Drainage in Landslide Repairs
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Presented By
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Water is an Elusive Design Quantity

- Avoid the Weak Plane and Water Problems

Movement or Water

Weak Plane
Typical Bench In Summer

- Very Little or No Water Found in Borings
During Construction after Rain

- Blanket >>>>>
- Outlet >>>>>
Water Continues to Flow

- Water below the Counter Berm with Drainage
Water Comes out Anytime
And Any Where

- At Times with Force
- Blow Holes
Water in Shale and Rock

- When Embankment is Constructed next to them.
- Water is highly likely
Spot Locations

- Mark the locations of wet areas.
- Provide local drainage.
Good for spot locations
Should have Coiled Perforated Pipe in the 57’s.
Piping is Likely (Horizontally)
Common Solution
(Bench Down)

- No Standard Details for
  - Type Pipe
  - Outlets

No Redundant Outlet

- One Outlet Gets Clogged
- All the Benches Become Saturated
Horizontal and Vertical Bench Drainage

- Water was Found Everywhere
- Bench Up Situation
  - Too Unstable to bench down
Benches

- Too Small
- Horizontal Wasting Material

Changes in Construction

- Widened the Benches
- It did work
Proposed Solutions
‘Two Situations’

- Bench Out Material
  - From Top Down
  - Place the Drainage and Fill at the Same Time

- Bench Up (Unstable Slope)
  - Small benches (maybe)
  - Drainage Added at Specific Elevations or Locations
  - Up to 20 feet Deep in Unstable Material
Bench Out Material

- Bench all Material out
- Put Drainage in as Benched
Bench or Left Side

PRECAST REINFORCED CONCRETE OUTLET (TYPICAL)

TYPICAL SECTION
SCALE = 1:20
712.09 Type A Fabric (Two Sides with # 8’s)
6” Item 605 707.33(Perforated) into page
6” Item 606 Conduit Type F Non-Perforated Outlet
Outlet or Right Side

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Along the Slope Outlet (F)

1) Type D Fabric
2) 20 Mil Plastic
3) 601 Type C Rock Protection
Sand Protection (G)

- 1) Fabric
- 3) Type C Rock Channel Protection
Top View

- This May Look Confusing
Notice the 1% Grades
Benches Graded at 1%
Outlets Every 200 feet
Field Outlets
Bench Up Situation

- Slope is unstable
- Can Not Bench Down
Closer Detail

- Fill to Specific Elevation
- Cut Trench into Existing and Fill (10 to 20 feet Deep)
- Same Outlets as before
Top View (Looks Confusing)
Blow Up of Top View

- Out Let every 200’
- Benches Graded at 1%
- Same Rock Outlets
Field Construction

- Excavate and Fill Immediately
- No one in the Trench

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Connections

- Connections Made Above Ground
Filling

- As Fast as you Can
Take Grade Checks

- Do not enter the trench
Cave-Ins

- These will happen
- Minimize the Probability
- Minimize the Open Trench
Boulders

- Boulders are likely
- Deal with them

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Zig Zag Up the Slope

- Put Drainage where you need to
- 4 to 1 Failed and 5:1 cut with Drainage
The End of Drainage or the Beginning

- Do not Forget about Water….
- Because Water Won’t Forget about You…