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Subject: Rulison Oil & Gas, Nuclear Testing and Other Environmental Issues.

Summary.
1-The present regulatory process that allows drilling near the Rulison Test site is filled with **uncertainties and unanswered questions.**

- The **Magnitude** of what could go wrong is considerable;
- Future problems could be practically **irreversible,** with damage that is very hard and/or expensive to remediate;
- **Economic loss** from some kind of highly publicized incident could be considerable;
- The oversight agencies have repeatedly acknowledged existence of considerable uncertainties.

2-Despite the repeated claims by the DOE, COGCC, and BLM that adequate precautions are being observed, the local citizens have reasonable health and environmental concerns.

3-Detailed chemical characterizations of the Rulison-area waters and gases have not been conducted. Hence, it is uncertain what restrictions should be regarded as adequate.

- The only real restriction is within the 40 acres;
- The 40 acres is almost certainly not adequate;
- COGCC proposes to make case by case determinations in a ½ mile radius;
- But under COGCC rules, the burden is apparently on the objector to show there is a problem, otherwise the application is approved;
- In any case, there is no scientific basis for thinking that the ½ mile zone is adequate, and considerable reason to think it is not;
- The three-mile zone doesn't really restrict anything as now being applied;
- In short, current measures are not adequate to ensure public health, safety and the environment.

In the face of such unknowns, **conservative approaches** are needed---approaches which assume significant margins of safety. The current regulatory measures are inadequate.

Introduction / Background. In the Fall of 1969, the Atomic Energy Commission together with Austral Oil detonated a 43 kiloton nuclear explosive device at a depth of 8,426 feet below the land surface at the Rulison site in an attempt to stimulate natural gas production. “This experiment was the deepest nuclear detonation ever performed in the United States.” (OGCC,1998). The explosion created extensive horizontal and vertical fractures to distances of at least several hundred feet of the original blast, which was the original goal---to generate better pathways for migration and collection of gas.

The specific characteristics of the original Rulison test “borehole” are not known. Many of the DOE reports imply that it was an “emplacement well”, but at the Nevada Test Site, similar underground explosions are conducted within borings or tunnels that may be 20 feet in diameter. Closing and totally sealing such large diameter tunnels can be very difficult, hence pathways for migration of gases and liquids may persist.

In subsequent years, numerous tests were performed by the U.S. Government (USG) to evaluate the performance of the Rulison explosion. In 1970 and 71, at least one re-entry well was drilled and tested, and a total of 420 million cubic feet of gas was produced and released into the atmosphere. While Austral Oil stated at a trade meeting in October 1971 (Reynolds, 1971) that they anticipated that studies would indicate that gas from the Rulison site would be judged suitable to be sold commercially, such approval did not occur. The gas was later deemed to be unsuitable for sale because it contained unacceptable concentrations of radioactivity (U.S. EPA, 2007).

The geologic formations in which the Rulison test was conducted are composed of many *discontinuous* sandstones, clays, organic shales, and coals. Hence, the ability of the gas to move through these rocks is limited. Thus the industry has historically asked the COGCC to approve greater well densities through time.

It is understandable that the industry wants high well densities so that they can maximize the volumes of gas extracted in the shortest possible time. However, this disregards the potential for gases and other contaminants to migrate significant distances—both horizontally and vertically---over the long-term, many more years than industry might ever consider for business purposes. And, it is these long-term consequences that hydrogeologists and regulators inevitably must reckon with, as is well documented at the Yucca Mountain site.

Because of the limited permeability to gas and water of these formations, the oil and gas (O&G) industry has developed massive hydraulic fracturing techniques to enhance the pathways for collection of gas. It is these created pathways, generated by both the original Rulison test blast and the hydraulic fracturing techniques that provide the enhanced pathways for possible migration of radionuclides and other contaminants in the Rulison region.

There is relatively limited experience with this kind of nuclear fracturing, and even less experience in how the results of nuclear and conventional fracturing techniques interact. In addition, the existence of hundreds of water and gas wells, many of which have never been adequately completed or abandoned (see URS discussion below), provides extensive potential pathways for migration of subsurface contaminants in the form of liquids and gases.

At some undetermined time following the 1969 test, U.S. Government (USG) and COGCC reports began to describe the existence of a development exclusion zone that required notification procedures for any O&G drilling within a 3 mile radius around the Rulison "test well." There was apparently some suggestion that drilling in this area would be restricted in the interest of protecting public health and safety and the environment. However, we are not aware of any documents that describe the process for adopting this exclusion zone, its technical justification, or any instances where drilling has been prevented due to the existence of this exclusion zone. In recent years, this exclusion zone has, in practice, shrunk to a radius of 0.5 miles around the test well.

Discussion. The local Rulison landowners and residents have a number of concerns with respect to the present O&G drilling near the Rulison site. These concerns seem, at this early stage of investigation, to have a reasonable scientific and technical basis, and cannot simply be dismissed as unfounded anxiety. There is every reason that they, others in the area, gas operators, and government agencies all should want to develop credible and science-based responses to these concerns. Ultimately all would benefit from answering these questions, which have not at this point been credibly answered by any of the considerable amount of work I have reviewed.

Consider the dilemma of the landowners of the properties within the general Rulison Test area. Various stages of oil and gas exploration and development activities are booming within a few hundred yards of their homes, in sight of their kitchen windows and in some cases on their properties.

Created Pathways. They know that local seismic and induced hydraulic fracturing [fracing] activities have created fractures in the local rocks which are intended to act as pathways for improved collection of oil. Furthermore, the public has read news stories detailing gas leaks from 5000 feet and more underground that resulted in gas and water bubbling to the surface, creating geysers in some locations, cracking home foundations, resulting in evacuation of homeowners (COGCC, 2006, 2007; Fort Morgan Times, 2007).

Fracing Compounds. Fracing compounds are composed of potentially toxic substances such as diesel fuel, which contains benzene, ethylbenzene, toluene, xylene, naphthalene and other chemicals; polycyclic aromatic hydrocarbons; methanol; formaldehyde; ethylene glycol; glycol ethers; hydrochloric acid; and

sodium hydroxide. Numerous studies have shown that between 20 and 40% of the fracturing fluids may remain in the formation (US EPA 2000, 2002; Puri *et. al*. 1991).

These concerns are aggravated by the fact that their lands are above the site of the 1969 Rulison underground nuclear test, which was *intended* to create additional fractures in the rock, thereby allowing enhanced recovery of natural gas. The enhanced fracturing may also allow greater mobility of groundwater.

Much of the local public lacks confidence in the technical and intellectual independence of the State and Federal regulatory agencies and the oil and gas companies themselves.

There are hundreds of technical papers and reports describing the Rulison Project. Many of these are less objective science than efforts to convince the public that there is no reason to fear releases of radionuclides or any other contaminants to the local environment. These documents have been prepared by Federal, State and local agencies between at least 1969 and the present. With a few exceptions, the institutional and intellectual bias of these reports is impressive. Despite the weight of these supposedly disinterested reports, there are numerous sound technical, financial and political reasons why reasonable citizens should be concerned about the proposed drilling within the immediate area of the Rulison Project.

Information Bias*.* The majority of the recent, publicly-available environmental data has been collected by representatives of the oil and gas industry. Such data and reports are hardly produced by independent sources.

Even though the Rulison Test took place in 1969, many of the technical documents that contain details such as water, gas and sediment concentrations are *still classified*.

Modeling Focus by Regulators. Suggestions that future computer model simulations will answer the fears of the public concerning any releases to the environment from the Rulison test site are, at best, naïve. At worst, they promote the quite mistaken assumption that such models can provide the level of certainty suggested.

The scientific and technical community is filled with dissenting opinions about the ability of such computer simulations to provide long-term, quantitatively-reliable results (Konikow and Bredehoeft, 1992; Pilkey, 2007). Such models are subject to far too much error, require far too many *a priori* assumptions, and are far too abstract to truly satisfy the skepticism of a public made wary by a considerable history of rosy projections that have led to less than rosy results. Modeling produces a tremendous quantity of numbers. But numbers are less needed here than wisdom and a methodical approach to obtaining widely accepted answers.

Adequate data are lacking on the actual concentrations, specific chemical forms and methods of transport for many of the radionuclides and other chemical constituents likely to be released from the Rulison site. For example, it is only recently that researchers have begun to appreciate the degree to which radionuclides (and other constituents) can be transported along ground water pathways while attached to tiny, colloidal particles---especially at nuclear test and processing sites (McCarthy and Zachara, 1989; Ramsey, J.L. and others, 2000). Hence, their model assumptions contain significant error when it comes to generating truly meaningful, quantitative predictions.

The form of the exercise depends on its goal. There needs to be a clear discussion of goals at the outset, before we go rushing in to any approach. If the goal is to generate a sense of security by developing numbers, modeling is the method of choice. But if the goal is to reach a result in which there is wide confidence on the part of local citizens, industry and others, the public would be much better served if the regulatory agencies focused on empirical fact-based approaches rather than modeling: the collection of actual samples from Rulison-area waters and gases. In this situation these are much more useful in building confidence that we are approaching the right answers than are computer simulations. To enhance trust, credibility, and acceptable results, such samples should be collected and analyzed by parties independent of both the O&G industry and the government nuclear agencies. Greater public confidence would accrue if knowledgeable representatives of the public were allowed to observe the sampling activities.

Confused Regulatory Oversight. The actual regulatory oversight roles of the various State and Federal agencies regarding Rulison Site development are exceedingly confusing even to the informed public. Clearly the COGCC has the primary role in issuing O&G permits, but the related roles of the US DOE, US BLM, the Colorado Dept. of Public Health and Environment (CDPHE), the Colorado Water Quality Control Commission, etc. seem confused and undefined with respect to the Rulison Site.

As an example, numerous Rulison documents (see Earman *et. al.* 1996; Davis and Houston 2005) discuss the relevance of a drinking water standard for tritium of 20,000 picocuries per liter (pCi/ L). However, no such standard exists in the normal compilation of either Colorado or US EPA Drinking Water Standards. Furthermore, when inquiries are made to the Denver-based specialists for both US EPA and the CDPHE, no specific information is available regarding this tritium standard. Cordilleran (2006) analytical sheets contain radionuclide standards that could not be explained by either the EPA or CDPHE offices.

The Burden of Proof. To get to acceptable answers will require a serious, sustained and transparent scientific effort. Attempts to “short cut” the painstaking work of science in areas like this usually sow distrust. And when it is clear that

the “short cut” answers don’t satisfy the public, and the process has to be done again, the “short cut” approach often backfires and winds up taking longer than doing the job right in the first place.

The local citizens have apparently been told by the COGCC that they have the burden of proof to show there is any concern. This is terribly troubling because the kind of scientific process needed is largely beyond the capability of ad hoc groups of local citizens. In any case, it is astonishing that government would set off an atom bomb, then tell the citizens it is their job to do the science to show whether there is any concern for public health or the environment.

How Close Can Drilling be Safely Done? Two drilling exclusion boundaries have been established for the Rulison Site, apparently by the COGCC (US EPA, 2007) --- a 3 mile radius and a 0.5 mile radius from “surface ground zero”. When a company applies to drill within the 3-mile radius, COGCC notifies the DOE, which then has the opportunity to comment on the application and or request that sampling and analysis be conducted as part of the permit. We do not know what kinds of comments DOE has ever offered, or what they regard as a “safe” or “unsafe” radius for drilling, or what science justifies whatever answer they may offer.

“An application to drill within the 0.5 mi. radius requires a full hearing before the commission.”

It would appear, however, that there are no legal controls to guarantee that the DOE take any active role in overseeing the activities described above. Nor is there anything to prevent approval by COGCC of wells being drilled closer and closer to the site. (“The last one worked; let’s try a little closer.”) COGCC apparently presumes approval and puts the burden on concerned citizens to come forward with the technical case to show there should be any restrictions.

Monitoring. The actual details of monitoring of gas and water samples from O&G wells are also confusing. *Frequently it appears that such samples are predominantly collected by industry representatives themselves and that this monitoring is “voluntary.”* Often it is unclear which party has actually collected samples, and the details of sampling and handling procedures are often not presented. We are not clear that all of these data are in fact publicly available.

Much of the monitoring data available from DOE, EPA and COGCC sources seems to be incomplete and fail to analyze many of the chemical constituents that may have been rendered more mobile because of the original Rulison Test and the subsequent O&G development activities. More complete monitoring should include a much broader suite of metals / metalloids, non-metals, organic compounds (see discussion above) and radionuclides. It appears that the lists of chemical constituents presently being determined in both water and gas samples are inadequate to truly answer the landowners’ questions regarding potential

contamination and risk. [The URS (2006) report discussed below also makes many of the same observations.]

In addition, in some analyses (i.e. Cordilleran 2006) the analytical reporting limits for some important "tracer" constituents, such as tritium, are far too high to be of use in determining the presence of potential contamination from the Rulison test. [1 TU (tritium unit) is approximately 3.19 pCi/L].

Cooper *et. al.* 2005 state that the most significant radionuclides mobile in waters at the Rio Blanco site are: tritium, krypton-85, chloride-36, iodine-129, technicium-99, and antimony-125. Numerous reports state that the most significant radionuclides in the gas phases at comparable test sites are tritium, krypton-85, carbon-14, argon-37, and argon-39. Most of the nuclides mentioned above are not included in any Rulison monitoring. In addition, it seems reasonable to monitor for the presence of helium [tritium in methane commonly decays to helium].

Most pragmatically, Rulison samples could be monitored in the field using portable gross alpha, beta and gamma "sniffers"—scintillometers.

Existing Ground Water Impacts*.* The Mamm Creek Hydrgeology Report (URS, 2006) suggests, despite its careful language, that past O&G activities have created problems that are of concern to the landowners in the Rulison area. For example, they describe numerous examples of well completion inadequacies and "poor plugging and abandonment procedures" that could easily create pathways for migration of subsurface contaminants. In addition, they state that the water quality in several wells has been degraded by O&G-related activities (see p. 6-2 to 6-3). The discussions involving "baseline" water quality raise numerous questions as many of these areas have only recently been sampled even though they have been subject to O&G development activities for many years. It is very questionable that such data reliably reflect actual baseline conditions---that is, conditions prior to any O&G activities.

The Recommendations section of the URS report (URS 2006, p.7-1 through 7-3), describes numerous inadequacies in the gas well data stored in the COGCC on-line data base.

These URS observations confirm that the Rulison-area landowners have significant reasons to be concerned about the potential migration of subsurface contaminants from both the Rulison Test and other O&G-related activities.

Geochemical Consequences. It is common for the cement-grout mixtures used to complete wells [O&G, water] to generate strongly alkaline conditions, with pHs often between 9 and 12. Because of the well completion problems noted above, these alkaline pH conditions in portions of some wells can create geochemical environments that may mobilize elevated concentrations of numerous metals and

metalloids such as arsenic, antimony, chromium, manganese, molybdenum, nickel, selenium, strontium, uranium, vanadium, etc.---many of which may be radioactive. These and other trace constituents may be mobilized where acidic fracing compounds remain in the formations, as described above.

CONCLUSIONS

At present, the public and regulators are **uncertain** what restrictions should be regarded as adequate.

- The only real restriction is within the 40 acres.
- The 40 acres is almost certainly not adequate.
- COGCC proposes to make case by case determinations in a ½ mile radius.

But under COGCC rules, the burden is apparently on the objector to show there is a problem, otherwise the application is approved.

- In any case, there is no scientific basis for thinking that the ½ mile zone is adequate, and considerable reason to think it is not.
- The three-mile zone doesn't really restrict anything as now being applied.
- In short, current measures are not adequate to ensure public health, safety and the environment.

In the face of such unknowns, **conservative approaches** are needed---approaches which assume significant margins of safety. The current regulatory measures are inadequate.

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