

# **COAL OUTCROP FIRE SUPPRESSION IN THE NORTH DAKOTA BADLANDS**

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## **ABSTRACT**

The Abandoned Mine Lands Division of the North Dakota Public Service Commission conducted its first coal outcrop fire suppression project during the winter of 2003. The objective was to extinguish coal seam outcrop fires actively burning on U.S. Forest Service lands in the badlands of southwestern North Dakota. An estimated 30 coal seam outcrop fires were ignited as a result of a 1999 grass fire that burned about 70,000 acres of grasslands in North Dakota, near the Montana border.

A primary concern was the possibility of additional grass fires igniting as a result of the burning coal seams. Since the 1999 fire, at least four subsequent grass fires have already been attributed to the burning coal seams. Left alone, underground lignite coal fires have been documented to burn for decades in North Dakota.

Overburden thickness and coal seam depths varied between the sites. All sites displayed a typical slumped appearance where the coal seam had previously burned, leaving nothing but ash, scoria and sterile soil in its wake. The typical fracturing and slumping process of overburden associated with burning coal seams allows combustion gasses to escape and a new supply of oxygen to feed the burning underground coal—allowing the fire to progressively grow.

Due to limited funding, suppression activities were conducted on only eight of the highest priority sites. One of the sites was considered too big for complete excavation, based on available funding. Intercept trenches were excavated through the coal seam and around all burning portions of this site. The remaining seven sites were reclaimed by complete excavation of all burning materials, inter-mixing with overburden materials and enclosed in a burial trench. Requirements for topsoil and subsoil handling, drainage control, surface restoration, seeding and safety issues are discussed.

## **INTRODUCTION**

What started out as a small, routine weed-burning project for a local Sidney, Montana resident on Halloween night in 1999, quickly developed into an uncontrolled wildfire that spread across the prairie grasslands and badlands of western North Dakota. Combining with a second wildfire in the tinder-dry badlands, valuable grass for wildlife and cattle, fences, power poles, outbuildings and one home was destroyed. Billed as the largest wildfire in recent history, an unanticipated cold front on the heels of 70 mph wind gusts fueled the fire that within only 14 hours decimated an estimated 70,000 acres.

Two weeks after the initial containment, the “Gap” fire was declared to be officially controlled, but what the 150 firefighters from Montana and North Dakota didn’t know, was that fires of a different type were just beginning to take form underground. The North Dakota badlands abound with lignite coal and many of the outcroppings of those coal seams were also exposed to, and ignited by the wildfire.

### **Historical Background**

The area of southwestern North Dakota contained within the fire perimeter is known as the Little Missouri National Grasslands. In 1934, a Federal land purchase program known as the Land Utilization Projects, purchased land from struggling depression-era farmers. The Soil Conservation Service managed the lands and leased the new public ranges to ranchers for grazing. In 1960 the Land Utilization Projects was designated as National Grasslands under the administration of the National Forest Service. The Little Missouri National Grasslands of western North Dakota is the country’s largest national grassland area encompassing more than 1 million acres. The federal lands are also interspersed with private ownership property.

### **Geologic Setting**

The North Dakota badlands along the Little Missouri River are carved from the Paleocene age Bullion Creek and Sentinel Butte Formation deposits. The Little Missouri badlands began to form about 600,000 years ago, when a glacier diverted the Little Missouri River from its northerly-flowing route into Canada’s Hudson Bay, to an easterly-flowing route to the Missouri River and ultimately into the Gulf of Mexico.

After its diversion by the glaciers, the Little Missouri River flowed over a shorter, steeper route than before, and due to the resulting increased gradient it began to cut vigorously downward, eroding and carving the badlands. The varied landscape of the badlands includes hundreds of hills, buttes, mesas, rugged terrain, rolling prairies, wooded draws and short to mid-grass vegetation. Much of the badlands terrain, particularly buttes, hilltops and cap rock are covered with scoria, or clinker formed from coal outcrop fires dating back to prehistoric times. The clinker is produced by the baking and fusing of clay and competent overburden materials above the burning coal seam.

The baked materials have a predominantly reddish appearance attributed to the mineral hematite.

Lignite coal underlies much of the western two-thirds of North Dakota. Lignite is a low-rank coal, meaning it has been altered only slightly by heat and pressure, is still relatively soft, and has a relatively low heat value (approximately 6,800 Btu). Lignite is generally high in moisture content and volatile matter. North Dakota lignite has a low sulfur content and relatively low ash content.

## **Project Background**

Soon after the 1999 Gap fire, reports from ranchers of coal seam fires began filtering into the U.S. Forest Service, McKenzie Ranger District office in Watford City, North Dakota. Reports of newly discovered coal outcrop fires continued for the next four years. Since that time, the U.S. Forest Service has been called to extinguish several grass fires in the badlands, four of which were traced back to burning coal veins.

Working on a limited budget, the Forest Service has been conducting maintenance and monitoring of the approximately 30 coal outcrop fires over the past four years. Maintenance work has included scraping of vegetation away from the burn front, water dousing and chemical application to kill vegetation within close proximity. A couple of small-scale intercept trenching projects were also conducted, with limited success. The burning coal seam areas vary from about 1/10 acre up to 1 acre or more in size.

The U.S. Forest Service contacted representatives of the Abandoned Mine Lands Division (AML) of the North Dakota Public Service Commission (PSC) and inquired if we would be amenable to assist in fire suppression efforts. Coal outcrop fire suppression normally falls outside of AML jurisdiction, and authority to conduct this project was obtained as a result of a cooperative agreement between the U.S. Forest Service and the U.S. Department of the Interior, Office of Surface Mining. Funding for the project was provided through a \$37,000 grant received by the PSC from the Office of Surface Mining, Casper, Wyoming.

## **OBJECTIVE AND METHODS**

The objective of the project was to conduct fire suppression efforts on as many of the highest priority sites as possible, based on available funding. The goal was complete excavation and burial of all burning/hot coal and combustible materials. The highest priority site was considered too big for complete excavation processes, and requirements for construction of an intercept trench were included with the project specifications.

At a minimum, the contractor was required to provide an excavator and dozer/front end loader. Additionally, at least two fully-charged fire extinguishers were required to be onsite at all times. Work was not allowed on excessively windy days and the fire danger index was required to be within an acceptable range during project work. A pre-bid onsite meeting was conducted to afford an opportunity to prospective bidders

to receive clarification of the project specifications, inspect selected site locations and access requirements.

**A listing of standard requirements for project work was included as part of the bid specification package and included the following:**

1. Remove and stockpile topsoil or suitable plant growth material from around/within the defined project areas.
2. Excavate intercept trench or burial trenches at prescribed depths for burial of competent overburden and/or burning materials.
3. Excavate and emplace burning materials into the burial trenches. Blend or intermix the burning/hot materials with clay or approved overburden in lifts as directed. Excavation of the active burn face is considered complete when the coal seam is cool to the touch. Water quenching (as required) will be performed by U.S. Forest Service personnel.
4. Cover the backfilled trenches with approved material. Ensure that all buried materials are isolated from other combustible materials. Any combustible material removed from trenches or borrow areas must be covered or mixed with inert soil material.
5. Grade area to blend with surrounding topography and re-establish drainage.
6. Re-spread salvaged topsoil (where available) over disturbed areas. Drag the graded area with a spike-tooth harrow or equivalent and clean up the site.



**Condensation is formed by steam venting from a burning coal seam.**

In addition to the above, a one-page work plan narrative was given to bidding contractors to give further guidance on specific items of work to be conducted by each piece of machinery on site. The U.S. Forest Service also offered the use of its water truck and personnel for quenching of burning materials if required.

Coal fire suppression work began on November 14, 2003 and was completed by December 10, 2003. Suppression activities were conducted on eight of the highest priority sites. Winter in North Dakota means snow. Although snow cover did not inhibit work, it did provide for precarious access of heavy equipment to some of the sites located at higher elevations, on hill-sides and within drainages. Once the heavy equipment was mobilized on-site, 4-wheel ATV's were used to transport the contractor's work crew and reclamation personnel.



**Excavation of an intercept trench.  
Note the “runner” to the left of the bucket.**

One of the sites was considered to be too big for complete excavation, based on the size of the project, thickness of the coal and overburden, and available funding. A 2-tiered series of intercept trenches was excavated around all burning portions of the site. Trench excavations were approximately 4 feet wide and completed to one foot below the bottom of the coal seam into the blue underclay and backfilled with inert, noncombustible

material. In time, the burn front will come into contact with the intercept trench and extinguish the fire due to removal of the fuel supply.

Fractured and slumping overburden was typical at all of the coal outcrop fire sites. As the coal fire progressed farther into the hill, this fracturing and slumping process allowed combustion gasses to escape and a new supply of oxygen to feed the burning underground coal. The visibly slumped areas are where the coal seam had previously burned, leaving nothing behind but ash, scoria and sterile soil.

Fumaroles venting steam and smoke were also common at all of the fire sites. In the context of this project, a fumarole is described as a crack or opening in the overburden which allows for the escape of combustion gasses into the atmosphere. Most of the fumaroles exhibited a slowly-venting characteristic, although fumaroles at a couple of the sites exhibited an intense, thrusting characteristic inherent with very aggressive, hot fires. Many of the sites displayed hot “runners”. These runners or burn areas, typically 3-6 feet in diameter, shoot out in front of the burn face following fractures in the coal seam. Most of the runners were not observable from surface, although an occasional runner would surface 50-75 feet in front of the burn face. A large percentage of work time at all of the sites was dedicated to chasing down and eliminating these runners with the excavator.

Several of the sites displayed burned and charred grass directly above the overburden fractures, an attest to the intense heat encountered with burning lignite seams. Lignite coal can burn at temperatures up to 1000 degrees Fahrenheit.



**Typical badlands topography associated with the coal outcrop fires.**

The first order of business at all of the sites was to dig an exploratory hole with the excavator to determine overburden and coal seam thickness, and formulate specifics of the project design based on that information. The excavator used on this project was a 120 John Deere and the front end loader was a 544E John Deere. Most of the exploratory holes were dug 10-15 feet up-gradient of the burn face and were generally 4 feet wide, 10 feet long, and deep enough to get through the coal seam. Typically, the coal seams averaged 4-9 feet thick and the overburden averaged 6-12 feet thick.

A buffer zone of topsoil/suitable plant growth material was stripped around the periphery of all sites a minimum of 20 feet in width. The buffer zone stripping allowed for adequate respread material after suppression activities, and also served to eliminate a fuel source (vegetation) as work was being conducted. Additionally, any topsoil or subsoil salvaged for respread or mixing was stockpiled and windrowed up-gradient or in the direction of the prevailing winds in an attempt to eliminate the potential for airborne fugitive burning embers. Most of the excavating and material mixing work was conducted on the first day we arrived at a new site. Inspection of the exposed coal seams was generally conducted the following morning and backfilling was initiated when the coal face was cool to the touch.

Excavation of the burning material was conducted systematically from down-gradient to up-gradient. All of the coal seams outcropped on the sides of hills or buttes, with the fire front progressing into the hill. Consequently, the farther into the hill that the fire has progressed, the thicker the overburden would be. As the contractor dug into a burning coal seam, the steam and smoke coming in contact with cold air rendered much of the project work to be conducted by feel, for hours on end. The plume of steam and smoke at most of the sites was visible for miles. A burial trench was constructed immediately down-gradient and parallel with the length of the burn front and as close as possible to allow the excavation bank to be within the swing radius distance of the excavator.

Most of the burial trench excavation cuts were 3-6 feet deep, depending in part on the thickness of the coal seam and overburden. The excavator then began pulling out burning material from the burn front and emplacing that material into the burial trench. As the excavator digs farther into the burning coal seam, the trench cut will keep moving towards the coal face (into the hill). The excavated burning and hot materials in the burial trench were then mixed with subsoil/overburden and previously burned ash/scoria by the loader. The above-listed process continued until the entire section of exposed coal face was cool to the touch. Water quenching of material in the burial trench was not deemed necessary on this project because of the cold weather, snow cover and low fire hazard.

Contract specifications required payment for project work based on material handling and measured cut volumes, or a negotiated hourly rate for each piece of equipment utilized.

The Commission decided to accept a quoted hourly rate from the contractor for both the excavator and front-end loader. Based on the production of the equipment operators, the hourly rate proved to be the best choice.



**The plume of steam and smoke from this site was visible for miles.**

### **RESTORATION AND REVEGETATION**

All of the sites were backfilled and graded to their approximate original contour, with positive drainage required. Topsoil was respread and the areas were then finish graded, back-dragged, harrowed and seeded. The seed mixture that was used included the following: Oats, Rosana Western Wheatgrass, Goshen Prairie Sandreed, Lodorm Green Needlegrass, Bad River Blue Grama, Itasca Little Bluestem, Appar Lewis Blue Flax, Prairie Coneflower, Prairie Junegrass and Black Sampson.

### **RESULTS AND DISCUSSION**

A total of 17 working days were required to complete suppression activities at 8 project sites at a cost of \$37,000. Additional work remains to be done on the remaining 20 or so sites. Additional coal outcrop fire sites may be discovered. The PSC will submit another grant application to the Office of Surface Mining for additional grant money to continue coal fire suppression efforts at the other sites in 2004.

Subsequent site inspections of the reclaimed coal fire sites indicate that all burning materials have been sufficiently extinguished during project work. No indications of continued burning are evident such as visible venting, sulfurous smell, fracturing or slumping of overburden.

Late fall or winter fire suppression work substantially reduces the risk of fires being caused by construction activities. One drawback to cold-season work is the occasional frozen chunks of topsoil and subsoil that could not be broken up with heavy equipment. We expect that once thawed, most of the chunks should break up with time.



**Steam and smoke venting from an outcrop fire at sundown.**

#### **REFERENCES**

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