

A photograph of a mine tunnel. In the foreground, a worker wearing a white hard hat, a blue long-sleeved shirt, a red safety vest, and khaki pants is walking away from the camera. The tunnel walls are made of reddish-brown rock with visible horizontal layering. In the middle ground, there is a closed, dark-colored door or gate. The floor is covered with reddish-brown dirt and small rocks. The lighting is somewhat dim, typical of an underground mine.

# Best Practices for physical hazard closure at underground mines

Mine Design, Operations & Closure  
Conference

2010

Fairmont Hot Springs, MT



# Reclamation Issues

A photograph showing a mine entrance or pit. The opening is supported by several large, weathered wooden beams. Inside the pit, there is a pool of dark water. The surrounding area is rocky and appears to be a site of active or abandoned mining. The ground is uneven and covered with loose rocks and debris.

- **Air, water, soil**
- **Acid mine drainage**
- **Tails and slag**
- **Physical hazards**
  - **Buildings**
  - **Pits and highwalls**
  - **Mine entries**
  - **Subsidence features**



# Physical hazard issues

A large, rusted metal mill component, possibly a headframe or shaft, is the central focus of the image. It is situated within a dilapidated wooden structure, likely a mill building or headframe, which shows signs of significant decay and structural failure. The background features a clear blue sky and some green trees, suggesting an outdoor industrial or mining site. The overall scene conveys a sense of neglect and potential physical hazards associated with old industrial infrastructure.

- Mill buildings and headframes
  - Unstable
  - Contaminated
  - Could hide other hazards
- Shafts, adits, raises
- Highwalls and open pits
- Subsidence
  - Cracks
  - Stopes
  - Intersection caves



# Surface mine features & hazards



- **Highwalls**
  - Unstable
  - Sediment and leaching
- **Pits**
  - Falling
  - Drowning
  - Leaching

**Drowning, ATV accidents and falling are the top three causes of fatalities at AML sites (geology.com)**



# Head frames and Buildings

- Collapsing
- Falling
- Sumps, service tunnels
- Contaminants and chemicals

**But often considered historical**

08/31/2005





# Mine openings

- **Shafts**
  - Vertical or near vertical
  - May be in rock or lined or timbered in overburden
- **Adits**
  - Horizontal to slight incline
  - Hard rock term
  - Often dry
- **Raises**
  - Used for ventilation
  - For closure, treat as a shaft
- **Portals**
  - Primarily coal
  - Could be inclined
  - Often produce water





# Mine opening hazards

- **Falling**
- **Gases**
- **Entrapment**
- **Falls of ground**
- **Fauna**
- **Endanger rescue personnel**
- **Conduits for water in and out**





# Types of closures

- Full closure, permanent, no ingress
  - Backfill, concrete, foam, steel, grouting
- Permanent with secure ingress
- Permanent with ventilation
  - Culvert with or without gating
- Full closure with animal ingress
- Culvert with fill and gating



# Who does this work?

- **Federal Agencies**
  - BLM, OSM, USFS, NPS
  - USF&W, NRCS, BOR, USACE (limited)
- **State/Provincial Agencies**
  - AML, DNR/DEP
- **Mining Companies**
- **Contractors**



# Closure methods and resources

- Shafts and raises (and most stopes)
  - Fences
  - Backfill
  - Blasting
  - Concrete
  - Foam
  - Steel
  - Cable nets
  - Cupolas
  - Culverts
  - Tires





# Closure methods and resources

- **Adits/portals**
  - Fences
  - Backfill
  - Blasting
  - Block walls
  - Concrete
  - Stacked rock
  - Cable nets
  - Full gates
  - Foam
  - Culverts
  - Tires





# Closure methods and resources

- **Subsidence features**

- Fences

- Backfill

- Concrete

- Grout

- Bentonite

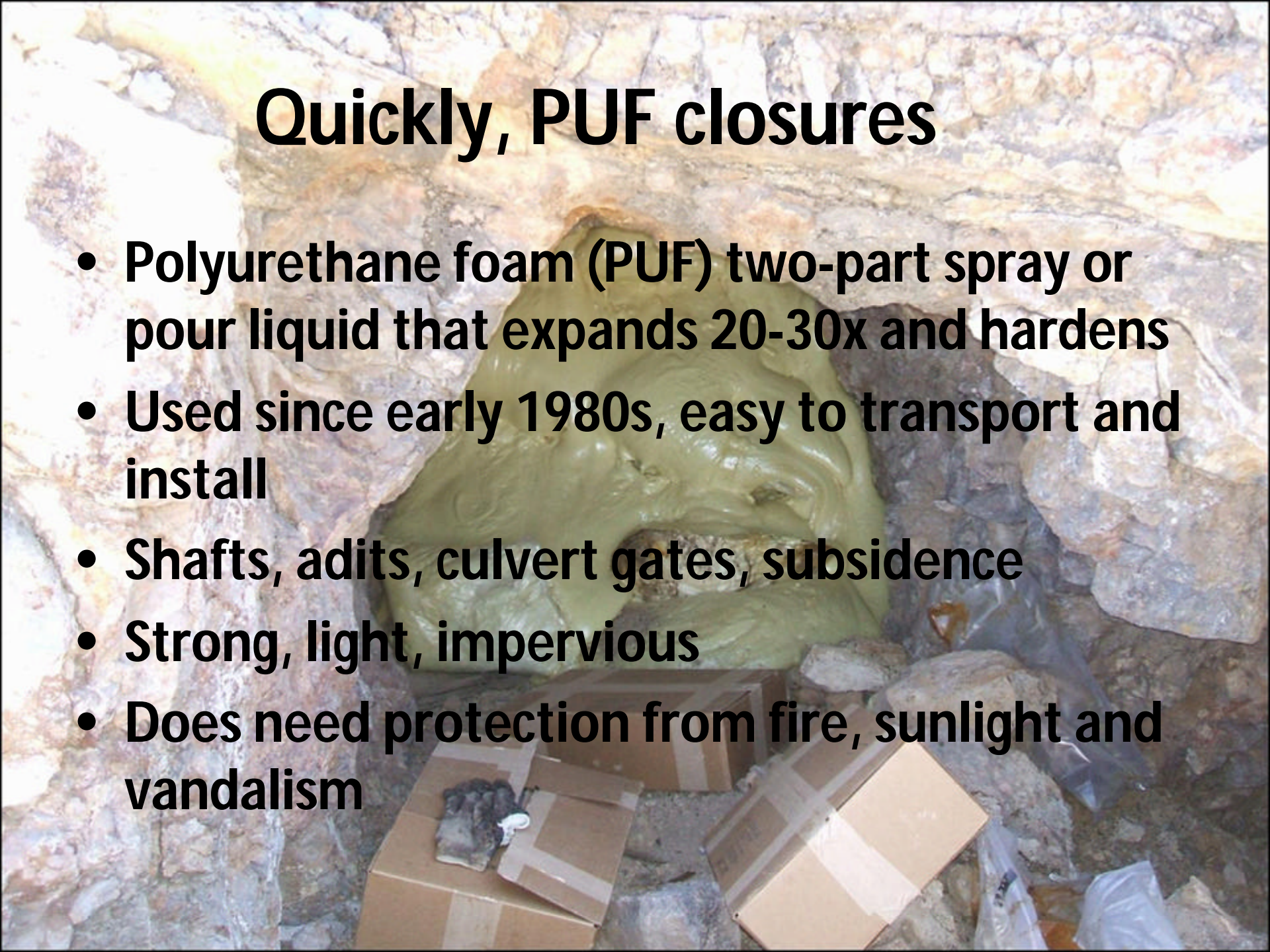
- Foam





# Quickly, PUF closures

- Polyurethane foam (PUF) two-part spray or pour liquid that expands 20-30x and hardens
- Used since early 1980s, easy to transport and install
- Shafts, adits, culvert gates, subsidence
- Strong, light, impervious
- Does need protection from fire, sunlight and vandalism



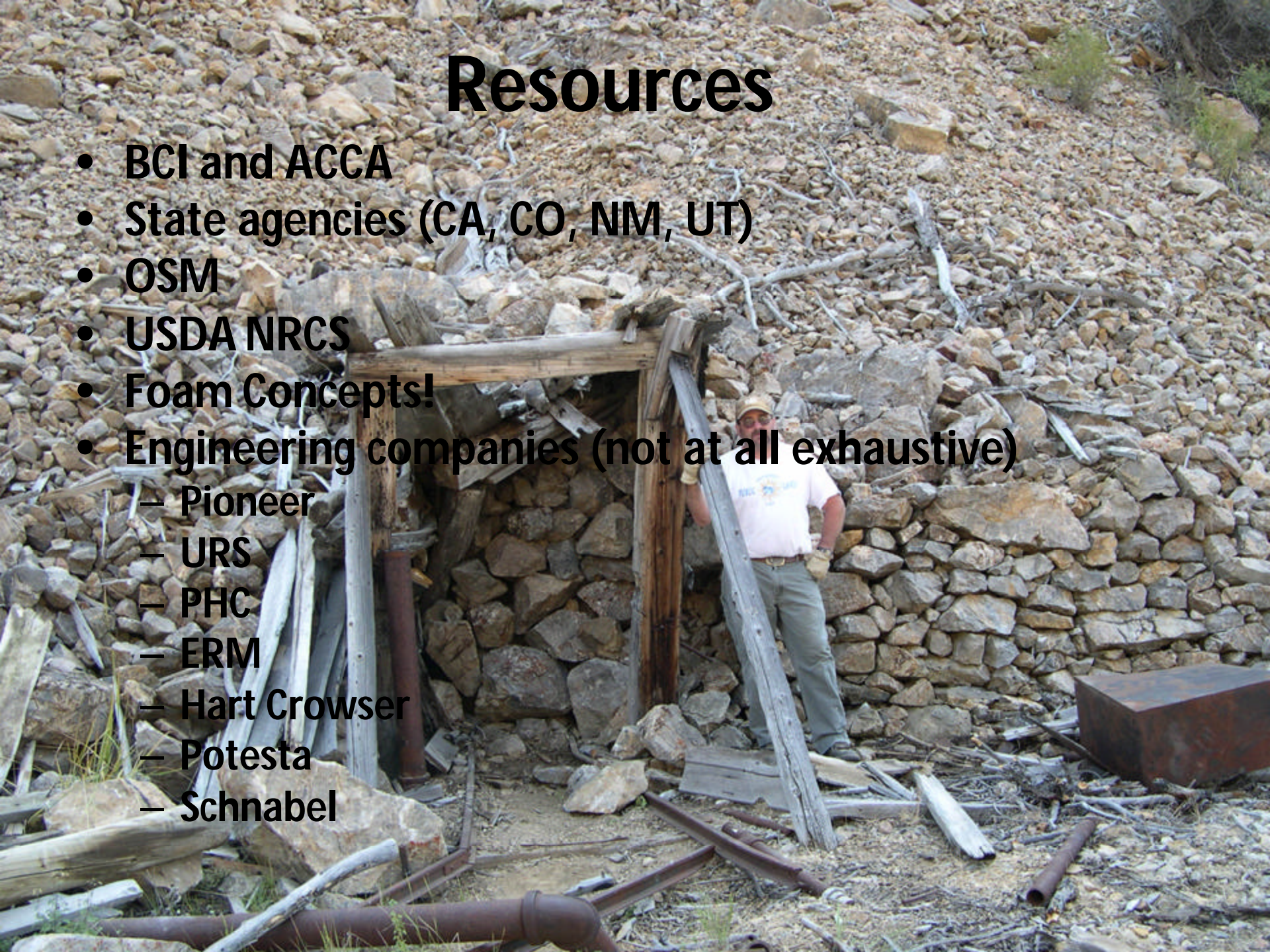






# Resources

- BCI and ACCA
- State agencies (CA, CO, NM, UT)
- OSM
- USDA NRCS
- Foam Concepts!
- Engineering companies (not at all exhaustive)
  - Pioneer
  - URS
  - PHC
  - ERM
  - Hart Crowser
  - Potesta
  - Schnabel





# **So, in MY opinion- what are “best practices”**

**Best practices are methods that close the hazard safely, quickly and permanently and require very little maintenance.**

**They should be immune to erosion, vandalism and deterioration.**

**They should minimize surface water infiltration and be sympathetic to the cultural and aesthetic aspects of the site.**





# What should be avoided

- Things that are rarely adequate or cost effective
  - Blasting
  - Fencing
  - Block walls/stacked rock
  - Pre-cast decks
  - Steel doors
  - Backfill







**Attempt to shoot down hanging wall to close an adjacent subsidence**

ERM photo





## **Fence around shaft**

Off some website





**Previously backfilled shaft**

FCLLC photo





## **Pre-cast bridge decks**

CO DRMS website photo



# What works well

- **Cast in place concrete**
- **Foam**
- **Steel mesh and cable nets**
- **Combinations of foam and**
  - **Concrete**
  - **Backfill**
  - **Culverts**
  - **Tires**







**Adit prior to closing with foam**

FCLLC photo





**Closed and foam covered with rock**

FCLLC photo





## **Laid rock wall**

CO DRMS website image





## Open shaft

FCLLC photo





**Shaft being filled with foam**

FCLLC photo





## **Water filled shaft**

FCLLC photo





## **Foam placed directly on water**

Plug was later covered with rock

FCLLC Photo





## Historic shaft house over timbered shaft

Stabilized with foam and concrete without moving the structure

PHC photo





**Shaft timbers exposed and cleaned with water hose**

PHC photo





## Rebar over foam plug

PHC photo





**Concrete pad prior to backfill with soil**

PHC photo





## **Subsidence at inby end of box portal**

FCLLC photo





## Surface manifestation of same feature

OSM photo





**Foam used to close slope, support backfill**

OSM Photo





## Final grading and seeding

OSM Photo





## **Foam under a garage**

Foam will prevent further erosion, keep fill from migrating and support corner of structure

Alabama AML photo





## **Slot raise opening into a large stope**

FCLLC Photo





**Foam wedge or “cork” placed in throat of raise**

AIS photo





**Fill placed over foam**

AIS photo





## **Shaft with debris plug**

Could be closed in a similar manner to previous shaft. Foam will not displace debris plug, but will support concrete and reduce erosion.

FCLLC photo





## Foam to underform concrete

FCLLC photo





## Rebar mat over foam plug

MO AML Photo





## **Concrete monolithic plug over foam**

MO AML Photo

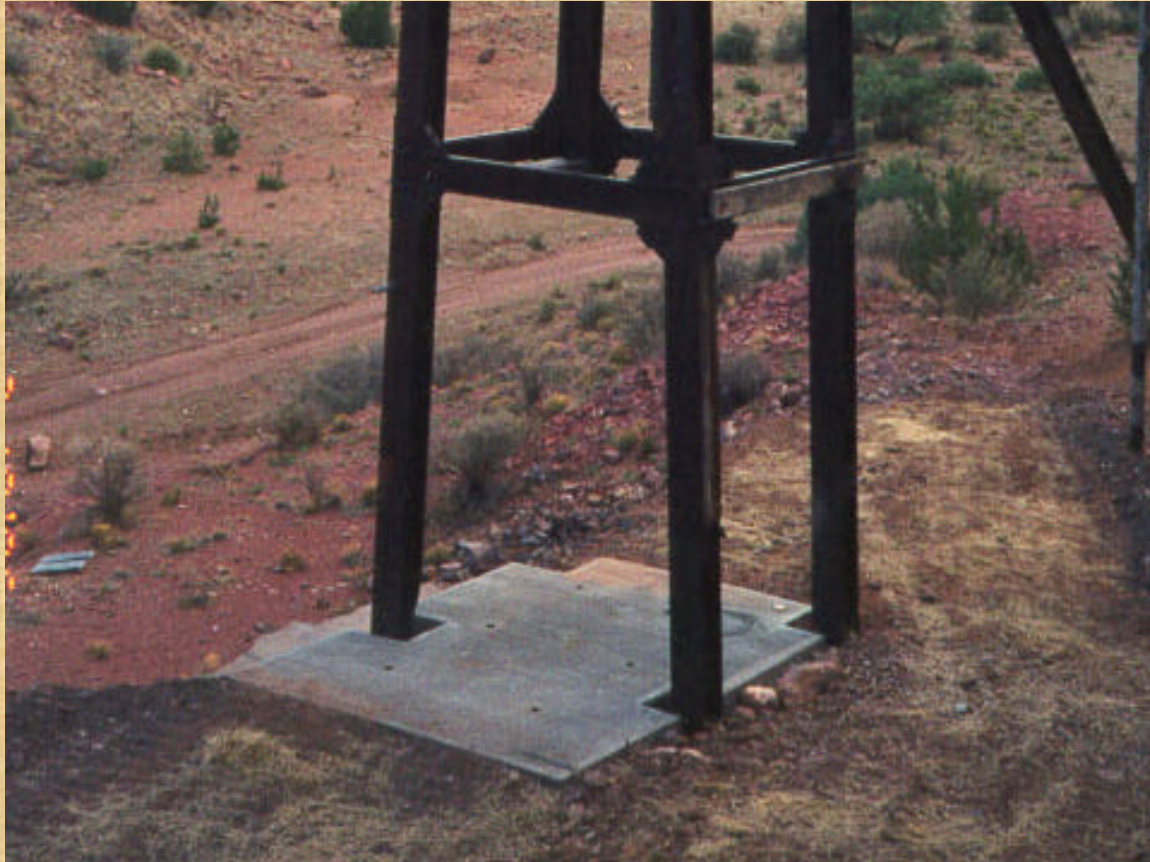




## Shaft and headframe with concrete pad

NM AML website photo





**Concrete plug in place**

NM AML website photo





**Similar closure, blends in well with landscape**

NM AML website photo





## **Bat cupola**

Culvert foamed in shaft, cupola placed on pad around shaft collar

NM AML website photo





## Shaft with culvert and grating

NM AML website photo





## **Another shaft with culvert and gate**

NM AML website photo





## **Full gate in adit**

NM AML website photo





## **Full gate in adit**

Note removable bars

NM AML website photo





## Gate in concrete pipe

FCLLC photo





## Gate in HPDE culvert

USFS photo





## **Culvert foamed in shaft with drain pipe**

NM AML website photo





## Gate at grade

NM AML website photo





## **Multiple openings along scissor fault**

Might be suited to cable net, steel mesh or tires

FCLLC Photo





## **Cable net with bat windows**

NM AML website photo





## **More cable net**

NM AML website photo





## **Steel mesh over shaft with observation bridge**

NM AML website photo





## **Steel mesh over stope**

NM AML website photo





## **Culvert gate in shaft with rock backfill**

NM AML website photo





**Shafts with all waste rock encapsulated in foam**

Iona Construction photo





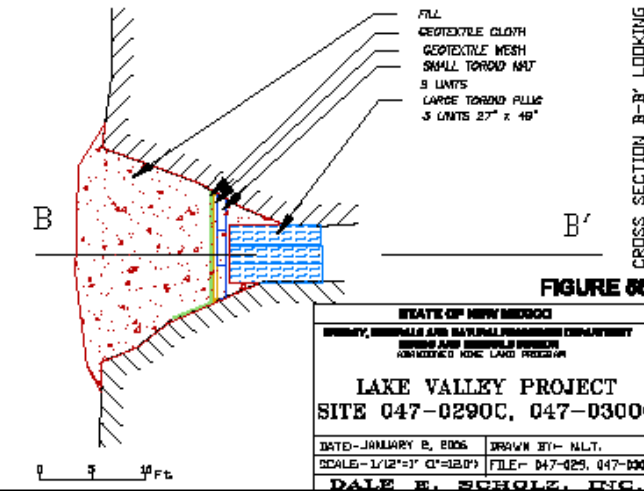
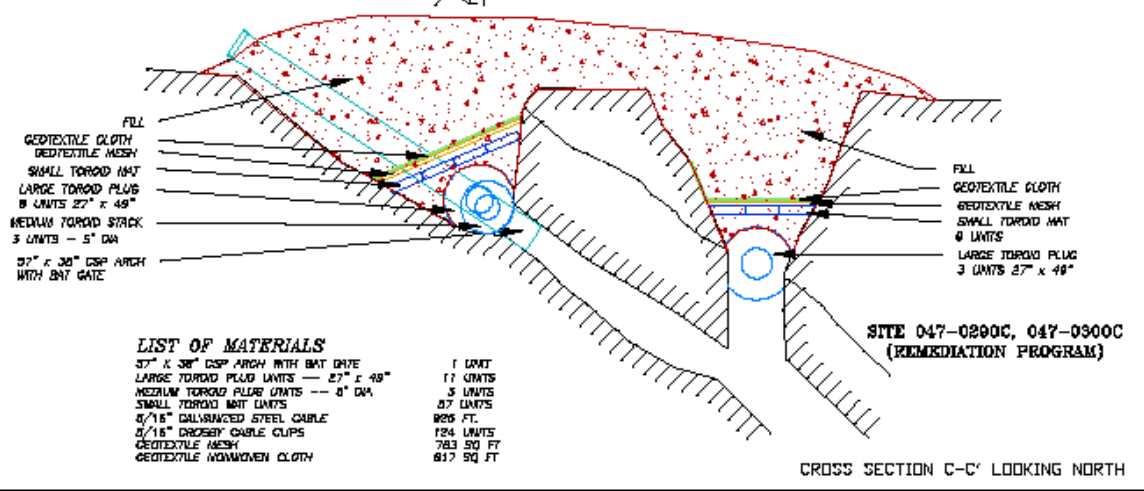
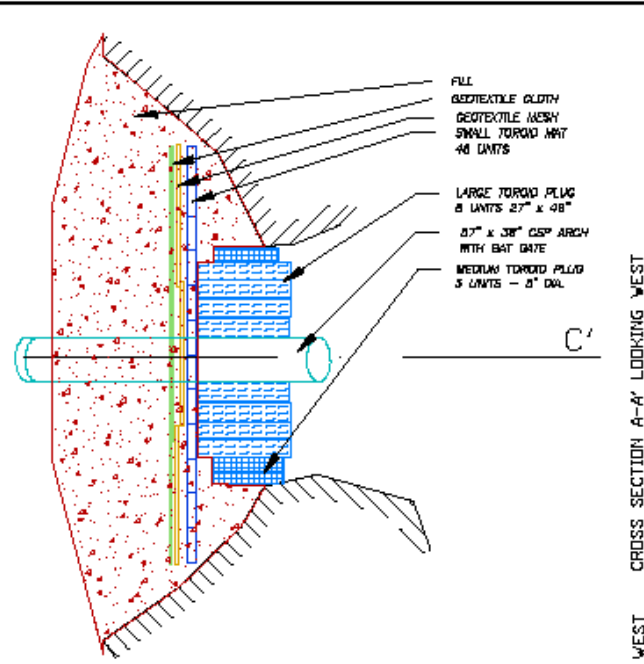
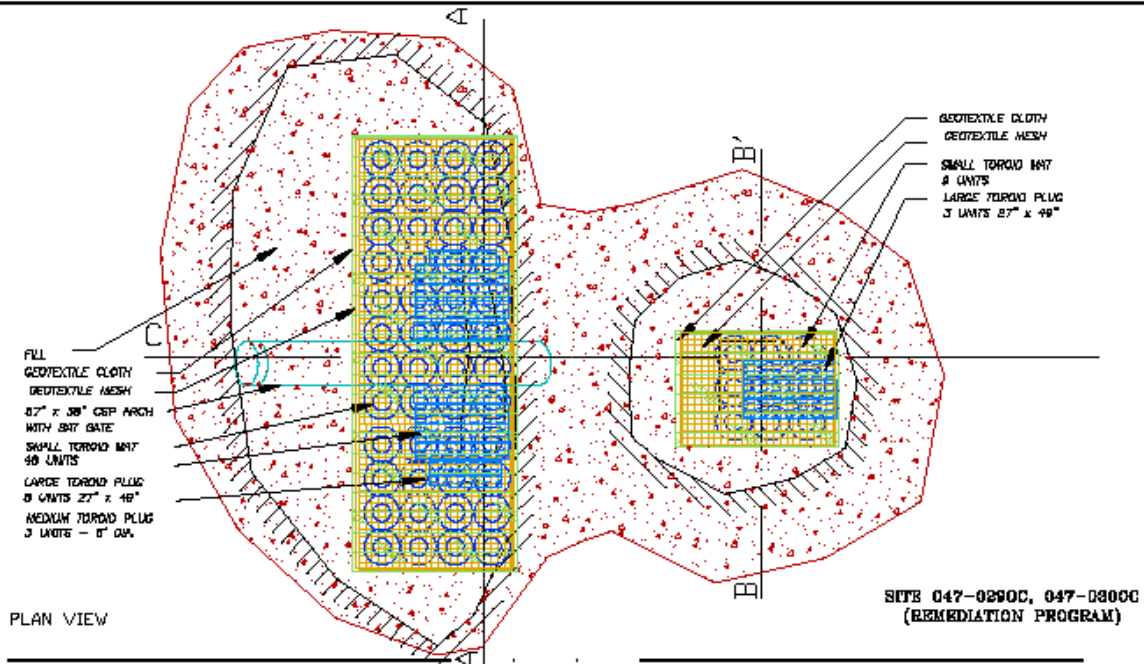
## **Culvert and gate in an inclined stope opening**

Culvert provides ventilation into a tourist mine

FCLLC Photo



047-0290, 047-0300 (1) REV PILING PLAN SCALE 1" = 6'



**LIST OF MATERIALS**

37" x 38" CSP ARCH WITH BAT GATE	1 UNIT
LARGE TOROID PLUG UNITS -- 27" x 49"	17 UNITS
MEDIUM TOROID PLUG UNITS -- 8" DIA.	3 UNITS
SMALL TOROID MAT UNITS	87 UNITS
3/16" GALVANIZED STEEL CABLE	825 FT.
3/16" DROSBY CABLE CLIPS	124 UNITS
GEOTEXTILE MESH	783 SQ FT
GEOTEXTILE NONWOVEN CLOTH	817 SQ FT

STATE OF NEW MEXICO  
 DEPT. OF NATURAL RESOURCES  
 DIVISION OF LAND MANAGEMENT

**LAKE VALLEY PROJECT**  
**SITE 047-0290C, 047-0300C**

DATE - JANUARY 8, 2006    DRAWN BY - ALLT.  
 SCALE - 1/12" = 1'    C/S - 1/20"  
 FILE - 047-029, 047-030  
**DALE E. SCHOLZ, INC.**

0 5 10 Ft.





## **Pouring foam directly in subsidence crack**

FCLLC photo





**Subsidence cracks over coal mine, cleaned out and foamed**

WV DEQ photo





## **Intersection cave subsidence**

OSM Photo





## **Small chimney type subsidence**

AL AML Photo



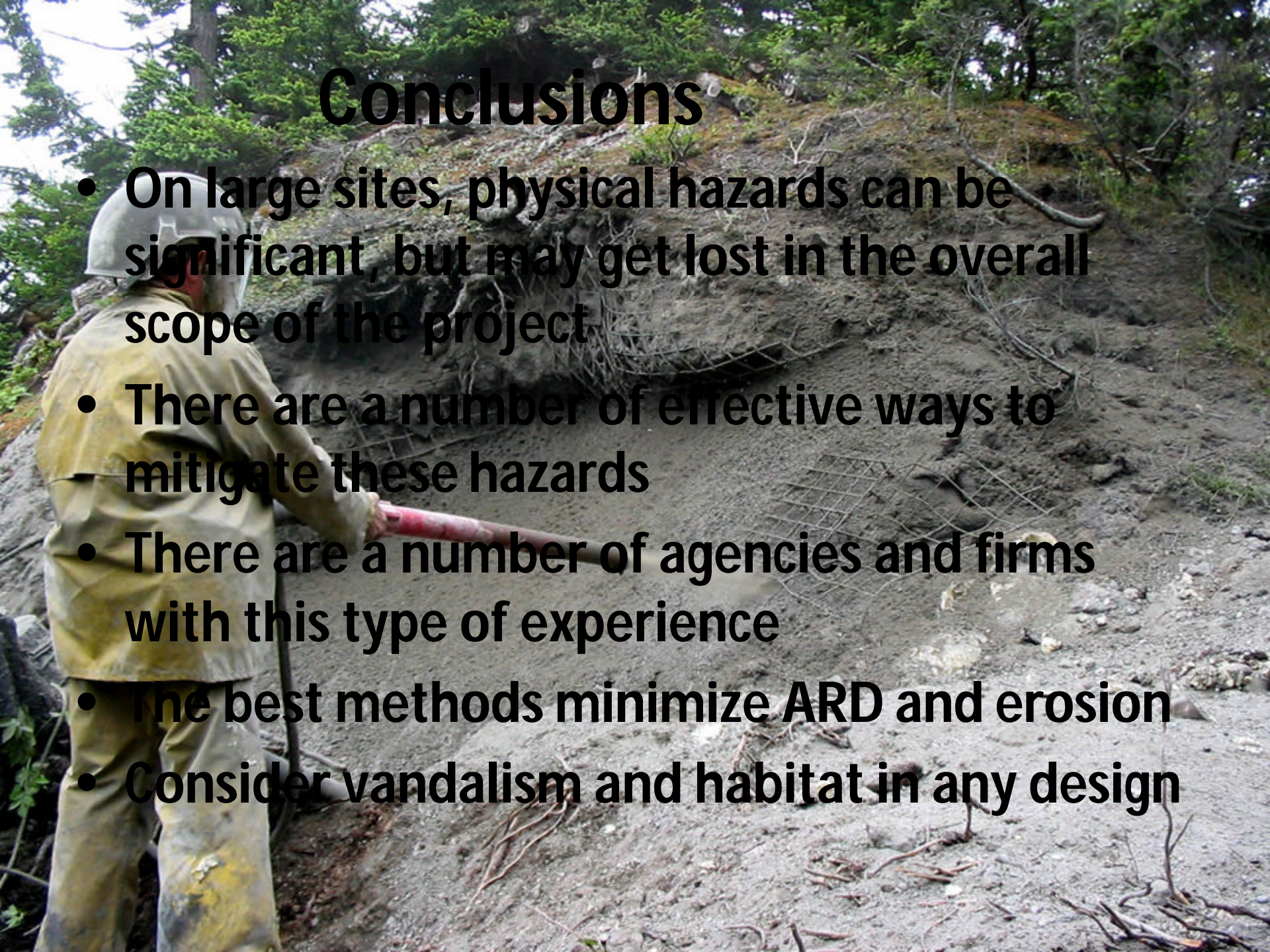


## **Foam prior to backfill**

AL AML Photo



# Conclusions

- On large sites, physical hazards can be significant, but may get lost in the overall scope of the project
  - There are a number of effective ways to mitigate these hazards
  - There are a number of agencies and firms with this type of experience
  - The best methods minimize ARD and erosion
  - Consider vandalism and habitat in any design
- 



# Thank you

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**Thanks to many who over the years have perfected these techniques and allowed me to share them with you.**