West Lost Trail Creek Sturzstrom: A Composite Landslide

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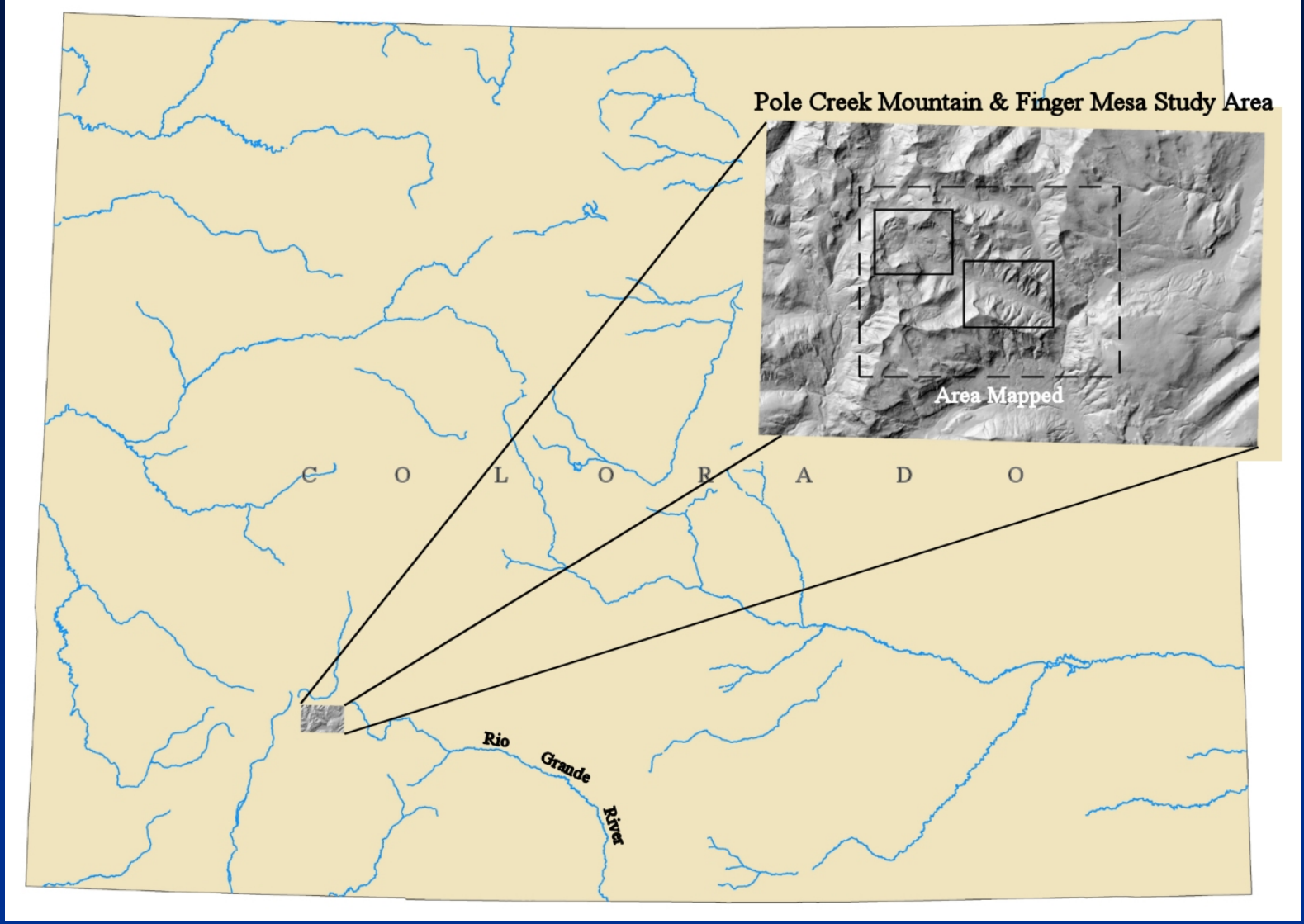
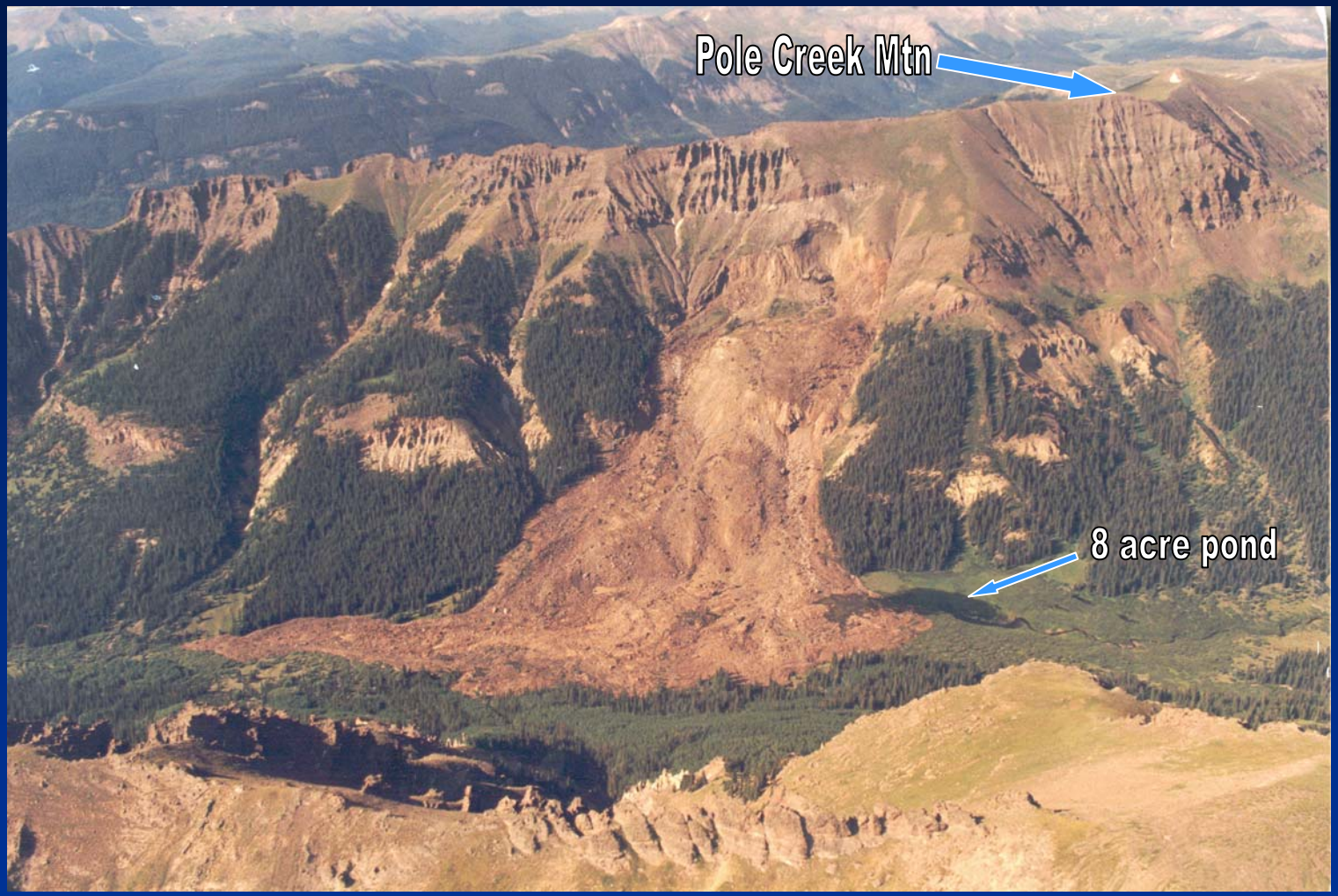


- The 1991 West Lost Trail Creek Landslide occurred on the boundary of the Pole Creek Mountain and Finger Mesa 7.5-min quadrangles in the upper Rio Grande watershed.

West Lost Trail Creek Landslide



- 8 million cubic meters of rock debris slid down slope in about 25 to 30 seconds, between elevations of 12,400 and 11,000 feet. Pole Creek Mtn lies at el. 13,716 ft. Photo by Dave Noe

1991 West Lost Trail Creek Landslide

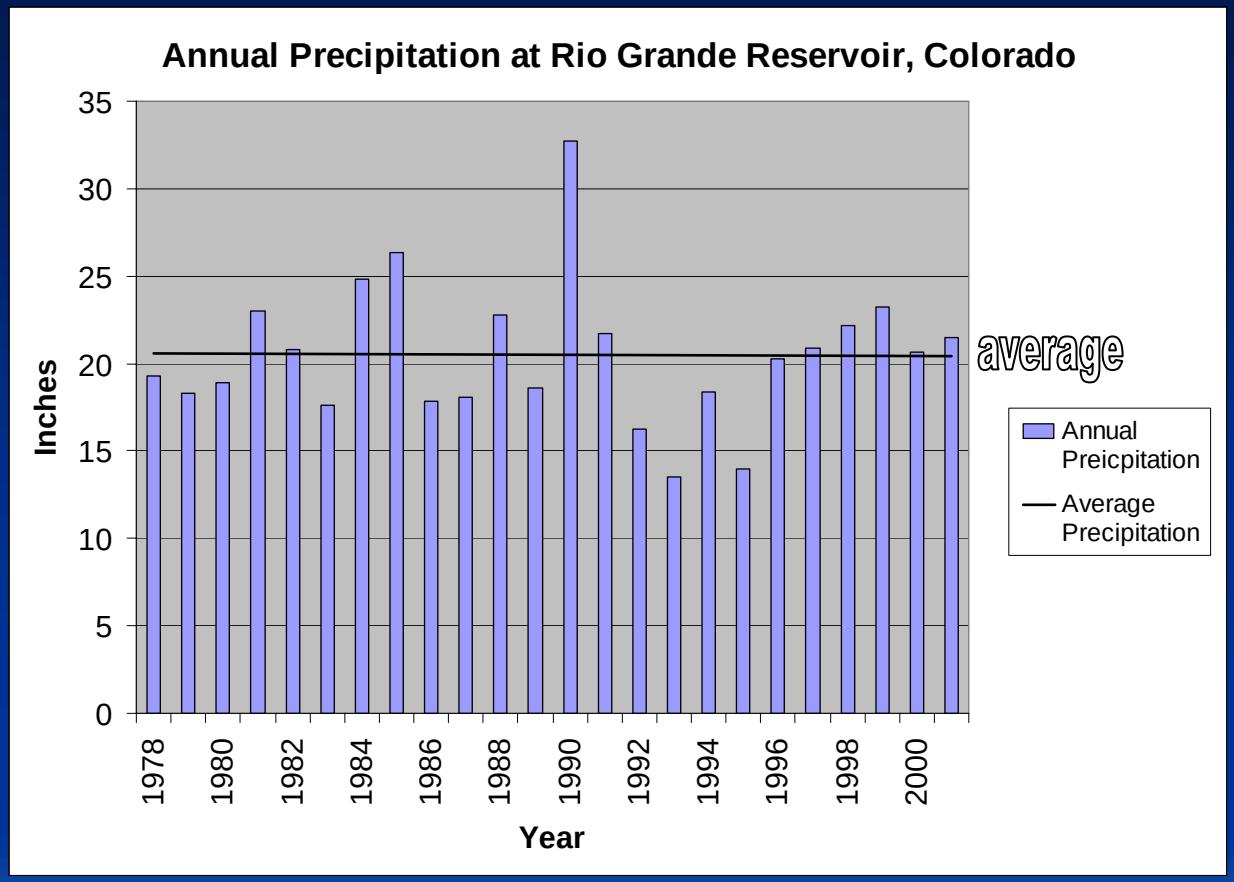
- Occurred on Tuesday afternoon July 30, 1991
- Eyewitness account and photos suggest that slide began as a series of en-echelon rock slumps and transitioned into a debris avalanche.
- Material translated approximately 1 km in 25-30 seconds; with an average velocity about 115 ft/sec, or 78 mph
- Slide flowed into West Lost Trail Creek Valley creating a landslide dam.

- View looking up at the debris field from the distal toe

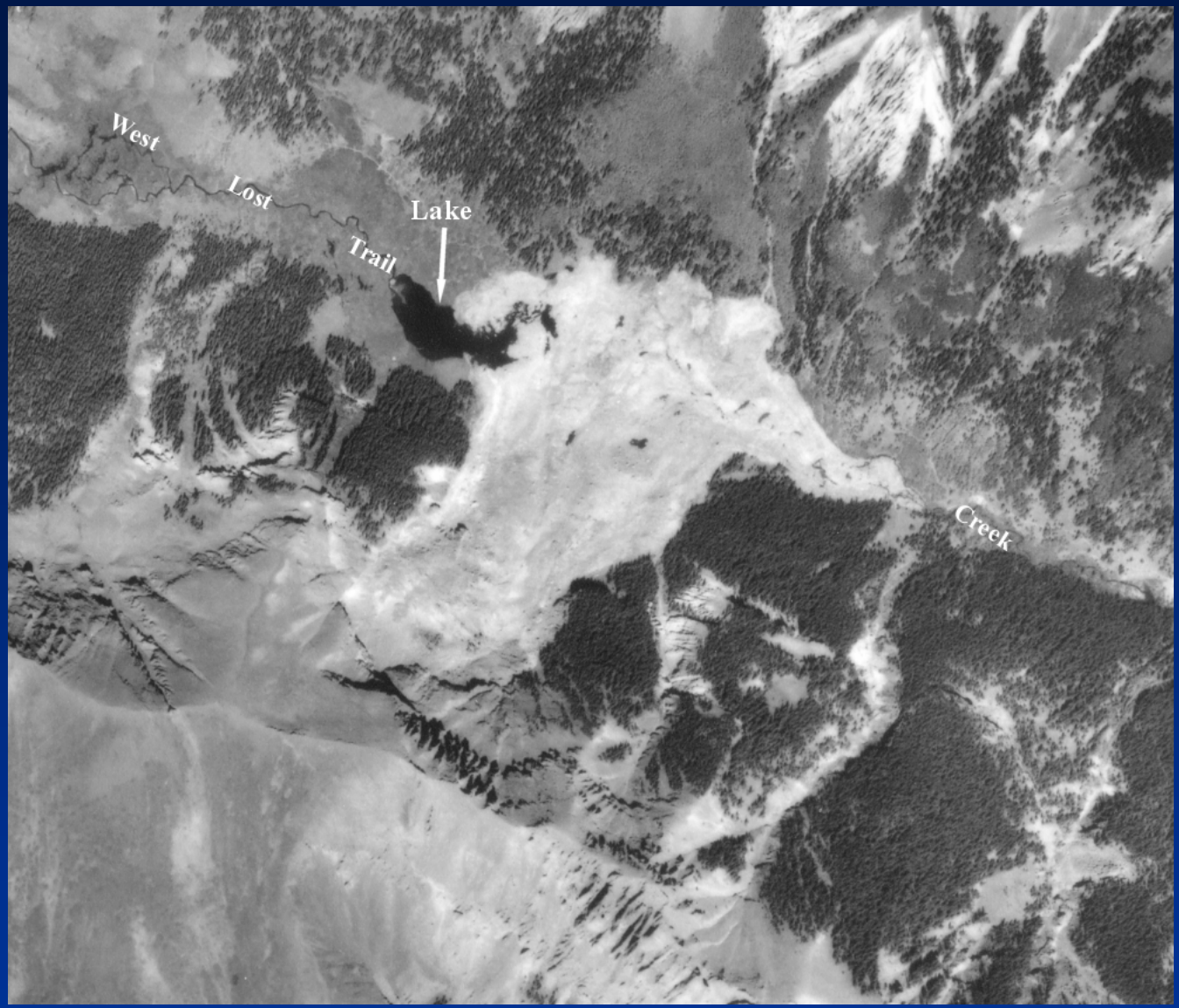
DISTAL RIM OF STURZSTROM TOE

- The slide gouged up portions of the indurated valley bottom like a giant dozer blade. The slide appears to have stopped rather suddenly, leaving a steeply inclined toe 3 to 5 m high.

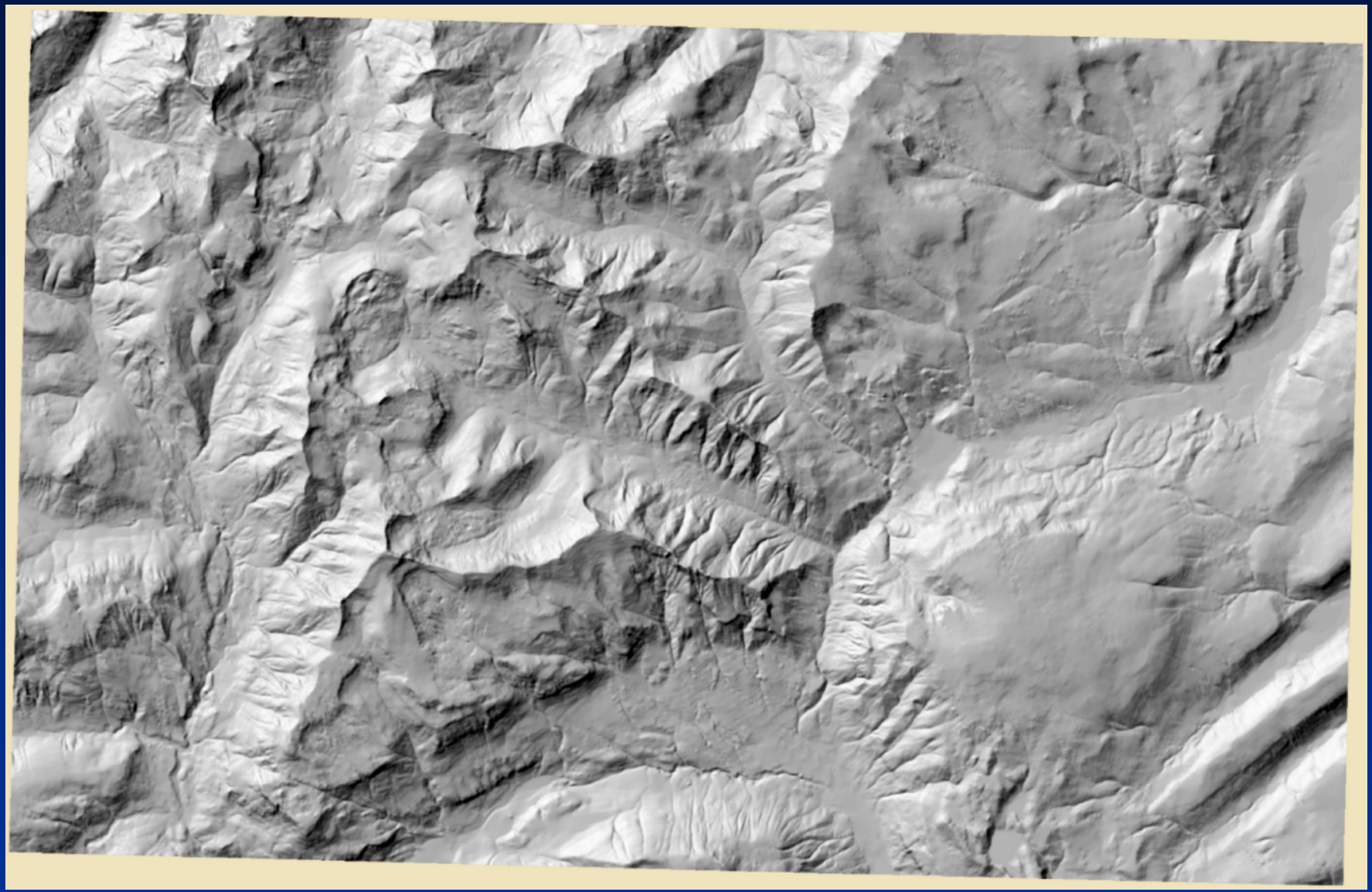
1990-91 was an exceptional year



- The seasonal precipitation was 165% of normal during the water year preceding the landslide

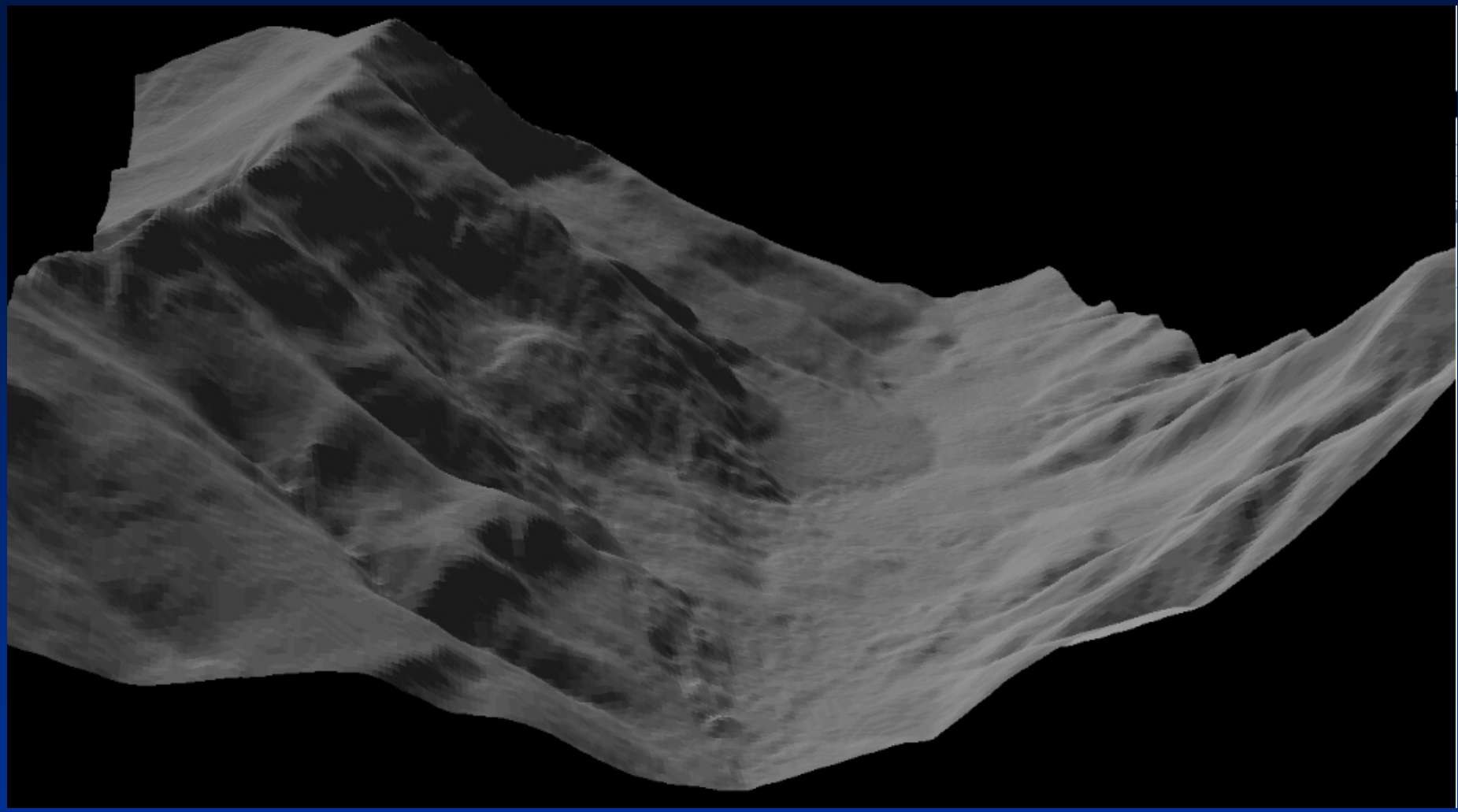


- Aerial photo imaged in September 1998 showing the lake formed along West Lost Trail Creek and the isolated ponds throughout the debris field

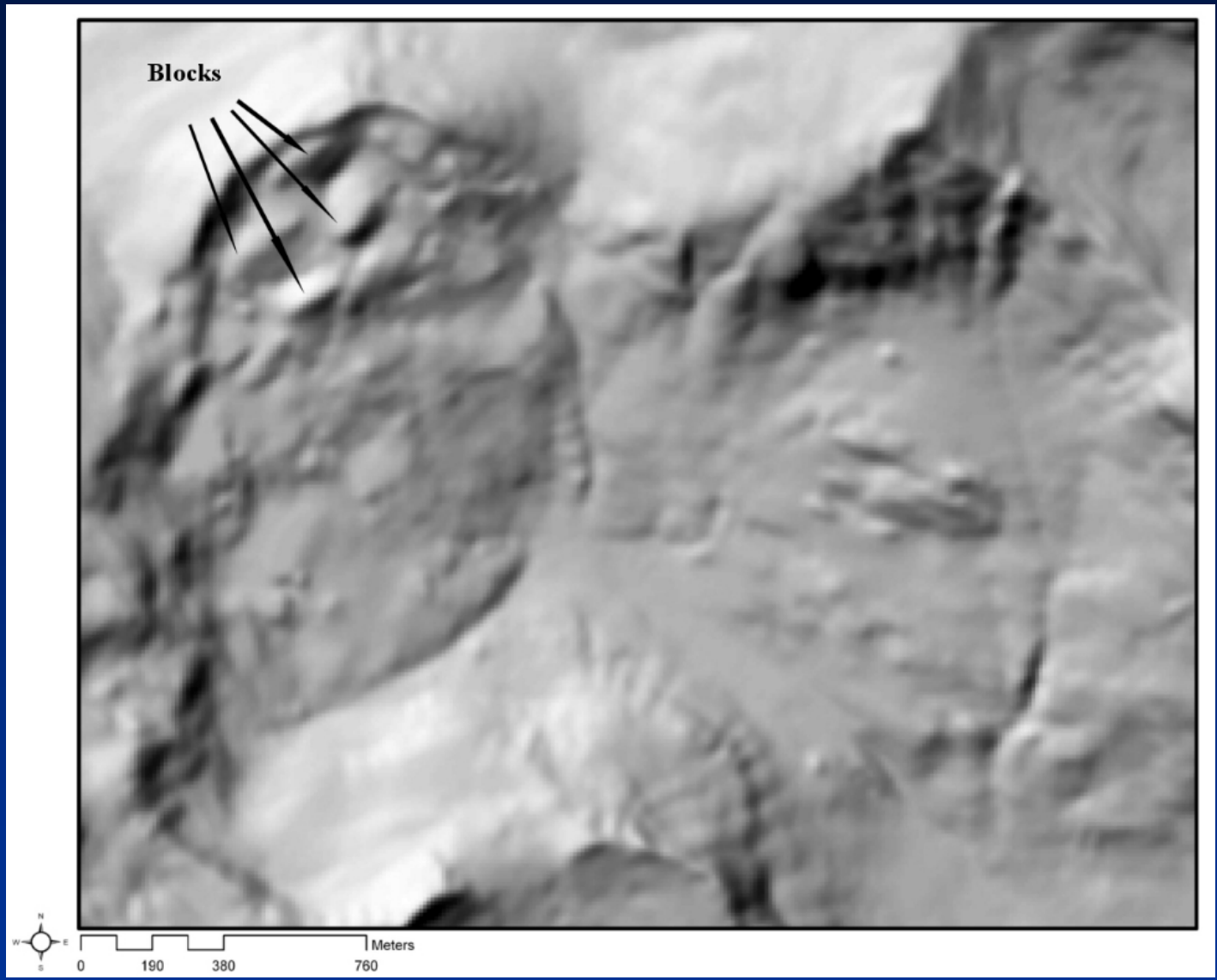


- 10 m Digital Elevation Models for the Pole Creek Mountain and Finger Mesa quadrangles, based on September 1998 photos

- Landslide inventory map created on a shaded relief DEM covering 65 km² area surrounding the subject landslide (arrow)



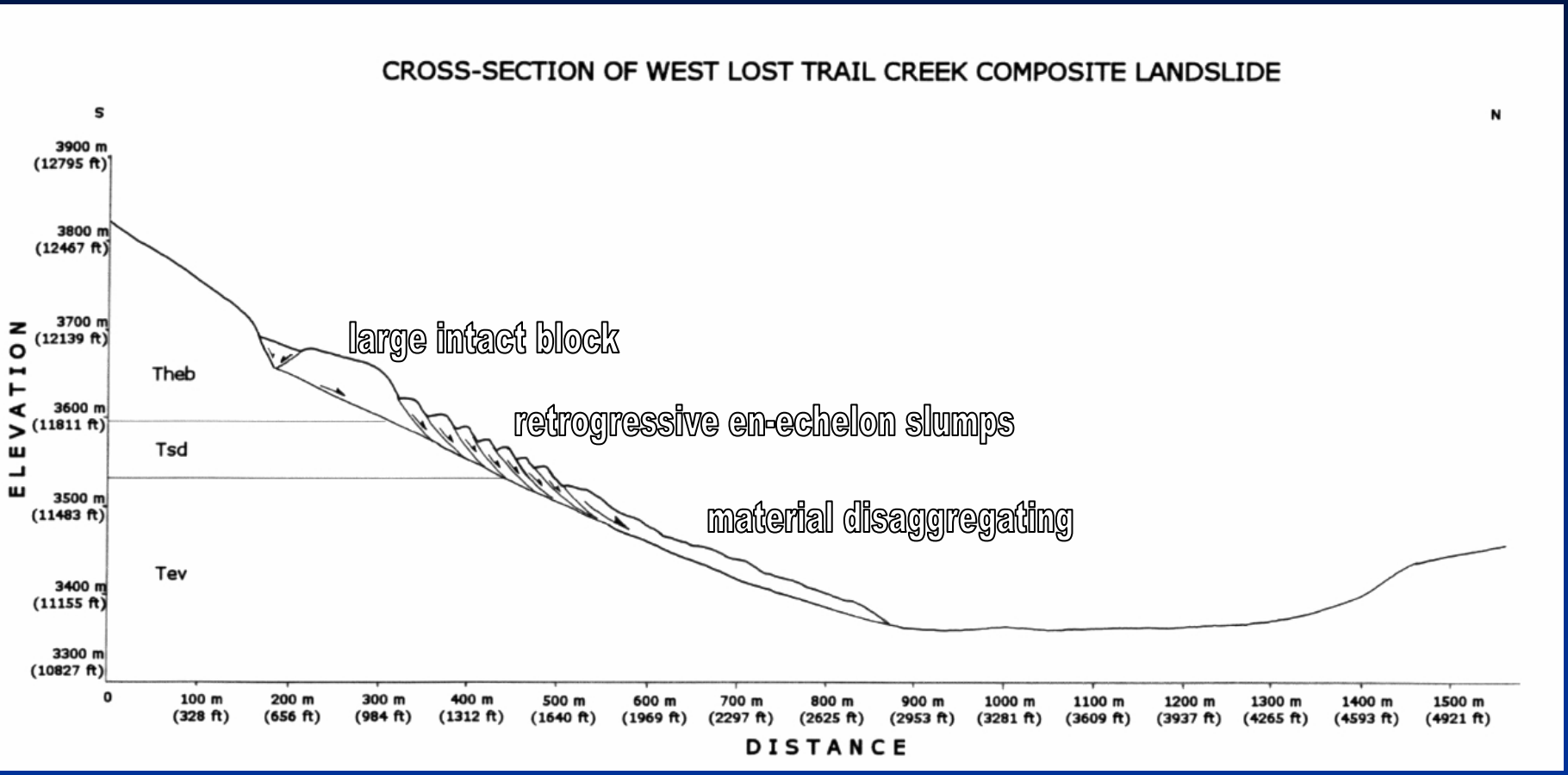
- Oblique view of the 1991 West Lost Trail Creek landslide on the10 m DEM prepared from 1998 photos using MicroDEM/Terrabase II



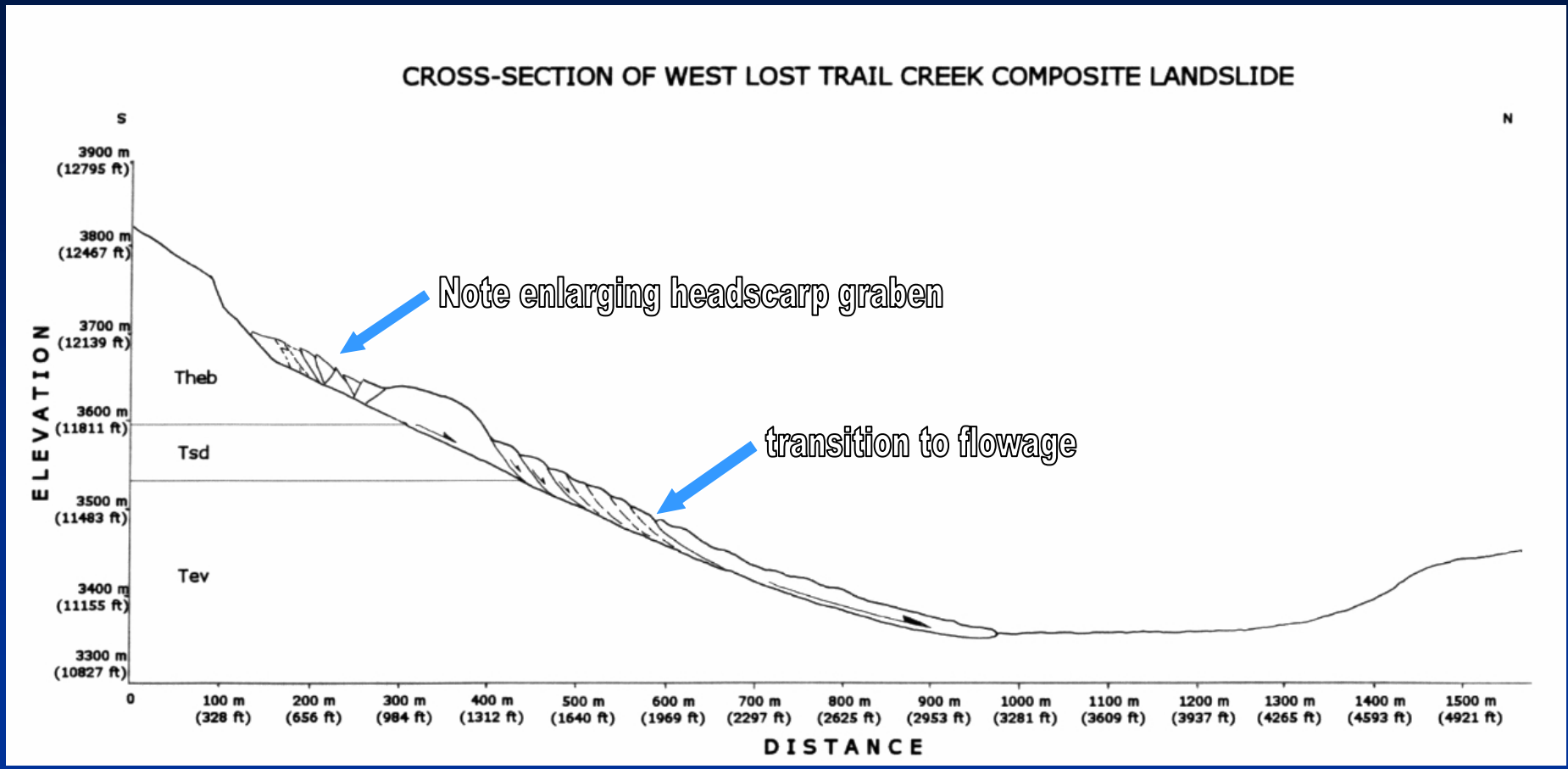
- Portion of shaded 10 meter DEM at head of the valley, about 3 km upstream of the 1991 landslide. Note blocks greater than 100 meters across are easily discerned in the DEM

- Landslide inventory map of upper West Lost Trail Creek watershed

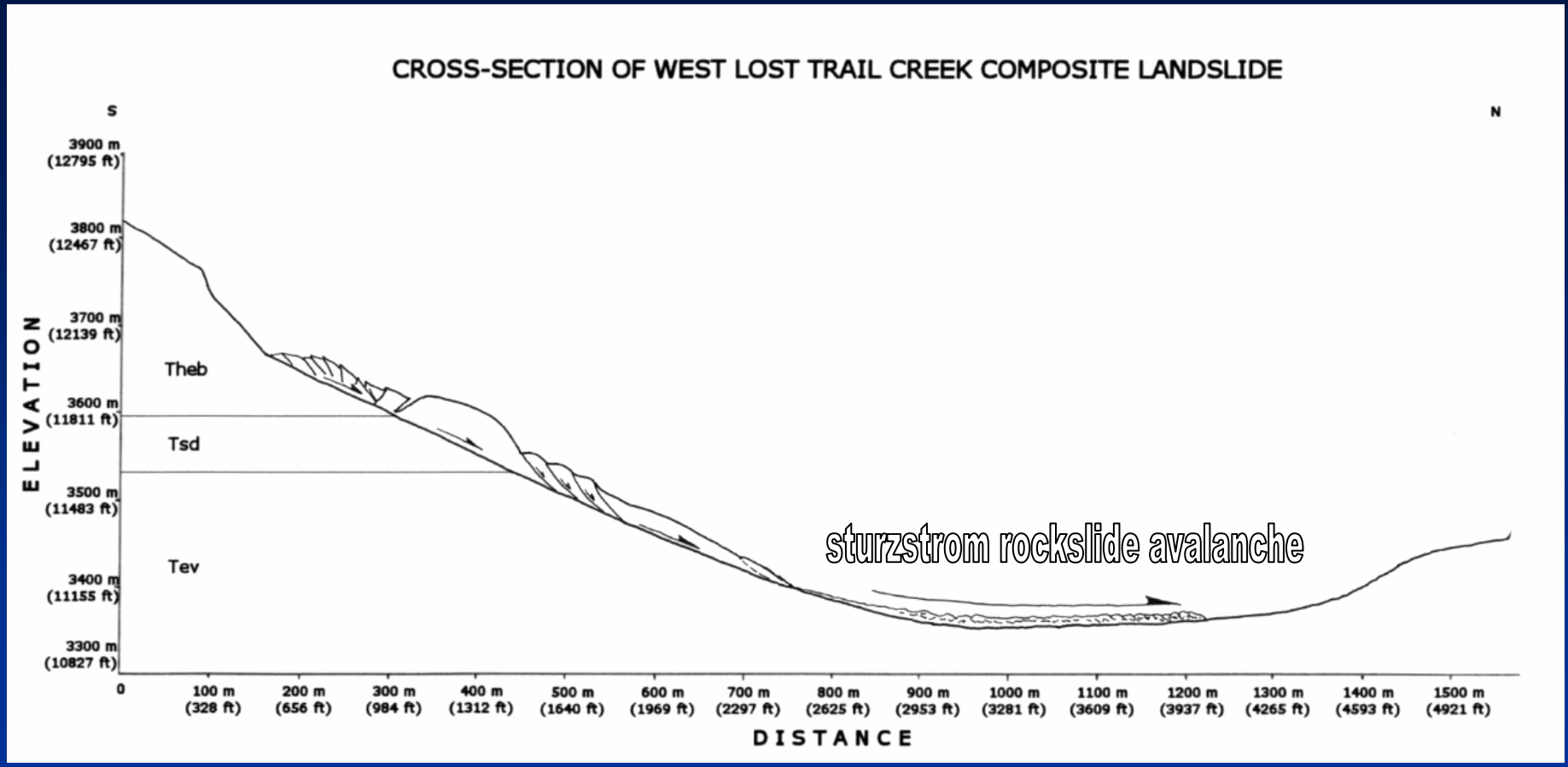
- Landslide inventory map of the West Lost Trail Creek area on **pre-slide topography**. Dashed line surrounds the 1991 slide area. Note pre-existing slumps and flows.



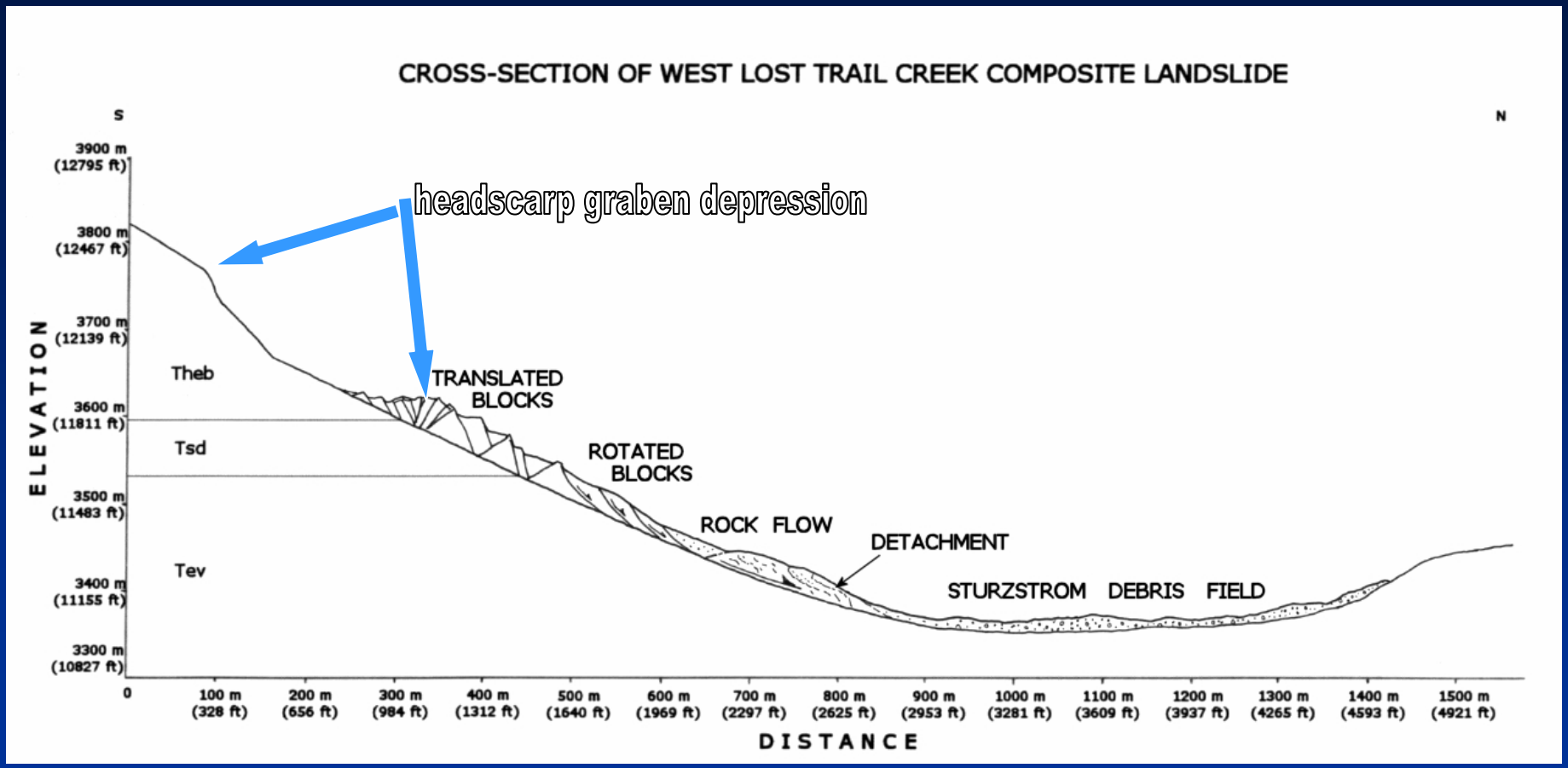
- The 1991 event appears to have initiated as a series of retrogressive rotational slumps, progressing upslope over a period of 10 to 15 minutes



- As the entire mass mobilized and began moving down slope, the lower portion detached and fluidized.



- The disaggregated material detaches and flows as a sturzstrom rockslide avalanche



- Cross section through 1991 sturzstrom after movement ceased, showing the various components of the slide mass

WHAT IS A STURZSTROM ?

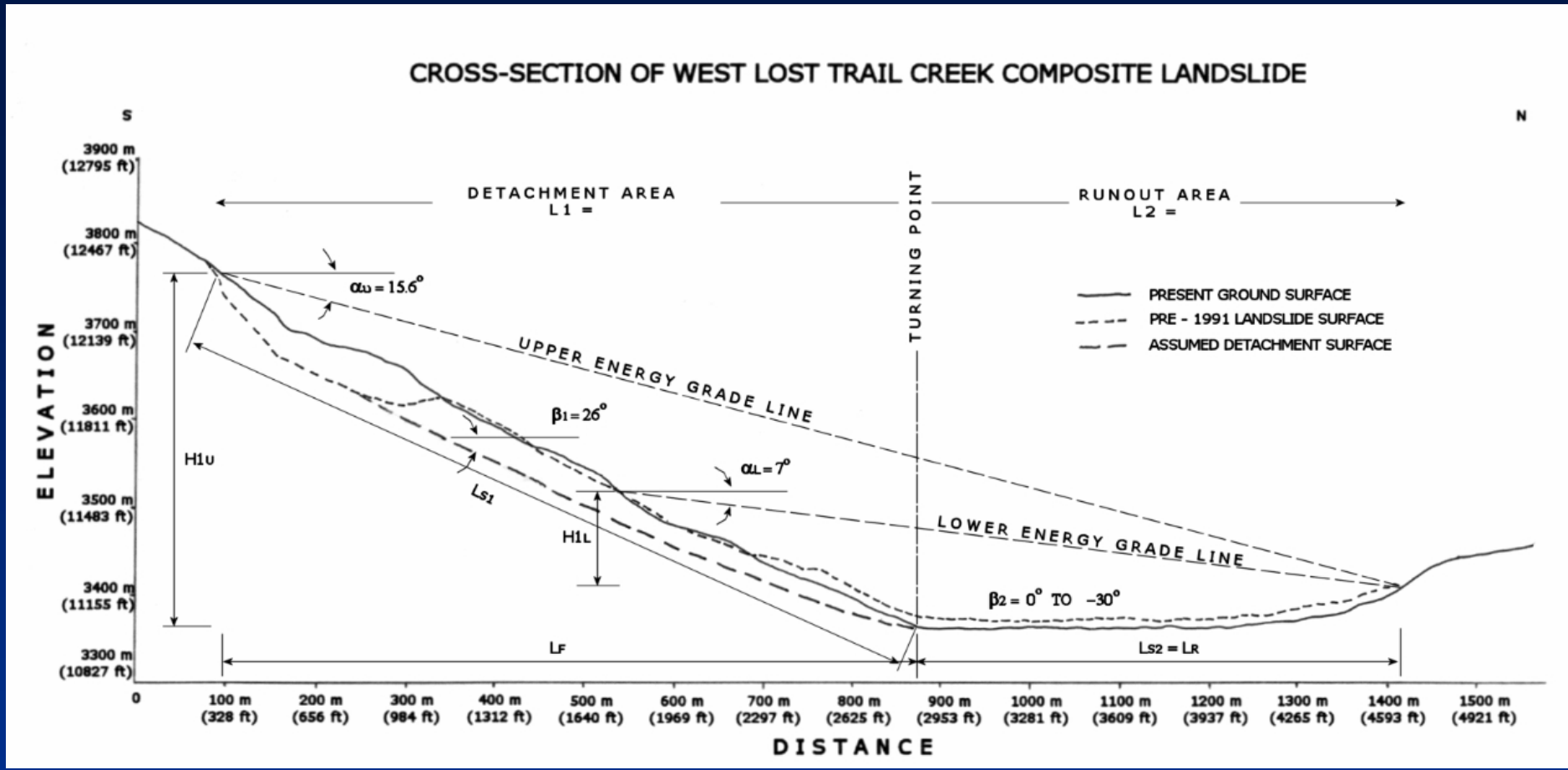
- Sturzstroms are rockfall avalanches or rockflow rubble streams which are characterized by movement at great speed over excessive distances
- Heim (1932) observed that sturtzstroms require:
  - a minimum volume of 500,000 cubic meters of rock
  - an initial fall height of at least 150 meters (500 ft)
  - slope of at least 25 degrees
- Legros (2002) and Iverson (2003) have shown that strurztsroms translate greater distances because of their conservation of mass and momentum

- Surface of the debris field filling the valley bottom, looking downstream.

Sturzstroms characterized by:

- Near complete loss of interparticle shear stress while moving more than some minimum speed

  - conservation of mass and momentum appears to drive the phenomenon
- Conforms to fluid-like flow path
- Dilates like fluid on low gradient runout slope.
- As spreading and dilation occur, basal friction increases, resulting in rapid deceleration.



- Energy Line Models used for evaluating sturzstroms. Complete detachment only occurred below el. 11,480’
- The lower ELM predicted runout (1926 ft) within 10% of that observed (1739 ft) and should have taken 32 seconds to decelerate (25 to 30 estimated by observer)

Varying Particle Sizes

- Particle size ranges between about 6 inches and almost 50 feet. Water percolates through with ease

Impoundment of West Lost Trail Creek

- An 8 acre lake has backed up behind the debris dam
- Water is percolating through the debris field

What factors control removal of landslide dams?

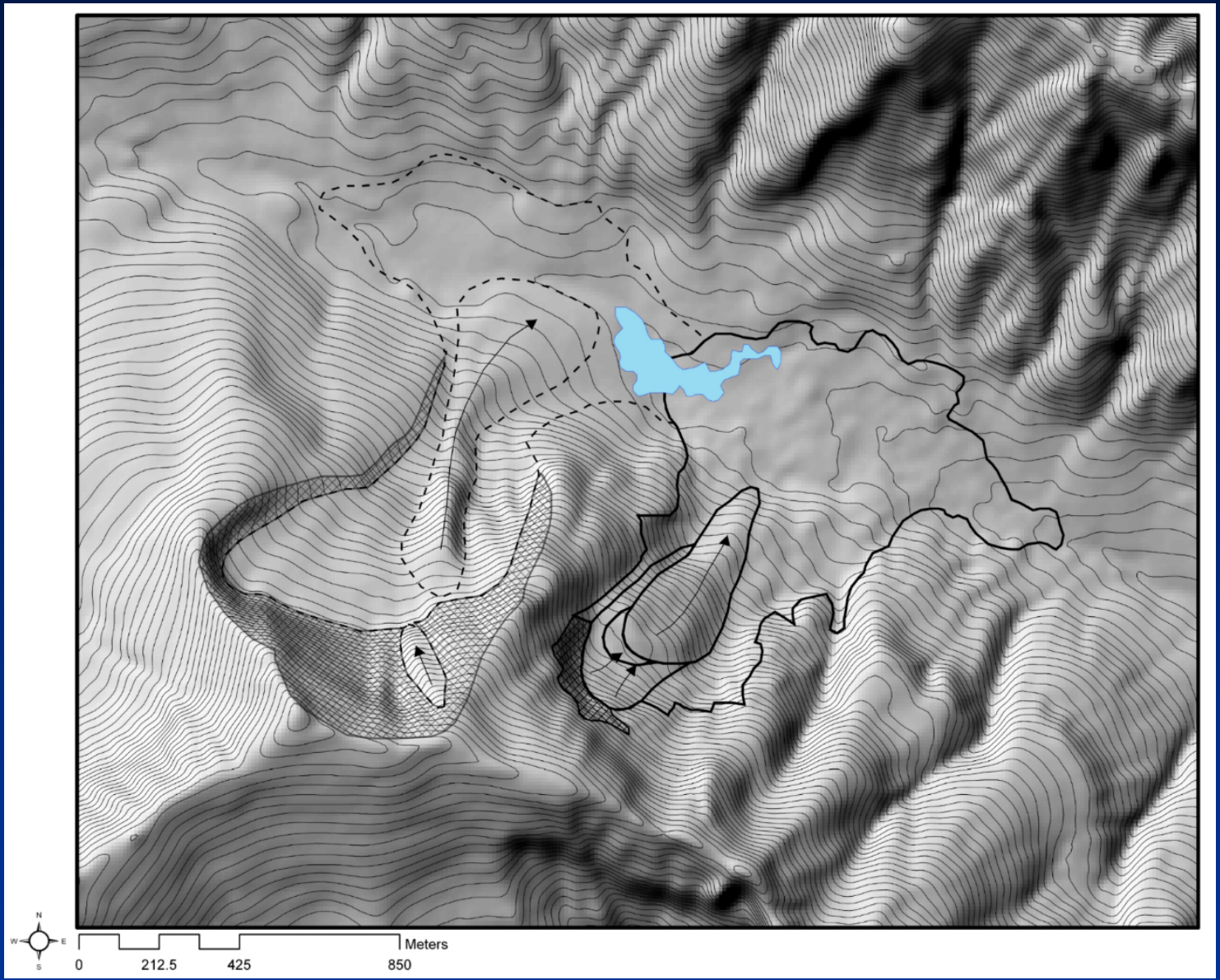
1. Hydraulic conductivity of slide mass (a. amount of fines in the debris; b. characteristics of bed load; and c. volume of bed load delivered to the site)
2. Tributary watershed upstream of the dam site
3. Volume of water impounded behind the landslide dam (available stream power for downcutting)
4. Volume of the slide mass blocking any potential outlet
5. Hydraulic grade of this same outlet path
6. Erodability of the slide debris (cohesion, slake durability and abrasion) or the country rock

Life Expectancy of a Landslide Dam

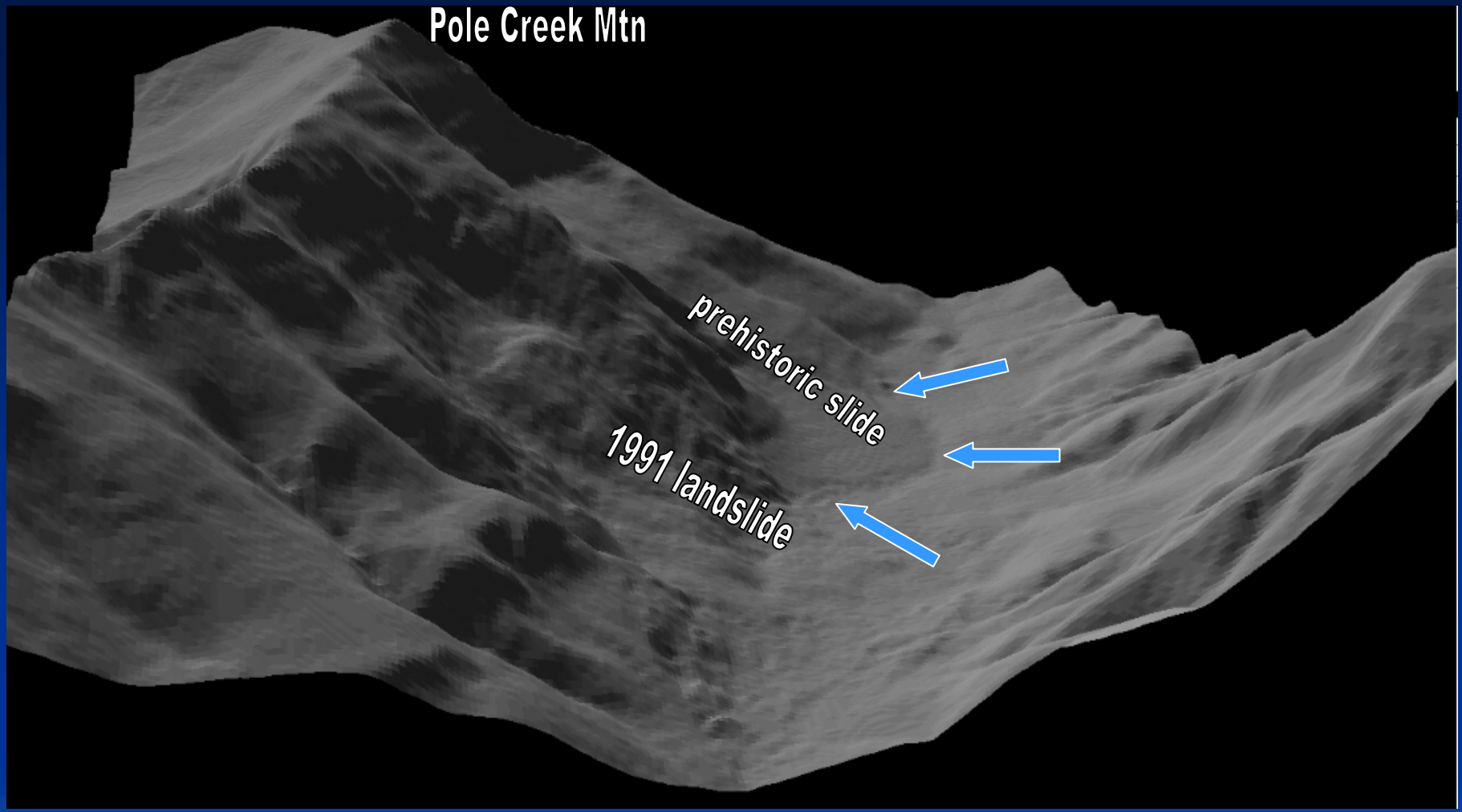
- Erosion may not play a significant role here because water is freely percolating through the debris (very few fines at this location)
- Ratio of lake volume (36 ac-ft) to the slide volume (10.46 million yds^3) and watershed area (11.5 mi^2) is much smaller than most large landslide dams
- By comparison, the 1925 Gros Ventre Landslide impounded a lake volume of 164,000 ac-ft with a slide volume of 50,000,000 yds^3 and tributary watershed of 596 mi^2

A FUNDAMENTAL AXIOM

- If we want to predict which physical processes are operative in a given area or how long such processes take to occur; all we have to do is look over the area carefully, searching for similar features and evaluate these critically
- In this case, we didn't have to look far
- An even larger sturzstrom occurred just upstream of the 1991 event



- 10 m contour map of the slide area showing 1991 slide and larger prehistoric event immediately upstream

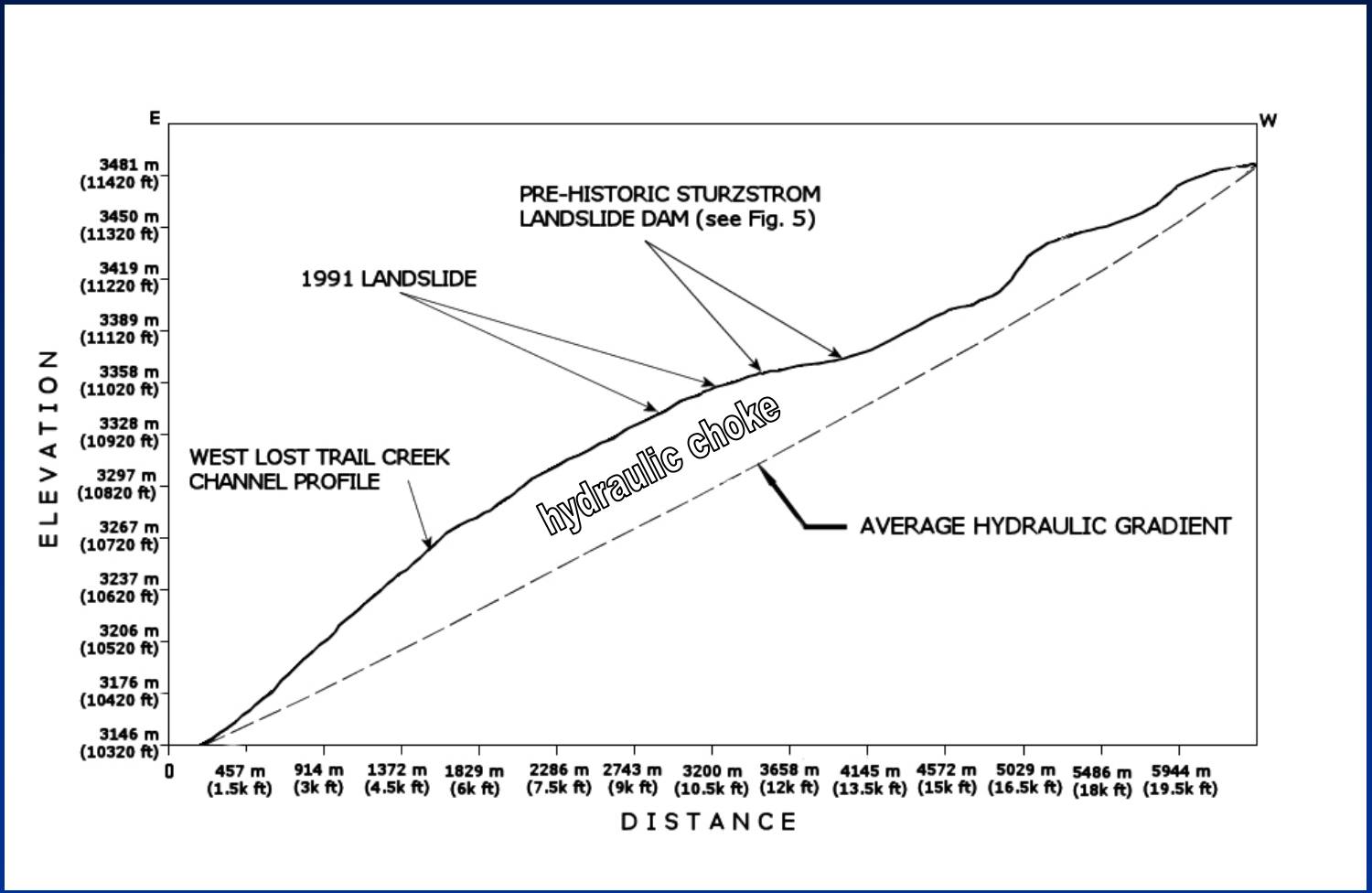


- The sturzstrom which detached from Pole Creek Mountain has been circumvented by the channel

Possible Outcomes

- Prehistoric landslide dams upstream seem to have been gradually excavated by low stream power flow rather than by high energy short-pulse overtopping with catastrophic outbreak floods
- Within the next 250 to 500 years the slide mass may collect enough fines from West Lost Trail Creek to progressively inhibit infiltration at the upstream end
- The pond could then encroach the debris field and gradually spill sufficient discharge to develop a series of quasi-stable rapids, similar to what presently exists immediately upstream

Ample evidence of past landslippage



- Channel profile along West Lost Trail Creek. The convex-upward profile is diagnostic of a channel containing more debris than it has hydraulic capacity to remove (Hack, 1973).

Future Risk of Slope Failure

- Several older slides preexisted the 1991 event; it appears these lacked the requisite mass and initial fall (momentum) to become strurzstroms
- Future catastrophic failure unlikely, because:

  - Upper slide mass does not appear to be of sufficient triggering volume

  - Main cause of 1991 slide is the low strength of the San Juan Tuff, which has been buttressed by the1991 slide debris.

CONCLUSIONS

- West Lost Trail Creek valley is blanketed by active and dormant bedrock landslides developed mostly within the San Juan Tuff
- The 1991 West Lost Trail Creek Slide appears to be a composite landslide, with the portion below elevation 11,500 feet mobilizing as a sturzstrom rockslide avalanche.
- Although there is an abundance of slide activity in this portion of the San Juan Mountains, sturzstroms appear to be relatively infrequent events