Geotechnical Society of Edmonton Annual Student Presentations

Landslide hazard assessment, Town of Peace River, AB

Focusing on the landslide movements and their behaviors

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Supervised by
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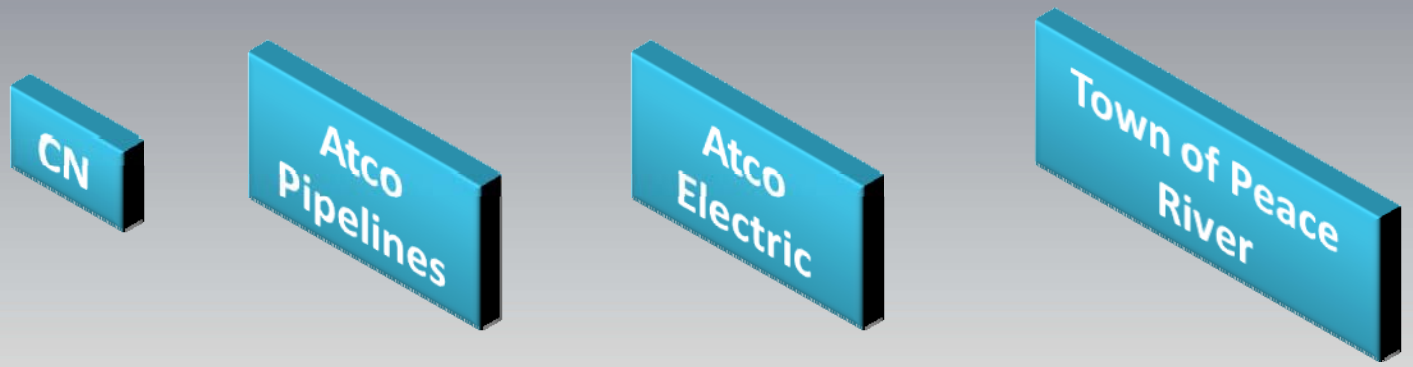
Background

Development of a Geohazard Assessment Methodology for the Town of Peace River, Alberta

University of Alberta & **Alberta Geological Survey**

Dept. Civil and Environ. Eng.

Dept. Physics



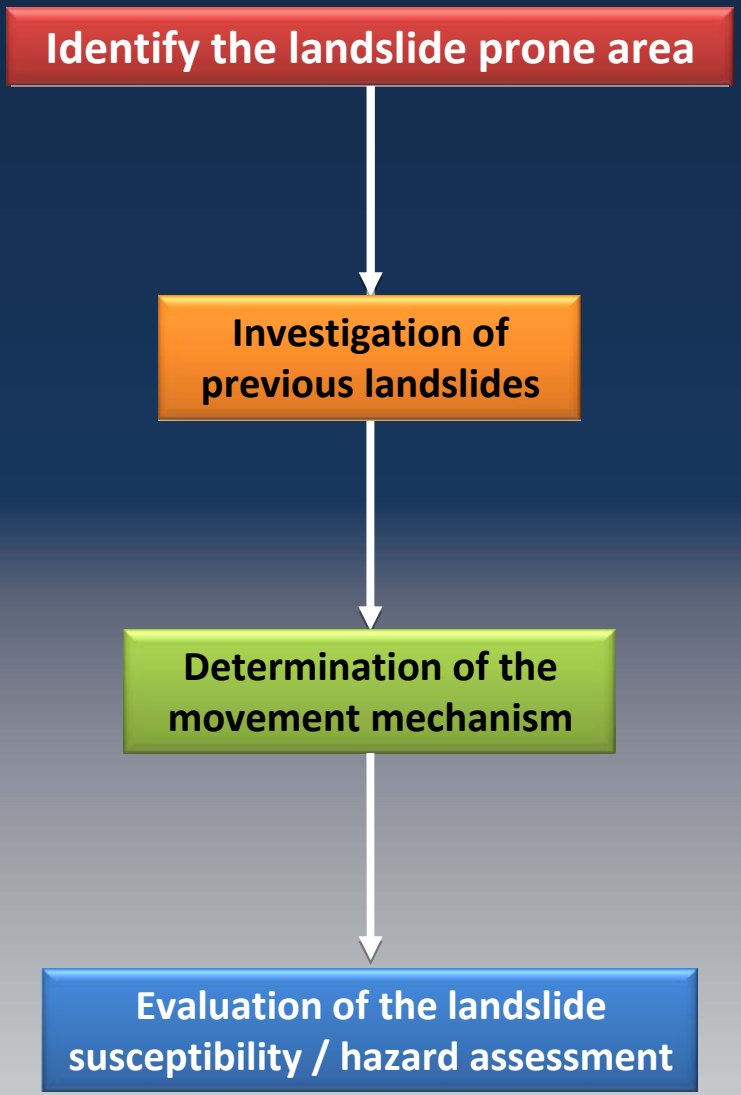
Research Objective

- Identify the landslide prone area by;

Landslide hazard assessment

Based on

Historic landslide information

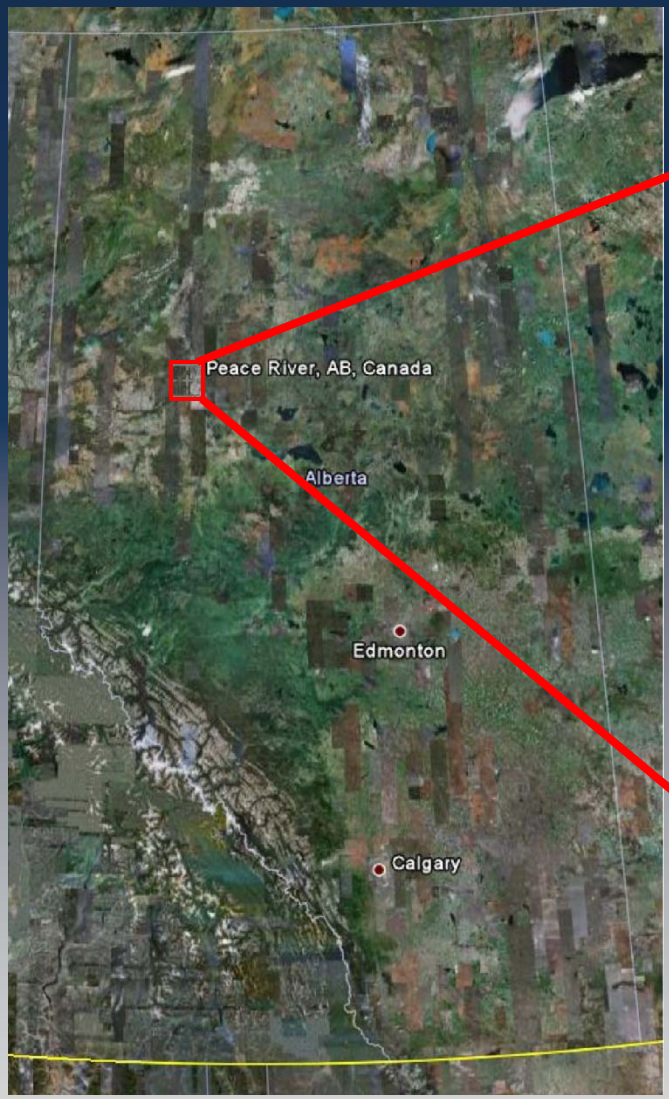


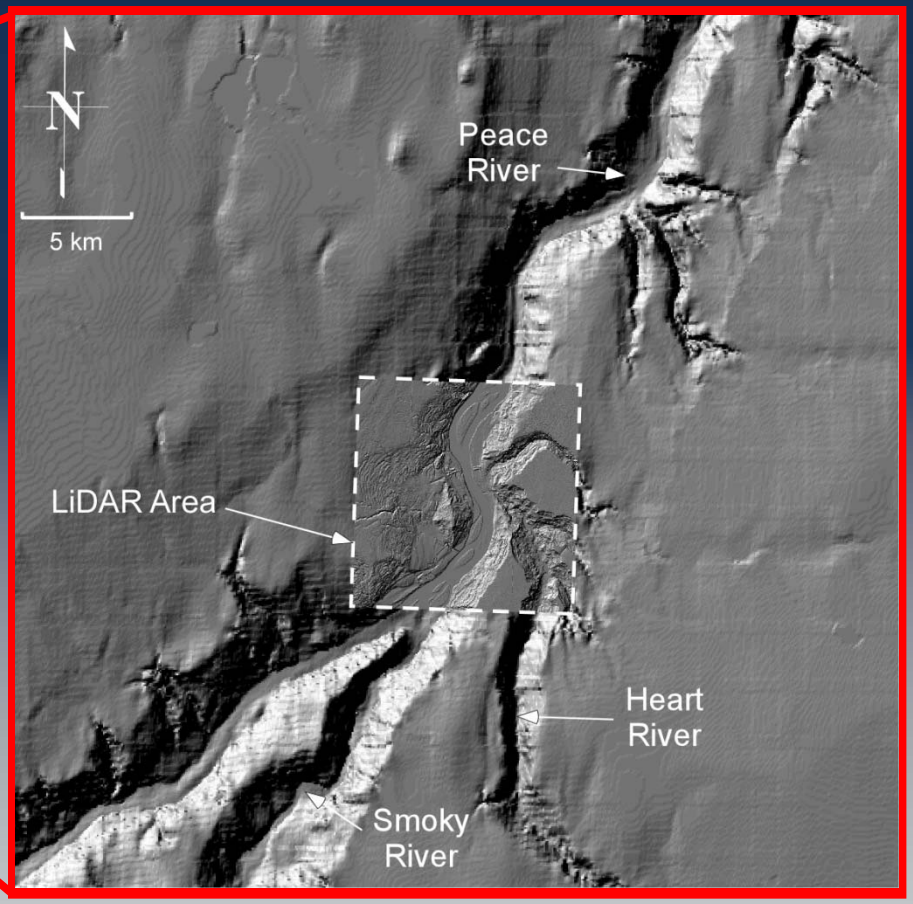
Contents

- Landslides in the Peace River area
  - Site description
  - Previous work
  - Landslide case studies
  - Lab tests
  - Movement characteristics
- Future works
  - Susceptibility and hazard assessment

Site description

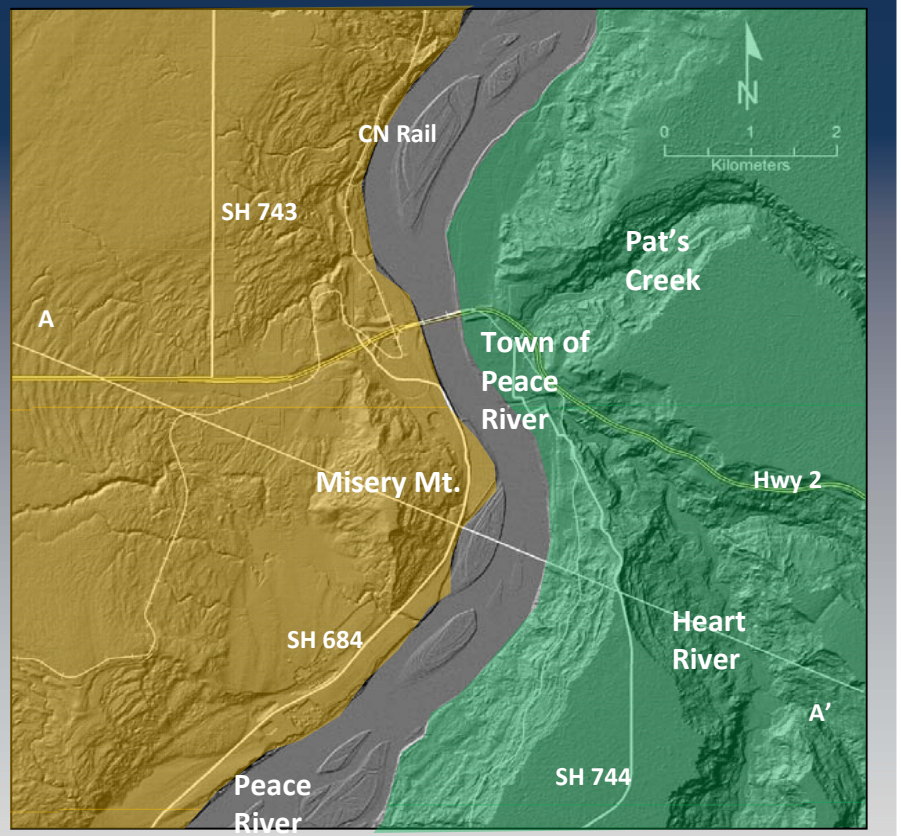
So, where is the Peace River?





Site description (Cont'd)

- Physical appearances
  - West bank
    - Slope length: 4,000m, flat (2.5-7.5°)
    - Misery mountain (10-13°)
    - Upland: much flatter (-1°)
  - East bank
    - Much steeper (6-14°)
    - Transportation routes traverse steep ravines of the Heart River and Pat's Creek



Site description (Cont'd)

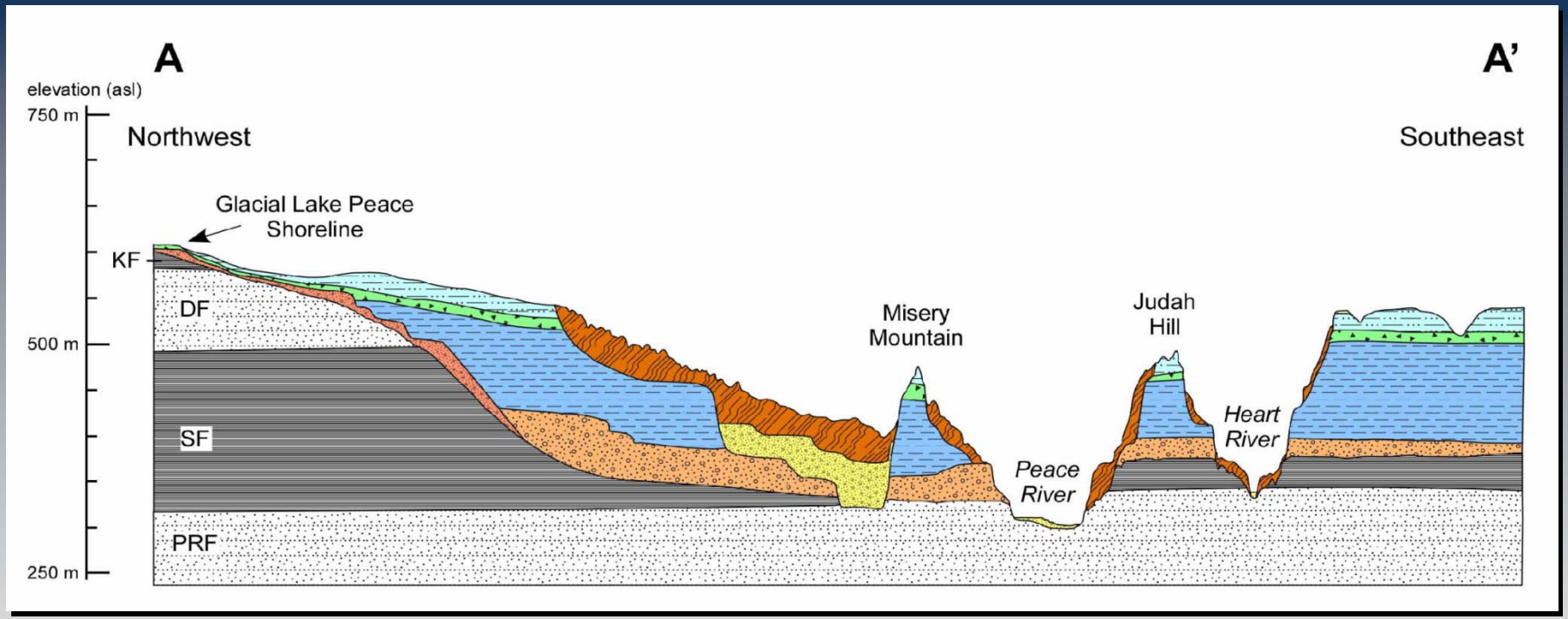
Site description (Cont'd)

Site description (Cont'd)

- Geological features

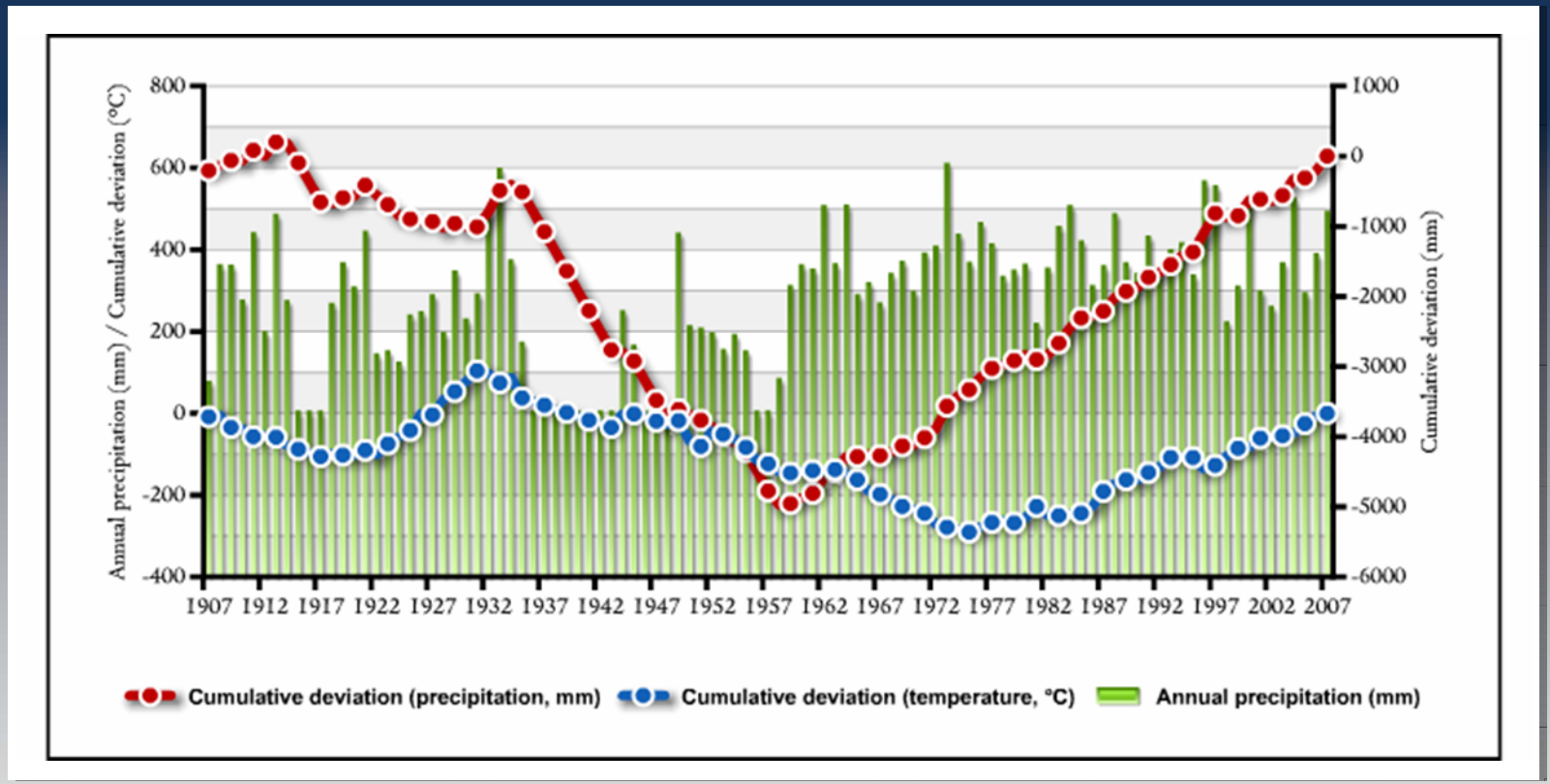
Bedrock formations	Buried channels
Glaciolacustrine, Glacial overburden	Terrace deposits

Morgan et al., 2008



Site description (Cont'd)

- Landslides history
  - Geologically immature valleys
  - Accelerated since 1970s.



Previous work

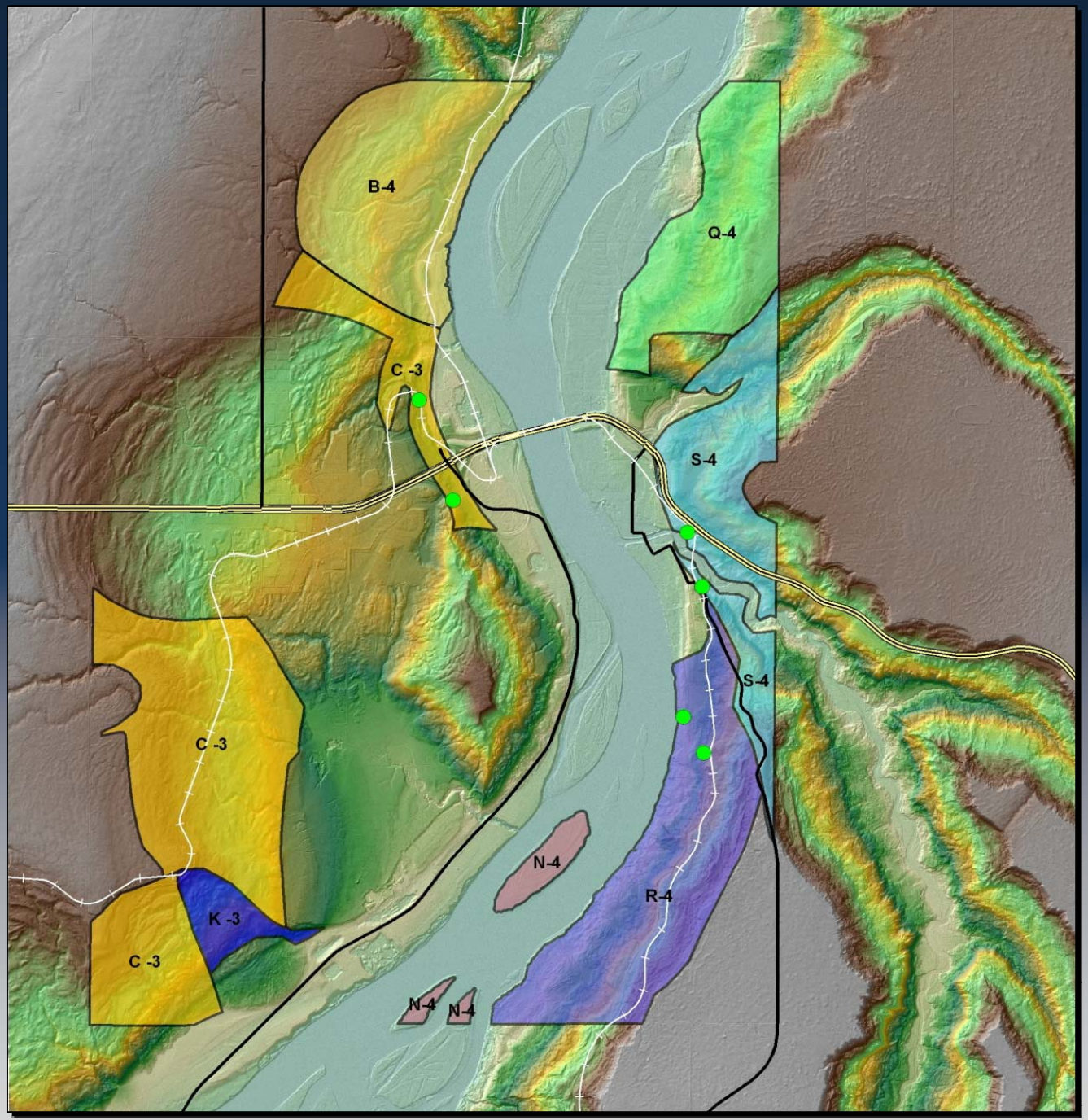
- Hardy and Associates (Nov., 1978)
  - Identify the areas which slope stability plays a major role when they are developed
  - Sources for the study: Contour maps, aerial photographs, published reports etc.
  - Used physiographic units

Letters

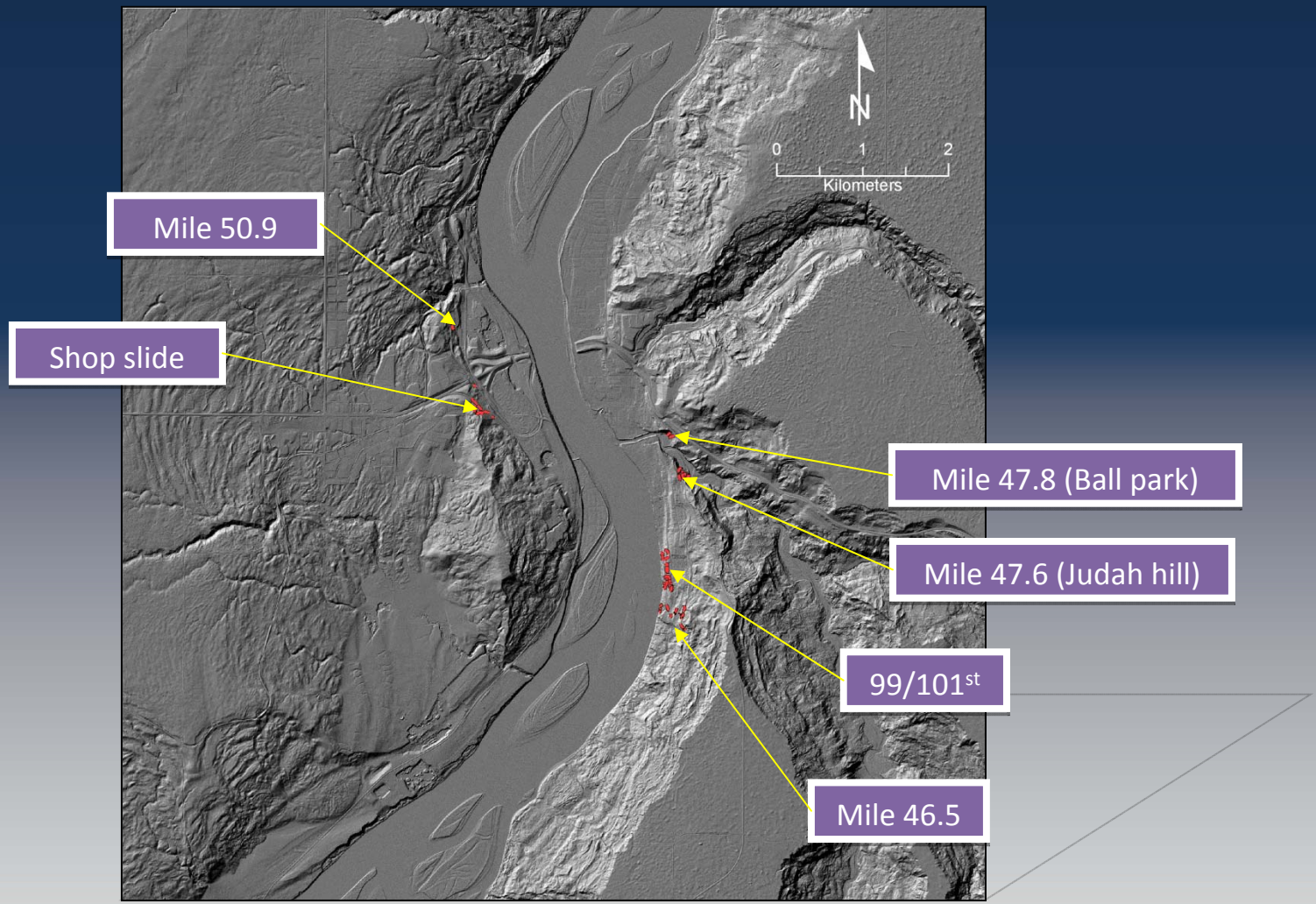
A	Upland plateau	K	Scarp and toe of slope rapid failure (unstable)
B	Large slide mass	M	Scarp and toe of slope rapid failure (stable)
C	Slumped bank	N	Smaller islands
D	Upper terrace	P	Toe of shallow slides
E	Major slides blocked the original channel course	Q	Severe shallow slides
F	Recent terraces and islands	R	Deep seated landslides
G	Large hill (Misery Mt.)	S	Slopes in tributaries
H	Abandoned channel course	T	Upper level terraces
J	Transition (terrace to upslope)	U	Old slumped areas

Roman numerals

I	Unaffected by any slope failure
II	Areas of old landslides
III	Areas which are stable, but would be unstable when they are developed
IV	Presently unstable


B-4
Q-4
C -3
S-4
S-4
C -3
N-4
R-4
K -3
C -3
N-4
N-4

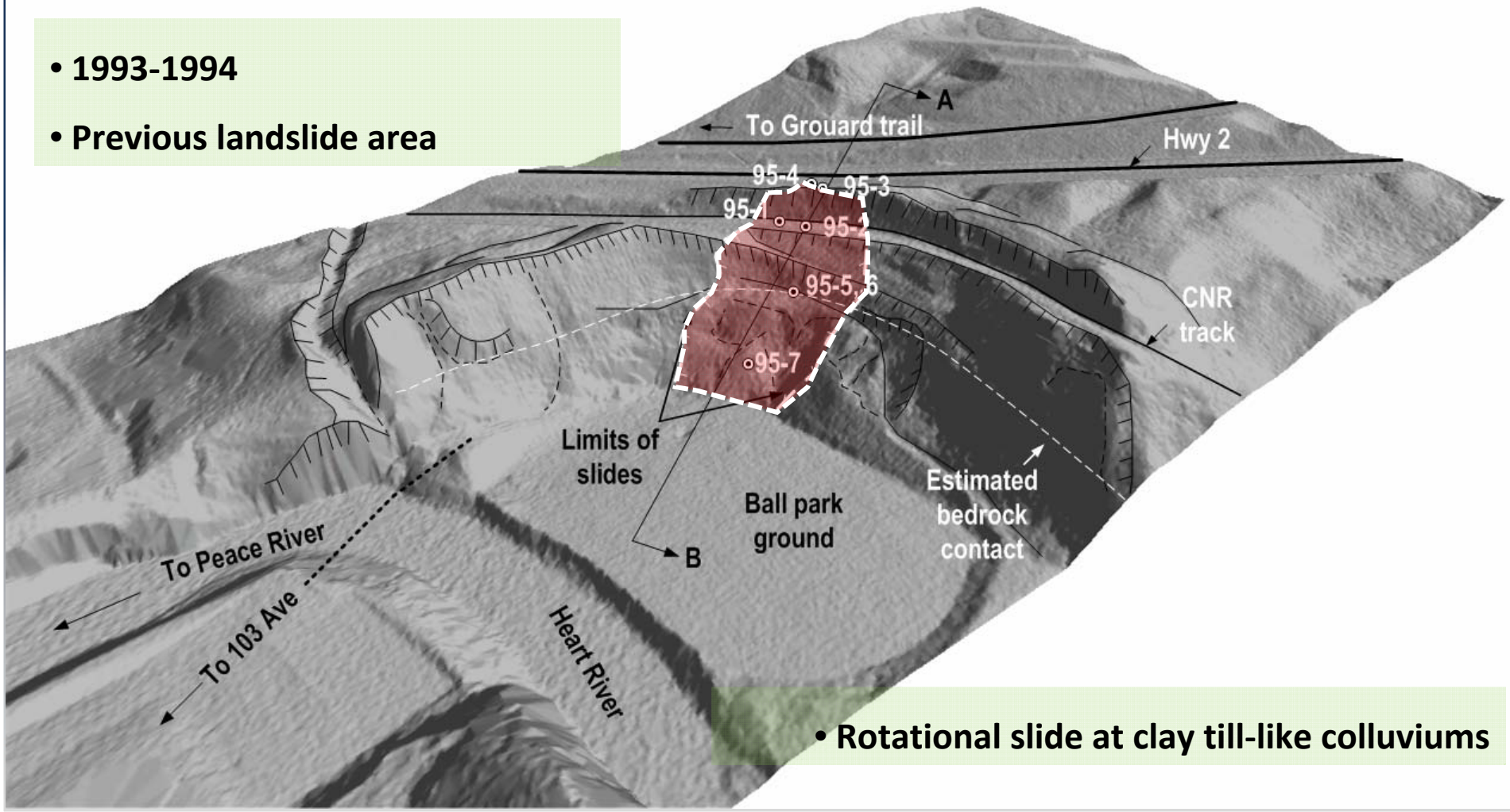
Landslide case studies



Landslide case studies (Cont'd)

- Mile 47.8

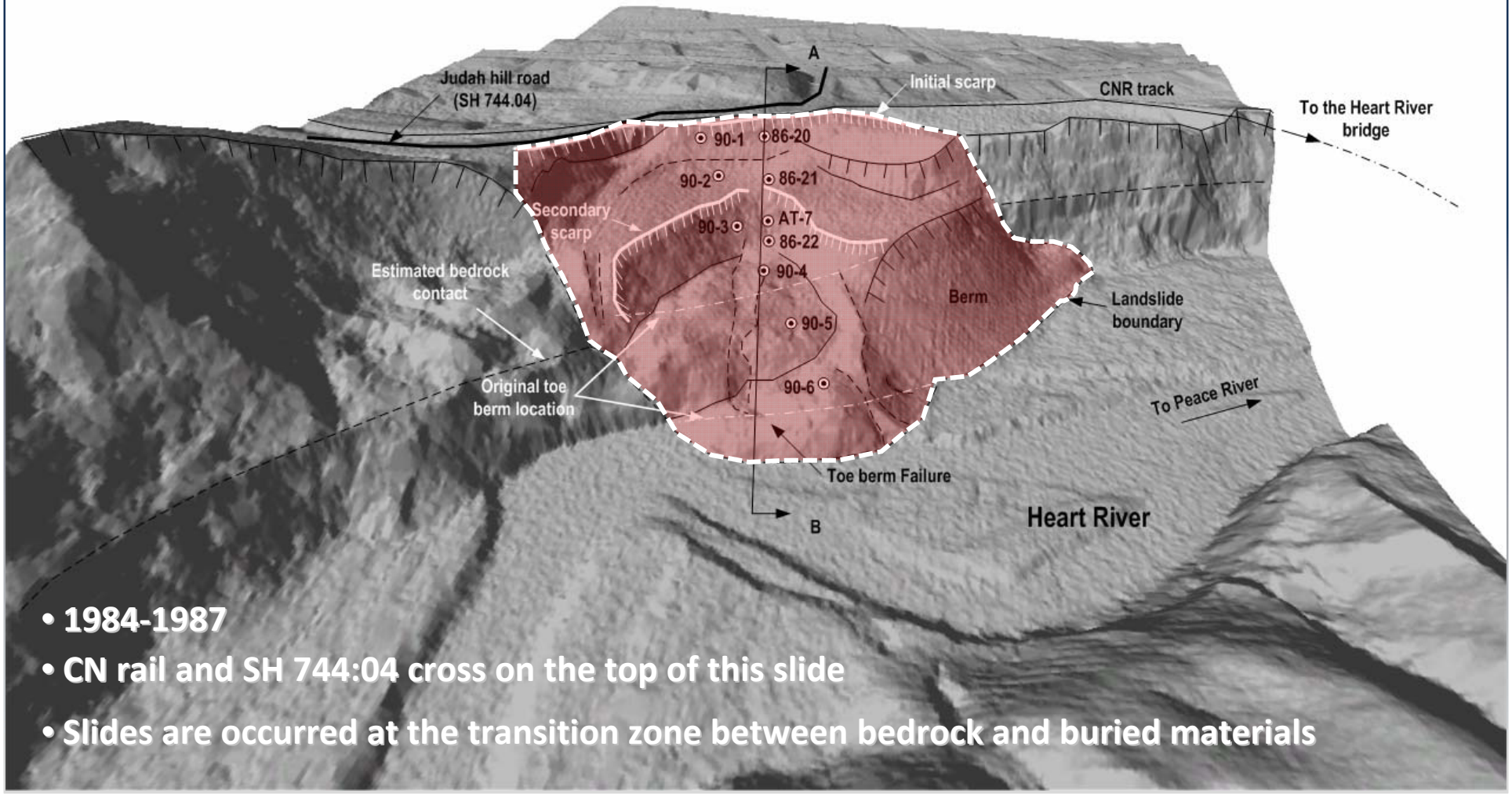
- **1993-1994**
- **Previous landslide area**



- **Rotational slide at clay till-like colluviums**

Landslide case studies (Cont'd)

- Mile 47.6

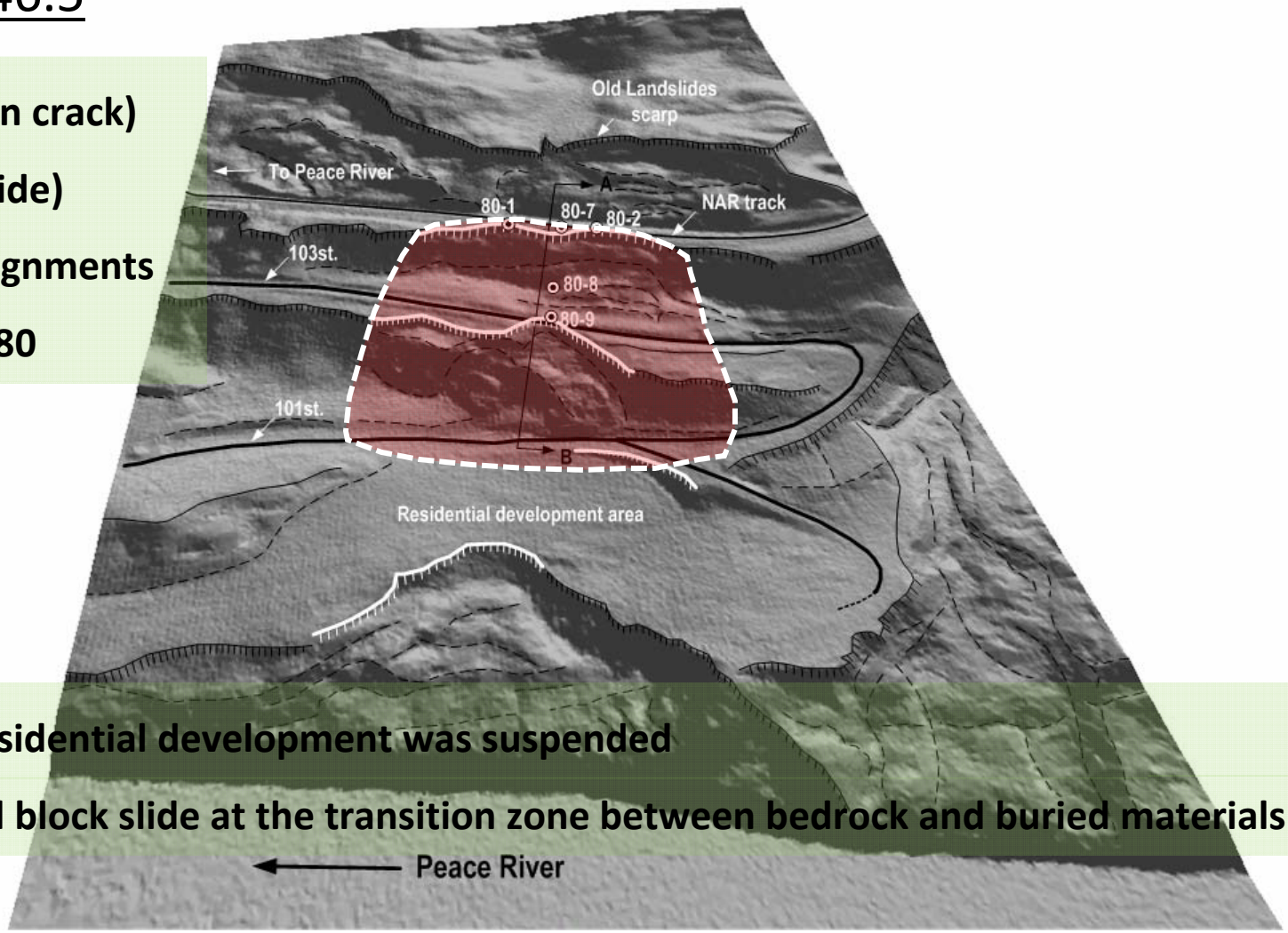


- 1984-1987
- CN rail and SH 744:04 cross on the top of this slide
- Slides are occurred at the transition zone between bedrock and buried materials

Landslide case studies (Cont'd)

- Mile 46.5

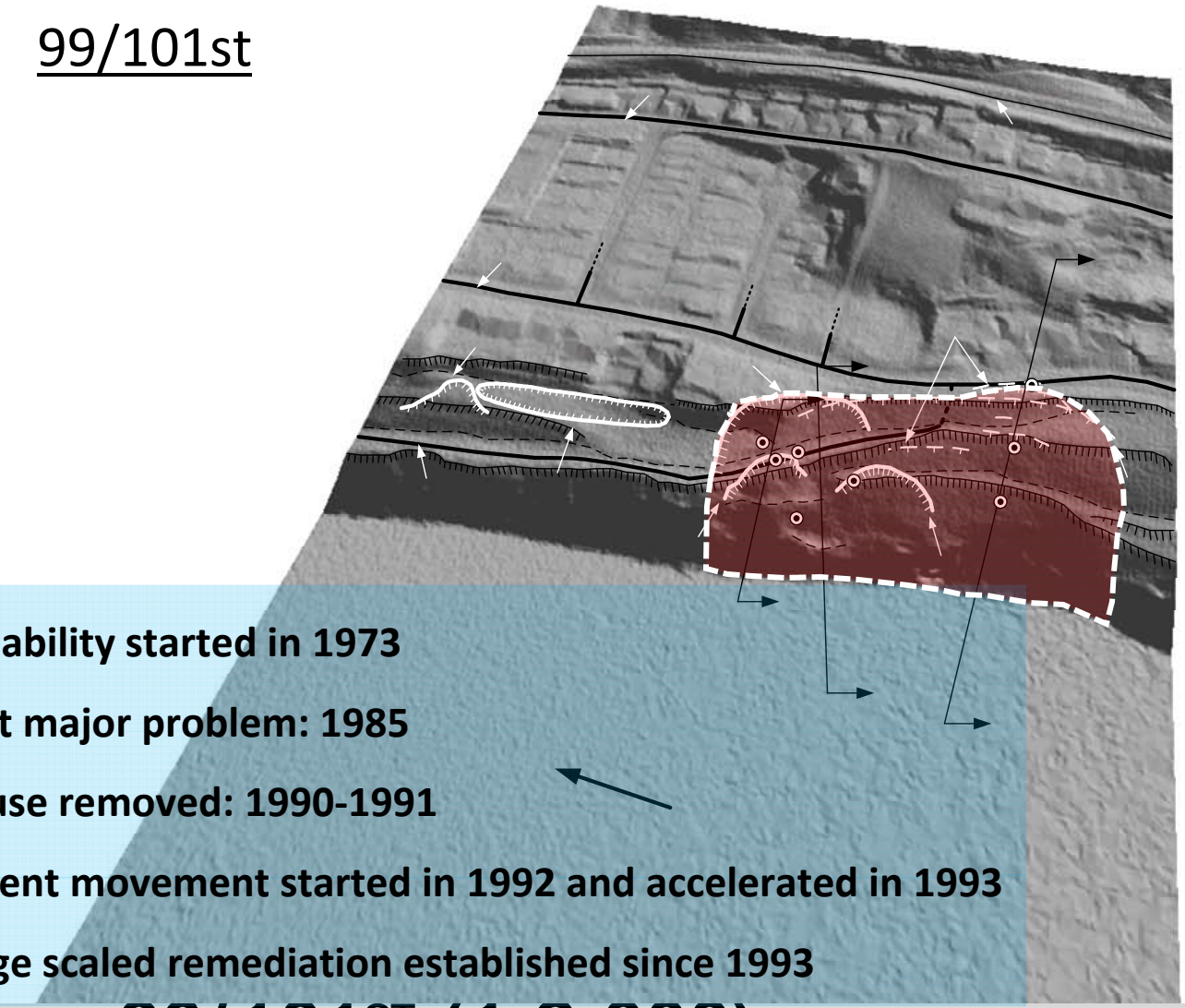
- 1978 (Tension crack)
- 1980 (Landslide)
- Railway realignments in 1966, 77, 80



- Proposed Residential development was suspended
- Translational block slide at the transition zone between bedrock and buried materials

Landslide case studies (Cont'd)

- 99/101st



- **Instability started in 1973**
- **First major problem: 1985**
- **House removed: 1990-1991**
- **Recent movement started in 1992 and accelerated in 1993**
- **Large scaled remediation established since 1993**

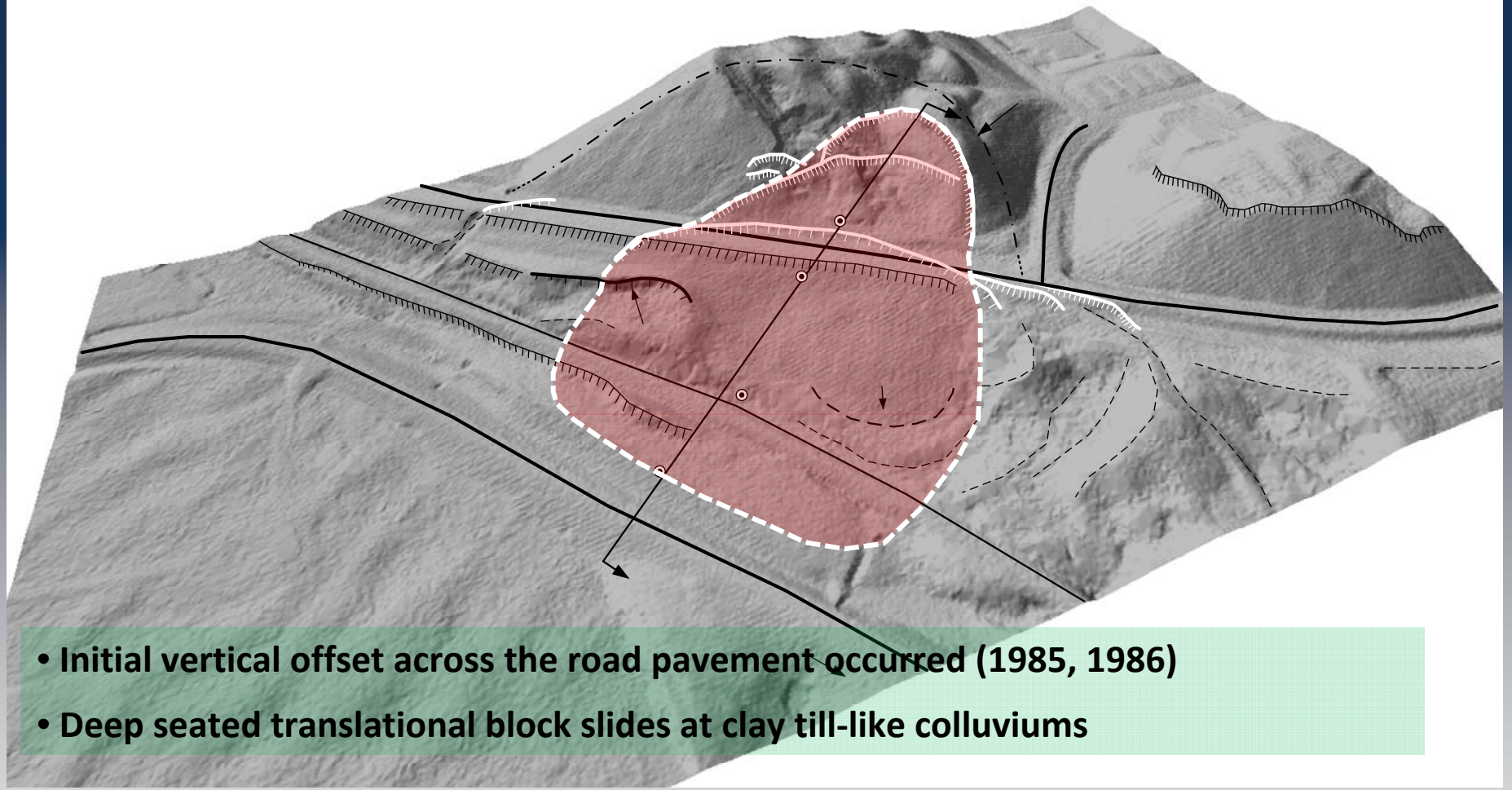
99/101ST (1:2,000)

Landslide case studies (Cont'd)

- 99/101st (Cont'd)

Landslide case studies (Cont'd)

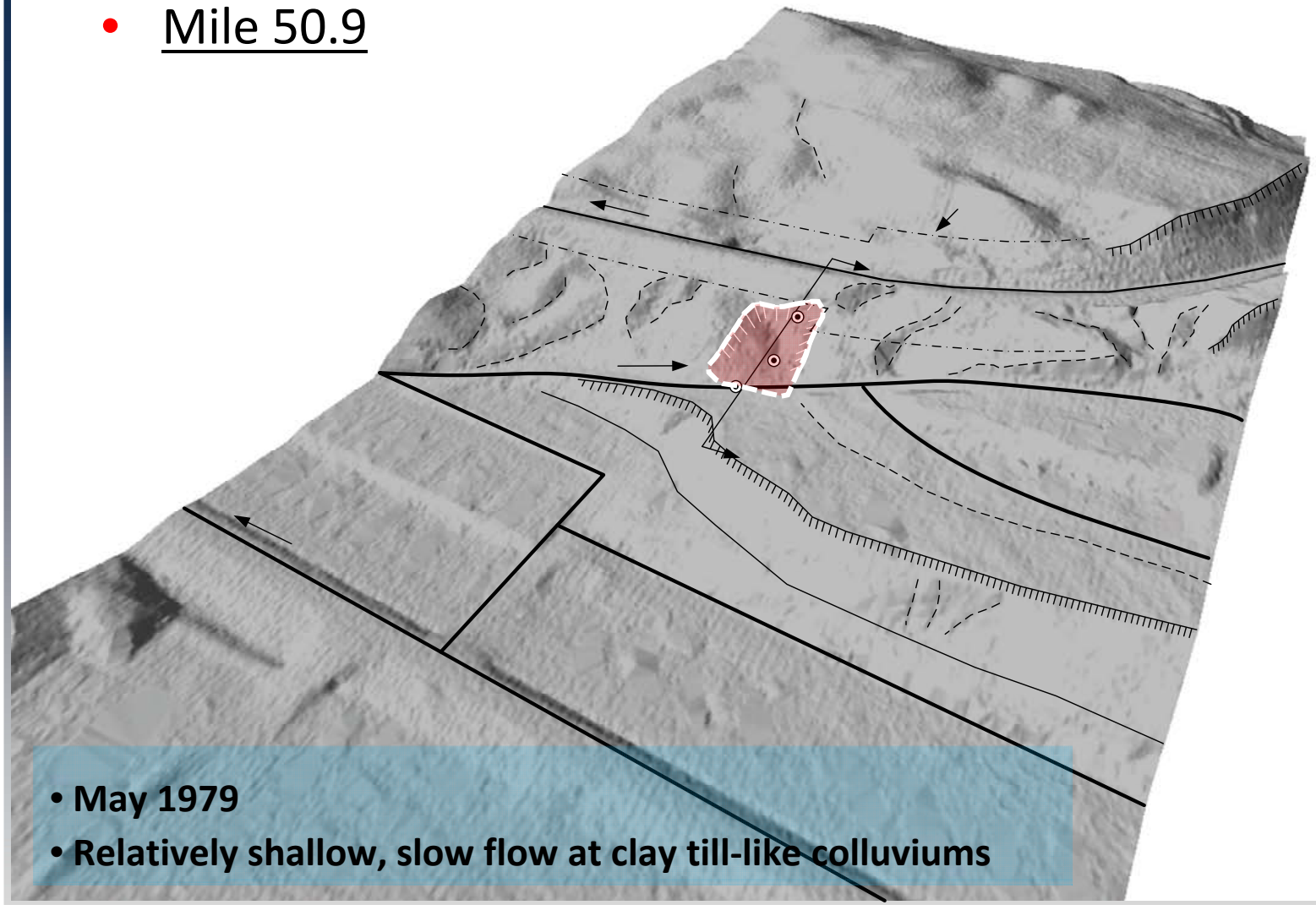
- Shop slide



- **Initial vertical offset across the road pavement occurred (1985, 1986)**
- **Deep seated translational block slides at clay till-like colluviums**

Landslide case studies (Cont'd)

- Mile 50.9

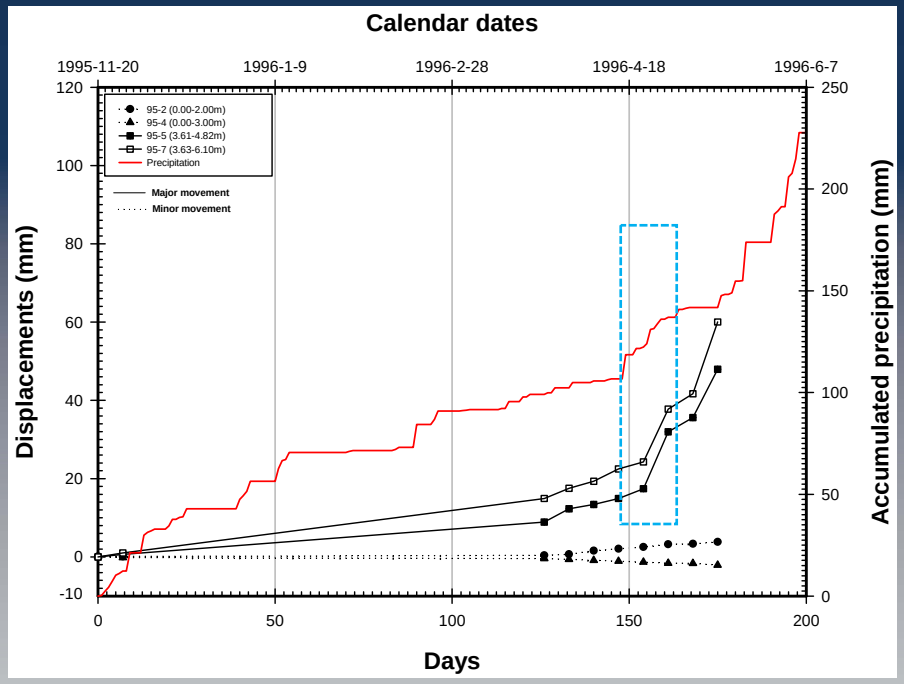


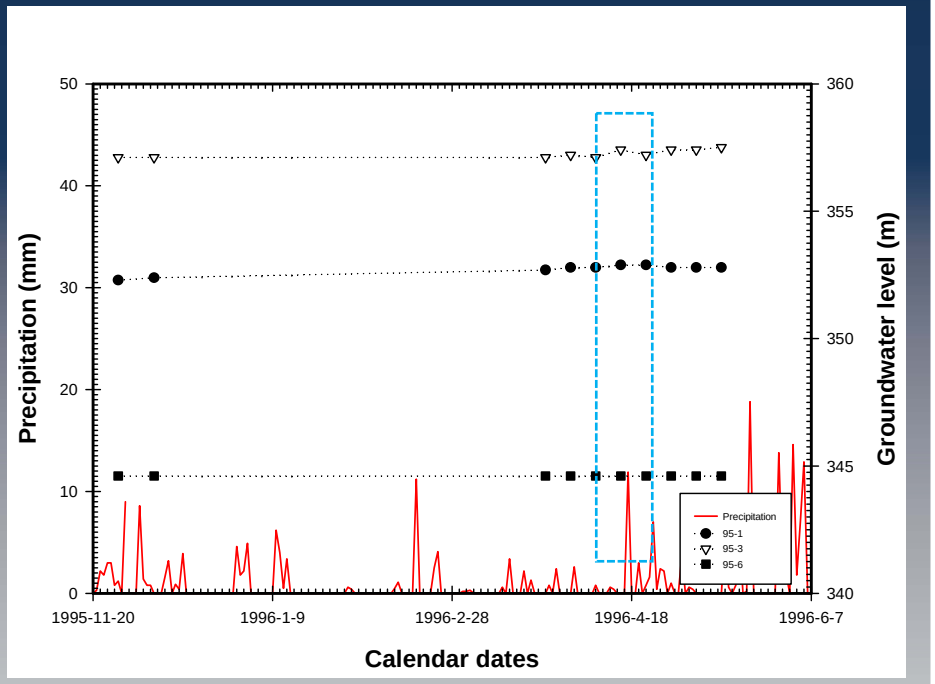
- **May 1979**
- **Relatively shallow, slow flow at clay till-like colluviums**

Landslide case studies (Cont'd)

- Movements vs. precipitations and ground water level

Mile 47.8

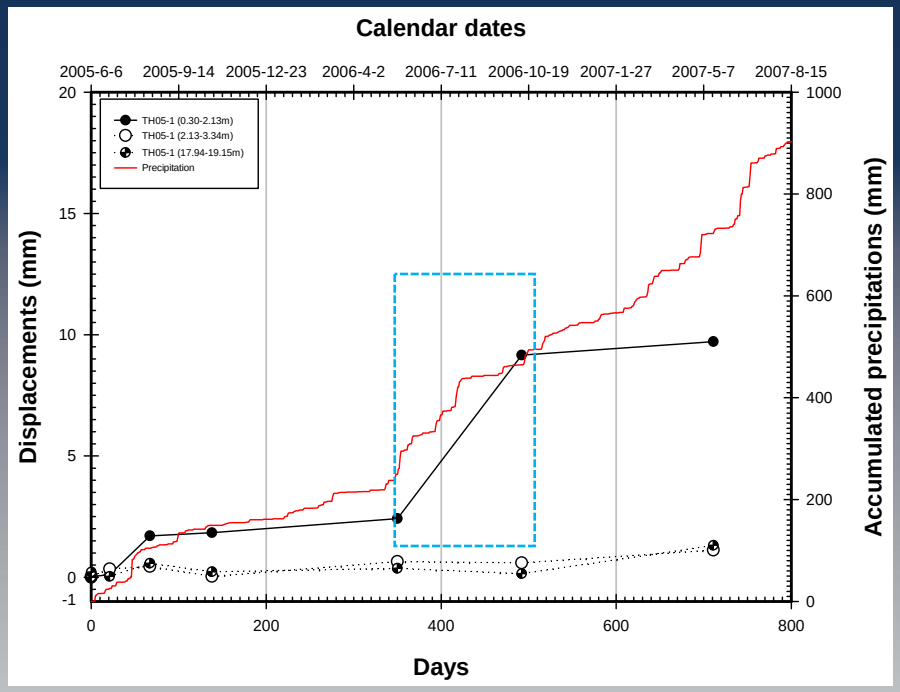


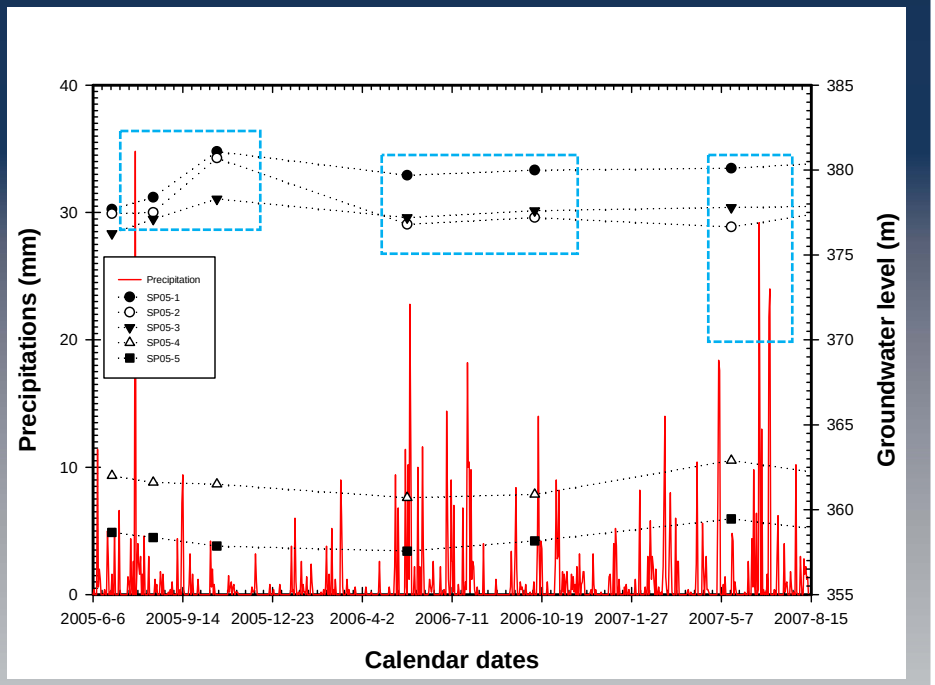


Landslide case studies (Cont'd)

- Movements vs. precipitation and ground water (cont'd)

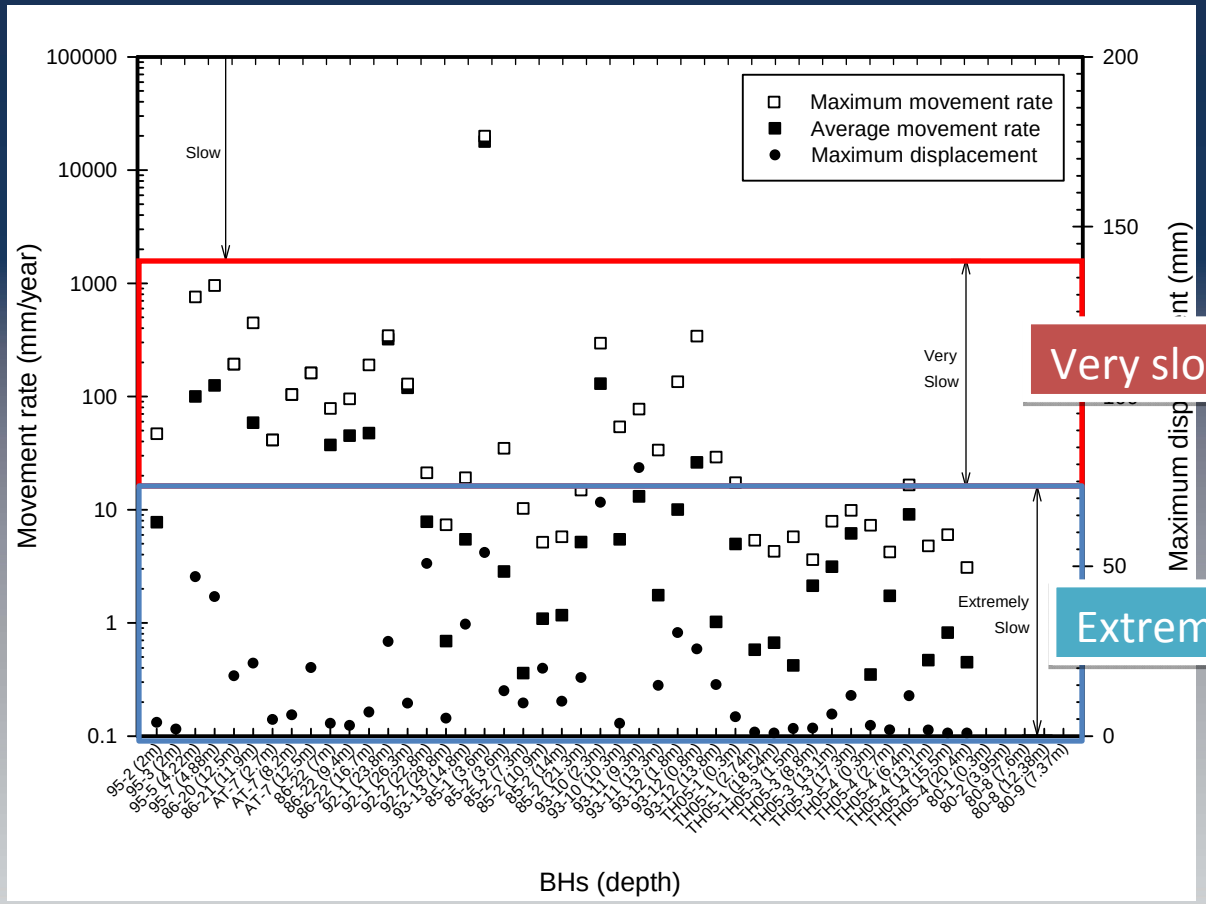
Shop slide





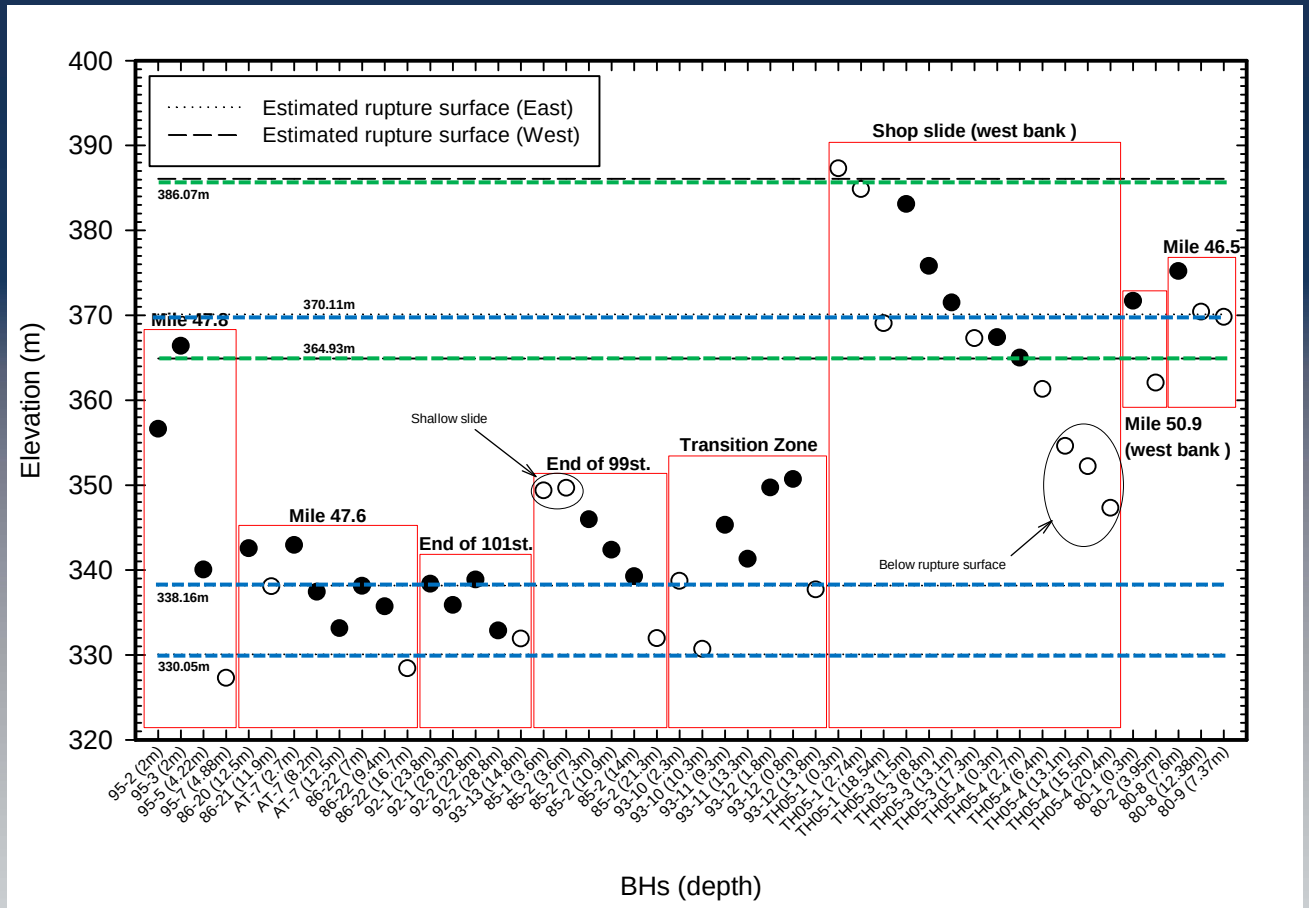
Landslide case studies (Cont'd)

- Total movements



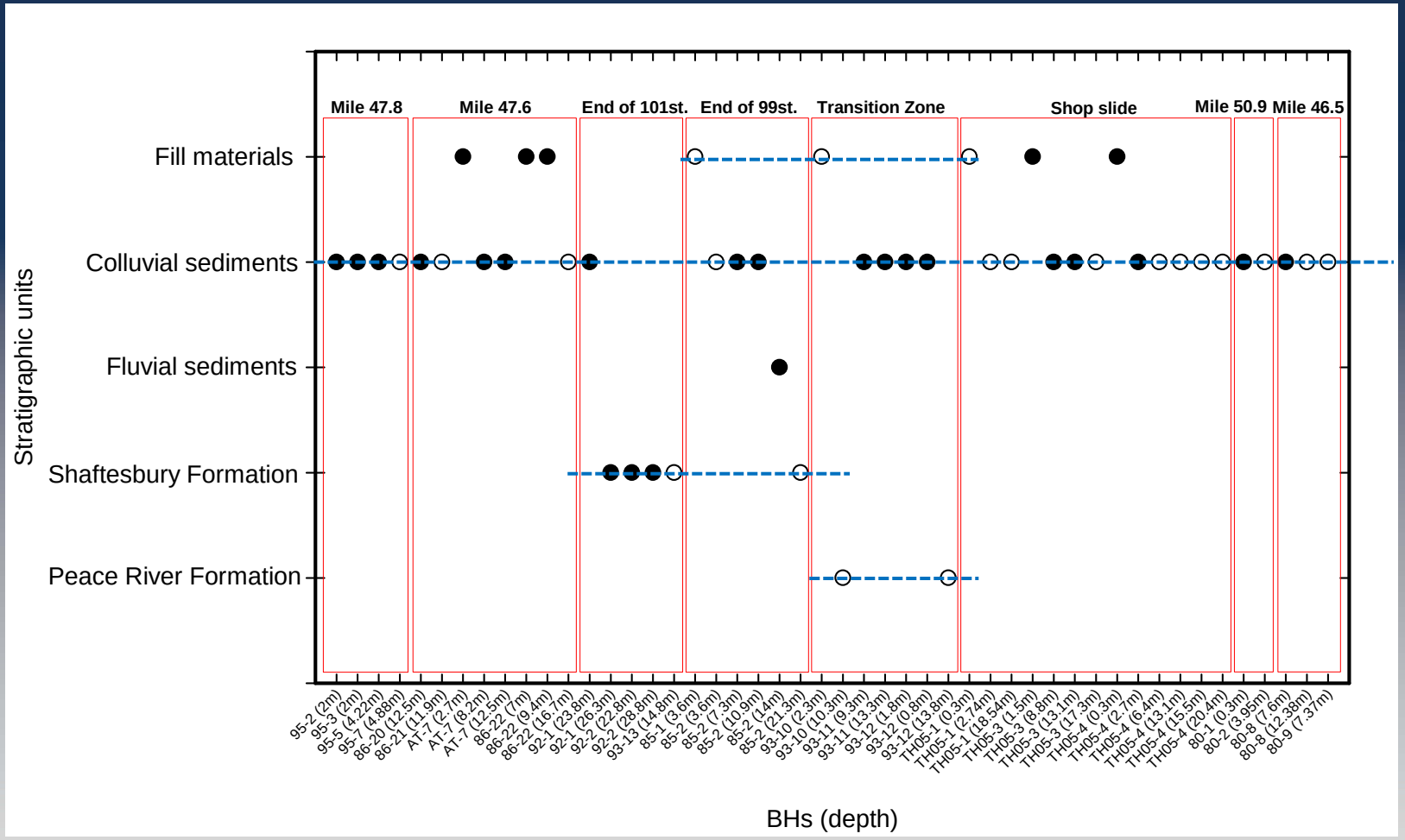
Landslide case studies (Cont'd)

- Rupture surface elevations



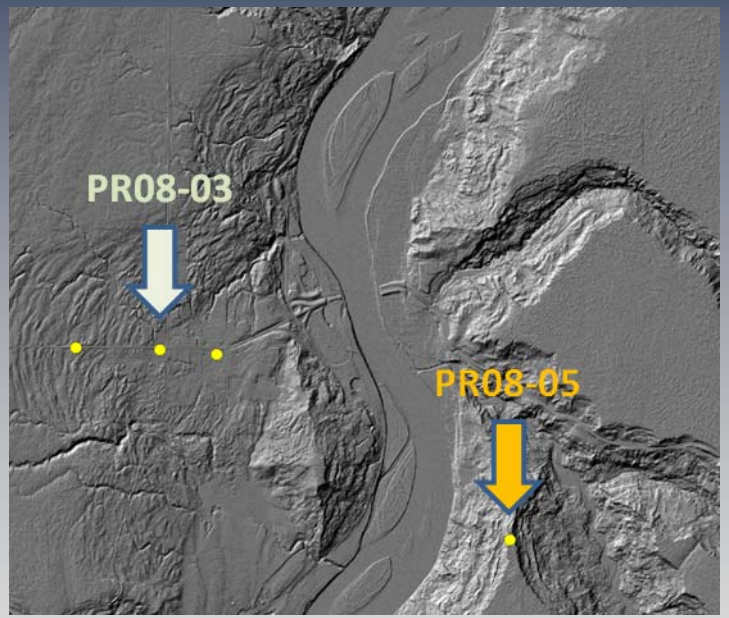
Landslide case studies (Cont'd)

- Soil profile on the rupture surface

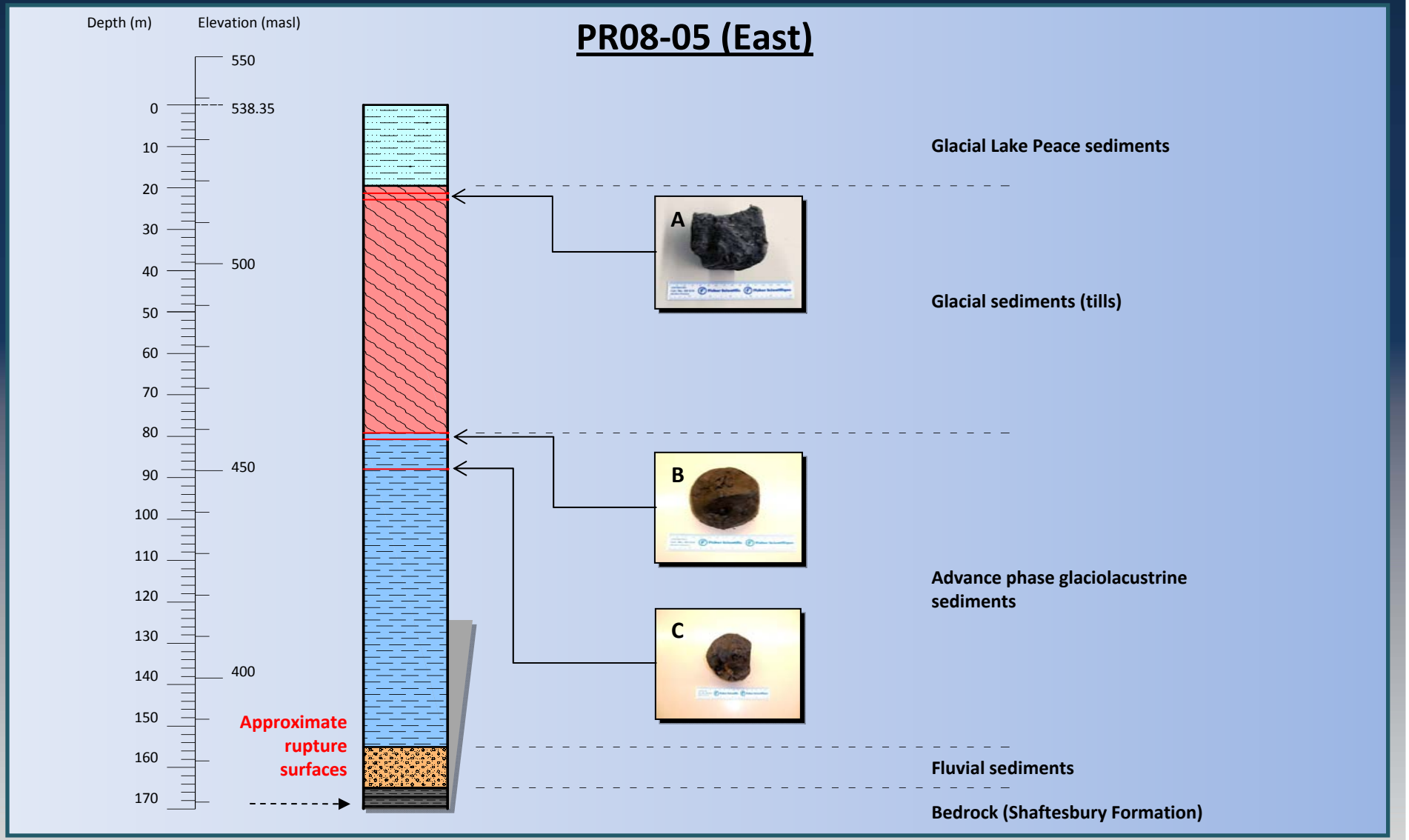


Lab tests

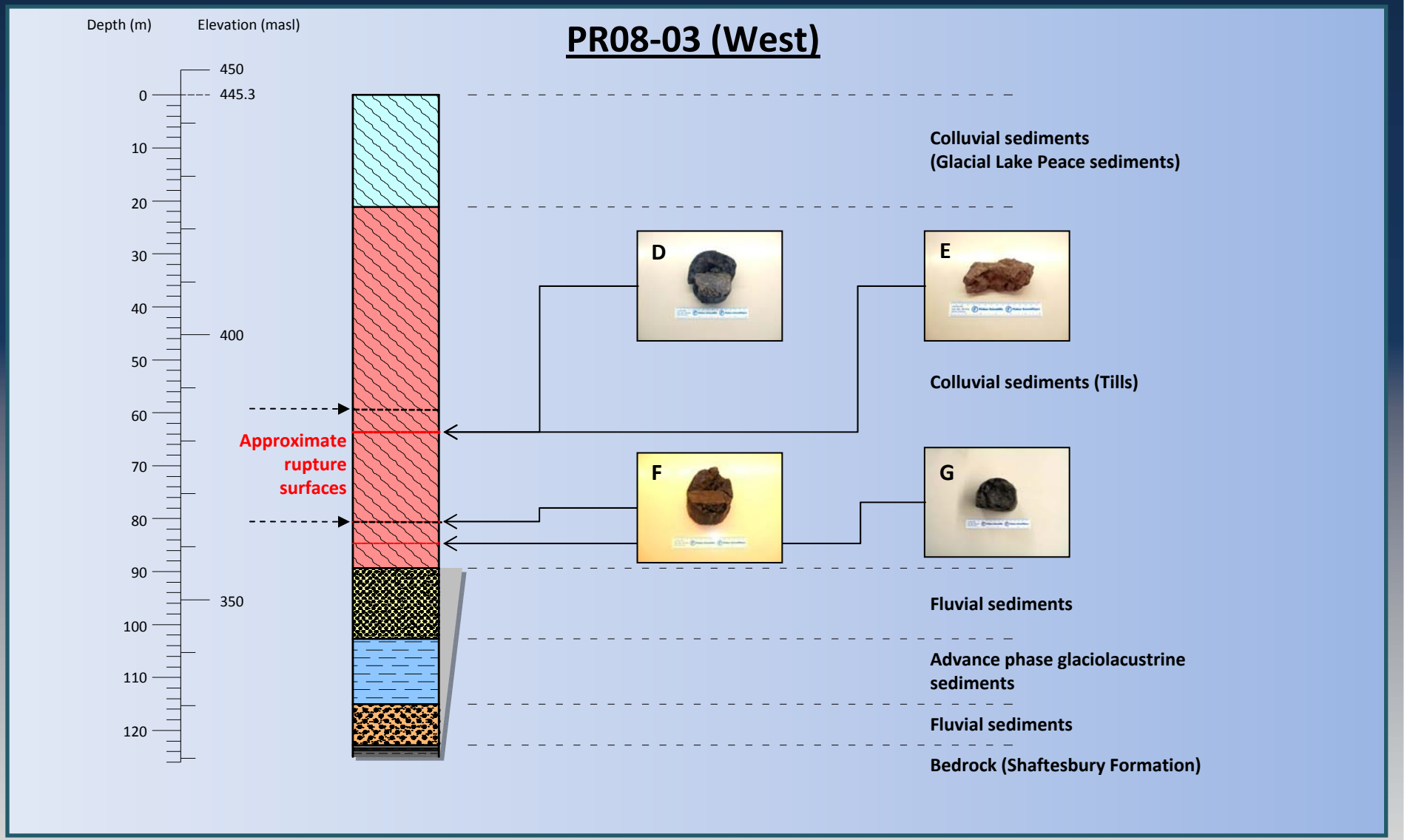
- Identify geotechnical properties of landslide materials
- Focusing on approximate rupture surfaces
  - East bank: 330.05 / 338.16 / 370.11 masl **Bedrock**
  - West bank: 364.93 / 386.07 masl **Colluvial sediments**
- Sampling borehole elevation
  - AGS (2008)
  - West bank: 445.30-320.33 masl
    - PR08-03
  - East bank: 538.35-361.40 masl
    - PR08-05



Lab tests (Cont'd)

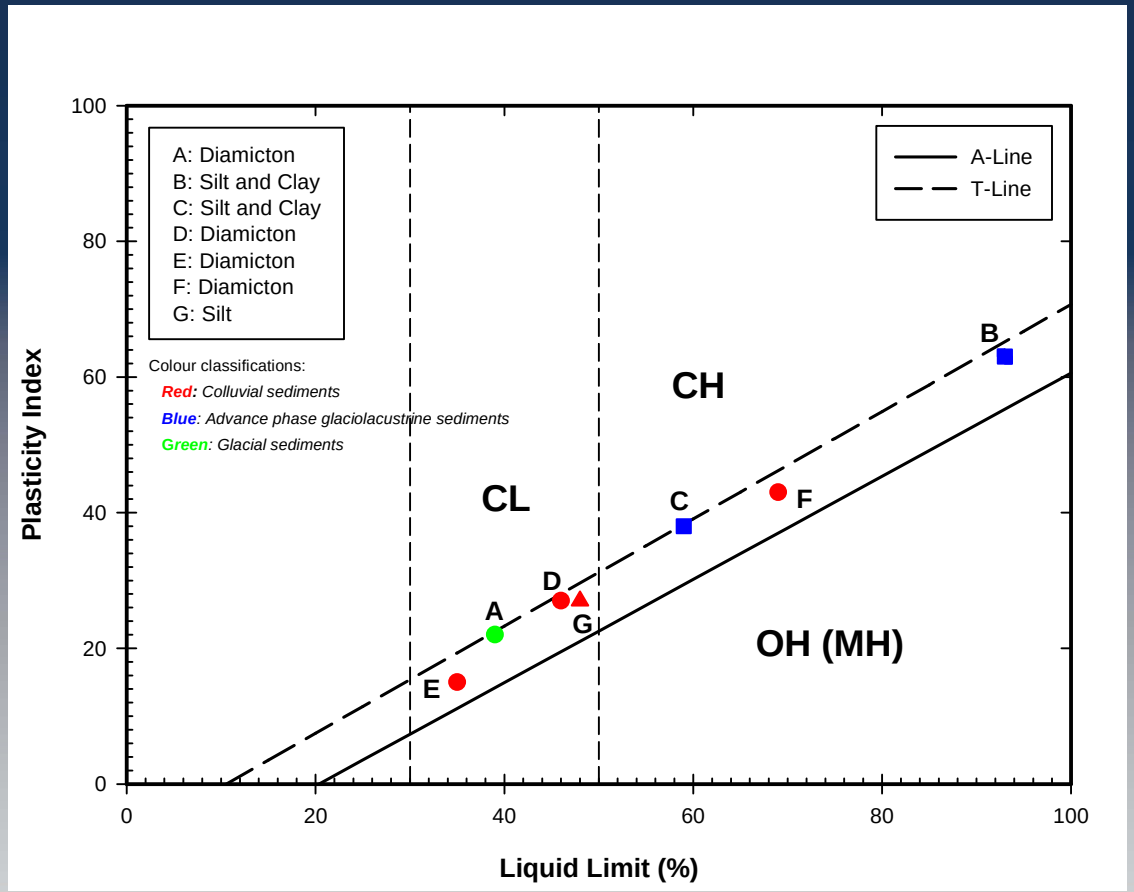


Lab tests (Cont'd)

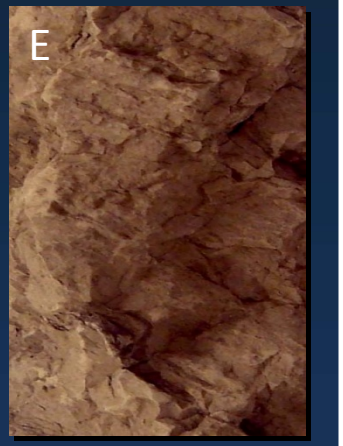


Lab tests (Cont'd)

- Plasticity chart



Lab tests (Cont'd)



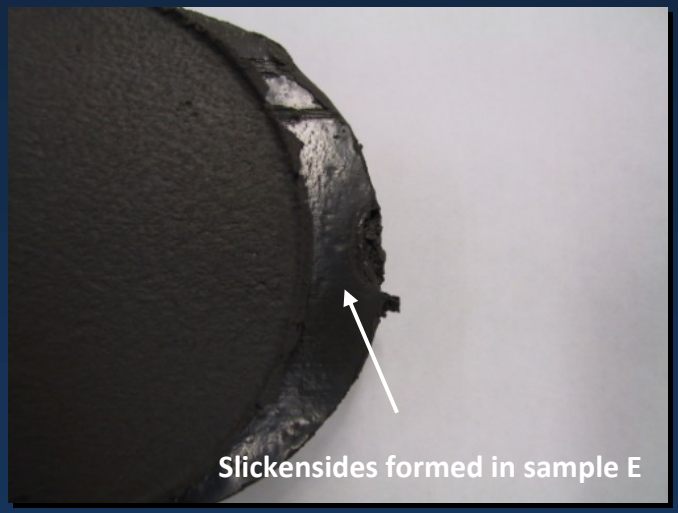
- Direct shear test
  - Sample descriptions

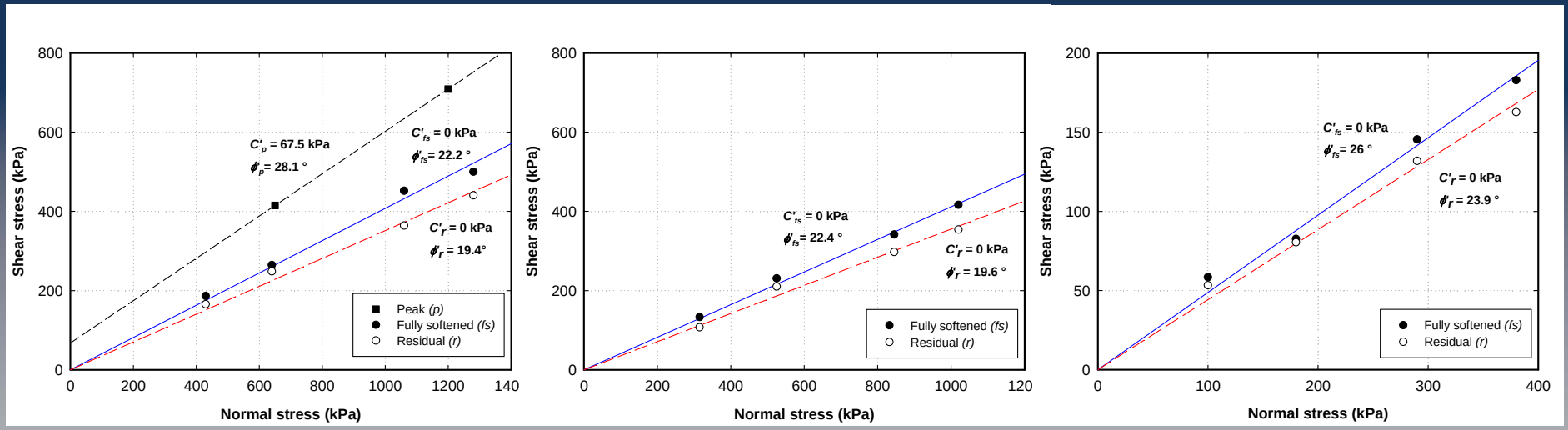
Diamicton	Colluvial sediments	Samples F and E
	Glacial sediments	Sample A
Silt and Clay	Advance phase glaciolacustrine sediments	sample B


Direct shear test machine

Lab tests (Cont'd)

- Direct shear test (Cont'd)
  - Diamicton





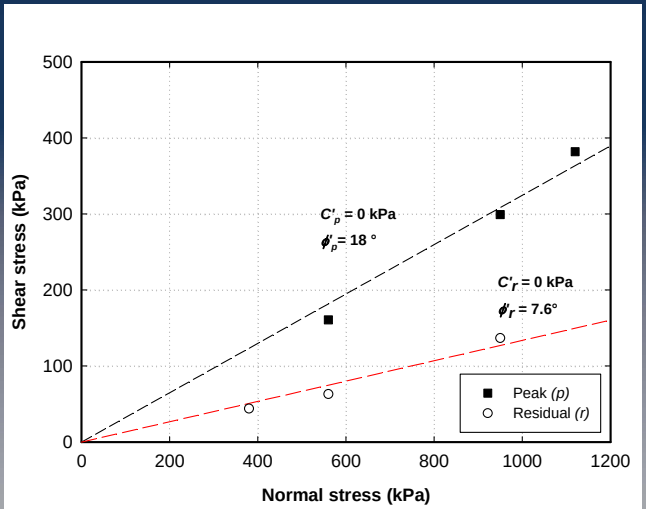
Sample F **Sample E** **Sample A**

Colluvial sediments

Glacial sediments

Lab tests (Cont'd)

- Direct shear test (Cont'd)
  - Silt and Clay



Sample B

Advance phase glaciolacustrine sediments

Formed Slickensides

Lab tests (Cont'd)

- Direct shear test (Cont'd)
  - Comparisons with previous values

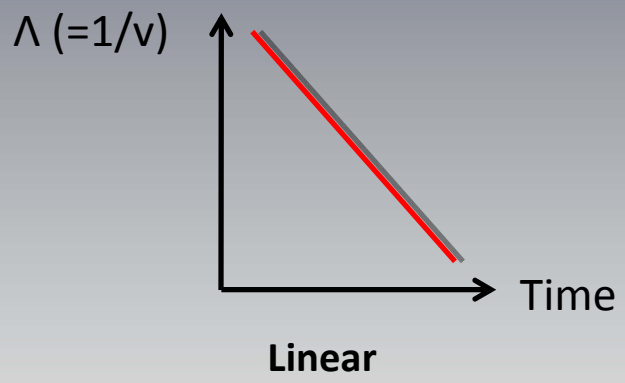
Till	Peak		Fully softened		Residual	
	C (kPa)	*Φ (°)*	*C (kPa)*	*Φ (°)*	*C (kPa)*	*Φ (°)*
Sharma (1970)	0	26-32	5.5	20-22	0	20
Ruel (1985)	3-20	28-32	-	-	-	-
Present study	**67.5**	**28.1**	**0**	**22.2-26**	**0**	**19.4-23.9**

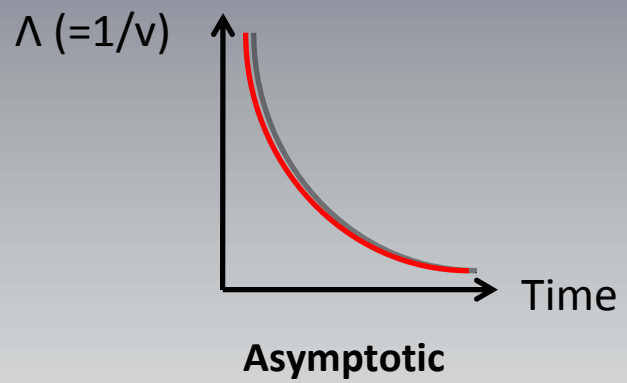
Clay	Peak		Fully softened		Residual	
	C (kPa)	*Φ (°)*	*C (kPa)*	*Φ (°)*	*C (kPa)*	*Φ (°)*
Sharma (1970)	6.9-18.6	20-30	24.2	17	0	10
Ruel (1985)	33	18	-	-	5	9
Present study	**0**	**18**	**-**	**-**	**0**	**7.6**

Movement characteristics

- Movement pattern of landslides
  - Velocity-time method (Λ-t approach)

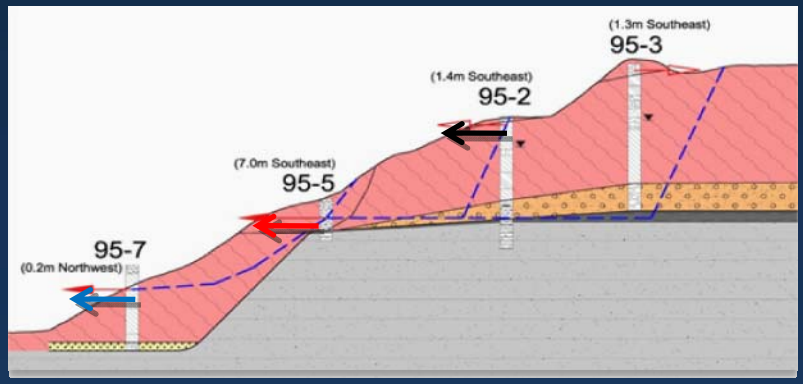
    "Failures in landslide are preceded by an accelerating trend"
  - Saito (1988), Voight (1988, 1989), Petley (2004)
  - 2 different patterns (in Λ-t space) during the accelerating phases
    - Linear: Brittle movement dominated → First time failure (Crack growth)
    - Asymptotic: Ductile movement dominated → Reactivation
  - Offers the possibility for determining the type of deformation

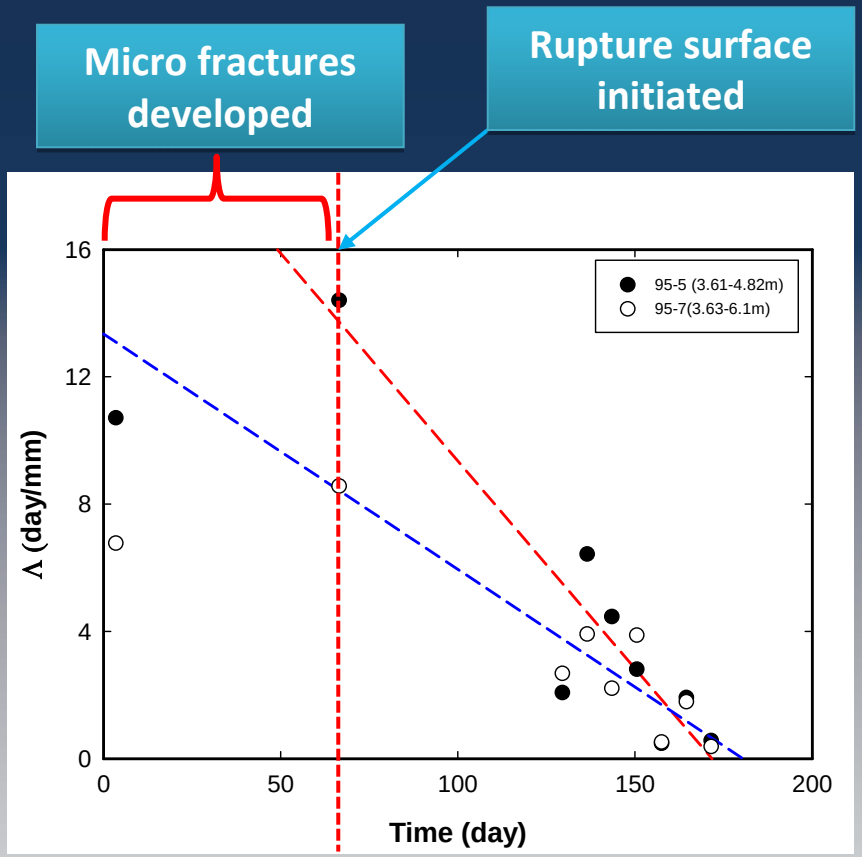


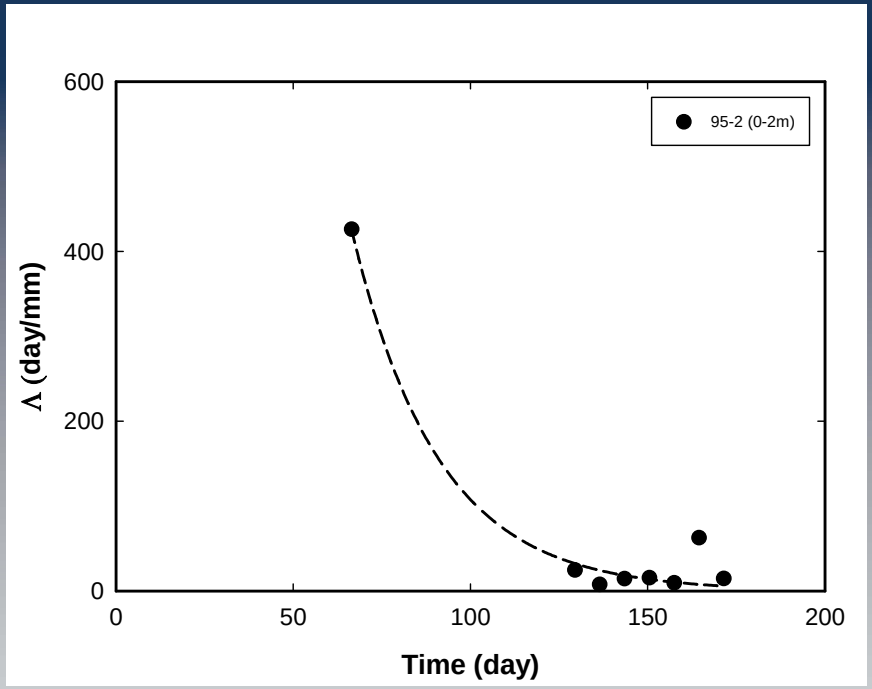


Movement characteristics (Cont'd)

- Movement pattern (Mile 47.8)

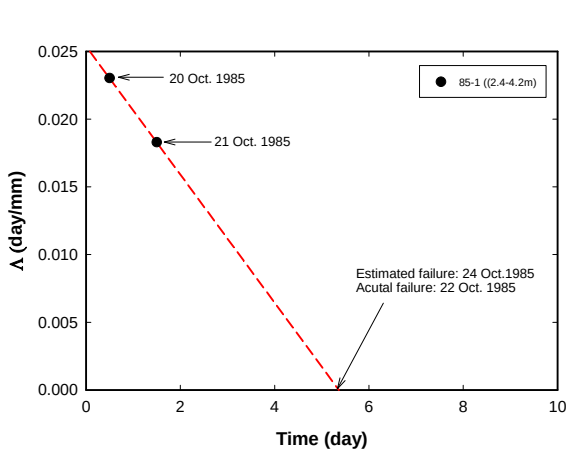


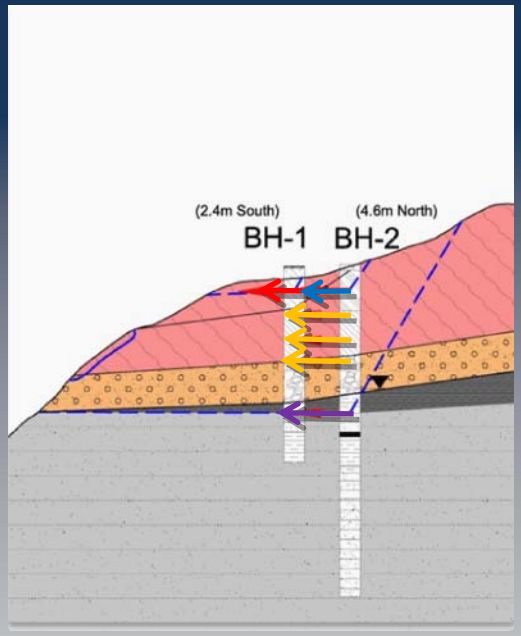


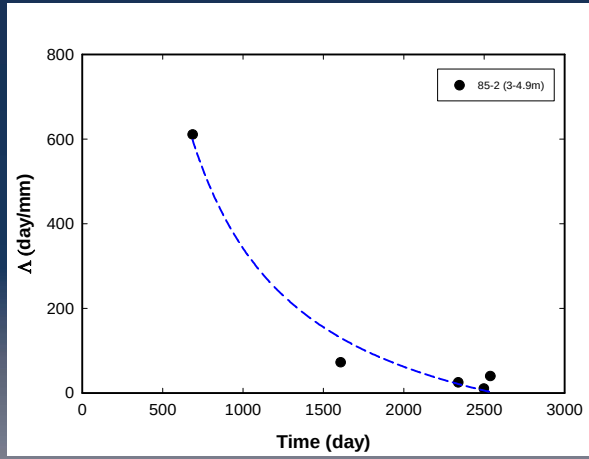


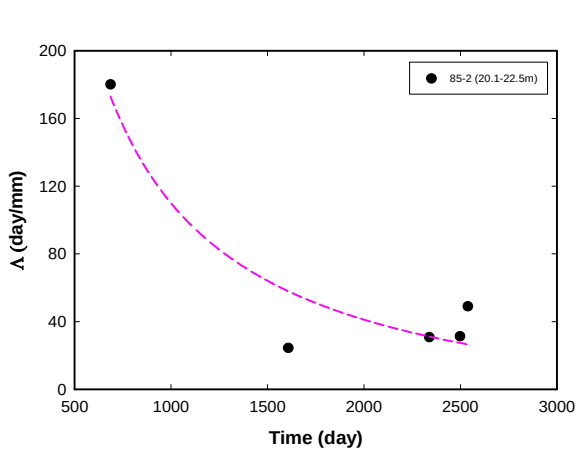
Movement characteristics (Cont'd)

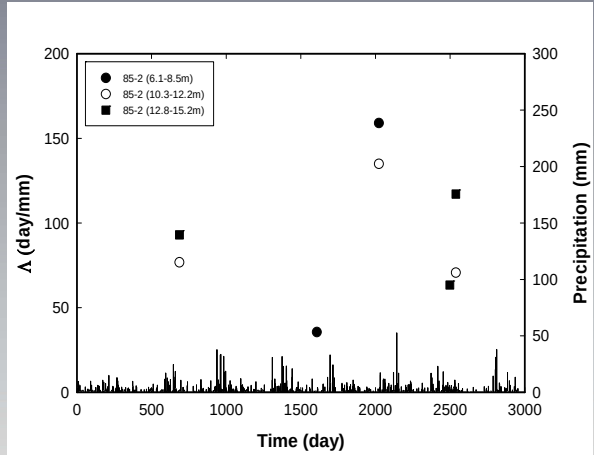
- Movement pattern (99/101st-End of 99st)



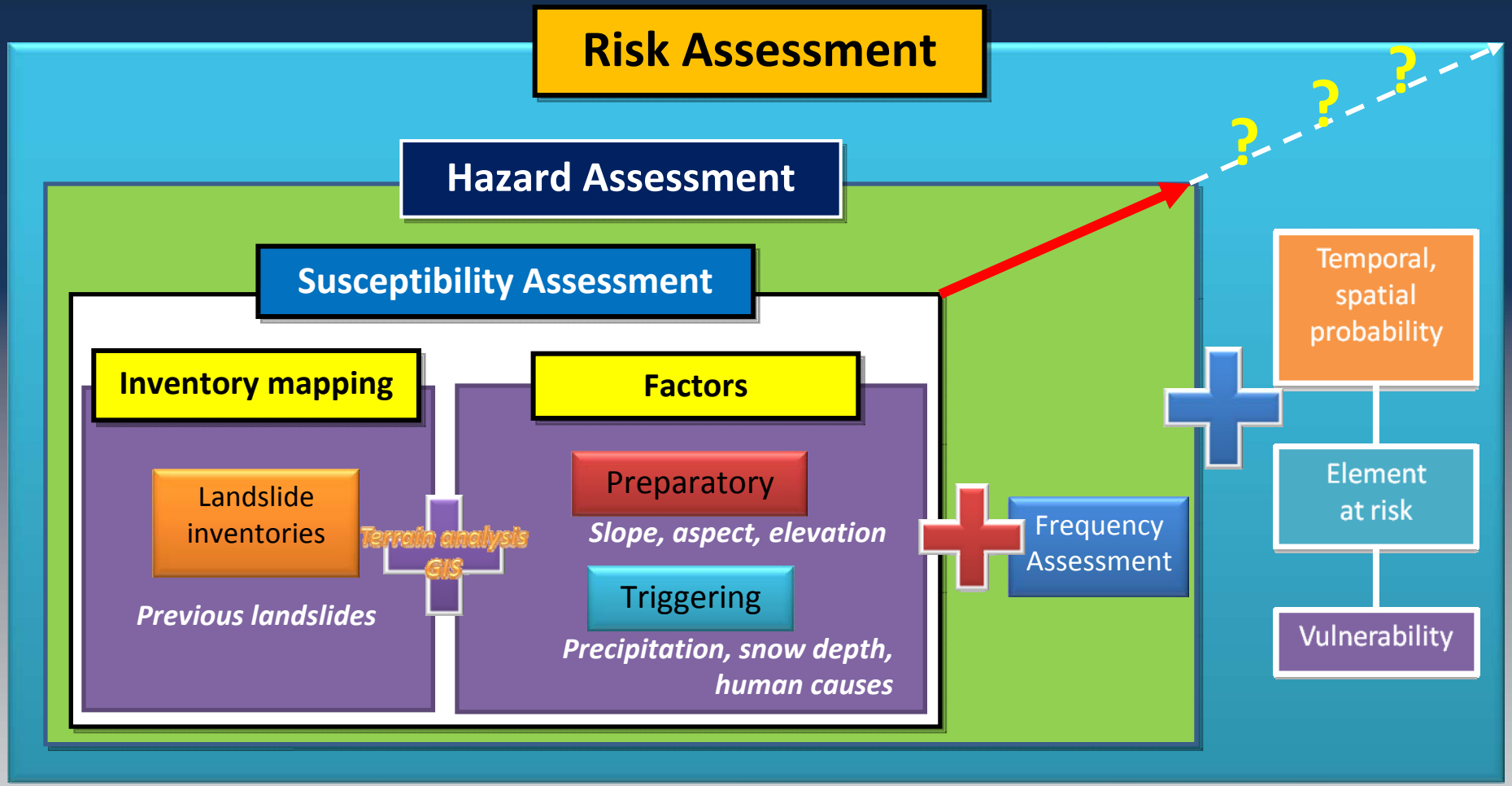








Susceptibility and hazard assessment



Acknowledgements

- Professors Martin and Cruden (University of Alberta)
- Corey Froese and James Morgan (Alberta Geological Survey)
- Natural Sciences and Engineering Research Council of Canada

Thank you for your attention!