

## APPENDIX B: ENVIRONMENTAL FACTORS

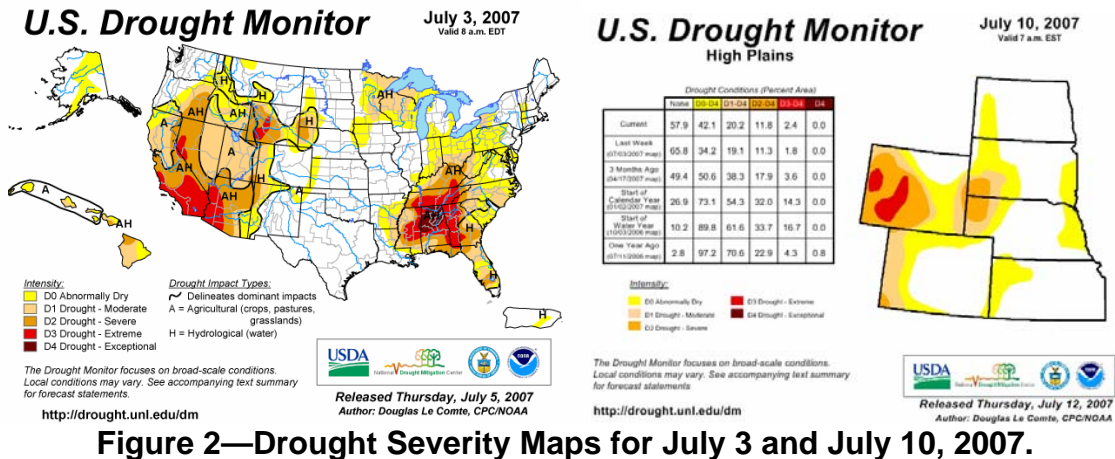
Appendix B, Environmental Factors, describes the weather and fire behavior on the Alabaugh Canyon Fire during the late hours of July 7, 2007 and the early hours of July 8, 2007. The discussion includes environmental conditions resulting in extreme fire behavior. Figure 1 is a photograph of the deployment area looking southwest. Alabaugh Canyon is located on top of the photo. Structure protection was initiated on the lower left side of the image. Grass and ponderosa pine fueled the fire with fire spread predominately from right to left of the image. The black arrow points to the deployment area.



**Figure 1 – Aerial View of Deployment Site**

### **Precipitation and Drought Conditions**

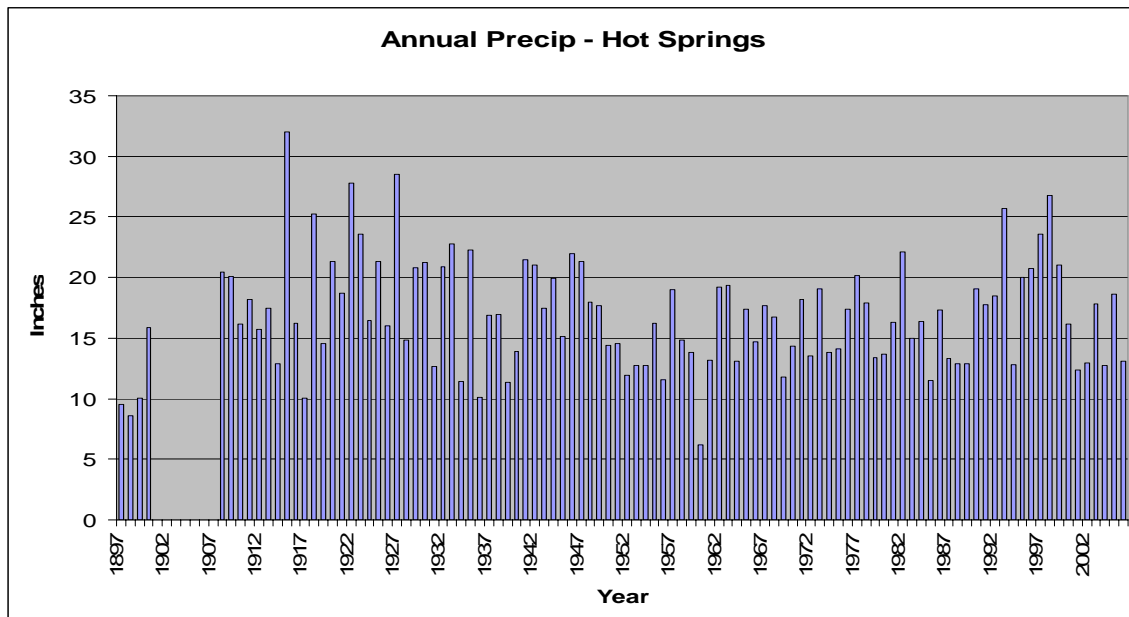
Drought has persisted over the Southern Black Hills for the past several years. Although the Drought Monitor for July 3, 2007 indicates severe drought conditions, NWS sources suggest that the conditions could have been upgraded to extreme for the Southern Black Hills for the July 3 period. The July 10, 2007, update for the High Plains Drought Monitor indicates that the drought continued to persist over the area (see figure 2).



**Figure 2—Drought Severity Maps for July 3 and July 10, 2007.**

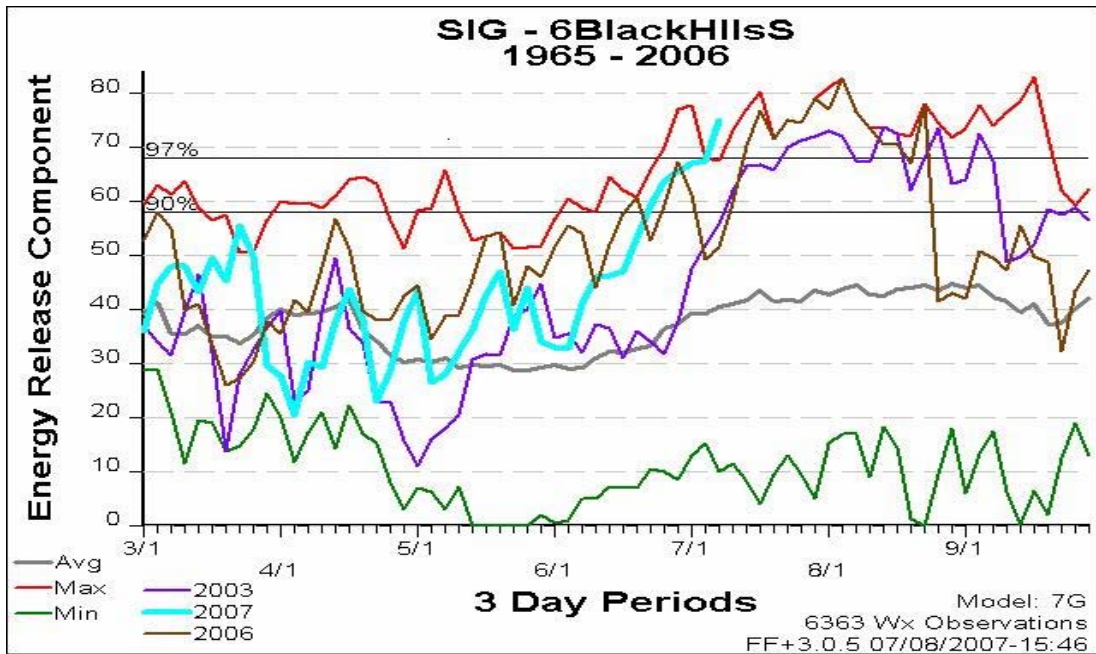
Annual rainfall departure of normal averaged 66% for the Southern Black Hills. The Hot Springs weather observation station, about 3 miles northeast of the Alabaugh fire, reported 63% departure from normal. Since mid-May, no significant precipitation had occurred with the exception of 0.2 inches on June 13, and .02 inches on June 22.

Hot Springs weather observations date back to the late 1800's as shown in figure 3. Annual rainfall varied throughout the century with some years experiencing record rainfall and other years of drought. Between the early 1990's and the late 1990's, a period of wet conditions existed. After the late 1990's, drought conditions began to set in. Rainfall continues to lag to date.



**Figure 3 – Annual Precipitation for Hot Springs Reporting Station**

Red Canyon Remote Automated Weather Station (RAWS) located about 10 miles to the west, northwest of Alabaugh Canyon tracks Energy Release Component (ERC) – values that track seasonal fire danger trends. In this case, the ERCs were calculated using fuel model G, or large, down woody material. Southern Black Hills ERC value was 75 and above the 97th percentile, representing extraordinary dryness (see figure 4). This validates current drought conditions for the area.



**Figure 4 — Southern Black Hills ERC Values**

### Fire Weather Planning Forecast

Weather conditions that existed across the west for July 7 were hot and unstable. The high-pressure ridge that existed over the area had moved east, and a weak cold front in Montana was pushing south. A trough of low pressure ahead of the cold front set up conditions to form towering cumulus thunder cells over the southern Black Hills. The potential for thunderstorms combined with hot, dry, windy conditions prompted the Rapid City NWS to produce special weather products.

The National Weather Service issued a fire weather planning forecast at 0509 hours, Saturday, July 7. A Fire Weather Watch was also in effect that afternoon and evening in southeast Wyoming and western South Dakota for hot temperatures, low relative humidity, and the potential for dry lightning. The nighttime forecast for July 7 called for the Lightning Activity Level of 3, the Haines Index of 6, and an ERC of 75, above the 97 percentile. General fire weather forecasts that are issued by the NWS are broadcasted by the Great Plains Dispatch Center at approximately 1000 hours and 1600 hours daily.

## Fire Weather Watches and Red Flag Warnings for Fire Weather Zone 262

A fire weather watch was issued at 0520 hours, Friday, July 6, by Rapid City NWS for the Southern Black Hills. The fire weather watch was in effect Saturday afternoon through Saturday evening for high temperatures (100-107 degrees F), RH's down to 10%, and southwest winds shifting to northwest winds.

The fire weather watch issued on Friday, July 6 was updated at 1428 hours. The updated watch reiterated that the earlier July 6 fire weather watch remains in effect for hot temperatures, low RH, breezy SW winds, and potential dry lightning from Saturday afternoon through Saturday evening (July 7).

The fire weather watch from Friday, July 6, was elevated to a red flag warning at 1551 hours on Saturday July 7 and was valid until 2100 hours on July 7. The red flag warning was issued for dry thunderstorms with hot, dry air. The red flag warning was allowed to expire, or cancelled, on July 7, at 2117 hours by the Rapid City NWS.

### Spot Weather Forecast

A spot weather forecast was requested by Alabaugh Fire Operations on July 7 at 2300 hours and was completed by the NWS at 0106 hours on July 8. The spot weather forecast was delivered via radio to the IC at 0130 hours on July 8. The IC then transmitted the forecast to personnel on the fire. The forecast discussion indicated that scattered thunderstorm across the area had produced numerous outflow boundaries resulting in erratic winds. There was a chance for additional thunderstorms (mixture of wet and dry) near the burn area with gusty winds and occasional cloud to ground lightning.

### Thunderstorms and Outflow Winds

Between 1600 hours and 1700 hours on July 7, radar indicated thunderstorms in the area. Lightning from the thunder cells was the cause of the fire. Radar images for the evening of July 7 can be seen in figure 5.

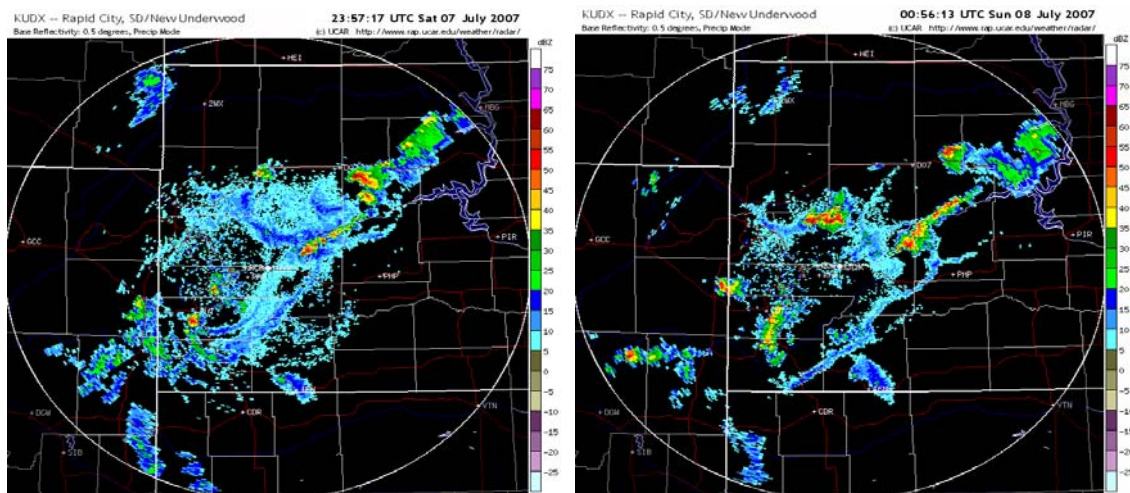
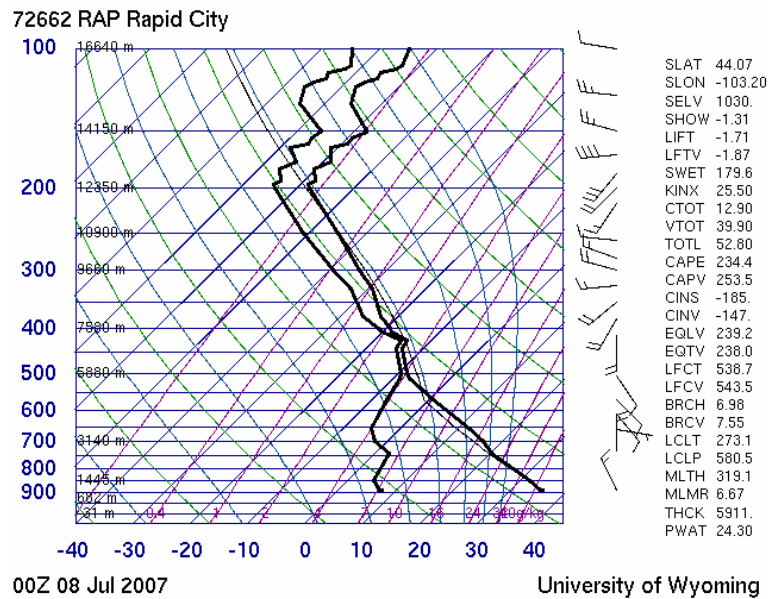


Figure 5 – Thunderstorms over SW South Dakota - Source NWS

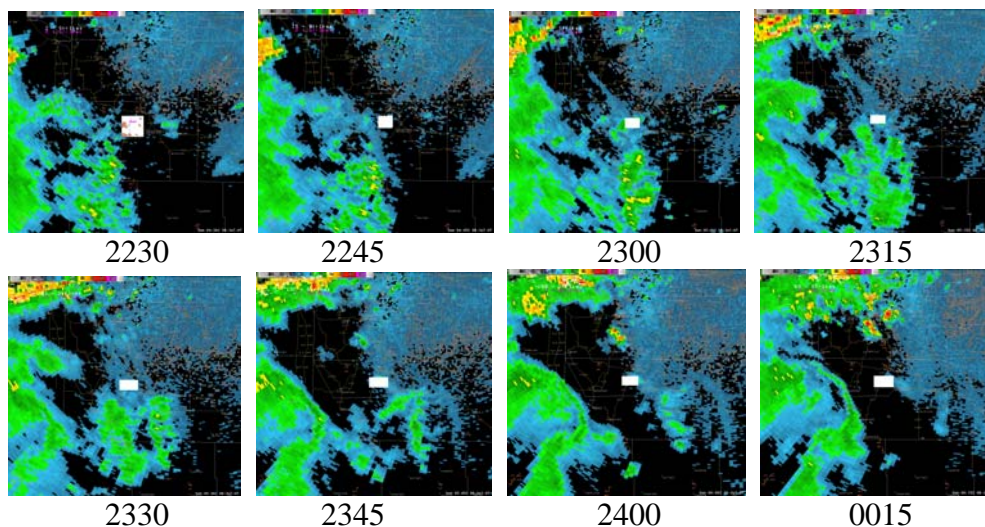
On July 7 at 1800 hours, conditions were ripe for thunderstorm downdrafts and outflow winds. When the temperature and dew point form an inverted V as shown in figure 6, it demonstrates a classic signature for microburst outflow winds.



**Figure 6 - Upper-air soundings (skew-t) indicate unstable air.**

NWS radar captured outflow wind boundaries between 2230 hours on July 6 and 0015 hours on July 7 (see figure 7). These organized air flows would have a direct impact on fire behavior.

- Boundaries of air masses collide over fire area (white square)
- Air mass boundaries are moving about 28 mph from the NW
- Outflow boundary arrives over fire area around 2345
- Estimated (empirical) peak wind gusts 38-39 mph



**Figure 7 - Radar reflectivity of moving thunderstorm outflow on July 6 – Source NWS**

## Remote Automated Weather Stations

Red Canyon RAWS is located approximately 10 miles to the WNW of the Alabaugh Canyon Fire. Red Canyon RAWS indicated very little variation with temperature and RH for the past 10 days. Temperatures exceeded 100 degrees and RH's were below 10 percent.

On July 6 1200 hours, Red Canyon RAWS reported wind speed between 5 and 10 mph, general direction from the south continuing until 1200 hours on July 7. Winds shifted northerly in the afternoon averaging about 5 mph. Wind gusts of 32 mph occurred at 1900 and 36 mph at 2400 hours on July 7 (see figure 8).

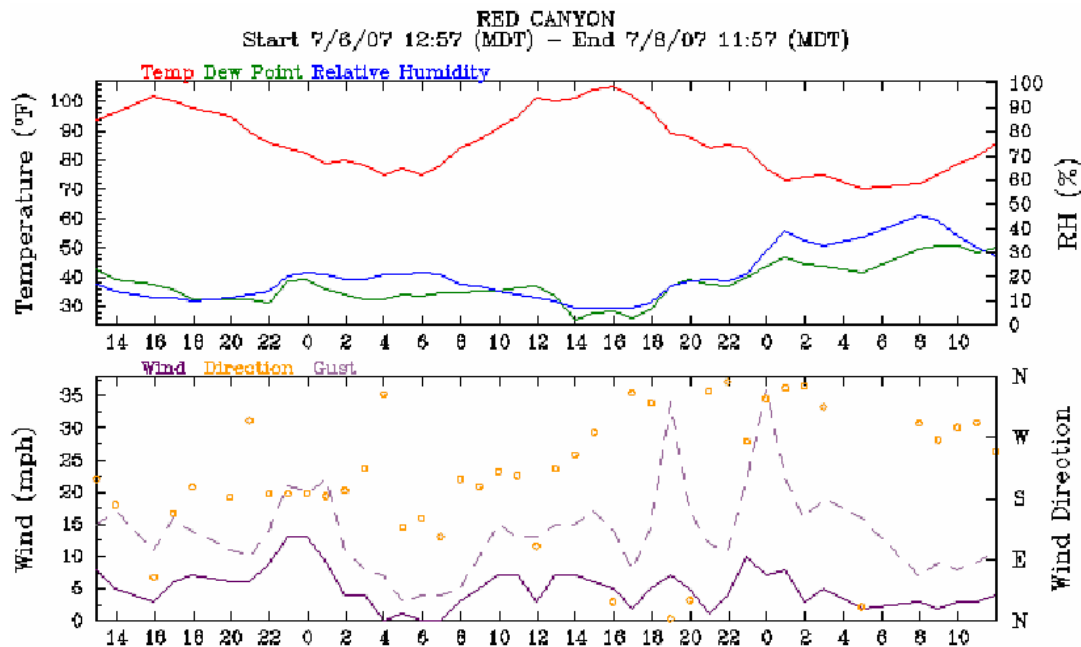


Figure 8 – Red Canyon RAWS for July 6, 7, & 8

Observed July 7 weather on the incident:

- Maximum Temperature = 105°F
- Minimum Relative Humidity = 7%
- Winds NW 5-8 mph, Peak Wind Gusts NW 36 mph

## Fuels

Fire-behavior fuel models representing the entire fire area include:

- Fuel Model 2 - Grass with litter understory
- Fuel Model 4 - Chaparral – Jack Pine low canopy
- Fuel Model 8 - Closed timber litter
- Fuel Model 9 - Long-needle pine litter

In late spring, the Southern Black Hills received several inches of rain that produced a heavy crop of grass that averaged 12 inches in depth. As the grass cured, fire hazard increased. Because of the

tall grass and abundant litter fuels in much of the ponderosa pine, the stands were conducive to torching and crowning. Grass was also receptive to heavy spotting. Figure 9 represents the typical fuel profile (fuel models 2 and 9) in the area to the west of Alabaugh Canyon.



**Figure 9 - Representative fuel types (note structure on right side of photo)**

### **Fuel Moistures**

Live fuel moistures in pine were abnormally low. Ponderosa pine live fuel moistures were between 85 and 92 % for Hell Canyon Ranger District. Considered cured, grass fuel moistures were at 43% on the south end of the district and 125% on north end. Large fuel moistures (1000 hr) for July 7 at the Red Canyon RAWS, G-model, were reported at 9%.

### **Topography**

Alabaugh Canyon runs in a north to south direction and is west of the deployment site. Northwest winds generally drain down the canyon. Slopes along the canyon are about 20% and crest at the rim 300 feet above the bottom. The canyon bottom consists of mostly grass while the sides of the canyon consist of pine. Rolling terrain to the east of Alabaugh Canyon (deployment area) contain a mosaic of pine stands and grass. There is very little elevation relief in the rolling terrain. Fire spread in this area would have been influenced by wind and not slope.

## Recent Fire Behavior

Recently observed fire behavior on fires in the Black Hills was similar in nature to the fire behavior experienced on Alabaugh Canyon Fire with the exception of grass. Curing of the grasses on those fires had not been completed and fires did not spread in the grass to the extent that they did on the Alabaugh Canyon Fire. The down woody fuels, however, exhibited intense fire behavior. Ponderosa pine stands containing down, woody material (G-model) exhibited flame lengths between 6 to 8 feet with moderate rates of spread. Torching was common in ponderosa pine stands on these earlier fires.

In contrast, the Alabaugh Canyon Fire had cured, deep grass that, under the extraordinarily dry, windy conditions, exhibited rapid rates of spread.

## Fire Progression

When the fire was first reported at approximately 1906 hours MDT on July 7, it was in the bottom of Alabaugh Canyon. The fire moved south in grass towards some ponderosa pine stands on the east side of the drainage and resisted initial attack control actions. Once in the stands, the fire moved up the slope on the east side of the canyon cresting at the rim near Pine Shadows subdivision. Once on the rim, the fire began to grow in size, and spread southeast along the rim. During the course of the evening, intermittent wind gusts from thunderstorm outbursts caused the fire to change directions, pulse, and quiet down. Torching and crowning ponderosa pine stands caused spot fires up to  $\frac{1}{4}$  to  $\frac{3}{4}$  miles ahead of the main fire. At or about 2345 hours on July 7, the fire made a significant run. Fire behavior intensified due to an increase in winds and resulted in spot fires near the safety zone. As the fire moved towards the 27891 Cascade Springs Road, the following fire behavior was observed during the maximum high wind period (July 7, 2400 hours):

Flame lengths –

- 100-150' crown fire
- 15-20' forest litter
- 6-8' in the grass

Rates of spread –

- 3-4 mph crown fire
- 1-3 mph forest litter
- 3-8 mph in the grass

The primary burnout operations around 27891 Cascade Springs Road and down the road added fire to the landscape. The backing fire to the west of the house was initially effective. Following the primary burn out, a secondary burn out further west was initiated at approximately 0016 hours on July 8. At the same time, thunderstorm outflow winds estimated at 36 miles per hour reached the area, and the fire behavior around the house and in the open area became extreme.

During this wind event, one firefighter said the wind blew so hard that it nearly sprung the hinges of the truck's open door. Moreover, the fire was observed to cover large, continuous areas 60 feet long in the grass area north of the deployment site. Smoke blanketed the area. Just before and during deployment (west of the Cascade Springs house), ponderosa pine stands crowned on three sides of the deployment site that produced extremely intense radiant heat (see figure 10,

purple area). The fire continued in a south and southeast direction and subsided enough for evacuation of the injured minutes later.



**Figure 10 – Fire spread and radiant heat around the deployment site**

The Alabaugh Canyon Fire exhibited extreme fire behavior. The environmental conditions – drought, dry, heavy fuel loads, thunderstorms, and hot, dry winds – culminated in a fire that caused great destruction. As it was, the fire was so intense that it consumed most of the fuel in its path, including homes, and was finally contained at 10,324 acres.

### **Standard Firefighting Order #3:**

**Base all actions on current and expected behavior of the fire**

Lindon Wiebe  
Fire Behavior Specialist