STATE OF NEW MEXICO
BEFORE THE WATER QUALITY CONTROL COMMISSION

In the Matter of:	)	
PROPOSED AMENDMENT TO 20.6.2 NMAC (Copper Rule)	)	No. WQCC 12-01(R)

EXHIBIT SCOTT – B-1

CLOSURE DISCUSSION
TAILING DAMS AND
MINE ROCK STOCKPILES

Technical Committee Presentation
Copper Rules
June 5, 2012

Jim Scott

- Principal Geotechnical Engineer with URS for 35 years
- BS (Arizona State University) and MSCE (Purdue University)
- P.E. in NM, AZ, CO, and B.C.
- Mining industry experience includes engineering analyses and design for development, operation, reclamation, and closure projects
- URS Principal-In-Charge for work at the Bagdad Mine in AZ (Mammoth, Upper Mammoth, and Mulholland tailing impoundments)
- New Mexico experience includes work at Chino Mines Company, Cobre Mine, Tyrone Mine, Hidalgo Smelter, Questa Mine, and Four Corners Generating Facility

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Closure Issues

- Tailing Dams
  - NMOSE criteria
  - Design storm events (surface water conveyance)
  - Top surface grading
- Mine Rock Stockpiles
  - Non-water impounding
  - Investigations
  - Stability
  - Acceptable Factors of Safety

New Mexico Office of the State Engineer
Dam Safety Closure Criteria for Tailing Dams

- Jurisdictional tailing dams
- Closure or Reclamation Plan is prepared
- Plan addresses
  - Long-term stability (static and dynamic conditions)
  - Control of surface runoff to minimize erosion
  - Plan for long-term monitoring
  - Engineer to supervise construction of plan
- Construction completion
  - Completion report
  - Materials test data and photographs
  - As-built drawings
  - Certificate of completion

Design Storm Events (Surface Water Conveyance)

- Spillways/diversion channels for TSF
  - ½ PMF – PMF
- State-of-the-Practice for TSF and Rock Piles (surface channels/ditches)
  - NM – Chino 100-yr return period
    - Tyrone 100-yr return period
    - Cobre 100-yr return period
    - Mining Act 100-yr return period (stream diversions)
  - AZ BADCT – 100-yr return period
  - MSHA/OSM – 100-yr return period
- Consider stability of channels/ditches
- Good maintenance program just as necessary as good design and construction

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Factors Influencing Closure Stability and Safe Performance of Tailing Dams

- Shear Strength of Slope Materials/Foundation
- Pore Pressure/Phreatic Surface Location
- Slope Angle
- Unit Weight of Materials in the Slope
- Loading Condition (steady-state, seismic)
- Factor of Safety (FS) (NMOSE)
  - 1.5 (steady-state)
  - 1.1 (seismic)
- NMOSE criteria includes liquefaction potential evaluation

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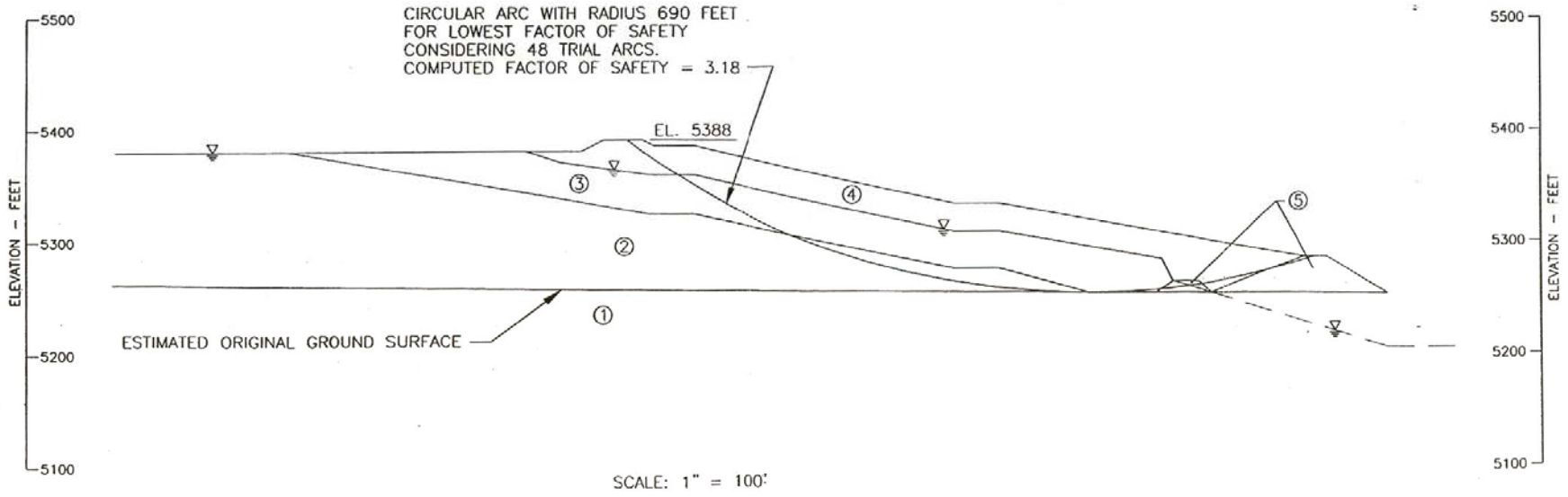
NOTES:

1. STABILITY ANALYSES WERE PERFORMED WITH A COMPUTER USING THE SLOPE STABILITY PROGRAM "UTEXAS3" USING SPENCER'S METHOD.
2. PORE WATER PRESSURES IN TAILING DEFINED BY PIEZOMETRIC LINE ASSUMING HYDROSTATIC CONDITIONS.
3. SEE FIGURE 3.1 FOR LOCATION OF STABILITY STUDY SECTION P2-P2'.

ASSUMED MATERIAL PROPERTIES

SOIL TYPE NO.	MATERIAL DESCRIPTION	UNIT WEIGHT (pcf)	EFFECTIVE STRESS SHEAR STRENGTH	
			FRICTION ANGLE (degrees)	COHESION (psf)
1	NATURAL FOUNDATION SOILS	135	40	0
2	TAILING SLIMES	134	35	0
3	INTERLAYERED SANDS/SLIMES	132	35	0
4	UNDERFLOW SANDS	120	36	0
5	STARTER DAM AND SLIMES/SEPARATION DIKE	132	35	0



SCALE: 1" = 100'

TSF Top Surfaces

- Develop post-settlement contours
  - Grading plan
  - Drainage system
- Settlement due to
  - Drain down
  - Weight of top surface cover (2-3')
- State-of-the-Practice top surface grades of 0.5 % for TSFs (largely driven by scale)

Mine Rock Stockpiles

- Non-Water Impounding (different than tailing dams)
  - Does not impound process water
- Historical Background
  - First International Conference on Stability in Open Pit Mining, Vancouver, BC (1970)
  - Second International Conference on Stability in Open Pit Mining, Vancouver, BC (1971)
  - Third International Conference on Stability in Open Pit Mining, Vancouver, BC (1981)
  - Fourth International Conference on Stability in Open Pit Mining, Denver, CO (2001)
  - Canada Centre for Mineral and Energy Technology (CANMET) Pit Slope Manual – Waste Embankments (1977)
  - USDA Forest Service Guide – Stability of Non-Water Impounding Mine Waste Embankments (1980)
  - SME, AIME Workshop – Non-Impounding Waste Rock Dumps (1985)

Mine Rock Stockpiles (cont'd.)

- British Columbia Mine Waste Rock Pile Research Committee (1991-1994)
  - Investigation and Design Manual (1991)
  - Dump Stability Rating Scheme
    - Dump Stability Class (I – IV)
    - Failure Hazard (Negligible – High)
  - Operating and Monitoring Manual (1991)
  - Methods of Monitoring (1992)
- Tailings and Mine Waste Conferences (yearly)
- First International Seminar on the Management of Rock Dumps, Stockpiles, and Heap Leach Pads, Perth, Australia (2008)

Mine Rock Stockpile Investigations

- Investigations (field and laboratory)
  - Site characterization
  - Hydrology
  - Geology
  - Seismicity
  - Foundation Soils/Bedrock engineering properties
  - Mine Rock engineering properties
- Numerous investigation guides
  - BC Guidelines – Mined Rock and Overburden Piles Investigation and Design Manual (1991)
  - SME – Design of Non-Impounding Mine Waste Dumps (1985)
  - AZ BADCT Guidance Manual (2004)
  - MSHA – Engineering and Design Manual, Coal Refuse Disposal Facilities (2009)
  - California DMG Special Publication 117 (2002)
  - TRB Landslide Analysis and Control, Special Report 176 (1978)

Mine Rock Stockpile Stability

- Factors Affecting Stability
  - Configuration (height, volume, slope angle)
  - Foundation Slope/Confinement
  - Foundation Conditions
  - Mine Rock Properties (durable igneous/metamorphic rocks, low susceptibility to weathering, low fines, free draining, high strength)
  - Construction Method
  - Piezometric/Climatic Conditions
  - Seismicity
- Material Strengths
  - Empirical Correlations (Leps (1970), Barton and Kjaernsli (1981), Barton (2008), Hoek (1990), Hoek and Brown (1997))
  - Large Scale Direct Shear Tests
  - Triaxial Shear Tests
  - In situ (BPTs, PMTs, NALPTs, SPTs)
- Phreatic/Piezometric Conditions
  - Test Holes
  - Monitoring Wells
  - Piezometers
  - Observations

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Mine Rock Stockpiles
Acceptable Factors of Safety

- NM Mining Act (1999)
  - Piles shall be constructed and maintained to minimize mass movement
- NMDOT
  - Use AASHTO design criteria
  - 1.3 for static loads
  - 1.1 for seismic loads
- AZ BADCT Guidance Manual (2004)
  - Establish whether or not discharge can occur
  - Static stability
    - 1.5 w/o testing
    - 1.3 w/testing (material shear strengths)
  - Dynamic stability
    - ≥1.1 w/o testing
    - ≥ 1.0 w/testing (material shear strengths)

Mine Rock Stockpiles Acceptable Factors of Safety (cont'd).

- British Columbia Mine Waste Rock Pile Research Committee
  - Consider the following factors
    - Shear strength
    - Material composition
    - Foundation conditions and geometry
    - Short-term (during construction) vs. long-term (reclamation) slopes
    - Consequence of failure
    - Field control
    - Engineering judgment
  - Factor of Safety
    - Long-term static 1.3 – 1.5
    - Pseudo-static (earthquake) 1.0 – 1.3
    - Ranges reflect understanding of site-specific conditions

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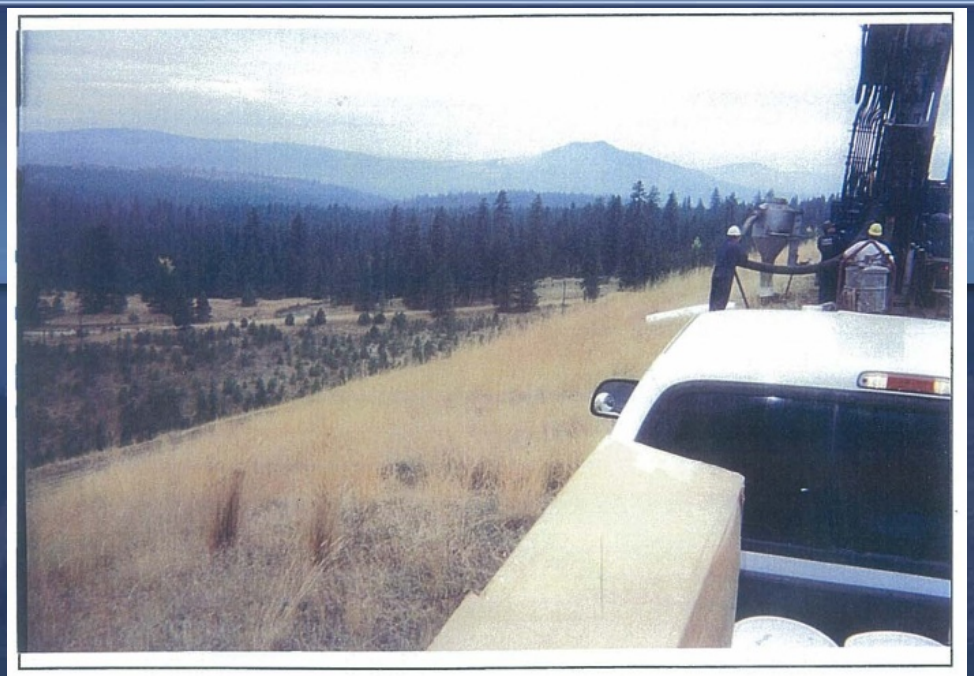
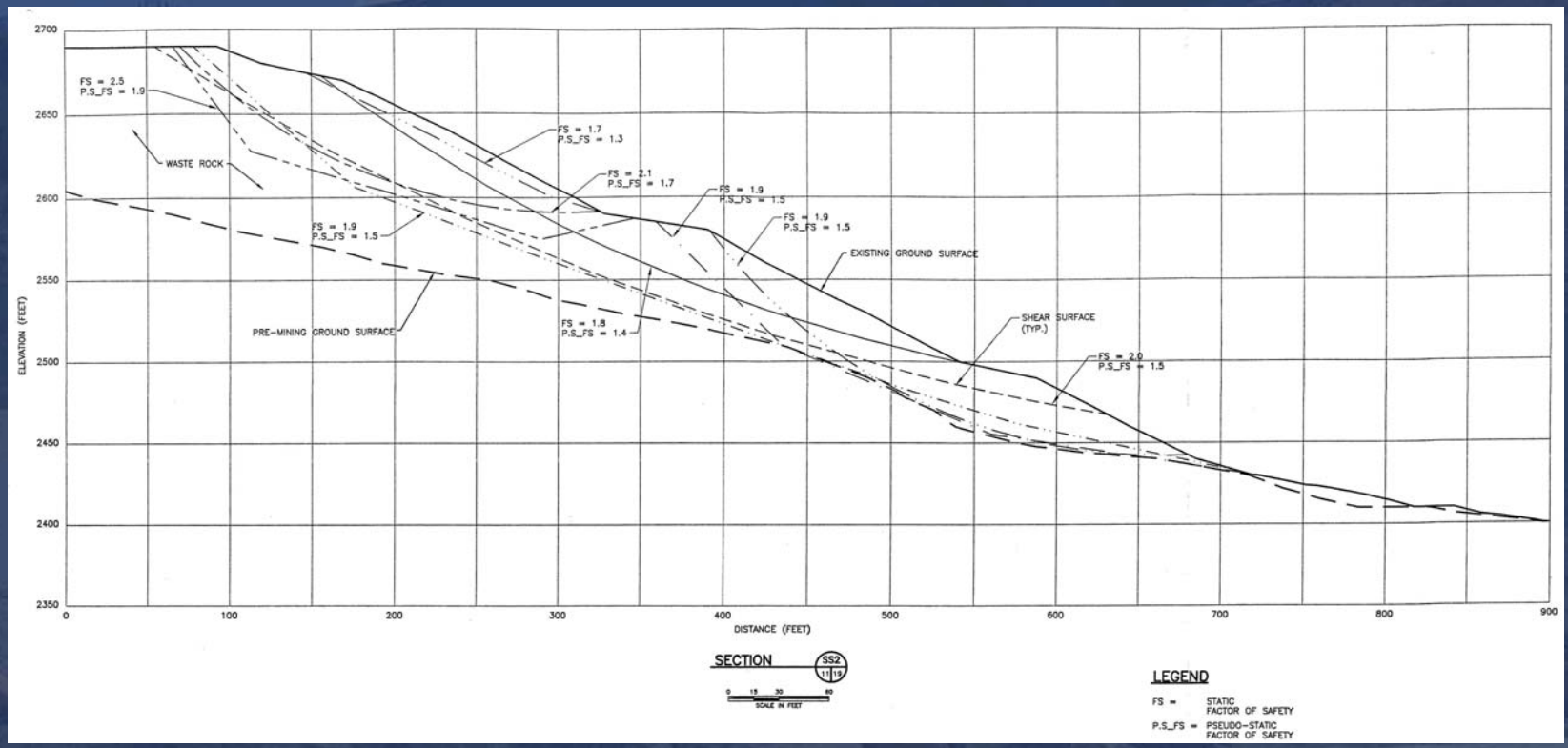
State-of the-Practice Factors of Safety Mine Rock Stockpiles

- Western U.S. hard rock copper mines
- FS=1.3 (static) and 1.0 (seismic)
- Site-specific investigations (field and lab)
  - Mine rock properties
  - Foundation conditions




2700
2650
2600
2550
2500
2450
2400
2350
ELEVATION (FEET)
0
100
200
300
400
500
600
700
800
900
DISTANCE (FEET)
FS = 2.5
P.S_FS = 1.9
WASTE ROCK
FS = 1.9
P.S_FS = 1.5
PRE-MINING GROUND SURFACE
FS = 1.7
P.S_FS = 1.3
FS = 2.1
P.S_FS = 1.7
FS = 1.8
P.S_FS = 1.4
FS = 1.9
P.S_FS = 1.5
FS = 1.9
P.S_FS = 1.5
EXISTING GROUND SURFACE
SHEAR SURFACE
(TYP.)
FS = 2.0
P.S_FS = 1.5
SECTION
SS2
11
15
0
15
30
60
SCALE IN FEET
LEGEND
FS = STATIC FACTOR OF SAFETY
P.S_FS = PSEUDO-STATIC FACTOR OF SAFETY

QUESTIONS / COMMENTS?