Mining Under Bodies of Water

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Pittsburgh Safety and Health Technology Center

Virginia Professional Engineers in Mining Seminar

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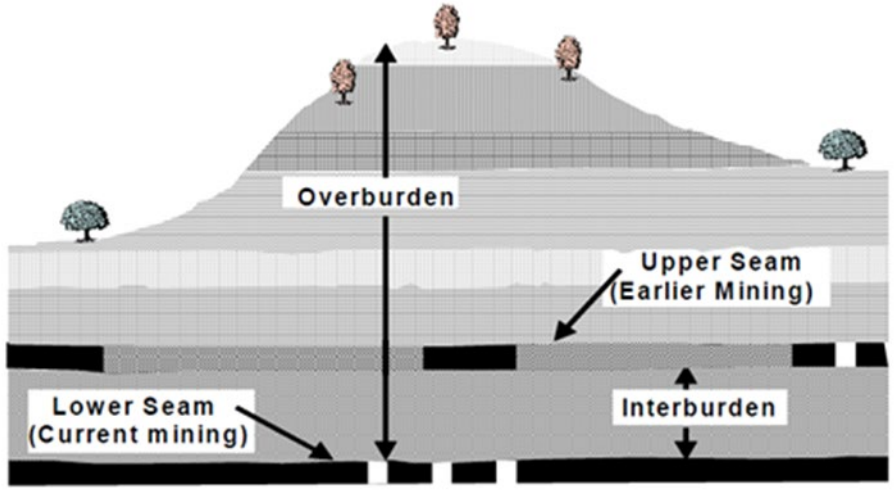
Presentation Topics

- Inundation and Infiltration Causes
- Conducting a Hazard Potential Assessment
- Minimum Overburden/Interburden Criteria
- Case Study



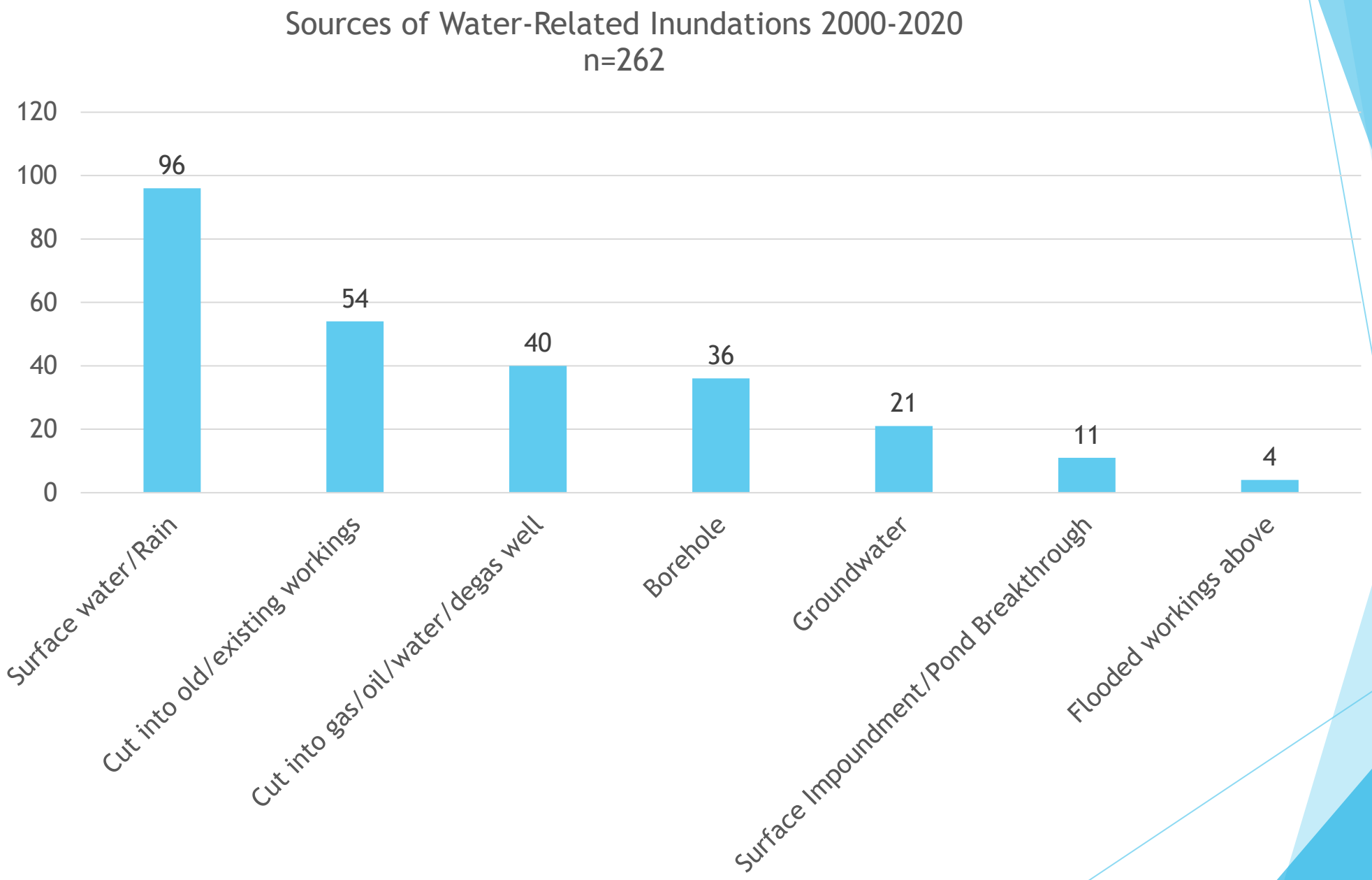
30 CFR § 75.1716

Whenever an operator mines coal from a coal mine opened after March 30, 1970, or from **any new working section** of a mine opened prior to such date, in a manner that requires the construction, operation, and maintenance of tunnels **under any river, stream, lake, or other body of water, that is, in the judgment of the Secretary, sufficiently large to constitute a hazard to miners,** such operator shall **obtain a permit** from the Secretary which shall include such terms and conditions as he deems appropriate **to protect the safety of miners working or passing through such tunnels from caveins and other hazards.** Such permits shall require, in accordance with a plan to be approved by the Secretary, **that a safety zone be established beneath and adjacent to such body of water.** No plan shall be approved unless there is a minimum of cover to be determined by the Secretary, based on test holes drilled by the operator in a manner to be prescribed by the Secretary. No such permit shall be required in the case of any new working section of a mine which is located under any water resource reservoir being constructed by a Federal agency on December 30, 1969, the operator of which is required by such agency to operate in a manner that protects the safety of miners working in such section from cave-ins and other hazards.

[35 FR 17890, Nov. 20, 1970, as amended at 60 FR 33723, June 29, 1995]

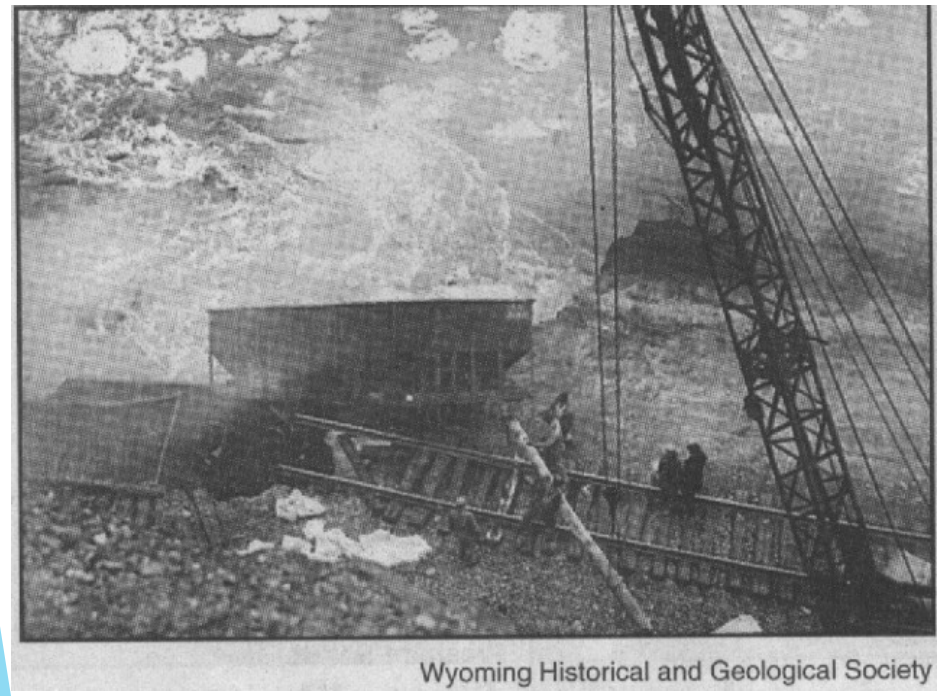
Causes of Inundations and Infiltration

- Permeability increase due to mining - Subsidence
- Sinkhole development
- Mining near or through geologic discontinuities (faults, karst, etc.)
- Intercepting boreholes, oil and gas wells, water wells, shafts
- Cut into adjacent mine workings
- Flooding from surface waters
- Inadequate or failed pumping capabilities


Sources of Water-Related Inundations 2000-2020
n=262
120
100
80
60
40
20
0
96
54
40
36
21
11
4
Surface water/Rain
Cut into old/existing workings
Cut into gas/oil/water/degas well
Borehole
Groundwater
Surface Impoundment/Pond Breakthrough
Flooded workings above

Water Infiltration can:

- Inundate the working section or areas down-dip
- Alter ventilation
- Block escape and travelways
- Cause roof degradation or floor softening
- Release other contaminants into the mine atmosphere



Wyoming Historical and Geological Society

Wilkes-Barre Record

12 Missing and 33 Rescued After River Breaks Into Mine Near Pittston

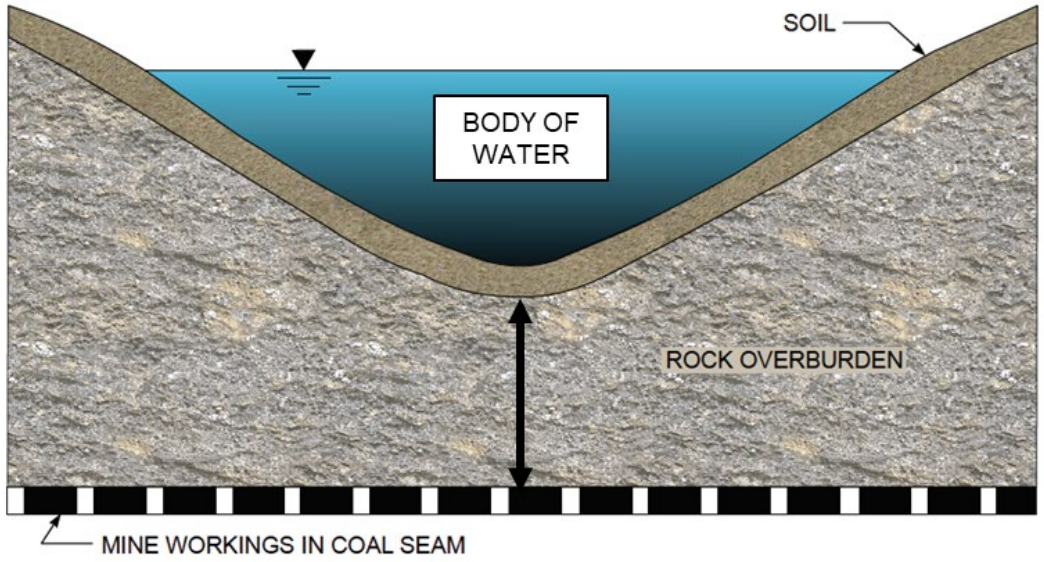
Cars Dropped In Pit to Try To Plug Break

Governor Declares Emergency

Rescued Men Brought Out on Ropes Through Nearby Shaft

Conducting a Hazard Potential Assessment

- Evaluation of whether proposed mining beneath an overlying water body constitutes a hazard to miners.
  - Water Body
  - Proposed Mining
  - Overburden or interburden characteristics



Water Sources

- Surface Waters: Lakes, rivers, impoundments/ reservoirs, streams, ponds
- Ground Waters: Fault zones, karst caves, fractured ground
- Mine Waters: Overlying mine pools, mines pools in same seam (adjacent mines or impounded behind seals)

Hazard Potential of Water Source

- Catastrophic: water bodies that can completely flood the mine workings
  - Examples: Oceans, large lakes, large rivers, very large mine pools
- Major: finite-size water bodies which are smaller than the available mine storage capacity
  - Examples: Large streams, small lakes, relatively small mine pools
- Limited: water bodies with volumes can be controlled by the pumping capacity in the mine
  - Examples: Farm ponds, small streams, low spots in dewatered mines

Proposed Mining

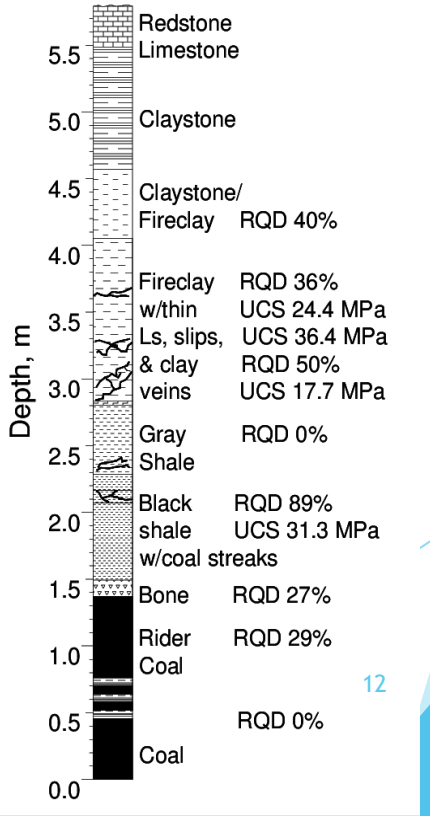
- What type of mining?
  - room-and-pillar, partial extraction/retreat mining, full extraction/longwall mining
- What is the mining height, entry width, and pillar dimensions?
- What is the direction of mining?
  - up-dip or down-dip

Proposed Mining (continued)

- How big is the mine? Are there potential storage areas?
- Where will the water flow and accumulate?
  - Alter ventilation or block escapeways?
- What are the pumping/dewatering capabilities?

Overburden/Interburden Characteristics

- Evaluate the ability of OB/IB strata to prevent an inundation.
- Thickness and composition of solid strata between proposed workings and base of the water body
  - Corehole logs with geologic information such as rock type, RQD, fracture logs, etc.
  - Strata type and strength of the OB, IB, mine roof, and mine floor



Information Circular 8741

Results of Research To Develop Guidelines for Mining Near Surface and Underground Bodies of Water

By Clarence O. Babcock and Verne E. Hooker

UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF MINES

CRITERIA FOR DETERMINING WHEN A BODY OF SURFACE WATER CONSTITUTES A HAZARD TO MINING

Prepared for

United States Department of the Interior
Bureau of Mines

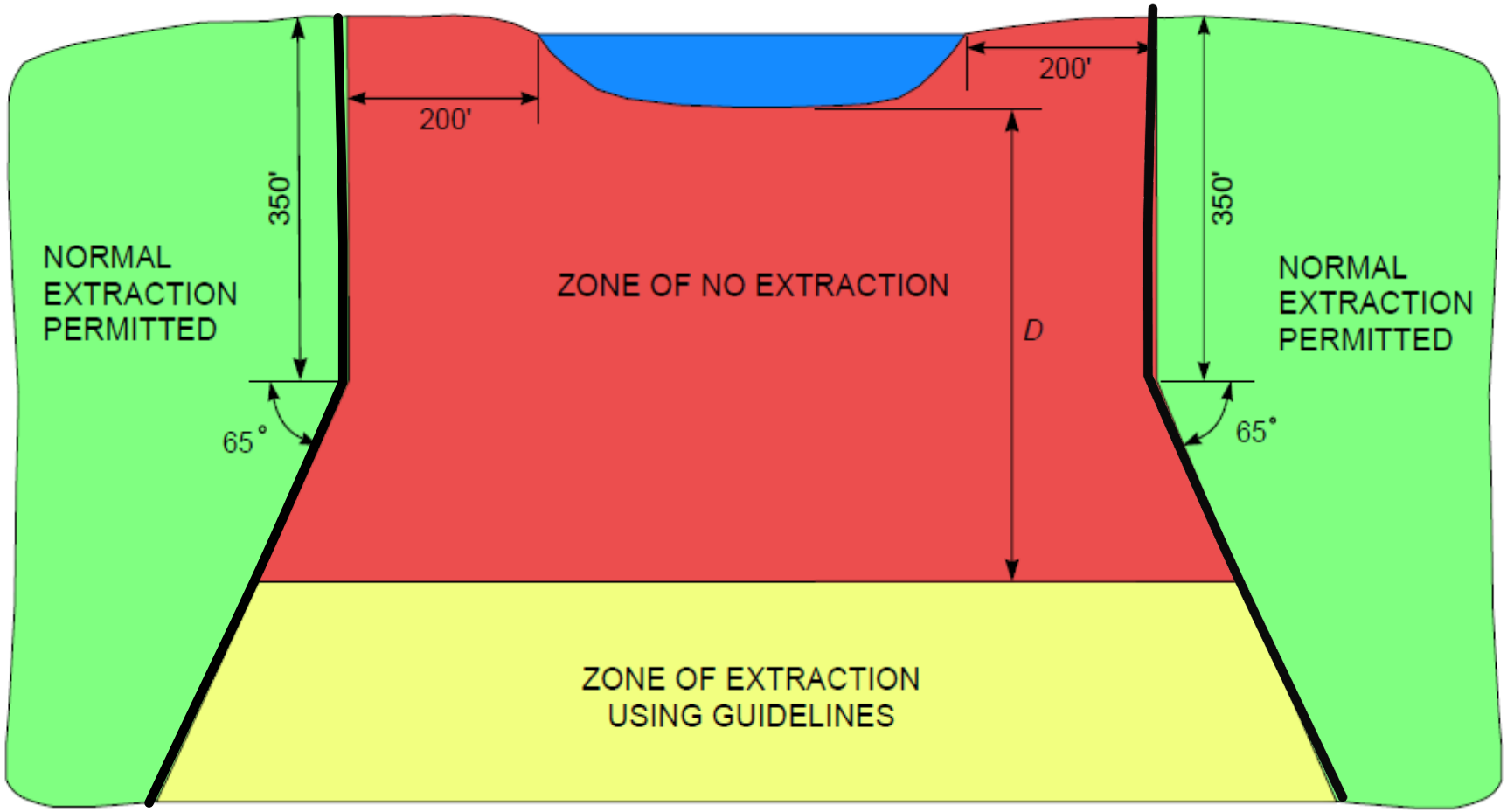
by

ENGINEERS INTERNATIONAL, INC.
2514 Wisconsin Avenue
Downers Grove, Illinois 60515

FINAL REPORT

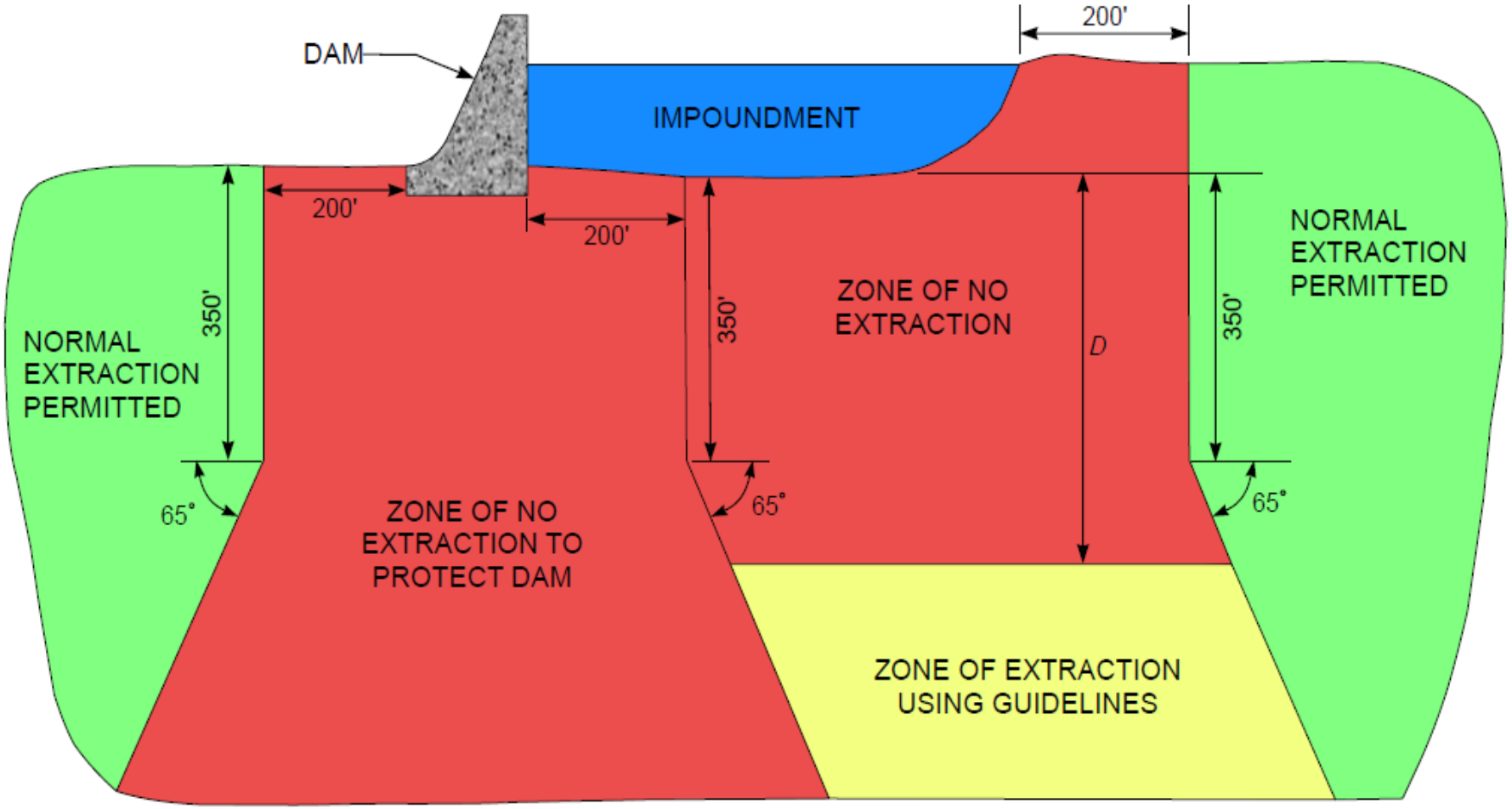
Contract No. J0285011

August 1979



ROOM AND PILLAR	$D = 5s$ or $10t$, whichever is larger	s = maximum entry width (ft)
PANEL	$D = 3p$ or 270 feet, whichever is larger	p = panel width (ft)
TOTAL EXTRACTION	$D = 60t$	t = extraction height (ft)

8.6a SAFETY ZONE BENEATH BODY OF SURFACE WATER



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TOTAL EXTRACTION	$D = 60t$	t = extraction height (ft)

8.6b SAFETY ZONE BENEATH DAM AND IMPOUNDED BODY OF SURFACE WATER

Example: Room-and-Pillar Mining

- Room-and-pillar mine
- 20 foot entries
- 5 feet mining height

- Overburden needed (larger of):

$$5 * entry\ width = 5 * 20' = \mathbf{100\ feet}$$

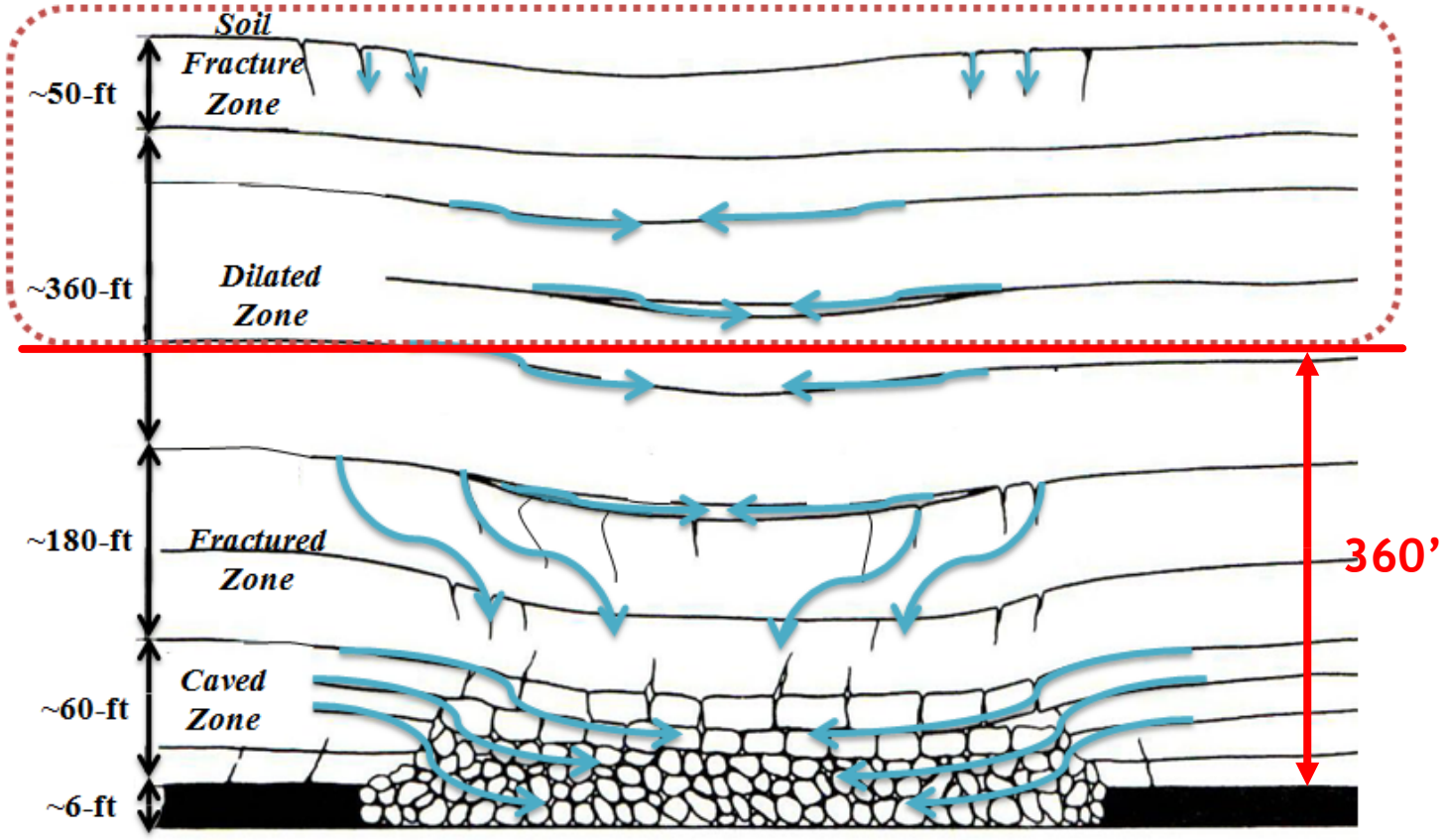
or

$$10 * mining\ height = 10 * 5' = 50\ feet$$

Note: where at least one competent bed of sandstone or similar material is present in the strata and has a thickness ≥ 1.75 * entry width, mining at lesser cover may be considered.

Example: Full Extraction Mining

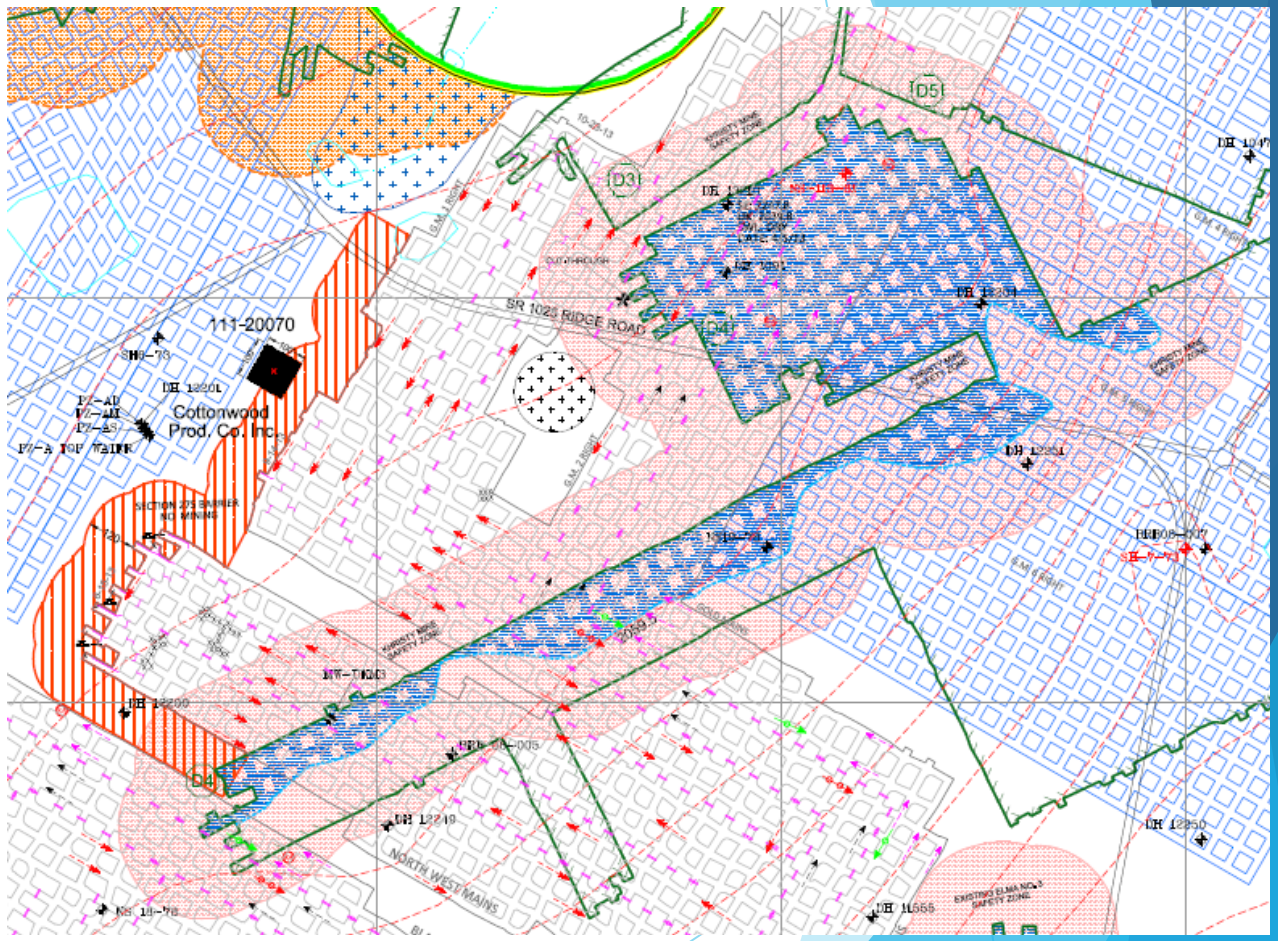
$$6\ feet\ mining\ height\ * 60 = \mathbf{360\ feet}$$



Adapted from Kendorski and Consultant (1993) and Peng (2008)

Other Considerations

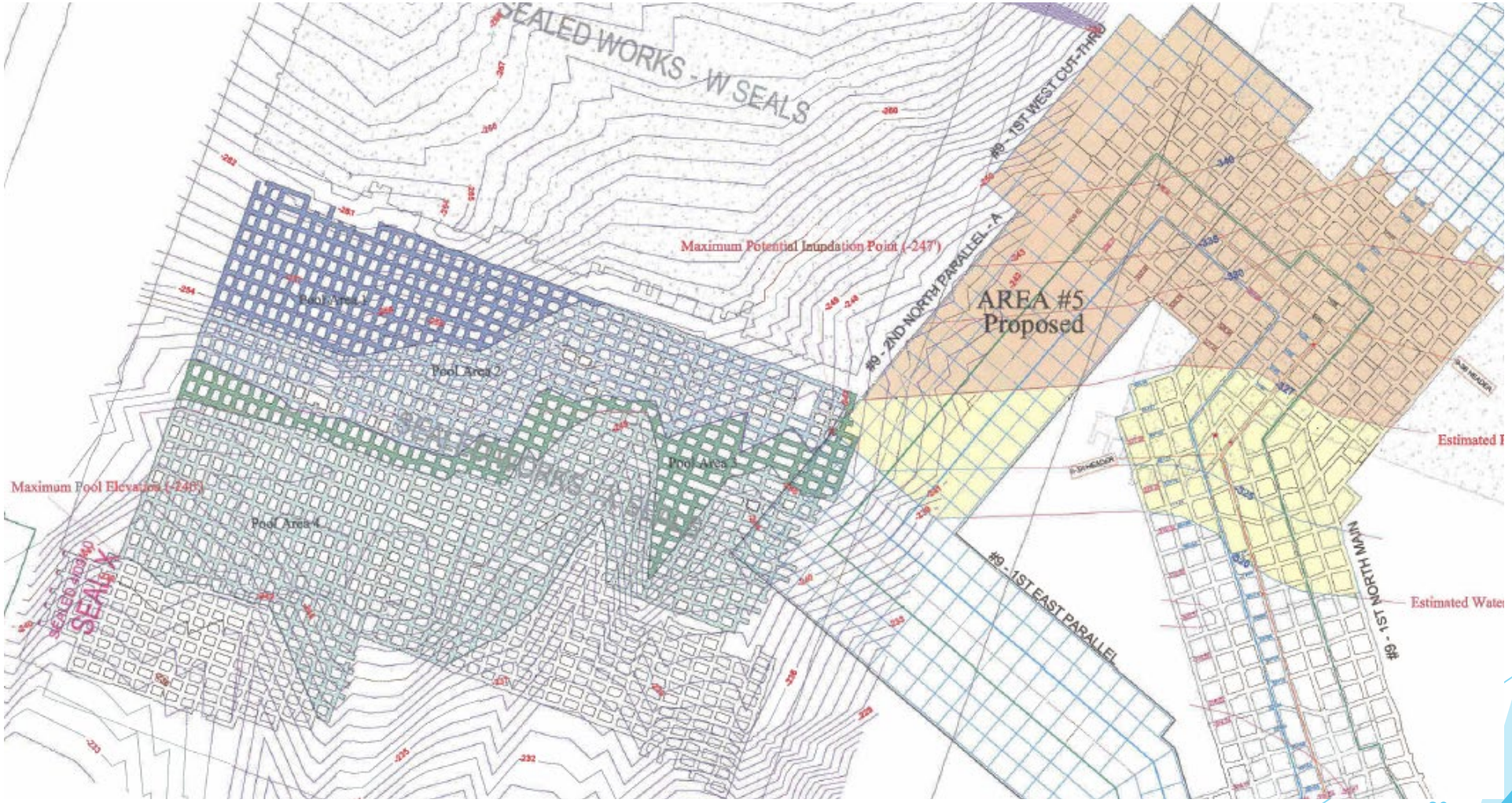
- What methods were used to estimate the volume of water?
- Will the volume of the water source fluctuate?
- Is dewatering needed or possible?
- Are there more robust precautions/ safety procedures when mining beneath the water body or within the safety zone?
- Are there evacuation provisions?



Items to Consider in Evacuation Provisions

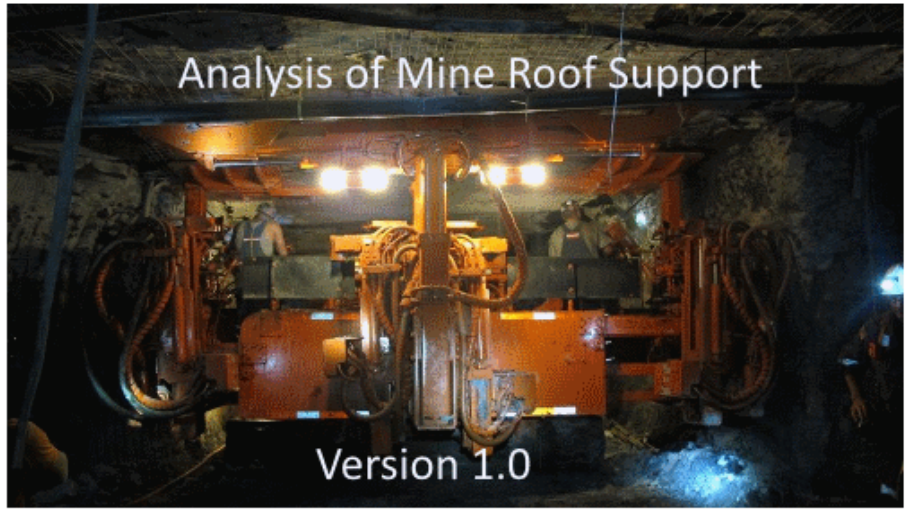
- Entry heights
- Distance to portal
- Floor gradient and low areas
- Estimates of Inflow velocity
- Evaluation of passible escapeways (inundation analysis)
- Action/Alarm level(s) that would trigger further evaluation or evacuation (monitoring system)
- Communication and Hazard Recognition Training

Inundation Analysis



Mitigating Risks through Ground Control

- Pillar Stability
- Install Standing Support or Supplemental Roof Support
- Skin Control (roof mesh)



Permit Approval Options

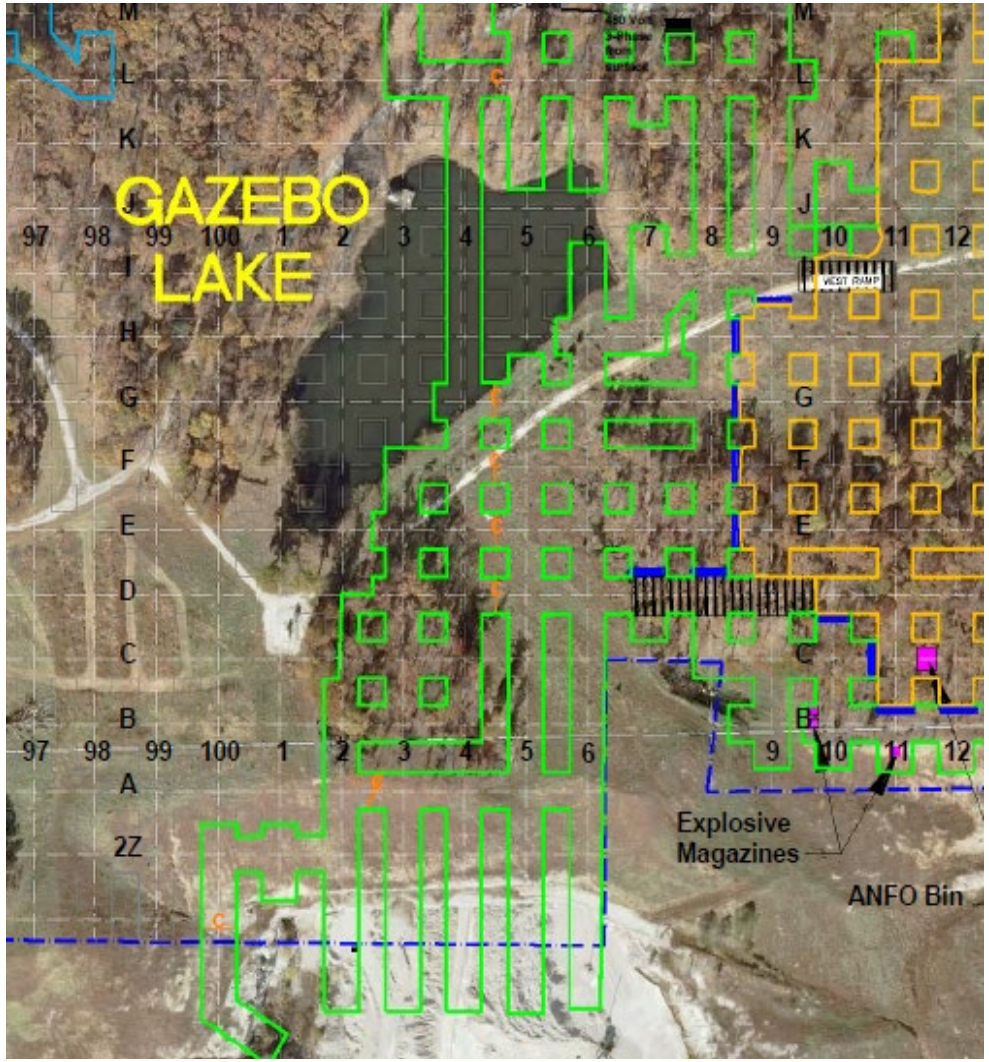
- Permit mining (based on depth, size of water body, etc).
- Permit, but
  - Limit to first mining only
  - Limit potential for roof falls
  - Require larger pillars
  - Require monitoring
  - Require down-dip water storage
  - Restrict area that can be mined
- Or, drain the water body prior to mining

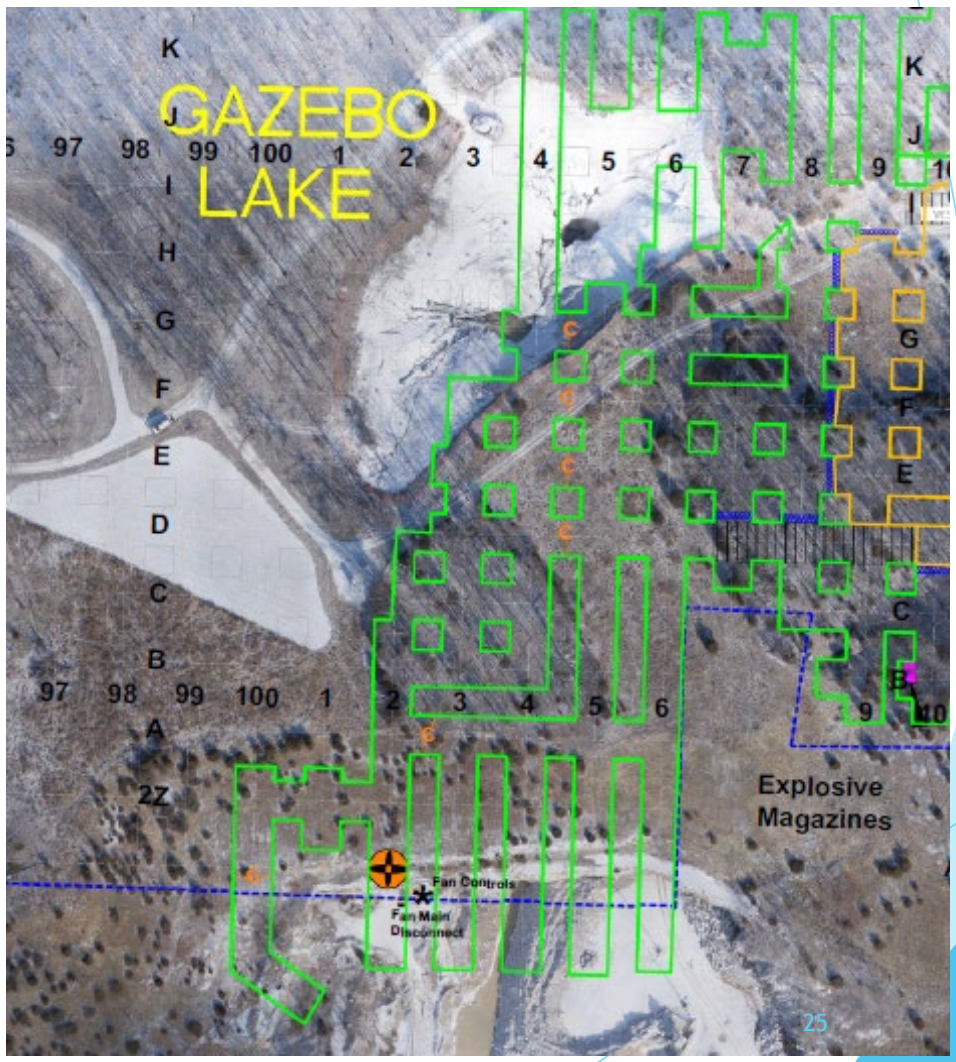
Case Study

Inundation Case Study

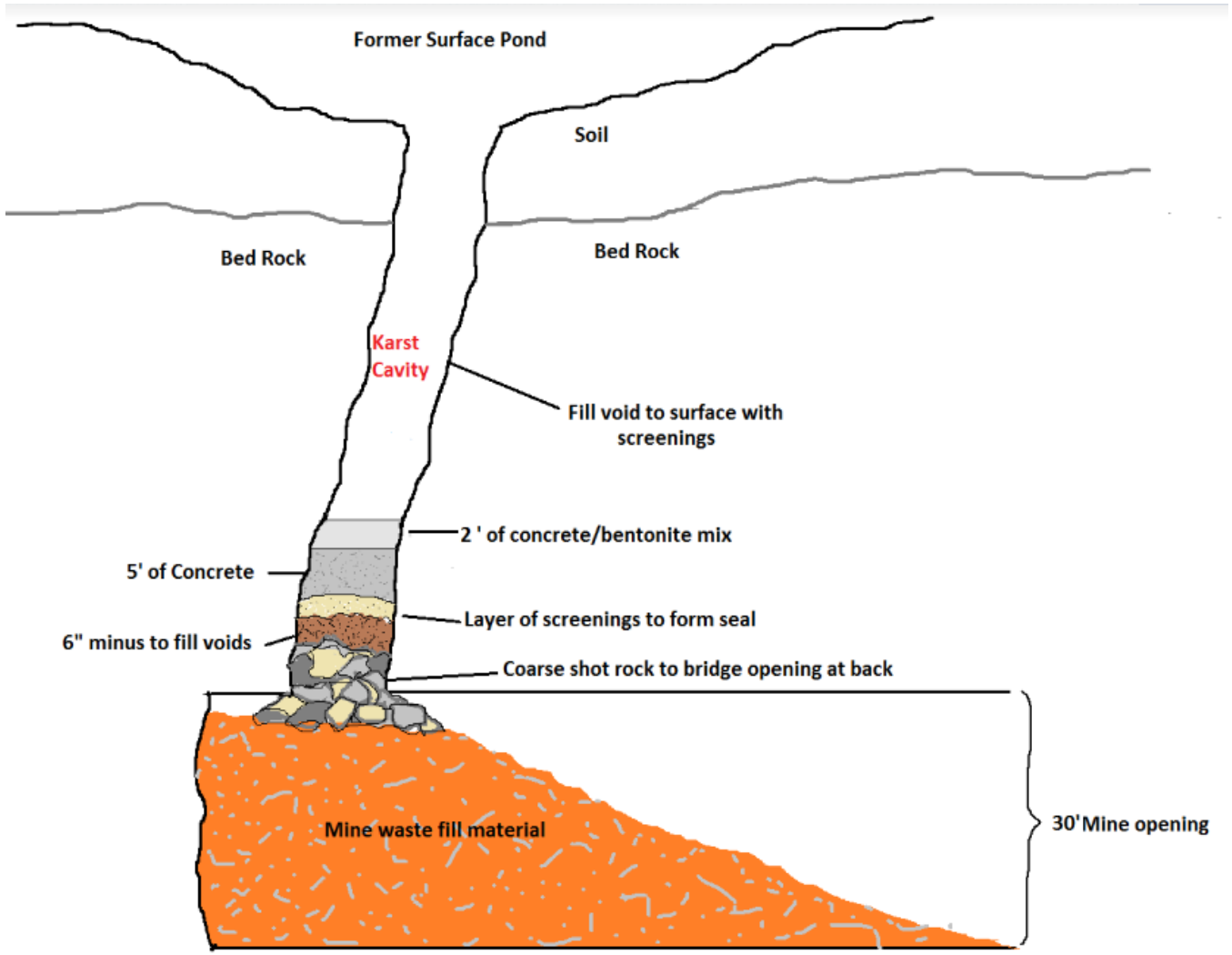
- Underground Limestone Mine
- January 20, 2020 Escalation Report:
  - “Caller is reporting the surface lake flooded the underground mine”
- No miners were present within the mine at the time of the inundation
- Surface lake was owned by the mine and ~1.5 acres.

Before and After Overlays

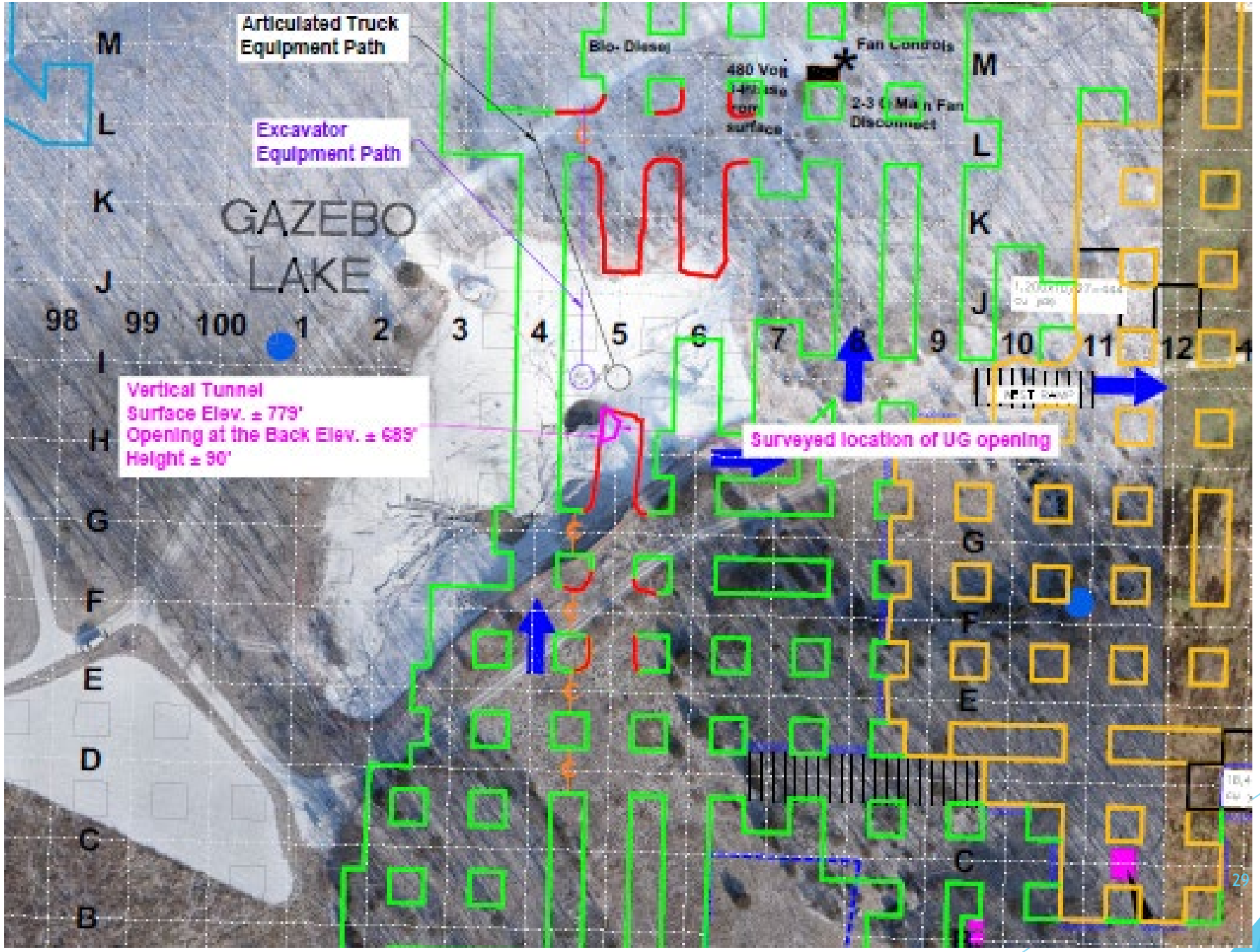




Sinkhole Diagram

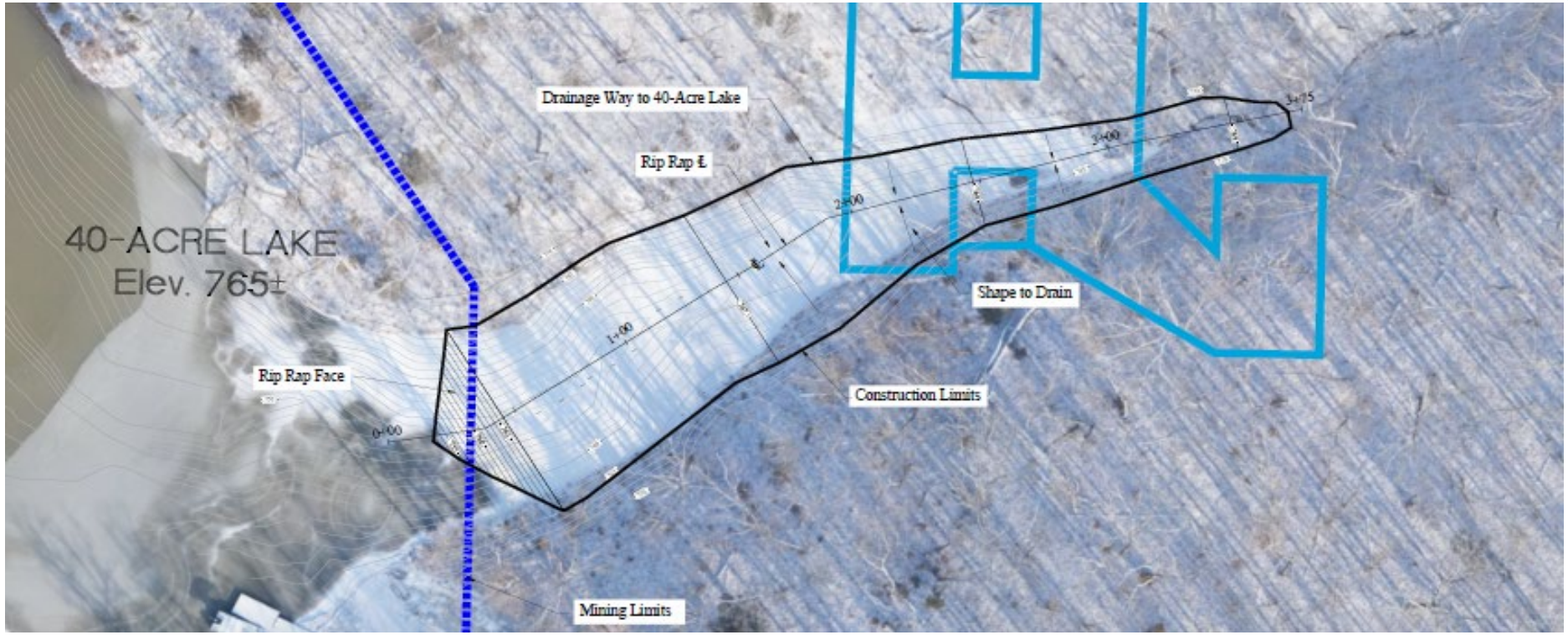


~25 feet in diameter; ~90 feet deep (overburden)


Articulated Truck
Equipment Path
Excavator
Equipment Path
GAZEBO
LAKE
Bio- Diesel
480 Volt
Fan Controls
Main Fan
Disconnect
Vertical Tunnel
Surface Elev. ± 779'
Opening at the Back Elev. ± 689'
Height ± 90'
Surveyed location of UG opening
M
L
K
J
I
H
G
F
E
D
C
B
98
99
100
1
2
3
4
5
6
7
8
9
10
11
12

Operator's Repair Plan

- Plug sinkhole from underground and surface
  - Back stow material to full room height (~30') underground
  - Sinkhole backfilled from surface and concrete plug constructed
- Deconstruct Gazebo Lake (i.e., regrade to prevent future water accumulation)
- Prevention Plan: "restricts future mining beneath any water impoundment at the facility"
  - Small area to the northwest suspected to be located under a water body
  - Operator inspected area for karst features and was monitoring for water
- Geologic information: corehole logs and geology discussion
  - Solution cavities (karst)


Drainage Way to 40-Acre Lake
Rip Rap ℄
40-ACRE LAKE
Elev. 765±
Shape to Drain
Rip Rap Face
Construction Limits
Mining Limits

Questions?

Contact: Megan Lavage

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Mine Safety and Health Administration

Pittsburgh Safety and Health Technology Center

Mine Waste and Geotechnical Engineering Division