APPENDIX AI

STABILITY ANALYSIS OF GATEROAD DESIGN

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Because of witness testimony regarding extensive floor heave in Headgate 1 North, experienced particularly on development but noted behind the longwall face, analyses of the gateroad pillar design was undertaken for Headgate 1 North, the HG 22, and the 'new' TG 22. The analyses were performed using the NIOSH software AMSS (Analysis of Multiple Seam Stability). Review of mine map overlays in conjunction with the following stability analyses indicates that the 1 North Panel was not adequately designed for the overburden and multiple seam conditions that were encountered. It appears that although the mine had longwalled beneath Powellton longwall panels near the end of the previous district, the overburden was less, and the old-style longwall panels in the overlying seam were narrower (500 feet). Even a cursory review of mine map overlays indicates that the 1 North Panel, the first in the new district, would pass perpendicularly beneath gob/solid and remnant pillar configurations, defined by longwall panels in the overlying Powellton seam. This should have prompted the incorporation of an even higher margin of safety in the panel design. However, as discussed below, the gateroad design did not even meet the minimum Pillar Stability Factors recommended by NIOSH in areas of combined multiple seam interaction and high overburden. It should be further noted that even though the pillars as shown on the mine map were of inadequate size, underground observations revealed that entries were commonly mined even wider (23 feet), with resulting pillars that were even smaller than portrayed on maps. Using the actual as-mined dimensions would result in even lower Pillar Stability Factors than portrayed in the design.

Headgate 1 North

Headgate 1 North was developed as a 3-entry gateroad beginning by November 2008, utilizing 100-foot crosscut centers, with 95-foot centers from the #1 to #2 entry, and 105-foot centers from the #2 to #3 entry. Prior to this, the section had been begun from the 6 North Belt as a 5-entry section in July 2008. The 1 North Panel was the first to be developed beneath Powellton seam longwalls since May 2005, at the end of the previous district, when Panel 20 crossed diagonally beneath a 500-foot wide longwall panel. Maximum overburden, based on comparison with structure contours for the Eagle seam provided by the company and a standard USGS topographic map, is 1,290 feet. Headgate 1 North passes beneath several gateroads in the Powellton seam, located 170 feet above, which represent a gob/solid boundary between crosscuts 60-65, with gateroads between mined-out longwall panels interpreted to represent remnant pillars farther west. For purposes of AMSS analyses, the 4-entry gateroads are treated as a single barrier, the width of which is measured to the outside ribs of the outside pillars, a distance of 160 feet. A long barrier between adjacent room-and-pillar workings may represent a remnant pillar configuration near crosscut 45, particularly if the floor has been softened in the Powellton seam, or if pillar extraction has been performed.

CMS&H District 4 provided a copy of an AMSS analysis for Headgate 1 North, dated December 14, 2009, which was conducted by District 4 personnel following deterioration of the headgate. The analysis indicated that the Pillar Stability Factor for tailgate loading essentially met the NIOSH recommended value of 1.13, utilizing a gob/solid boundary beneath the Powellton seam longwall panels, and assuming 990 feet of overburden. The Accident Investigation team reviewed the analysis and conducted its own analysis for purposes of comparison. Based on field visits to the Powellton and Eagle seams in this area, the Accident Investigation team analysis used different values for seam height than indicated in the submitted analysis. The submitted analysis appears to address the vicinity of Crosscut 60-65, beneath the gob/solid boundary represented by the Powellton longwall. Based on the analysis seam height of five feet, the 1 North Panel headgate appears to meet the NIOSH recommended value of 1.13. However, field experience indicates that a more realistic value of seam height is seven feet, which substantially reduces the Pillar Stability Factor to 0.82 for tailgate loading conditions, and no longer meets the NIOSH recommended value. The Accident Investigation team's analysis indicated that in order for the gateroad design to meet the NIOSH recommended Pillar Stability Factor of 1.13, the pillars would have to be increased to 125-foot crosscut and entry centers, compared to the current 100-foot crosscut and 95- to 105-foot entry centers.

Although the gateroads were subjected only to headgate loading conditions, an AMSS analysis conducted by the Accident Investigation team indicates that it should have been apparent that the gateroad design was not robust enough to meet the recommended stability factors beneath the deepest overburden in combination with Powellton gateroad crossings. The Accident Investigation team represented the Powellton gateroad crossings as remnant pillars 160 feet wide, surrounded by adjacent longwall gob 620 feet in width that, at 1,290 feet of overburden, resulted in pillar stability factors under headgate loading conditions of only 0.93 (0.52 for tailgate loading conditions, which were not encountered). This not only does not meet the NIOSH recommended value of 1.13, but generates a "condition yellow" warning ("A major interaction should be considered likely unless a pattern of supplemental roof support such as cable bolts or equivalent is installed; rib instability is also likely") for development, and a "condition red" warning ("A major interaction should be considered likely even if a pattern of supplemental roof support is installed; it may be desirable to avoid the area entirely") for tailgate loading. In the vicinity of Crosscut 45, the 1 North Panel Headgate passed beneath an 80-foot barrier between two room-and-pillar sections, at 1,260 feet of overburden. The AMSS calculated Pillar Stability Factor for the headgate is only 0.93 following the interpretation that the pillars in the Powellton Seam are no longer carrying load, either due to floor softening from water or undersized pillars that have crushed out or were retreat mined. The value of 0.93 does not meet the NIOSH recommended value of 1.13.

It was recorded in inspector's notes and documented by witness testimony that a water inundation occurred on the 1 North Panel on November 16, 2009, which forced the panel to be shut down for nearly two weeks while water was pumped out, due to the restrictive effect on the ventilation system between the longwall face and the Bandytown fan. Based on review of mine maps, the longwall was between 1 North Headgate Crosscuts 61 to 52 during that period, with the face located at Crosscut 55 in mid-November. This area is significant in that it occurs beneath the transition in the overlying Powellton Seam from a series of longwall panels to room-and-pillar workings, separated by a 220-foot wide barrier. At best, the transition represents a gob/solid boundary and, if the room-and-pillar workings were retreat mined or if floor softening allowed pillar punch, at worst represents a wide barrier between two gobs. Overburden in this area is up to 1,180 feet. Thus, it is plausible that differential subsidence above the 1 North Panel occurred beneath the barrier, causing joints or fractures to increase their aperture sufficiently to allow communication between the Eagle and Powellton seams.

1 North Panel Tailgate

The 1 North Panel tailgate was developed using five entries, utilizing 100-foot crosscut and 80-foot entry center spacing, resulting in 80 x 60-foot rectangular pillars. It should be noted that because the 1 North Panel was the first panel in the new longwall district, the tailgate would never be subjected to tailgate loading, and instead would be subjected to only headgate loading conditions. However, according to witness testimony and review of the 2008 Annual Ventilation Map, dated 1/15/2009, what became the 1 North Panel tailgate was originally developed as a 7-entry submains configuration, a non-standard gateroad design, although mine management subsequently elected to use this configuration as a longwall tailgate when the longwall equipment was forced to return earlier than expected from the Logan’s Fork Mine due to encountering adverse geologic conditions (cutting sandstone roof). The 7-entry submains configuration began to be developed from the Glory Hole Mains in January 2008 and continued until October 2008 when the two left-hand entries were dropped, continuing as a 5-entry submains configuration by December 2008. Stability analysis using AMSS indicates that beneath the remnant pillar configuration of overlying Powellton Seam gateroads flanked by 620-foot wide longwall gobs, at depths approaching 1,200 feet such as was encountered during the November 2009 water inundation, the 1 North Panel 5-entry tailgate is characterized by a Pillar Stability Factor of only 0.95, which does not meet the NIOSH recommended value of 1.13. At the longwall face position at the time of the April 5, 2010 explosion, the Pillar Stability Factor of 1.11 was slightly less than the recommended value of 1.13, with the tailgate beneath 970 feet of overburden and a remnant pillar configuration in the overlying Powellton Seam. If the 1 North Tailgate had remained a submains, and not been subjected to longwall loading conditions, the pillar stability factors would have exceeded the values recommended by NIOSH even when subjected to the worst combination of overburden depth and multiple seam interaction.

22 Headgate

Following mining of the 1 North Panel Headgate, the 22 Headgate was developed toward the west under similar conditions of overburden and multiple seam interaction. However, pillar sizes were increased to 120-foot crosscut and entry centers, while the panel face was decreased to 890 feet due to having to drive a parallel “new 22 Tailgate” following failure of the 1 North Headgate. Because the gateroads would only be subjected to headgate loading, the larger pillars would be expected to offer better stability than the 1 North Panel gateroads, represented by a Pillar Stability Factor of 1.47 even assuming a gob/solid boundary in the overlying Powellton Seam. If the boundary is represented as a remnant pillar flanked by gob, the Pillar Stability Factor for headgate loading conditions is reduced to 1.30, which still exceeds the NIOSH recommended value of 1.13 but is lower than the 1.35 required by the company's P-2 Guidelines (Section II, Page 4).

<u>22 Tailgate</u>

Following deterioration of the 1 North Headgate when subjected only to headgate loading conditions, CMS&H District 4 required the mine to drive a new gateroad to serve as the tailgate for the proposed 22 Panel. The 'new TG 22' was begun parallel to the 1 North Headgate, separated by an 80-foot barrier and reducing the proposed 22 Panel from 1,000 feet in width to only 890 feet in width. In order to eliminate side abutment stress from the 1 North Panel, the barrier would have to have been 335 feet wide, a distance defined by 9.3 times the square root of the 1,300-foot overburden. The use of the wider barrier is justified because the adjacent 1 North Panel headgate was in failure and would have offered little or no protection from side abutment stress. The 'new TG 22' utilizes the same pillar size as the failed 1 North Headgate, represented by 100-foot crosscut centers with 95-foot centers from the #1 to #2 entry, and 105-foot centers from the #2 to #3 entry. Therefore, the result in terms of stability should not have been expected to be different from that experienced on the 1 North Headgate, although the narrower panel width would be expected to improve stability. Beneath the greatest overburden of 1,300 feet, between Crosscuts 75-80, which coincides with a Powellton gateroad crossing, the Pillar Stability Factor for headgate loading conditions is only 0.93, which does not meet the NIOSH recommended value. Thus, it can be concluded that despite driving a new tailgate for the 22 Panel, the design was not modified in any way, and should have still been expected to allow degraded ground conditions in the anticipated high cover and multiple seam conditions.