Rockfall
and
Catch Berms

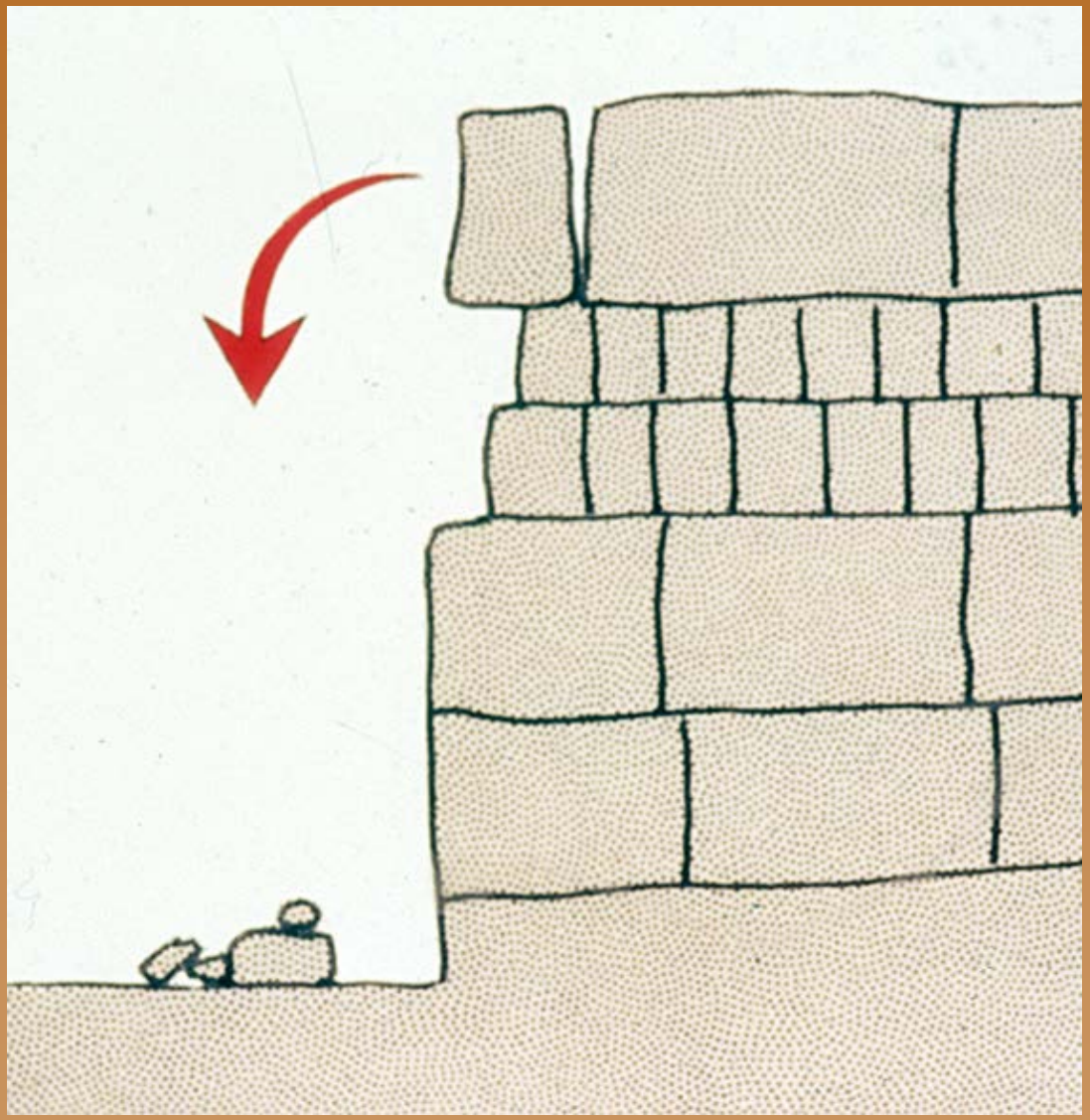
These slides are excerpts from various "Highwall Stability" presentations by MSHA Technical Support Division.

Eliminating Rockfall Hazards

1. **Recognize hazardous conditions:**
   - Through a better understanding of highwall composition and geometry, and identifying areas of “loose” rock.

2. **Remediate the condition:**
   - Remove hazard – scaling, trim blasting, etc.
   - Control hazard – catch berms or benches, mesh fences on highwall face, etc.
   - Prevent exposure – relocate work areas or restrict access to area

Rockfalls



Intact blocks of rock on a fractured highwall are susceptible to falling when they are unconfined.

Rockfalls Pose Impact and Obstruction Risks to Vehicular Traffic

The size of the rock relative to size of the vehicle will contribute to the hazard.

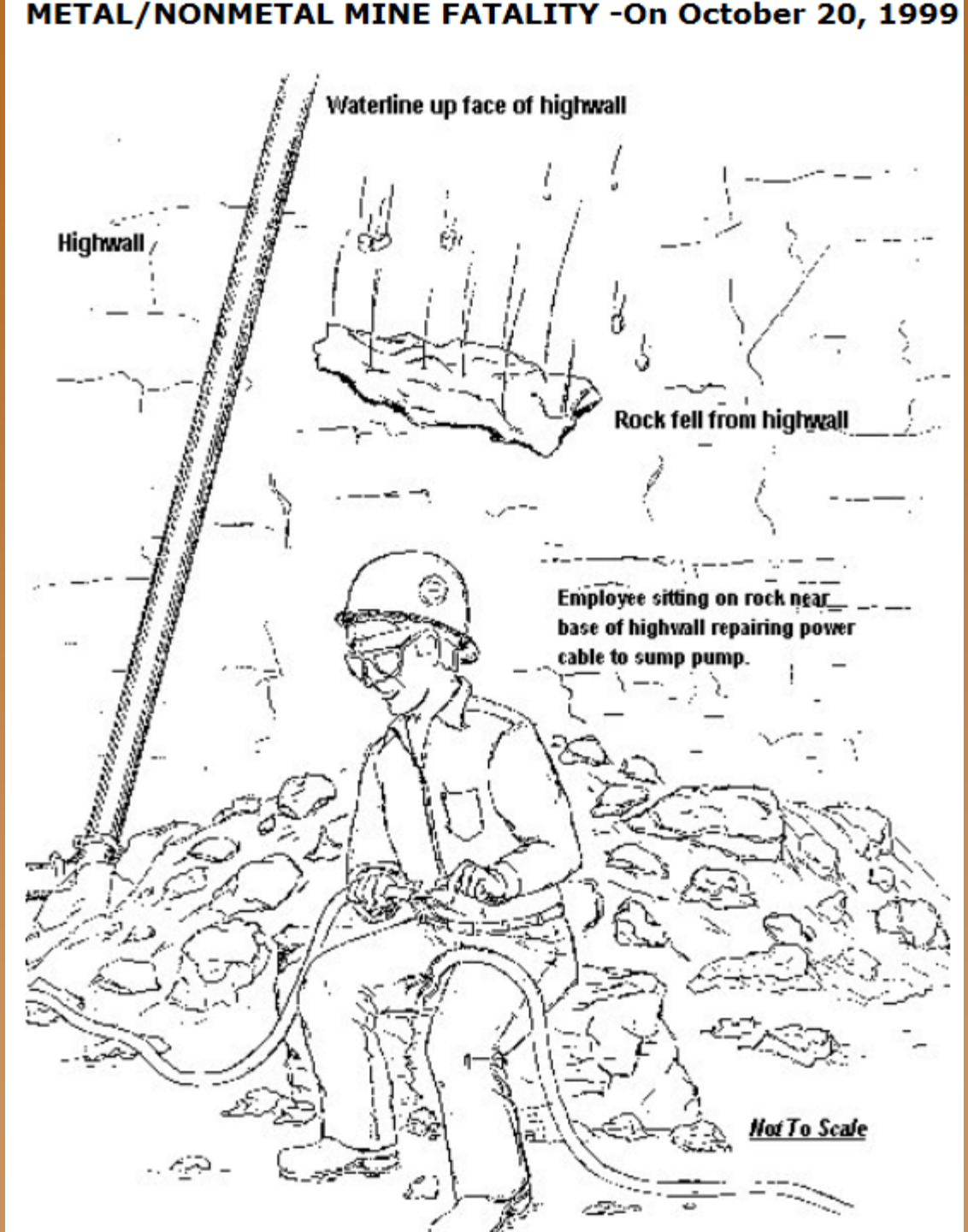
Rockfalls

- **Rock size/weight, drop height, and highwall geometry are critical in evaluating rock fall hazards.**
- **Rock weight and drop height will determine the damage potential of a falling rock when it strikes.**
- **Geometry of the highwall will affect how a rock falls and where it lands.**

Rockfalls Pose an Impact Risk to Personnel On-Foot

- 1999 (TN) – Driller fatally injured at base of 230 ft. highwall
- Rock measured 4” x 4” x 3” & weighed under 3 pounds

- 1999 – Alabama limestone quarry
- Electrician sitting about 20 feet from base of 120 ft. highwall, with his back to the wall
- Unknown rock size struck victim in head causing fatal injury
- Investigators observed other loose rock at the top of highwall that had not been scaled



For comparison: The Hard Hat Impact Test Standard involves dropping an 8 lb. steel ball 5 feet, which has a kinetic energy of 40 ft.-lbs.

Height of Fall (feet)	Approx. Weight (lbs)	Equivalent Cube Size (inches)	Max. Speed (mph)	Kinetic Energy (ft-lbs)	Approx. Force of Impact [1] (lbs)
50	2.5	3	39	125	500
100	2.5	3	55	250	1,000
125	2.5	3	61	313	1,250
160	2.5	3	69	400	1,600
50	20	6	39	1000	4,000
100	20	6	55	2000	8,000
125	20	6	61	2500	10,000
160	20	6	69	3200	12,800

[1] Assuming that the ground surface is soft enough that the rock penetrates the ground surface 3-inches upon impact. A smaller penetration results in a larger force of impact.

Effects of Highwall Geometry on a Rockfall

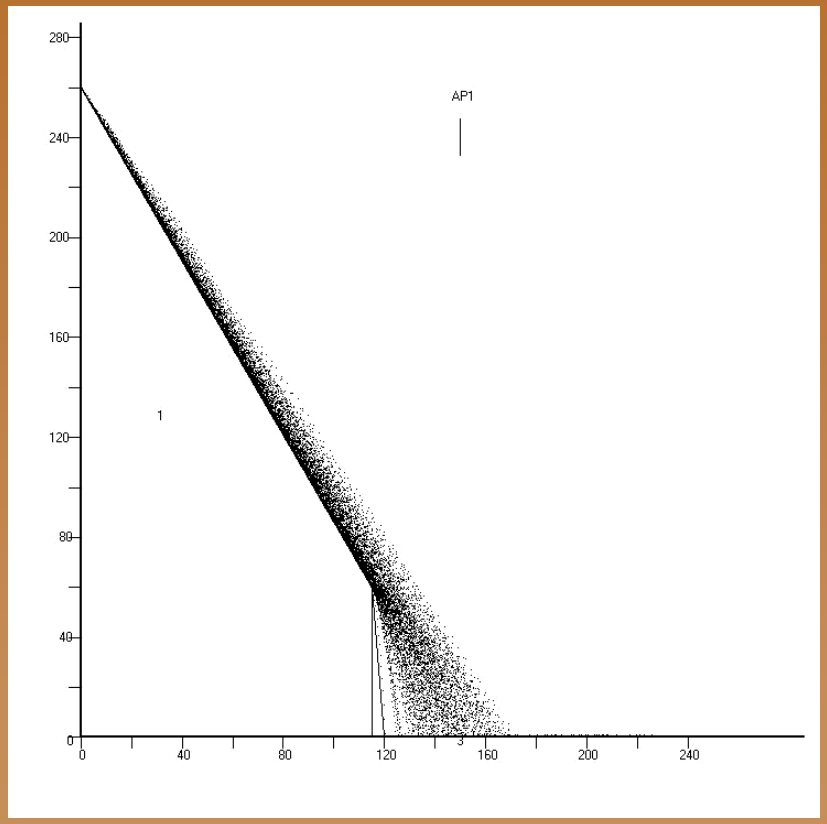
Highwall Geometry

Launch Feature

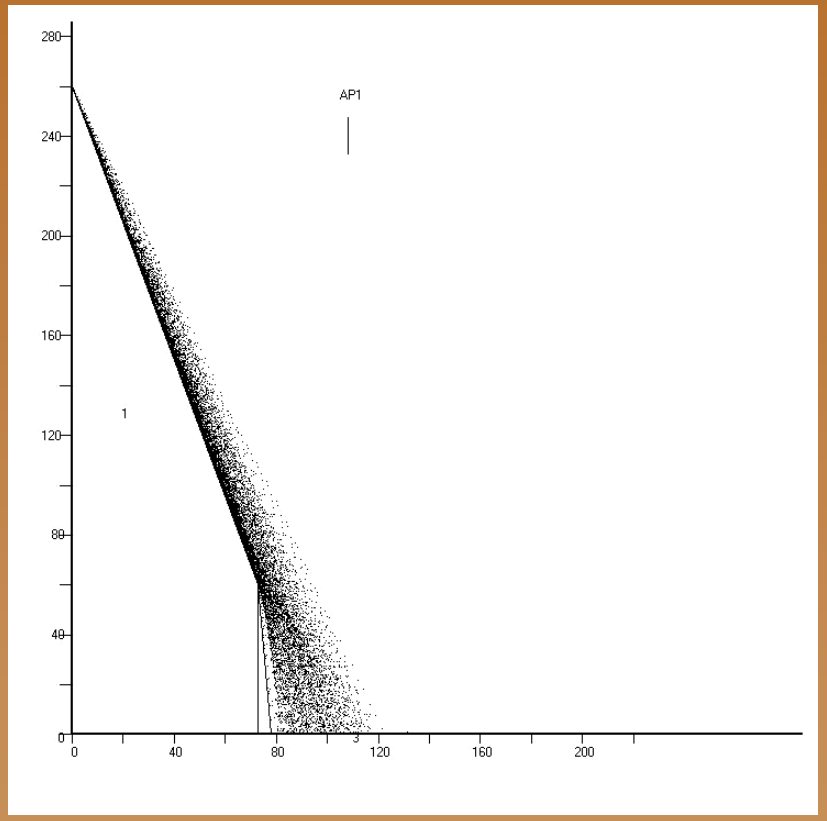
Computer Modeling

- Computer models such as the Colorado Rockfall Simulation Program (CRSP) can be used to design rockfall protection measures.
- Program Capabilities:
  - model field conditions,
  - apply random affects,
  - run many simulations, and
  - analyze patterns.
- Inputs – cross-section, surface roughness, normal and tangential coefficients, rock size and shape.

70-degree vs. 80-degree slope angles

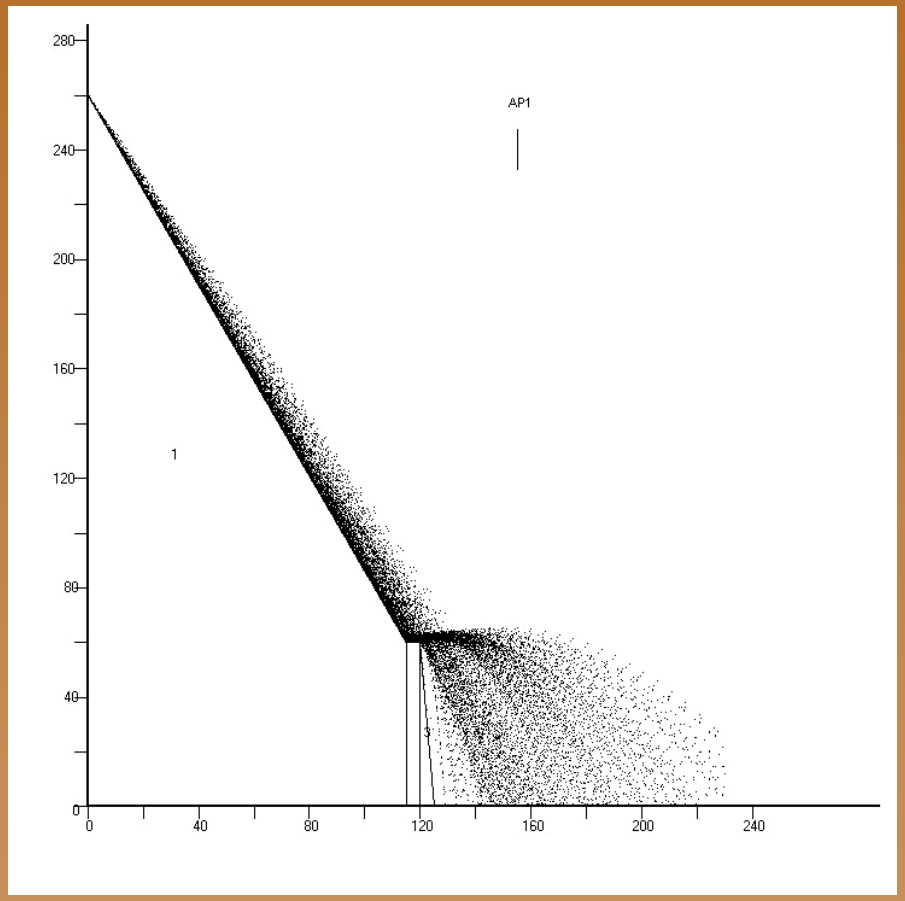


50 feet

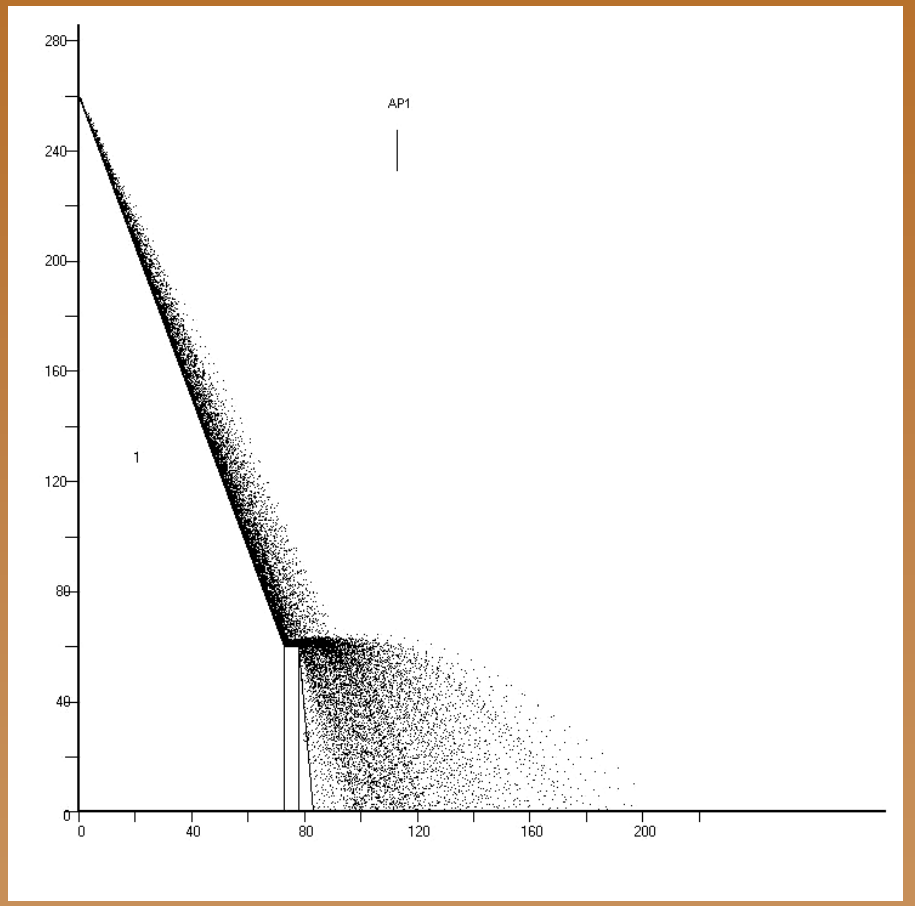


40 feet

Highwalls with a Ledge

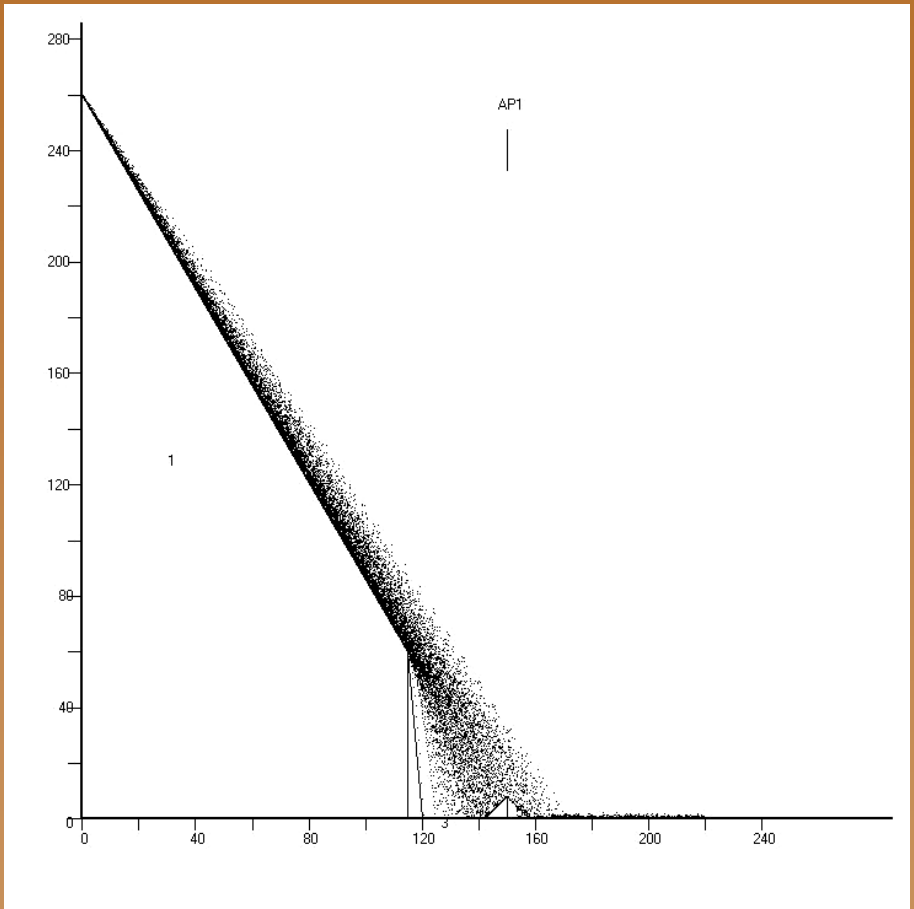


130 feet

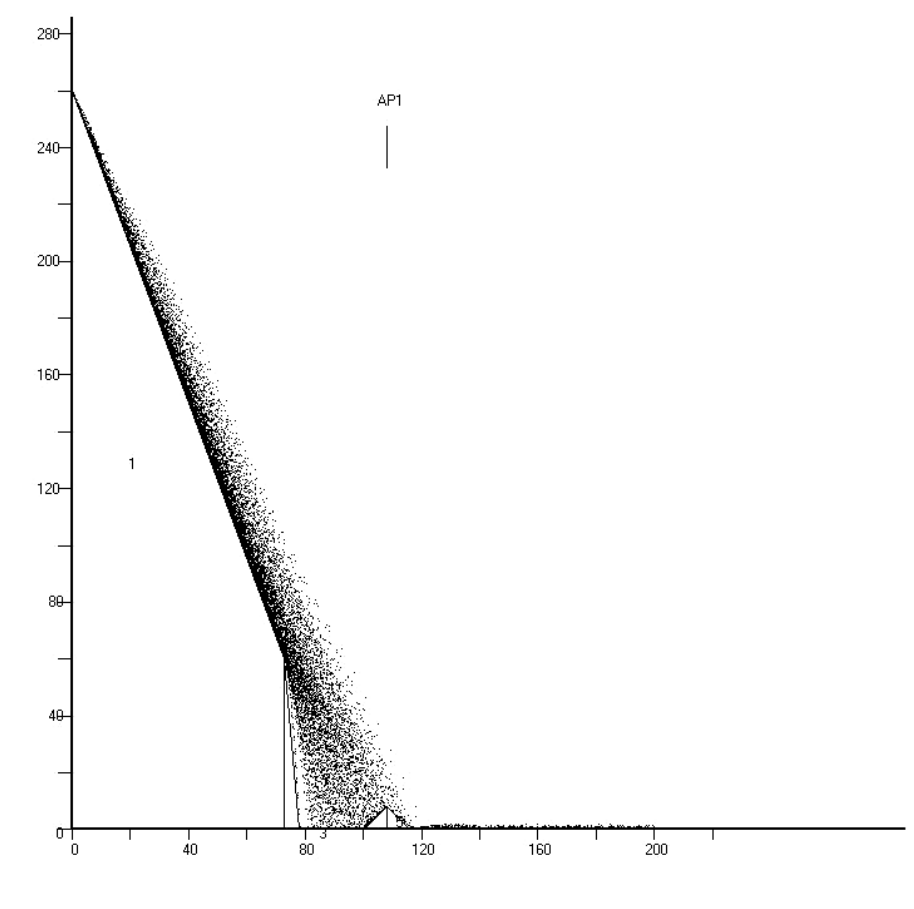


120 feet

Highwalls with a Berm 30 feet from Toe

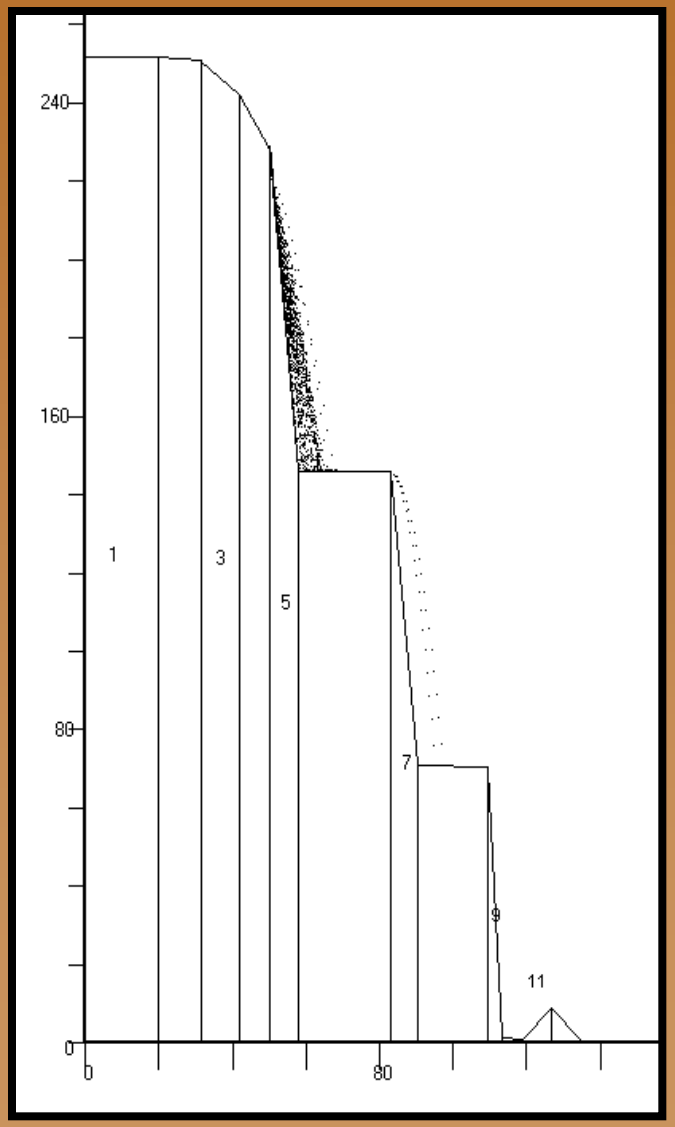


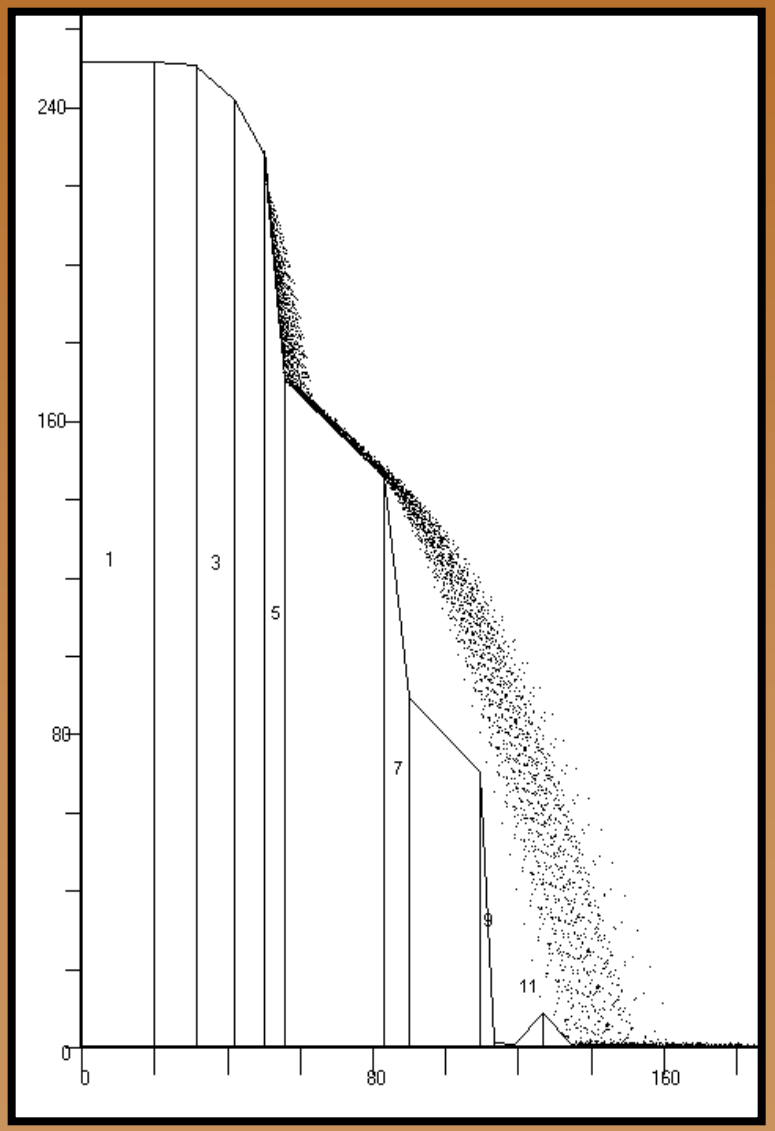
70 degree slope angle



80 degree slope angle

Highwall with Full Benches and Berm at Toe





Catchment Berms

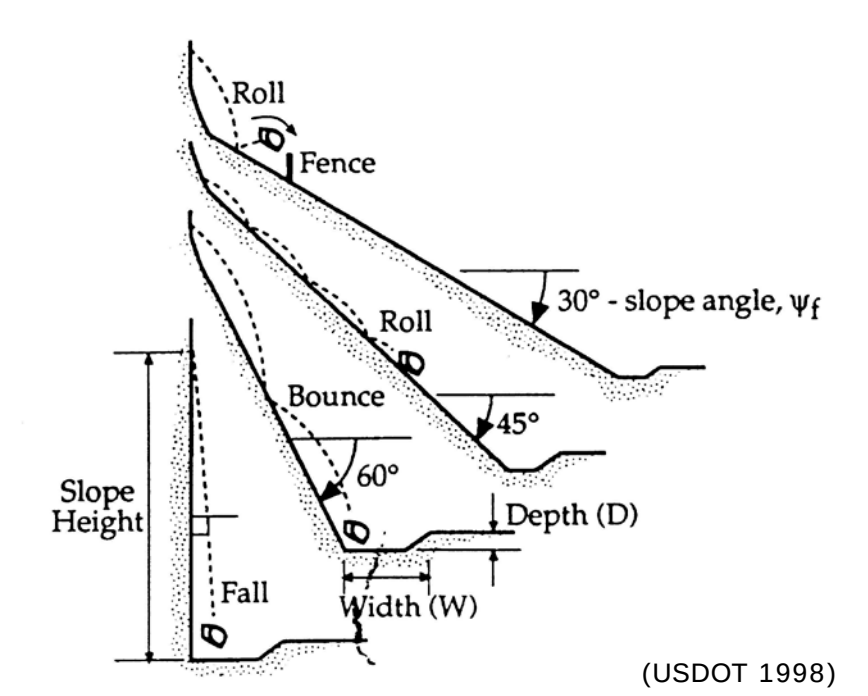
Catchment Berms

- Berms can effectively be used to control rock fall hazards.
- Berms create a catchment basin to contain falling material.
- Berms are also an effective barrier to keep personnel out of area.
- Berms must be properly sized and located.
- Berms must be maintained.

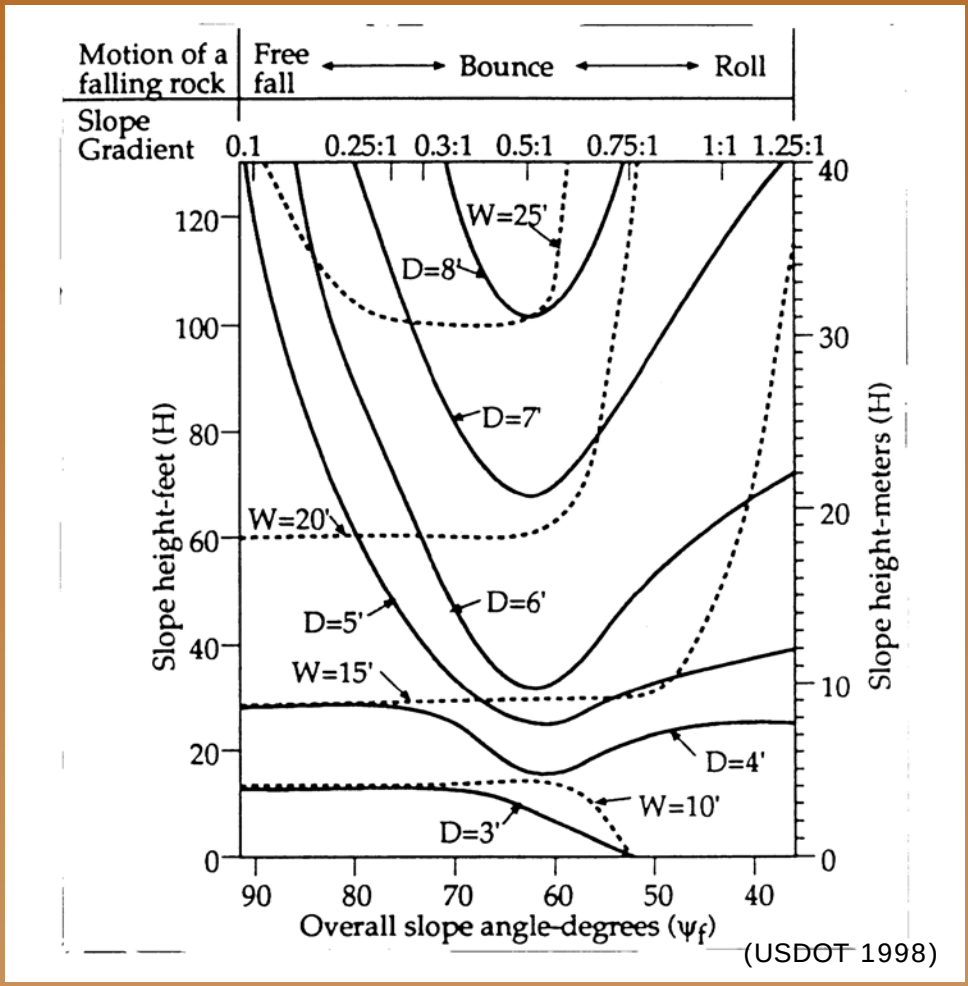
Berm Not Containing Material

Is Berm Properly Sized and Located?

Berm Design



(USDOT 1998)



(USDOT 1998)

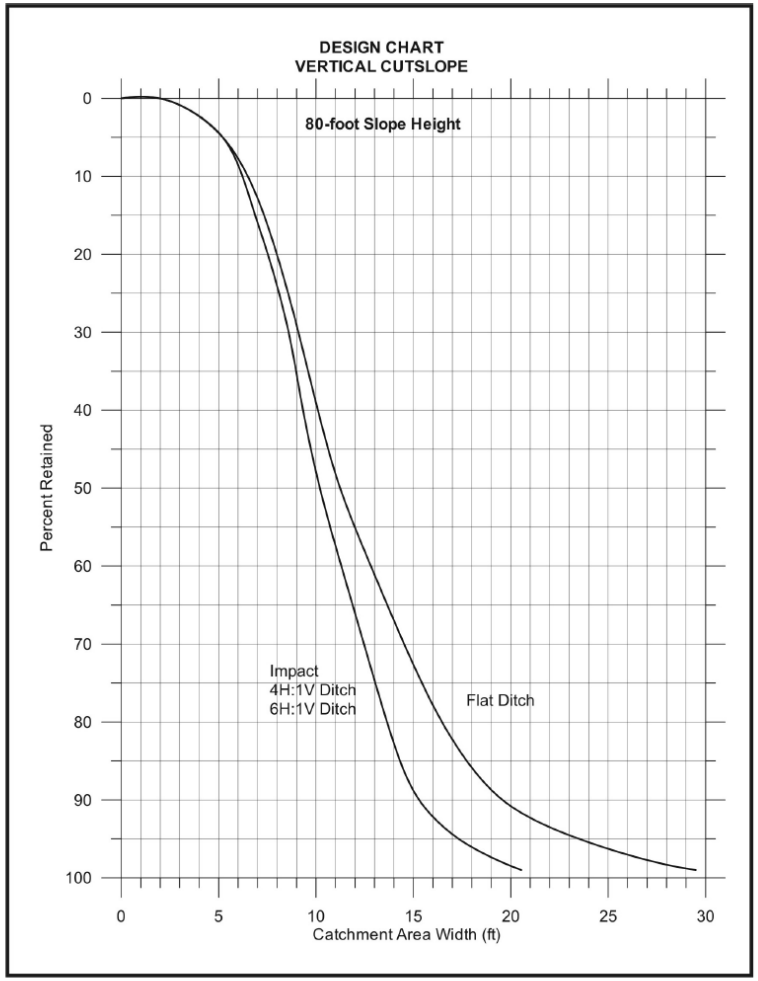
Methodology originally developed from rock catch ditches along highway.

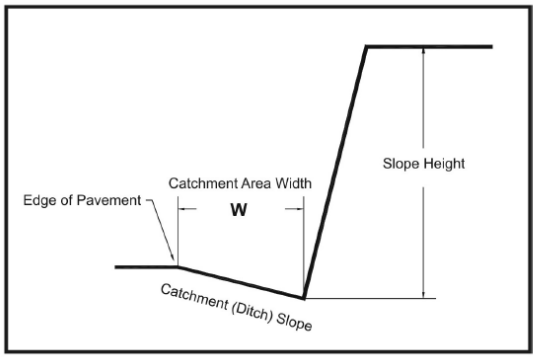
Rockfall Studies

- Original work by Arthur Ritchie in 1960's, Washington State Dept. of Highways
- Updated research produced the "Rockfall Catchment Area Design Guide," November 2001, Oregon Dept. of Transportation (ODOT)

(http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/RockfallReportEng.pdf)

Oregon DOT Rockfall Catchment Area Design Chart





Quick Reference - 80-Ft Slope Catchment Area Width - **W**				
Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	**W** (ft)	**W** (ft)	**W** (ft)
50%	10	10	10	11
75%	13	13	13	15
80%	14	14	14	16
85%	14	14	14	18
90%	15	15	15	20
95%	17	17	17	24
99%	21	21	21	30

Figure 5.5: Design chart for 80-foot high vertical cutslopes (ODOT 2001)

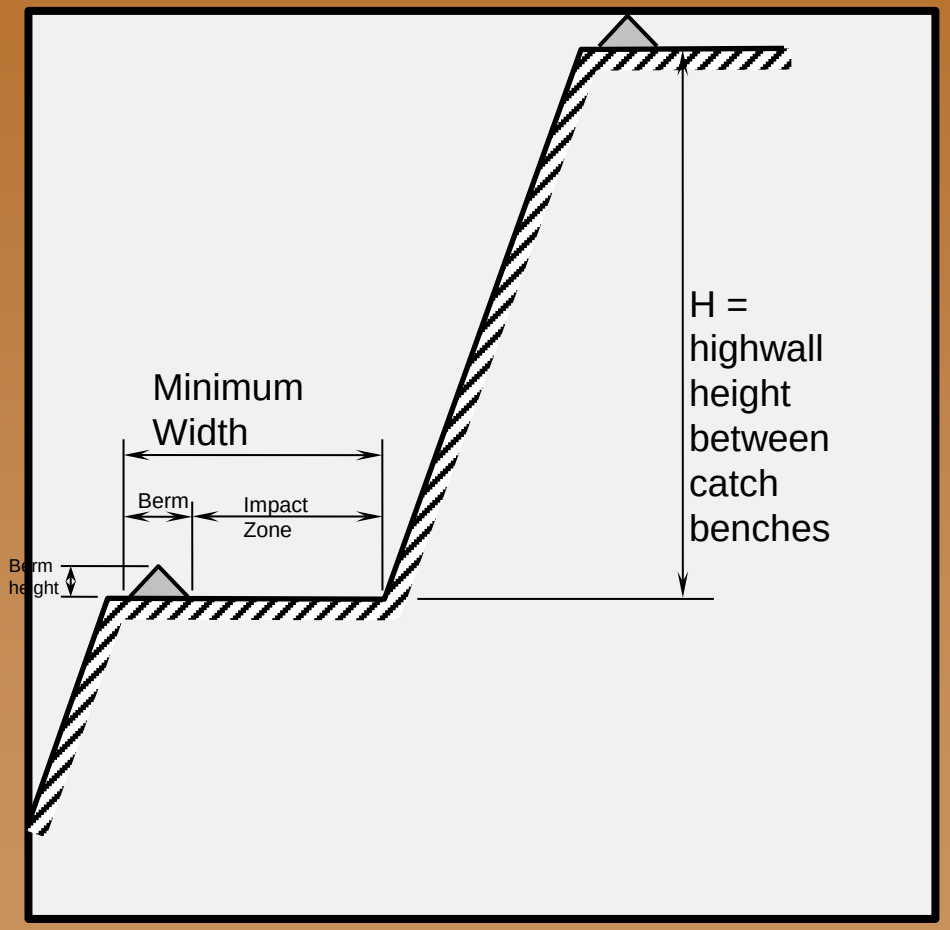
Berm Distance from Highwall

Old Rule of Thumb* =

0.25 x highwall height (H)

Call (1986) “Modified Ritchie” criteria*:

- Minimum Width = 15 feet + 0.2 H
- Berm height = 3 feet + 0.04 H



*Equations are for guidance only, not endorsed by MSHA

For Additional Assistance

Contact Your Local MSHA Office

(https://www.msha.gov/about/program-areas/metal-and-nonmetal-mine-safety-and-health)

Or

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