Environmental Report: Coalbed Natural Gas Effects on the Fortification Creek Area Elk Herd

U.S. Department of the Interior
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Buffalo Field Office
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ABSTRACT

The Fortification Creek Area (FCA) lies within the center of the Powder River Basin (PRB) and provides habitat for a geographically isolated prairie elk herd. The term FCA is being applied to the 122,933 acre yearlong elk range designated by the Wyoming Game and Fish Department (WGFD). The surface and mineral ownership pattern of the area is a mixture of federal, private, and State of Wyoming; the Federal government is a 44% surface landowner, and an 83% fluid mineral estate owner. Within the yearlong range are the crucial seasonal ranges (crucial winter and parturition) which comprise 71,755 acres or 58% of the yearlong range. Inside the crucial ranges is the 12,832 acre Fortification Creek Wilderness Study Area (WSA) which contains a 640 acre Wyoming state section within its boundaries. Data from 26 radio-collared elk monitored since April 2005 indicate that the herd of 230 elk depends heavily upon the WSA and northern half of the crucial ranges.

Coalbed Natural Gas (CBNG) development is encroaching upon the FCA which with the exception for the WSA is leased for fluid mineral development. BLM conducted this cumulative effects analysis to determine the effects of CBNG development on this geographically isolated elk herd.

Baseline conditions were evaluated to identify how the elk herd is coping with the existing mineral development. In February 2005 when the 26 elk were captured and fitted with radio collars, there were 71 producing wells within the FCA including; 10 oil wells, 6 CBNG wells, and 55 conventional natural gas wells. Elk avoided using habitat within 1.7 miles of well sites and 0.5 miles of roads. Eighty percent of the FCA is within 0.5 miles of a road. Vegetation and topography in relation to wells and roads were also evaluated, but these factors did not explain elk avoidance of wells and roads. Although the existing level of mineral development has affected the elk herd, the herd remains healthy and productive.

After evaluating the baseline effects, effects from the foreseeable CBNG development was modeled. Development was based upon an 80 acre well spacing scenario proposal received from CBNG operators. Approximately 10,491 acres of the 122,933 ac yearlong range (8.5%) would be directly disturbed with the proposed development. The elk herd is expected to be restricted to the WSA which may be able to support a herd of 46 to 64 elk for the 20 year duration of CBNG development. No security habitat would be available outside the WSA.

Thirty-four free-flowing water wells provide an important water source for the elk herd during the summer. Sixteen wells completed within or near the coal seams would be lost from CBNG drawdown, if the Smith coal seam is developed an additional three flowing wells would be lost. The fate of the remaining 15 shallow Wasatch formation water wells is dependent upon the site-specific geology. Where there is hydraulic communication, several years of CBNG related drawdown would be required to reduce the water flow, while water wells without hydraulic communication with the coal seams would remain unaffected by CBNG development.

The drilling/construction phase of CBNG development is forecasted to last 10 years with another 10 years of CBNG production. Following the CBNG phase, elk are expected to again fully utilize the FCA but it would likely take at least an additional 20 years for the habitat and population to recover to pre-CBNG conditions.

INTRODUCTION

The U.S. Department of the Interior - Bureau of Land Management (BLM) has leased the Federal mineral estate within the Fortification Creek area (FCA), which is in northeastern Wyoming (T50-54N, and R74-77W in Campbell, Johnson, and Sheridan Counties)[Figure 1]. The term Fortification Creek Area is being applied to the yearlong elk range designated by the Wyoming Game and Fish Department (WGFD) which is the core use area for the elk (containing 99% of radio-collar locations). Within the FCA, the Federal government is a 44% surface landowner, and an 83% fluid mineral estate owner. A number of natural gas production companies have shown an interest in producing the natural gas bearing coal beds within the FCA. Coal bed natural gas (CBNG) production has occurred throughout northeastern Wyoming for several years. The Powder River Basin Final Environmental Impact Statement (PRB FEIS) evaluated effects to elk at the scale of the 8 million acre PRB FEIS project area. The PRB FEIS analysis did not specifically address the Fortification Creek herd in its cumulative effects analysis.

BLM requested, in December 2004, site-specific information from CBNG companies planning to develop the FCA. The companies submitted maps showing where wells were likely to be drilled along with a potential road/utility corridor network and some associated facilities such as impoundments for produced water and compressors. The information submitted was what the companies proposed in the near future. Approximately 1/3 of the area did not have development identified. BLM placed wells on a similar pattern (80 acre spacing) in remaining areas since CBNG development is likely there also.

This document provides an analysis of cumulative impacts pursuant to the National Environmental Policy Act (NEPA) that CBNG development may have on the elk herd that resides in the FCA.

Overview of the Projected Development

A detailed description of general CBNG operations can be found in Chapter 2 of the PRB FEIS, beginning at page 2-10. Full FCA development at the 80 acre well density is statistically characterized in Table 1. The table includes 65 conventional wells in production, May 2007.

Table 1 Projected Infrastructure with Full CBNG Development (80 acre spacing) of the Fortification Creek Area added to existing conventional development.

Proposed Facility	Powder River Projection [1]	Per-well Factor[2]	Yearlong Range Total	Crucial Range Total
Wells (no.)				
Federal	23863			
Non federal	15504			
Total	39367		1386	745
Well Pads (no.)				
Federal	15425	0.391826	543	292
Non federal	10572	0.26855	372	200
Total	25997	0.660375	915	492
Roads (miles)				
Improved	7135	0.181243	251.20	135.03
Two-track	10619	0.269744	373.87	200.96
Total	17754	0.450987	625.07	335.99
Pipeline (miles)				
<3 in polyvinyl pipe	14127	0.358854	497.37	267.35
12 in polyvinyl pipe	5311	0.13491	186.99	100.51
12 in steel pipe	1408	0.035766	49.57	26.65
Total	20846	0.52953	733.93	394.50
Overhead Electric (miles)	5311	0.13491	186.99	100.51
Compressors (no.)				
Booster units	1060	0.026926	37	20
Reciprocating units	298	0.00757	10	6
Total units	1358	0.034496	48	26
Booster stations	184	0.004674	6	3
Reciprocating stations	61	0.00155	2	1
Total stations	245	0.006223	9	5
Water Facilities (no.)				
Surface discharge	606	0.015394	21	11
Infiltration	3091	0.078518	109	58
Containment impoundments	12	0.000305	0	0
Injection wells	305	0.007748	11	6
LAD facilities	68	0.001727	2	1
Short-term Disturb. (acres)	202843	5.152615	7141.52	3838.70
Long-term Disturb. (acres)	95138	2.416694	3349.54	1800.44
Total Disturb. (acres)	297981	7.569309	10491.06	5639.14

1. Numerics come from the Powder River Basin FEIS.
2. Percentage factor based on the total number of wells in the Powder River Basin. Example: 39,367 PRB wells / 15,425 Federal well pads = 0.391826

Definitions

The Council on Environmental Quality (CEQ) regulations at 40 CFR § 1508.7 and 8 define *direct effects* as: [those effects] which are caused by the action and occur at the same time and place.

indirect effects as: [those effects] which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable.

and *cumulative effects* as: the impacts on the environment which results from the incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative effects can result from individually minor, but collectively significant, actions taking place over a period of time.

Consistent with the CEQ regulations, the terms "effects" and "impacts" are used synonymously.

Herd Overview

Elk occurred in the FCA historically; however, because of the lack of roads and difficult access little information on numbers and distribution existed. Following a period of absence, the Fortification Creek elk herd was re-established in 1952 and 1953 by the release of transplanted elk. Another transplant of 19 yearling bulls was released into the area in June, 1974. The herd reached a population of nearly 140 head by 1980. In 1981, based upon landowners input related to crop damages, the WGFD set a population management objective of 150 head. Though not quantified, there was some habitat loss in the area as a result of oil and gas development by the early 1980's. Over the years the herd had gradually increased to a 1990 post season population estimate of about 400 elk. There has been discussion over the years of raising the herd unit objective, but landowner concern about higher population levels and the lack of public access for management have deterred the WGFD from raising the herd unit objective (Jahnke 2006). Liberal hunting seasons from approximately 1998-2002 reduced the herd to the population objective. Currently there are an estimated 230 elk in the Fortification Creek herd. The WGFD population management objective for the herd remains at 150.

Estimates of the herd productivity, as measured by reproduction, are shown in Table 2. The productivity of a big-game herd is often used as an indicator of the overall health and welfare (e.g., stress levels, nutritional condition, etc.) of a population. Relatively high herd productivity is closely associated with a good nutritional plane resulting from a desirable forage/range condition. Pre-hunt productivity estimates indicate the Fortification Creek herd health is good to excellent.

Table 2. Fortification Creek Elk Herd Productivity (2001-2005)[1]

Year of Classification Survey	Pre-Hunting Season Classification Calves:100 Cows (Sample size [n] = # of Head)[2]	Post-Hunting Season Classification Calves:100 Cows (Sample size [n] = # of Head)[2]
2001	52 (45)	34 (59)
2002	N/A[3]	N/A[3]
2003	51 (69)	50 (106)
2004	N/A[3]	32 (66)
2005	41 (114)	39 (62)

Source: Wyoming Game and Fish Department herd unit statistics

1. Calves/cow ratios are used as an observable indicator of population productivity. Generally, the following elk herd classification interpretations are made (calves/100 cows = productivity rating): 10-19 = very poor; 20-29 = poor; 30-39 = fair; 40-49 = good; 50 or greater = excellent.
2. Small sample sizes can be extremely variable, and may not reflect actual conditions
3. Observation periods when a minimum (cut-off) sample size of 40 head was unobtainable

The herd was first hunted in 1968. In 1992, a 2.5 year study was initiated by the WGFD in cooperation with the BLM and area landowners, with the collaring of 17 cow elk. Data from this study allowed the WGFD to delineate seasonal ranges. Table 3 displays a breakdown of the existing mineral development (May 2007) with the foreseeable development (Table 1) within the elk yearlong range and the crucial ranges. Yearlong range is where a population of animals makes general use of suitable habitat sites within the range on a year round basis. Animals may leave yearlong range under severe conditions. Crucial range is generally defined as any particular seasonal range or habitat component which has been documented as the determining factor in a population's ability to maintain or reproduce itself at a certain level. The crucial elk seasonal ranges are crucial winter range (CWR) and parturition [calving] areas. The Wyoming Oil and Gas Conservation Commission (WOGCC) May 2007 data set was used to query existing development. WOGCC data revealed 159 wells within the FCA; 64 conventional wells (53 natural gas and 11 oil) and 95 CBNG wells (Figure 1).

Table 3. Existing and Proposed Wells within the FCA.

Elk Range	Existing Conventional Wells	Existing CBNG Wells	Proposed CBNG Wells in FCA	Total Wells
Yearlong	64	95	1,291	1,450
Crucial Ranges	23	19	726	768

Studies of radio telemetered elk from the Fortification Creek herd in the early 1990's showed some elk ranging out of the FCA as far north as Montana. More recent studies of radio telemetered elk (26 head from a herd of roughly 230) from the Fortification Creek herd have shown that 15% of the collared elk have been observed east of Wild Horse Creek, on the west side of the Powder River, south along the Kinney Divide, and occasionally as far north as Sonnette, Montana. The FCA itself, however, remains the core use area for this herd containing 99% of the radio-collar monitoring locations within the herd unit area (Laird 2005). The herd unit area is the area in which the WGFD is managing for elk. The long distance range use extensions to Montana in the north are probably reflective of the relative habitat continuity along the Powder River Breaks. All of these observations support the fact that elk are a wide ranging species, and will naturally move around to some degree from their core habitat at least seasonally, and in some instances, on a permanent basis.

Two categories of analysis were performed; first existing data sets were used to evaluate elk habitat selection in relation to existing mineral development and variables such as vegetation and topography; second, models were created projecting elk habitat effectiveness under varying development scenarios.

HABITAT SELECTION

Methods

Location data has been collected on the 26 radio-collared elk since April 2005. Helicopter net-gunning was used to capture elk for the installation of very high frequency (VHF) radiocollars in February 2005. Radiocollars were placed on five yearling bulls and 21 adult cows ranging between two and five years of age. The elk were provided a month to recover from the shock of collaring and resume normal movement patterns before tracking began. Tracking was conducted at least monthly with more frequent flights during parturition (calving), hunting, and winter seasons. Radiomarked elk were located from fixed wing aircraft, therefore observations are limited to daylight and fair to good weather conditions. BLM has received elk location data from the WGFD contracted pilot through January 2006.

Elk data were combined for the entire year and not stratified by season. Winter snowfall is rarely sufficient to limit elk or vehicle movement for extended periods. The Fortification Creek herd is non-migratory and utilizes their range throughout the year. Human activity varies little between seasons. Visual examination of the data confirmed that elk locations did not indicate seasonal range shifts.

In addition, one adult cow elk was fitted with a global positioning system (GPS) transmitter, which through satellite telemetry recorded her position once every five hours. A five hour interval between data points was chosen as five is not a factor of 24, hours in a day. Battery life for the collar was projected to be one year. The collar collected data from February 11, 2005 until September 28, 2006. The objective of the GPS collar was to provide insight into nocturnal and poor weather condition elk activities.

Mineral Development

First, BLM evaluated VHF collared elk locations in relation to well and road data (Table 4). BLM examined these data sets to determine if the elk were selecting habitats near wells and roads or avoiding them; using habitat near wells and roads greater than or less than the proportion available. The selection/avoidance concept is discussed further below. Producing wells as of February 2005 were selected from the Wyoming Oil and Gas Conservation Commission (WOGCC) well data set to evaluate elk use in relation to wells; 71 producing wells included 10 oil wells, 6 CBNG wells and 55 conventional gas wells. All wells were combined due to the small number of CBNG wells. With the various well types being intermingled, it would also be difficult to differentiate CBNG well effects from conventional well types. Roads open to motor vehicles were selected from BLM's road database; the dataset was reviewed by BLM personnel familiar with the FCA to remove roads no longer in use from the database.

We examined two analysis areas, the elk yearlong range (FCA) and the combined crucial ranges (crucial winter range plus parturition range). The importance of the crucial ranges is exemplified by their disproportionably heavy use. The Fortification Creek delineated yearlong elk range is 122,933 acres in size, and with uniform effort, a total of 648 observations were recorded therein. The delineated crucial ranges (crucial winter and parturition) comprise 71,755 acres 58% of the yearlong area. If all the elk range acreage was of equal importance and value, it would logically follow that 58% of the 648 elk observations (376) would be located in the crucial ranges. In actuality, 602 (93% of the total observations, or 60% more observations than expected) of the 648 observations were made in the crucial ranges, thereby demonstrating their importance to the herd.

Four distances were chosen for evaluation. A 0.5 mile parameter was chosen to as it was used in the PRB FEIS. Displacement within Fortification Creek, based on anecdotal observations, was estimated to be greater than 0.75 miles. Powell (2002) in a Jack Morrow Hills study reported 1.24 mi avoidance from oil and gas activity. Sawyer et al (2007) reported elk use, in another Jack Morrow Hills study, is highest in areas greater than 1.73 mi from roads during summer and 0.75 mi during winter. Jack Morrows Hills is an open sagebrush dominated landscape much like Fortification Creek. The two herds share other similarities such as both herds are hunted and there is motorized vehicle activity within both areas. These similarities make the findings of the Jack Morrow Hills studies applicable to Fortification Creek. The most recent Jack Morrow Hills study included 33 global positioning system (GPS) collars collecting points every four hours, independent of weather and daylight (Sawyer et al. 2007).

Elk show avoidance of an area if they are located (observed) within a given area less than the proportion of which that habitat is available (expected) or selection if elk are located within the given area more than the proportion the habitat is available. For example if 12% of the yearlong range lies within 0.5 miles of a well; then 12% (77) of the 648 elk locations would be expected within this category. Fewer observations indicate avoidance, while more observations indicate an attraction or selection.

The chi-square test was used to evaluate differences between the observed and expected values. A chi-square value greater than 3.841 means that there is a 95% probability (p=0.05) that something other than chance is responsible for the difference between the observed and expected values. In other words, if the chi-square value is greater than 3.841, we are 95% certain that there is a statistical difference between the observed elk use and the expected elk use.

Tables of results are provided for analyses performed within the buffer distance categories (i.e. <0.5 mi, 0.5 mi – 0.75 mi, 0.75 mi to 1.25 mi, etc.). The analyses were also performed across the buffer categories (i.e. < 0.5 mi, < 0.75 mi, < 1.25 mi, etc.) but not displayed. The across category results are not displayed for two reasons; first all the data are provided in the within category tables that readers could calculate the across category results for themselves, and secondly one category could unduly influence across category results. In other words if a strong avoidance is shown in the <0.5 mi category, those data may bias the <0.75 mi category towards avoidance. In most analyses, the within category results and across category results were similar; where the results differed, the across category results are presented.

Concern was raised that the VHF data might be biased towards avoidance of wells and roads as the data were collected only during the day time, concurrent with activities such as well metering and maintenance; and that if night time data were available it might demonstrate that elk do not avoid minerals infrastructure at night when there is no human activity. The GPS collar was used to evaluate this theory; the GPS data were examined in relation to wells and roads as described above for the VHF collar data. Two runs were made, one with the complete GPS data set and a second to represent night time (7pm – 7am) or non-working hours.

To further evaluate if the observed elk locations were due to chance or if other factors were responsible for the distribution of elk locations, the well and road analyses were repeated with a like number of random points.

Avoidance may develop over time as the mineral development increases over the years. To evaluate this hypothesis, data from the mid-1990s Fortification Creek elk study and the Wyoming Oil and Gas Conservation Commission (WOGCC) were used to examine elk use in relation to conventional wells existing prior to that study. Forty conventional wells were present in January 1992, 34 natural gas and six oil. There were no CBNG wells within the FCA at this time. Elk locations were analyzed within the same buffer distances (Table 5a & 5b).

Vegetation

The next analysis was to examine whether vegetation influenced the observed elk use. Vegetation data in the form of a Landsat Thematic Mapper image, 30 meter resolution, of the Buffalo Field Office, classified by vegetation type, was used. The mid-1990s Fortification Creek elk study found that the elk preferred the juniper/ponderosa pine habitats and wooded draws. These preferred habitats were selected from the vegetation classification, and then their availability within the study areas and the selected buffer distances were calculated. Elk use within the distance buffers was then evaluated. Expected elk observations were based on the percentage of preferred habitat within the buffer being evaluated.

Topography

In the Fortification Creek area with its sparse forest cover, topographic features likely provide the predominant cover for elk. Topographic roughness was measured by calculating the standard deviation of digital elevation model (DEM) points within 200 meters of each DEM point and averaging them for each distance zone. A DEM is a grid of elevation points; a 10 m DEM would be a grid of points every 10 meters. Two-hundred meters was selected since Morgantini and Hudson (1979) reported that elk typically stay within 100-200m of cover while foraging. Standard deviation describes topographic variability, or roughness, better than other variables such as slope (Jellison 2006, Naugle et al 2006). The standard deviation is a statistic that explains how tightly all the various examples are clustered. When the examples are pretty tightly bunched together, the standard deviation is small. When the examples are spread apart, the standard deviation is large. In "rough" break country, such as Fortification Creek, with widely fluctuating elevations the standard deviation is high; whereas a relatively level surface (i.e. floodplain) would have a low standard deviation.

Results and Discussion

Mineral Development

Results of the current habitat selection analysis (VHF collars) are provided in Table 4a. The results indicate, with 95% certainty, that elk are selecting areas away from the existing natural gas wells at least as far as 1.7 miles; the results were statistically different for both the yearlong range and the crucial ranges (Figure 2a).

Elk may not be avoiding roads beyond 0.5 miles, as they used habitats further than 0.5 miles from a road more than expected (Figure 3a). Elk used areas within 0.5 miles of an existing road approximately 30% less than expected within both the yearlong range and the crucial ranges. Beyond 0.5 miles from a road, elk use was much higher than expected within both the yearlong range and the crucial ranges.

Elk use is concentrated in the WSA and northern half of the FCA, approximately 90% of the radio collar locations (580 of 648) are north of Fortification Creek

Research has clearly demonstrated that elk avoid roads and that aversion to roads is associated with multiple factors including: topography, vegetation, and vehicle traffic (Frair et al. In Press, Sawyer et al. 2007, Rowland et al. 2005, Christensen et al. 1993, Lyon 1983, Lyon and Jensen 1980, Thomas 1979). Despite a wealth of information about how roads and motorized traffic affect elk and their habitats, gaps in our knowledge remain. For example, while we know that elk response to roads generally varies depending on the level and type of motorized traffic, we have little knowledge about the precise levels of such disturbance that elicit a response, and the duration of that response (Rowland et al.2005).

Where human activity is both non-lethal and predictable, elk have become habituated to human disturbances associated with roads, such as in Banff, Rocky Mountain, and Yellowstone National Parks (Frair et al. In press, Cassirer et al. 1992, Schultz and Bailey 1978). Elk herds, such as Fortification Creek, subjected to hunting and less predictable human activity are less tolerant of roads; with the ecological footprint of a road possibly extending several kilometers from the road (Frair et al. In press, Rowland et al. 2005). Rowland et al. (2005) cite a paper by Gucinski et al. (2001) which states "in public wildlands management, road systems are the largest human investment and the feature most damaging to the environment."

Another interpretation of the Fortification Creek data is that elk can not avoid roads by more than one-half mile. Table 4a also presents the area available within each of the buffer categories, and there is little area available greater than one-half mile from a road. In fact, eighty percent of the FCA, including the WSA, is within one-half mile of a road. Elk locations are clustered within the non-motorized WSA. The number of radio-collared elk locations within the WSA was nearly half the total observations (302 of 648). With the WSA comprising 10% of the FCA (12,832 acres out of 122,930 acres), the 302 observations are more than 4.64 times greater than the 65 observations that would be expected based on area alone. Elk are likely avoiding roads, using the available habitat, to the best of their ability, but may avoid roads to a greater extent if it were possible. It appears that elk are being pushed into the WSA by the current level of mineral development.

The movements of the GPS collared cow elk mirrored those of the VHF collared elk discussed above. The GPS cow avoided well sites at least to 1.7 miles and roads by 0.5 miles regardless of time of day (Table 4b, Figures 2c & 3c). The data presented is for the yearlong range, an analysis within the crucial ranges was not performed. Although it appears that time of day may not be a factor in elk avoidance of wells and roads, it should be noted that these are the movements of a single elk and that she may not accurately reflect the entire Fortification Creek population.

Table 4a. Elk Habitat Selection in Relation to Existing Wells and Roads (VHF collars).

	<0.5 mi	0.5-0.75mi	0.75-1.25mi	1.25-1.7 mi	> 1.7mi	Total
Wells						
Yearlong Range						
Available Habitat (ac)[1]	17,642	8,341	14,907	11,783	70,261	122,933
Expected Elk Use[2]	93	44	79	62	370	648
Actual Elk Use[3]	13	12	24	33	566	648
Elk Selection (%)[4]	-86%	-73%	-70%	-47%	+53%	
Chi-square[5]	68.811	23.242	37.908	13.643	103.349	
Crucial Ranges						
Available Habitat (ac)	6,975	4,079	8,236	6,604	45,860	71,755
Expected Elk Use	59	34	69	55	385	602
Actual Elk Use	8	9	24	25	536	602
Elk Selection (%)	-86%	-74%	-65%	-55%	+39%	
Chi-square	43.612	18.588	29.433	16.686	59.458	
Roads						
Yearlong Range						
Available Habitat (ac)	98,906	13,710	9,172	1,144	0	122,930
Expected Elk Use	521	72	48	6	0	648
Actual Elk Use	357	93	134	64	0	648
Elk Selection (%)	-31%	+29%	+177%	+961%	0	
Chi-square	51.624	6.125	154.083	560.667		
Crucial Ranges						
Available Habitat (ac)	56,548	8,161	6,118	928	0	71,755
Expected Elk Use	474	68	51	8	0	602
Actual Elk Use	332	86	120	64	0	602
Elk Selection (%)	-30%	+26%	+135%	+700%	0	
Chi-square	42.540	4.765	93.353	392.000		

[1]Acreage within a specified distance of a well for the analysis area.
[2]Number of elk expected to be observed based on the amount of habitat available to them. If 12% of the analysis area lies within 0.5 miles of a well, then one would expect there to be 12% or 77 of the 648 total elk observations.
[3]Actual number of elk observed within the specified distance of wells.
[4]The percent avoidance (negative) or selection (positive) is the percent change from what was observed and what was expected. For example, the 83% avoidance shown within 0.5 miles of a well is the percent reduction from the 77 elk expected and the 13 elk observed.
[5]Chi-square test for probability of difference between observed values and expected values. A chi-square value greater than 3.841 means that there is a 95% probability (p=0.05) that something other than chance is responsible for the difference between the observed and expected values.

Table 4b. Habitat Selection of a Single GPS Collared Elk in Relation to Existing Wells and Roads.

All GPS locations	<0.5 mi	0.5-0.75mi	0.75-1.25mi	1.25-1.7 mi	> 1.7mi	Total
Wells						
Available Habitat (ac)	17,642	8,341	14,907	11,783	70,261	122,934
Expected Elk Use	327	154	276	218	1301	2276
Actual Elk Use	93	28	101	96	1958	2276
Elk Selection	-0.715	-0.819	-0.634	-0.560	0.505	
Chi-square	167.106	103.503	110.952	68.398	332.007	
Roads						
Available Habitat (ac)	98,906	13,710	9,172	1,144	0	122,932
Expected Elk Use	1831	254	170	21	0	2276
Actual Elk Use	1130	390	652	104	0	2276
Elk Selection	-0.383	0.536	2.840	3.910	0	
Chi-square	268.487	73.049	1369.176	323.842		
Night (7pm-7am)						
Wells						
Available Habitat (ac)	17,642	8,341	14,907	11,783	70,261	122,934
Expected Elk Use	167	79	141	111	665	1163
Actual Elk Use	47	21	53	48	994	1163
Elk Selection	-0.718	-0.734	-0.624	-0.569	0.495	
Chi-square	86.136	42.498	54.945	36.141	163.139	
Roads						
Available Habitat (ac)	98,906	13,710	9,172	1,144	0	122,932
Expected Elk Use	936	130	87	11	0	1163
Actual Elk Use	606	200	314	43	0	1163
Elk Selection	-0.352	0.542	2.619	2.973	0	
Chi-square	116.173	38.099	595.039	95.665		

Table 4c presents the random point results; this analysis portrays a distribution of points known to have no relationship to mineral development or any other factor. In theory the results should indicate no statistical difference for any category tested. Keeping with a 95% degree of certainty, chi-square > 3.841, results for all categories evaluated except 0.75-1.25 mi from wells indeed showed no statistical difference between the observed values and expected values. The chi-square tests run across categories resulted in no statistical difference for the <1.25 mi category, chi-square = 0.107. These results confirm that there is no relationship between the random points and mineral development but also that statistical difference can occur even by chance. The random point results further support that mineral development, wells and roads, are influencing elk habitat use and selection.

Table 4c. Random Points in Relation to Existing Wells and Roads.

	<0.5 mi	0.5-0.75mi	0.75-1.25mi	1.25-1.7 mi	> 1.7mi	Total
Wells						
Yearlong Range						
Available Habitat (ac)	17,642	8,341	14,907	11,783	70,261	122,933
Expected Points	93	44	79	62	371	650
Actual Points	86	37	98	71	358	650
Selection (%)	-8%	-16%	+24%	+14%	-4%	
Chi-square	0.568	1.144	4.668	1.215	0.490	
Roads						
Available Habitat (ac)	98,906	13,710	9,172	1,144	0	122,933
Expected Points	523	72	48	6	0	650
Actual Points	501	85	56	8	0	650
Selection (%)	-4%	+17%	+15%	+32%	0	
Chi-square	0.923	2.158	1.161	0.629	0	

The apparent avoidance of wells and roads may have developed as the mineral activity increased over the years. Elk use in relation to roads was not tested, as a dataset for 1992 roads was not available. Within category results for the 1990s dataset differed from the current study. Results are graphically portrayed in Figure 4. Although raw numbers indicated avoidance of wells out to 1.25 miles within the yearlong range or 0.75 mi within the crucial ranges, only elk use within 0.5 mi of existing wells for the yearlong range analysis showed a statistical difference (Tables 5a). In other words only yearlong range within 0.5 mi of a well was used statistically less than expected based on availability. Combining the categories indicated statistical avoidance of 1.25 mi from wells within the yearlong range, and within 0.75 mi of wells within the crucial ranges, but not within 0.5 mi of wells within the crucial ranges. The results indicate that mineral development influenced elk habitat selection in the 1990s, but to what extent is uncertain.

Avoidance may have increased since the mid-1990s as the mineral development increased. This is very similar to long-term mule deer studies which have concluded that mule deer continue to avoid oil and gas facilities several years after drilling (Madson 2006, Lustig 2003).

Elk use appears to have shifted north since the mid-1990s. During the initial study 40% of the recorded elk locations (186 of 468) were south of Fortification Creek compared to 10.5% (68 of 648) in the current study.

Table 5a. Elk Habitat Selection, 1990s Study, in Relation to Existing Wells (within categories).

	<0.5 mi	0.5-0.75mi	0.75-1.25mi	1.25-1.7 mi	> 1.7mi	Total
Yearlong Range						
Available Habitat (ac)[1]	11,755	7,078	15,267	14,034	74,799	122,933
Expected Elk Use (%)[2]	44	27	58	53	282	464
Actual Elk Use (%)[3]	29	21	55	67	292	464
Elk Selection (%)[4]	-35%	-21%	-5%	+26%	+3%	
Chi-square	5.323	1.223	0.119	3.716	0.332	
Crucial Ranges						
Available Habitat (ac)	4,741	3,117	8,034	7,930	47,934	71,755
Expected Elk Use (%)	27	18	46	45	273	409
Actual Elk Use (%)	18	11	50	58	272	409
Elk Selection (%)	-33%	-38%	+9%	+28%	0.00	
Chi-square	3.013	2.577	0.387	3.625	0.005	

[1]Acreage within a specified distance of a well and percentage of the overall analysis area.
[2]Number of elk expected to be observed based on the amount of habitat available to them. If 10% of the analysis area lies within 0.5 miles of a well, then one would expect there to be 10% or 49 of the 464 total elk observations.
[3]Actual number of elk observed within the specified distance of a well, and percentage of the total elk observations.
[4]The difference in the number of elk observed from the number that was expected. The percentage avoidance (negative) or selection (positive) is the percent change from what was observed and what was expected. For example, the 40% avoidance shown within 0.5 miles of a well is the percent reduction from the 10% expected use and 6% actual use.

Table 5b. Elk Habitat Selection, 1990s Study, in Relation to Existing Wells (within categories).

	< 0.5 mi	< 0.75 mi	< 1.25 mi	< 1.7 mi	> 1.7 mi	
Yearlong Range						
Available Habitat (ac)	11,755	18,833	34100	48134	74799	122,933
Expected Elk Use (%)	44	71	129	182	282	464
Actual Elk Use (%)	29	50	105	172	292	464
Elk Selection (%)	-35%	-30%	-18%	-5%	+3%	
Chi-square	5.323	6.253	4.367	0.516	0.332	
Crucial Ranges						
Available Habitat (ac)	4741	7858	15892	23822	47934	71,755
Expected Elk Use (%)	27	45	91	136	273	409
Actual Elk Use (%)	18	29	79	137	272	409
Elk Selection (%)	-33%	-35%	-13%	+1%	0%	
Chi-square	3.013	5.567	1.481	0.011	0.005	

Vegetation

The results displayed in Table 6 and Figures 5 and 6 indicate that vegetation does not explain the observed elk use. The amount of preferred elk habitat appears to decrease away from well sites, being statistically different within 0.75 mi of well sites and greater than 1.7 mi from wells, but not between these two distances. Expected elk use was calculated based on the amount of preferred habitat available. Elk use was statistically lower than expected out to 1.7 miles from existing wells and statistically greater than expected beyond 1.7 miles. Road results were similar to the previous roads analysis, with elk avoiding even preferred habitats within 0.5 mi of roads. Beyond 0.5 mi from roads, elk use was greater than expected. Vegetation is not a primary factor in the observed elk avoidance of wells and roads.

Table 6. Available Preferred Elk Habitat and Selection in Relation to Existing Wells and Roads.

	<0.5 mi	0.5-0.75mi	0.75-1.25mi	1.25-1.7 mi	> 1.7mi	
Wells						
Yearlong Range						
Available Acres	17,642	8,341	14,907	11,783	70,261	122,930
Observed Habitat	560	188	259	181	954	2142
Expected Habitat	307	145	260	205	1224	
Chi-square (habitat)	207.542	12.520	0.002	2.880	59.676	
Elk Expected	169	57	78	55	289	648
Elk Observed	13	12	24	33	566	648
Chi-square (elk use)	144.409	35.406	37.704	8.644	266.620	
Crucial Ranges						
Available Acres	6,975	4,079	8,236	6,604	45,860	71,755
Observed Habitat (ac)	492	181	246	175	843	1,936
Expected Habitat	188	110	222	178	1237	1936
Chi-square (habitat)	490.450	45.733	2.546	0.057	125.681	0
Elk expected	153	56	76	54	262	602
Elk Observed	8	9	24	25	536	602
Chi-square (elk use)	137.406	39.721	36.024	15.902	286.132	
Roads						
Yearlong Range						
Available Area (ac)	98,922	13,693	9,172	1,142	0	122,929
Observed Habitat (ac)	1,705	205	193	40	0	2,143
Expected Habitat	1,724	239	160	20	0	2142.04
Chi-square (habitat)	0.203	4.732	6.887	20.304	0	0
Elk expected	516	62	58	12	0	648
Elk Observed	357	93	134	64	0	648
Chi-square (elk use)	48.8890	15.4790	97.9230	222.590	0	
Crucial Ranges						
Available Area (ac)	56548	8,161	6,118	928	0	71,755
Observed Habitat (ac)	1573	159	167	35	0	1,934
Expected Habitat	1524	220	165	25	0	1934
Chi-square (habitat)	1.566	16.896	0.027	3.988	0	0
Elk expected	490	49	52	11	0	602
Elk observed	332	86	120	64	0	602
Chi-square (elk use)	50.747	26.930	89.000	258.863	0	

Topography

Topography is not statistically different for any distance tested from wells or roads either within the yearlong range or the crucial range subset (Table 7). Beyond 1.7 mi is not included for the roads analysis as there are no areas within the FCA greater than 1.7 miles from a road. Topographic roughness, does not adequately explain the observed elk use (Figures 7 and 8).

Table 7. Topographic Roughness in Relation to Existing Wells and Roads.

	Statistical Mean[2]	Data Range[3]	Data Standard Deviation[4]	Chi-square
Wells				
Yearlong Range	15.2	0-36	4.86	
<0.5 mi	12.713	1-29	3.821	0.407
0.5-0.75mi	13.218	2-28	4.051	0.258
0.75-1.25mi	13.238	0-28	3.871	0.253
1.25-1.7 mi	13.602	1-28	3.811	0.168
> 1.7mi	16.368	0-36	4.974	0.090
Crucial Ranges	15.243	0-36	4.542	
<0.5 mi	13.193	3-29	3.69	0.276
0.5-0.75mi	14.017	2-28	4.244	0.099
0.75-1.25mi	13.732	1-28	4.058	0.150
1.25-1.7 mi	13.716	2-27	3.782	0.153
> 1.7mi	16.005	0 - 36	4.61	0.038
Roads				
Yearlong Range	15.372	0-36	4.869	
<0.5 mi	9.08	0-24	3.06	2.575
0.5-0.75mi	10.36	0-23	3.09	1.634
0.75-1.25mi	10.64	0-23	3.03	1.457
1.25-1.7 mi	10.8	2-25	2.96	1.360
Crucial Ranges	15.389	0-36	4.538	
<0.5 mi	14.83	0 - 36	4.51	0.020
0.5-0.75mi	16.47	2-35	4.28	0.076
0.75-1.25mi	17.28	3-31	4.16	0.232
1.25-1.7 mi	18.2	8-30	4.12	0.513

After examining current elk habitat selection, mid-1990s habitat selection, preferred vegetation availability in comparison to elk use, and topography, only avoidance of minerals infrastructure, wells and their associated roads adequately explains the observed elk habitat selection.

Principal investigators from a southeastern Colorado study indicate that their preliminary data, first year of five completed, suggests that elk may adjust to CBNG activities post drilling (Hayden-Wing 2007). Seven radio-collared elk (from a 12,000 to 16,000 elk herd) were routinely located within a producing CBNG field (construction/drilling phase completed). Global positioning system (GPS) collars enabled elk locations to be collected both day and night. Elk stayed within the CBNG field during the day seeking cover within pinion-juniper vegetation; at night the elk foraged in more open habitat types including adjacent to roads and well pads.

Although the preliminary results from the southeastern Colorado study are intriguing and much may be learned from this study, the Colorado situation is not directly comparable to the Fortification Creek situation. Both Fortification Creek elk monitoring efforts used traditional radio-collars with locations being recorded only during daytime under favorable weather conditions. BLM evaluated cover (vegetation and topography) and elk distribution against well locations and roads. The Fortification Creek elk avoided roads and wells despite the availability of nearby cover. The vegetation in southeastern Colorado looks to be denser providing greater cover. Fortification Creek CBNG development is primarily proposed (95 existing CBNG wells with the potential for 1,291 more wells assuming 80 acre spacing); whereas the Colorado field is largely developed, development occurring from 2000 to 2002, and is now in the production/operations phase. The Colorado Division of Wildlife (CDoW) stated the elk largely left the study area while the CBNG field was being developed (Vitt 2007).

One GPS collar was deployed on a Fortification Creek cow elk in February 2005 which recorded her location every five hours. BLM retrieved this collar and evaluated the circadian movement patterns of this one elk. Her activity, day and night, were consistent with the other traditionally collared Fortification Creek elk; she avoided wells and roads regardless of the time of day. Although one collar is insufficient to make inferences about the population it supports the results of the non-GPS collars.

The apparent habituation of the Colorado elk to CBNG development may be that the elk are behaving similarly to non-hunted populations. Much like elk in a national park, because of the very limited hunting pressure, the Colorado elk may have habituated to the controlled, predictable, non-lethal, human activity within the gas field. The Colorado CBNG development is primarily on private lands with some State owned parcels. Hunting access, during the late August to January season, is controlled by the private land owners whom are managing for trophy bulls. It is likely that, in order to maintain trophy class bulls, only a few hunters are authorized access at any one time and that only a few elk are harvested during the entire four to five month hunting season. The CDoW indicated that most hunting is done outside the study area with approximately six hunters allowed access to the study area at any one time (Vitt 2007). Unfortunately, the CDoW does not have data specific to the study area, as it is a small segment of a large herd unit (12,000-16,000 elk).

The Fortification Creek ownership pattern may be similar to the southeastern Colorado situation, with private landowners controlling access to the public lands however; the hunting pressure is much greater. Fortification Creek elk seasons prior to 2003 were very liberal in an effort to bring the elk population down to the management objective; the average harvest from 1998 through 2002 was 90 elk per year (WGFD 2005). The Fortification Creek hunting season is currently limited to approximately one week in October; where in 2003, 43 hunters spent approximately 151 recreation days and harvested 22 elk (WGFD 2005). The greater hunting pressure in Fortification Creek is likely a factor that has kept elk from habituating to oil and gas activities.

CUMULATIVE EFFECTS

The spatial extent for the cumulative effects, like the habitat selection analyses, is the WGFD yearlong range. Cumulative effects are the impacts on the environment which results from the incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. The temporal scale is twenty years, the projected lifespan of CBNG activities.

Population

The effects of the proposed project on elk populations are difficult to predict because of the many unknown factors associated with each of the potential effects and the potential for a synergistic or countervailing relationship among the individual effects. Because determining the reaction of elk in the FCA is difficult, it may be more appropriate to frame the potential cumulative effects of CBNG development to this species in terms of a likelihood, or probability. For this reason, the following three impact scenarios are offered. An additional factor that coincides with each of the scenarios is that some additional mortality due to vehicular collisions and poaching would be likely (Jahnke 2006), as has already been seen in other parts of the Powder River Basin with big-game animals.

Scenario #1 – Mass Abandonment of the Entire FCA (Least probable)

As with most big-game species, elk are very traditional animals in the sense of their habitat use and affinities, and once accustomed to a home range and territory, tend to cling closely to it. The Fortification Creek elk herd was re-introduced to the area in the 1950s and has acclimated and adjusted to this vicinity. Over that 50 year period of time they have established their own local traditions as a herd. Therefore, it is highly unlikely the herd would in mass, abandon their Fortification Creek home, and move to another area as a result of CBNG activities, although individual animals might do so (see scenario #3). Knight (1981), in a Michigan study with heavier vegetation cover, concluded that certain types of oil field activities could affect the daily movements of elk, but not likely the overall distribution of an elk herd. Furthermore, even if the herd was so inclined, there are no closely surrounding habitats that are not already being impacted by CBNG activities. Therefore, this scenario is deemed very improbable.

Scenario #2 – Complete Habituation to CBNG Activities (Possible, but unlikely)

Elk are very wary and quite mobile animals capable of ranging widely. They do not generally habituate to human presence and activities. They take "flight" easily whenever a threatening presence is perceived, although they can become accustomed to humans in non-threatening situations, as witnessed in some national parks. However, hunted populations of elk are very suspicious of humans and nervous, and tend to take "flight" easily. The Fortification Creek herd is hunted, and is "flighty", as has been observed first hand. Hunting seasons from 1998-2002 were very liberal, averaging 90 elk harvested annually, to reduce the herd to its population objective (WGFD 2005). In this "breaks" type of habitat, the typical elk response is to place some topographical barrier (e.g., ridge) between them and the human disturbance. Johnson and Lockman (1979) observed that elk actively avoided oil field development activities in southwestern Wyoming montane habitats, and Ward (1979), in a study observing elk heart rates, found increased heart rate activity in elk in close proximity to human traffic on roads. Powell (2003) found avoidance (up to 1.25 miles) of oil and gas development activities in the Jack Morrow Hills desert elk herd of southwestern Wyoming. All of the above cited studies involve hunted elk herds, and all of these studies strongly suggest that total habituation of Fortification Creek elk to CBNG development is possible, but highly unlikely.

Scenario #3 – Reduced Herd Residing in Fortification Creek (Most Probable)

Because of their affinity for the FCA and their wary nature, the most probable scenario for elk response to the proposed CBNG development is for the herd to stay in the FCA and attempt to avoid the CBNG activities. During development, projected to last five to ten years, road and facility construction and human activity is apt to be taking place on most of the ridges and drainages in the FCA. The elk population is necessarily expected to be stressed and impacted almost continuously during the construction phase. With decreased human activity, the impact level may ease somewhat during the production phase, projected to last another ten years.

In an attempt to quantify the actual impact to the elk population, the current collared elk study was examined as a "benchmark reference" for gauging impacts. Of 26 collared elk, four (4) of these animals (about 15%) have been observed to routinely venture outside the FCA, though most of them (3 of 4) seasonally return. Expanded to the whole herd population, we would expect about 35 of the existing 230 head to venture outside the FCA, at least occasionally.

Small populations are subject to genetic inbreeding, and stochastic events such as fires, severe winter, disease, drought, etc. that make them intrinsically more vulnerable to extinction (Gilpin and Soule 1986). Populations that are isolated, like the Fortification elk herd, are more sensitive to these internal (genetic) and external (stochastic) elements. In isolated populations, due to a closed gene pool with no gene immigration, deleterious genes can become more prevalent through time. There is enough genetic interchange with surrounding elk herds that genetics is likely not a concern to the Fortification Creek herd (Jahnke 2006). Stochastic events such as fires or severe winter storms can remove individuals from populations or impact habitat to the extent the carrying capacity is reduced. In fact, at least two recent wildfires have occurred in the WSA. In populations that are small in number and isolated, or largely so, such events are magnified because there are proportionally fewer animals left (i.e., little or no insulation or buffering effect) with little potential for immigration into the population. The Buffalo Field Office experienced three wildfires in 2006 greater than 12,000 acres. One fire was greater than 20,000 acres.

In the absence of a stochastic event, the WSA could sustain a reduced elk population for the projected twenty year duration of CBNG development. It is difficult to project how many animals a given area could support without long-term habitat use and forage utilization studies. Lacking such long-term data, BLM predicts that the WSA may be able to maintain 46 to 64 elk with the proposed level of CBNG development, 80 acre well spacing including the State section and with no development buffer from the WSA boundary.

Population estimates were derived by first evaluating whether the WSA contained the crucial habitat types and sufficient area to support elk. The WSA, including the State section, contains 8,950 acres of CWR and 10,600 acres of parturition range. The collared elk currently depend heavily on the WSA; the number of radio-collared elk locations within the WSA was nearly half the total observations (302 of 648). Published elk literature indicates minimum area home ranges for elk varied from 766 to 4,151 acres (3.1 to 16.8 sq. km) (Waldrip and Shaw 1979). BLM concluded the WSA contains sufficient habitat types and area to support elk.

The final step was to predict the potential population size that the WSA could support. The current population (230) was chosen over the population objective (150) as a starting figure because the herd is currently productive and in good health. Since the movements of the collared elk are concentrated in the northern half of the FCA including the WSA, the southern portion of the CWR and parturition range were removed from consideration; 19,100 acres of CWR and 29,650 ac of parturition range are currently supporting 230 elk. In other words the northern half of the FCA is largely supporting 230 elk. Within the WSA are 8,950 ac of CWR and 10,600 ac of parturition range. A simple proportion of the acreage by habitat type within the WSA was then calculated 0.47 (8,950/19,100) for CWR and 0.36 (10,600/29,650) for parturition range; the proportion multiplied by the current population provided the estimated population that the WSA could support, 108 for CWR and 83 for parturition range. Under the proposed development scenario, 80 acre well spacing, the habitat effectiveness modeling discussed in the next section of this report predicts approximately 5,337 ac of CWR and 6,045 ac of parturition range will be available for elk following development. The population estimates that the WSA could support under the proposed development, using the proportion calculations described above, are 64 ((5337/19100)*230) for CWR and 46 ((6045/29650)*230) for parturition range.

Conservation biologists recommend an effective population of at least 50 for a long-term minimum viable population (Franklin 1980). The effective population is the number of individuals actively breeding thereby contributing to the population. The 2003 WGFD annual report (WGFD 2005) provides population parameters that estimate the Fortification Creek effective elk population to be 64% (117/168) of the total population (100 mature cow elk and 7 mature bulls in a total population of 168). The proposed development scenario results in an effective population from 29 (46*0.64) to 41(64*0.64) elk. The true effective population would likely be less, as the above calculations do not account for a polygynous breeding system but assumes all mature bulls and cows successfully breed annually. Achieving an effective population more than 50 may not be a great concern in Fortification Creek since the CBNG development is projected to only last 20 years and there is genetic interchange with elk in Montana.

Concentrating elk into the WSA would likely result in increased stress, increased disease, and reduced productivity with an overall reduction in herd health. The minimum area home range mentioned above represents the minimum area needed to supply an individual's basic needs; however most individuals typically use a much larger area in their seasonal and annual movements. A commonly used methodology for estimating animal home ranges is percent kernel use, where a weighting factor is utilized to draw a home range around a given percentage of the animal's locations, 95% being common. Average seasonal home range estimates for cow elk in a nearby, northern Black Hills, non-migratory herd was 24,636 acres (99.7 sq. km) in summer and 25,773 ac (104.3 sq. km.) in winter (Benkobi et al. 2005). Ninety-five percent of the Fortification Creek GPS collared elk locations are included in a 22,000 ac area. Non-migratory elk populations typically still have seasonal range shifts (Peek 1982). The Fortification Creek WSA does not contain sufficient area to enable elk to move freely, the inability to move freely will likely result in decreased herd health such as increased stress and disease levels, and reduced productivity. In twenty years, when CBNG fields are reclaimed and vegetation recovers elk numbers are expected to rebound. But it would likely take several decades for the habitat and population to recover to pre-CBNG conditions.

In conclusion, with the proposed level of CBNG development the WSA could likely support 46 to 64 elk for twenty years, but lacking the ability to roam freely, the overall herd health would likely decrease. Following CBNG reclamation, it would likely take several decades for the habitat and population to recover to pre-CBNG conditions.

Habitat

Bromley (1985) provides a good overview of the type and nature of environmental impacts of conventional petroleum exploration and development on wildlife in general, as well as the implications of wildlife management in this kind of an industrial setting. While the focus of this document was on conventional petroleum field activities, the nature of the environmental impacts are essentially the same for CBNG development, though the pace and duration of the impacts could vary.

Southerland (1993) characterizes the type of impacts to habitat based on general effects categories, as follows: 1.) Habitat loss / destruction; 2.) Habitat fragmentation; 3.) Habitat simplification; and 4.) Habitat degradation. These general effects categories are further defined as follows:

Quantity

- ***Habitat Loss / Destruction*** – the destruction of a natural ecosystem through its "conversion" to another land use. In each conversion, the original natural characteristics of the land are eliminated, while the associated habitat values are modified to varying degrees, or totally lost. Physical alterations of many kinds can cause destruction.

Quality

- ***Habitat Fragmentation*** – the breaking of larger blocks of habitat into smaller blocks in a fashion that destroys the unit integrity and functionality of the habitat for "area sensitive" species.
- ***Habitat Simplification*** – the removal of ecosystem components (e.g., standing dead trees, cover logs, stream debris, sensitive submerged plants, etc.) and the loss of microhabitats (e.g., nests and dens, etc.) that are rendered unusable by human intrusion.
- ***Habitat Degradation*** – the decrease in the health or ecological integrity of "intact" habitats (e.g., chemical contamination, drawdown of aquifers, invasion of exotic plants and animals, etc.).

Any or all of these various forms of impacts may play out, either simply, additively, or with multiplicity in the FCA.

Water Availability

The FCA is a semi-arid landscape with few perennial water sources. Water is an important factor for elk distribution during summer and fall with nearly all summer observations during the WGFD's 1990s study being near springs, seeps, draws, or along major drainages (Oedekoven 1998). Collared elk locations during the current study exhibited a similar preference particularly for draws and drainages. An important water source for the FCA elk is water wells for domestic livestock use. Several are flowing wells, where the pressure is sufficient to bring water to the surface without pumping. The flowing wells provide year-round water sources benefiting livestock and wildlife. A FCA landowner has expressed concern in declining discharge from his domestic water wells (Burton 2007). Causes for the observed declines are unknown.

Methods

The Wyoming State Engineer's Office (WYSEO) Ground Water Rights Database (http://seo.state.wy.us/wrdb/index.aspx) was queried to identify flowing water wells, wells with either a negative or zero static depth. The WYSEO database identifies well depth but does not identify the bed or formation from which the water is being drawn.

The Wyoming Geological Survey (WYGS) and other partners modeled coalbed stratigraphy for the PRB. The model (http://ims.wrds.uwyo.edu/prb/index.html) was developed from geophysical well data collected from over 6,000 oil, gas, and CBNG wells. The database can generate geologic columns or cross sections anywhere in the project area which show the depth of various subsurface horizons, such as coal beds or geologic formations. The WYGS model was queried using the flowing water well locations to identify the geologic formation to which the water wells were drawing. Water well locations are recorded by quarter-quarter section resulting in a maximum error of 660 ft, radius of quarter-quarter, when identifying well locations.

Analysis
A query of the Wyoming State Engineer's Office (WYSEO) Ground Water Rights Database indicates 34 flowing wells are registered within the FCA (Figure 9) (Table 8)[1]. Fifteen wells, including the six P122697W wells, draw from the Wasatch bed which is well above the coal seams being developed for CBNG. Drilling and geophysical logs from CBNG wells show that the coal seams are separated from the overlying Wasatch Formation sandbeds by a relatively continuous low permeability claystone layer (PRB FEIS at 4-50). This claystone layer restricts hydraulic communication between the coal and the overlying Wasatch sands and therefore effects are difficult to evaluate. Permeability of other layers in the geologic column and the separation distance between the coal and the Wasatch sands also influence the hydraulic communication between the coal and the Wasatch water wells. Geologic variability makes it difficult to identify, without intensive site-specific work, which Wasatch wells have hydraulic communication with the underlying coals and therefore would be impacted by CBNG development. If there is hydraulic communication, then it would likely take several years before drawdown effects from pumping groundwater from the coal are apparent in the overlying Wasatch sands (PRB FEIS at 4-50). Where there is no hydraulic communication there would be no impacts from CBNG development on the flowing water wells.

Three wells draw water from a Fort Union layer above the Smith coal seam. The Smith seam appears to be of little commercial interest therefore it would likely also take years of coal seam dewatering before these three flowing wells would be impacted by CBNG development. If the Smith seam was developed, then CBNG drawdown effects would result in the loss of these three flowing water wells.

The remaining 16 flowing wells were completed within or just above coal seams being targeted for CBNG (Anderson, Cook, and Wall). Ground water draw down resulting from CBNG development would result in the loss of free-flowing water from these wells affecting elk distribution during the summer months.

Summer (July through September) locations, 2005 and 2006, from the single GPS collared elk were compared to the flowing water well locations. The VHF dataset from the current study was not used as there were only eight data collection flights during the summer period, and elk are unlikely to be at water during the daytime when the data were collected. The GPS cow elk appears to have used four of the flowing wells. Fifteen percent of the summer data points, 102 of 676, were within one-half mile of the four flowing wells. Three of the wells are located along Bull Creek and one along Fortification Creek. Ninety-seven of the 102 points were split evenly between two of the Bull Creek wells. The southern Bull Creek well is 1,387 ft deep in an aquifer between the Cook and Wall coal seams which would be drawn down when the CBNG is developed. The northern high use Bull Creek water well is 200 ft deep in the Wasatch bed which if there is hydraulic communication with the underlying coals would require several years of CBNG related drawdown before the flow is affected.

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[1] Six of the wells have the same permit number (P122697W) and depth but different locations, in reality this is likely one well and not six.

Table 8. Flowing Water Wells within the Fortification Creek Area.

Well	Township	Range	Section	Aliquot	Well Elev.	Depth	Bed
P1673W	0510N	0770W	9	NESE	3905	905	above L. Anderson
P2394W	0510N	0770W	27	NENE	3950	875	Anderson
P2724W	0520N	0760W	6	SENW	4242	965	above L. Anderson
P6504W	0520N	0760W	20	NWSW	4090	1110	Canyon
P7056W	0520N	0750W	17	SWSW	4126	153	Wasatch
P7064W	0520N	0760W	5	SWNW	4177	850	above L. Anderson
P7066W	0520N	0760W	5	SWNW	4177	895	above L. Anderson
P7067P	0520N	0750W	17	NWSW	4067	491	Anderson
P7068P	0520N	0750W	18	NWNW	4090	441	above Smith
P9669P	0530N	0760W	35	SWNE	3978	1045	above Wall
P18011P	0520N	0760W	31	SWSW	3945	800	above L. Anderson
P18012P	0520N	0760W	18	NWSW	3938	200	Wasatch
P18103P	0520N	0770W	1	NWSW	3893	700	above L. Anderson
P18104P	0520N	0770W	12	NWSE	3918	640	Anderson
P35639W	0500N	0760W	15	NENE	4554	200	Wasatch
P35642W	0500N	0760W	32	NENE	4554	112	Wasatch
P35644W	0500N	0760W	22	SWSE	4199	30	Wasatch
P35645W	0500N	0760W	30	SENW	4321	27	Wasatch
P65287W	0520N	0760W	20	NWSW	4090	1387	above Wall
P84466W	0500N	0770W	12	SWSW	3980	840	above Anderson
P84468W	0500N	0770W	12	NESE	4095	780	above Smith
P84469W	0500N	0760W	7	SESE	4137	300	Wasatch
P84486W	0500N	0760W	30	NWSW	4442	8	Wasatch
P122697W	0510N	0770W	2	SESW	4213	650	Wasatch
P122697W	0510N	0770W	10	SENW	4213	650	Wasatch
P122697W	0510N	0770W	11	NENE	4213	650	Wasatch
P122697W	0510N	0770W	13	NWNE	4213	650	Wasatch
P122697W	0510N	0770W	14	SWNE	4213	650	Wasatch
P122697W	0510N	0770W	15	SWNE	4213	650	Wasatch
P128269W	0520N	0750W	28	SWSE	4332	601	above Smith
P142937W	0510N	0770W	9	NESW	3882	1398	Cook
P142939W	0510N	0770W	9	NESE	3905	1750	Wall D
P143121W	0530N	0760W	31	NENE	3921	1038	Cook
P145612W	0510N	0770W	36	SESE	4347	10	Wasatch

Habitat Effectiveness

The spatial extent for the habitat effectiveness modeling, like the habitat selection analyses, is the WGFD yearlong range. Habitat effectiveness is the degree to which habitat features fulfill specific functions; the degree to which a species or population is able use their habitat. The temporal scale is twenty years, the projected lifespan of CBNG activities.

CBNG development fragments habitats through placement of linear facilities such as roads and pipelines. The impacts from fragmentation can vary depending on the use of the feature. For example, a road used daily would displace elk by reducing habitat effectiveness as well as fragmenting habitat. The placement of linear elements can also act as vector routes for invasive plant species (e.g., downy brome and leafy spurge) that can reduce the forage value of the area by out competing native plants, and in the case of brome, increase the potential for wildfire.

Disturbance from human activity is probably the largest potential impact from the foreseeable development. The PRB FEIS used "habitat effectiveness" - the degree to which habitat features fulfill specific habitat functions; the degree to which a species or population is able to continue using a habitat for a specific function - in an attempt to assess the effect of human disturbance on elk populations.

Methods

To assess habitat effectiveness BLM used a geographic information system (GIS) visual modeling technique to gain an understanding of the potential impact magnitude from CBNG activity on habitat effectiveness within the FCA. Existing conditions, including past and present mineral development, was used as the baseline for comparison as the elk herd is healthy and would likely increase above management objective if not hunted to maintain the current population.

Modeling is an attempt to simplify complex real world situations in an attempt to understand the primary forces driving the real world situation. Models include assumptions. This modeling effort is no different. Habitat effectiveness in relation to roads was modeled, as roads represent the greatest impact to the FCA elk, physically fragmenting the available habitat and displacing elk with their vehicle/human activity. The model does not include traffic levels which could influence habitat effectiveness, but assumes traffic levels would remain similar to current levels.

The model examined a 0.5 mile, or line-of-sight, elk displacement (loss of habitat effectiveness) from roads. A 0.5 mile displacement parameter was chosen to be consistent with the PRB FEIS. However, it should be noted the studies cited in the EIS were based on forested mountain environments (Lyon 1979, Ward 1976). Displacement within Fortification Creek may be greater, perhaps more than three times greater, based on anecdotal observations within Fortification Creek (>0.75 mi) and studies within similar arid environments. A recent Jack Morrow Hills study reported 1.73 mi avoidance from roads during summer (Sawyer et al. 2007), while Powell (2002) in an earlier Jack Morrow Hills study reported 1.24 mi avoidance from oil and gas activity.

The visibility model accounts for topography in the form of a digital elevation model (DEM), but does not include vegetation screening. Vegetative cover is likely not an important variable for the model as less than 2% of the FCA is in a preferred vegetation type, ponderosa pine or juniper. An initial model run tested a 10 meter DEM versus a 30 m DEM. The results showed that the 10 m DEM did not add to the model results. Therefore a 30 m DEM was used in the models to reduce model run time and file size.

Parameters for observer height (elk) and source height (vehicles) were also evaluated. Results indicated that the heights tested, 5 ft and 6 ft respectively, were too low for the model to be sensitive to these parameters. No height parameters were used in the final model runs.

Other assumptions included in the model are as follows: 1.) secure elk habitat was defined as those blocks of contiguous effective habitat >250 acres in size that would be unaffected by CBNG activities; 2.) the FCA is not pristine – some activity (e.g., roads, etc.) already exist in the area, and any analysis should properly be based off of the existing situation; 3.) the Fortification Creek elk herd is functioning in a relatively normal (though impacted) manner at this point in time; and 4.) habitat loss does not translate in a direct linear fashion to population loss (e.g., *not* every acre of habitat lost equals 1 [or 100] animal[s] lost) – rather, this relationship is stochastic and on a gradient of habitat degradation until some indefinite impact threshold is triggered which causes a radical change in the animal population.

An initial "theoretical" model was tested, within the crucial ranges, attempting to achieve minimum road density by using straight line roads from well to well without regards to topography. Different road designs were reviewed to achieve the minimum necessary roads, i.e. the roads run parallel north-south with only a single connecting road running east-west. The State section encompassed in the Wilderness Study Area (WSA) was included in the projected development with one road placed through the WSA for access. With the exception of the one road providing access to the State section, roads were not placed within the WSA. The development scenarios tested was the traditional 80 acres spacing (8 wells/section) industry has proposed for the FCA.

A parameter the theoretical model was sensitive to was point distance. The feature being examined was roads (vehicle activity); however, the visibility model runs from points, not lines. Simple straight line roads were drawn from well to well, or two points per road segment (one at each well). For example, if the road consisted only of points one mile apart then the circular 0.5 mi radius areas being evaluated from each point would not overlap, leaving large portions of the entire model area unevaluated. Additional points were added into the roads without changing the road shape or distance. A parameter of 325 ft between points was used in the final models for an overlap of 8 points within a 0.5 mi radius.

Two types of habitat were considered in the model habitat effectiveness and security habitat. Habitat effectiveness is the total area greater than 0.5 miles from roads, or less than 0.5 miles from a road but not visible from a road. It generally refers to the available habitat during nonhunting conditions, particularly summer and fall (Lyon 1983). To simplify the model, all area is considered useable habitat, vegetation and other factors affecting habitat suitability are not included. Security habitat is a subset of effective habitat. Elk often retreat when disturbance in their usual range is intensified, such as during the hunting season, with elk appearing to be most comfortable or secure within effective habitat areas of a minimum size (Lyon 1983). A commonly used minimum patch size for security habitat is 250 contiguous acres more than 0.5 miles from an open road (Christensen et al. 1991, Leege 1984).

The theoretical model (Table 9) provides useful information on effect scale and provides a benchmark for more realistic road designs. However, we felt with the roads drawn independent of topography, potential critiquing of the theoretical model may overshadow its value. Therefore, we ran a second model using topography to site the roads (Table 10). Industry provided BLM with a proposed road system for much of the FCA on an 80 acre spacing pattern. Additional roads were added to represent the foreseeable CBNG development in the areas where industry did not provide a proposed road network. Roads were placed along ridge lines and along drainages to mimic industry design and a more likely scenario. Coincidentally, ridge lines and drainage bottoms tend to be the sites most used by elk in the FCA, making them valuable habitat sites. An initial run was made within the crucial ranges where no roads were removed; a second run was done within the yearlong range where duplicate (parallel) roads and roads with no discernable destination (well site, stock tank, etc,) were removed. The two scenarios provide an opportunity to evaluate the benefit of removing unnecessary roads.

Results and Discussion

Table 9 shows the percent change in effective area and security area from the existing conditions for the theoretical model, and Table 10 for the realistic model.

Eighty acre spacing with minimum "theoretical" roads (8 wells/sec) (Figure 11) would result in a 60% reduction in security habitat, compared to present conditions (Figure 10), leaving no security habitat outside the WSA. The theoretical model predicts a 55% loss of effective habitat from present conditions.

Table 9. Comparison of Existing Conditions and Habitat Effectiveness Model Results within Elk Crucial Ranges, Fortification Creek Elk Herd, Powder River Basin, Wyoming. (Theoretical Roads)

Model	Road Miles (mi/sec)	Effective Habitat (Acres)[1]	Number of Security Patches[2]	Security Area[2] (Acres)
Existing Conditions	153 (1.36)	29,349	16	23,770
80 acre spacing (8 wells/Section)	264 (2.35) X^2: 80.529	13,230 (-55%) X^2: 8852.845	1 (WSA)	9,548 (-60%) X^2: 8509.267

1. Habitat effectiveness is the total area greater than 0.5 miles from roads or not visible from a road.
2. Secure elk habitat is defined as those blocks of contiguous habitat >250 acres in size that would be unaffected (directly or indirectly) by CBNG activities.

Table 10. Comparison of Existing Conditions and Habitat Effectiveness Model Results within Fortification Creek Elk Herd, Powder River Basin, Wyoming. (Realistic Roads)

Model	Roads Miles (mi/sec)	Effective Habitat (Acres)[1]	Number of Security Patches	Security Area (Acres)
Yearlong Range				
Existing Conditions	294 (1.53)	54,530	32	38,905
80 acre spacing (8 wells/Section)	641 (3.34) X^2: 409	14,498 (-73%) X^2: 29,389	1 (WSA)	8,065 (-80%) X^2: 24,447
Crucial Ranges				
Existing Conditions	153 (1.36)	39,861	24	28,440
80 acre spacing (8 wells/Section)	399 (3.56) X^2: 395.529	10,800 (-73%) X^2: 21187.168	1 (WSA)	7,904 (-72%)[1] X^2: 14828.667

3. The difference in acreage between the one security area in the yearlong and crucial range analyses is due to differences in the road datasets modeled. Roads that did not appear necessary were removed from the yearlong analysis, but not from the earlier crucial range only analysis.

The realistic model resulted in a 73% habitat effectiveness loss and 80% loss of security habitat for the yearlong scenario (Figure 12). No security habitat is predicted to remain outside the WSA. The difference in security habitat available between the yearlong range scenario (8,065 ac) and the crucial range scenario (7,904 ac) illustrates the sensitivity of the analysis to varying road networks. The difference between the theoretical roads and realistic roads also indicates the importance of road siting. These effects are projected to last for the duration of the CBNG development, drilling through reclamation (twenty years).

Lyon (1983) demonstrated that elk habitat effectiveness is reduced by at least 25% with adding one mile of road to a previously undisturbed square mile of land; two miles of road per square mile can reduce effective habitat by 50%. With road densities above three miles/square mile even very dense cover becomes largely ineffective; as road density increases to six miles/square mile, elk habitat use falls to zero (Lyon 1979). The Fortification Creek crucial ranges currently have a road density of 1.36 mi/sq. mi. with 45% of the area considered effective habitat (39,861 ac/71,755 ac). Christensen et al. (1991) recommend a standard of maintaining at least 30% of an analysis area as security habitat. Existing FCA conditions barely meet this standard, with 31% (38,905 ac/122,930 ac) of the yearlong range and 40% (28,440 ac/71,755 ac) of the crucial ranges being considered security habitat. The WSA was included in road density calculations. It is important to include the WSA as it is a part of the FCA landscape. If the WSA was excluded from the road density calculation, then road densities would increase.

SUMMARY

Approximately 10,491 of the total 122,930 acres of yearlong range in the Fortification Creek Elk Herd area, or 8.5%, would be directly disturbed with the proposed development (80 acre spacing) given the assumptions of the PRB FEIS (Table 1). If more reservoirs were to be proposed than were projected in the PRB FEIS, impacts could increase substantially. Direct habitat loss impacts are likely to last several decades; 10 to 20 years for the operational life of the wells and infrastructure, followed by reclamation, and recovery of the vegetation community's structure and function that existed prior to development. Vegetation and population recovery would likely take minimally an additional two decades.

Vegetation and topography are not the predominant factors in determining FCA elk movements. Human activities associated with mineral activities are having the greatest influence on elk habitat selection. The elk have adjusted to the current level of development, by favoring the WSA and crucial ranges, but how much more development they can tolerate is unknown. Elk are exhibiting an avoidance of existing wells by at least 1.7 mi; and are avoiding roads by at least 0.5 miles but realistically can not avoid roads any further with the existing road network. Elk are expected to continue to avoid wells and roads for 20 years, the duration of the CBNG activities. Road location, mileage, and traffic levels are paramount in determining elk habitat effectiveness.

BLM predicts that the WSA may be able to maintain 46 to 64 elk with the proposed level of CBNG development

There are 34 flowing stock wells of which 16 within or near the coal seams would initially be affected by CBNG drawdown, if the Smith coal seam is developed an additional three flowing wells would be lost. Where there is hydraulic communication, several years of CBNG related drawdown would be required to reduce flow from the Wasatch formation water wells (15).

No security habitat is available outside the WSA with eight CBNG wells per section.

PREPARERS AND COORDINATION

Principal Authors

Dave Roberts – Wyoming State Office, Wildlife Biologist
Thomas Bills – Buffalo Field Office, Environmental Coordinator and Wildlife Biologist

Contributors

Paul Beels – Buffalo Field Office, Associate Field Manager
Paul Christian - Buffalo Field Office, GIS Specialist
Diane Adams – Buffalo Field Office, GIS Specialist

Reviewers

Bureau of Land Management

Chris Hanson – Buffalo Field Office, Field Manager
Brenda Vosika-Neuman – Wyoming State Office, Physical Scientist

U.S. Fish and Wildlife Service

Kathleen Erwin – Wyoming Field Office (Cheyenne), Fish and Wildlife Biologist
Brad Rogers – Wyoming Field Office (Buffalo), Fish and Wildlife Biologist

Wyoming Game and Fish Department

Vern Stelter – Headquarters (Cheyenne), Habitat Coordinator
Lynn Jahnke – Region 3 Office (Sheridan), Regional Wildlife Coordinator
Bert Jellison – Region 3 Office (Sheridan), Habitat Biologist

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