Complex Earth Slide-Flows in Glaciolacustrine Deposits Over the Past 100 Years in Jeffersonville, VT.

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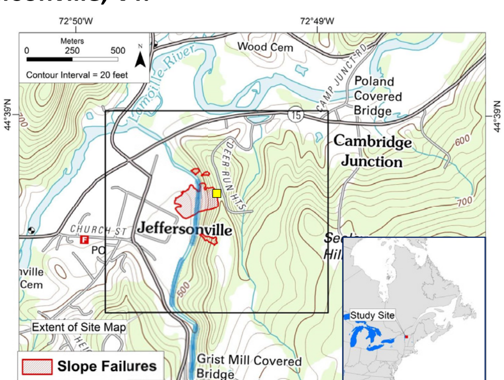
Analysis of soil strength, pore water pressure, precipitation, seismic profiling, and subsurface movement may help elucidate conditions for failure.

≈27,000 m^3 displaced on 18 April 1999

Photo: J. Kim, Vermont Geological Survey

Slope failures are located east of the Brewster River in Jeffersonville, VT.



Base map: USGS Jeffersonville Quad.

Landslide chronology was determined from archival imagery, orthophotos, and observations.

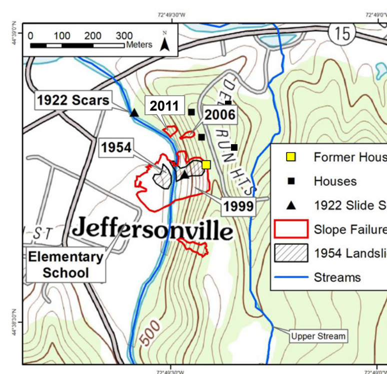
2011

2006

1999 (3)

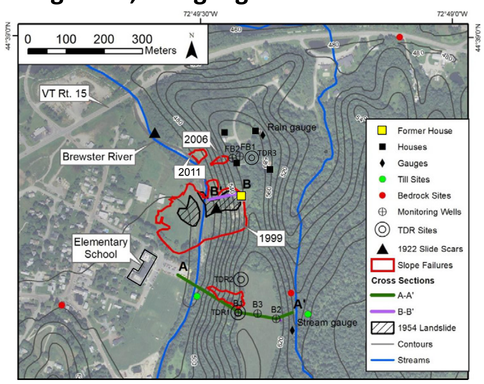
1954

Pre-1922



Base from USGS. Contour interval = 20 feet.

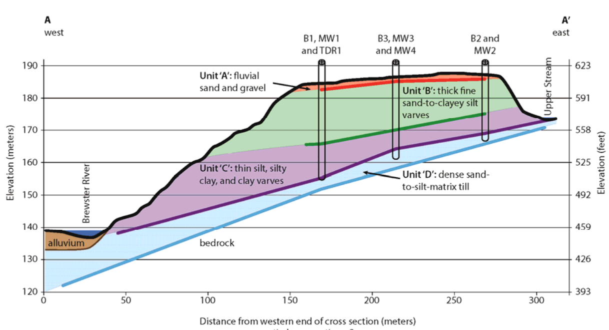
Location map for borings, cross-sections, TDR sites, monitoring wells, and gauges.



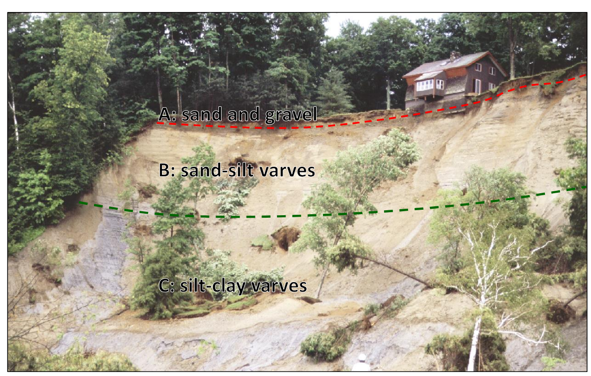
Base from 2008 orthophotos. Contour interval = 20 feet.

Specialty Drilling and Investigation assisted with installation of wells and core collection.

Stratigraphy was determined through field mapping, borehole analysis, and seismic profiling.



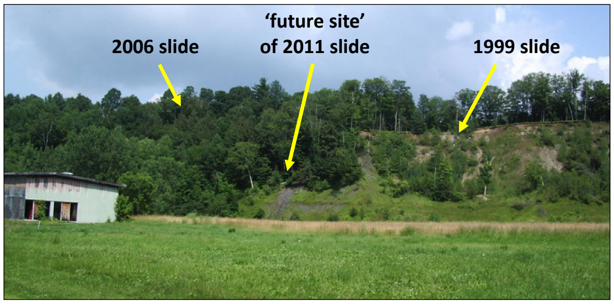
Units A, B, and C exposed after the 1999 event that removed over 27,000 m³ from a 46 m high terrace.



Looking east across Brewster River

Photo: J. Kim, Vermont Geological Survey

Stratigraphy was confirmed with exposures associated with subsequent failure events.



Looking east across Brewster River

The local fire department used the residence for one of their training exercises.


Deposits have been characterized and correlated with regional stratigraphy.

Environment of Deposition		*Materials*	*Unit*
Stream Terrace (<10,000 y bp)		Sand and gravel	A
Lake Vermont	Fort Ann Stage	Sand-silt varves	B
	Coveville Stage	Silt-clay varves	C (upper)
Lake Mansfield		Silt-clay varves	C (lower)
Subglacial (>13,600 y bp)		Till	D

The terrace, Unit A, is capped by Holocene fluvial sands and gravel.

Late Pleistocene glaciolacustrine deposits of Unit B represented by 1.5-2.5 ft thick layers of fine sand separated by thin silty-clay layers (thick varves).

Photo: J. Kim

Base of sandy layer is often undercut in the thick varves of Unit B.

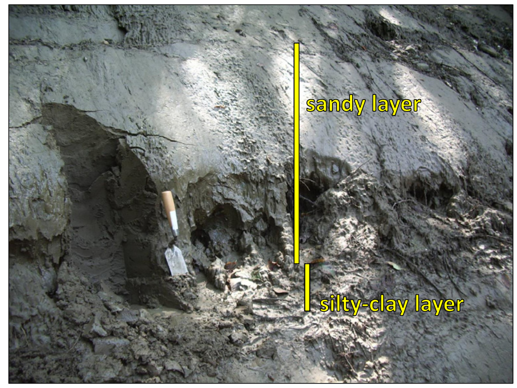


Photo: G. Springston

Late Pleistocene glaciolacustrine deposits of Unit C represented by stiff varves of fine sands and clayey-silt (brown), and silty-clay (grey) varves.

Photo: G. Springston

Two types of slope failures characterize this region.

Landslide gulley complexes:

- Smaller events, continuous.
- Common in the sand and gravel (Unit A), and the sand-silt horizons (Unit B).
- Cause: high permeability, low cohesion, and precipitation.

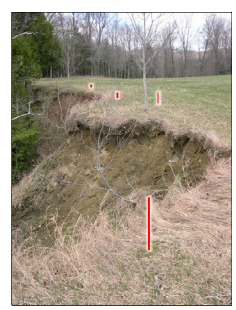


Photo: L. Kanat

Two types of slope failures characterize this region.

Complex earth slide-flows:

- Larger events, sporadic.
- Incorporates Units A, B and C.
- Driving force: water(?).
- Shallow rotational components, yet primarily translational sliding of earth blocks and earth flows.
- 1999 slide: 46 m high with a failure slope angle 34°.

Photo: J. Jenkauskas

Complex earth slide-flows have a runout length ≈233 m, extending ≈110 m across the river; travel angle of 11.2°.

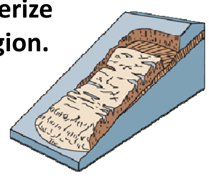
Photo: VT Landscape Change Program #LS21623_000; P. Bierman

Debris impacted house at the southwest extent of the runout, near the elementary school.

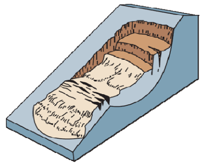
Photo: VT Landscape Change Program #LS21615_000; P. Bierman

Complex earth slide-flows characterize the catastrophic failures in this region.

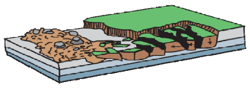
Initial failure, translational slide, peeled away material from the entire slope.



Remaining, unstable material, failed in a rotational fashion within Unit C.



The long runout is related to the high water content of the material.

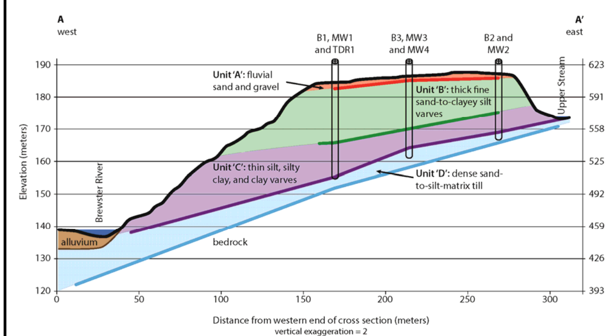


http://pubs.usgs.gov/fs/2004/3072/pdf/fs2004-3072.pdf

Rotational movement took advantage of a décollement zone defined by the top of the grey bench.

S. Wright, 1999 NEIGC VT. Photo: VT Landscape Change Program #LS21620_000; P. Bierman

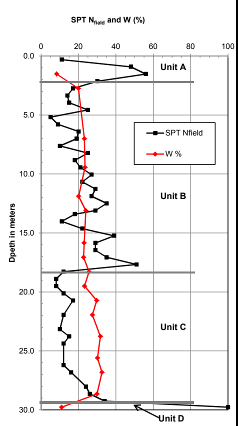
Laboratory work, gauges and monitoring wells provide insight into groundwater movement.



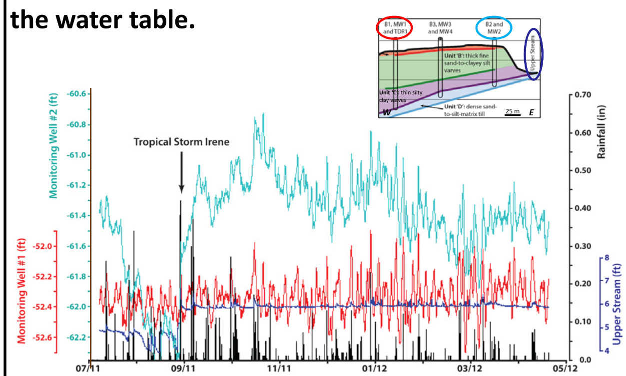
Engineering characteristics of each unit are clearly delineated.

Stratigraphic Unit	A	B	C	D
Average SPT-N (blows/ft)	36	23	16	>100
USCS Group	SP-SM	SM	CL	SC-SM
Soil Classification	Poorly graded sand with silt and gravel	Silty sand with sandy lean clay lenses	Lean clay with silty lenses	Silty clayey sand with gravel
Unit Weight (kN/m³)	20	18	17.5	21
Cohesion (kPa)	0	0	62	200
Effective Angle of Internal Friction	40°	*31°	*30°	40°
K (m/s)	1.5×10^{-4}	3×10^{-5}	2×10^{-7}	7×10^{-8}

* Direct shear test



Data from July 2011 through May 2012 show no lag time between precipitation events and changes in the water table.



Weiss 2012

Possible causes for the complex earth slide-flows:

- Increased pore pressure in the upper units (Bierman et al. 1999).
- Upper stream on east side of terrace.
- Low hydraulic conductivity in Unit C.
- Toe erosion.

Rip-rap restricts historical eastward undercutting of the slope by the Brewster river.

2013
2007
1995
1948
1927

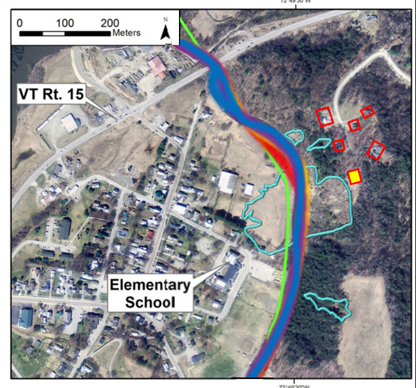


Photo: L. Kanat

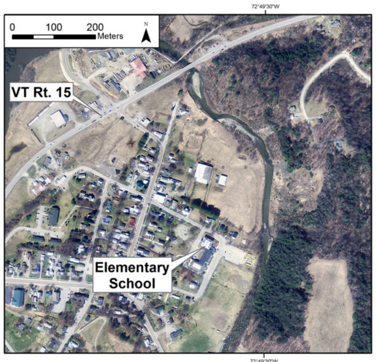
Preliminary conclusions from this work:

- Area of greatest concern is north of 1999 slide; secondary concern is above the school.
- Heavy or extended rains or heavy snowmelt could make slope failures more likely.
- Any future toe erosion by the river would make slope failures more likely.
- Slope failures at this site can apparently occur long after the driving event.

Future work at Deer Run Heights:

- Infiltration rates.
- Extend floodplain to the west.
- Assess contribution of the upper stream.

Future slope failures can be expected to extend across the river, placing the village at risk from direct landslide damage or from damming of river.



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