



## Coal Mine Barrier Pillar Design

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Geologist, Roof Control Division

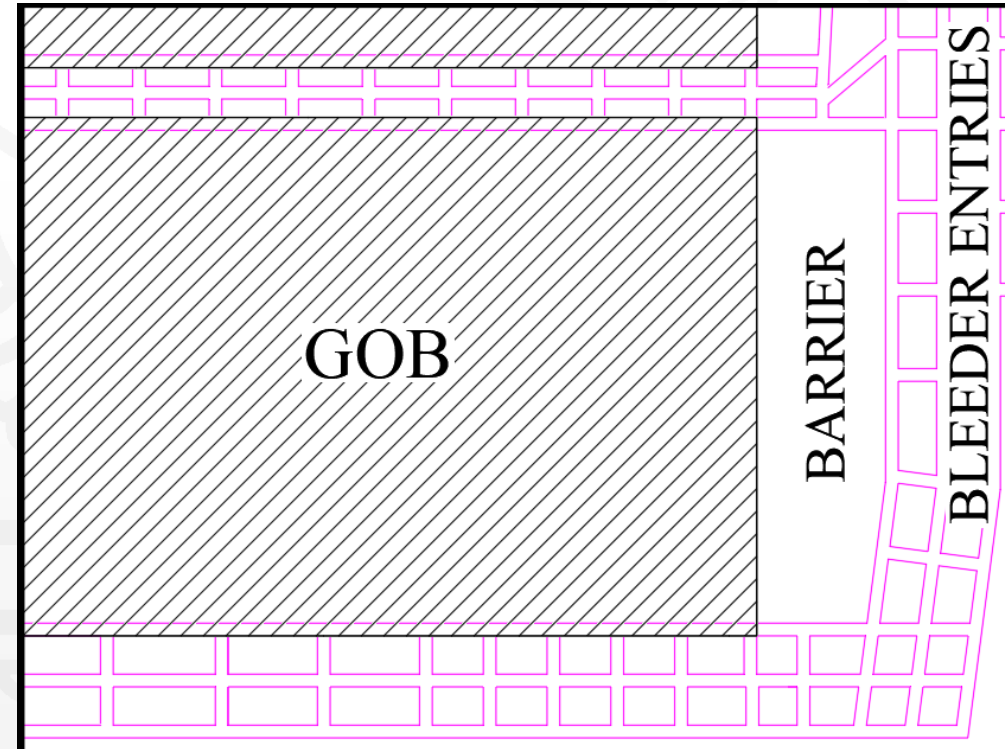
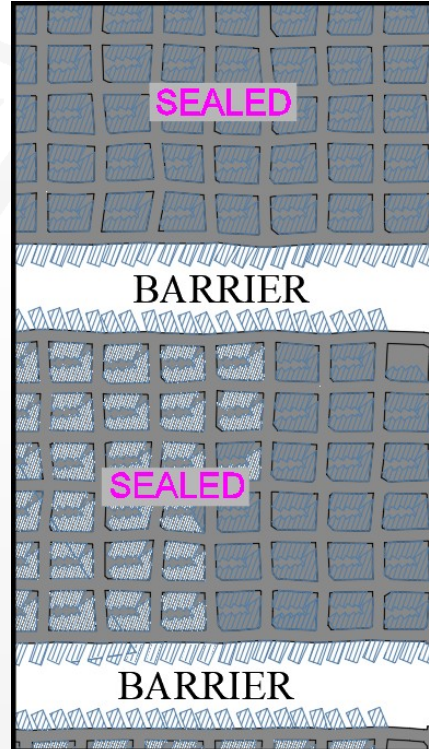
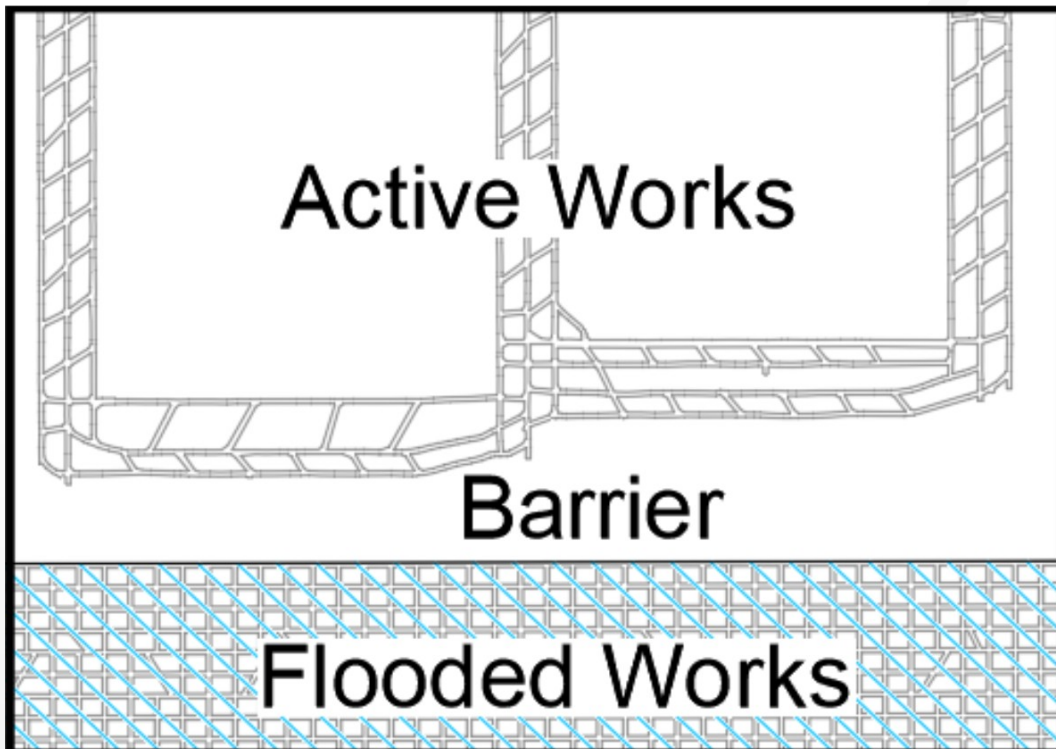


# Agenda

- Evaluating Barrier Pillars
- Barrier Pillars in Longwall Mining
- Barrier Pillars in Room & Pillar Mining
- Knox Mine Disaster
- Crandall Canyon – 15 Years Later
- Future Challenges
- Summary

# What is a Barrier Pillar?

- A block of coal left unmined to protect or isolate adjacent mined areas





# Evaluating Barrier Pillars

- Evolution of formulas

Dunn's Rule

Old English Barrier Pillar Law

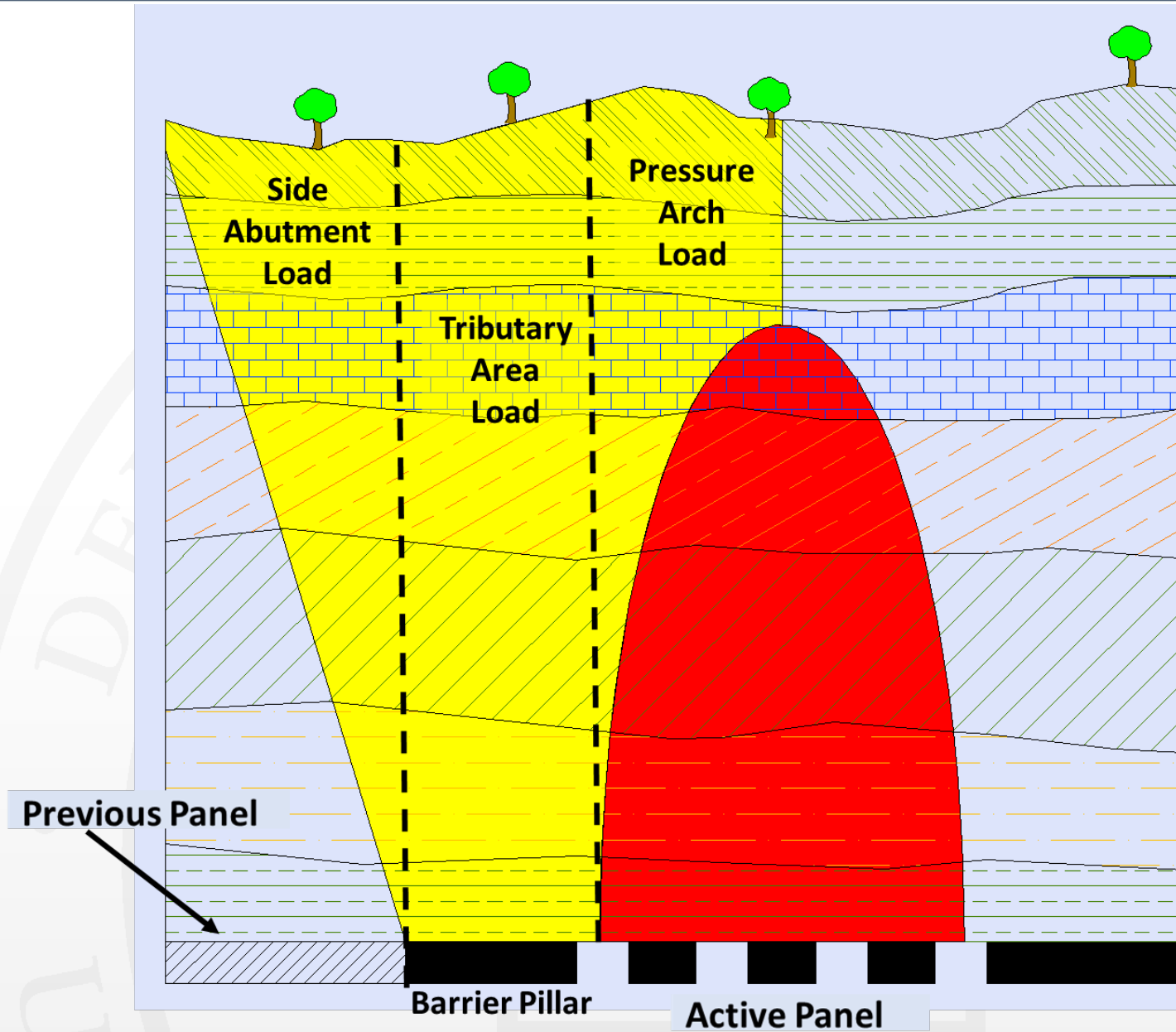
Ash & Eaton Impoundment Formula

Pennsylvania Mine Inspector's Formula

British Coal Rule of Thumb

Pressure Arch Method

# Pressure Arch





# Evaluating Barrier Pillars

- Analysis of Coal Pillar Stability (ACPS) Software
- LaModel Software



Input Development / Room-and-Pillar Parameters

Development Defaults Retreat Multiple Seam

Loading condition

- Development load (no nearby gob)
- One active retreat section
- One active section & one side gob
- One active section & two side gobs

Active gob parameters

Extent of active gob (ft)

Abutment angle for active gob (deg)

First side gob parameters

Extent of first side gob (ft)

Abutment angle for first side gob (deg)

Barrier pillar width for first side gob (ft)

Depth of slab cut in barrier pillar (ft)

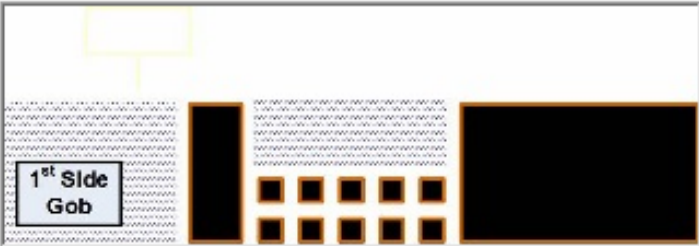
Pillars left in the side gob(s)

Row A

Pillars left in the active panel

1<sup>st</sup> Side Gob

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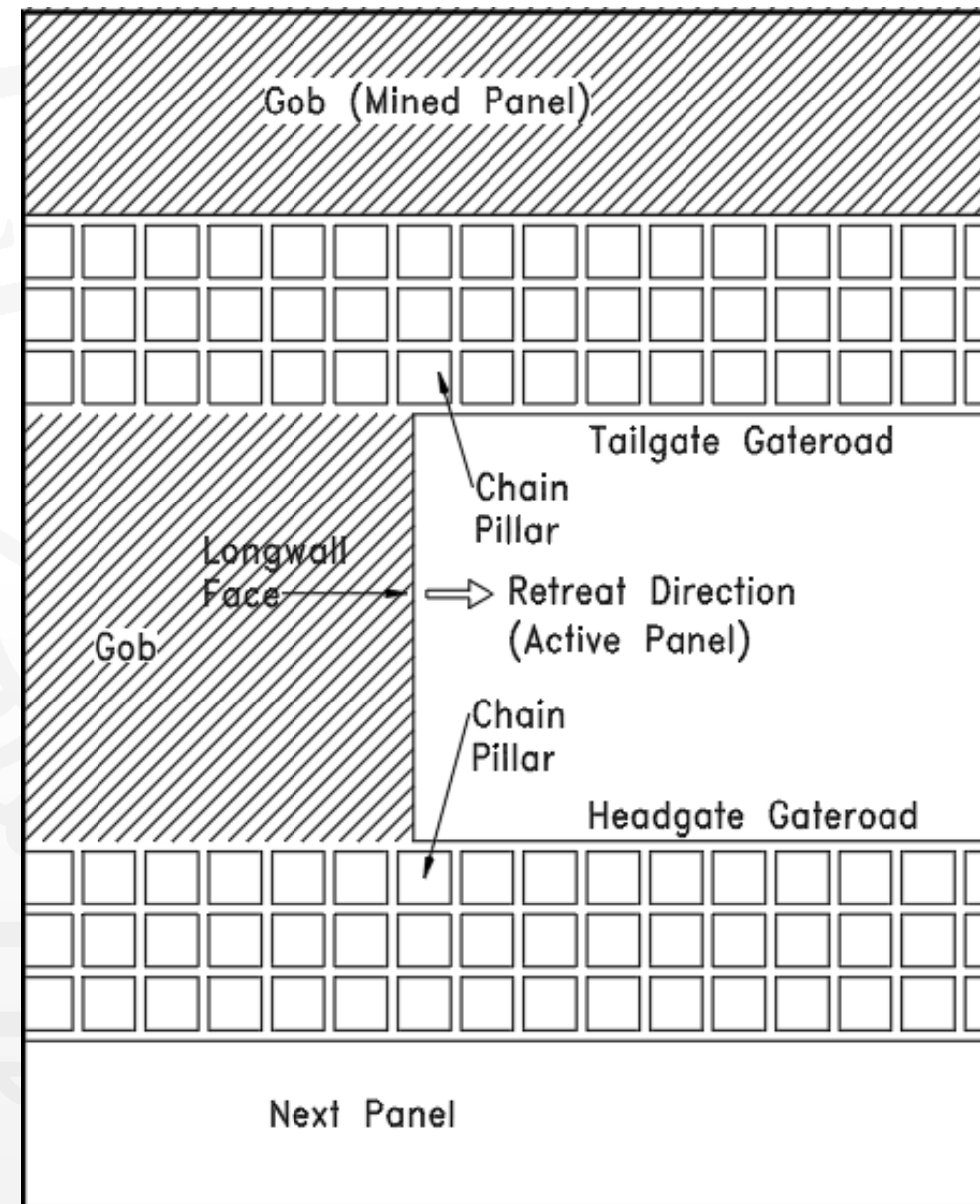






# Longwall Chain Pillars

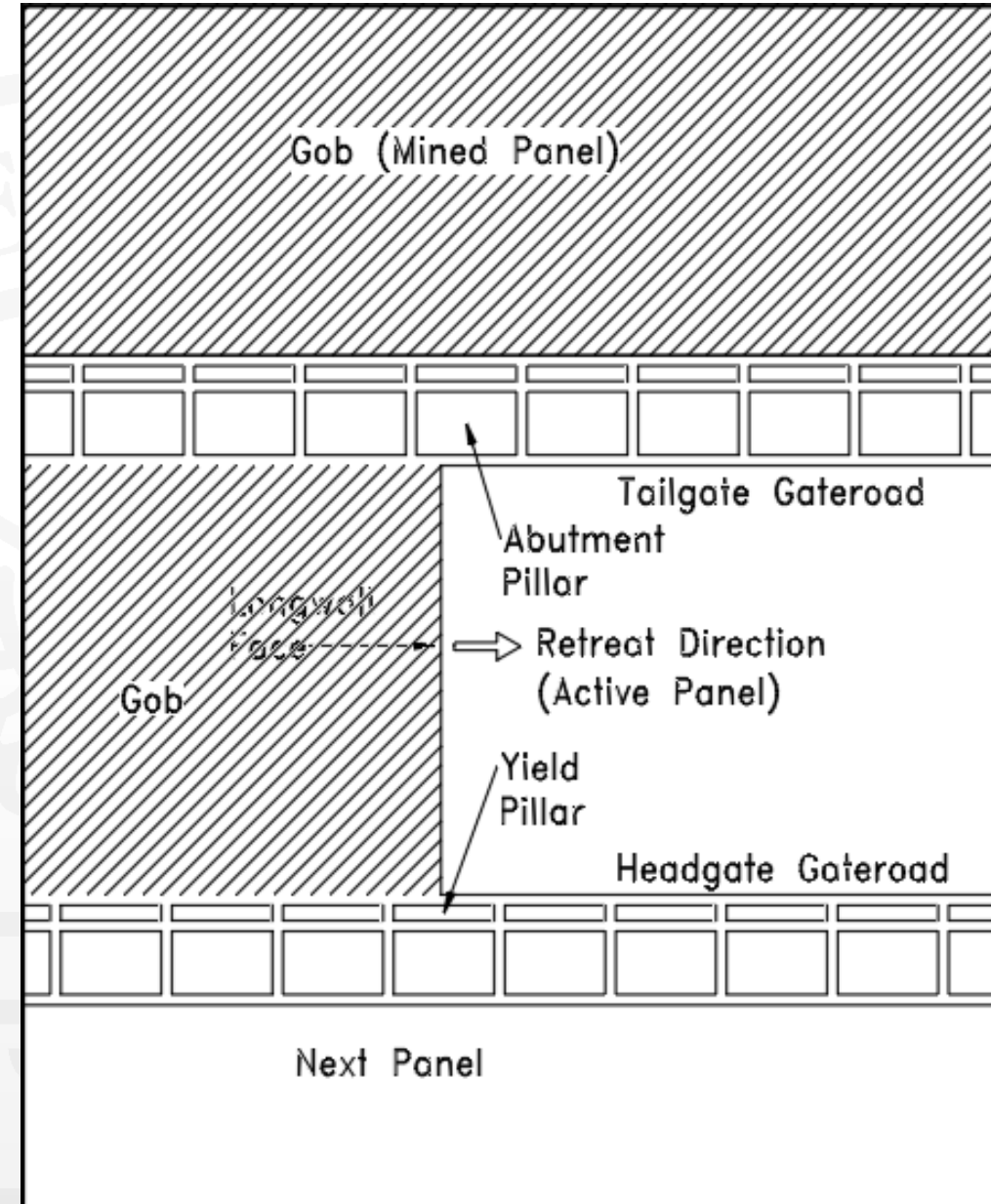
- Common layout in Central Appalachia and Illinois Basin
- Typically three or four entries with equal sized pillars
- Commonly used for weaker, shale dominated roof geology and depths less than 1,000 feet.





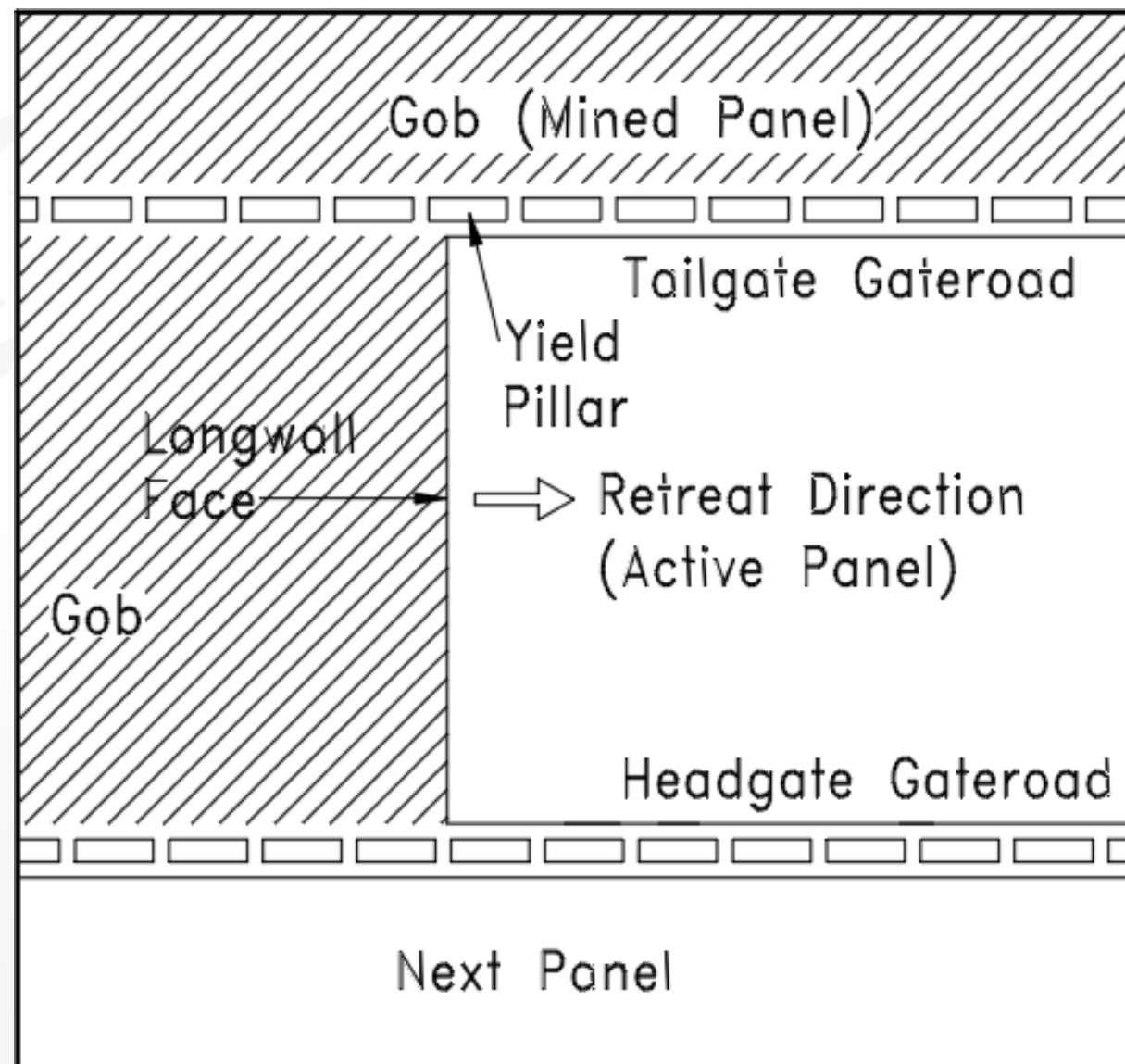
# Longwall Yield-Abutment Pillars

- Common layout in Northern Appalachia
- Commonly used for shale dominated roof geology and depths less than 1,000 feet.



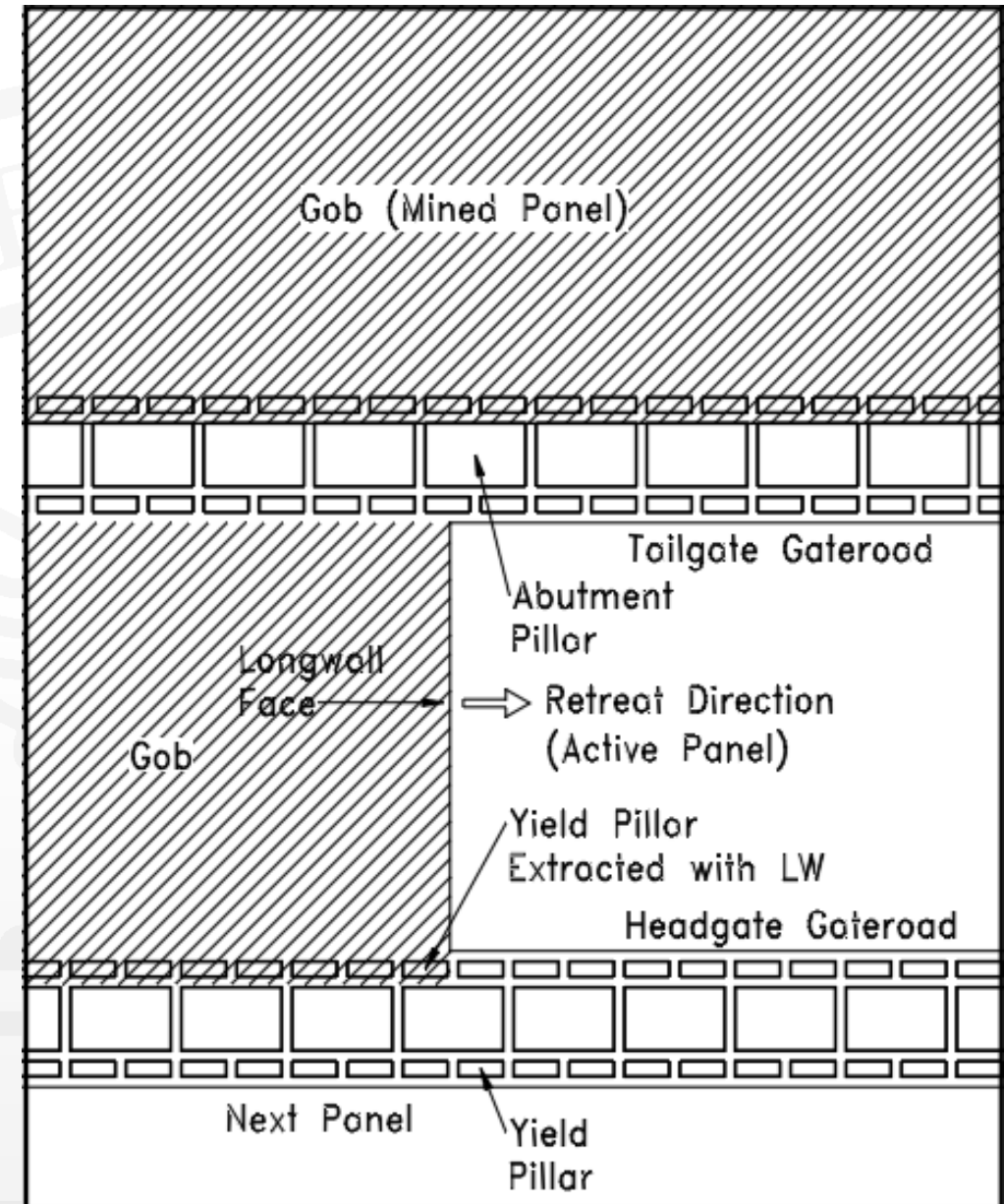
# Longwall Yield Pillars

- Common layout in western mines
- Better suited for strong geology and depths that exceed 1,000 feet
- Utilized to help minimize burst risk
- Requires a Petition for Modification from MSHA to drive less than three entries



# Longwall Yield-Abutment-Yield Pillars

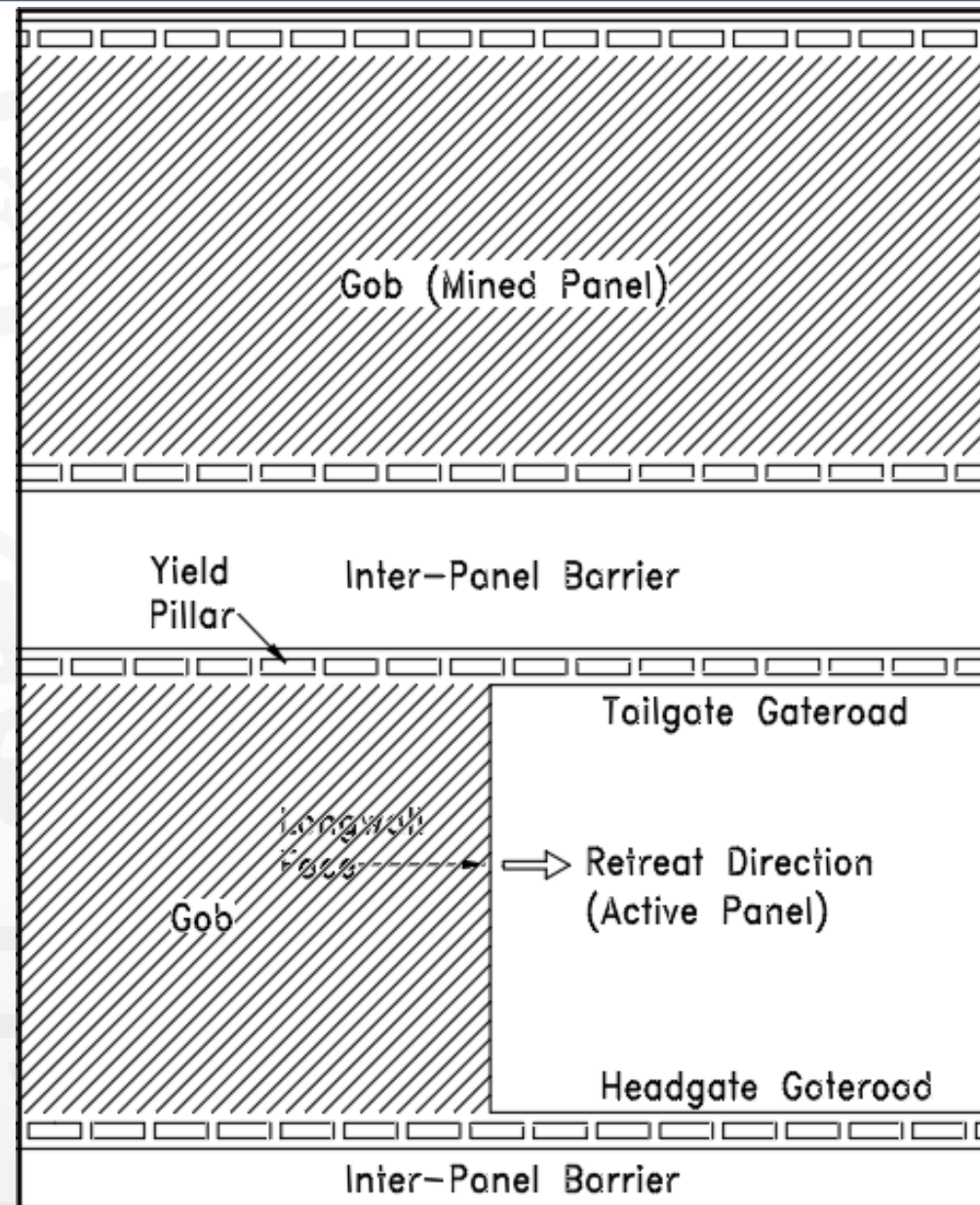
- Common layout in gassy mines in Southern Appalachia
- Four entries are not ideal for drivage rates, but are necessary for ventilation
- Depths in the 1,000 to 2,000 foot range and strong roof geology





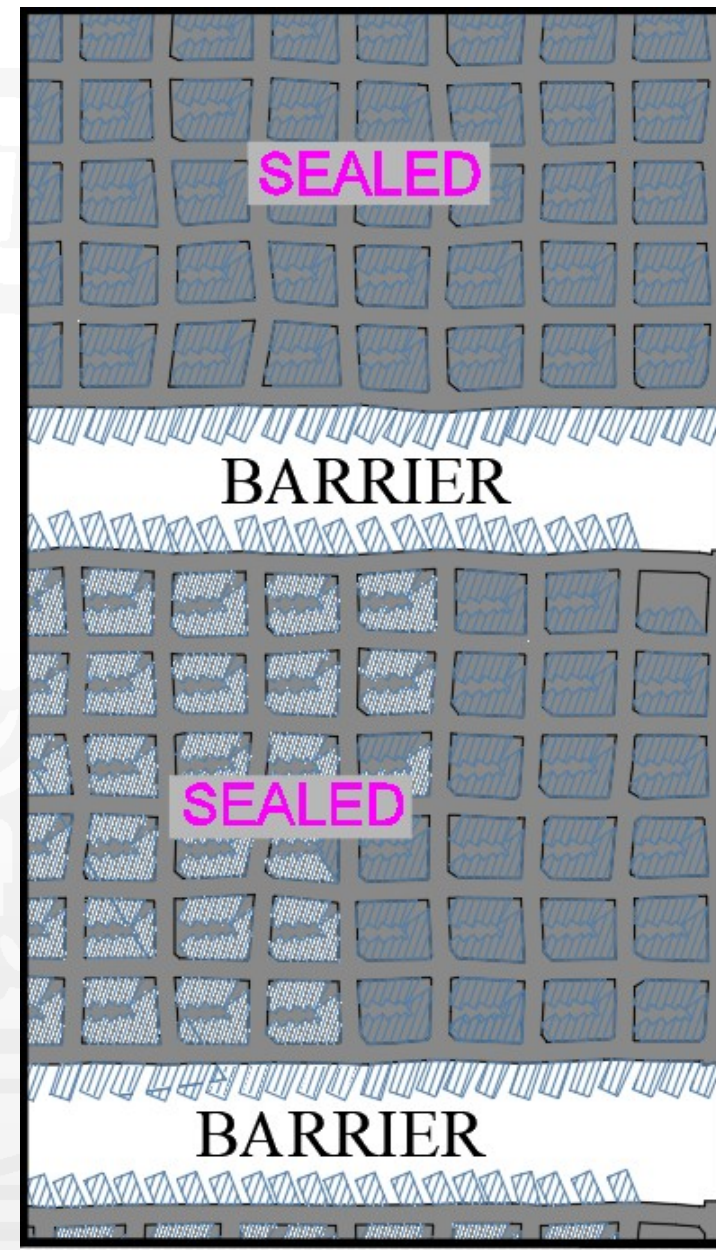
# Inter-Panel Barriers

- Utilized in Southern Appalachia and Western mines
- Utilized in seismically active and bump-prone longwalls
- Controls tailgate bursts, but not headgate



# Retreat Mining Barrier Pillars

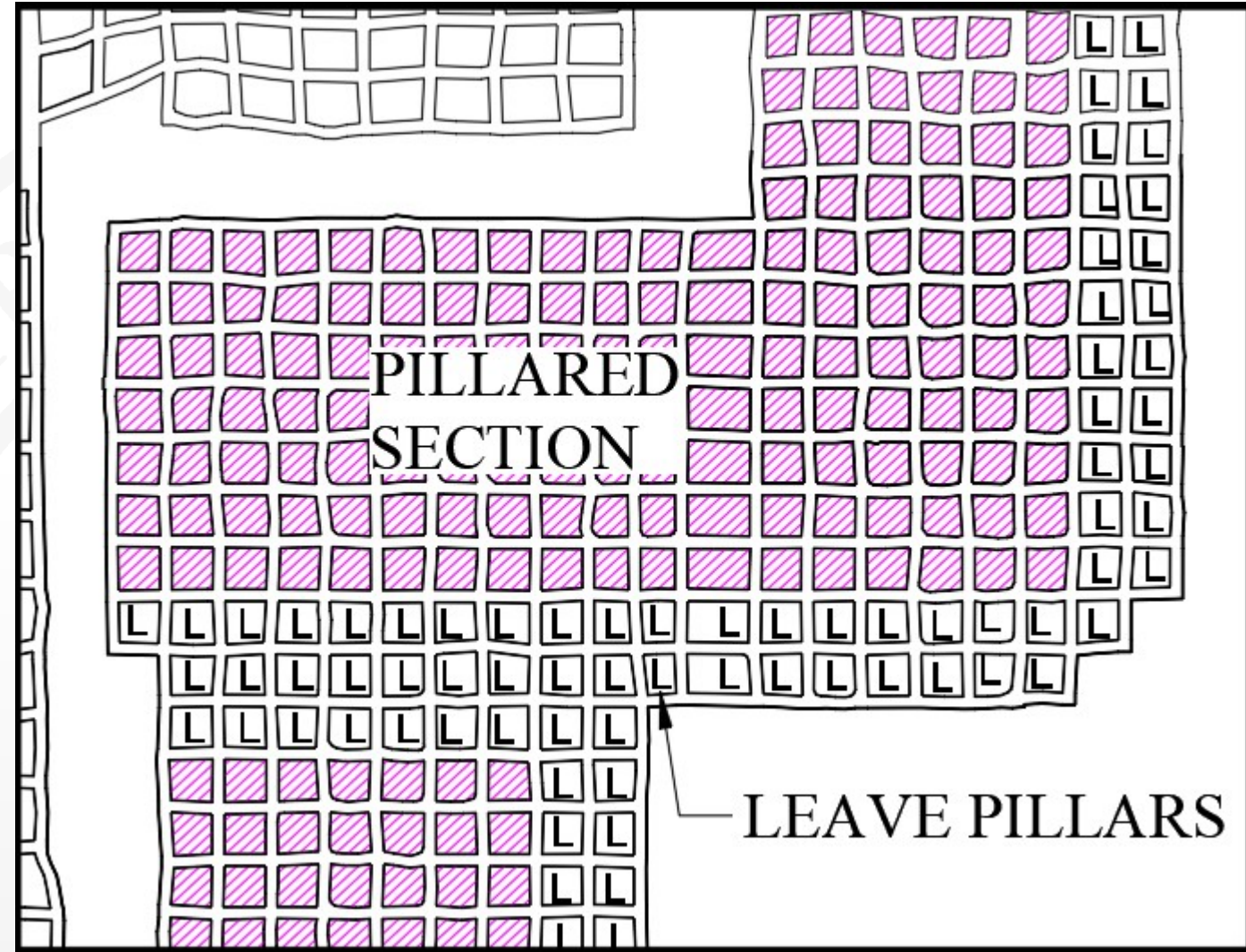
- Utilized to compartmentalize pillared sections
- The barriers are occasionally mined (slabbed), but must be evaluated in their final form
- Especially wide pillar sections may not see the full benefit of the pressure arch





# Retreat Mining Leave Pillars

- Pillars left behind to create a composite barrier
- Utilized for ventilation and escapeway purposes

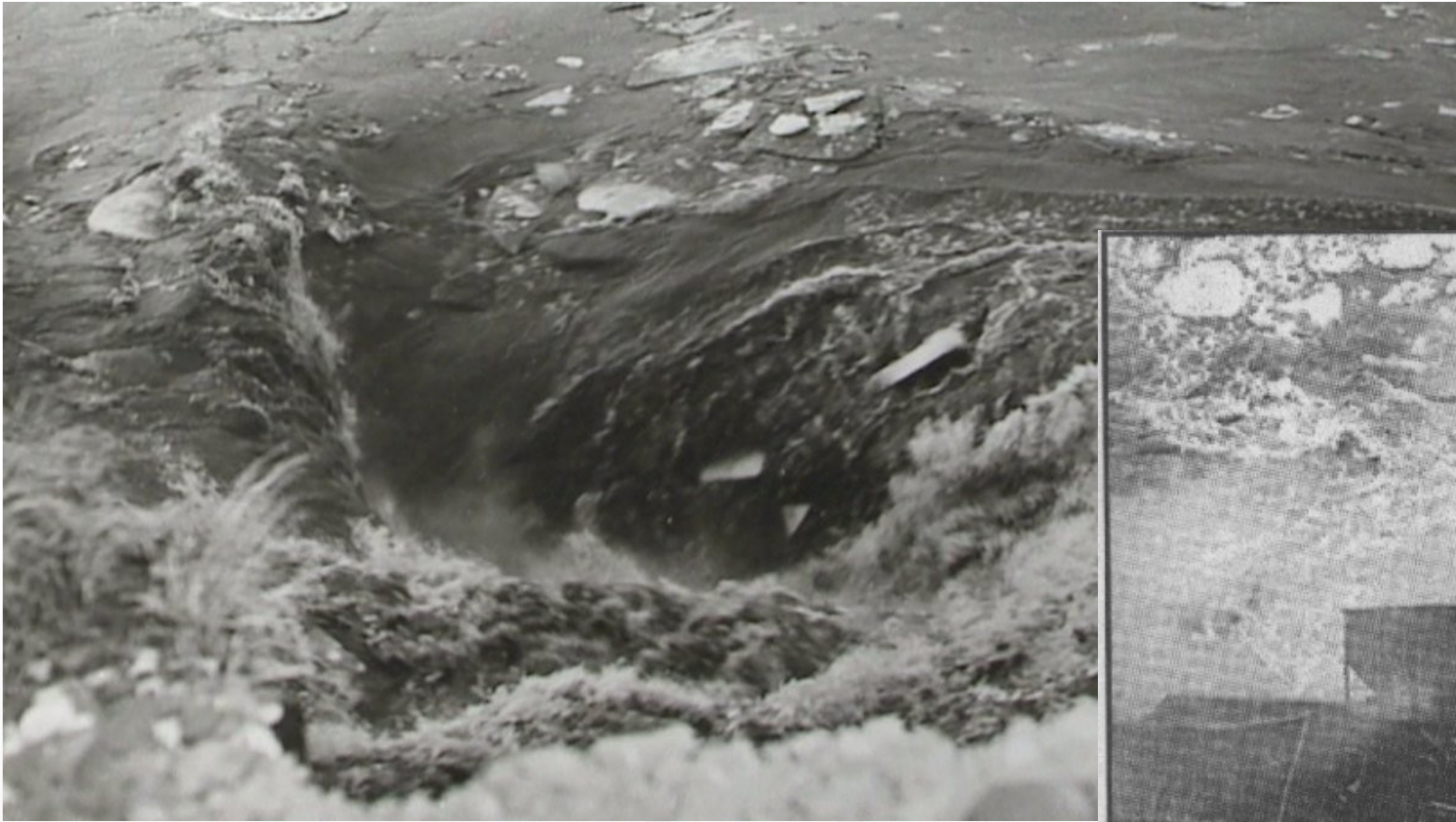




# Water Inundation

- The 1959 Knox Mine Disaster
- Mined into the Susquehanna River
- An estimated 10 billion gallons filled the mine

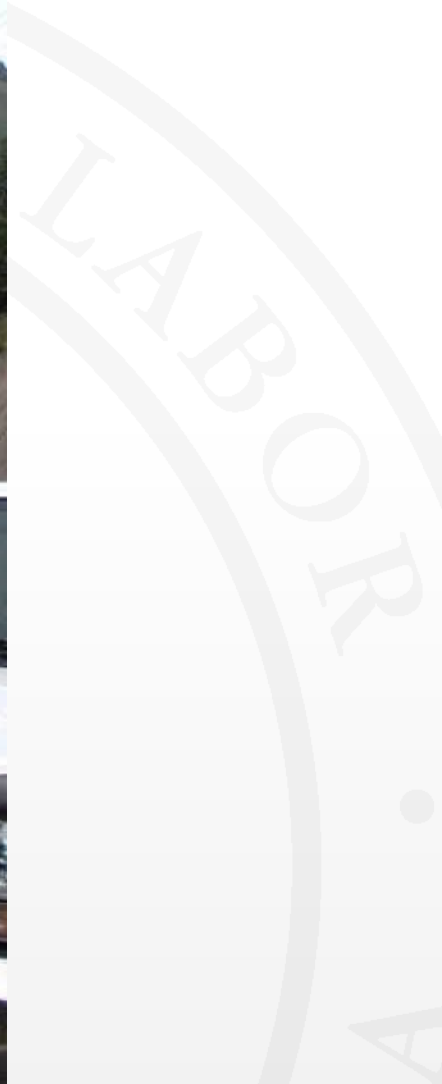




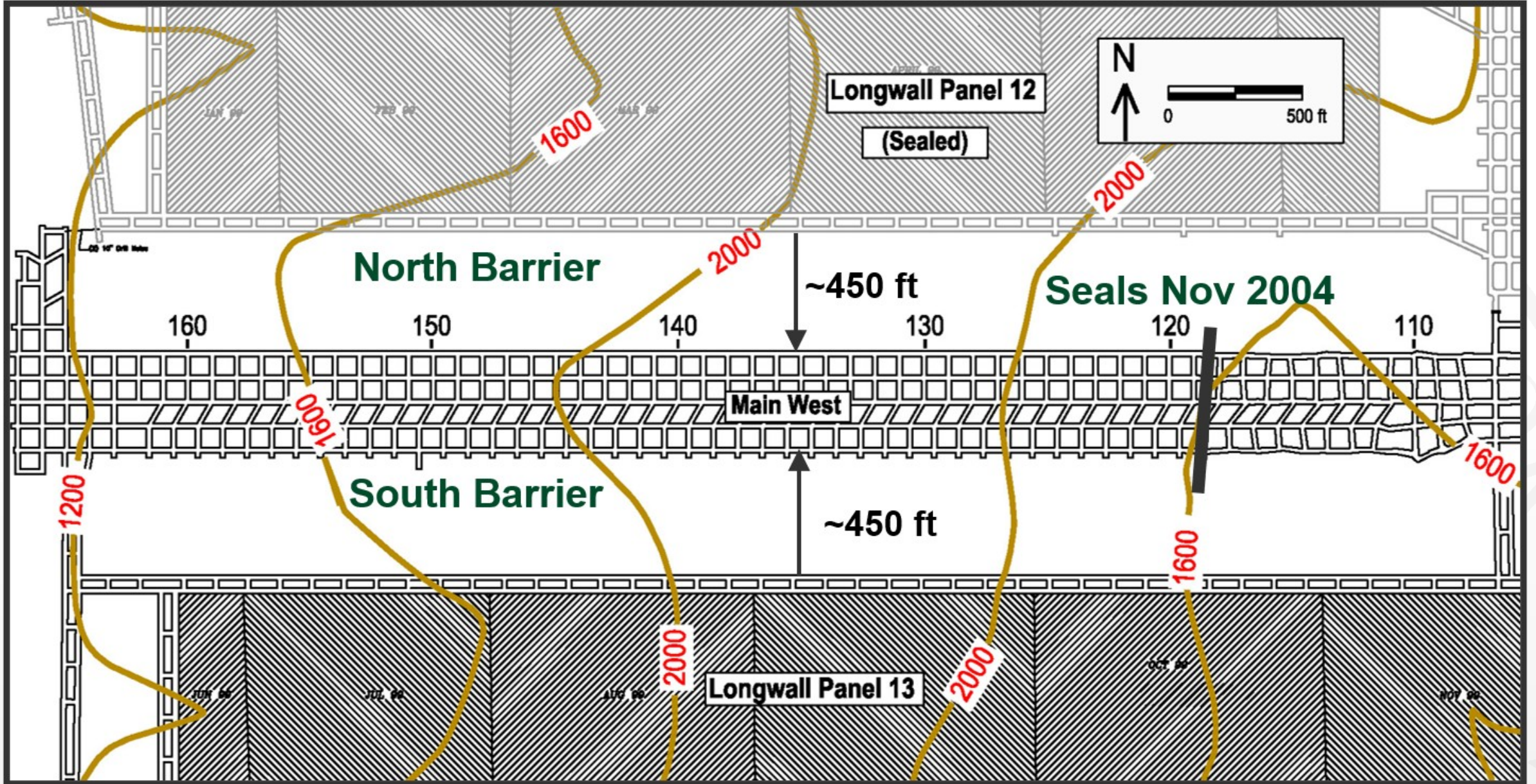




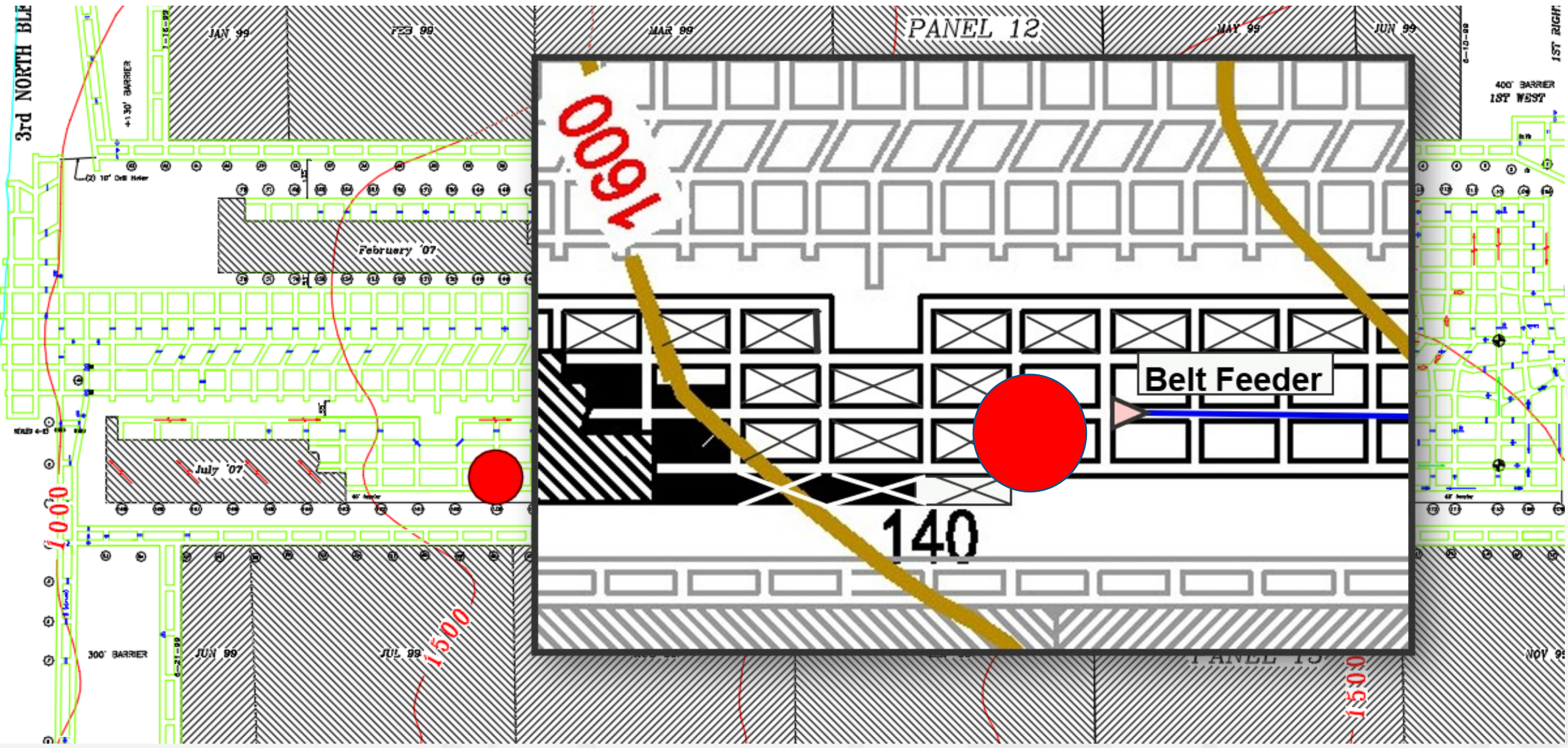
# Crandall Canyon 15 Years Later









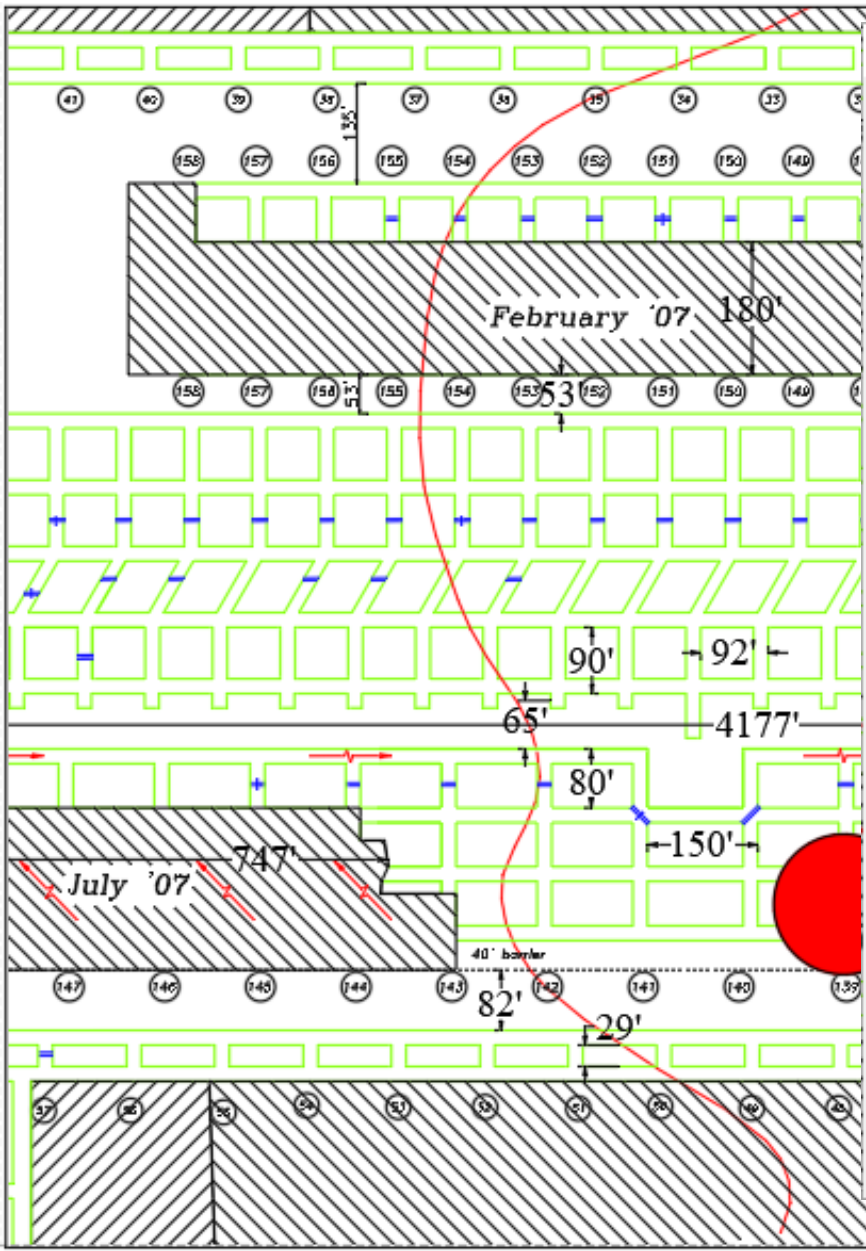






South Barrier 4entry Looking inby CC120 in #3 entry, 8/9/07 – Bump Damage





### Input Development / Room-and-Pillar Parameters

**Development** | Defaults | Retreat | Multiple Seam

**Pillar system specifications**

Entry height (ft)	8	Number of entries	10
Depth of cover (ft)	1600	<input checked="" type="checkbox"/> Advanced geometry	
Crosscut angle (deg)	90	<input checked="" type="checkbox"/> Retreat mining	
Entry width (ft)	20	<input type="checkbox"/> Multiple seam	
Crosscut spacing (ft) (center-to-center)	0	Average extraction ratio (%)	38.2

**Center-to-center entry spacing**

P1	P2	P3	P4	P5	P6	P7	P8	P9	<input type="checkbox"/> Equal spacing
80	80	80	65	90	90	90	90	53	

**Advanced geometry data**

Crosscut spacing									<input type="checkbox"/> Equal crosscuts
150	150	150	4177	92	92	92	92	92	
Crosscut angle									<input type="checkbox"/> Equal angles
90	90	90	90	90	60	90	90	90	

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**Calculation Results**

[ACPS Output]

[SINGLE SEAM PILLAR SYSTEM STABILITY FACTORS]

Development.....	0.80
*Development loading includes two side gobs.	
Retreat.....	0.45
*Retreat loading includes two side gobs.	

[BARRIER PILLAR STABILITY FACTORS]

[Development]

FIRST SIDE GOB BARRIER.....	0.67
SECOND SIDE GOB BARRIER.....	0.58

[Retreat]

FIRST SIDE GOB BARRIER.....	0.45
SECOND SIDE GOB BARRIER.....	0.35

[WARNINGS]

C. Analysis of the ACPS case history data base suggests that when the depth of cover is greater than 1000 ft, the risk of pillar failure is increased when the ACPS SF is less than 1.5 or (1.3 if the pillar system width is less than 425 ft and the Barrier Pillar SF exceeds

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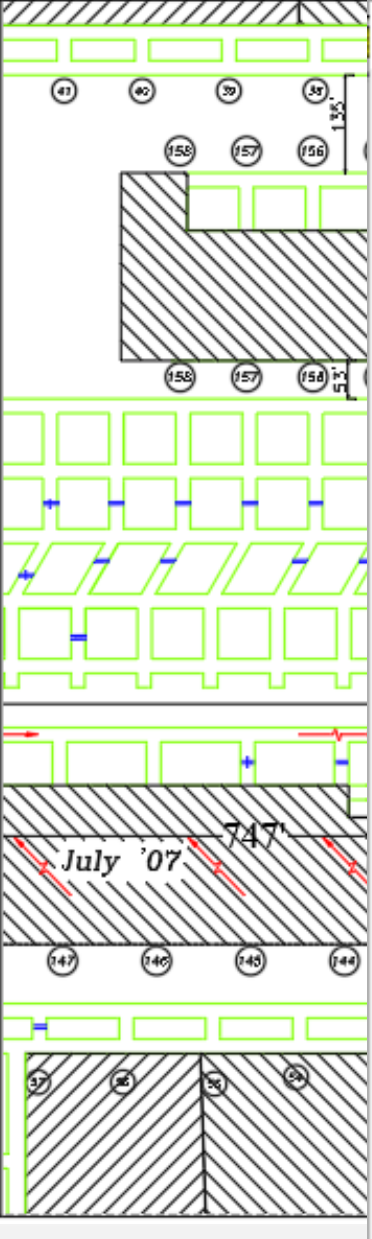
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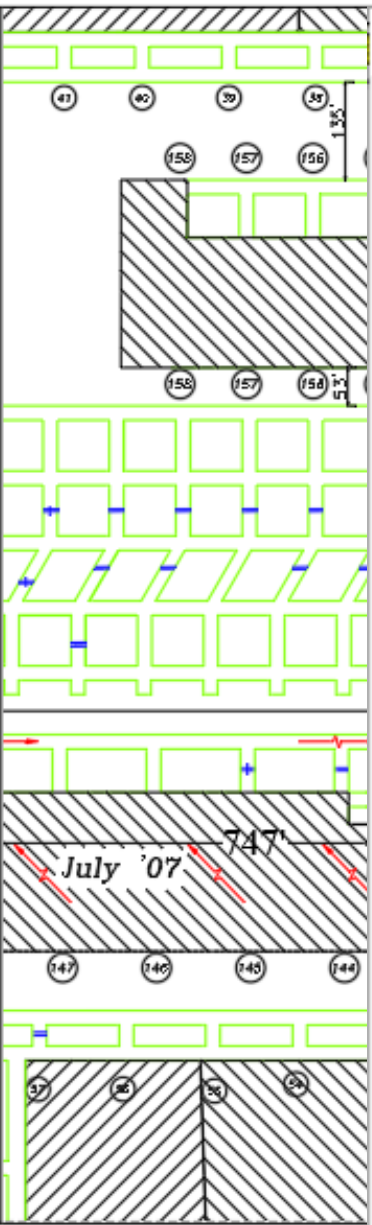
Multiple Seam

f) 5170  
g) 21  
h) 82  
i) 40

f) 180  
g) 21  
h) 53  
i) 0

OK





### Calculation Results

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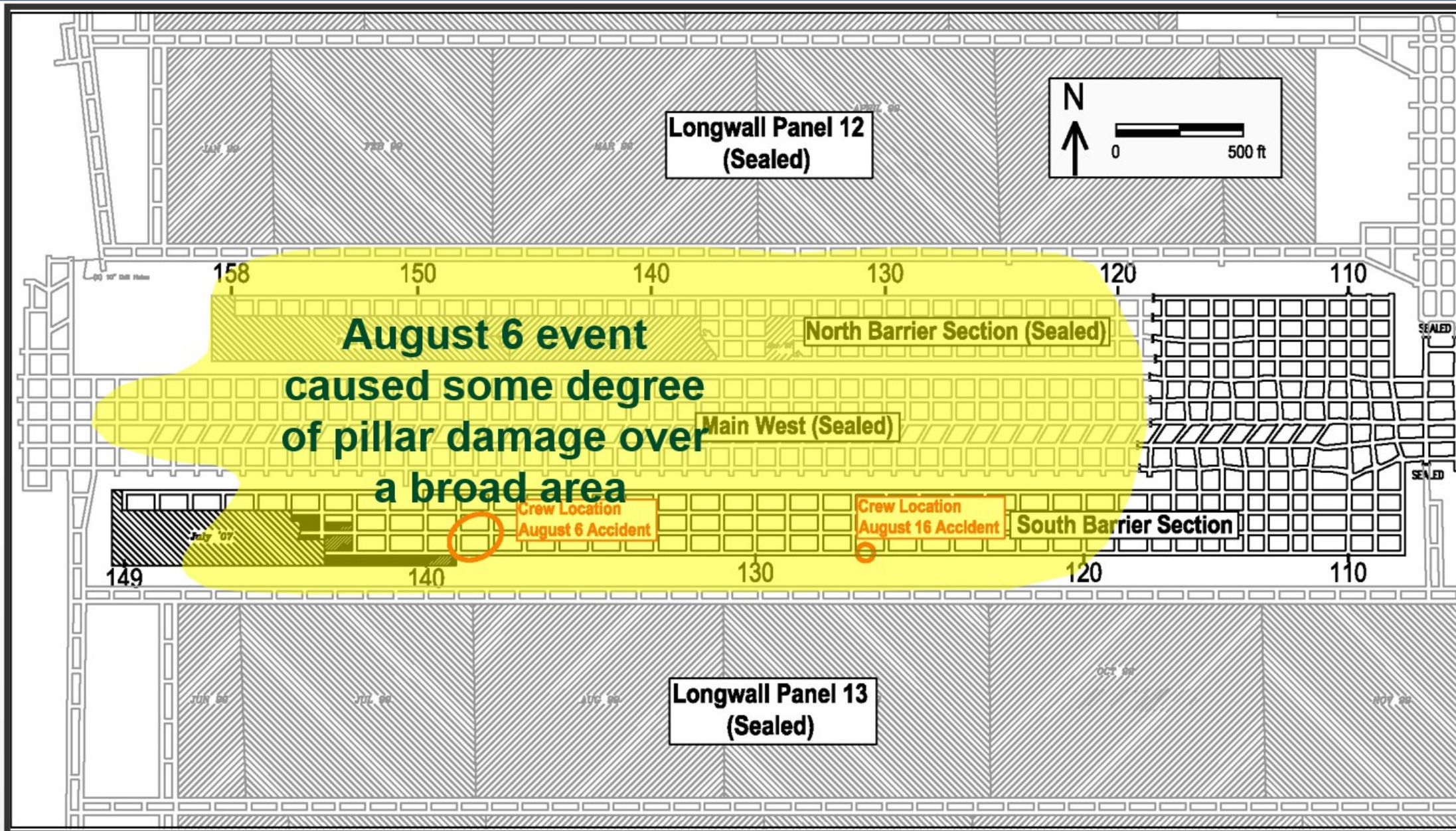
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Multiple Seam

f) 5170
g) 21
h) 82
i) 40
j) 180
k) 21
l) 53
m) 0

OK







# Future Challenges to Pillar Design

- Increasingly deep cover
- More multiple-seam mining interactions
- Challenging geologic conditions
- Variability in pillar composition
- More gas well protective pillars



## Summary

- Properly designed barrier pillars are an essential part of safe mining
- ACPS is a straightforward and fast method for evaluating barrier pillars
- The Roof Control Division is available to help!
  - email: [PillarInititive@DoL.gov](mailto:PillarInititive@DoL.gov)
- Analysis of Roof Support Systems (AMRS)
  - [www.MineGroundControl.com](http://www.MineGroundControl.com)





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