APPENDIX E. ENVIRONMENTAL MITIGATION BEST PRACTICES

- The geologic suitability of the formation should be assessed including structure and stratigraphy, local and regional hydrology, the areal extent and permeability of confining zones, and the anticipated impacts of fracturing (on conductivity, porosity and permeability, hydrology, rock mechanics, etc.).
- Detailed models based on relevant geologic and engineering factors should be constructed to help determine the "zone of contact" of the induced fractures (i.e., the physical and chemical extent of fractures and displaced fluids), and consider cumulative impacts.
- Existing and abandoned wells within the zone of contact should be evaluated and repaired as necessary to prevent them from becoming pathways for injected or displaced fluids to migrate into drinking water.
- Operators and service companies should also have plans for managing cumulative water use and wastewater handling that outline key aspects such as the source, timing, and necessary volume; methods for on-site storage, maximizing recycling and non-potable water use, and mitigating environmental impacts; chemical additives to be used; produced water composition; and assessment of disposal options.
- Wells that will be fractured must be constructed, starting with careful selection of drilling fluid and proper hole cleaning and conditioning to ensure a strong bonding of cement and casing.
- Wells must isolate drinking water from brines, hydrocarbons and other contaminants and should be tested using casing pressure tests, cement compressive strength tests, casing show tests, and cement evaluation logs.
- Operators should develop comprehensive plans for groundwater monitoring before and after hydraulic fracturing takes place, including installation of appropriately spaced, dedicated groundwater monitoring wells.
- During hydraulic fracturing, actual fracture growth and placement should be measured using tiltmeters, microseismic techniques, and possibly tracers in fracturing fluid, (Mordick).
- Environmental Mitigation Best Practices under development by the Environmentally Friendly Drilling Systems Program (EFDS; www.efdsystems.org):
- Maximize the amount of reservoir that can be accessed from a single well pad. Consider small footprint drilling rigs and rollout roads made of heavy-weight composite fencing that hold potential to further mitigate surface disturbance from drilling rigs.
- Reduce the footprint of hydraulic fracturing through centralized frac facilities that involve offsite operations and innovative fracturing technologies, such as a novel process using minimal pumping equipment, low volumes of frac fluid, and green additives. acoustic fences to mitigate noise impacts, handheld air quality monitoring devices, membrane treatment methods for recycling flowback and produced water, and mobile field site water treatment systems. Techniques for on-site brine (produced water) treatment and analysis should be evaluated, (Burnett).

Other Key points include:

- Both radioactive and chemical tracers can be used for tracking the placement of frac fluids in the sub-surface. Typically, the proppant (sand) is tagged with the tracer and then injected, and a tool is put down the wellbore to determine in which perforation the tracer was placed.
- Research institutions are working on the development of field-portable dissolved methane detectors/sensors.

- Casing and cementing in the intermediate zone between the base of the surface casing and top of production casing of the wellbore are important because stray gas migration may pose greater risk to groundwater than frac fluids. Currently, only the State of New York requires cementing in that zone.
- Biocides are added to frac fluid stream in the same manner as sand is and must be handled safely.
- Incorporation of a health impacts assessment into the pre-planning stage of drilling and fracturing, conducted in collaboration with local organizations and institutions, may be a useful step toward addressing public health concerns.
- Pre-planning and site characterization should include identification of abandoned wells that could be within range of a planned frac job to prevent fluid migration into potentially degraded wells that could serve as conduits to a groundwater aquifer.
- Flowback and produced waters have high salinity concentrations, but not typically so high that they cannot be treated sufficiently to be re-used for fracturing.

Other:

- Known water bearing zones in the project area are generally protected by drilling requirements and reviewed as part of the drilling plan that is contained in the Application for Permit to Drill (APD).
- Stormwater Pollution Prevention and Control Plans are required by the State of Nevada before any surface disturbance associated with construction actions greater than 1 acre in size. On a case-by-case basis, the Authorized Officer may require additional erosion control measures to reduce the volume of surface runoff and subsequent sediment transport. The operator would stockpile the topsoil from the surface of well pads which would be used for surface reclamation of the well pads. Reserve pits would be re-contoured and reseeded as described in the APD. Upon abandonment of the wells and/or when access roads are no longer in service , the Authorized Officer would issue instructions and/or orders for surface reclamation/restoration of restoration of the disturbed areas as described in the APD and implement interim reclamation measures.
- Mitigations normally restrict surface disturbing activities within 500 feet of surface water and/or riparian areas to protect the water and riparian resources and within ¼ mile of occupied residences.
- All depletions would require consultation with USFWS and all water discharged would require State permits under the National Pollution Discharge Elimination System (NPDES) and approval by the BLM at the APD stage; potential impacts would be mitigated at that time.
- The use of practices such as but not limited to closed-loop mud systems or plastic-lined reserve pits would reduce or eliminate seepage of drilling fluid into the soil and eventually reaching groundwater.
- The casing and cementing requirements imposed on proposed wells would reduce or eliminate the potential for groundwater contamination from drilling muds and other surface sources.
- Interim reclamation of the portion of the well pad not needed for production operation, re-vegetating the portion of the pad that is needed for production operations, as well as re-vegetating road ditches would reduce long-term impact.

Additional mitigation could include, but would not be limited to:

- the use of recycled water for drilling below the surface casing zone, installation of backflow preventers, drilling oil and gas related water wells to aquifers below those providing residential water and then cementing from the nearest shale/clay zone below the deepest culinary/livestock water well in the vicinity back to the surface, and
- insuring that access to water wells is only provided to authorized users.
- Using the lowest quality water necessary and cementing the water well to surface will reduce the chances that oil and gas related water wells are not drawing from the aquifers providing the residential water or allowing the mixing of lower quality waters with potable sources.
- Additionally, drilling with oil-base mud or in areas where shallow groundwater may be encountered, the use of closed-loop or semi-closed loop drilling systems may be required.
- Floodplains would be managed in accordance with Executive Order 11988.

University of Wyoming School of Energy Resources Hydraulic Fracturing: A Wyoming Energy Forum January 17, 2012

And Bibliography Sources