew Yates with the Osage. You know, we've used the 10,000 parts per million as our basic USDW. Did you just say that you were going to try to change that to 5,000 parts per million?

MIKE WORDEN: No. I'm saying that our current -- one of our two current rules says 5,000, and that's going to be changed to ten so that it all matches.

ANDREW YATES: Okay.

STEVEN WELLS: In the BLM rules.

MIKE WORDEN: Yeah, in the BLM rules, yes. So EPA has the 10,000 parts per million established, and BLM in actuality has it established, but one of our rules says 5,000 and we're going to change that, or we propose changing that to ten so there's no confusion.

Thank you for asking a clarifying question. That was what -- that was something I was trying to make a point, and apparently I, by the looks on everybody's faces, I hadn't made that point.

From:	Kelly.Suzanne@epamail.epa.gov
To:	Dutta, Subijoy
CC:	Kobelski.Bruce@epamail.epa.gov; Kumar.Chitra@epamail.epa.gov; John Ajak; Jollie.Jeff@epamail.epa.gov; Bergman.Ronald@epamail.epa.gov; Steven Wells
Sent:	1/10/2013 3:19:28 PM
Subject:	Re: Fw: Follow up on Dec 19 meeting at EPA-east

Subijoy et. al:

Thanks again for hosting the meeting on 1/8 at your office. As promised I've attached below my signature line some relevant citations and publically vetted language on our USDW definition and comments to expand vs. restrict as promised.

We would be happy to review and or assist in drafting language that might meet your specific need if you find this information is not exactly what you could use regarding background on the nexus between your term usable water and our USDW definition.

Thanks again.

Sue

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A USDW is defined as an aquifer or a portion of an aquifer that:
Supplies any public water system; or 2. Contains sufficient quantity of groundwater to supply a public water system; and i. currently supplies drinking water for human consumption; or ii. contains fewer than 10,000 milligrams per liter (mg/L) total dissolved solids (TDS); and B. Is not an exempted aquifer
*NOTE: Although aquifers with greater than 500 mg/L TDS are rarely used for drinking water supplies without treatment, the Agency believes that protecting waters with less than 10,000 mg/L TDS will ensure an adequate supply for present and future generations.
Some relevant citations in our regulations regarding the USDW regulation:

Key Concepts.docx

Preamble language on USDW definition:
full text of preamble can be found at http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf.
The relevant page #s so that you don't have to read the whole preamble are pages 77235 and 77252:

- Page 77235: EPA has defined through its UIC regulations that USDWs are underground aquifers with less than 10,000 milligrams per liter (mg/L) total dissolved solids (TDS) and which contain a sufficient quantity of ground water to supply a public water system (40 CFR 144.3).
- Page 77252: Last column contains relevant summary text on range of comments we recieved on our USDW defintition and a high level response on the agency's position at the time of the rulemaking.

Response to comment language regarding USDW classification under the UIC Program

- Instead of having you read 500 pages I've extracted some of the relevant comments here that explain stakeholders request for expanding the current 10,000 TDS USDW classification; including our response.
- You'll probably get more of the protect to 3,000 TDS so I thought these responses would be relevant for understanding the "expansion" type comments.

Letter ID: 0206 Comment ID: 22209 Letter Lines: 66 to 84
Comment Code: 1610 1.3.1 Risks to USDWs
Comment Code: 3100 2.1 Proposed Geologic Siting Requirements (40 CFR 146.83)
Comment: - The USDW classification must be reconsidered when siting Class VI wells. The best sources of drinking water are already being used by utilities. Coupled with challenges resulting from climactic changes, population growth and land development, many utilities are turning to more challenging groundwater sources such as those that are very deep or have high salinity concentrations, also because the pumping costs for these deep wells are no longer prohibitive given the lack of sufficient water elsewhere. Some of these new sources could fall outside of the current definition of a USDW, in that the aquifer has a TDS concentration higher than 10,000 ppm. EPA's proposed rule promises protection of USDWs from endangerment yet there are no anti-degradation provisions in the proposed regulation to protect other groundwater supplies, such as those aquifers that are not classified as a USDW but have been, or may be, identified as a future drinking water source. The TDS criterion was written at a time when many advanced water treatment technologies were generally cost prohibitive. In light of the changes in the hydrological and technological landscape, we recommend that EPA reexamine the classification of USDWs based on TDS when considering the siting of Class VI geosequestration wells. The potential need to use saline aquifers for potable supply, particularly in water-stressed areas,
should take precedence over the sequestration of carbon dioxide there.

EPA Response: The Agency acknowledges commenter concerns about water resources and future water resource availability. However, modifying the definition of a USDW is outside the scope of the GS rulemaking. USDWs are defined as aquifers currently being used as sources of drinking water or those capable of supplying a public water system and they have a total dissolved solids (TDS) content of 10,000 milligrams per liter or less (§144.3). The primary goal of the UIC Program under the SDWA is to protect USDWs in order to ensure a reliable supply of drinking water for the American public. The GS rule, as part of the UIC program regulations, continues the program's tradition of ensuring the protection of USDWs. The permitting, siting, construction, operation, monitoring, and post-injection site care requirements in the GS rule built on a long-standing protective regulatory framework, tailored to the unique characteristics of CO2 GS.

Letter ID: 0213 **Comment ID:** 22922 **Letter Lines:** 158 to 168
Comment Code: 1270 1.1.2 Comments on other rules/issues
Comment: Climate change, drought, and the depletion of traditional ground water supplies due to population growth and land development are causing drinking water utility managers to look at new sources of drinking water that have not traditionally been considered as sources of drinking water. Coupled with improvements in desalination and other treatment technologies, drinking water sources of high salinity are being used for water supply. AMWA recommends that EPA reexamine the current classification of a USDW (i.e., an aquifer with a total dissolved solids (TDS) concentration of less than 10,000 mg/L) when siting Class VI geosequestration wells. The potential need to use saline aquifers for potable supply, particularly in water-stressed areas, should take precedence over the sequestration of carbon dioxide there.
Individual Response: EPA clarifies that addressing climate change, drought, and the depletion of traditional ground water supplies are outside the scope of the Class VI GS rulemaking. Rather, the purpose of the Class VI GS rule is to ensure consistency in permitting underground injection of CO2 at GS operations across the United States and provide requirements to prevent endangerment of USDWs in anticipation of the eventual use of GS to reduce CO2 emissions. The Agency acknowledges commenter concerns about water resources and future water resource availability. However, modifying the definition of a USDW is outside the scope of the Class VI GS rulemaking. USDWs are defined as aquifers currently being used as sources of drinking water or those capable of supplying a public water system and have a total dissolved solids (TDS) content of 10,000 milligrams per liter or less (§144.3). The primary goal of the UIC program under the SDWA is to protect USDWs in order to ensure a reliable supply of drinking water for the American public. The Class VI GS rule, as part of the UIC program regulations, continues the program's tradition of ensuring the protection of USDWs. The permitting, siting, construction, operation, monitoring, and post-injection site care requirements in the GS rule build on a long-standing protective regulatory framework, tailored to the unique characteristics of CO2 injected for the purpose of GS.

Letter ID: 0213 **Comment ID:** 22925 **Letter Lines:** 188 to 209
Comment Code: 2126 1.6.1.2 Comments opposing injection into deep saline
Comment: AMWA is also concerned about using saline aquifers for carbon sequestration. In a climate-stressed and ultimately water-stressed world, it is quite possible that these aquifers will be used as drinking water supplies in the near future. For example, EPA states in the rule proposal that deep saline aquifers that have >10,000 TDS will account for 88% of geosequestration sites. Many of these aquifers may actually be targeted for water supply. The experience of drinking water systems in Florida and other areas has
demonstrated that TDS measurements in USDWs are a moving target. The upper Floridan aquifer is currently about 8000 mg/L TDS. However, in pumping this already brackish aquifer, the upwelling of more saline waters from below is occurring. In addition, some utilities are considering pumping from deeper wells with a higher salinity for drinking water supply and using reverse osmosis to
treat for TDS. As the protection of current and future drinking water supplies is paramount, AMWA suggests that when there are competing uses in an aquifer, the needs of the aquifer for drinking water supply should take precedence over other municipal or

industrial uses and the risk of unintended impacts on potable water supplies is unacceptable. AMWA suggests that EPA require a more rigorous scientific evaluation in the final rule about how potential risk to potable aquifers will be avoided in the site characterization for a CO2 geosequestration project.
Individual Response: EPA clarifies that the final rule requires the Director to notify the director of the state public water system supervision program (PWSS) when a draft permit becomes available for public comment. EPA expects that the PWSS director will provide input to the Director regarding competing needs for water resources and whether to grant a permit. The Agency acknowledges commenter concerns about water resources and future water resource availability. However, modifying the definition of a USDW is outside the scope of the GS rulemaking. USDWs are defined as aquifers currently being used as sources of drinking water or those capable of supplying a public water system and they have a total dissolved solids (TDS) content of 10,000 milligrams per liter or less (§144.3). The primary goal of the UIC Program under the SDWA is to protect USDWs in order to ensure a reliable supply of drinking water for the American public. The GS rule, as part of the UIC program regulations, continues the program's statutory mandate of ensuring the protection of USDWs. The permitting, siting, construction, operation, monitoring, and post-injection site care requirements in the GS rule built on a long-standing protective regulatory framework, tailored to the unique characteristics of CO2 GS. EPA clarifies that a state's Class VI primacy program may be more stringent then the federal requirements. For example, a state has the discretion to ban GS projects from taking place in specific formations or other areas where there are water resource issues. EPA believes that state permitting authorities are in the best position to make determinations about the appropriateness of a particular site based on all available information, including drinking water supply needs.

Letter ID: 0172 **Comment ID:** 23451 **Letter Lines:** 62 to 78
Comment Code: 1220 1.1.1.1 Terminology and definitions
Comment Code: 4400 2.4.4.3 Allowing injection above or between USDWs (seeking comment)
Comment: Potential USDW Above 10,000 TDS:
Since states and water utilities in many areas of the U.S. are currently addressing drought and water rights and availability issues, the proposed rule should provide for states to include protections for well sites with potentially viable sources of drinking water, such as saline aquifers and aquifers above 10,000 (mg/L) total dissolved solids (TDS) level that might serve as a viable drinking water source. ASDWA recommends that states be allowed regulatory flexibility to consider these aquifers as potential drinking water sources.
Please note that there is some variance among states with regard to this issue. While some states would like Congress to consider changing the current Safe Drinking Water Act (SDWA) language to preclude these aquifers as potential sequestration sites, other states are actively looking for additional sequestration sites and would prefer that the proposed regulation and the current Safe Drinking Water Act (SDWA) language keep the current 10,000 TDS (mg/L) definition for a USDW. Thus, we recommend state-specific flexibility on this matter.
Individual Response: EPA is not changing the USDW definition; changing the definition of a USDW is outside the scope of the GS rulemaking. The GS rule focuses on ensuring protection of USDWs, as required under the SDWA, by establishing regulations to ensure the safe injection of CO2 for long-term storage. EPA recognizes that there is increasing demand for water resources and that technology improvements may make high TDS aquifers viable drinking water sources. EPA believes these potential resources should be considered when injection depth waivers are sought. Therefore, the final GS rule at §146.95(b) requires the Director to consider these issues in determining whether an injection depth waiver is appropriate. Specifically, the Director must consider whether alternative injection sites are available; community needs, demands, and supply from drinking water resources; planned needs, potential and/or future use of USDWs and non-USDWs in the area; and a plan for securing alternative resources or treating USDW formation waters in the event of contamination related to the Class VI injection activity. For additional information on the waiver approach, please see the final rule and preamble, as well as EPA's responses to comments on the Notice of Data Availability and Request for Comment.

"Dutta, Subijoy" ---01/08/2013 06:49:54 PM---Jeff: It was good to talk with the awe-inspiring group and the discussion was

From: "Dutta, Subijoy" <sdutta@blm.gov>
To: Jeff Jollie/DC/USEPA/US@EPA
Cc: Ronald Bergman/DC/USEPA/US@EPA, Bruce Kobelski/DC/USEPA/US@EPA, Chitra Kumar/DC/USEPA/US@EPA, John Ajak <jajak@blm.gov>, Steven Wells <s1wells@blm.gov>, Suzanne Kelly/DC/USEPA/US@EPA
Date: 01/08/2013 06:49 PM
Subject: Re: Fw: Follow up on Dec 19 meeting at EPA-east

Jeff:
It was good to talk with the awe-inspiring group and the discussion was surely quite thought-provoking.
As a follow up, attached are:
1. Short discussion points, unedited... if you/anyone present in the meeting want to add to it and send back to everyone, that would be real nice..
2. BLM Onshore Orders #1, #2 , and #7 which are the existing rules that govern Drilling and Production from Oil &

Gas Operations in the BLM leases and they apply to all wells administered by the BLM, including those on Federal, tribal, and individual Indian trust lands.
In general these rules and regs are generally accessible from the link below: http://www.blm.gov/wy/st/en/programs/energy/Oil_and_Gas/Onshore_Operations.html

Hope this helps.
I look forward to receiving the "Usable Water" piece from Suzanne.

Subijoy

On Mon, Jan 7, 2013 at 1:31 PM, <Jollie.Jeff@epamail.epa.gov> wrote:

Subijoy, just a quick follow up to my email from this morning. As it stands now - Chitra Kumar, Bruce Kobelski, Suzanne Kelly, and I will be traveling to your office tomorrow for our coordination meeting. Ron Bergman has a meeting conflict and will likely not be able to attend.

Jeff
****

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----- Forwarded by Jeff Jollie/DC/USEPA/US on 01/07/2013 01:25 PM -----

From: Jeff Jollie/DC/USEPA/US
To: "Dutta, Subijoy" <sdutta@blm.gov>
Cc: Ronald Bergman/DC/USEPA/US@EPA, Bruce Kobelski/DC/USEPA/US@EPA, Chitra Kumar/DC/USEPA/US@EPA, "John Ajak" <jajak@blm.gov>, Steven Wells <s1wells@blm.gov>, Suzanne Kelly/DC/USEPA/US@EPA
Date: 01/07/2013 08:36 AM

Subject: Re: Follow up on Dec 19 meeting at EPA-east

Subijoy, thanks for sending your presentation from December 19, it was very informative. We'll get back to you today with confirmation on those that will be coming to your office for tomorrow's meeting. -Jeff
****

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"Dutta, Subijoy" ---01/04/2013 03:48:28 PM---Jeff: Chitra called me around Noon today and asked for a copy of my Dec-19

From: "Dutta, Subijoy" <sdutta@blm.gov>
To: Jeff Jollie/DC/USEPA/US@EPA
Cc: Bruce Kobelski/DC/USEPA/US@EPA, Chitra Kumar/DC/USEPA/US@EPA, "John Ajak" <jajak@blm.gov>, Ronald Bergman/DC/USEPA/US@EPA, Steven Wells <s1wells@blm.gov>, Suzanne Kelly/DC/USEPA/US@EPA
Date: 01/04/2013 03:48 PM
Subject: Re: Follow up on Dec 19 meeting at EPA-east

Jeff:
Chitra called me around Noon today and asked for a copy of my Dec-19 presentation. I somehow forgot to copy that to the USB provided to me. Anyway, it is attached here.
Chitra also discussed about a follow up meeting next Tuesday at 3 PM at our BLM Office, 20 M Street SE to have consistency between the EPA guidance and the Supplemental HF Rule so that when OMB looks at the siblings they find the uniformity.

Chitra was going to check with Bruce and others and let me know how many of you would come and confirm the time/Date. I will be waiting to hear back on that.

I am available and so is John Ajak. I will check with Steve Wells, our Division Chief if can join us as well.
I have reserved/continued our HF-Team Room for the discussion where we have HF-Sketches all around.

Subijoy
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On Thu, Dec 20, 2012 at 12:05 PM, <Jollie.Jeff@epamail.epa.gov> wrote:

> Subijoy,
>
> It was good to meet with you and John yesterday also. Attached below is a fact sheet that provides the highlights of our UIC Class II permitting guidance. Let me know if you have questions, or comments. I checked ORDs website and it doesn't look like they have posted the HF study progress report yet. If I can get some more information on that I'll let you know. Back in May, we made a table of comparisons between your proposed rule and our guidance. I attached that comparison table below in case it helps with any of your internal discussions.
>
> Jeff
>
> http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/hfdieselfuelsfs.pdf
> *(See attached file: Comparison of BLM regs to HF guidance_May30_2012.docx)*

****

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"Dutta, Subijoy" ---12/20/2012 10:36:07 AM---Hello Jeff et al. It was good to meet with all of you yesterday.

From: "Dutta, Subijoy" <sdutta@blm.gov>
To: Jeff Jollie/DC/USEPA/US@EPA
Cc: Suzanne Kelly/DC/USEPA/US@EPA, Chitra Kumar/DC/USEPA/US@EPA, Bruce Kobelski/DC/USEPA/US@EPA, Ronald Bergman/DC/USEPA/US@EPA, John Ajak <jajak@blm.gov>, Steven Wells <s1wells@blm.gov>
Date: 12/20/2012 10:36 AM
Subject: Re: Follow up on Dec 19 meeting at EPA-east

Hello Jeff et al.
It was good to meet with all of you yesterday.
Here is another comment from the Tribe - The Ute Tribal Business Council. Hopefully that will provide you with the drift and some insight on the Tribal issue/s.

It'd be of value to get the highlights of your guidance as Chitra and Sue mentioned about sending it to me yesterday/today. Our package editing/insertion of the supplemental rule is in its final phase and will be done tomorrow.

Subijoy

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www.blm.gov; email: sdutta@blm.gov*(See attached file: RHF-Comment42_Ute_Tribal_Business_Council.pdf)*

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[attachment "SDUTTA-Fracking-Dec19-2012.pdf" deleted by Jeff Jollie/DC/USEPA/US]

Water Management for Hydraulic Fracturing in Unconventional Resources—Part 4

Using Mechanical Vapor Compression as a Desalination Technology

John M. Walsh, Cetco Energy Services

This is the fourth article of a series covering water management in hydraulic fracturing (HF) in unconventional resources. In the first article, published in June, water management and planning were discussed. Fluid properties and characterization were discussed in the second article, published in August. In the third article, published in October, suspended solids removal using coagulation/flocculation and electrocoagulation was discussed. An explanation was given as to why those technologies are justified based on the characteristics of flowback fluids. This article discusses the use of mechanical vapor compression (MVC) as a desalination technology.

The series of articles is intended to identify and explain the technologies used in HF and explore whether they are appropriate and cost effective. When talking with operators, their comments often suggest that there are too many technologies from which to choose and little basis upon which to make the selections. Water management for HF has become a magnet for every water treatment scheme imaginable. Thus, it is helpful to look at a few successful technologies in some detail to understand why they are appropriate.

In general, desalination of recycle flowback water is becoming less important. New formulations of salt-tolerant polymers and fluids are being developed and applied. Some of the HF fluids are more expensive on a per pound basis, but become cost-competitive when overall reduction in water source, treatment, and disposal costs are taken into account. Nevertheless, there is still a need in some regions to desalinate. This is particularly true when specific compounds must be removed, such as boron or scaling components.

Desalination Technologies

In industrial and municipal water treatment, two technologies used for desalination are thermal processes and membranes. Thermal desalination processes are much older than membrane processes. Despite the rapid advance of membrane processes in the past 2 decades, at least one-third of the installed worldwide desalination capacity is provided by thermal desalination. Other desalination technologies, such as ion exchange, electrodialysis, and softening, are not applicable for the high salinities of HF flowback fluids.

Because of the high fouling tendency of HF flowback fluids and the high salinity in some regions, membrane-based desalination technology is not viable. Spiral wound nanofiltration and reverse osmosis (RO) membranes are the workhorses for onshore applications and offshore desalination of seawater. Neither can be used when the concentration of organic fouling material exceeds a few tens of mg/L. As discussed in Part 2 of this series, the slickwater formulations contain several hundred mg/L of spent polymer. The linear and cross-linked gels (mostly guar-based polymer) contain a few to several thousand mg/L of organic fouling material.

In industrial and municipal water treatment, the main thermal desalination technologies are multistage flash (MSF), multiple-effect distillation (MED), and MVC. The global market shares of these processes are 87%, 12%, and 0.2%, respectively (Global Water Intelligence 2006). A variation of these technologies is a hybrid combination of MED and thermal vapor compression, which has a high energy efficiency compared with the others. MSF process uses multiple evaporation chambers, each having lower pressure and, therefore, lower temperature. The chambers, or stages, are designed for maximum heat recovery.

Thermal desalination processes consume more energy than the RO processes. Depending on the particular technology, the energy required can be as high as 10 to 15 kWh/m^3 of water (1.6 to 2.4 kWh/bbl). This is high compared with 5 kWh/m^3 (0.8 kWh/bbl) for RO in a seawater application, which by itself is considered to have a significant energy requirement for

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pumping. However, the reliability, low fouling tendency, and extensive field experience with the thermal desalination technologies keep them in demand, particularly for large facilities where waste heat is available.

The MSF and MED systems are often applied in cogeneration plants, where power and water are produced simultaneously. Both systems require low-pressure heating steam, which can be easily extracted from the power plant at low cost.

Mechanical Vapor Compression

The MVC system is operated solely on electric power, which can be a benefit or a drawback. It offers an advantage because it can be applied where no waste heat is available. However, the high costs of electricity make it less preferable in the industrial and municipal water industries.

MVC is a niche technology with features that make it appropriate for desalination of flowback fluids in HF. Because it does not require waste heat, it is the preferred desalination technology for use in some HF operations.

Fig. 1 illustrates the MVC process, which includes the following steps:

- Incoming (feed) brine is heated in a waste heat recovery heat exchanger (preheater). The hot effluent brine and fresh water is used to heat the incoming brine.
- The brine enters the MVC unit at the top of the tube bundle where it is sprayed onto the outside of the tubes. The brine flows over the tubes as a thin film.
- Vapor is generated from the brine, which is sucked into the vapor compressor. The compressor has a dual function. It lowers the gas pressure, which promotes evaporation, and it compresses the vapor, which heats it (like a heat pump), and pushes the vapor into the side of the tube bundle.

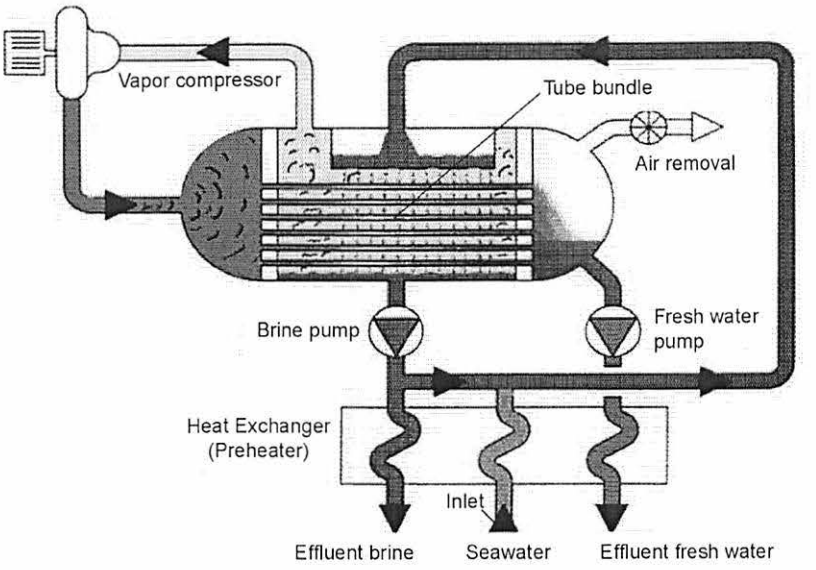

Fig. 1—A process flow diagram for mechanical vapor compression.

- The hot vapor exchanges heat with the cooler brine, thus causing the vapor to condense. The condensed fresh water is discharged.
- A stream of brine is discharged from the bottom of the brine sump and is pumped to the top of the tube bundle, together with incoming brine.
- A fraction of the circulating brine is discharged. Referred to as the drawdown, it is expressed as a fraction of the flow rate of the incoming feed brine. If the drawdown is 10%, then its salinity is 10 times that of the incoming brine. In this case, the recovery is 90%.

In any of the desalination processes, the flow rate of concentrated brine is a critical process parameter. The smaller the flow volume, the greater the concentration of waste brine. Scaling potential is the limiting factor. It is possible to further concentrate the brine into a high-solids sludge, which could be dried into a granular solid, and it is possible to produce salt products. However, the additional process steps add significantly to cost and are generally not practiced. Instead, the concentrated waste brine is disposed, and the economics of desalination must also include the cost of the waste disposal.

An important point that is often overlooked in discussions of MVC is that it does not involve distillation. Distillation requires nucleate boiling, in which vapor is generated on the surface of a heat exchange tube. Since vapor is such a poor conductor of heat, local tube surface temperature can be several degrees above the boiling point of the liquid. If the tube is immersed in the boiling liquid, then there is a hydraulic head that must be overcome to form the vapor, which further increases the temperature of boiling. The presence of vapor on the tube surface and the elevated temperatures create a scaling potential for all but the most pure liquids. Thus, distillation is not appropriate for fluids with high scaling and fouling tendency.

The MVC processes are more precisely referred to as evaporation

processes. Nucleate boiling is minimized to lower the scaling potential and allow desalination of highly contaminated feed streams. Vapor is generated by heating across a large surface area and with the application of partial vacuum so that the operating temperature is well below the boiling point of the liquid.

MVC has been applied in steamflood (for example, Oxy's Mukhaizna field in Oman) and steam-assisted gravity drainage projects in Alberta, Canada (Heins 2010).

In oilfield application, typical scale-forming components include the carbonates (calcium, magnesium, and iron carbonate) and silica. The carbonates are problematic since their solubility decreases with higher temperature. As carbon dioxide is vaporized out of the brine, the pH of the brine increases, which causes the carbonates to precipitate.

Other techniques used to prevent scale deposits include large surface area (and low thermal driving force), mist mats to prevent liquid carry-over into the vapor, the use of scale inhibitors, softening, ion exchange, pH adjustment, the use of seeded slurry, or the use of ball pigs. Equipment suppliers, such as Sasakura Engineering, provide scale prevention strategies optimized for oilfield brines. Scaling and fouling are also concerns in the auxiliary equipment, such as the heat exchangers. Companies, such as Alfa Laval, have developed large surface area vertical heat exchangers that reduce fouling.

Among various desalination technologies, mechanical vapor recompression (MVR, or alternately MVC) stands out as appropriate for HF application in a semipermanent or modular configuration.

Stages of Field Development Determine Water Treatment Technologies

To understand where and why MVC is appropriate for HF flowback treatment, the unique aspects of the economics of HF flowback water treatment must be considered.

In the June article, the stages of field development were discussed. A brief review emphasizes the reasons why evaporation technologies are being deployed for modular applications and not being deployed from mobile units.

The three stages of shale field development are defined below in terms of the type of water treating equipment deployed. It is important to make a distinction between the stages of field development because they are critical to the selection of water treatment technology.

The stages of field development and the appropriate water treatment technology are:

Stage 1: Remote and isolated well development—mobile water treating systems
Stage 2: Well clusters with some in-field drilling and completions—modular water treating systems
Stage 3: Extensive in-field development with infrastructure to transport water to and from a centralized treatment facility—centralized water treatment plants

Mobile Stage of Development

In the early stage of development of an unconventional field, a number of individual wells are drilled and completed. In the United States, mineral rights are owned by the land leaseholders. The initial wells in a region will typically be drilled in remote and isolated areas. If water recycling is carried out, the water treating equipment must be mobile. Such equipment is compact and placed on a flatbed truck.

The economics of this kind of water treatment are significantly different from those of industrial water treatment. Capital cost is typically a small fraction of the total cost. Most of the cost of water treatment is due to staff time related to transportation to site, setup of the equipment, operation of the equipment, and demobilization and return transportation. If the equipment is complex, additional operators and time are required to mobilize and set up the equipment, adding to the cost. If the capacity is low, additional time is required to process the water volumes. In general, the water treatment rate must be at least 5 to 7 bbl/min of water to justify the cost. Lower capacity will take too long, and the cost of on-site personnel will be too high. Thus, appropriate equipment in this stage of development is compact, simple, and relatively high capacity. Few technologies meet these criteria. Because MVC does not meet the criteria, there are few, if any, mobile MVC units operating successfully in HF flowback applications, to my knowledge.

Modular Stage of Development

As field development progresses, the leases are secured and the drilling campaign becomes more structured. Clusters of wells are drilled and completed. It is then possible for several adjacent wells to be developed in sequence or simultaneously, thus facilitating the use of a modular water treating system.

A daisy chain or hub-and-spoke type of water piping arrangement can be constructed to feed the water treatment unit and convey treated water to the wells that require it. Lay-flat hose, storage tanks, and pond liners are components of the water management tool kit. In this case, a semipermanent/modular water treatment facility is justified. The equipment is transported on a flatbed truck. It requires a few weeks to prepare the site and erect the equipment. When a few or several wells are involved, the construction cost of a modular treating system is justified.

Aquatech and Fountain Quail are among the companies that provide modular treating systems. Aquatech's modularized evaporation system is

designed for rapid installation. It is transported in modular units and erected with a minimum of field staff. Fountain Quail's system is an MVR evaporator packaged in self-contained skid-mounted units. It is capable of processing 20,000 BWPD and requires three operators. The capacity of the system must be integrated into the storage capacity of spent HF flowback water, the storage capacity of fresh water, the volume of water required for each HF, and the load recovery. The MVR system is being applied in several shale developments, including the Barnett and Marcellus.

Centralized Stage of Development

Later in field life, there may be many wells in relatively close proximity. Over time, the construction of a water conveyance network together with a centralized water treatment facility becomes justified, as is the current trend in the Marcellus Shale. It has also been successfully implemented in the Pinedale Anticline in southwestern Wyoming (Boschee 2012). The capital costs of the water transport system and the water treatment facility are the main cost drivers and contribute significantly to the overall cost. Because of plant automation and the ability to achieve relatively stable steady-state operation, the number of operators is minimized, compared with the previous stages of field development.

In the centralized application of desalination, MVC is not the only thermal desalination that could be applied. If low-grade steam is available, MSF or MED could be used for reduction of energy use. OGF

For Further Reading

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U.S. Department of Energy

The Water-Energy Nexus: Challenges and Opportunities

MARCH 2014

Table of Contents

Foreword

Water resource scarcity, variability, and uncertainty are becoming more prominent both domestically and internationally. Because energy and water are interdependent, the availability and predictability of water resources can directly affect energy systems. We cannot assume the future is like the past in terms of climate, technology, and the evolving decision landscape. These issues present an important set of challenges to address.

DOE can play a leadership role by bringing more science, technology, and analytical capability to the water-energy nexus, drawing on expertise in R&D programs and engaging the strengths of the national labs. Importantly, many issues surrounding the energy-water nexus affect assets owned and operated by private sector entities; developing public-private partnerships in this area can help leverage DOE capacity.

This Water-Energy Nexus: Challenges and Opportunities report builds on the Department's previous work in this area and provides a foundation for future action. This report is a next step towards a comprehensive response to the challenges before us. It presents extensive data and analysis to frame the opportunities. We hope it will also encourage others to engage in a dialogue and work together to address the challenges. Systematically and proactively addressing the water-energy nexus will help us all ensure a reliable and sustainable energy system.

Ernest J. Moniz

The highly fragmented federal authority and responsibilities in managing the country's water has contributed to the deterioration of water quality in many parts of the country, according to Gleick and Christian-Smith (2012). States' role in overseeing water rights allocation and permitting is equally important.

4.2.1 Water Rights and Permitting at the State Level

State-level water rights and permitting inform the decision making of any significant water user. Because water issues vary greatly by region, water resource policies—even policy frameworks—can vary greatly from state to state (Kimmell and Veil 2009). With respect to surface water, states generally follow some variation of two governance doctrines—the prior appropriation doctrine and the riparian doctrine. Groundwater governance is slightly more complex.

Table 4.1. Framework for Surface Water Law

Legal Framework in the West	Western States
Pure prior appropriation (9)	Alaska, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming
Prior appropriation, formerly riparian (6)	Kansas, North Dakota, South Dakota, Oregon, Texas, and Washington
Mixed riparian-appropriation (3)	California, Nebraska, and Oklahoma
Legal Framework in the East	***Eastern States***
Pure riparian (8)	New Hampshire, Vermont, Rhode Island, West Virginia, Ohio, Tennessee, Missouri, and Louisiana
Regulated riparian (21)	Alabama, Arkansas, Connecticut, Delaware, New York, New Jersey, Maryland, Illinois, Indiana, Iowa, Kentucky, Massachusetts, Pennsylvania, Mississippi, Minnesota, North Carolina, South Carolina, Georgia, Florida, Virginia, and Wisconsin

Source: Gleick and Christian-Smith 2012

Prior Appropriation Doctrine

The vast majority of the states in the arid Western climate follow the prior appropriation doctrine, under which water allocation is made on a first-come, first-serve basis and not linked to land ownership (Getches 2009). Because of relative water scarcity, water rights are linked to a specific basin and many states prohibit transfers between basins. Furthermore, users must prove that their rights are being exercised and put to a beneficial use or the rights can be deemed abandoned and terminated. In times of water shortage, those who last obtained a legal right to use the water must yield to the senior right holders, although if any of the latter's rights have not been exercised and put to a beneficial use, such a right could be deemed forfeited.

Riparian Doctrine

The riparian doctrine, also called the "common law" doctrine, is tied to land ownership and mostly recognized in Eastern states where water is relatively abundant. Owners of land bordering waterways have a right to use water that flows past the land for any reasonable purpose. In addition, all landowners have an equal right to use the water because no one possesses a greater right through prior use. Water rights may not be bought or sold and when water runs short, users have to "share the shortage in proportion to their rights" (Kimmell and Veil 2009). About half of the Eastern states have also adopted what is called regulated riparianism, or water-use permits for non-riparian landowners to acquire water rights for a limited period of "reasonable" use (Gleick and Christian-Smith 2012).

Figure 4.3. Water governance policies in the United States, by state.

Power plants in riparian areas have had fewer issues finding and using surface water for cooling, mainly due to relative water abundance. As a result, open-loop cooling, which requires higher water withdrawal but also enables greater generation efficiency, is more prevalent in these areas. As shown in Figure 4.4, power plants in riparian states withdraw more water on a per power plant and average basis than plants in prior appropriation states.[23] Power plants in areas generally following prior appropriation rules (Western states) do seem more prone to utilizing non-surface water or alternative sources of water (e.g., brackish water, seawater, reclaimed water, and groundwater) (see Figures 4.5 and 4.6).

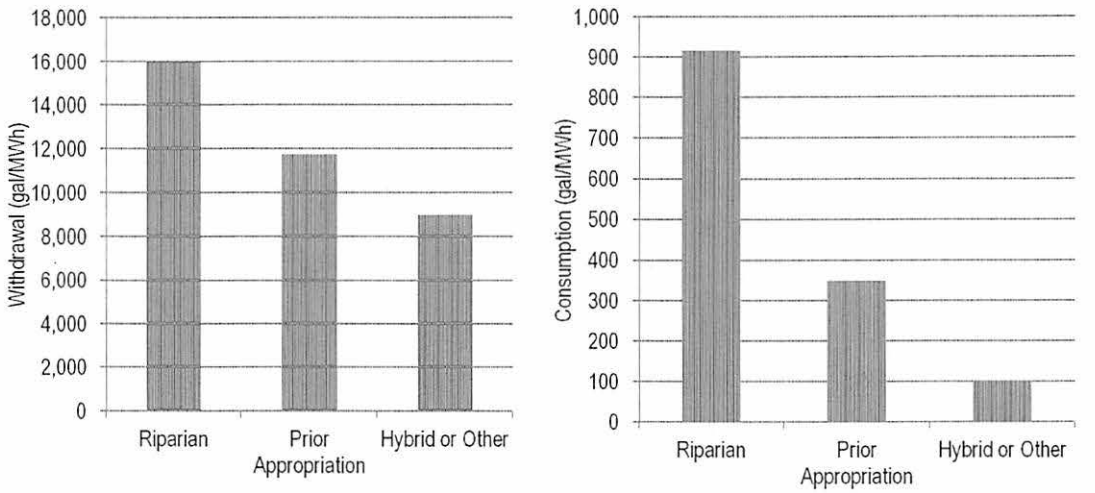

Figure 4.4. Average water withdrawal and consumption per power plant in areas of riparian, prior appropriation, and hybrid or other doctrine.
Data source: EIA Form 860, 923 (EIA 2013a, EIA 2013b)[24]

[23] This is based on both fresh and non-fresh water source use.

[24] The type of water governance information is from Gleick and Christian-Smith (2012). Riparian includes pure riparian and regulated riparian states. Prior Appropriation includes states that have been prior appropriation doctrine implementers all along (pure prior appropriation states) or currently prior appropriation states that are formerly riparian states (prior appropriation, formerly riparian states). Hybrid or Other includes states that implement both prior appropriation and riparian doctrines and states like Hawaii that has a completely different doctrine than other states.

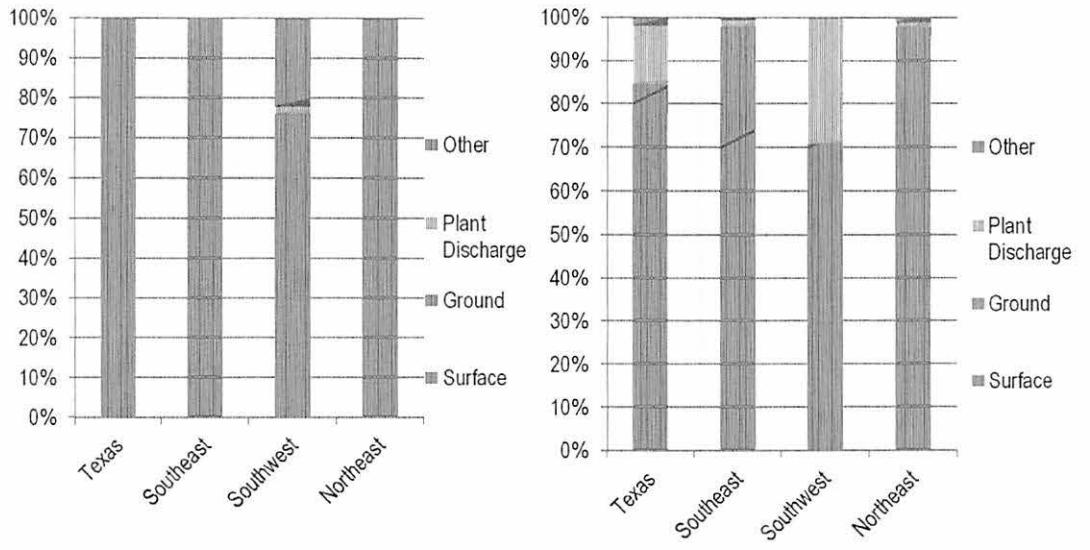

Figure 4.5. Percent of water withdrawn and consumed at thermoelectric power plants by water source in four regions of the United States.
Data source: EIA Form 860, 923 (EIA 2013a, EIA 2013b)[25]

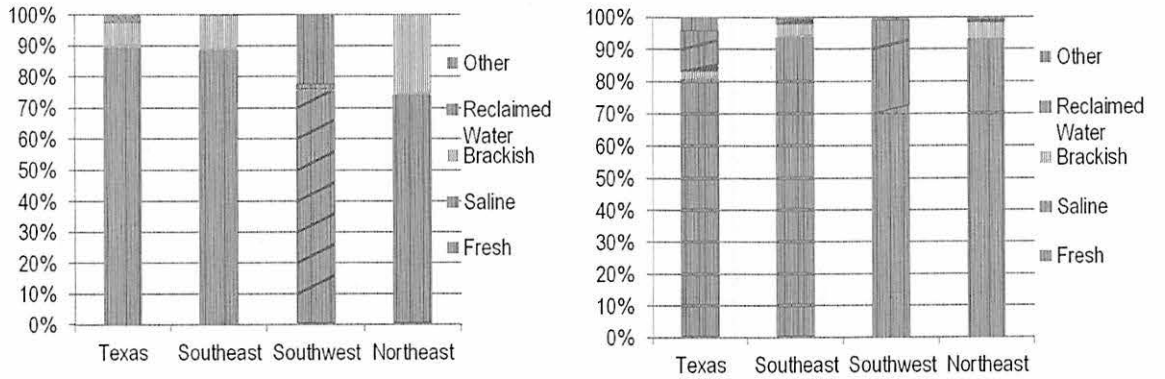

Figure 4.6. Percent of water withdrawn and consumed at thermoelectric power plants by water quality type in four regions of the United States.
Data source: EIA Form 860, 923 (EIA 2013a, EIA 2013b)

Some of the Western states administer a hybrid doctrine. In general, these are states that initially enforced a riparian rights system and continue to recognize riparian uses even though they later adopted a prior appropriations doctrine. Three western states—California, Nebraska, and Oklahoma—that follow a hybrid system allow riparian landowners under some circumstances to assert new uses superior to those with appropriative rights.

[25] Regional breakdowns are as follows: Southwest - California, Arizona, Utah, Nevada, Colorado, New Mexico, Wyoming; Southeast - Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee; Northeast (and Ohio) - Connecticut, Delaware, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Vermont.

Exhibit 2

SCIENTIFIC AMERICAN™

ENVIRONMENT

Fracking Can Contaminate Drinking Water

It took nearly a decade, but former EPA scientist Dominic DiGiulio has proved that fracking has polluted groundwater in Wyoming

By Gayathri Vaidyanathan, ClimateWire on April 4, 2016

Credit: Education Images / Contributor via Getty Images

Former EPA scientist Dominic DiGiulio never gave up.

Eight years ago, people in Pavillion, Wyo., living in the middle of a natural gas

basin, complained of a bad taste and smell in their drinking water. U.S. EPA launched an inquiry, helmed by DiGiulio, and preliminary testing suggested that the groundwater contained toxic chemicals.

Then, in 2013, the agency suddenly transferred the investigation to state regulators without publishing a final report.

Now, DiGiulio has done it for them.

He published a comprehensive, peer-reviewed study last week in *Environmental Science and Technology* that suggests that people's water wells in Pavillion were contaminated with fracking wastes that are typically stored in unlined pits dug into the ground.

The study also suggests that the entire groundwater resource in the Wind River Basin is contaminated with chemicals linked to hydraulic fracturing, or fracking.

This production technique, which involves cracking shale rock deep underground to extract oil and gas, is popular in the United States. It's also controversial. There are thousands of wells across the American West and in California that are vulnerable to the kind of threat documented in the study, DiGiulio said. He is now a research scholar at Stanford University.

"We showed that groundwater contamination occurred as a result of hydraulic fracturing," DiGiulio said in an interview. "It contaminated the Wind River formation."

The findings underscore the tension at the heart of the Obama administration's climate change policy, which is based on replacing many coal-fired power plants with facilities that burn cleaner natural gas.

That reliance on natural gas has sometimes blinded agencies to local pollution and health impacts associated with the resource, said Rob Jackson, an earth scientist at Stanford and co-author of the study. In 2015, EPA said in a controversial draft study that hydraulic fracturing has not had "widespread, systemic impacts on drinking water resources in the United States" (*Greenwire*, June 4, 2015).

"The national office of EPA has tended to downplay concerns of their own investigators, in part because the Obama administration has promoted natural gas," Jackson said. "Natural gas is here to stay. It behooves us to make it as safe and environmentally friendly as possible."

EPA spokeswoman Julia Valentine said the agency hasn't yet finalized its assessment that natural gas has no "widespread, systemic impacts." As part of that process, the agency will evaluate all recent research, including DiGiulio's study, she said.

Encana Corp., the company that operated in the Pavillion basin, said repeated testing has shown people's water wells are safe for consumption.

"After numerous rounds of testing by both the state of Wyoming and EPA, there is no evidence that the water quality in domestic wells in the Pavillion Field has changed as a result of oil and gas operations; no oil and gas constituents were found to exceed drinking water standards in any samples taken," said Doug Hock, an Encana spokesman.

LABS CAN'T SEE FRACKING CHEMICALS

Water testing began in 2009 when the local EPA office responded to complaints

from residents. EPA headquarters, and DiGiulio, got involved in January 2010.

"Conducting a groundwater investigation related to fracking is extremely complicated," DiGiulio said. "It is difficult because a lot of the compounds used for hydraulic fracturing are not commonly analyzed for in commercial labs."

These labs were originally set up for the Superfund program, under which EPA cleans up the most contaminated sites in the nation. They are great at detecting chemicals found at Superfund sites but not as good at detecting chemicals used in fracking, DiGiulio said.

"You have some of these very water-soluble exotic compounds in hydraulic fracturing, which were not amenable to routine lab-type analysis," he said.

One such chemical was methanol. The simplest alcohol, it can trigger permanent nerve damage and blindness in humans when consumed in sufficient quantities. It was used in fracking in Pavillion as workers pumped thousands of gallons of water and chemicals at high pressure into the wells they were drilling. About 10 percent of the mixture contained methanol, DiGiulio said.

So the presence of methanol in the Pavillion aquifer would indicate that fracking fluid may have contaminated it. But methanol degrades rapidly and is reduced within days to trace amounts. Commercial labs did not have the protocol to detect such small traces, so DiGiulio and his colleagues devised new procedures, using high-performance liquid chromatography, to detect it. They devised techniques for detecting other chemicals, as well.

By then, Pavillion was roiling in controversy as EPA and residents collided with industry. EPA had drilled two monitoring wells, MW01 and MW02, in 2011, and its testing had found benzene, diesel and other toxic chemicals. But these

results were contested by oil and gas industry representatives, who criticized EPA's sampling techniques (*EnergyWire*, Oct. 12, 2012). They pointed to a technical disagreement between EPA and the U.S. Geological Survey on the best methods to cast doubt on EPA's overall findings.

EPA realized it needed a consensus on its water testing methodology. In February 2012, it assembled a technical team from the USGS, Wyoming state regulators and tribal representatives from the Wind River Indian Reservation. They retested the monitoring wells in April 2012.

This time, they also tested for methanol. But EPA never released those results to the public. In 2013, the agency backed out of its investigation in Pavillion, handing it over to state regulators, who moved forward using a $1.5 million grant from Encana (*EnergyWire*, June 21, 2013). DiGiulio said the decision had come from EPA's senior management.

METHANOL, DIESEL AND SALT

Industry representatives repeatedly pointed out that EPA had not published a peer-reviewed study on its findings.

"If the EPA had any confidence in its draft report, which has been intensely criticized by state regulators and other federal agencies, it would proceed with the peer review process," Steve Everley, a spokesman for Energy in Depth, an industry group, said at the time. "But it's not, which says pretty clearly that the agency is finally acknowledging the severity of those flaws and leaning once again on the expertise of state regulators."

In December 2015, state regulators published a draft of their findings. It stated that fracking had not contributed to pollution in Pavillion, according to the *Casper Star Tribune*. The report said the groundwater is generally suitable

for people to use.

When DiGiulio retired from EPA in 2014, he trained his sights on Pavillion. He felt he had to finish his work.

"EPA had basically handed the case over and a peer-reviewed document was never finalized," he said. "If it is not in the peer-reviewed literature, then it presents a problem with credibility in terms of findings. It is important that the work be seen by other scientists and enter the peer review realm so that other scientists will have access to virtually everything."

Since 2012, a trove of new data had accumulated from USGS, EPA and state regulators. He obtained EPA's methanol testing results through a Freedom of Information Act request and downloaded the rest of the information from the Wyoming oil and gas regulator's website. All of it was publicly available, waiting for the right person to spend a year crunching the information.

The end result: a peer-reviewed study that reaffirms EPA's findings that there was something suspicious going on in Pavillion. More research is needed.

The sampling wells contained methanol. They also contained high levels of diesel compounds, suggesting they may have been contaminated by open pits where operators had stored chemicals, DiGiulio said.

The deep groundwater in the region contained high levels of salt and anomalous ions that are found in fracking fluid, DiGiulio said. The chemical composition suggests that fracking fluids may have migrated directly into the aquifer through fractures, he said.

Encana had drilled shallow wells at Pavillion, at depths of less than 2,000 feet and within reach of the aquifer zone, said Jackson of Stanford University.

"The shallow hydraulic fracturing is a potential problem because you don't need a problem with well integrity to have chemicals migrate into drinking water," he said.

The study also shows that there is a strong upward flow of groundwater in the basin, which means contamination that is deep underground could migrate closer to the surface over time.

"Right now, we are saying the data suggests impacts, which is a different statement than a definitive impact," DiGiulio said. "We are saying the dots need to be connected here, monitoring wells need to be installed."

SHALLOW WELLS ARE PREVALENT

EPA came to the same conclusion in a blistering response last week to Wyoming's draft findings.

"Many of our recommendations suggest that important information gaps be filled to better support conclusions drawn in the report, and that uncertainties and data gaps be discussed in the report," said Valentine, the EPA spokeswoman.

The state had tested people's water wells and detected 19 concerning chemicals. But regulators had concluded that only two chemicals exceeded safe limits and the water could be used for domestic purposes. EPA disagreed. Nearly half the 19 chemicals are unstudied, and scientists do not know the safe level of exposure, EPA stated.

Keith Guille, spokesman for Wyoming's Department of Environmental Quality,

declined to comment on DiGiulio's study and on EPA's response to the state's draft report. The state is finalizing its findings and has its eyes set on the future, he said.

"We are not done yet," Guille said.

Energy in Depth, the industry group that had earlier criticized EPA for not publishing a peer-reviewed study, said that DiGiulio's study is "a rehash of EPA's old, discredited data by the very researcher who wrote EPA's original report."

Jackson stressed that the contamination seen at Pavillion could occur in other states where, according to a study published last year in *Environmental Science & Technology* on which he was the lead author, fracking sometimes occurs at shallow depths. That includes the Rocky Mountain region, New Mexico, Colorado, Utah, Montana and California. At present, no state has restrictions on how shallowly a company can frack, he said.

"Shallow hydraulic fracturing is surprisingly common, especially in the western U.S.," Jackson said. "Here in California, half of the wells are fracked shallower than about 2,000 feet."

Given the threat, fracking deserves much greater scrutiny than it has so far received from the Obama administration, said Hugh MacMillan, a scientist with the environmental group Food and Water Watch.

"Communities have never argued that every well goes bad; they've argued that when you drill and [are] fracking thousands, too many go bad," he said. "For those living on groundwater, it becomes a matter of luck, and that's not right, because over years, more and more people's luck runs out."

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ABOUT THE AUTHOR(S)

Exhibit 3

ENVIRONMENTAL Science & Technology

Article

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Impact to Underground Sources of Drinking Water and Domestic Wells from Production Well Stimulation and Completion Practices in the Pavillion, Wyoming, Field

Dominic C. DiGiulio*,[†] and Robert B. Jackson[†,‡,§]

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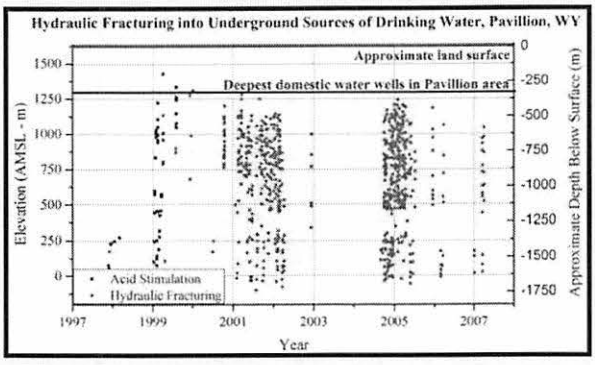
Supporting Information

ABSTRACT: A comprehensive analysis of all publicly available data and reports was conducted to evaluate impact to Underground Sources of Drinking Water (USDWs) as a result of acid stimulation and hydraulic fracturing in the Pavillion, WY, Field. Although injection of stimulation fluids into USDWs in the Pavillion Field was documented by EPA, potential impact to USDWs at the depths of stimulation as a result of this activity was not previously evaluated. Concentrations of major ions in produced water samples outside expected levels in the Wind River Formation, leakoff of stimulation fluids into formation media, and likely loss of zonal isolation during stimulation at several production wells, indicates that impact to USDWs has occurred. Detection of organic compounds used for well stimulation in samples from two monitoring wells installed by EPA, plus anomalies in major ion concentrations in water from one of these monitoring wells, provide additional evidence of impact to USDWs and indicate upward solute migration to depths of current groundwater use. Detections of diesel range organics and other organic compounds in domestic wells <600 m from unlined pits used prior to the mid-1990s to dispose diesel-fuel based drilling mud and production fluids suggest impact to domestic wells as a result of legacy pit disposal practices.



INTRODUCTION

Between 2005 and 2013, natural gas production in the U.S. increased by 35% largely due to unconventional gas production in shale and tight gas formations.[1] Between 2013 and 2040, natural gas production is expected to increase another 45% with production from tight gas formations in particular increasing from 4.4 to 7.0 trillion cubic feet (59%) primarily in the Gulf Coast and Dakotas/Rocky Mountain regions.[1] Tight gas formations already account for 26% of total natural gas production in the United States today.[2]

In the U.S. Code of Federal Regulations (CFR), there are two federal regulations for protecting groundwater resources for present and future use relevant to oil and gas extraction – "Underground Source of Drinking Water" (USDW) and "usable water." A USDW is defined in 40 CFR 144.3 in requirements for the Underground Injection Control program promulgated under Part C of the Safe Drinking Water Act (SDWA) as "an aquifer or its portion: (a)(1) Which supplies any public water system; or (2) Which contains a sufficient quantity of ground water to supply a public water system; and (i) Currently supplies drinking water for human consumption; or (ii) Contains fewer than 10 000 mg/L total dissolved solids; and (b) Which is not an exempted aquifer." With the exception of use of diesel fuels, the Energy Policy Act of 2005 ("EPAct") exempted hydraulic fracturing from the SDWA, thereby allowing injection of stimulation fluids into USDWs. However, under Section 1431 of the SDWA, the Administrator of EPA may take action if impact to a USDW "may present an imminent and substantial endangerment to the health of persons."

The term "usable water" applies to lands containing federal or tribal mineral rights regulated by the Bureau of Land Management (BLM). This term is applicable to the Pavillion Field because tribal mineral rights are associated with more than half of production wells there. In the BLM Onshore Oil and Gas Order No. 2, usable water is defined as water containing ≤10 000 mg/L total dissolved solids (TDS) – a definition maintained in the March 2015 BLM rule on hydraulic fracturing (43 CFR 3160). In 43 CFR 3160, BLM retained a threshold for groundwater protection at 10 000 mg/L stating, "Given the increasing scarcity and technological improvements in water treatment, it is not unreasonable to assume aquifers with TDS levels above 5000 ppm are usable now or will be usable in the future." However, on September 30, 2015, the U.S. District Court for Wyoming granted a

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preliminary injunction filed by the States of Wyoming and Colorado to stop implementation of the BLM rule based on the assertion that the EPAct precludes BLM rulemaking.[3]

In 2004, EPA[4] documented the widespread use of hydraulic fracturing in USDWs colocated in formations used for coal bed methane (CBM) recovery. EPA[4] acknowledged likely groundwater contamination as a result of this activity but stated that the attenuation factors of dilution, adsorption, and biodegradation would reduce contaminant concentrations to safe levels prior to reaching domestic wells that are generally shallower than production wells. Thus, EPA[4] distinguished impact to USDWs from impact to domestic wells. In 2014, while defining the chemical abstract numbers of fluids designated as diesel fuels, EPA revised its position and stated that injecting stimulation fluids directly into USDWs "presents an immediate risk to public health because it can directly degrade groundwater, especially if the injected fluids do not benefit from any natural attenuation from contact with soil, as they might during movement through an aquifer or separating stratum."[5]

The Pavillion Field (Figure 1) is located east of the Town of Pavillion in Fremont County, WY, in the west-central portion

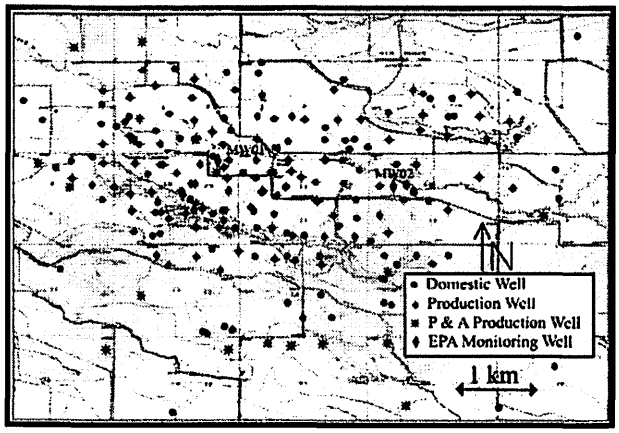

Figure 1. Central portion of the Pavillion Field illustrating locations of domestic water wells, production wells, plugged and abandoned (P&A) wells, and EPA monitoring wells (labeled). The entire Field, with labels for production and domestic wells and approximate locations of unlined pits, is illustrated in Figure SI A5. The geographic area in which the Field is located is illustrated in Figure SI A1.

of the Wind River Basin (WRB) (Figure SI A1). The field consists of 181 production wells including plugged and abandoned wells. Conventional and unconventional (tight gas) hydrocarbon production in the Pavillion Field is primarily natural gas from sandstone units in the Paleocene Fort Union and overlying Early Eocene Wind River Formations. However, oil has also been produced from production wells in these formations, primarily in the western portion of the field close to the suspected location of a fault (SI Sections A.1 and A.2).

In response to complaints regarding foul taste and odor in water from domestic wells within the Pavillion Field, EPA initiated a groundwater investigation in September 2008 under the Comprehensive Environmental Response and Liability Act (CERCLA).[6] This investigation remains the only one in which CERCLA has been invoked to investigate potential groundwater contamination due to hydraulic fracturing.[7] Under CERCLA, impact to both groundwater resources and domestic wells is evaluated, in contrast to limiting evaluation to impact to domestic wells as is common in oil- and gas-field-based investigations.

EPA conducted two domestic well sampling events in March 2009 (Phase I)[6] and January 2010 (Phase II).[8] Between June and September 2010, EPA installed two monitoring wells, MW01 and MW02, using mud rotary drilling with screened intervals at 233–239 m and 296–302 m below ground surface (bgs), respectively. These monitoring wells were installed to evaluate potential upward solute transport of compounds associated with well stimulation to maximum depths of current groundwater use (~322 m).[9] EPA sampled MW01 and MW02 during the Phase III (October 2010) and Phase IV (April 2011) sampling events.

In December 2011, EPA[9] released a draft report summarizing results of the Phase I–IV sampling events. EPA documented groundwater contamination in surficial Quaternary unconsolidated alluvium attributable to numerous unlined pits used for disposal of diesel-oil-based (invert) drilling mud and production fluids including flowback, condensate, and produced water prior to the mid-1990s. EPA[9] also documented injection of stimulation fluids into USDWs and concluded that inorganic and organic geochemical anomalies at MW01 and MW02 appeared to be attributable to production well stimulation. EPA received numerous comments both challenging and supporting its findings in the draft EPA report.[10−37] We reviewed and considered these comments when preparing this manuscript.

A substantial amount of data has been collected since publication of the 2011 draft EPA report, adding to an already extensive data set. In April 2012 (Phase V) the EPA[38,39] split samples with the U.S. Geological Survey at MW01[40,41] and MW02.[42] In 2014, the Wyoming Oil and Gas Conservation Commission (WOGCC) released a report on production well integrity[43] and in 2015 released a report on surface pits.[44] In December 2015, the Wyoming Department of Environmental Quality (WDEQ) released a report on sample results of a subset of domestic wells previously sampled by EPA.[45]

We conducted a comprehensive analysis of all publicly available online data and reports, to evaluate impact to USDWs and usable water as a result of acid stimulation and hydraulic fracturing. Although injection of stimulation fluids into USDWs in the Pavillion Field was previously documented by EPA,[9] the potential impact to USDWs at depths of stimulation was not assessed. We evaluate potential upward migration of contaminants to depths of current groundwater use using data from MW01 and MW02. We also evaluate potential impact to domestic wells as a result of legacy disposal of production and drilling fluids in unlined pits.

■ MATERIALS AND METHODS

Sources of EPA reports, versions of the Quality Assurance Project Plan (QAPP), and Audits of Data Quality (ADQs) are provided in Table SI H1. Sources of analytical data and associated information on quality assurance and control are summarized in Table SI H2. ADQs were conducted by EPA for Phase I–IV investigations to verify the quality of analytical data and consistency with requirements specified in the QAPP.

In response to a comprehensive information request by EPA regarding oil and gas production and disposal activities in the Pavillion Field, the field operator, Encana Oil & Gas (U.S.) Inc., provided Material Safety and Data Sheets (MSDSs) of products used for well stimulation to EPA[46] (Table SI C3). During the Phase V sampling event, EPA developed a gas chromatography-

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Table 1. Summary of Major Ion Concentrations of Domestic Wells in the Wind River Indian Reservation (WRIR), Fremont County, WY, and within and around the Pavillion Field

	WRIR[a]			Fremont County[b]			within and around Pavillion Field[c]		
parameter (mg/L)	n	median	range	n	median	range	n	median	range
TDS	154	490	211–5110	77	1030	248–5100	65	925[†]	229[†]–4901[†]
Ca	149	10	1–486	77	45	1.7–380	48	50.8	3.32–452
Mg	128	2.2	0.1–195	77	8.2	0.095–99	45	5.32	0.024–147
Na	153	150	5–1500	77	285	4.5–1500	72	260	38.0–1290
K	149	2.0	0.2–30	77	2.45	0.1–30	43	1.36	0.179–10.5
SO_4	154	201	2–3250	77	510	12–3300	88	590	29.0–3640
Cl	154	14	2–466	77	20	3–420	48	21.1	2.60–77.6
F	154	0.7	0.1–8.8	76	0.9	0.2–4.9	46	0.88	0.20–4.1

[a]With the exception of potassium, from Daddow.[48] Information on potassium extracted from Daddow.[53] [b]From Plafcan et al.[51] There is overlap of 19 sample results with Daddow.[48,53] [c]Major ion concentrations in domestic wells[6,8,9,39,45,52] summarized in Table SI B2. Mean values used for domestic wells sampled more than once. [†]Number of sample results. [†]TDS for EPA data estimated using linear regression equation from Daddow[48] TDS (mg/L) = 0.785 × specific conductance (μs/cm) − 130 (n = 151, r^2 = 0.979)

flame ionization-based approach to obtain a lower reporting limit (50 μg/L) for methanol compared to commercial laboratory analysis (5000 μg/L). We obtained this data set as the result of a Freedom of Information Act request to EPA.[47]

We reviewed over 1000 publicly available well completion reports, sundry notices, drilling reports, and cement bond and variable density logs accessed from the WOGCC Internet site using API search numbers to determine dates of well completion, depths of surface casing, top of original or primary cement, and numbers and depths of cement squeeze jobs (injection of cement through perforated production casing to remediate or extend existing primary cement). Similarly, we reviewed online information to document well stimulation practices summarized in Tables SI C1 and SI C2.

The field operator analyzed major ions in produced water samples at 42 production wells in 2007 (Table SI D1). EPA collected produced water samples at four production wells in 2010 and analyzed them for organic compounds (Table SI D3).[8] The field operator also conducted mechanical integrity and bradenhead (annular space between production and surface casing) testing between November 2011 and December 2012. In addition to sustained casing pressure at many production wells during that period (Table SI D2), water flowed through the bradenhead valve to the surface at four production wells (SI Section D.3). Aqueous analysis of bradenhead water samples by the field operator was limited to major ions (Table SI D1). Production well string and brandenhead gas samples were collected for benzene, toluene, ethylbenzene, xylenes (BTEX) and light hydrocarbons (Table SI D2).

To evaluate the effect of purging volume on water quality, EPA collected ten samples through time (Table SI 3a) during the Phase V sampling event at MW01. Based on EPA's purging procedure, we developed a model incorporating plug flow in casing and mixing in the screened interval (SI Section E.3, Figure SI E4). Our simulations indicated that virtually all (99.997%) of water entering the sampling train at the surface at the time of the first sample collection at MW01 originated directly from the surrounding formation (i.e., no stagnant casing water) (Figure SI E6). MW02 was a low flow monitoring well. The cause of low flow is unknown but could be due to several factors, including low relative aqueous permeability due to gas flow or insufficient removal of drilling mud during well development. During the Phase V sampling event, MW02 was repeatedly purged over a 6-day period to ensure that sampled water originated from the surrounding formation (SI Section E.2, Figure SI E5). A discussion of monitoring well construction, including schematics for MW01 (Figure SI E1) and MW02 (Figure SI E2), is provided in SI Section E.1.

RESULTS AND DISCUSSION

Groundwater Resources in the Pavillion Area. The Wind River and Fort Union Formations are variably saturated fluvial depositional systems characterized by shale and fine-, medium-, and coarse-grained sandstone sequences. Lithology is highly variable and difficult to correlate from borehole data. No laterally continuous confining layers of shale exist below the maximum depth of groundwater use to retard upward solute migration. A comprehensive review of regional and local geology, including a lithologic cross-section in the vicinity of MW01 and MW02 (Figure SI A4), is provided in SI Sections A.1–A.6.

Domestic wells in the Pavillion area draw water from the Wind River Formation—a major aquifer system in the WRB.[48,49] From the surface to approximately 30 m bgs, groundwater exists under unconfined conditions.[50] Below this depth, groundwater is present in lenticular, discontinuous, confined sandstone units with water levels above hydrostatic pressure, and in some instances flowing to the surface,[48,50,51] indicating the presence of strong localized upward gradients. The majority of documented domestic well completions in Fremont County[51] and five municipal wells in the Town of Pavillion[52] west of the Field are completed in the Wind River Formation.

Flow to the surface was observed in a domestic well during the Phase II sampling event,[6] and as mentioned, at four production wells during bradenhead testing in 2012. While the overall vertical groundwater gradient in the Pavillion Field is downward, these observations indicate that localized upward hydraulic gradients exist in the Field, which is relevant to potential upward solute migration from depths of production well stimulation. The deepest domestic wells in the Pavillion Field and immediate surrounding area are 229 and 322 m bgs, respectively (Table SI B1). Two municipal wells were proposed, but not drilled, in the Pavillion Field as replacement water for domestic wells at depths of 305 m bgs,[52] similar to the depth of MW02 installed by EPA.

Major ion concentrations of domestic wells in the Pavillion field (summarized in Table SI B2) are typical of the Wind River Indian Reservation (WRIR),[48] west of the Pavillion Field, and

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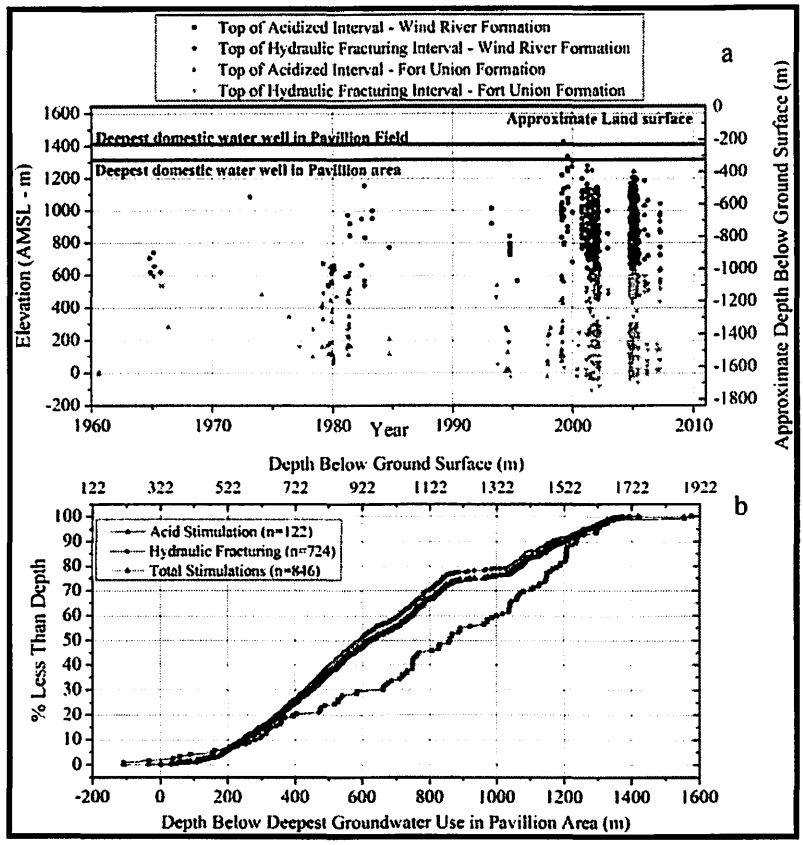

Figure 2. (a) Elevation in absolute mean seal level (AMSL) and approximate depth below ground surface of documented acid and hydraulic fracturing stimulation stages. (b) Cumulative distribution of stimulation stages as a function of depth below deepest groundwater use in the Pavillion Field. Documentation of stimulation stages is absent at a number of production wells so that numbers presented here are a lower bound.

in Fremont County,[51] where the Pavillion Field lies, (Table 1) with TDS levels <5000 mg/L. TDS concentrations in the Wind River Formation appear to vary with lithology rather than depth (white coarse sandstone associated with lower TDS values).[52] There are no apparent trends in TDS levels with depth from data sets from the WRIR,[53] Fremont County,[51] and domestic wells in and around the Pavillion Field.

The Fort Union Formation is not used for water supply in the Pavillion area. However, the formation is highly productive and permeable where fractured[49] with TDS values from 1000 to 5000 mg/L.[54] An aquifer exemption was obtained to enable disposal of produced water in a disposal well perforated in the Fort Union Formation[55] at a location 5.6 km northwest of the Pavillion Field. Use of this well was suspended due to failure of well casing. Thus, the Wind River and Fort Union Formations in the Pavillion Field meet the regulatory definition of USDWs, as explicitly stated by EPA,[9,55] and of usable water as defined by the BLM.

Well Stimulation Depths, Treatments, and Chemical Additives. Exploration of oil and gas in the Pavillion Field commenced in August 1953 with increasingly shallow stimulations through time (Figure 2). The first acid stimulation and hydraulic fracturing stages (injection over one or more discrete intervals) occurred in June 1960 and October 1964, respectively. Acid stimulation ceased in 2001. To date, the last stimulation stage (hydraulic fracturing) occurred in April 2007. Most production wells were completed and stimulated during several periods of increased activity, especially after 1997 (Figure 2a). Acid stimulation and hydraulic fracturing occurred as shallowly as 213 and 322 m bgs, respectively, at depths comparable to deepest domestic groundwater use in the area (Figure 2a). Approximately 10% of stimulation stages were <250 m of deepest domestic groundwater use whereas approximately 50% of stimulation stages were <600 m and 80% were <1 km of deepest domestic groundwater use (Figure 2b).

Surface casing of production wells—the primary line of defense to protect groundwater during conventional and unconventional oil and gas extraction—is relatively shallow in the Pavillion field with a median depth of 185 m bgs (i.e., shallower than the deepest groundwater use) and range of 100–706 m bgs (Figure SI C1). There is no primary cement below surface casing, often for hundreds of meters, for 55 of 106 (~52%) production wells for which cement bond logs are available (Table SI C1, Figure SI CI). There is currently no requirement in Wyoming for placement of primary cement to surface casing or to ground surface.[45]

Instantaneous shut in pressures (ISIP) (wellhead gauge pressure immediately following fracture treatment) were similar for acid stimulation and hydraulic fracturing (Figure SI C2) suggesting that both matrix acidizing and acid fracturing (no proppants used[56]) occurred in the Pavillion Field. Acidizing solutions used in the Pavillion Field typically consisted of a 7.5% or 15% hydrochloric acid solution plus additives described in well completion reports as inhibitors, surfactants, diverters, iron sequestration agents, mutual solvents, and clay stabilizers.

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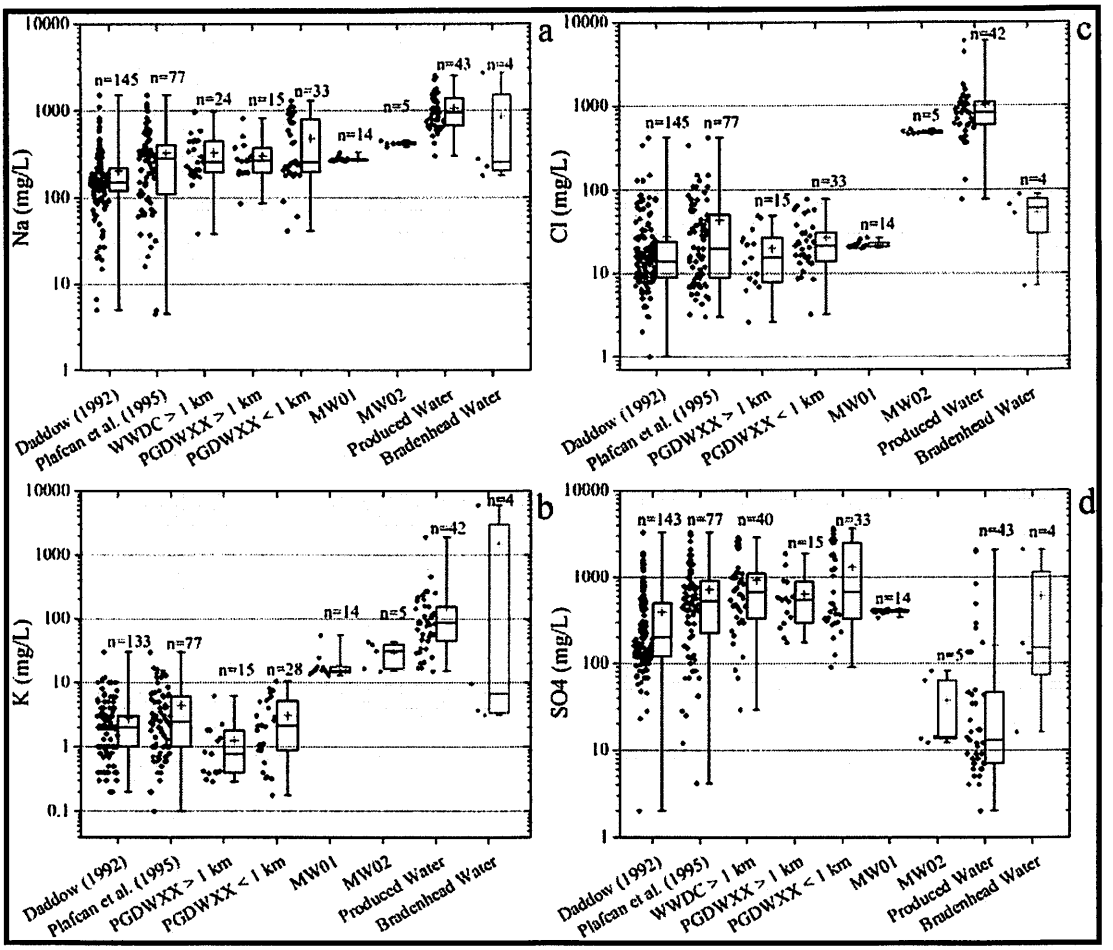

Figure 3. Box and whisker plots of minimum and maximum, quartiles, median (line in boxes), mean (crosses in boxes) of (a) Na, (b) K, (c) Cl, (d) SO_4 for domestic wells inventoried by Daddow[48,53] and Plafcan[51] in the Wind River Indian Reservation and Fremont County, respectively, sampled by EPA[6,8,9,39] and WDEQ[45] (PGDWXX series) greater than and less than 1 km from a production well, Wyoming Water Development Commission[52] (WWDC series) greater than 1 km from a production well, EPA monitoring wells[9,39] (Tables SI E2b, SI E3b), and produced water and bradenhead water samples (Table SI D1). Domestic wells sampled more than once, including data from Daddow,[53] are represented with a mean value. Fourteen measurements in Daddow[53] < 1 mg/L for potassium are not illustrated. Data points at MW01 and MW02 are samples collected during Phase III, IV, and V sample events.

Acidizing solutions were often flushed with a 2, 4, or 6% potassium chloride (KCl) solution. Pad acid, to initiate fractures, contained 10−50% heavy aromatic petroleum naptha. Corrosion inhibitors contained isopropanol and propargyl alcohol. Clay stabilizers contained methanol. Musol solvents used for acid stimulation consisted of 60−100% 2-butoxyethanol and 10−30% oxylated alcohol (Table SI C3).

Prior to 1999, "salt solutions" were commonly used for hydraulic fracturing. After 1999, a 6% KCl solution was used extensively for hydraulic fracturing often combined with CO_2 foam, with subsequent flushing using a 6% KCl solution. There were reported losses of KCl solutions during stimulation (e.g., at Tribal Pavillion 12−13 "lost thousands of bbls KCl"). Undiluted diesel fuel was used for hydraulic fracturing at three production wells before 1985. From the mid-1970s through 2007, there was widespread use of gelled fracture fluids (gelled water, linear gel, and cross-linked gel). Diesel fuel #2 was used for liquid gel concentrates (Table SI C3). Ammonium chloride, potassium hydroxide, potassium metaborate, and a zirconium complex were used as cross-linkers.

Gelled fracture fluids were used extensively with CO_2 foam (Table SI C4). Between 2001 and 2005, "WF-125" was used with CO_2 foam (often with a 6% KCl solution) for hydraulic fracturing (Table SI C5). A stimulation report (one of only three publicly available throughout the operating history of the Field) and MSDSs indicate that WF-125 contained diesel fuel #2, 2-butoxyethanol, isopropanol, ethoxylated linear alcohols, ethanol, and methanol. During 2001, WF-125 and unidentified product mixtures were used with a 6% KCl and a 10% methanol solution and CO_2 foam for hydraulic fracturing followed with a 6% KCl and 10% methanol solution flush. Other WF-series compound mixtures of unknown composition were also used with CO_2 foam and in some cases with N_2 gas. Methanol, isopropanol, glycols, and 2-butoxyethanol were used in foaming agents (Table SI C3). Ethoxylated linear alcohols, isopropanol, methanol, 2-butoxyethanol, heavy aromatic petroleum naptha, naphthalene, and 1,2,4-trimethylbenzene were used in surfactants (Table SI C3). Slickwater (commonly with a 6% KCl solution) was used for hydraulic fracturing with and without CO_2 foam in 2004 and 2005, respectively (Table SI C6).

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At least 41.5 million liters (or ~11 million gallons) of fluid was used for well stimulation in the Pavillion Field (calculated from Table SI C2). Given lack of information at numerous production wells, this is an underestimate of actual cumulative stimulation volume. The cumulative volume of well stimulation in closely spaced vertical wells in the Pavillion Field is characteristic of high volume hydraulic fracturing in shale units.[57] In evaluating solute attenuation in USDWs, EPA[4] did not consider cumulative volumes of injection of well stimulation fluids in closely spaced vertical production wells common to CBM and tight gas production.

Evaluation of Impact to USDWs and Usable Water. In the Pavillion Field, impact to USDWs and usable waters depends upon the advective-dispersive solute transport of compounds (or their degradation products) used for well stimulation to water-bearing units (sandstone units at or near water saturation). Water-bearing units exist throughout the Wind River and Fort Union Formations in the Pavillion Field. For instance, production well Unit 41X-10 was recommended for plugging and abandonment in 1980 because of "problems with water production and casing failure." In 1980, drilling logs at Tribal Pavillion 14–2 stated "Hit water flow while drilling at 4105–4109 ft" bgs. The magnitude of produced water production in the Pavillion Field is variable with some wells having high produced water production (e.g., 17.9 million liters ~4.7 million gallons at Tribal Pavillion 23–10 from July 2000 to present) (Table SI C2). In some cases, stimulation fluids were injected directly into water bearing units. For instance, at Tribal Pavillion 14–1, a cast iron bridge plug was used to stop water production in 1993 from an interval where hydraulic fracturing occurred using undiluted diesel fuel in 1964 (Table SI C2).

The migration of stimulation fluid to water-bearing sandstone units in the Pavillion Field also likely occurred during fracture propagation and subsequent leakoff (loss of fluid into a formation in or near the target stratum). Leakoff increases in complex fracture networks as a result of lithologic variation over short distances and contact of stimulation fluid with permeable strata[58−61] expected during hydraulic fracturing in fluvial depositional environments of the Wind River and Fort Union Formations. Leakoff can remove much or most of the fracturing fluid even for moderate sized induced fractures.[58,59] Maximum ISIP values for acid stimulation and hydraulic fracturing were 19.5 and 40.1 MPa (Figure SI C2), respectively, equivalent to ~2000 and ~4100 m of hydraulic head. Pressure buildup during hydraulic fracturing far in excess of drawdown expected during produced water extraction makes full recovery of stimulation fluids unlikely.[4,62]

The migration of stimulation fluids to water-bearing units also likely occurred as a result of loss of zonal isolation during well stimulation (SI Section D.1). Casing failure occurred at five production wells following well stimulation. Cement squeezes were performed above primary cement often days after hydraulic fracturing without explanation[63] at six production wells, potentially because of migration of stimulation fluid above primary cement. At one production well, stimulation fluid was injected just 4 m below an interval lacking cement outside of the production casing with a stimulation pressure of only 1.3 MPa indicating potential entry into the annular space.

Major ion concentrations in produced water sampled after stimulation (Table SI D1) were distinct from values expected in the Wind River Formation as evidenced by sample data from the WRIR,[48,53] Fremont County,[51] and domestic wells in and around the Pavillion Field which were representative of the Wind River Formation regardless of distance from production wells (Table 1, Figure 3). Using combined data sets in and around the Pavillion Field, and the nonparametric Mann–Whitney test (null hypothesis that two sample sets come from the same population), sodium, potassium, and chloride concentrations were higher and sulfate concentrations lower in produced water compared to concentrations expected in the Wind River Formation ($p = 6.6 \times 10^{-19}$, 2.1×10^{-15}, 2.6×10^{-16}, and 4.4×10^{-19}, respectively), providing direct evidence of impact to USDWs at depths of stimulation. Also, potassium increased with calcium concentrations and sulfate increased with TDS concentrations, respectively, in domestic wells but not in production wells (Figures SI D1). Chloride is a major component of TDS concentrations in production wells. Potassium/calcium and chloride/sulfate concentration ratios were higher in production wells than in domestic wells (Figures SI D2), further indicating anomalous potassium, chloride, and sulfate concentrations in production wells.

Produced water samples were collected from gas–water separators at four production wells and analyzed for organic compounds (Table SI D3, Figure SI D3) during the Phase II sampling event.[6] Samples from one production well appeared to be from both an aqueous and an apparent nonaqueous phase liquid with the latter exhibiting thousands of mg/L of benzene, toluene, ethylbenzene, xylenes (BTEX). Synthetic organic compounds methylene chloride and triethylene glycol (TEG) were detected in produced water samples at 0.51 and 17.8 mg/L, respectively indicating anthropogenic origin. Methylene chloride has been detected in flowback water in other systems,[64] including 122 domestic wells above the Barnett Shale TX,[65] and in air sampled near well sites.[66]

Sample Results at MW01 and MW02. Concentrations of potassium in MW01 and MW02 were higher than expected values in the Wind River Formation (Figure 3) at p-values of 2.6×10^{-13} and 1.2×10^{-06}, respectively. High pH values (>11 standard units) were observed during purging at both monitoring wells (Tables SI E3b, SI E4b, Figures SI E5, SI E6, SI E7), indicating that elevated potassium concentrations may have been attributable to release of potassium from potassium oxides and sulfates during curing of cement[67−71] used for monitoring well construction. However, a number of observations were inconsistent with cement interaction as a causative factor for elevated pH, and there was extensive use of compounds containing potassium including potassium hydroxide during stimulation (Table SI C3). Water in contact with hydrating cement is saturated or oversaturated to portlandite ($Ca(OH_2)$)[72−74] and remains oversaturated prior to degradation or carbonation.[75−78] In contrast, water from monitoring wells was highly undersaturated to portlandite. Elevated pH in monitoring wells was not observed during monitoring well development until natural gas intrusion occurred in the wells, suggesting degassing as a possible cause of elevated pH (SI Section E.5). Also, potassium was detected at a concentration of 6000 mg/L in a bradenhead water sample having a pH of 10.86 standard units from Tribal Pavillion 13–1 (Table SI D1). This may indicate either high potassium concentration at depths below EPA monitoring wells due to well stimulation (water from bradenhead samples originated at some unknown distance above cement outside production casing at each production well) or interaction of bradenhead water with wellbore cement.

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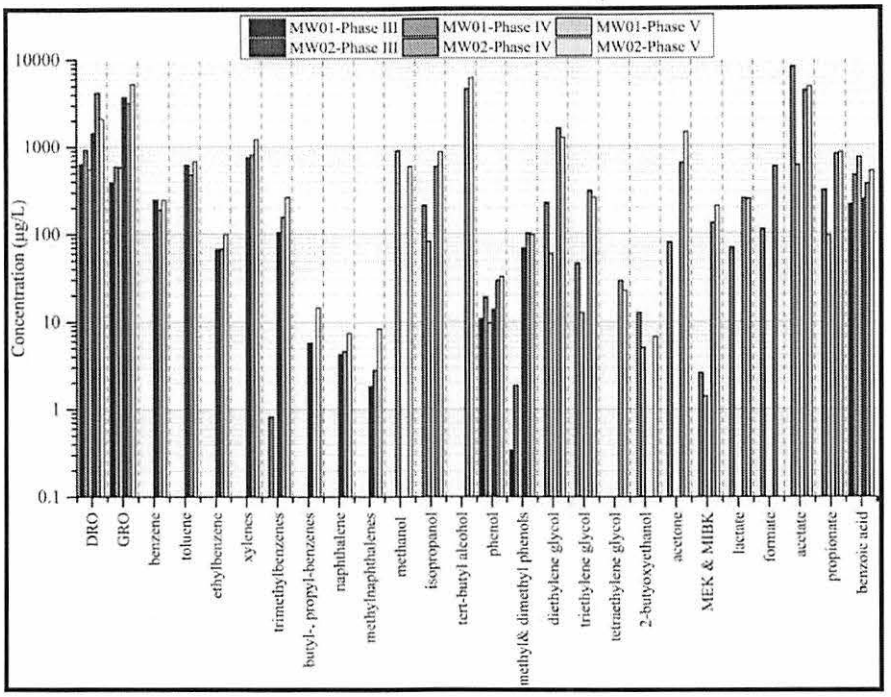

Figure 4. Summary of organic compounds detected by EPA in MW01 and MW02 during Phase III, IV, and V sampling events. Glycols, alcohols, and low molecular weight organic acids were not analyzed in Phase III. Alkylphenols and methanol (GC-FID method) were only analyzed in Phase V. Organic compounds detections for MW01 and MW02 are summarized in Table SI E3a and Table SI E4a, respectively.

The median chloride concentration at MW02 was 469 mg/L (Figure 3), well above expected values in the Wind River Formation ($p = 7.0 \times 10^{-07}$). Compounds containing chlorides (e.g., KCl solutions) were used extensively for stimulation in the Pavillion Field. Sulfate concentrations in MW02 were below expected values in the Wind River Formation ($p = 2.7 \times 10^{-07}$) and not dissimilar ($p = 0.40$) to produced water concentrations. The Cl/SO_4 concentration ratio was similar to produced water (Figure SI D2) at MW02. Chloride and sulfate concentrations in MW01 were more typical of the Wind River Formation which may be due variation in well stimulation practices both spatially and over time.

Concentrations of organic compounds detected in MW01 and MW02 are summarized in Tables SI E3a, SI E4a and Figure 4. Diesel range organics (DRO) and gasoline range organics (GRO) were detected in MW01 and MW02 with maximum DRO concentrations of 924 and 4200 μg/L, respectively and GRO concentrations of 760 and 5290 μg/L, respectively. Benzene, toluene, ethylbenzene, *m,p*-xylenes, and *o*-xylene were detected in MW02 at maximum concentrations of 247, 677, 101, 973, and 253 μg/L, respectively, but were not detected at MW01. The maximum contaminant level (MCL) of benzene is 5 μg/L, so the observed maximum value was 50 times higher than the MCL. Nondetection of BTEX at MW01 is surprising given that the well was gas-charged (foaming during sampling, Figure SI E9) with similar light hydrocarbon composition to MW02 (Table SI E5). Nondetection of BTEX may be due to increased dispersion and biodegradation of these compounds at the shallower depth of this well. We could find no published information on BTEX compounds in groundwater at concentrations detected in MW02 occurring above a gas field in the absence of well stimulation. However, further testing, such as compound specific isotope analysis of BTEX components present in natural gas from the Pavillion Field (Table SI D2) and water from MW02, is necessary to attribute detection of BTEX to well stimulation.

1,3,5-, 1,2,4-, and 1,2,3-Trimethylbenzene were detected at maximum concentrations of 71.4, 148, and 45.8 μg/L, respectively in MW02 and at an order of magnitude lower concentrations in MW01. Naphthalene, methylnaphthalenes, and alkylbenzenes were also detected in MW02 at concentrations up to 7.9, 10.2, and 21.2 μg/L, respectively. Similar to BTEX compounds, detection of trimethylbenzenes, alkylbenzenes, and naphthalenes could in principle reflect nonanthropogenic origin but natural gas from the Pavillion Field and in EPA monitoring wells is "dry" (ratio of methane to methane through pentane concentration >0.95) (SI Section A.2, Table SI E5). Also, oil production in the vicinity of monitoring wells is very low or zero especially in the vicinity of MW02 (Table SI C2, Figure SI A5). Thus, the detection of higher molecular weight hydrocarbons in groundwater is unexpected. Trimethylbenzenes and naphthalenes were present in mixtures used for well stimulation (Table SI C3).

Other organic compounds used extensively for well stimulation were detected in MW01 and MW02 (Figure 4). Methanol, ethanol, and isopropanol were detected in monitoring wells at up to 863, 28.4, and 862 μg/L, respectively (Figure 4). *Tert*-butyl alcohol (TBA) was detected at 6120 μg/L in MW02. Detection of TBA in groundwater has been associated with degradation of *tert*-butyl hydroperoxide used for hydraulic fracturing.[79] Another potential source of TBA is degradation of methyl *tert*-butyl ether (MTBE) associated with diesel fuel.[80−84]

Diethylene glycol (DEG) and TEG were detected in both monitoring wells at maximum concentrations of 226 and 12.7 μg/L, respectively, in MW01, and at 1570 and 310 μg/L respectively, in MW02 (Figure 4). Tetraethylene glycol was detected only in MW02 at 27.2 μg/L. MSDSs indicate that

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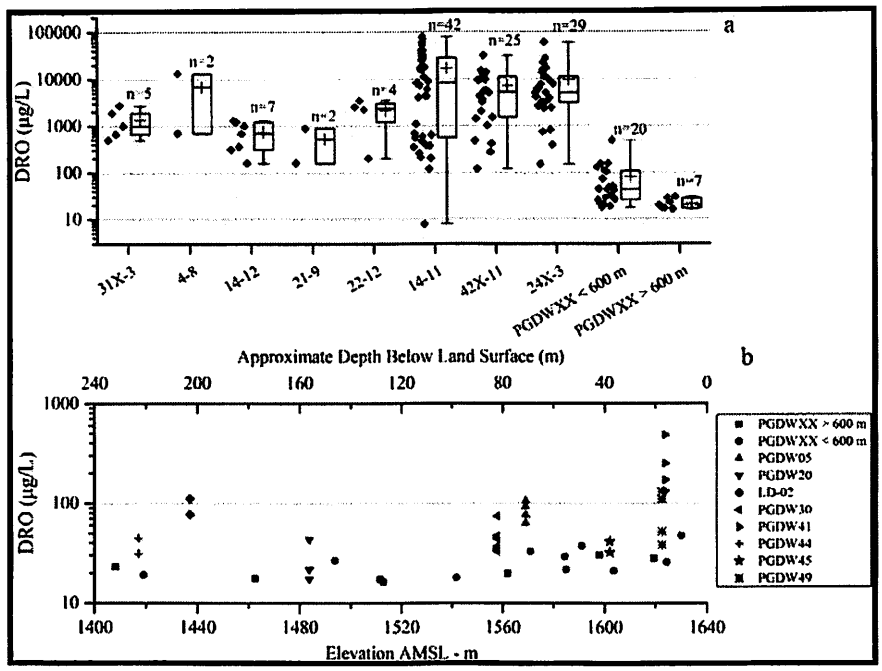

Figure 5. (a) Box and whisker plots of minimum and maximum, quartiles, median (line in boxes), mean (crosses in boxes) of diesel range organics (DRO) in shallow monitoring wells near unlined pits potentially receiving production fluids (abbreviations of production wells in Table SI C1) and domestic wells[6,8,9,39,45] (LD-20 and PGDWXX series) less than and greater than 600 m from pits. Mean values are used for domestic well sampled more than once. (b) DRO as a function of elevation and approximate depth below surface for domestic wells with results of multiple sample events illustrated.

DEG was used for well stimulation. Use of TEG was not specified. Polar organic compounds, including DEG, are commonly used as cement grinding agents.[85−88] DEG and TEG have been detected in leachate from cured cement samples under static (no flow) conditions.[89] Similar to elevated potassium detection, it is possible that detection of glycols could be attributable to cement used for monitoring well construction. However, mass flux scenario modeling, commonly used to evaluate potential concentrations of exposure of compounds released from materials in contact with drinking water under dynamic (flowing) conditions,[90] was conducted on MW01 (SI Section E.7) indicating unlikely impact. The relevance of dynamic testing is corroborated by the observation that detection of DEG and TEG was limited to a water sample from a gas production well[91] with nondetection in water samples from 83 domestic wells at five retrospective study sites[79,91−94] using high performance liquid chromatography with dual mass spectrometry at a reporting limit 5 µg/L in EPA's national study on hydraulic fracturing. 2-Butoxyethanol, a glycol ether used extensively for well stimulation in the Pavillion Field (Table SI C3), was detected in both monitoring wells at a maximum concentration of 12.7 µg/L. 2-Butoxyethanol was not detected in leachate from cured cement.[89].

The low molecular weight organic acids (LMWOAs) lactate, formate, acetate, and propionate were detected in both monitoring wells at maximum concentrations of 253, 584, 8050, and 844 µg/L, respectively (Figure 4). LMWOAs are anaerobic degradation products associated with hydrocarbon contamination in groundwater.[95,96] Acetate has been detected in produced water,[97−99] in impoundments used to hold flowback water from the Marcellus Shale,[100] and in produced water from the Denver-Julesburg Basin, CO.[101] Acetate and formate were detected in flowback water from two different fracturing sites in Germany with investigators concluding that these compounds were likely of anthropogenic origin resulting from degradation of polymers used in the fracturing fluid.[102] Formate and acetate are also degradation products of methylene chloride.[103] Benzoic acid, a degradation product of aromatics, was also detected in both monitoring wells at a maximum concentration of 513 µg/L.

Phenols were detected in both monitoring wells with maximum concentrations of phenol, 2-methylphenol, 3&4-methylphenol, and 2,4-dimethylphenol at MW02 at 32.7, 22.2, 39.8, and 46.3 µg/L, respectively. Ketones were also detected in both monitoring wells with maximum concentrations of acetone, 2-butanone (MEK), and 4-methyl-2-pentanone (MIBK) at MW02 at 1460, 208, and 12.5 µg/L, respectively. Acetone, MEK, phenol, 2-methylphenol, 3&4 methylphenol, and 2,4-dimethylphenol were detected in produced water from the Denver-Julesburg Basin.[101] MIBK, MEK, and acetone may result from microbial degradation of biopolymers used for hydraulic fracturing.[101] Nonylphenol and octylphenol, commonly present in mixtures of ethoxlyated alcohols, were detected in both monitoring wells with maximum concentrations at MW02 at 28 and 2.9 µg/L, respectively. Ethoxlyated alcohols were used for well stimulation in the Pavillion Field.

Detection of organic compounds, especially those that cannot be attributed to cement, and degradation products of compounds known to have been used for production well stimulation in both MW01 and MW02 provide additional evidence of impact to USDWs and indicate upward solute migration to depths of current groundwater use. Installation of additional monitoring wells at depths similar to MW02, with sample analysis supplemented by state-of-the-art analytical methods better suited to detection of compounds present in

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stimulation fluids (e.g., liquid chromatography coupled with quadrupole time-of-flight mass spectrometry[104−106]), is necessary to evaluate long-term risk to domestic well users in the Pavillion Field.

Assessment of Potential Impact of Unlined Pits to Domestic Wells. EPA[7] previously reported disposal of diesel fuel-based (invert) drilling mud and production fluids (flowback, condensate, produced water) in unlined pits in the Pavillion Field and resultant groundwater contamination in surficial Quaternary deposits in shallow monitoring wells sampled by EPA in the vicinity of three unlined pits but did not document the extent of these disposal practices. At least 64 unlined pits were used for disposal of drilling fluids of which invert mud was disposed in 57 pits consisting of up to 79% diesel fuel (Tables SI F1, SI F2). As many as 44 of 64 unlined pits were used or likely used for disposal of production fluids. Unlined pits were emptied and closed in 1995.[107,108]

A summary of information available on disposal of drilling and production fluids in pits is provided in Table SI F2. This summary includes results of soil and groundwater sampling, excavation volumes and associated criteria (1000−8500 mg/kg total petroleum hydrocarbons), proximity and direction of unlined pits to domestic wells, and recommendations by WOGCC[44] for further investigation (or no investigation).

The field operator has collected groundwater samples in surficial Quaternary deposits at 12 unlined pit locations.[44] The highest reported concentrations of GRO and DRO were 91 000 and 78 000 μg/L, respectively (Figure 5, Table SI F2). Benzene, toluene, ethylbenzene, and xylenes were detected at five locations at concentrations up to 1960, 250, 240, and 1200 μg/l, respectively (Table SI F2). Thus, sample results indicate impact to surficial groundwater in Quaternary deposits.

There may be as many as 48 domestic wells within 600 m of unlined pits of which 22 domestic wells were sampled by EPA[6,8,9,39] and 11 were resampled by WDEQ[45] (Table SI F3). DRO concentrations in domestic wells <600 m from unlined pits likely receiving production fluids were elevated ($p = 0.003$) compared to domestic wells >600 m from unlined pits (Figure 5a). DRO was detected at 752 mg/kg in a reverse osmosis filter sample from a domestic well (PGDW20) during the Phase II sampling event[8] (Table SI F3). Concentrations of DRO in domestic wells generally decreased with depth (Figure 5b). Another potential source of DRO in some domestic wells (Table SI G1) is invert mud remaining in boreholes. However, differentiation from other source terms (unlined pits and stimulation) is not possible with currently available data (SI Section G.1).

At two domestic wells (PGDW05 and PGDW30), chromatograms for DRO analysis suggest a diesel fuel source (Figure SI F1a, b). Chromatograms of aqueous (Figure SI F2a) and carbon trap samples (Figure SI F2b) for DRO at another domestic well (PGDW20) indicated the presence of heavy hydrocarbons in water. All three domestic wells are located near unlined pits likely used for disposal of production fluids.

Adamantanes were detected at low aqueous concentrations (<5 μg/L) at four domestic wells (PGDW05, PGDW20, PGDW30, and PGDW32) (Table SI F3). Admantane, 2-methyl adamantane, and 1,3-dimethyladamantane were detected in a reverse osmosis filter sample at PGDW20 at concentrations of 420, 9400, and 2960 μg/kg, respectively. Adamantanes were detected in produced water up to 74 mg/L (Table SI D3) indicating disposal in unlined pits as a potential source term. The inherent molecular stability of admantanes and other diamondoid compounds imparts thermal stability resulting in enrichment in manufactured petroleum distillates.[109] Diamondoids are resistant to biodegradation[110,111] resulting in their use as a fingerprinting tool to characterize petroleum and condensate induced groundwater contamination.[112]

2-Butoxyethanol was detected at 3300 μg/L in a domestic well (PGDW33)[45] (Table SI F3). The depth of this domestic well is only 9.1 m bgs and is located within 134 m of an unlined pit used for disposal of production fluids. Other compounds, including BTEX, associated with production well stimulation (e.g., isopropanol) were detected at lower concentrations (<10 μg/L) in other domestic wells (Table SI F3). Sample results at domestic wells suggest impact from unlined pits and the immediate need for further investigation including installation of monitoring wells in the Wind River Formation. Since flood irrigation is common in the vicinity of unlined pit areas, the lateral extent of groundwater contamination is potentially greater in the Wind River Formation than in overlying surficial Quaternary deposits due to "plume diving" (i.e., uncontaminated water overlies portions of a contaminant plume).[113−115]

Our investigation highlights several important issues related to impact to groundwater from unconventional oil and gas extraction. We have, for the first time, demonstrated impact to USDWs as a result of hydraulic fracturing. Given the high frequency of injection of stimulation fluids into USDWs to support CBM extraction and unknown frequency in tight gas formations, it is unlikely that impact to USDWs is limited to the Pavillion Field requiring investigation elsewhere.

Second, well stimulation in the Pavillion Field occurred many times less than 500 m from ground surface and, in some cases, at or very close to depths of deepest domestic groundwater use in the area. Shallow hydraulic fracturing poses greater risks than deeper fracturing does,[57,116] especially in the presence of well integrity issues[117,118] as documented here in the Pavillion Field. Additional investigations elsewhere are needed.

Finally, while disposal of production fluids in unlined pits is a legacy issue in Wyoming, this practice has nevertheless caused enduring groundwater contamination in the Pavillion Field. Impact to groundwater from unlined pits is unlikely to have occurred only in the Pavillion Field, necessitating investigation elsewhere.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.est.5b04970.

Supplemental discussion and tables summarizing data sets are provided in the Supporting Information (SI) portion of the paper (PDF)

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Notes

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Exhibit 4

Date: December 26, 2017

Subject: Examination of Groundwater Resources in Areas of Wyoming Proposed for the 1st Quarter 2018 BLM Lease Sale

From: Gregory Oberley, Ground Water Scientist
Dominic DiGiulio, Ph.D., PSE Healthy Energy

Background

Lease parcels are within the High Plains District (Buffalo, Casper and Newcastle Field Offices) and the Wind River/Bighorn Basin District (Lander, Worland and Cody Field Officies.) The High Plains District proposal includes 81 parcels comprising 45,003 acres and the Wind River/Bighorn Basin District proposal includes 89 parcels comprising 125,507.140 acres.[1]

Concerns with Compliance with Onshore Oil and Gas Order No. 2

Definitions

BLM *"Onshore Order #2 requires that the proposed casing and cementing programs shall be conducted as approved to protect and/or isolate all usable water zones, and casing along with cement is extended well beyond fresh-water zones to insure [ensure] that drilling fluids remain within the well bore and do not enter groundwater."*

Wyoming OGCC Rules identify freshwater and potable water in Chapter 1 under definitions.

Chapter 1. Section 2. (t)

*"**Fresh Water** and **Potable Water** are defined as water currently being used as a drinking water source or having a total dissolved solids (TDS) concentration of less than 10,000 milligrams per liter (mg/l) and which:*

(i) Can reasonably be expected to be used for domestic, agricultural, or livestock use; or,

(ii) Is suitable for fish or aquatic life."

The definition of groundwater is also defined in Chapter 1. Section 2. (x)

*"**Groundwater**, for purposes of these rules and consistent with Wyoming Department of Environmental Quality Chapter 8, as revised April 26, 2005, "Quality Standards for Wyoming Groundwaters", means groundwater will be protected except for Class VI Groundwater of the State that is unusable or unsuitable for use:*

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[1] A portion of the parcels identified in the latter district are actually located within the Rock Springs Field Office of the High Desert District but the actual EA review apparently does not include the review information related to these proposals.

(i) Due to excessive concentrations of total dissolved solids or specific constituents; or,

(ii) Is so contaminated that it would be economically or technologically impractical to make water useable; or,

(iii) Is located in such a way, including depth below the surface, so as to make use economically and technologically impractical."

The High Plains Environmental Assessment (HPEA) associated with this lease sale mentions shallow alluvial and confined Tertiary, Cretaceous and Paleozoic aquifers exist. The HPEA also states that, "all freshwater zones would be protected." However, no background information is presented that would identify how operators would be expected to protect these ground water resources. In addition, the HPEA does not mention that BLM requirements identified in Onshore Order #2 above. The HPEA uses a term (freshwater) for ground water resources that is not defined by BLM introducing the potential for production well design that is not protective according to Onshore Order #2.

The Wind River/Bighorn Basin Environmental Assessment (WRBBEA) does not mention ground water resources or Onshore Order #2. The WRBBEA does reference the Lander Field Office FEIS Section 4.1.3 for analysis of cumulative impacts. Section 4.1.3 does briefly mention existing groundwater resources. This section also mentions that oil and gas operations have the ability to impact ground water quality but that, "In general, however, safeguards such as casing design and selection of injection well receiving horizons protect groundwater quality." Again no mention of Onshore Order #2 is found in this section that explains how this will be done. The location of aquifers can be determined both areally and in depth, but neither the EIS or the EA prescribe the depths or the base of which aquifers shall be protected according to Onshore Order #2.

Identification of Usable Water Zones in Lease Areas

Our review has identified EISs such as the Lander Field Office EIS where aquifers have been identified. Even the WRBBEA identifies these beneficial ground water resources. However, it is not established within either of these documents that any of these aquifers meet the definition of usable water as defined in Onshore Order #2 and ultimately whether BLM will require specific aquifers to be sufficiently isolated from drilling and production activities on these leases.

Usable water zones according to Onshore Order #2 are not specifically identified within EISs or EAs for this proposed lease sale. Identification of usable water is feasible for the proposed leases and should be addressed prior to the lease sale. At a minimum, the EAs for the proposed lease areas should list aquifers within the lease areas that have the potential to meet the definition of usable water and which must be protected in well construction.

There are many available resources that can be used to develop an understanding which aquifers meet the definition of usable water prior to the APD process.

Principal Aquifer Designation – USGS

The USGS has defined a principal aquifer as, "a regionally extensive aquifer or aquifer system that has the potential to be used as a source of potable water." The U.S. Geological Survey (USGS) recently published a report (Stanton et al. 2017 available at https://pubs.er.usgs.gov/publication/pp1833) identifying principal aquifers within 3,000 feet of the surface having brackish groundwater resources in the United States.[2] In the USGS report, fresh groundwater is defined as water having less than 1,000 mg/L total dissolved solids (TDS). Brackish groundwater is defined as water having between 1,000 to 10,000 mg/L (TDS). Highly saline groundwater is defined as water having over 10,000 mg/L TDS.

Principal aquifers in lease areas covered by the Buffalo, Casper, Newcastle Lander, Worland and Cody Field Offices appear to be those associated with Lower Tertiary, Upper and Lower Cretaceous, and Paleozoic Formations (**Figure 1**).[3]

The Lower Tertiary, Upper Cretaceous, and Lower Cretaceous Formations were formed under fluvial depositional environments which varied between freshwater systems and shoreline marine systems. Information provided in the USGS reports indicates that these formations consist largely or entirely of fresh and brackish groundwater. Paleozoic aquifers formed under marine depositional systems. Fresh or brackish groundwater in these Paleozoic aquifers is a function of distance from a recharge zone, distance and time of groundwater travel, and replacement of connate water. Since, Paleozoic aquifers contain up to ~80% fresh and brackish groundwater, displacement of connate water is evident in these formations.

U.S. Geological Survey Produced Water Data Base

The Produced Water Data Base for Wyoming contains over 25,000 records and includes well information that is useful for identifying usable water. It includes: well location, depth, formation names well name and TDS concentrations.[4]

U.S. Geological Survey Brackish groundwater in the United States

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[2] There was insufficient information available to characterize groundwater resources below 3,000 feet. That does not mean that usable water below 3,000 feet is absent.
[3] Principal aquifers in the Lander Field Office are associated with the lower Tertiary and Paleozoic strata. Within the Buffalo, Casper and Newcastle Field Offices principal aquifers would include the lower Tertiary, Upper Cretaceous and the Paleozoic aquifers. The leases within the Worland and Cody Field offices should also acknowledge the Tertiary, Upper Cretaceous and Paleozoic aquifers.
[4] This information is available at: https://energy.usgs.gov/EnvironmentalAspects/EnvironmentalAspectsofEnergyProductionandUse/ProducedWaters.aspx#3822349-data

The report evaluates the water quality conditions for the Principal Aquifers and Aquifer Systems for the United States.[5]

Wyoming Geological Survey Water Basin Plans – Ground Water Reports

The Wyoming Geological Survey has completed Ground Water Reports for most basins in Wyoming except the Powder River Basin.[6] The Wind River/Bighorn Basin and Green River Basin Groundwater Reports have evaluated the potential for future use and have also provided water quality information related to various aquifers and aquifer systems.

The Wind River Bighorn Basin Groundwater Report (WRBBGR) states, "Virtually all aquifers and some confining units have some potential for development, depending on quantity and quality requirements and technical considerations." This statement points out that good quality water can exist in many areas at various depths.

More specifically, the WRBBGR evaluates the potential for future use for individual aquifers within each basin. Within the Wind River Basin the lower Tertiary, Upper Cretaceous and a couple of Paleozoic aquifers are identified as having high potential for future use.

In the Wind River Basin the Wind River formation ranges from 100 feet in thickness to over 5,000 feet towards the center of the basin and is exposed at the surface over much of the basin. TDS concentrations ranged from 224 to 5,110 mg/L, with a median of 707 mg/L. The Paleozoic aquifer system is approximately 2,000 feet thick and underlies most of the basin. The Madison and Tensleep formations have been identified as the most productive aquifers in the system and their TDS values range in the Tensleep aquifer from 146 mg/l to 1,060 with a median of 208 mg/l and the Madison aquifer ranges from 181 mg/l to 920 mg/l with a median concentration of 216 mg/l. Appendix E1 Wind Bighorn Basin Groundwater Report.

In the Bighorn Basin the primary Paleozoic aquifer is the Tensleep and TDS values range from 156 mg/l to 3,750 mg/l with a median of 259 mg/l. Appendix E2 Wind Bighorn Basin Groundwater Report.

Tables 1 and 2 provide information from the Wyoming Geological Survey Groundwater Reports that would assist with determining the potential for usable water zones. These tables primarily address usable water zones that are "most likely" to be drilled through and cased during drilling and well construction.

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[5] Regional reports are available and the pertinent report for these lease areas is the Mid-Continent evaluation. The link is found at: https://water.usgs.gov/ogw/gwrp/brackishgw/studypublications.html

[6] The completed Ground Water Report online links can be found at: http://waterplan.state.wy.us/basins/7basins.html .

The Ground Water Report for the Greater Green River Basin discusses the major alluvial, sandstone and limestone aquifers found in Wyoming. Further analysis of the location and depths of these state declared major aquifers should be completed by BLM prior to leasing.

Existing Production Well Design Near Proposed Lease Areas

A review of well records available online for existing federal oil and gas production wells located near two of the proposed lease areas in Fremont County and Sweetwater County was done. Many of the lease parcels for the proposed March 2018 sale overlie the same aquifers encountered by these existing production wells.

The reviewed records reveal that in very few instances cement bond logs are provided in the online WOGCC data base or if present in the data base, they do not demonstrate that cement behind casing is adequate to protect these high value aquifers.[7] As a result these records do not demonstrate that Onshore Order #2 has been complied with at these federally approved production wells. Given the statements by Western Energy Alliance indicating widespread noncompliance with Onshore Order # 2, it cannot be assumed that compliance will be accomplished when drilling permits are processed.

Conclusion

Due to the lack of information within the WOGCC online data base, our review did not determine whether Onshore Order #2 has been complied with at the APD stage for existing production wells. The existing NEPA documents related to the proposed lease sales also do not address the location of usable water, or establish how those waters will be isolated and protected as required by Onshore Order # 2. The information to address this issue is readily available from several sources. Because industry has indicated that Onshore Order # 2 is not being complied with at the APD stage, it is important that this issue be addressed before issuing new oil and gas leases.

[7] In addition, the resources described above identify other high value aquifers in the proposed lease areas that are deeper than the production wells we evaluated for compliance with Onshore Order #2. But if new proposals are made for wells that depths that would drill through these aquifers, additional analysis of Onshore Order #2 compliance would be necessary.

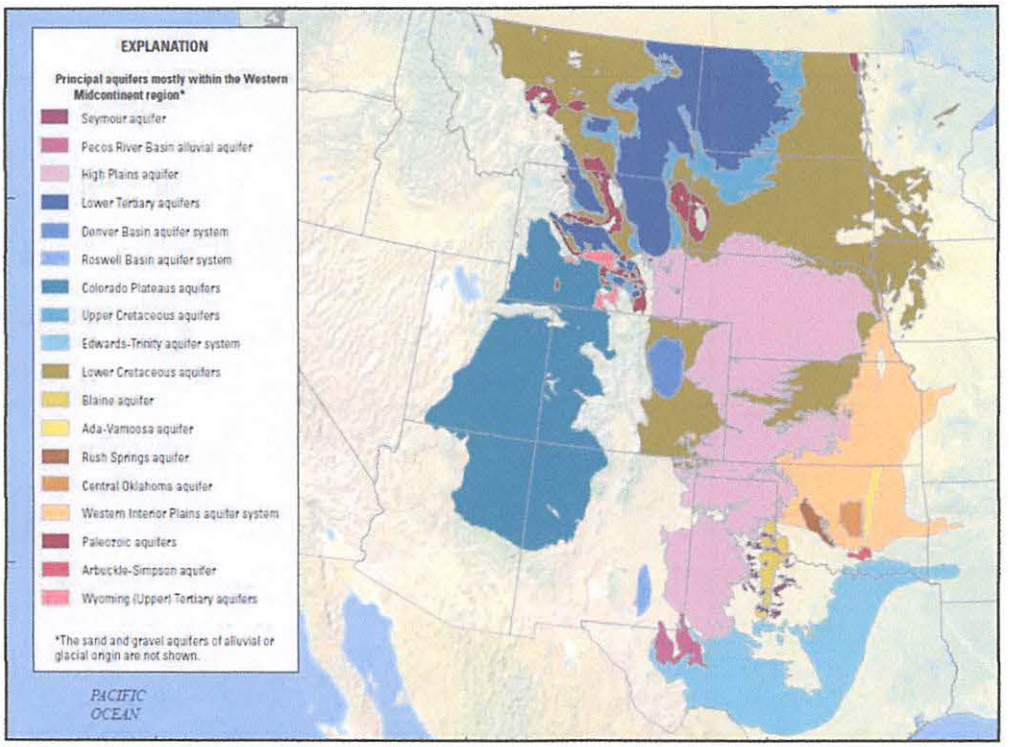

Figure 1. Principal aquifers within the Western Midcontinent. From Stanton et al. (2017)

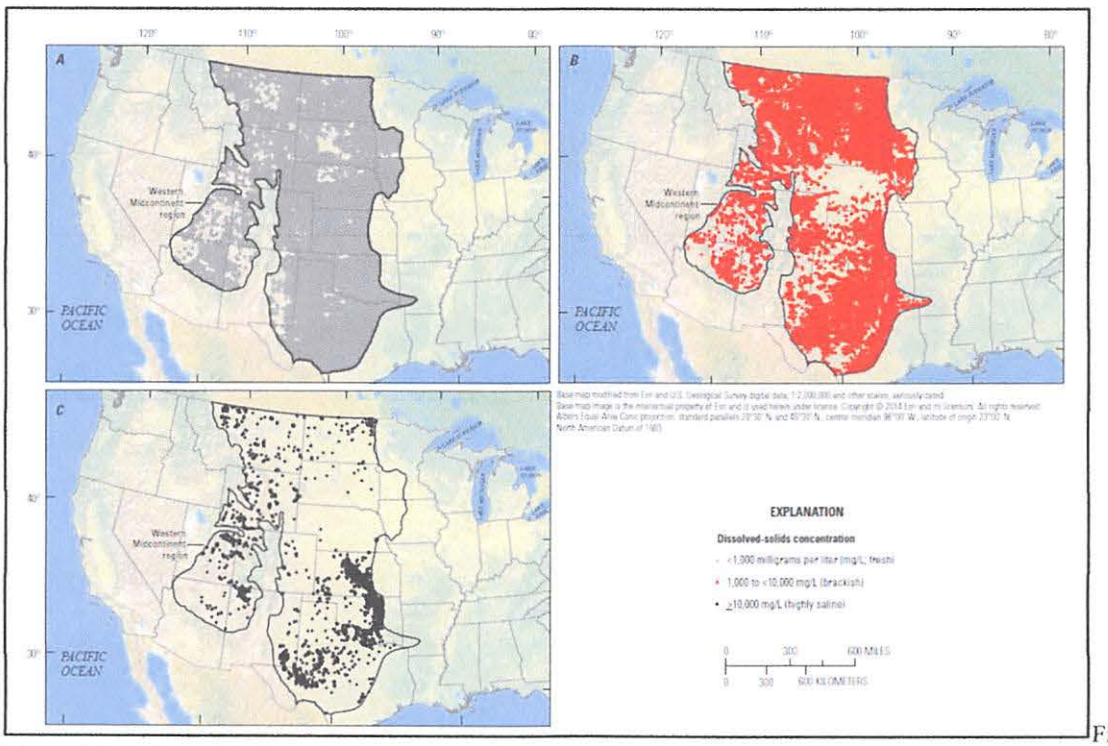

Figure **Figure 2** Locations of wells producing: a. fresh groundwater, b. brackish groundwater, and c) highly saline ground in the Western Midcontinent Region. From Stanton et al. 2017

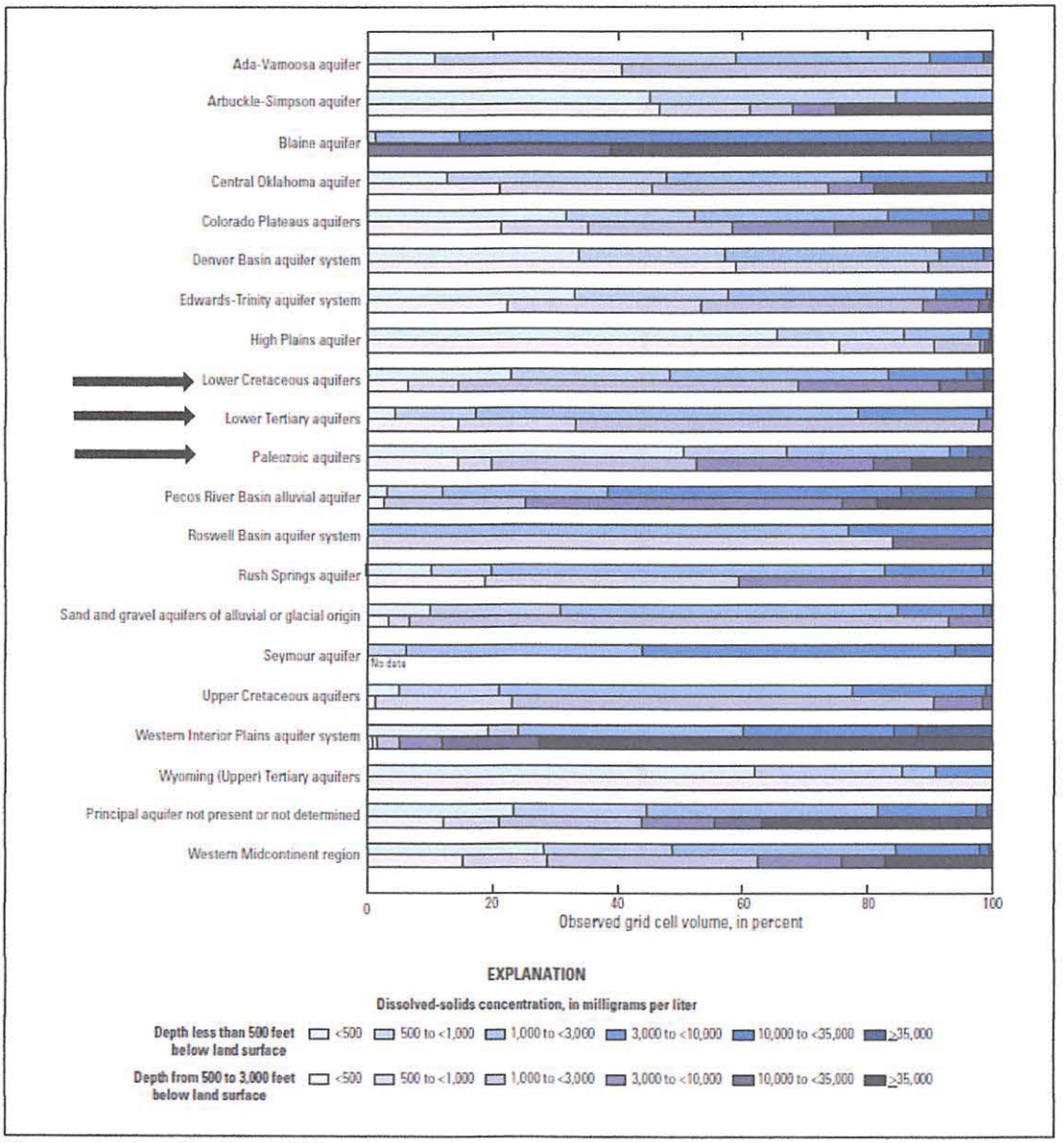

Figure 3. Distribution of dissolved solids concentrations as a percentage of observed grid volume by principal aquifer and depth in the Western Midcontinent Region. Aquifer systems denoted in black arrows are located within the March 2018 proposed lease areas.

Table 1. Aquifers with current high use or potential high use located in the Wind River Basin (Wyoming Geological Survey "Wind River Bighorn Basin Groundwater Report")

Hydrodeologic Unit	Current Uses	Median TDS (mg/L)	Thickness (ft)
Wind River Aquifer	Domestic Municipal Stock/Irrigation Industrial	707 (n=243)	Up to 5,000
Tensleep Aquifer	Domestic Municipal Stock/Irrigation Industrial	208 (n=15)	200 to 600
Madison Aquifer	Domestic Municipal Stock/Irrigation Industrial	216 (n=13)	Up to 700

Table 2. Aquifers with current high use or potential high use located in the Green River Basin (Wyoming Geological Survey "Greater Green River Basin Groundwater Report") and (SEO Data Base)

Hydrodeologic Unit	Current Uses	Median TDS (mg/L)	Thickness (ft)
Wasatch	Domestic Municipal Stock/Irrigation Industrial	**377 (n=315)**	**5,000-8,000**

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Education

B.S., Environmental Engineering, Temple University, Philadelphia, PA (1982)
M.S., Environmental Science, Drexel University, Philadelphia, PA (1988)
Ph.D., Soil, Water, and Environmental Science, University of Arizona, Tucson, AZ (2000)

Areas of Expertise: soil vacuum extraction/bioventing, gas sparging, soil-gas sampling, gas permeability testing, vapor intrusion, stray gas (CH_4, CO_2) migration, hydraulic fracturing

Employment (in Chronological Order)

Military Service: U.S. Marine Corps: Active duty 1975-1978, Camp Pendleton, CA, Honorable Discharge in 1981.

Environmental Engineer (Remedial Project Manager): U.S. Environmental Protection Agency, Region III, Philadelphia, PA: Jun 1980 – Dec. 1981 and Sep 1982 – Jan 1988. Duties included: conducting investigations (e.g., remedial investigations, risk assessments, feasibility studies, sample collection) under the Comprehensive Environmental Response and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA), federal contractor oversight, preparation of consent orders and initiation of enforcement actions.

Environmental Engineer: Tetra-Tech, Newark, DE: Jan 1988 - Jun 1988. Duties included: conducting investigations under CERCLA and RCRA, collecting, ground-water, soil, sediment, air, and soil-gas samples.

Environmental Engineer: U.S. Environmental Protection Agency, Office of Research and Development, Ada, OK: Sep 1988 – Mar 2014 (retired). Duties included providing regulatory oversight assistance to EPA remedial project managers and conducting research related to subsurface gas flow and vapor transport. Research included: (1) Development of methods to improve the effectiveness of soil vapor extraction, bioventing, and air sparging subsurface remediation systems including lead authorship of EPA's primary technical resource document in these areas; (2) Co-development of analytical solutions and associated codes for estimation of gas permeability and gas flow in soil; (3) Development of analytical solutions to simulate combined solute and vapor transport in soil including lead authorship of the model VFLUX; (4) Development of field methods to improve active soil-gas sampling especially pertaining to leak and purge testing; (5) Development of forensic techniques (use of hydrocarbon degradation products and radon) and assistance in development of EPA guidance to evaluate vapor intrusion (migration of organic compounds from ground water to indoor air); (6) Development of ground water and soil gas monitoring strategies including assistance in development of EPA's Class VI rule on geologic sequestration of carbon dioxide; (7) Development of methods to evaluate impact to Underground Sources of Drinking Water (USDWs) under the Safe Drinking Water Act and stray gas migration due to hydraulic fracturing. Research activities included conducting seminars, workshops, and short courses to States.

Branch Chief: U.S. Environmental Protection Agency, Office of Research and Development, Ada, OK: (3 detail periods over a cumulative period of 1 ½ years). Duties included: research planning, management of funding and other scientists, and completion of various administrative functions.

Research Associate and Visiting Scholar: Stanford University, Stanford, CA: Apr 2014 - present. Duties include conducting research related to evaluating impact to UDSWs and domestic water wells as a result of hydraulic fracturing.

Environmental Engineer: Subsurface Gas Solutions, Ada, OK: June 2015 – Dec 2016. Duties included providing consulting service to EPA and private clients on issues related to subsurface gas flow and vapor transport including, vapor extraction, dual vapor extraction, bioventing, gas sparging, vapor intrusion, stray gas migration, and, soil-gas sampling.

Senior Research Scientist: PSE Healthy Energy, Ithaca, NY: Jan 2017 – present. Duties include evaluating the impact of oil and gas development on human health, water resources (groundwater and surface water), and greenhouse gas emissions in the United States and abroad.

Scientific Awards

5 EPA Bronze Medals: (1) Development of EPA Guidance Document on Soil Vacuum Extraction, (2) Technical Support to EPA's Program and Regional offices on Subsurface Gas Flow and Vapor Transport, (3) Development of EPA Guidance on Vapor Intrusion, (4) Research on Vapor Intrusion, (5) Development of Class VI Rule on Geologic Sequestration of Carbon Dioxide

3 EPA Honor Awards: (1) Development of a National Risk Management Research Laboratory Strategic Research Plan, (2) Development of a Protocol to Assess Vapor Intrusion; (3) Technical support at Leaking Underground Storage Tank Sites

3 EPA Scientific and Technological Achievement Awards: (1) Innovative Design of Soil Vacuum Extraction Systems, (2) Development of Analytical Model to Simulate Transient Flux of Volatile Organic Compounds in Soil to Ground Water and the Atmosphere, (3) Simulation of Geochemical Impacts to Ground Water from Leakage of Carbon Dioxide

Peer-Reviewed Journal Publications, EPA Reports, and Book Chapters in Chronological Order

DiGiulio, D.C.; Shonkoff, S.B.C.; Jackson, R.B. The Need to Protect Fresh and Brackish Groundwater Resources During Unconventional Oil and Gas Development. *Current Opinion in Environmental Science & Health* **2018** (accepted, undergoing revision).

DiGiulio, D.C.; Ruybal, C.J.; Hargrove, K.D.; Wilkin, R.T. *Leak, Purge, and Gas Permeability Testing to Support Active Soil-Gas Sampling*, EPA/xxx/x-xx/xxx, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, **2018** (accepted, undergoing revision)

DiGiulio, D.C.; Shonkoff, S.B.C. Is reuse of produced water safe? First, let's find out what's in it. *EM, Air & Waste Management Association*, August **2017**

DiGiulio, D.C.; Jackson, R.B. Impact to Underground Sources of Drinking Water and domestic wells from production well stimulation and completion practices in the Pavillion, Wyoming Field. *Environmental Science & Technology* **2016** 50, 4524-4536.

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Wilkin, R.T.; DiGiulio, D.C. Geochemical Impacts to groundwater from geologic carbon sequestration: Controls on pH and inorganic carbon concentrations from reaction path and kinetic modeling. *Environmental Science & Technology* **2010**, 44(12), 4821-4827.

DiGiulio, D.C., *Use of Soil-Gas, Gas Flux, and Ground Water Monitoring to Evaluate Potential Leakage to Underground Sources of Drinking Water, the Atmosphere, and Buildings During Geological Sequestration of Carbon* - Science in Action Fact Sheet. EPA/600/S-09/030, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, **2010**.

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DiGiulio, D.C.; Paul, C.; Cody, R.; Willey, R.; Clifford, S.; Kahn, P.; Mosley, R.; Lee, A.; Christensen, K. *Assessment of Vapor Intrusion in Homes near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples*. EPA/600/R-05/147, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, **2006**.

DiGiulio, D.C.; Varadhan, R. *Development of Recommendations and Methods to Support Assessment of Soil Venting Performance and Closure*, EPA/600/R-01/070, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, **2001**.

DiGiulio, D.C.; Varadhan, R. Limitations of ROI testing for venting design: Description of an alternative approach based on attainment of critical pore-gas velocities in contaminated media, *Ground Water Monitoring and Remediation* **2001** 21(1), 97-114.

DiGiulio, D.C.; Varadhan, R. Analysis of water and NAPL saturation, degradation half-life, and boundary conditions on VOC transport modeling: Implications for venting closure, *Ground Water Monitoring and Remediation* **2001** 21(4), 83-91.

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GREGORY OBERLEY

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EDUCATION

University of Colorado
Master of Science in Environmental Science 1987

Focus areas included: Hydrogeology, chemistry, statistics and water resources. My masters research paper compared typical ground water data analysis with various statistical approaches to data analysis for an aquifer in North Dakota.
Thesis: "Groundwater Movement in a Glacial Till Overlying a Buried Valley Aquifer"

University of Southern Colorado 1982
Bachelor of Science in Geology
Areas of Concentration: Hydrogeology, Water resources,

AWARDS

Deans List	1980 – 1982
Neal J. Harr Memorial Outstanding Student Award (Rocky Mountain Association of Geologists)	1981 – 1982
USEPA Bronze Medal – Coal Bed Methane Powder River Basin NEPA comments	2004
USEPA Silver Medal – Pavillion Wyoming Ground Water Sampling and Analysis	2012
USEPA Bronze Medal – Coordinating Ground Water Sampling for two National HF Study Sites	2015
USEPA Science and Technology Achievement Award – Work related to the National HF Study	2017

TEACHING EXPERIENCE

USEPA Ground Water Science Instructor (Basic Hydrogeology Concepts)	2004 - 2016
USEPA Ground Water Science Instructor (Ground Water Sample Collection and Measurement Methods)	2004 - 2016

EXPERIENCE HIGHLIGHTS

United States Environmental Protection Agency
Environmental Scientist/Ground Water Scientist/Region 8 Water Policy Advisor January 1985 – October 2017

During my tenure with the EPA Region 8 office in Denver, Colorado I worked in the Underground Injection Control Program, Superfund, NEPA, and Watershed and Aquifer Protection Unit.
Most of my services with EPA revolved around ground water protection activities and aquifer remediation.

My last 10 years with EPA more specifically focused on ground water impacts resulting from oil and gas exploration and production development in the western mountain states primarily Colorado, Wyoming and Utah.

In addition, my work included EPA Office of Research and Development as a coordinator for field work for two retrospective research sites associated with the: "Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States"

United States Geological Survey
Hydrologic Technician 1979 - 1982

This position provided the foundation for future field-work and analysis concerning surface water and ground water. Field work included collecting samples for field and laboratory analysis, conducting field laboratory analysis and shipping samples to laboratory for analysis.
In addition, physical field parameters were collected such as surface water flow measurements and depth to ground water for water well measurements.

PUBLICATIONS AND PAPERS

Hydraulic Fracturing for Oil and Gas: Impacts From the Hydraulic Fracturing Water Cycle on Drinking Water Resources
Contributing Author and Reviewer 2016

Investigation of Ground Water Contamination Near Pavillion Wyoming (Draft)
Contributing Author and Reviewer 2011

MEMBERSHIPS

National Ground Water Association

OTHER INTERESTS

SCUBA – I am a certified SCUBA Instructor and also certified to perform maintenance and Service on SCuBA equipment
Music – Play bass and guitar
Outdoor Interests - Bicycling, Golf, Skiing
Photography – Land and Underwater

Exhibit 5

First Quarter 2018 WY Oil and Gas Lease Sale
High Desert and Wind River/Bighorn Basin Districts of BLM
Review of potential effects to sage-grouse
Matt Holloran
FINAL_12/22/2017

Prioritizing Leasing of Non-Habitat

In order to achieve sage-grouse conservation goals, BLM's prioritization commitment must be applied with the intent of achieving minimal leasing in sage-grouse habitat. The BLM Buffalo Field Office (pg. 50; MR:3.4), Cody Field Office (pg. 29; MR:2.3), Worland Field Office (pg. 29; MR:2.3) and Casper/Newcastle Field Office (pg. 24; Management Objective 14) Approved Resource Management Plans (ARMPs; 2015) all state that, in order to provide the quantity, quality and connectivity necessary to maintain sustainable populations of sage-grouse, "priority will be given to leasing and development of fluid mineral resources outside of greater sage-grouse habitat." However, the BLM does not establish that leasing outside of PHMA or GHMA was prioritized or considered in the Bighorn District (BHD) or High Plains District (HPD) EAs for the First Quarter 2018 Oil and Gas Lease Sale in Wyoming (DOI-BLM-WY-R000-2017-0002-EA and DOI-BLM-WY-P000-2017-0002-EA respectively). Of the parcels proposed for lease in both districts, 68% (116 of 170 parcels) are located within sage-grouse habitat, and 77% of the acres (130,575 of 170,510 acres) being proposed for leasing are situated in sage-grouse habitat (BHD EA pgs. 3-39 and 3-44; HPD EA pgs. 48 and 49). By not prioritizing lease sales on lands outside of sage-grouse habitat, the BLM is not managing sage-grouse habitats at spatial scales necessary to sustain populations.

To effectively manage sage-grouse, it is critical that priority habitats are managed at landscape spatial scales. The Buffalo ARMP has the goal of "conserving, recovering and enhancing sage-grouse habitat on a landscape scale" (pg. 68; LR2.1); the Cody and Worland ARMPs include similar language in that limitations on mineral development "focuses on a landscape-scale approach to conserving sage-grouse habitat" (pg. 20); and the Casper/Newcastle ARMP establishes that "each BLM field office will develop landscape-scale restoration, conservation, and maintenance strategies" for sage-grouse (pg. 26). Large-scale approaches to habitat management are important because sage-grouse are considered a landscape-scale species as populations generally inhabit and rely on large, interconnected expanses of sagebrush (Connelly et al. 2004). Estimates of the size of a landscape capable of supporting breeding habitats of an interspersed population (e.g., an area with multiple leks spaced <6 mi apart) may exceed 385 to 1070 mi^2 (Leonard et al. 2000, Doherty 2008). Yet, the BLM concluded that areas containing the parcels being proposed for leasing would be satisfactorily mitigated for sage-grouse by applying the required stipulations as established in the appropriate ARMPs at the time of receiving an Application to Drill (APD; BHD EA pg. 3-39; HPD EA pg. 44). This establishes that the BLM will assess potential impact of developing a leased parcel at the site-scale—i.e., the scale at which potential impacts from development of a leased parcel would be the Density and Disturbance Calculation Tool (DDCT) assessment area (Buffalo ARMP pg. 40, SS WL-4024; Cody and Worland ARMPs pg. 37, Record #4110 and #4109 respectively; Casper/Newcastle ARMP pg. 34, MD SSS 2), which is, at the maximum, an 8 mile radius circle (approximately 200 mi^2) around the proposed development (see Attachment B Wyoming EO 2015-4). The maximum scale of assessment being pursued by the BLM is therefore up to 5 times less than what is necessary to effectively estimate landscape-scale impacts of the proposed leases on sage-grouse populations.

By not prioritizing lease sales on lands outside of sage-grouse habitat and instead relying solely on site-level approaches to mitigate potential impacts, the BLM is failing to manage sage-grouse at landscape spatial scales. Lek persistence (i.e., the probability that a lek will remain active) and population-level genetic diversity are strongly related to habitat connectivity at larger spatial scales (Knick and Hanser 2011, Row et al. 2016). In the majority of cases in Wyoming, this suggests that landscape-scale

management of sage-grouse must occur across multiple priority areas including the general habitat areas situated between these priority habitats (Edmunds et al. 2017). Prioritizing the leasing and development of lands outside of PHMAs and GHMAs and in unsuitable or marginally-suitable habitats (see BLM IM No. 2016-143) represents the BLM's approach to managing sage-grouse at these larger scales.

Reasonably Foreseeable Impacts

The BLM does not provide an analysis of the potential impacts to sage-grouse of developing the parcels being proposed for lease in the EA and in other recent or proposed BLM lease sales (e.g., DOI-BLM-WY-D000-2018-0001-EA), instead indicating that, without a discrete development proposal, surface disturbing activities cannot be reasonably predicted and therefore impacts cannot be assessed until the APD stage (e.g., BHD EA pg. 3-1). But, the BLM acknowledges that "after a lease has been issued, the lessee has the right to use as much of the leased lands as is necessary to explore, drill for, mine, extract, remove, and dispose of the oil and gas resources" resulting in surface disturbance (HPD EA pg. 8). Given that the BLM expects surface impacts as a direct result of leasing, the potential for development of the leases should be seen as reasonably foreseeable, and when "impacts are reasonably foreseeable at the leasing stage, NEPA requires the analysis and disclosure of such reasonably foreseeable impacts" (HPD EA pg. 44). In this context, the absence of a discrete development proposal does not preclude an assessment of the impacts from development of the leases. Such development is a foreseeable possibility and the potential direct and indirect effects (HPD EA pg. 51) of that development on sage-grouse should be assessed prior to the leasing stage and that assessment should be used to inform the parcels that are offered for lease.

Site-specific Mitigation Measures:--Mitigation developed through the ARMPs was carried into the EAs (BHD EA pg. 1-1; HPD EA pg. 6), and the BLM acknowledges that compensatory mitigation may be necessary based on site-specific environmental analyses (BHD EA pg. 3-6; HPD EA pg. 9). Mitigation measures are established in the EAs as timing limitations (TL), controlled surface use (CSU), and no surface occupancy (NSO) stipulations specific to habitat designation (PHMA or GHMA) and season (lek, breeding or winter) by lease parcel. In general, TL stipulations are a restriction on all surface disturbing and/or disruptive activities in specific areas during specific seasons; CSU stipulations consist of an anthropogenic surface disturbance cap of 5% and a density cap of 1 energy facility per 640 acres in the DDCT assessment area in PHMA; and NSO stipulations are restrictions on all surface occupancy and surface disturbing activities within 0.6 mi and 0.25 mi of leks in PHMA and GHMA respectively (e.g., BHD EA pg. 3-41, Table 3-7). These stipulations are focused on restricting the density of infrastructure in priority habitats, and reducing anthropogenic activity levels during the drilling phases of development. As the ARMPs and prioritization requirements recognize, however, stipulations alone are not sufficient to avoid all adverse impacts. For example, TL stipulations do not apply to the operation and maintenance of production facilities (e.g., HPD pg. 45) and CSU stipulations do not account for distance-effects of infrastructure. NSO stipulations are focused on reducing distance effects, but the NSO buffer distances are not sufficient to eliminate disturbance to leks. This suggests that residual effects will remain after the minimization measures established in the EA are implemented. The BLM should recognize these specifically as reasonably foreseeable impacts and address them at the time of the lease sale, e.g., by deferring parcels and/or requiring additional compensatory mitigation measures.

Although results from studies investigating sage-grouse response to human activity suggest that timing restrictions may be effective while being implemented (Dzialak et al. 2012, Holloran et al. 2015), researchers have noted that timing restrictions on construction and drilling during the breeding season will not prevent impacts at other times of the year or during other phases of development (e.g., production phases) and therefore may not be sufficient to minimize impacts over the life of a development (Walker et al. 2007, Doherty et al. 2008). If BLM chooses to offer these lease parcels, mitigation measures that minimize human activity throughout the life of potential development projects (e.g., requiring liquid

gathering systems in PHMA; Holloran et al. 2015) should be considered by BLM and established at time of lease sale.

Several authors have reported a "distance-effect" associated with the infrastructure of energy fields whereby sage-grouse are negatively influenced to a greater extent if infrastructure is placed near seasonal habitat with the response diminishing as distances from the habitat to infrastructure increase (Manier et al. 2013). The majority of the research has investigated the response of lekking sage-grouse to energy development, with studies consistently reporting impacts from infrastructure on the number of males occupying leks to approximately 2 miles, with lesser impacts consistently apparent to approximately 4 miles (Holloran 2005, Walker et al. 2007, Tack 2009, Harju et al. 2010, Johnson et al. 2011). Additionally, distance-effects of infrastructure associated with energy developments of between approximately 0.9 and 1.7 miles on average have been noted during nesting, brood-rearing, and winter (Doherty et al. 2008, Carpenter et al. 2010, Holloran et al. 2010, Dzialak et al. 2011, LeBeau 2012, Dinkins 2013, Fedy et al. 2014). If BLM chooses to offer these lease parcels, mitigation measures that minimize the effects of infrastructure on surrounding habitats (e.g., spatial prioritization of infrastructure at the scale of an individual lease parcel) should be established by the BLM prior to offering a lease.

Cumulative Impacts ("death by 1,000 cuts"):--The local scale at which the BLM is restricting its assessment of impact establishes a situation where the agency's ability to assess the cumulative effects of leasing and subsequently developing the parcels being considered for sale is severely limited. In the BHD (pg. 3-36) and the HPD (pg. 63) EAs, the BLM indicates that analyses of cumulative impacts for reasonably foreseeable scenarios of oil and gas wells is presented in the respective ARMPs. The BLM defines cumulative effects as "the impact on the environment which results from the incremental impact of the action when added" to current conditions and other reasonably foreseeable future actions "regardless of what agency or person undertakes such other actions" (BHD EA pg. 3-1). Yet, the effects analyses presented in the FEISs do not explicitly investigate cumulative effects across impacts, but focus on estimating the amount of surface area influenced by a single impact cumulatively across that impact (e.g., gas and oil wells; Manier et al. 2013). These analyses are done at the scale of a Management Zone, and provide relative estimates of the total acreage influenced by each impact type by the alternatives considered in the FEISs. The cumulative effects assessments cited in the EAs do not investigate the potential "incremental impacts" of developing the proposed leases on sage-grouse, and therefore do not provide an estimate of cumulative effects as suggested in the EA. Further, the effects analyses presented in the FEISs are not spatially-explicit and were summarized at much larger spatial scales, minimizing their applicability of estimating effects of leases individually or cumulatively in Wyoming.

As stated earlier, the BLM concludes that they do not have the data necessary to conduct a more specific impact and/or cumulative effects analysis (BHD EA pg. 3-1). However, the Assessment, Inventory, and Monitoring (AIM) strategy developed by the BLM has a goal of providing guidance and data necessary to integrate key ecological attributes into resource allocation decisions (pg. 13), including providing the approaches and data necessary to evaluate cumulative effects of management actions necessary for assessments of the potential effects of landscape change (pg. 16; Toevs et al. 2011). Clearly the AIM strategy addresses the concerns established in the EA that a lack of data precludes the ability to investigate potential landscape-scale impacts of developing proposed leases. Therefore, if BLM chooses to offer these lease parcels, assessments of potential impacts of developing proposed leases following approaches established in the AIM strategy would provide the BLM with reasonably foreseeable impact forecasts at scales appropriate for assessing cumulative effects, and are critical prior to offering the leases.

The EAs' failure to analyze the cumulative impacts of reasonably foreseeable future development is also problematic because the FEISs for the ARMPs do not provide this information. The BLM concluded in the FEISs that, although implementation of the ARMPs is unlikely to preclude projects that may negatively impact sage-grouse populations from proceeding, protective measures considered in project-

specific analyses cumulatively will result in protection of sage-grouse populations (Bighorn Basin FEIS pgs. 7-49 and 7-50). The BLM also concludes in the FEISs (pg. 4-293) that "precise quantitative estimates of impacts generally are not possible because the exact locations of future actions are unknown, or habitat types affected by surface-disturbing activities cannot be predicted."

After deferring the issue in its FEISs, the BLM now seeks to defer it again by making the same argument in the EAs. In effect, BLM offers a circular argument that, both at the ARMP and leasing stages, avoids addressing the need to manage at landscape spatial scales or consider cumulative effects of actions proposed.

Another issue with the BLM's site-specific approach to mitigation involves invasive plants. At the time of a site-specific application (e.g., an APD), vegetation including invasive species will be identified and the BLM may establish stipulations aimed at managing invasive species at that time (BHD EA pg. 3-35). This reliance on local-scale assessments and actions again restricts the ability of the BLM to manage sage-grouse habitats effectively at landscape spatial scales. The BLM acknowledges that "increased surface disturbance, motorized transportation, and human activity would increase the chance for invasive plants to establish and spread" (Bighorn Basin FEIS pg. 7-37). The primary concern in Wyoming is the spread of cheatgrass and the resulting changes in fire frequency which ultimately eliminate fire-intolerant species such as sagebrush from the landscape (Miller et al. 2011). The first principle in the Integrated Rangeland Fire Management Strategy (2015) developed by the BLM is to work at landscape scales precluding the need to develop management actions at multiple individual sites (pgs. 6 and 7). Further, in the National Framework for safeguarding America's lands from invasive species, the U.S. Department of Interior (2016) suggests that "preventing the introduction of invasive species is the first line of defense against biological invasion" (pg. 1). Therefore, given the need to work at landscape spatial scales to prevent the establishment of invasive plant species and safeguard against the resulting changes to fire frequency, and the importance of this prevention for the long-term maintenance of the sagebrush habitats sage-grouse depend, the BLM should consider the introduction and/or proliferation of invasive annual grasses a reasonably foreseeable impact and assess the potential consequences of these impacts prior to leasing. If BLM chooses to offer these lease parcels, assessments of potential impacts of the introductions and/or proliferation of cheatgrass as a result of developing proposed leases following approaches established as the Fire and Invasives Assessment Tool (www.sciencebase.gov/catalog/item/573d91f3e4b0dae0d5e57f83) would provide the BLM with reasonably foreseeable impact forecasts at scales appropriate for assessing cumulative effects, and are critical prior to offering the leases.

The site-specific scale at which the BLM is restricting their assessment of potential impact establishes a situation where the cumulative impacts of leasing and subsequently developing the parcels being considered for sale may not be realized until regional monitoring metrics suggest an adverse effect has already occurred (i.e., lek-based metrics assessed at the scale of a BLM Field Office; e.g., Casper/Newcastle ARMP Appendix D pg. 189). Sage-grouse are a landscape species (Connelly et al. 2004), yet within this landscape sage-grouse rely on habitats with a diversity of species and subspecies of sagebrush interspersed with a variety of other habitats (e.g., riparian meadows, agricultural lands, grasslands) that are used by sage-grouse during certain times of the year (e.g., summer) or during certain years (e.g., severe drought; Connelly et al. 2011). The diversity of resources sage-grouse require seasonally and annually must be considered holistically to provide the large, functional, connected habitat patches necessary to sustain the species. Edmunds et al. (2017) suggest that population trends within relatively small management areas (i.e., core areas; Wyoming EO 2015-4) can differ from trends in the overall management unit, indicating that regional-scale assessment metrics may not accurately depict what is occurring within the region. This suggests that an impact could be successfully mitigated at the site level, yet impacts may remain at larger scales (e.g., impacts to a critical travel corridor between seasonal ranges; impacts to a regionally-limiting seasonal habitat type); and these residual impacts would

go unnoticed until regional populations suffer. This is especially the case in much of Wyoming where the accumulated impact of developing multiple recent lease sales in sage-grouse habitat could be substantial. The BLM should address the potential cumulative effects of the potential consequences of developing each lease parcel (i.e., in the context of baseline or existing conditions) and all lease parcels in combination prior to proposing the leases to ensure that regional populations of sage-grouse are adequately mitigated for the multi-scale residual effects associated with developing the leases. Regional-scale impacts not sufficiently mitigated at the local scale could contribute to sage-grouse population declines at scales much larger than the management approach promoted by the BLM in the EAs, suggesting that user groups across the region could be impacted by actions resulting from the leasing of any individual parcel.

Literature Cited

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Connelly, J. W., S. T. Knick, M. A. Schroeder, and S. J. Stiver. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Western Association of Fish and Wildlife Agencies. Unpublished Report. Cheyenne, WY, USA.

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PERSONAL

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EDUCATION

2005 Ph.D., Zoology and Physiology, University of Wyoming, Laramie, WY, USA. Dissertation: *Greater sage-grouse* (Centrocercus urophasianus) *population response to natural gas field development in western Wyoming.* Dr. Stanley H. Anderson, advisor.

1999 M.S., Zoology and Physiology, University of Wyoming, Laramie, WY, USA. Thesis: *Sage grouse* (Centrocercus urophasianus) *seasonal habitat use near Casper, Wyoming.* Dr. Stanley H. Anderson, advisor.

1991 B.S., Biology, Colorado College, Colorado Springs, CO, USA.

RECENT POSITIONS HELD

2015 – present	Principal; Operational Conservation, LLC
2013 – present	Chief Scientist; Wildlife Management Research Support (a fiscally-sponsored nonprofit research organization)
2005 – 2015	Principal and Senior Ecologist; Wyoming Wildlife Consultants, LLC
2002 – 2005	Doctoral Researcher; Wyoming Cooperative Fish and Wildlife Research Unit; University of Wyoming
1999 – 2005	Research Scientist; Wyoming Cooperative Fish and Wildlife Research Unit; University of Wyoming

PROFESSIONAL EXPERIENCE

2005 – present: **Principal, Operational Conservation, LLC; Chief Scientist, Wildlife Management Research Support; Principal and Senior Ecologist, Wyoming Wildlife Consultants, LLC.**
Dr. Robert Crabtree (Fiscal Sponsor for Wildlife Management Research Support), President and Chief Scientist, Yellowstone Ecological Research Center; 2048 Analysis Drive, Suite B; Bozeman, MT 59718; crabtree@yellowstoneresearch.org.

I design, initiate and direct research and management programs specializing in long-term, coordinated conservation efforts focused towards science-based management of wildlife resources in the intermountain western U.S. The mission of my program is to develop and implement science-based solutions to wildlife management and conservation concerns. I am actively involved as a member of several multi-stakeholder working groups, technical teams, and advisory panels for conservation and management organizations where I routinely advise the development of science-based policies for the protection of wildlife populations and habitats. I have been working in the west for over 20 years developing and implementing conservation efforts aimed at enhancing greater sage-grouse and other sagebrush obligate species' habitats and populations. More recently I have been involved in a community-based program aimed at enhancing grassland habitats for neotropical migrants in the northern Great Plains. My duties include designing, funding, managing, analyzing, publishing and presenting orally original research and conservation approaches; fostering collaborative relationships and partnerships with state and federal agencies, industry, private landowners, NGOs and academia; managing research and business finances; supervising staff; and providing technical expertise for a wide variety of projects. I have authored or helped to author over 20 peer-reviewed publications, and regularly give presentations concerning wildlife and habitat conservation at professional conferences and to the general public. The day-to-day responsibilities of being a small business owner have provided me with unique and expanded leadership,

supervisory, team-building and collaboration, fundraising, budgeting and financial management, and communication experience.

Project-specific Information:

- *The Sagebrush Institute.* Co-PI. I am designing and initiating a Sagebrush Institute, which is a holistic strategy for implementing sustained conservation across the breadth of the sagebrush ecosystem, with a focus on building local-scale management into landscape-scale conservation. The premise for the Institute is that the work done to support sage-grouse conservation provides an opportunity to pursue the conservation model of the future, conceived broadly to encompass the sagebrush landscape as well as the multiple species and people that rely thereon. Financial support provided by the National Audubon Society.
- *North American Grassland Bird Conservation Program.* Co-PI. I am designing and implementing monitoring and conservation efficacy protocols for the National Audubon Society and their Conservation Ranching program in grasslands throughout the central flyway. Conservation Ranching is a landowner-focused program with the goal of providing economic security to participating landowners through the conservation of grassland habitats. These are regional-level efforts built on a foundation that can be applied across the grassland as well as other ecosystems (e.g., sagebrush). Financial support provided by the Margaret A. Cargill Foundation, the National Audubon Society and Ducks Unlimited.
- *Thunder Basin Coordination Initiative – Conservation on a Landscape Scale.* Co-PI. I am working with the Thunder Basin Grassland Prairie Ecosystem Association and the National Audubon Society in a coordinated on-the-ground conservation project in northeastern Wyoming detailing the steps required to move from planning conservation to implementing measures in a coordinated fashion to maximize landscape-scale conservation effect. Financial support provided by the Margaret A. Cargill Foundation.
- *Range-wide Greater Sage-Grouse Compensatory Mitigation Plan for the Bureau of Land Management.* Species Expert. I was a co-author of a comprehensive sage-grouse mitigation approach for the Bureau of Land Management lead by the Wildlife Conservation and Mitigation Program at Texas A&M Institute of Renewable Natural Resources.
- *Wyoming sage-grouse core area health assessment.* Co-PI. Project designed to quantify the response of sage-grouse populations to the implementation of the Greater Sage-grouse Core Area Policy in Wyoming. Financial support provided by the Wyoming Governor's Office, Wyoming Sage-grouse Local Working Groups, and the Pinedale Field Office of the Bureau of Land Management.
- *Greater sage-grouse habitat quantification tool: a multi-scaled approach for assessing impacts and benefits to greater sage-grouse habitat.* Species Expert. Colorado Parks and Wildlife and Environmental Defense Fund (EDF) project designed to develop and implement a Habitat Exchange for sage-grouse in Colorado and Wyoming. I worked on the science advisory team developing the habitat quantification tool. The habitat quantification approaches developed also provide the foundation for the Habitat Exchange established in Nevada. I continue to provide technical support to EDF staff assisting the development of a Habitat Exchange in Montana.
- *Upper Green River Conservancy.* Species Expert. I provide technical support for the development and implementation of a sagebrush landscape-focused conservation bank in southwestern Wyoming in support of WRA, Inc.
- *Sage-grouse and energy development: predicting population response to infrastructure for adaptively informing management and conservation.* Co-PI. Project designed to develop decision support tools (DSTs) and a framework for DST implementation for use minimizing on-site impacts of energy development to nesting female sage-grouse at the scale of an energy development. Financial support provided by the Wyoming State Office of the Bureau of Land Management.
- *Modeling sage-grouse habitat suitability in the Thunder Basin, Wyoming.* Co-PI. Project designed to develop spatial tools for informing and prioritizing sage-grouse conservation and restoration actions throughout northeastern Wyoming in support of a Candidate Conservation Agreement/with Assurances (CCA/CCAA). Financial support provided by the Thunder Basin Grassland Prairie Ecosystem Association and the Northeast Wyoming Sage-grouse Local Working Group.
- *Review of Draft and Final Greater Sage-grouse Environmental Impact Statements and Land Use Plan Amendments.* Species Expert. I reviewed and provided written and oral comment on the scientific rigor of the

draft and final EISs and LUPAs developed for sage-grouse across the western U.S. in support of the Pew Charitable Trust.

- *Enhancing fitness or gizzard envy: are sage-grouse selecting winter habitats in southwestern Wyoming with an eye towards eating dirt?* Co-PI. Field study designed to assess the importance of the availability and distribution of geophagy sites (places where soil is consumed) to sage-grouse selection of winter habitats in southwestern Wyoming. Financial support provided by the Upper Green River Basin Sage-grouse Local Working Group, the Wyoming Landscape Conservation Initiative, the Wyoming State Office of the Bureau of Land Management, and the Wyoming Agriculture Producer Research Grant Program.
- *Mitigation by Design: making the connection between habitat, disturbance, restoration and resource economics.* Co-PI. Project designed to define relationship(s) between: (a) wildlife habitat use and demographics, (b) impacts of development on ecosystem function and habitat values, and (c) restoration practices and costs to infer opportunity cost of energy development (based on cost of recovery). Financial support provided by the U.S. Geological Survey.
- *A study of the impacts of a wind energy development on greater sage-grouse in southeastern Wyoming.* Co-PI. Field study designed to assess the population-level effects of wind energy development on female sage-grouse seasonal habitat selection and demography. Financial support provided by multiple entities including: PacifiCorp Energy, EDP Renewables North America, Iberdrola Renewables, EnXco, National Wind Coordinating Collaborative, Shirley Basin/Bates Hole, Southwest and South Central Wyoming Local Sage-grouse Working Groups, United States Department of Energy, Wyoming Reclamation and Restoration Center and School of Energy Resources at the University of Wyoming, Avian Power Line Interaction Committee, the American Wind Energy Association, and the Margaret and Sam Kelly Ornithological Research Fund. Data collected during the first 2 years of this study were transferred to the University of Wyoming resulting in the MS thesis: *Evaluation of Greater Sage-Grouse Reproductive Habitat and Response to Wind Energy Development in South-Central, Wyoming* (LeBeau 2012).
- *Greater sage-grouse habitat enhancement plan in support of the wildlife hazard management plan for the Jackson Hole Airport.* Species Expert. I designed monitoring and adaptive management protocol, and advised on project implementation in support of a collaboratively developed sage-grouse habitat management and mitigation plan for Grand Teton National Park, Wyoming. I continue to provide technical support for the development of the EA necessary to implement the management actions suggested in support of EnviroSystems Management Inc.
- *Grazing influence, objective development, and management in Wyoming's greater sage-grouse habitat with emphasis on nesting and early brood-rearing.* Species Expert. State of Wyoming project designed to develop livestock grazing protocols for sage-grouse population conservation and sagebrush habitat management in Wyoming. I was a member of the team developing these protocols and assisted writing the report.
- *Sigurd to Red Butte No. 2 Transmission Line Environmental Impact Statement.* Species Expert. I assisted developing and writing the impact and mitigation assessment sections of the Sigurd to Red Butte transmission line EIS in support of EPG, Inc.
- *Wyoming Basin Rapid Ecoregional Assessment.* Species Expert. U.S. Geological Survey project designed to develop a rapid ecoregional assessment for the Wyoming Basin, with the goal of providing information to the Bureau of Land Management in support of regional planning and analysis for management of ecological resources in the region. I provided direction to the assessment of sagebrush habitats and sagebrush-dependent species and wrote these portions of the report.
- *Assessing the effectiveness of southwestern Wyoming core areas for greater sage-grouse conservation: a spatially-explicit demographic approach using management and resource development scenarios.* Species Expert. USGS project designed to develop decision support tools for exploring the implications of alternative resource development scenarios on individual sage-grouse in Wyoming. I assisted parameterizing models required to address objectives.
- *A study of the vegetative response of mule deer winter range to fertilization in southwestern Wyoming.* Co-PI. Field study designed to assess the effects of fertilization on mule deer winter range quality. Financial support provided by the Pinedale Anticline Project Office.
- *Greater sage-grouse seasonal habitat selection and demographics on a landscape destined for an in-situ uranium mine.* PI. Field study designed to establish a pre-development baseline for a sage-grouse population

that may be influenced by *in-situ* uranium mining activity such that a post-development BACI-designed study could be conducted. Financial support provided by Ur-Energy.

- *Holistic greater sage-grouse management on a ranch destined for wind development.* PI. Field study designed to forecast the population-level response of sage-grouse to wind energy development and use those projections to guide proactive conservation as informed through empirically-informed state-and-transition models. Financial support provided by Pathfinder Renewable Wind Energy, LLC.
- *Winter habitat selection of greater sage-grouse relative to activity levels at natural gas well pads in southwestern Wyoming.* PI. Field study designed to estimate differences in responses of wintering sage-grouse to natural gas field infrastructures with different levels of recurring human activity thereby empirically investigating a potential option for reducing on-site impacts of energy development to the species. Financial support provided by multiple entities including: Shell Rocky Mountain Production, QEP Energy Company, Ultra Resources Inc., Tom Thorne Sage-grouse Conservation Fund, and the Upper Green River Basin Wyoming Sage-grouse Local Working Group.
- *Identifying habitats for greater sage-grouse population persistence on Atlantic Rim, Rawlins, Wyoming: A process of protecting specific areas within a developing natural gas field critical for population sustainability in an adaptive management framework.* Research Initiator. Field study designed to identify areas-of-critical-conservation-concern based on limiting seasonal habitats, risk assessment, multi-seasonal occurrence, and seasonal juxtaposition for informing infrastructure placement within a developing gas field. This study was transferred to the University of Wyoming resulting in the MS thesis: *Quantifying habitat importance for greater sage-grouse (*Centrocercus urophasianus*) population persistence in an energy development landscape* (Kirol 2012).
- *Habitat mitigation planning for greater sage-grouse in the Upper Green River Basin, Wyoming.* PI. Field study designed to compile the wildlife and vegetative information, and establish the landowner contacts required to effectively prepare allotment scale habitat management plans. Financial support provided by the Tom Thorne Sage-grouse Conservation Fund, Upper Green River Basin Sage-grouse Local Working Group, and the North American Grouse Partnership.
- *Yearling greater sage-grouse response to energy development in Wyoming.* PI. Field study designed to ascertaining if natural-gas development influenced the distribution of, or the probability of recruiting into the breeding population yearling male and female sage-grouse. Financial support provided by multiple entities including: Bureau of Land Management, U.S. Department of Energy, Wyoming Game and Fish Department, Yellowstone-to-Yukon Initiative, EnCana Oil & Gas Inc., Ultra Resources Inc., and Shell Rocky Mountain Production.

2002 – 2005: **Ph.D. Candidate; University of Wyoming.**
Dr. Stanley H. Anderson (Advisor [deceased]); Leader, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, WY 82071; Dr. Matt Kaufman (*current unit leader*), (307) 766-5415 (voice); mkauffm1@uwyo.edu.

Project-specific Information:

- Doctoral researcher for the study: *Holloran, M. J. 2005. Greater sage-grouse* (Centrocercus urophasianus) *population response to natural gas field development in western Wyoming. Dissertation, University of Wyoming, Laramie, USA.* Field study designed to determine if and how the development of natural gas resources influenced greater sage-grouse populations in the upper Green River Basin of southwestern Wyoming.

1999 – 2005: **Research Scientist; Wyoming Cooperative Fish and Wildlife Research Unit.**
Dr. Stanley H. Anderson (Supervisor [deceased]); Leader, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, WY 82071; Dr. Matt Kaufman (*current unit leader*), (307) 766-5415 (voice); mkauffm1@uwyo.edu.

Project-specific Information:

- *Grazing system and linear corridor influences on greater sage-grouse* (Centrocercus urophasianus) *habitat selection and productivity.* Research Initiator. Field study designed to determine the effects of differing cattle

grazing practices on sagebrush dominated landscapes as they relate to sage-grouse seasonal habitat selection and productivity. This study was transferred resulting in an MS thesis (Kuipers 2004).

- *Sage-grouse* (Centrocercus urophasianus) *use of different-aged burns and the effects of coyote control in southwestern Wyoming.* Research Initiator. Field study designed to determine the temporal effects to sage-grouse survival and productivity of prescribed fire by quantifying use of different aged sagebrush burns. This study was transferred resulting in an MS thesis (Slater 2003).
- *Greater sage-grouse seasonal habitat selection and survival in Jackson Hole, Wyoming.* PI. Study designed to document sage-grouse seasonal habitat selection and survival, identified limiting seasonal range(s), and quantified habitat conditions associated with sustainable and increasing productivity in an isolated sage-grouse population in western Wyoming.

RECENT PEER-REVIEWED PUBLICATIONS and REPORTS

Wuenschel, A., A. L. Hild, G. B. Paige, and M. J. **Holloran**. *In Review.* Structural patterns in habitat revealed upon a fine-scale, spatially explicit investigation. Ecosphere.

Burkhalter, C., M. J. **Holloran**, B. C. Fedy, H. E. Copeland, R. L. Crabtree, S. C. Jay, B. A. Rutledge, and A. G. Holloran. *In Press.* Assessing landscape-scale habitat condition for an imperiled avian species: the greater sage-grouse in Wyoming. Animal Conservation.

Decker, K, A. Pocewicz, S. Harju, M. **Holloran**, M. Fink, T. P. Toombs, and D. B. Johnston. 2017. Landscape disturbance models consistently explain variation in ecological integrity across large landscapes. Ecosphere 8:e01775. 10.1002/ecs2.1775

LeBeau, C. W., J. L. Beck, G. D. Johnson, R. M. Nielson, M. J. **Holloran**, K. G. Gerow, and T. L. McDonald. 2017. Greater sage-grouse male lek counts relative to wind energy development. Wildlife Society Bulletin; DOI: 10.1002/wsb.725.

LeBeau, C. W., G. D. Johnson, M. J. **Holloran**, J. L. Beck, R. M. Nielson, M. Kauffman, E. Rodemaker, and T. L. McDonald. 2017. Greater sage-grouse, habitat selection, survival, and wind energy infrastructure. Journal of Wildlife Management; DOI: 10.1002/jwmg.21231.

Zabihi, K., G. B. Paige, A. L. Hild, S. N. Miller, A. Wuenshel, and M. J. **Holloran**. 2017. A fuzzy logic approach to analyze suitability of nesting habitat for greater sage-grouse in western Wyoming. Journal of Spatial Science; DOI: 10.1080/14498596.2017.1292965.

Holloran, M. J., B. C. Fedy, and J. Dahlke. 2015. Winter habitat use of greater sage-grouse relative to activity levels at natural gas well pads. Journal of Wildlife Management 79:630-640.

Kirol, C. P., J. L. Beck, S. V. Huzurbazar, M. J. **Holloran**, and S. N. Miller. 2015. Identifying greater sage-grouse source and sink habitats for conservation planning in an energy development landscape. Ecological Applications 25:968-990. http://dx.doi.org/10.1890/13-1152.1

Fedy, B. C., K. E. Doherty, C. L. Aldridge, M. O'Donnell, J. L. Beck, B. Bedrosian, M. J. **Holloran**, G. D. Johnson, N. W. Kaczor, C. P. Kirol, C. A. Mandich, D. Marshall, G. McKee, C. Olson, A. Pratt, C. C. Swanson, and B. L. Walker. 2014. Habitat prioritization across large landscapes, multiple seasons, and novel areas: an example using greater sage-grouse in Wyoming. Wildlife Monographs 190:1-39.

LeBeau, C. W., J. L. Beck, G. D. Johnson, and M. J. **Holloran**. 2014. Short-term impacts of wind energy development on greater sage-grouse fitness. Journal of Wildlife Management 78:522-530.

Manier, D. J., D. J. A. Wood, Z. H. Bowen, R. M. Donovan, M. J. **Holloran**, L. M. Juliusson, K. S. Mayne, S. J. Oyler-McCance, F. R. Quamen, D. J. Saher, and A. J. Titolo. 2013. Summary of science, activities, programs, and policies that influence the rangewide conservation of greater sage-grouse (*Centrocercus urophasianus*). U.S. Geological Survey Open-File Report 2013-1098. http://pubs.usgs.gov/of/2013/1098/

Fedy, B. C., C. L. Aldridge, K. E. Doherty, M. O'Donnell, J. L. Beck, B. Bedrosian, M. J. **Holloran**, G. D. Johnson, N. W. Kaczor, C. P. Kirol, C. A. Mandich, D. Marshall, G. McKee, C. Olson, C. C. Swanson, and B. L. Walker. 2012. Interseasonal movements of greater sage-grouse, migratory behavior, and an assessment of the core regions concept in Wyoming. Journal of Wildlife Management 76:1062-1071.

Johnson, D. H., M. J. **Holloran**, J. W. Connelly, S. E. Hanser, C. L. Amundson, and S. T. Knick. 2011. Influences of environmental and anthropogenic features on greater sage-grouse populations, 1997-2007. pp. 407-450 in S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA, USA.

Naugle, D. E., K. E. Doherty, B. L. Walker, H. E. Copeland, M. J. **Holloran**, and J. D. Tack. 2011. Sage-grouse and cumulative impacts of energy development. pp. 55-70 in D. E. Naugle (editor). Energy development and wildlife conservation in western North America. Island Press, Washington, DC, USA.

Naugle, D. E., K. E. Doherty, B. L. Walker, M. J. **Holloran**, and H. E. Copeland. 2011. Energy development and greater sage-grouse. pp. 489-503 in S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA, USA.

Holloran, M. J., R. C. Kaiser, and W. A. Hubert. 2010. Yearling Greater Sage-grouse Response to Energy Development in Wyoming. Journal Wildlife Management 74:65-72.

Cagney, J., E. Bainter, B. Budd, T. Christiansen, V. Herren, M. **Holloran**, B. Rashford, M. Smith and J. Williams. 2010. Grazing influence, objective development, and management in Wyoming's greater sage-grouse habitat with emphasis on nesting and early brood-rearing. University of Wyoming Cooperative Extension Service report B-1203. University of Wyoming, Laramie, USA.

Johnson, G., and M. **Holloran**. 2010. Greater sage-grouse and wind energy development: a review of the issues. Renewable Northwest Project, Portland, OR, USA. http://www.rnp.org/node/956

Kiesecker, J. M., H. Copeland, A. Pocewicz, N. Nibbelink, B. McKenney, J. Dahlke, M. **Holloran**, and D. Stroud. 2009. A framework for implementing biodiversity offsets: selecting sites and determining scale. BioScience 59:77-84.

Thompson, K. M., M. J. **Holloran**, S. J. Slater, J. L. Kuipers, and S. H. Anderson. 2006. Early brood-rearing habitat use and productivity of greater sage-grouse in Wyoming. Western North American Naturalist 66:332-342.

Holloran, M. J., and S. H. Anderson. 2005. Greater sage-grouse population response to natural gas development in western Wyoming: are regional populations affected by relatively localized disturbances? Transactions North American Wildlife and Natural Resources Conference 70:160-170.

Holloran, M. J., and S. H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. Condor 107:742-752.

Holloran, M. J., B. J. Heath, A. G. Lyon, S. J. Slater, J. L. Kuipers, and S. H. Anderson. 2005. Greater sage-grouse nesting habitat selection and success in Wyoming. Journal Wildlife Management 69:638-649.

Holloran, M. J., and S. H. Anderson. 2004. Greater sage-grouse seasonal habitat selection and survival in Jackson Hole, Wyoming. Completion Report. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, USA.

Holloran, M. J., and S. H. Anderson. 2003. Direct identification of northern sage-grouse, *Centrocercus urophasianus*, nest predators using remote sensing cameras. Canadian Field-Naturalist 117:308-310.

GRADUATE COMMITTEE INVOLVEMENT

- Wuenschel, Amarina. 2014. *Ecological and Fine-Scale Spatial variation in Vegetation at Sage-grouse Nests in western Wyoming*. Thesis, Department of Ecosystem Science and Management, University of Wyoming, Laramie, USA.
- Kirol, Christopher, P. 2012. *Quantifying habitat importance for greater sage-grouse (*Centrocercus urophasianus*) population persistence in an energy development landscape*. Thesis, Department of Ecosystem Science and Management, University of Wyoming, Laramie, USA.
- LeBeau, Chad, W. 2012. *Evaluation of Greater Sage-Grouse Reproductive Habitat and Response to Wind Energy Development in South-Central, Wyoming.* Thesis, Department of Ecosystem Science and Management, University of Wyoming, Laramie, USA.
- Macsalka, Natalie. 2011. *Assessing the conflict between wind energy development and sage-grouse conservation in Wyoming: An application using a spatially-explicit wind development model.* Thesis, Department of Agricultural and Applied Economics, University of Wyoming, Laramie, USA.

SELECT PROFESSIONAL PRESENTATIONS

2016 Holloran, M. J. (presenter). *How does science fit into Audubon's Conservation Ranching Program?* Audubon Rockies Conservation Ranching Workshop, Rapid City, SD, USA. *Invited*

2015 Holloran, M. J. (presenter). *Rangeland Monitoring.* Wyoming Sage-grouse Habitat Restoration Workshop, Casper, WY, USA. *Invited*

2014 Holloran, M. J. (panelist). *Sage-grouse and the Endangered Species Act.* 2014 Wyoming Energy Summit, Casper, WY, USA. *Invited*

2012 Holloran, M. J. (presenter) and J. Dahlke. *Burrowing owl nest predictive modeling for the Normally Pressured Lance (NPL) project area.* Wyoming Landscape Conservation Initiative 2012 Science Workshop, Rock Springs, WY, USA. *Offered*

2011 Holloran, M. J. (presenter). *Sage-grouse and natural gas development: lessons learned.* Northwest Wind Energy and Wildlife Symposium, Portland, OR, USA. *Invited*

2010 Holloran, M. J. (presenter). *Impacts of energy development on greater sage-grouse habitats in Wyoming.* 16th Wildland Shrub Symposium: Threats to Shrubland Ecosystem Integrity, Logan, UT, USA. *Invited*

2009 Holloran, M. J. (presenter). *Greater sage-grouse and energy development in Wyoming.* U.S. Forest Service Rocky Mountain Region Annual Wildlife Workshop, Fort Collins, CO, USA. *Invited*

2008 Holloran, M. J. (panelist). *Sage-grouse.* Wyoming Perspectives on Wyoming PBS. Riverton, WY, USA. *Invited*

2008 Holloran, M. J. (presenter). *The greater sage-grouse.* Wyoming Sage-grouse Conference: Proactively managing sage-grouse and their habitat on Wyoming's agricultural lands, Lander, WY, USA. *Invited*

2006 Holloran, M. J. (presenter). *Greater sage-grouse and livestock grazing in Wyoming.* The Wyoming Chapters of the Soil and Water Conservation Society and the Society for Range Management Annual Meeting, Sheridan, WY, USA. *Invited*

2005 Holloran, M. J. (presenter) and S. H. Anderson. *Greater sage-grouse response to natural gas field development in Wyoming.* X^{th} International Grouse Symposium, Luchon, France. *Offered*

2005 Holloran, M. J. (presenter) and S. H. Anderson. *Greater sage-grouse response to natural gas field development: are regional population levels affected?* 70^{th} North American Wildlife and Natural Resources Conference, Arlington, VA, USA. *Invited*

GROUP MEMBERSHIP

- Member of the Council of Scientists for the North American Grouse Partnership.
- Member of the Conservation Advisory Committee for the Thunder Basin Grasslands Prairie Ecosystem Association assisting the implementation of a CCAA/CCA.
- Member of the Advisory Committee for the Wyoming Natural Diversity Database.
- Past president of the Wyoming Chapter of The Wildlife Society.
- Member of the Wyoming State Governor's greater sage-grouse conservation task force.

REFERENCES

Available Upon Request

Exhibit 6

Report on Wyoming Lease Sale 1st Qtr 2018

By Ken Kreckel

Overview

This purpose of this report is to evaluate oil and gas leases offered in the 2018 1st Quarter Lease Sale of federal lands in Wyoming. This evaluation is done with an eye towards application of the criteria presented in BLM's Instruction Memorandum No. 2016-143. As stated in the memo: "This Instruction Memorandum (IM) provides guidance on prioritizing implementation decisions for Bureau of Land Management (BLM) oil and gas leasing and development." The criteria for leasing decisions are as follows.

First, the IM directs that BLM will first consider leasing parcels outside of priority habitat management areas (PHMAs) and general habitat management areas (GHMAs) for greater sage-grouse. Then lands in GHMAs may be considered in the prioritization sequence, followed by lands in PHMAs.

Second, when considering parcels within each category, BLM is to apply the following factors in prioritizing parcels:

1. Parcels immediately adjacent or proximate to existing oil and gas leases and development operations or other land use development should be more appropriate for consideration before parcels that are not near existing operations. This is the most important factor to consider, as the objective is to minimize disturbance footprints and preserve the integrity of habitat for conservation.
2. Parcels that are within existing Federal oil and gas units should be more appropriate for consideration than parcels not within existing Federal oil and gas units.
3. Parcels in areas with higher potential for development (for example, considering the oil and gas potential maps developed by the BLM for the GRSG Plans) are more appropriate for consideration than parcels with lower potential for development. The Authorized Officer may conclude that an area has "higher potential" based on all pertinent information, and is not limited to the Reasonable Foreseeable Development (RFD) potential maps from Plans analysis.
4. Parcels in areas of lower-value sage-grouse habitat or further away from important life-history habitat features (for example, distance from any active sage-grouse leks) are more appropriate for consideration than parcels in higher-value habitat or closer to important life-history habitat features (i.e. lek, nesting, winter range areas). At the time the leasing priority is determined, when leasing within GHMA or PHMA is considered, BLM should consider, first, areas determined to be non-sage-grouse habitat and then consider areas of lower value habitat.
5. Parcels within areas having completed field-development Environmental Impact Statements or Master Leasing Plans that allow for adequate site-specific mitigation and are in conformance with the objectives and provisions in the GRSG Plans may be more appropriate for consideration than parcels that have not been evaluated by the BLM in this manner.
6. Parcels within areas where law or regulation indicates that offering the lands for leasing is in the government's interest (such as in instances where there is drainage of Federal minerals, 43 CFR

§ 3162.2-2, or trespass drilling on unleased lands) will generally be considered more appropriate for leasing, but lease terms will include all appropriate conservation objectives and provisions from the GRSG Plans.

7. As appropriate, use the BLM's Surface Disturbance Analysis and Reclamation Tracking Tool (SDARTT) to check EOI parcels in PHMA, to ensure that existing surface disturbance does not exceed the disturbance and density caps and that development of valid existing rights (Solid Minerals, ROW) for approved-but-not-yet-constructed surface disturbing activities would not exceed the caps.

The majority of the sale tracts should be a lower priority for leasing under IM 2016-143. Most of the lease parcels are located in PHMA and/or GHMA. Moreover the bulk of the lease offerings are scattered throughout regions of Wyoming that have not experienced recent oil and gas development. An exception are tracts 47 through 50, located in T43-44N, R70 W, in and around the Hilight Oil and Gas Field in the Powder River Basin, which appear to meet some of the prioritization factors.

On the other hand, this area has seen a large increase in drilling due to the application of horizontal drilling coupled with artificial fracturing. This has opened a number of upper Cretaceous oil reservoirs to development, resulting in a large increase in oil production from the basin since 2010. This development is ongoing with multiple operators pursuing multiple reservoirs. The tracts up for leasing lie in and directly east of a large Cretaceous Turner formation development, as described in the following:

Tracts 47-50 [T43-44N, R70W] Parcels immediately adjacent or proximate to existing oil and gas leases and development operations and in an area with higher potential for development

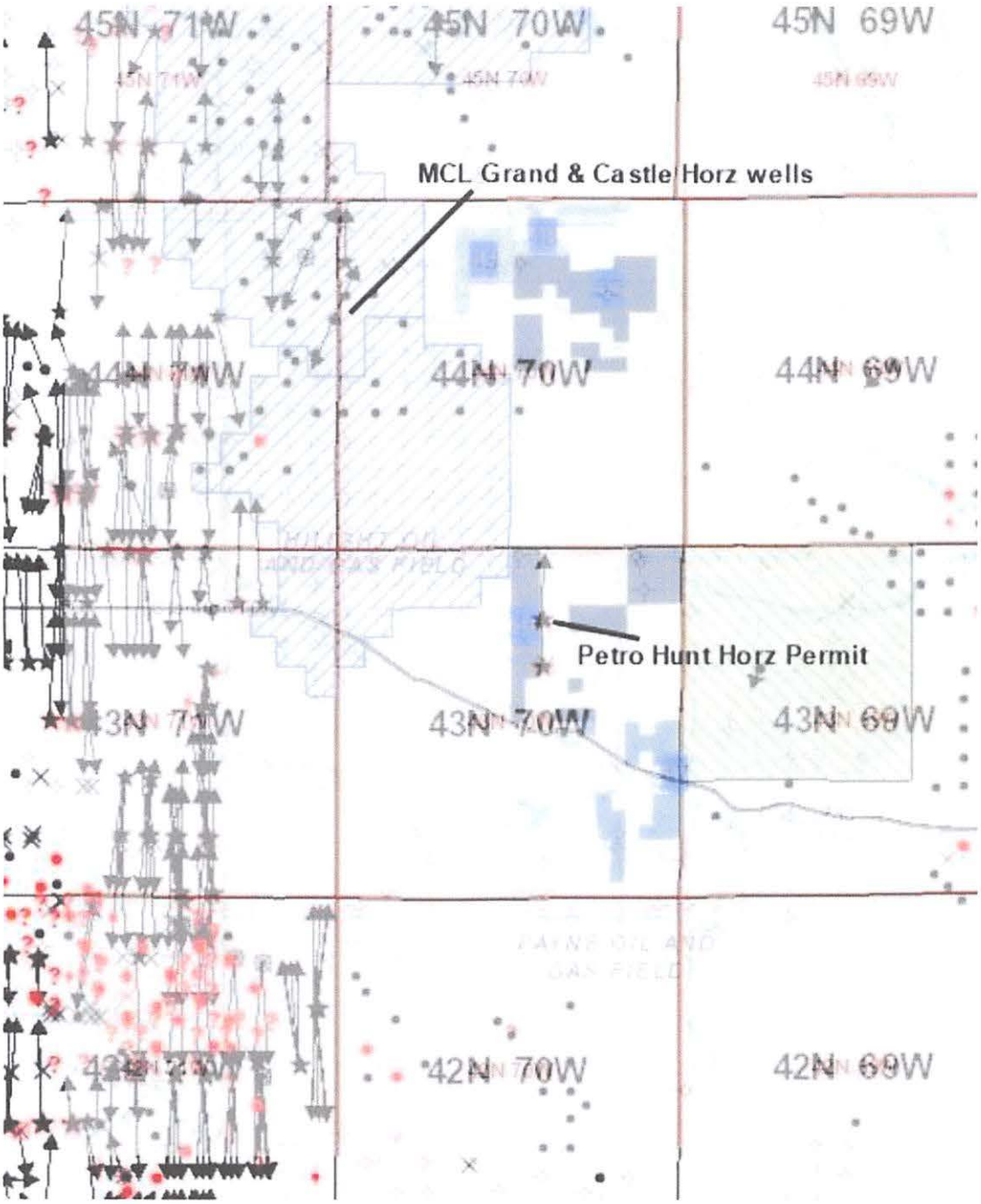


Figure 1: Sale tracts in blue. Note large number of offsetting horizontal wells and permits

Just to the west of the tracts are numerous permitted locations and several producing horizontal wells. Many of these are recent [2017] permits by Petro-hunt and others. The majority are dual wing horizontal wells targeting the Turner Formation. Of particular note is the Petro-Hunt permitted horizontal wells in 43N, 70W, as these are directly in and amongst tract 46, illustrating the near-term potential for development of this tract. Significantly these permits are being held confidential by the Wyoming Oil & Gas Commission.

Drilled wells of note are the MCL Grand 7-14 TH and Castle 13-41TH horizontal wells. These two wells were drilled in 2014 and have produced 110MBO, 151MMCF, and 75MBO, 137MMCF respectively from the Turner. Another Petro-Hunt horizontal well, located in the south half of 44N, 71W, produced 134MBO and 468MMCF since 2011.

All of this activity suggests that tracts 47-50 are "immediately adjacent or proximate to existing oil and gas leases and development operations" and these parcels are "in areas with higher potential for development." These are two factors considered under IM 2016-143. However, the lease parcels do not appear to satisfy two other prioritization factors: they are not located in an existing federal unit, and do not appear to be in an area covered by a field-development EIS.

Moreover, some of these tracts apparently lie in sage grouse management areas. See High Plains District EA Appx. A at 4.[1] This would indicate these parcels should be a lower priority for leasing.

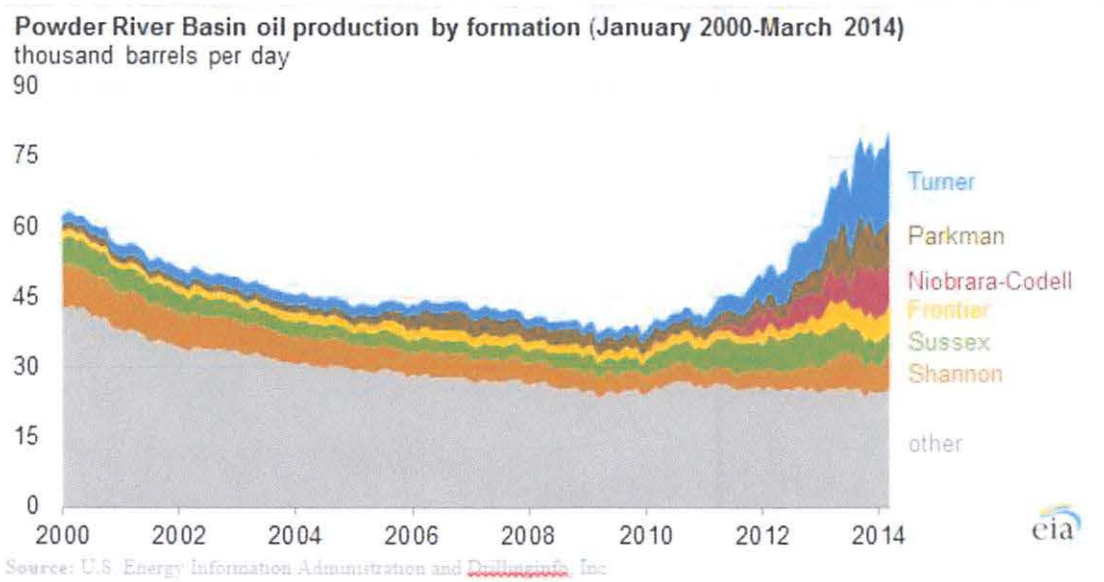
[1] Available at: https://eplanning.blm.gov/epl-front-office/projects/nepa/85072/126280/153838/Appendix_A,_Affected_Environment_Table_1stQ_2018.version2.pdf .

Background of this development

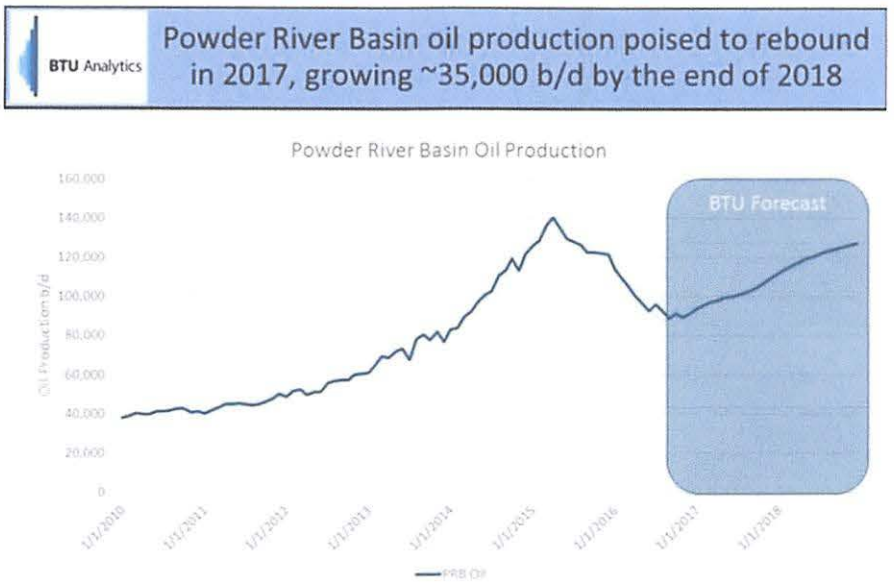
The Turner Formation is one of several upper Cretaceous sands currently under development by numerous operators in the Powder River Basin. This activity has been driven by technology, that is, the application of horizontal drilling and artificial fracturing [frac'ing]. These two technologies have improved the reservoir characteristics of several Cretaceous sandstone formations to the point where they are economical drilling targets. As published:

> In the past, oil production came from the higher-permeability portions of Wyoming's Turner, Parkman, Shannon, Sussex, and Frontier formations. With the application of horizontal drilling and hydraulic fracturing, larger portions of these formations have become profitable for commercial oil production

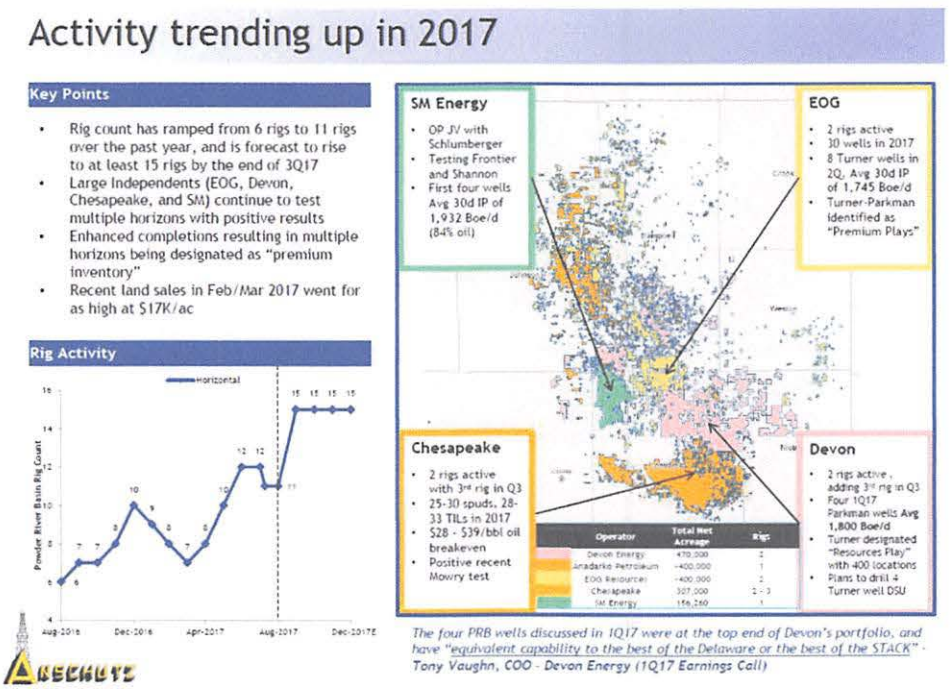
This has resulted in a dramatic upturn in production from these formations:



After a lull in activity during 2016, this activity ramped back up again in 2017 and is projected to increase in 2018:



Anschutz, one of the operators actively drilling in the play, provided some summary information in a Powder River Basin Overview delivered at the EnerCom Conference in August of 2017. Their view of drilling activity:



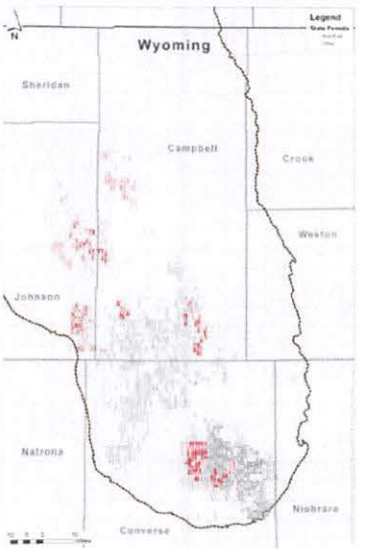
Drilling permits by operator are shown:

State Drilling Permits (as of July 31, 2017)

Ranking

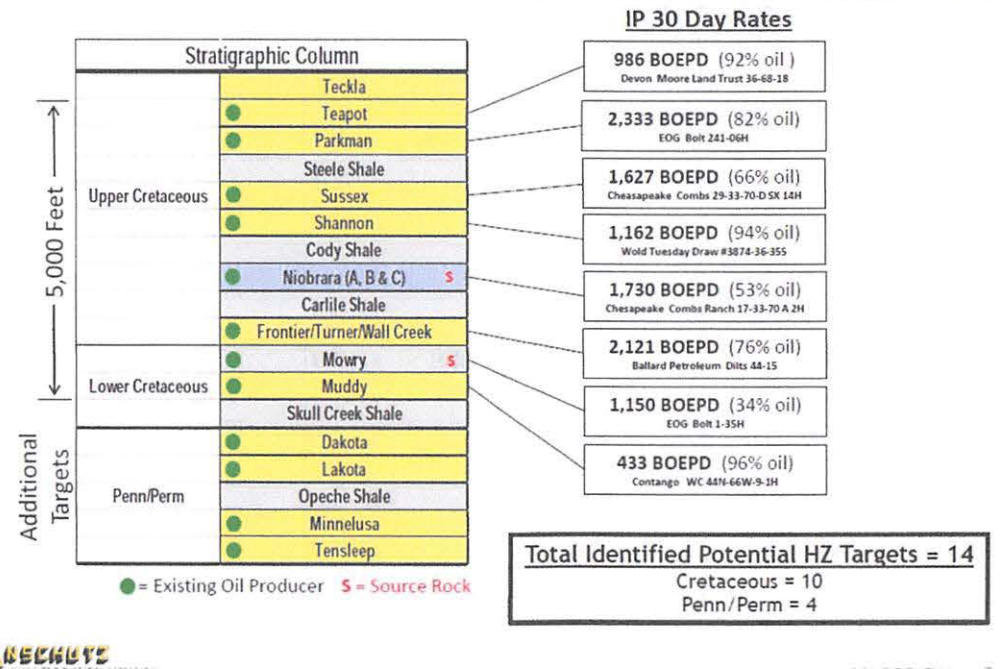
1) 2,220 - Anadarko
2) 1,098 - Wold
3) 1,022 - Anschutz
4) 992 - EOG
5) 411 - Peak
6) 234 - Devon
7) 186 - Chesapeake
8) 118 - Conoco
9) 134 - Ballard
10) 75 - SM
11) 687 - All others

Source: IHS



Anschutz summarizes the targets as follows:

PRB Targets and Notable Horizontal Rates



Lastly, Anschutz summarized their view of the future potential of this play. For their leasehold, they see nearly 6600 well locations developing over a billion barrels of oil. Note this is only one operator of several operators!

AEC PRB Resource Potential

Area	Gross Potential Locations*	Net Resource Potential (MMBOE)**	Main Targets
SE Converse	2,116	496	Parkman, Sussex, Shannon, Niobrara A/B/C, Turner, Mowry
South Central Campbell	1,169	118	Parkman, Sussex, Niobrara B/C, Turner, Mowry
SW Campbell & SE Johnson	1,810	305	Sussex, Shannon, Niobrara B, Frontier
NW Campbell	886	140	Sussex, Shannon, Mowry, Muddy
Other	609	64	Sussex, Niobrara B/C, Turner, Mowry, Muddy
Total	6,590	1,123	

*Gross potential locations based AEC's spacing assumptions per zone, per DSU, as follows; Parkman = 4, Shannon & Sussex = 2, Niobrara A, B & C = 8 each, Frontier & Turner = 4, Mowry = 4, Muddy = 2

**AEC EUR (MBOE) by horizon for LL's as follows; Parkman = 630, Shannon = 530, Sussex = 580, Niobrara = 1000, Frontier = 1080, Turner = 1170, Mowry = 550, Muddy = 600

This data further indicates that sale tracts 47-50 are located in an area with higher potential for development. These parcels are also immediately adjacent or proximate to existing oil and gas leases and development operations, which could make them a higher priority for leasing, as stated in BLM memo No. 2016-143. On the other hand, the value of sage-grouse habitat on some of the lease parcels, and lack of overlap with existing producing units, would weigh against offering the parcels.

Other Sale Tracts

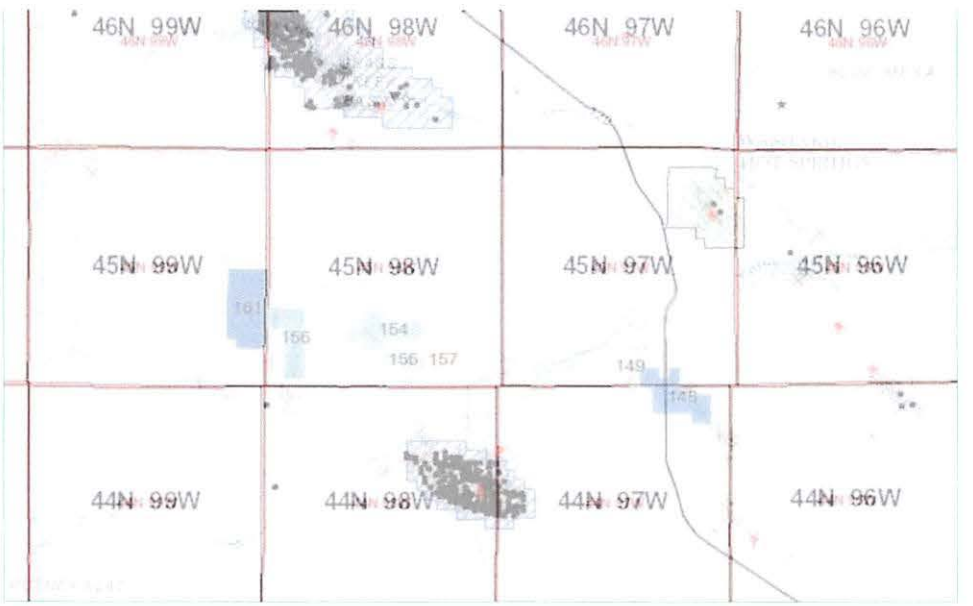
In contrast, most of the other parcels to be offered are: (a) located a substantial distance from any existing development; (b) in areas where no recent development has occurred or is occurring, indicating that there is not a high potential for development; (c) located outside of existing federal oil and gas units; (d) in areas without completed field-development environmental impact statements or master leasing plans. Additionally, a number of these tracts are in areas of high-value greater sage-grouse habitat, such as PHMAs.

As an example, the following tracts are proposed to be offered in the Big Horn Basin

Big Horn Basin

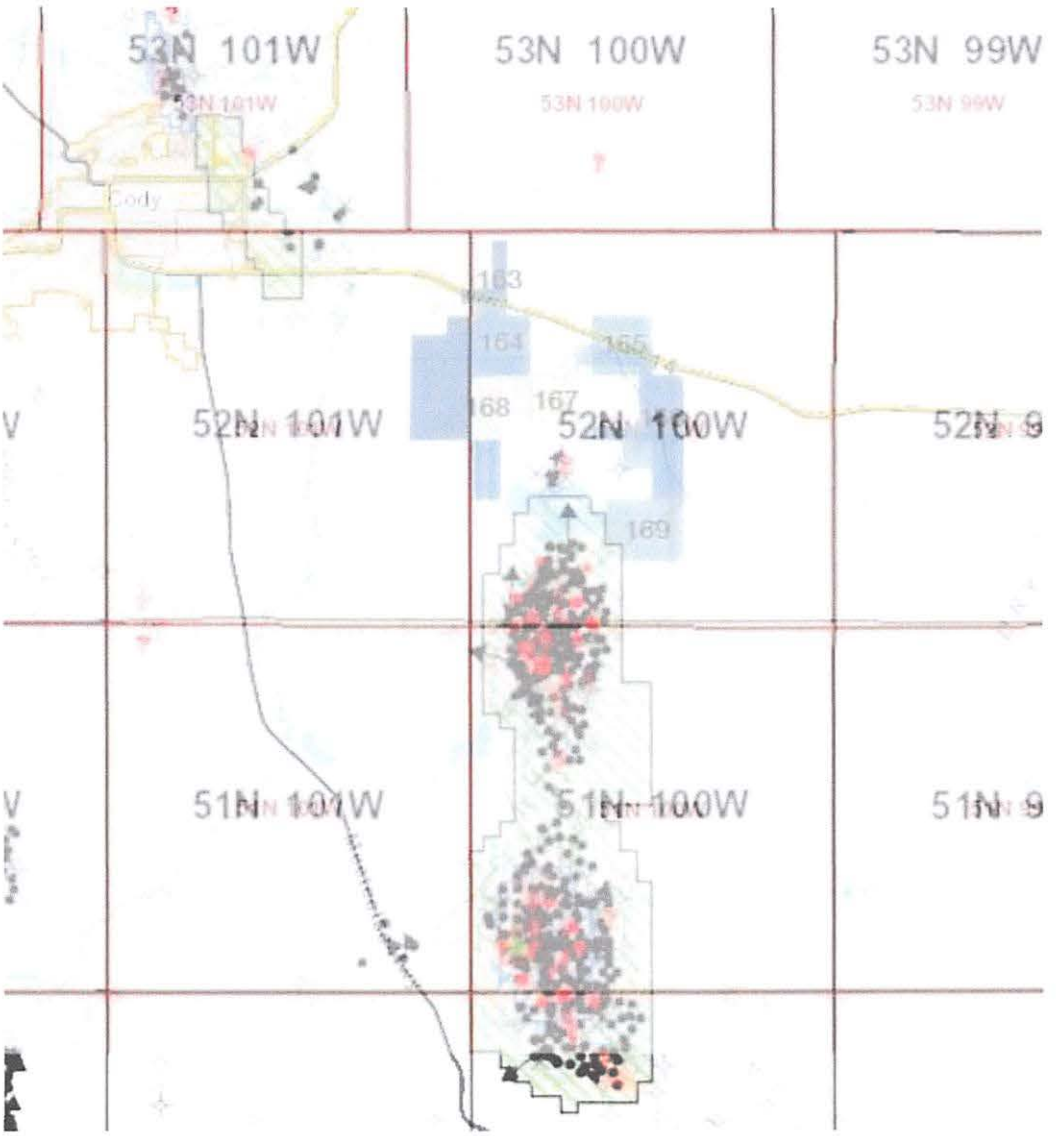
There are three groups of tracts in this basin. The production in this basin is concentrated in old, well defined structures with little prospectivity outside of the structures themselves. There has been little to no recent activity outside of the existing producing units.

Grass Creek Area



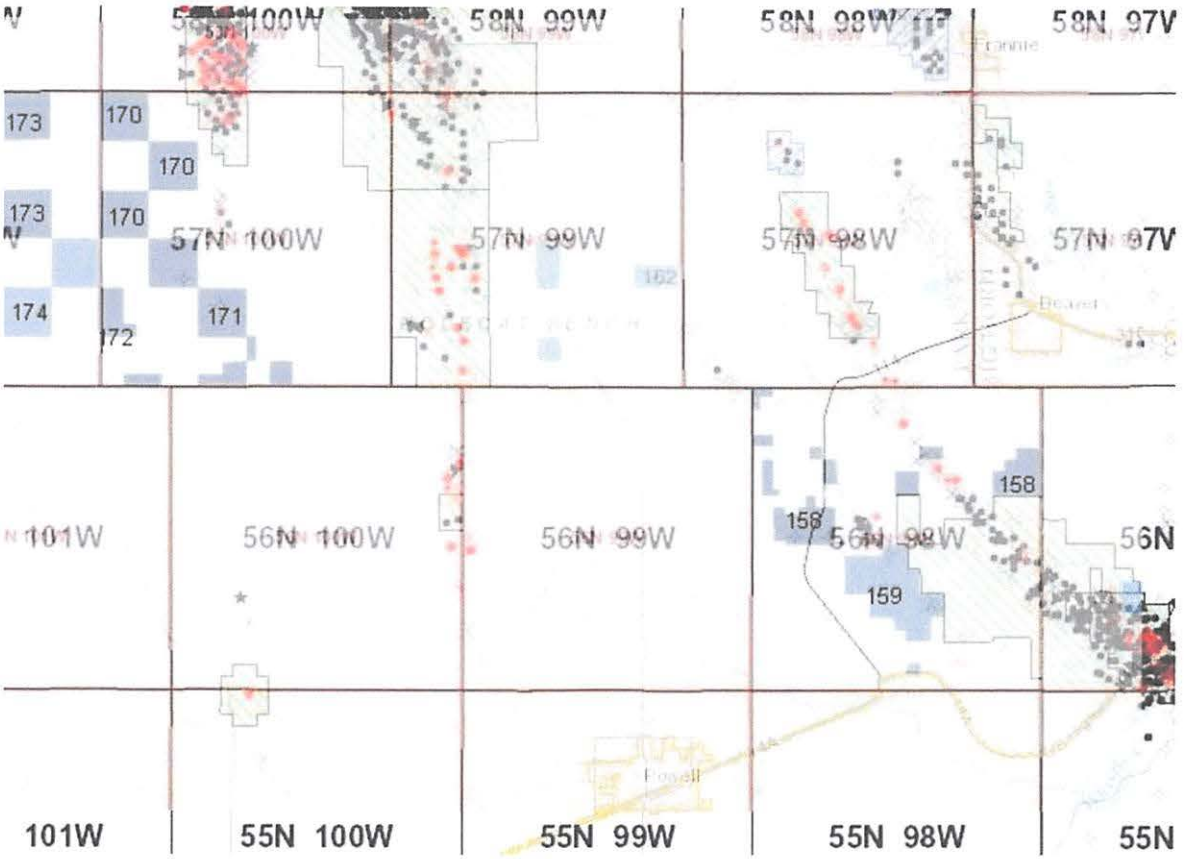
These tracts are located between 2 and 6 miles from oil producing fields. There has been little to no activity outside these units and the likelihood of future development is low. None of the tracts are within a federal unit or field-development EIS. And most or all of the tracts lie within PHMA or GHMA areas.

Oregon Basin



These tracts are clustered around the north end of Oregon Basin Field, another large oil producing field which has seen little recent activity. As it is a well-defined structure there is little to no development potential on these tracts. None of the tracts are within a federal unit or field-development EIS, and lie from 1 to 4 miles from the field. Most or all of the tracts are within PHMA or GHMA areas..

North of Cody, Wyoming



This area comprises several oil, large structural oil fields much like the previous two fields. The area has seen little recent activity. As the tracts are from 1 to 6 miles away from production there is little to no development potential. None of the tracts are within a federal unit or field-development EIS. Several of the tracts are within a PHMA area, and these are 3 to 6 miles away from any existing units.

Summary

Many or most of the tracts to be offered appear to be lands that should receive a low priority for leasing under the IM 2016-143 framework. Most of the parcels are located in PHMA or GHMA. While sale tracts 47-50 are located in an area with higher potential for development and these parcels are immediately adjacent or proximate to existing oil and gas leases and development operations, that is not true for most of the other parcels to be offered.

Kenneth Kreckel
3670 Placid Drive
Casper, Wyoming 82604
307 251 1370
E-mail: kreckel1@yahoo.com

HIGHLIGHTS:

Geo-scientist with over forty years' experience in the exploration and development of oil and gas reserves throughout the U.S. and Europe. Career highlights are:

- Proven oil & gas finder, with several hundred MMBOE discovered. Led the initiation, discovery and subsequent development of the Cotton Valley Reef play in east Texas during the 1990's.
- Eight years' experience as Exploitation Manager responsible for the development of multiple fields, especially in tight gas formations, as well as exploration throughout the southern region of the U.S.
- Expertise in horizontal drilling, especially in the Austin Chalk
- Many years' experience in developing tight gas sands
- Many years' experience in exploration and development in the Rocky Mountain region.
- Confirmed judgment in prospect evaluations
- Many years' experience managing multidisciplinary teams in successful exploration and development projects.
- Proficient at partner and contractor negotiations. Experienced with contracts.
- Performed numerous evaluations of company exploration assets.
- Many years as on-campus recruiter. Skilled in interviews and new employee evaluations.
- Particular ability with office relocations, and the establishment of new exploration offices.
- Experience in managing an exploration workstation support team.
- Personally designed and carried out numerous 3-D surveys. Particular expertise in cost-effective, suited-to-purpose surveys.
- Excellent at supervising seismic acquisition, processing and interpretation projects.
- Interpretation experience with several interpretation packages, most recently with SMT Kingdom
- Recent experience with Environmental Impact Statements and Assessments
- Recent extensive experience in developing and teaching an oil and gas focused associates degree program
- Recent experience in an international offshore geophysical and geological project
- Superior communication skills, especially written. [published author]

EXPERIENCE

2001-Current Geo-science Consultant

Bahamas Petroleum Company [2011-17] Long term major project in charge of the geophysical effort. Supervised PSTM and PSDM processing of the 80 km^2 **Pearl** 3D survey at CGG Veritas. Interpreted and mapped several prospects on both of the above versions of the survey, using Kingdom software. Reviewed inversion work, gravity and mag interpretations and so on. De-risked the prospects and brought them to a drillable stage. Presented results to management and numerous potential partners, as well as facilitating partner technical evaluations.

Rocky Mountain region drilling and environmental evaluations: Performed analysis of over sixty small to mid-size oil & gas projects in the Rocky Mountain region, with an emphasis on current gas development concerns. Analyze and comment on environmental impact statements, assessments, etc. Championed the use of directional drilling from multi-well pads. Extensive work with the Southern Utah Wildlife Alliance.

Casper College
125 College Drive
Casper, WY 82601

2007-2016 Department Head and Instructor

Head of Extractive Resources Department charged with building the program. Developed and taught courses in petroleum geology, well logging, geophysics, seismic interpretation, GPS and mapping, drilling, production, and refining. Acquired and installed several state-of-the-art software packages for instructor and student use.

Marathon Oil Company
P O Box 3128
5555 San Felipe Road
Houston, Texas 77056
713 629 6600

1998-2001 London, England Manager of Exploration Support

Responsible for the technical quality of interpretations of several geophysicists working throughout NW Europe. Managed UNIX workstation support department. Directly supervised geologic and geophysical support staff. Designed, contracted, and carried out several large 3D surveys. Supervised acquisition and processing of large multi-client surveys. Company representative with partners, research groups, NGO's, etc.

1990-1998 Tyler, Texas Exploitation Manager

Directed over thirty geo-science, engineering and land professionals engaged in exploration and development in East Texas, Gulf Coast onshore and Louisiana. Responsible for the initiation and successful development of the Cotton Valley Reef Play, discovering several fields totaling in excess of 200BCF, largely through the application of custom designed 3D technology. Drilled over 50 successful horizontal wells in the Austin Chalk. Also active in tight gas sand development in numerous fields. Initiated, presented, and secured $50MM annual budgets.

1988-1990 Midland, Texas Region Geophysicist

Responsible for the technical excellence of seismic interpretations in West Texas, the Mid-Continent, and Michigan Basin. Designed and carried out numerous seismic projects, from acquisition through interpretation.

1978-1988 Cody & Casper, Wyoming Geophysicist, Exploration Supervisor, Region Geophysicist

Interpreted and acquired seismic data throughout the Rocky Mountain Region, particularly the Thrust Belt, Paradox and Powder River Basins. Directly led the company effort in the Utah-Wyoming Thrust Belt, eventually rising to supervise several exploration teams working all of Utah. Involved in the discoveries in the Paradox Basin. Generated and drilled numerous wells in several plays. Ultimately worked as Region Geophysicist responsible for all technical work performed by several geophysicists working throughout the Rocky Mountain Region.

Texaco, Inc.

1974-1978 Bellaire, Texas Geophysicist & Geologist

As a geologist, developed fields in the Vicksburg of South Texas. As a geophysicist, explored in the Atlantic margin, Illinois Basin, and offshore Gulf of Mexico. Directly worked in seismic processing, interpretation and velocity mapping.

EDUCATION

Michigan Technological University, Houghton, Michigan B.S. Geology with Honor 1974

Extensive list of professional and technical courses.

Graduate of Marathon Management courses, including the Marathon Advanced Management Program at Indiana University.

ORGANIZATIONS

Society of Exploration Geophysicists
Mensa
Historical Novel Society

RECENT CIVIC POSITIONS

Member, City of Casper Optional One-cent #12 Sales Tax Committee, 2002
Commissioner, Casper Planning & Zoning Commission, 2003-2007

OTHER RELEVANT EXPERIENCE

Wrote feature articles for the Historical Novel Society publications, as well as a large number of book reviews. Conducted and published interviews with numerous successful authors.

Published several historical novels.