Appendix A. Well Pad Site Suitability Models and Methodology

In an effort to efficiently develop the Unit for extraction of natural gas, SG recognized GIS (Geographic Information Systems) as an ideal tool for locating potentially suitable sites within the Unit boundary. GIS is commonly employed for large-scale spatial analysis for its ability to compare, analyze and summarize a variety of phenomena across broad geographic areas. For the Bull Mountain Unit, SG utilized the technology to reveal sites that respect specific environmental, regulatory, and cost constraints. In order to enhance the quality of topographic and other data available for the project area, and thus the efficiency of selecting appropriate sites for well pads and ancillary facilities, SG contracted to acquire LiDAR (Light Detection and Ranging) data. LiDAR is a remote sensing technology that employs aerial lasers to determine distances, elevations, and other properties.

LiDAR was used to record individual points, one meter apart, which were then classified according to whether they reflect a point on the ground, vegetation, building or structure, or other element. Those points classified as ground points were used to produce a bare-earth model depicting the Unit's topography absent of any above-ground features. Similarly, those points classified as vegetation points produced data accurately depicting existing canopy cover, stand densities, and vegetation height. The high density of points allowed vertical accuracies of +/- 6 inches and horizontal accuracies of +/- 1.5 feet.

Site-suitability models combine a number of data sets across a given area to produce a final composite that ranks the appropriateness of the end use for all areas of a site. For the Bull Mountain Unit, the data included baseline LiDAR topographic and vegetation data, as well as site-specific information collected/delineated in the field (i.e. wetland and riparian areas) and/or information obtained from publicly available sources (e.g., Colorado Division of Wildlife habitat data). All data used in the analyses were grid data sets, or cells with a 10-foot pixel resolution, meaning each cell in the grid data represented a 10-foot x 10-foot area on the ground, or 100 square feet. The analyses utilized the following data sets to develop criteria for each site-suitability study:

1. Slope (steepness of the terrain)
2. Sensitivity to visual impacts from SH 133 and County Road 265 travel corridors
3. Proximity to existing road networks
4. Proximity to existing natural-gas pipeline systems
5. Proximity to delineated wetlands and wetland buffer zones
6. Proximity to stream networks and stream buffer zones
7. Proximity to known streams containing native cutthroat trout lineages
8. Soil erosion factors
9. Vegetated areas and open meadows

A series of five successive site-suitability models was run using eight different weighting factors to study the project area under separate scenarios, each of which prioritized different criteria. After the values for the individual data sets were determined and the weights assigned, the data sets were composited. The resulting data ranked each 10-foot x 10-foot cell in the grid on a scale of 0–9 with zero representing the least-suitable areas and 9 indicating areas of high suitability for well pad location and construction. In 2009, SG presented this technique to the BLM, and with BLM-requested modifications, proceeded with this technique. **Table A-1** shows the criteria and weighting factors for the Proposed Action (Model 5 results) and Alternative 1.

Table A-1. Criteria and Weighting Factors for Well Pad Site Selection, Proposed Action and Alternative I

Data Element	Criteria	Value (1–9)	Weight	
			Proposed Action	Alternative 1
Slope	0–4 %	9	30%	20%
	4–8 %	8		
	8–12%	7		
	12–15%	6		
	15–20%	5		
	20–33%	4		
	33–45%	3		
	45–60%	2		
	60+%	0		
Viewshed areas	Not visible	9	30%	10%
	Visible from CR 265 – bare surface	7		
	Visible from CR 265 – vegetation	6		
	Visible from Hwy 133 – bare surface	4		
	Visible from Hwy 133 – vegetation	3		
Colorado Cutthroat Trout Streams	>300’ from stream	9	0%	0%
Hydrology/wetlands	>500’ from pond, stream or wetland	9	10%	5%
	>300’ and <500’ from pond or stream	4		
	<300’ from pond or stream or <500’ from wetland	1		
	In pond, stream bed or wetland	0		
Meadows, vegetation canopy	Within open meadow (non-native pasture)	9	1%	0%
	Within canopied area	4		
Soil types	Kw (erosion) factor		4%	15%
	0.1	9		
	0.15	8		
	0.2	6		
	0.24	5		
	0.37	4		
Distance from existing roads	<500’	9	15%	35%
	500–1,000’	8		
	1,000–1,500’	7		
	1,500–2,000’	6		
	2,000–2,500’	5		
	>2,500’	3		
	In road bed	0		
Distance from existing pipelines	<500’	9	10%	15%
	500–1,000’	8		
	1,000–1,500’	7		
	1,500–2,000’	6		
	2,000–2,500’	5		
	2,500–3,500’	4		
	3,500–5,000’	3		
	5,000–7,500’	2		
	>7,500’	1		
	In pipeline ROW	0		

Based on the results of each model, 145 suitable well pad locations were identified. The number of locations was narrowed to the 50 most suitable sites that would adhere to defined environmental and regulatory constraints while also effectively draining the Unit of the natural-gas resource. The reduction was achieved by compiling statistics on the 145 identified suitable locations, followed by a more detailed review of each individual well pad. The statistics gathered for each well pad allowed all locations to be quickly ranked and evaluated by model suitability, impacts to hydrology zones, and overall length of roads and pipelines. After review of the compiled statistics, the 50 well pad locations with the best suitability values, least amount of road construction, and minimized slope and hydrology impacts were chosen as a foundation for the Proposed Action. Those 50 locations were then inspected in the field in much greater detail to gain a better understanding of the following site-specific impacts and how each well pad would contribute to the Proposed Action as a whole:

- The distance to adjacent well pad locations was considered in the refinement process to achieve a more uniform distribution across the entire Bull Mountain Unit that would effectively drain the natural-gas resource.
- Surface topography was studied to more accurately determine well pad placement and feasibility.
- Surrounding habitat and migration corridors were considered to reduce adverse impacts to local species.
- Wetlands and hydrology data sets were cross-referenced to refine the location of well pads near sensitive buffer zones.
- Existing road networks and slope data were checked on the ground to better understand accessibility of the proposed site and feasibility of road construction.
- Additionally, a number of visual studies were employed to minimize or eliminate impacts to critical viewsheds as determined by existing landowner surface-use agreements and primary travel corridors within the Unit.

All of these factors were combined and considered at each identified location, and the well pad was either eliminated or included in the Proposed Action. Minor changes were made to individual well pads as required. Existing and proposed well pad locations are shown in **Table 3** and **Figure 3**.

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