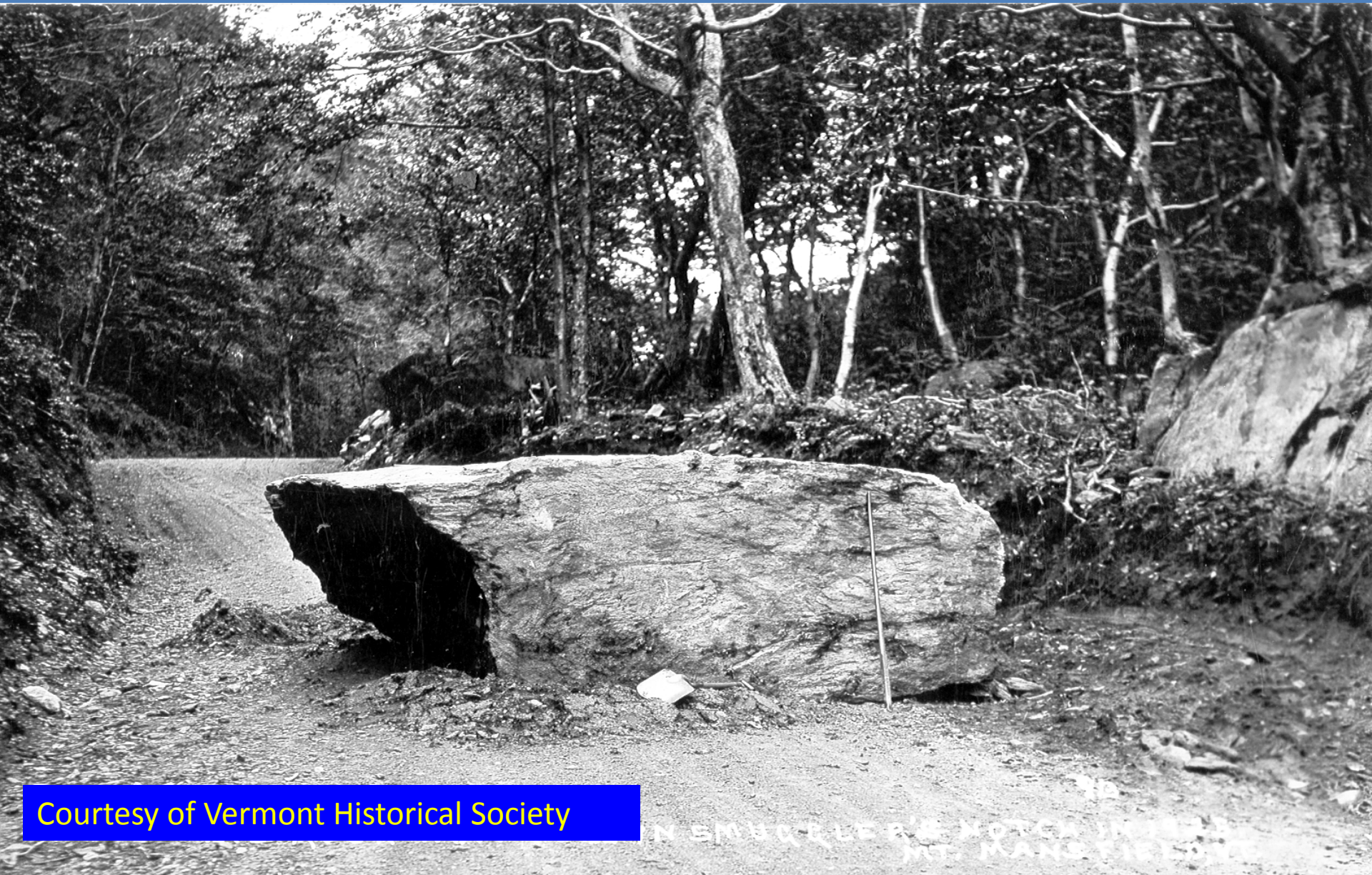


Rock Fall and Debris Flow Hazards in Smugglers Notch

Fallen Boulder in Middle of Smugglers Notch Road, about 1925

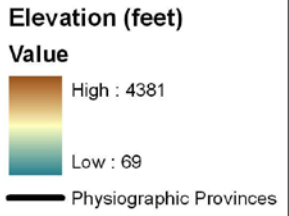
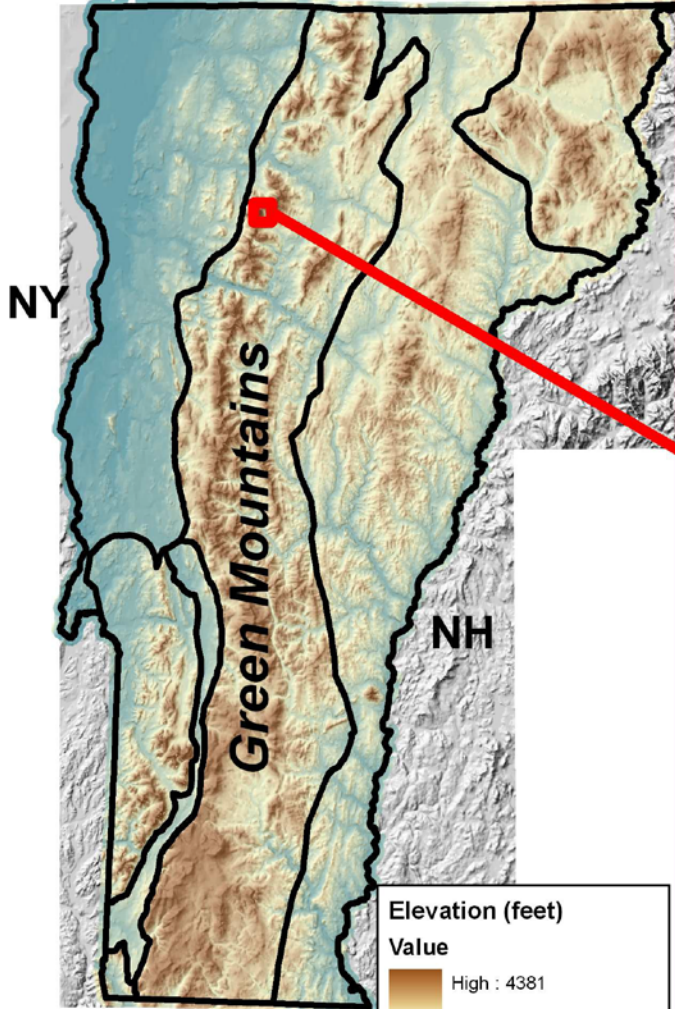


Courtesy of Vermont Historical Society

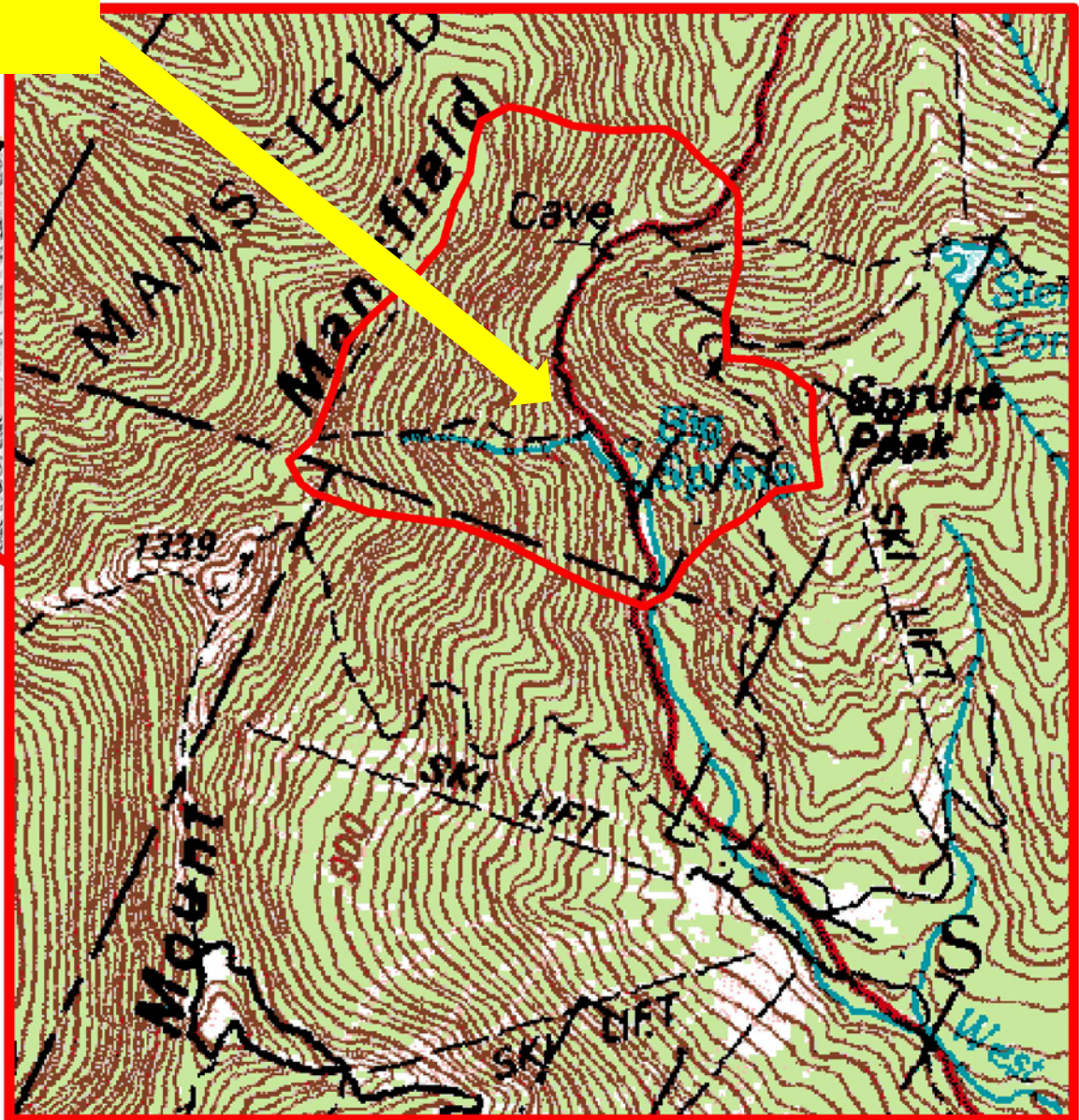
NEWBOLD LEWIS NOTES, 1925
MOUNTAIN MAN

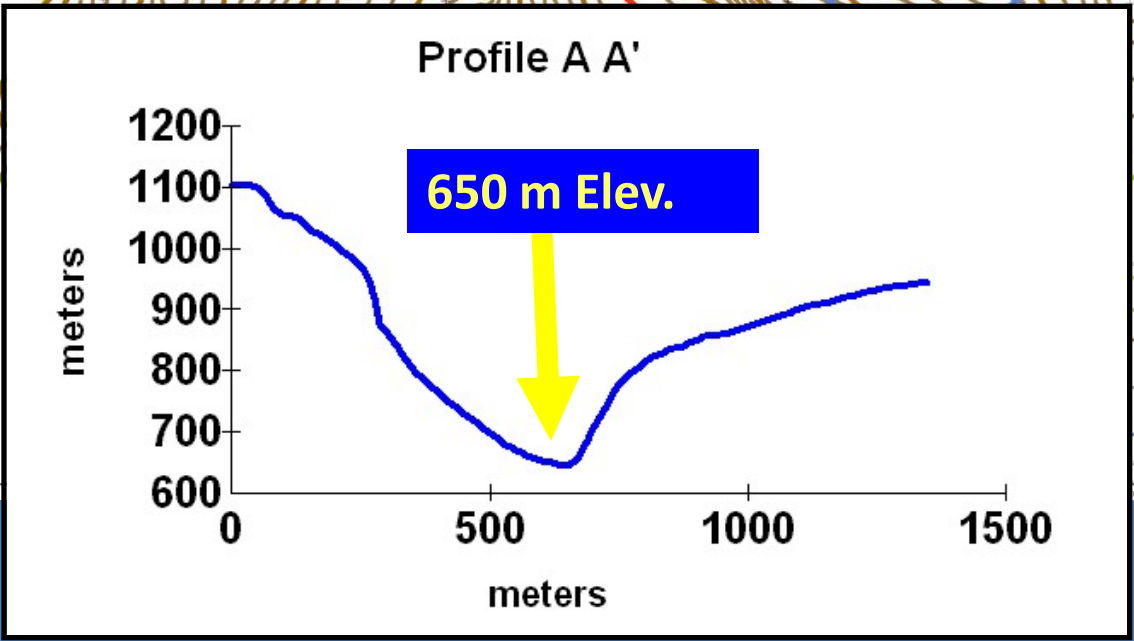
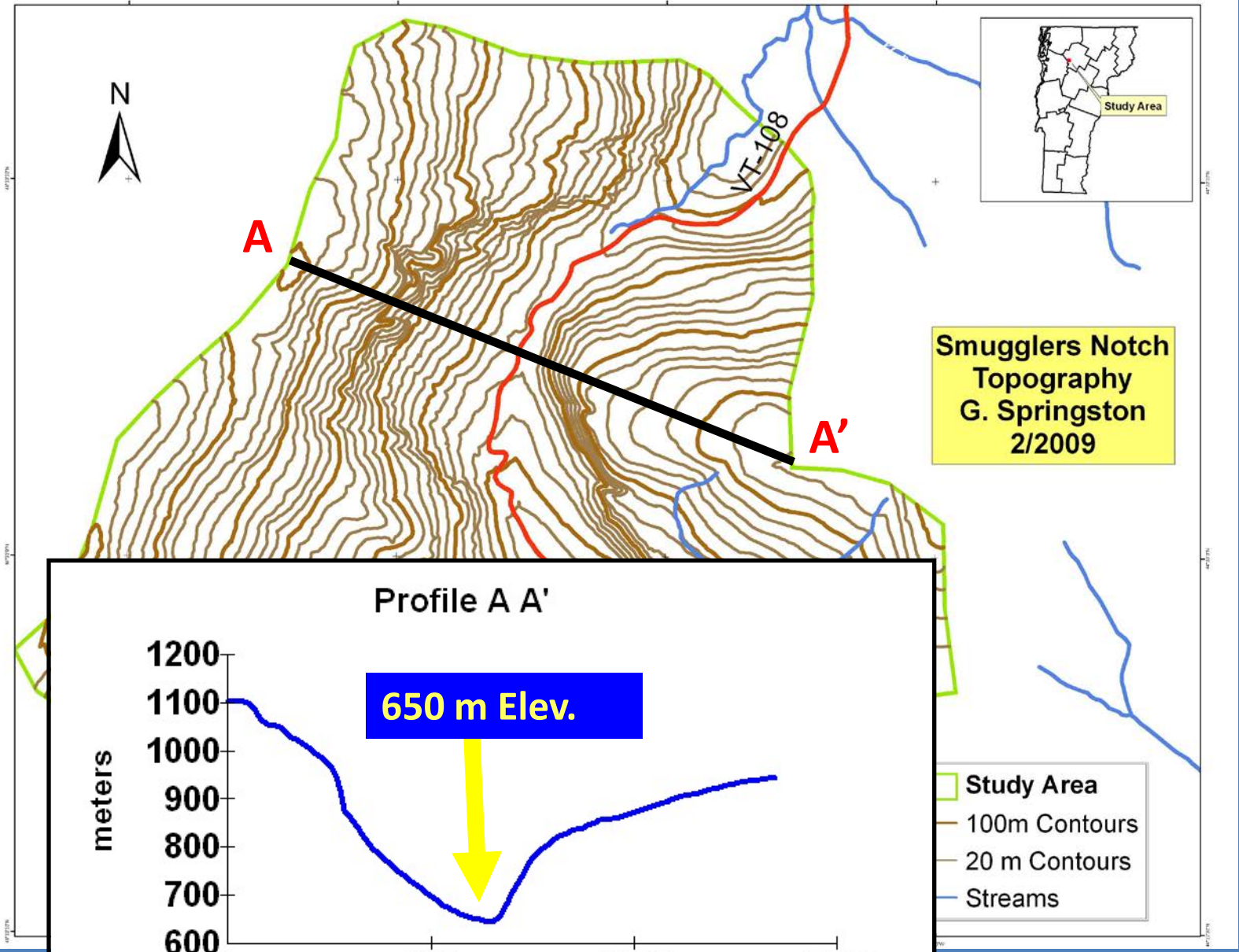
Study Area

Province of Quebec



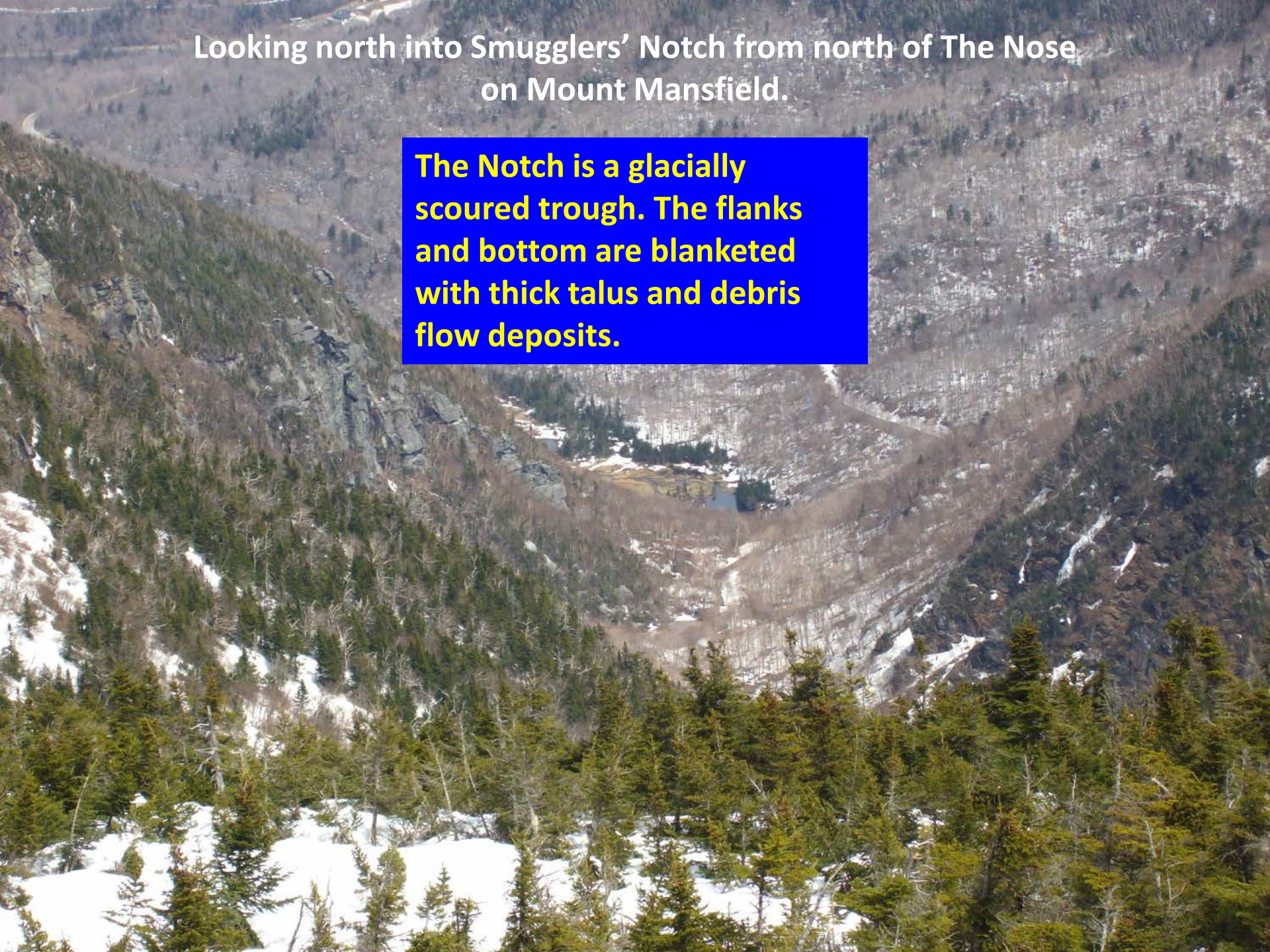
G. Springston
3/10/2009





Looking north into Smugglers' Notch from north of The Nose on Mount Mansfield.

The Notch is a glacially scoured trough. The flanks and bottom are blanketed with thick talus and debris flow deposits.



Elephant's
Head
buttress and
talus apron
on east side.

100 m

Talus

West Side
of Notch

160 m

2006
Rock
Fall

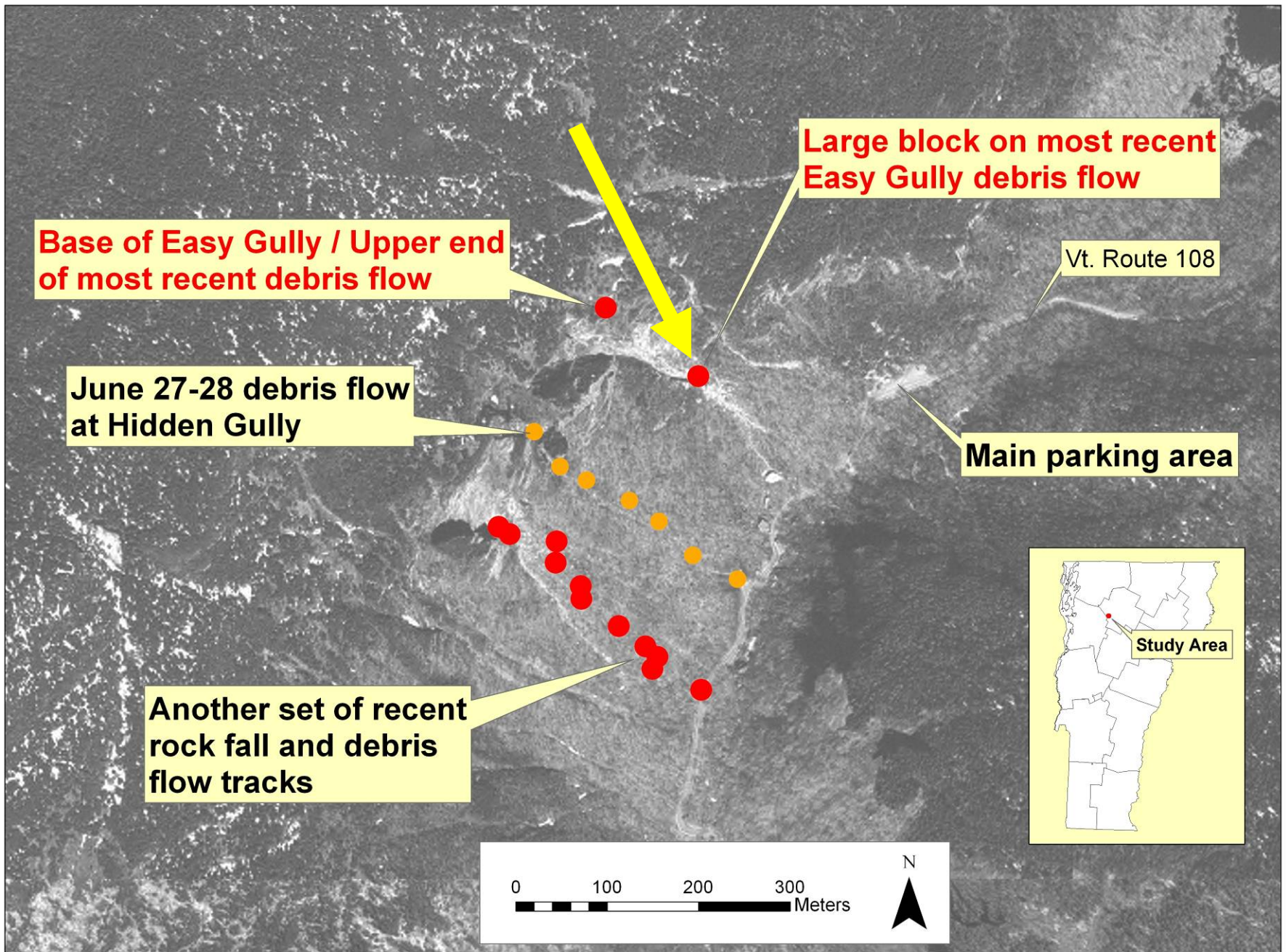


Figure 2. Orthophoto base map from Vermont Mapping Program aerial photos flown in 1996.

G. Springston, 8/25/2006

Looking southwest at large
block on surface of debris
flow.



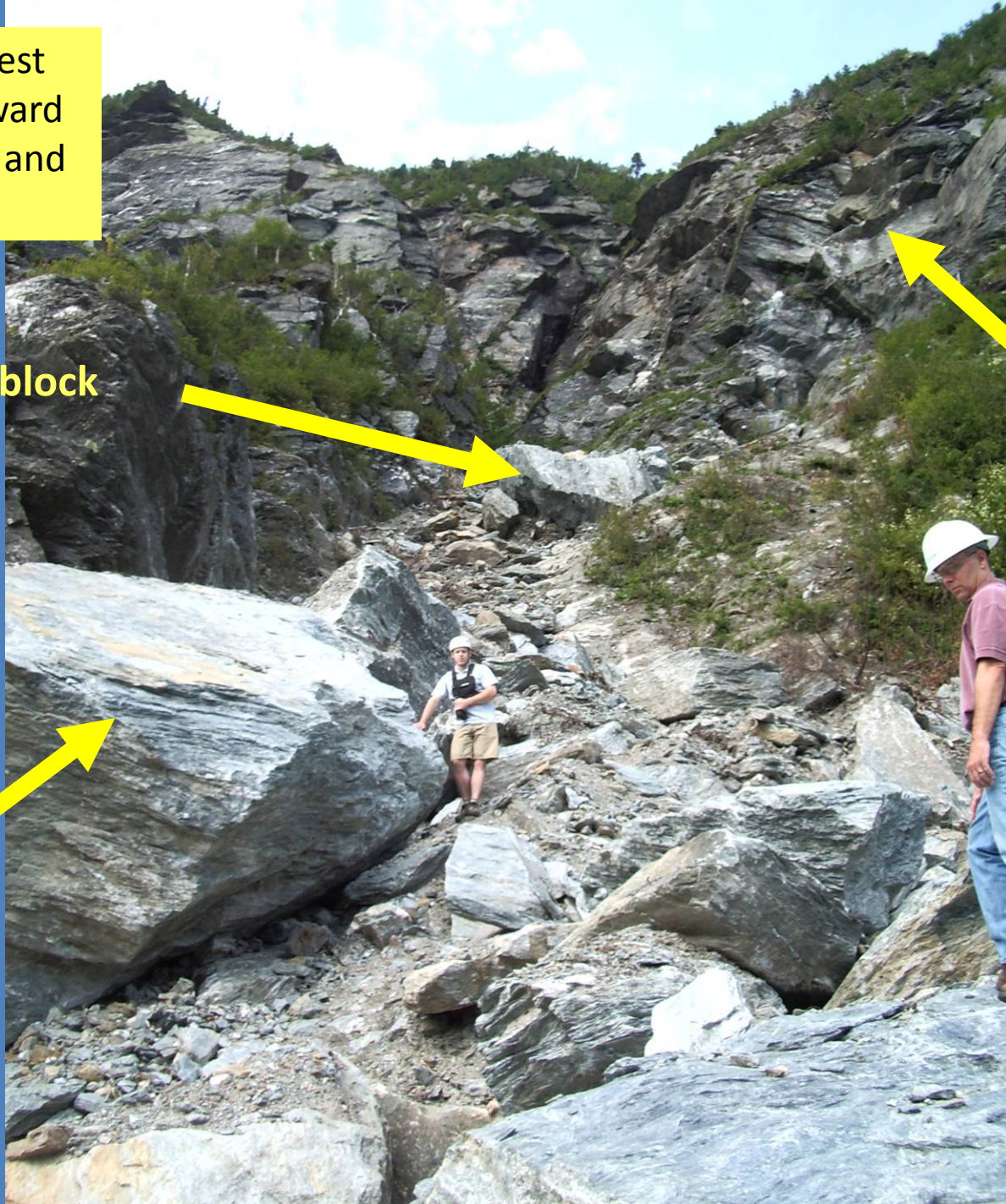
G. Springston
Photo 1894a
8/18/2006

Looking northwest
up the track toward
the source area and
Easy Gully.

Upper block

Source area

Largest block



G. Springston
Photo 1895a
8/18/2006

Looking
northwest at
overhanging
ledges in source
area for rock fall.



G. Springston
Photo 1900a
8/18/2006

Looking east down slide track showing site of impact on south side of Easy Gully.

Vt. Route 108

Bounce site

Blocks

G. Springston
Photo 1906a
8/18/2006



Looking southeast at
base of large block.

Lower end of large block

Keystone holding block in place

Bedrock

Larry Becker
Photo 007
8/18/2006



Rapelling down
Easy Gully.
Abundant
debris
underfoot.

**Note vegetation. These
gullies have abundant
water.**

**This is typical
source of
material for
debris flows
below.**

G. Springston
Photo 3782a
10/11/2007

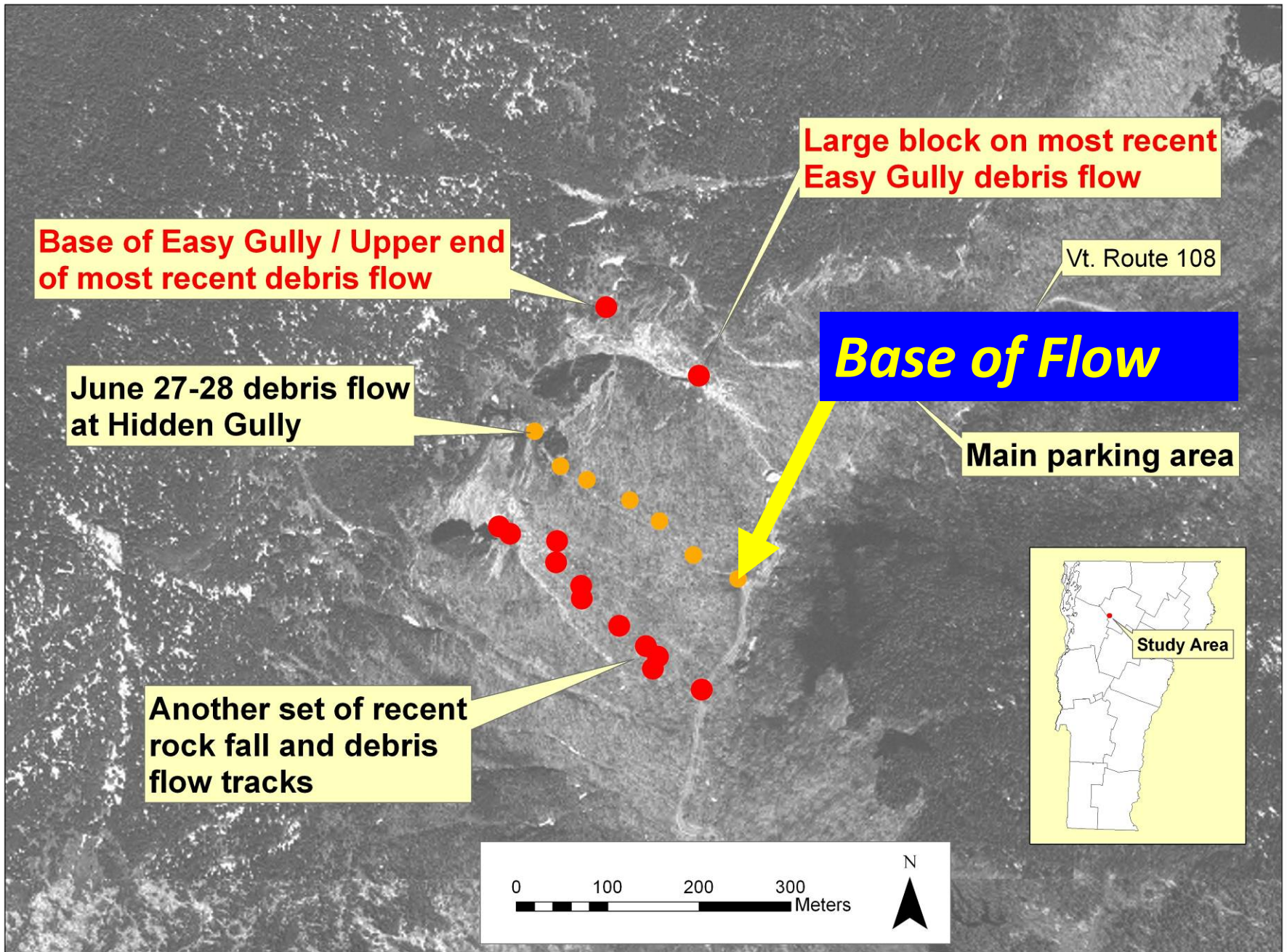


Figure 2. Orthophoto base map from Vermont Mapping Program aerial photos flown in 1996.

G. Springston, 8/25/2006

Debris Flow



Looking west at base of Hidden Gully at the debris fan formed by the recent debris flow. Debris removed by Agency of Transportation after each flow.

G. Springston
Photo 1777
7/5/2006

Looking up at debris
flow track. Note levees
of transported material
on each side.



G. Springston
Photo 1780
7/5/2006

Debris flow track showing levee deposit on south side.
Note scars on uphill sides of trees and boulders piled up
against them with imbrication up-slope.

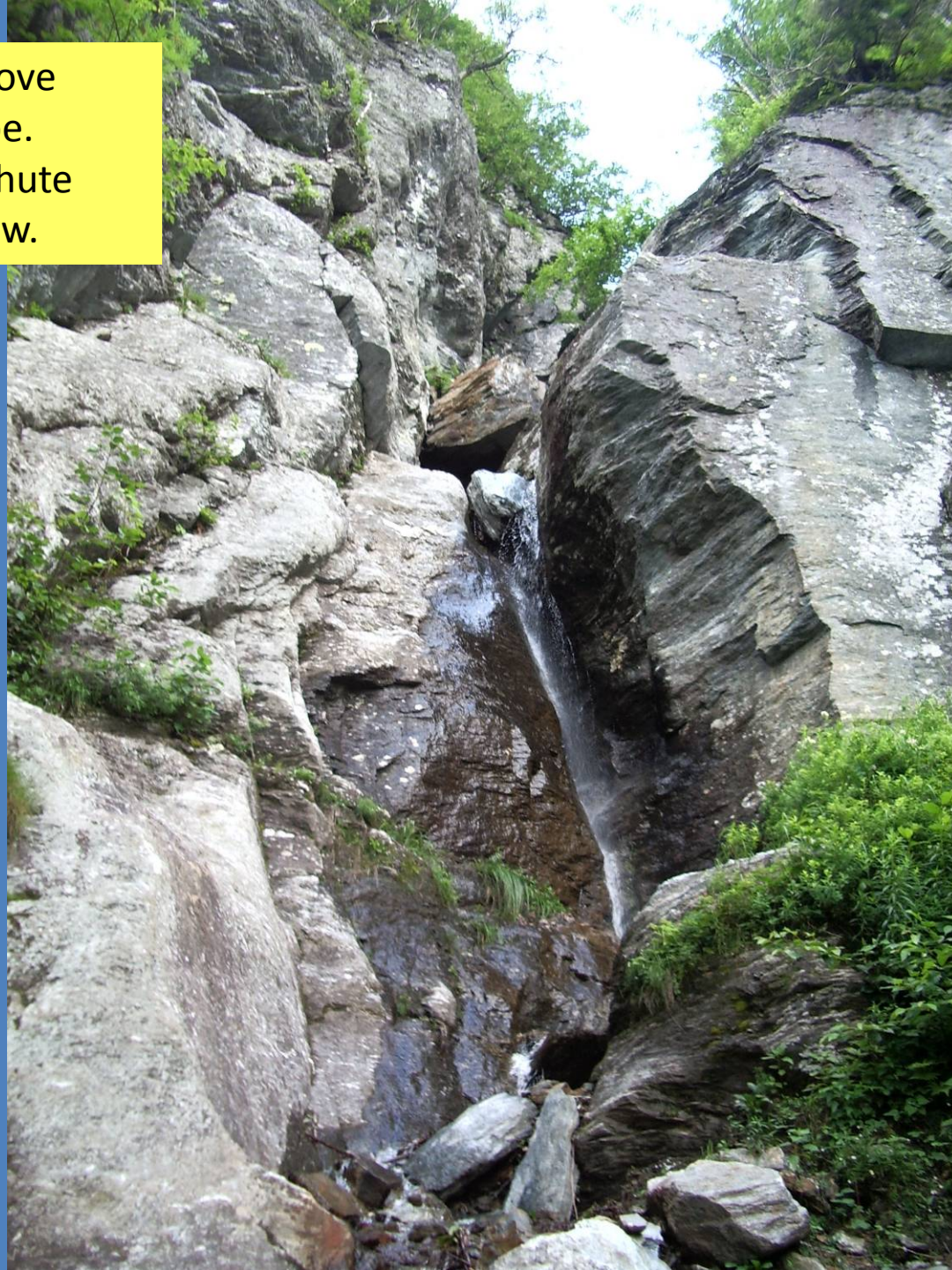


Scars

Imbrication

G. Springston
Photo 1791
7/5/2006

Bedrock cascade above
talus/colluvium slope.
Lower end of rock chute
that feeds debris flow.



G. Springston
Photo 1788a
7/5/2006

Styles of rock slope failure here are:

Falls

Topples

Slides

Wedge failures

G. Springston
Photo 3584a
10/2/2007

King Rock
and the
slide scar
north of
Cass's Gully
in 1911.



Left, Stowe
Historical
Society.
Right, from
*The
Vermont,*
1911, v. 16,
p. 21 – 26.



1921



Looking for Change over Time

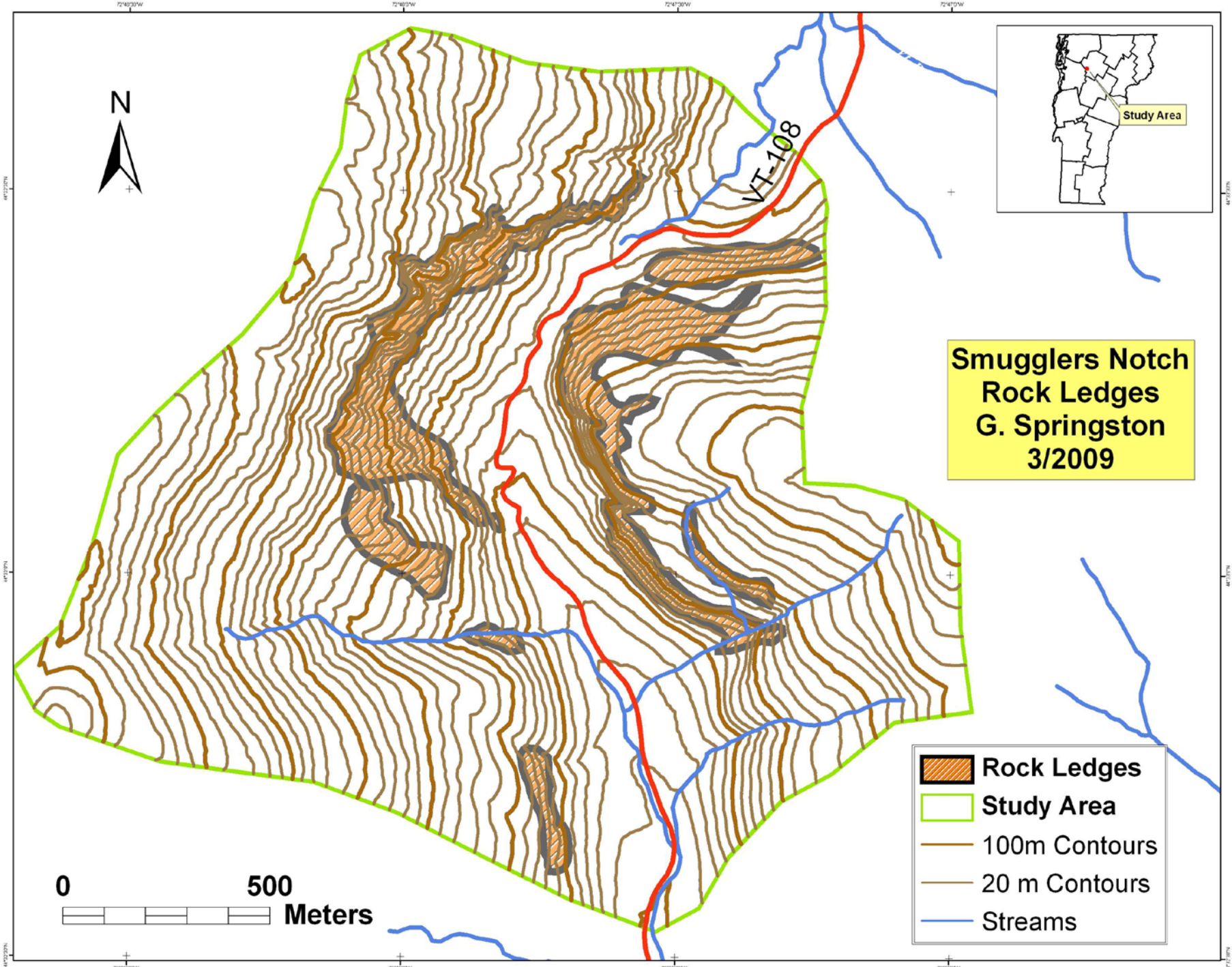
2007








Elephant's Head in 1921 and in 2007.

**Above: 1921. Landscape Change Program
Image LS06988. Courtesy of the Vermont
State Archives.**

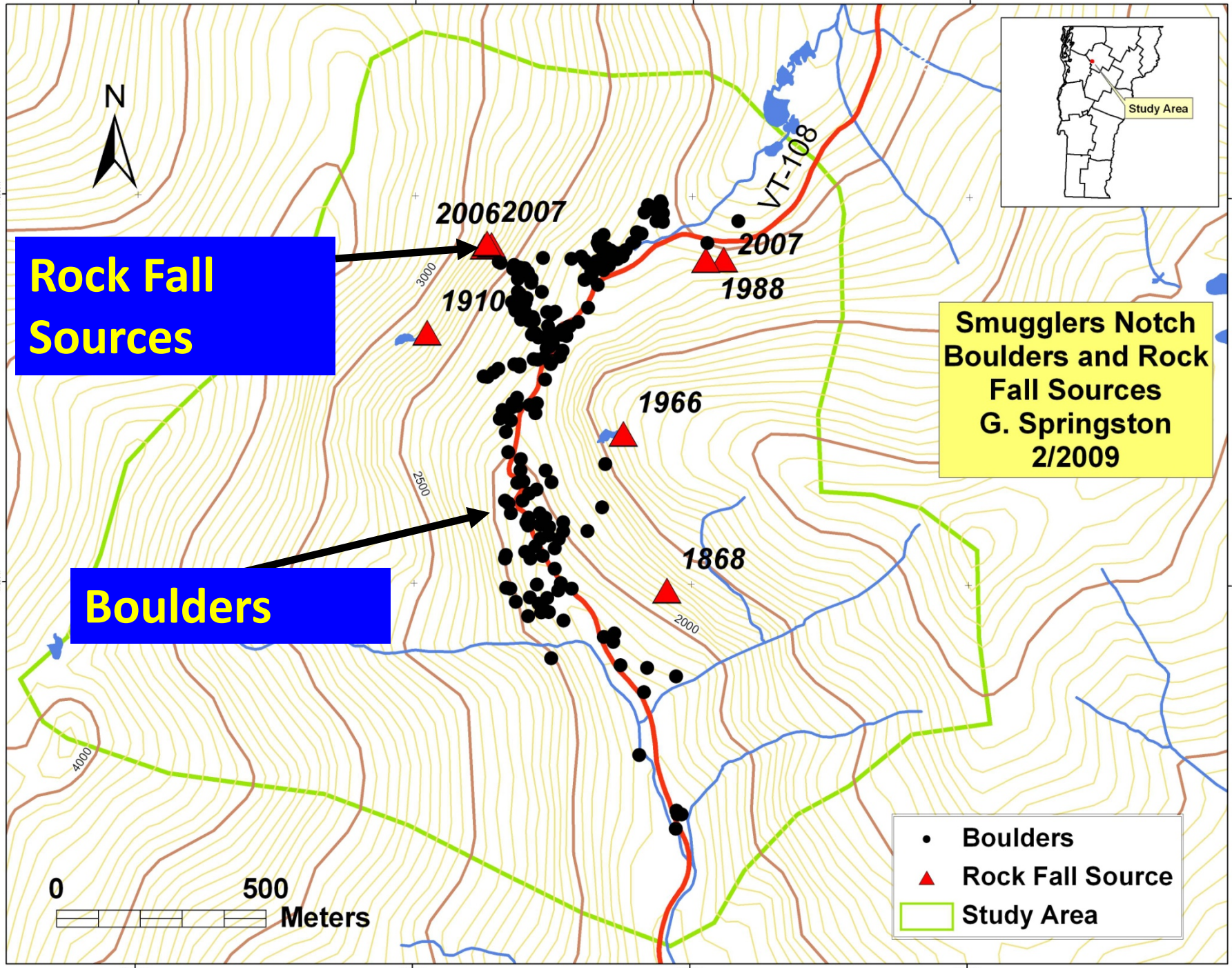
Below: July, 2007.



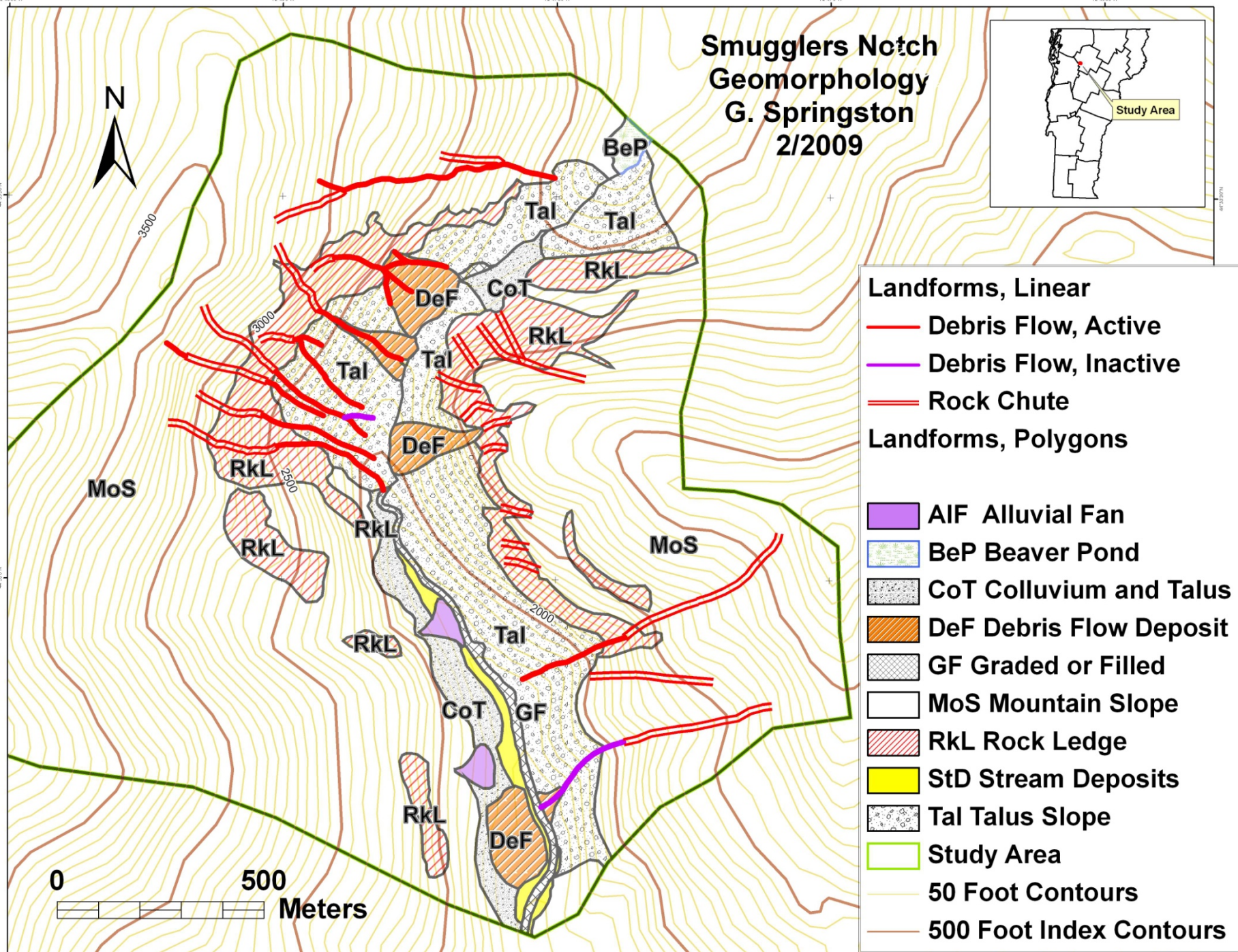
**Smugglers Notch
Rock Ledges
G. Springston
3/2009**

-  **Rock Ledges**
-  **Study Area**
-  **100m Contours**
-  **20 m Contours**
-  **Streams**

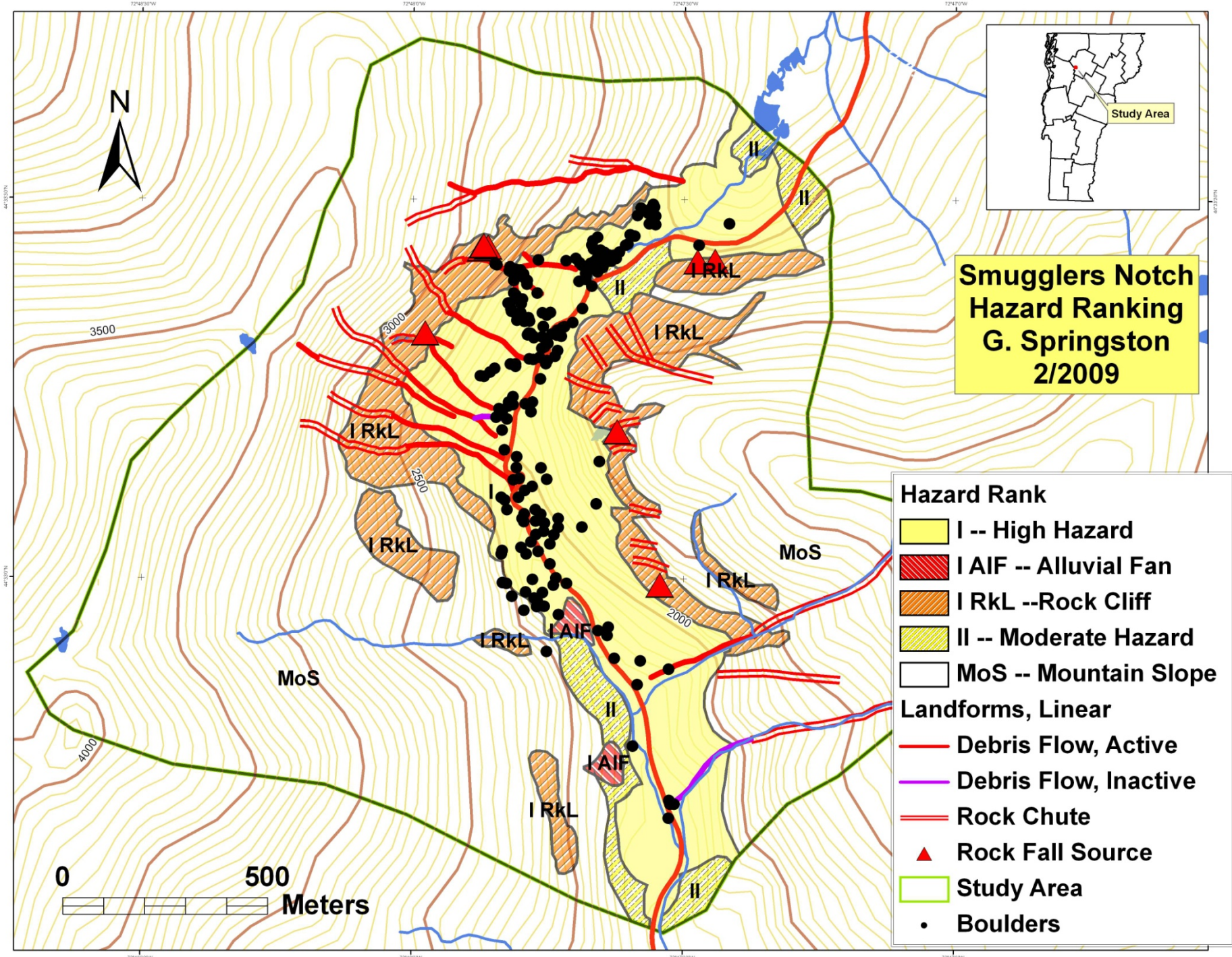
0 500 Meters



Smugglers Notch Geomorphology G. Springston 2/2009



- Landforms, Linear**
- Debris Flow, Active
 - Debris Flow, Inactive
 - = Rock Chute
- Landforms, Polygons**
- AIF Alluvial Fan
 - BeP Beaver Pond
 - CoT Colluvium and Talus
 - DeF Debris Flow Deposit
 - GF Graded or Filled
 - MoS Mountain Slope
 - RkL Rock Ledge
 - StD Stream Deposits
 - Tal Talus Slope
 - Study Area
 - 50 Foot Contours
 - 500 Foot Index Contours



**Smugglers Notch Hazard Ranking
G. Springston
2/2009**

- Hazard Rank**
- I -- High Hazard
 - II -- Moderate Hazard
- Landforms, Linear**
- I AIF -- Alluvial Fan
 - I RkL -- Rock Cliff
 - MoS -- Mountain Slope
 - Debris Flow, Active
 - Debris Flow, Inactive
 - Rock Chute
 - Rock Fall Source
 - Study Area
 - Boulders

0 500 Meters

3500

3000

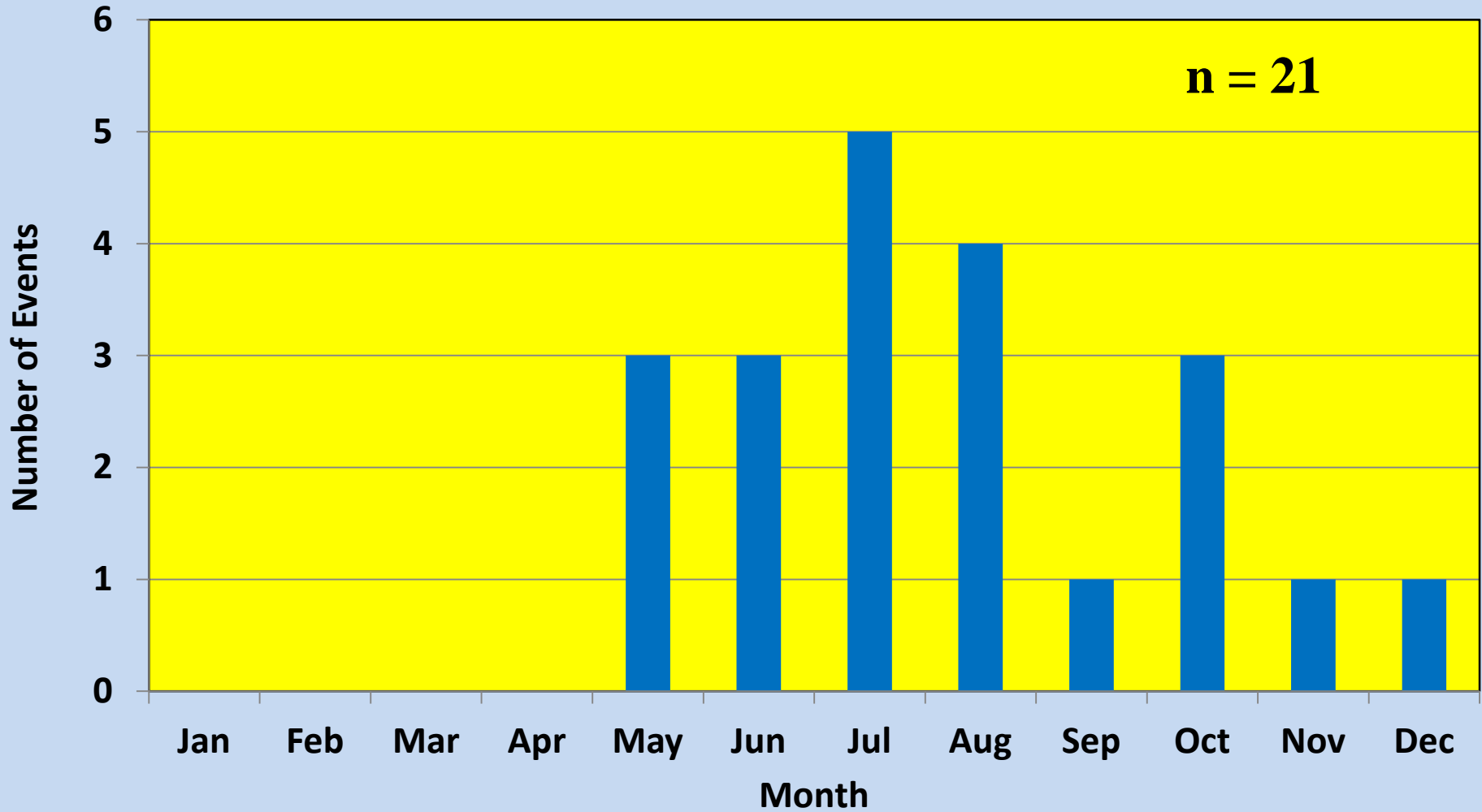
2500

2000

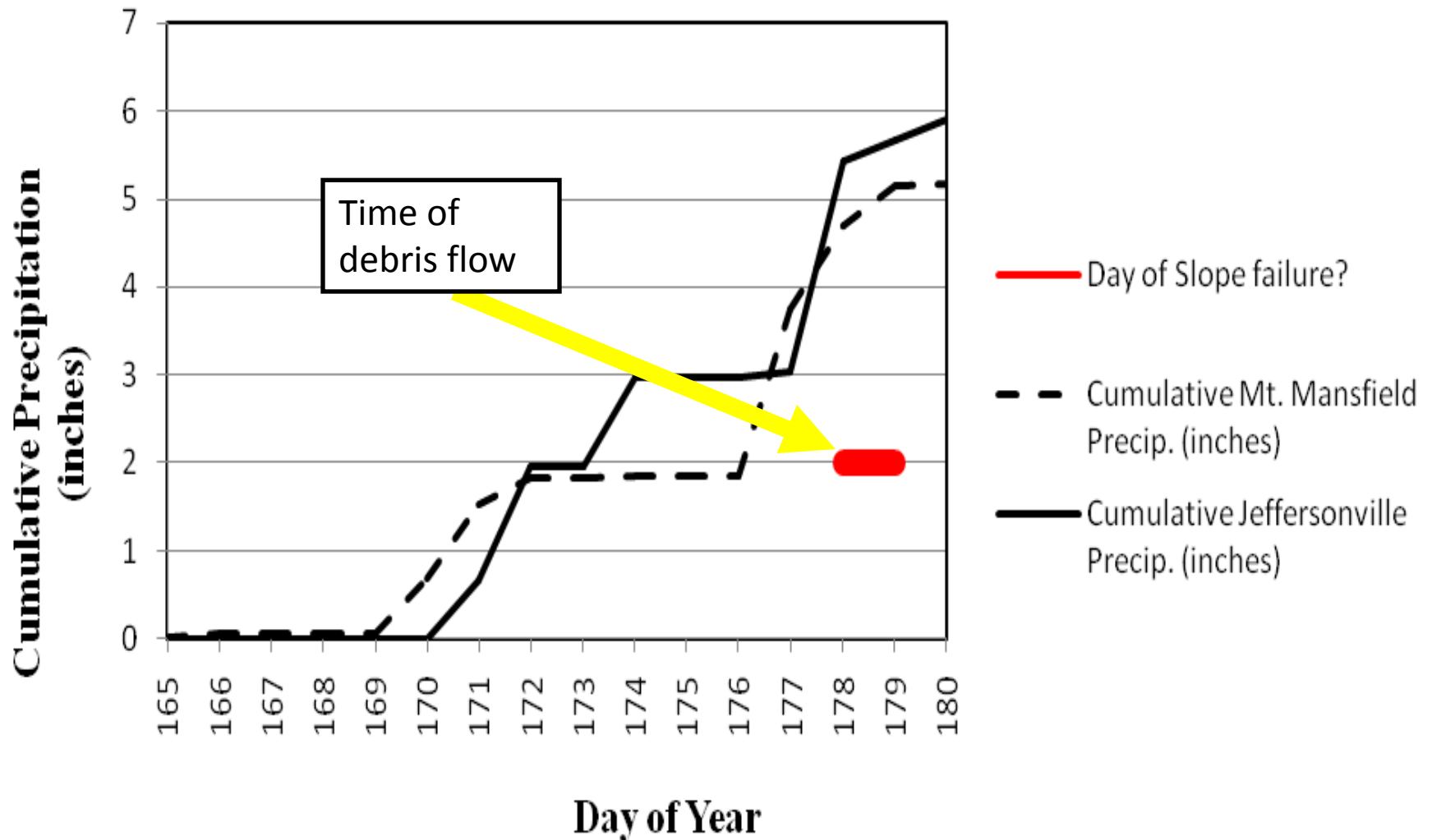
4000



Landslide Activity Near Smugglers Notch by Month



Cumulative precipitation prior to the debris flow event below Hidden Gully, June 27 or 28, 2006 (Day of year = 178 to 179).



How can we predict debris flow activity?

- At present, the most effective means of anticipating slope instability events in the Notch is to use a precipitation threshold.
- Milender (2004) proposes:
 - 1. Storm delivering 2 inches in 24 hours with peak intensity of 0.7 inches/hour or greater or...
 - 2. Storm delivering 2.5 inches or more over 30 hours.



Aerial view of west side

Active processes of slope degradation

Blocks falling off J2 cliff face

Rock chute or "gully" eroding back and weakening outer buttress. Gully is concentrator of both rock fall and storm runoff

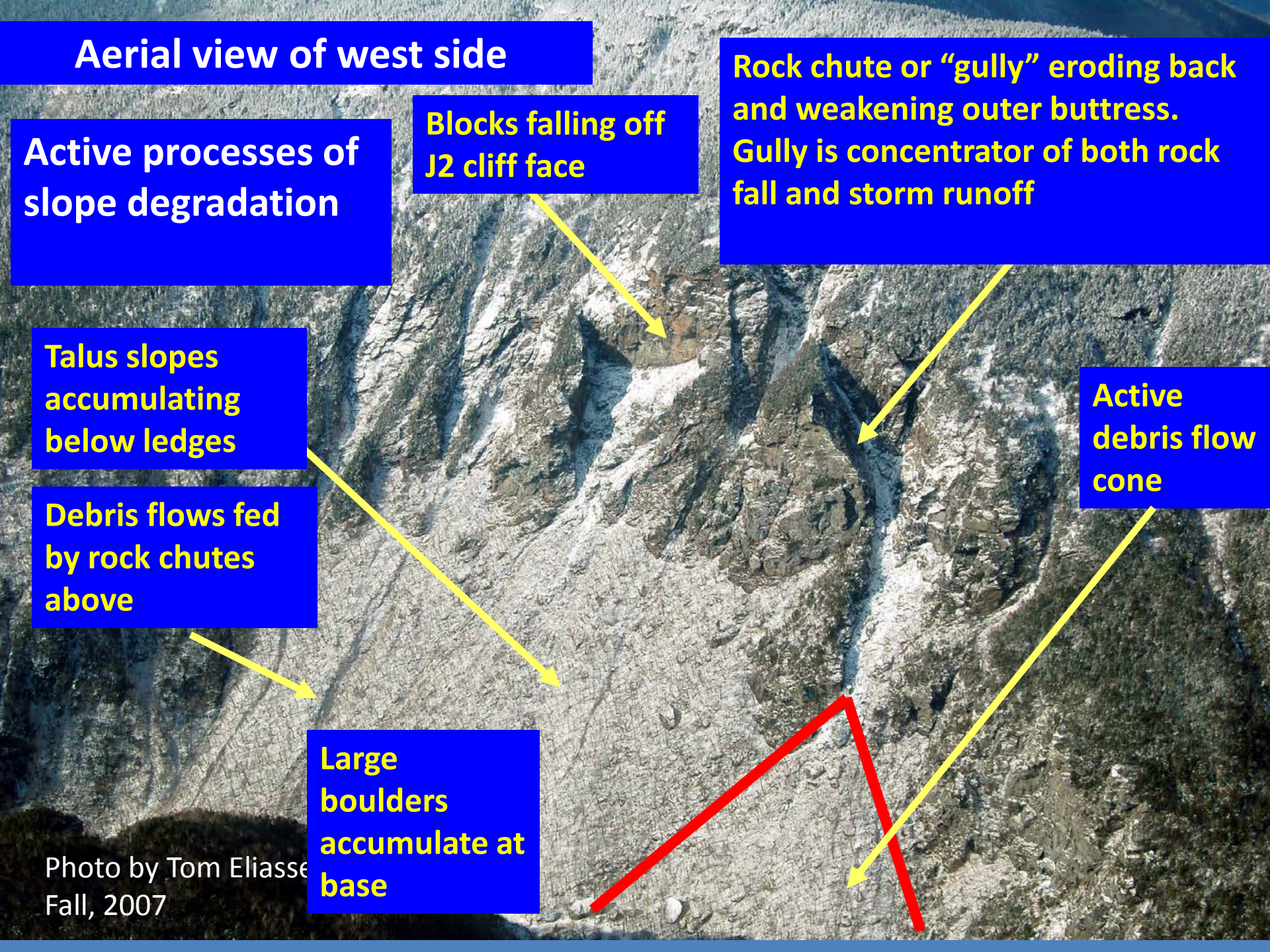
Talus slopes accumulating below ledges

Debris flows fed by rock chutes above

Active debris flow cone

Large boulders accumulate at base

Photo by Tom Eliassen
Fall, 2007



Smugglers Notch Conclusions

- **Rock falls and debris flows will occur in the future and they will usually reach the road.**
- **Individual blocks can exceed 500 or 1000 tons and individual debris flows can run to thousands of cubic meters.**
- **19 of 21 events occurred between May and October with peak in July.**
- **Strong connection between extreme precipitation events and landslides (especially the debris flows).**

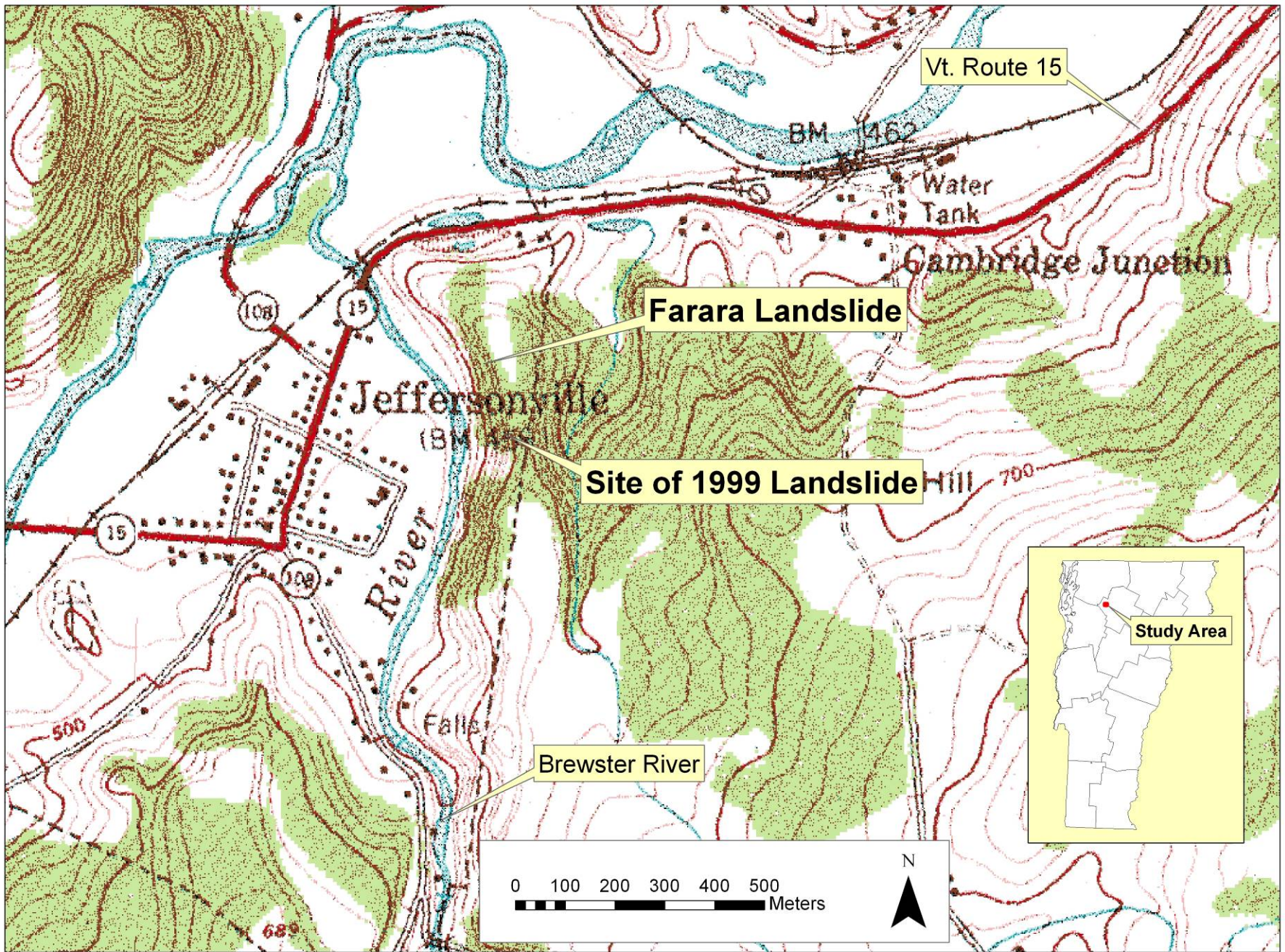


Figure 1. Base map from USGS 1:24,000 Jeffersonville Quadrangle, 1948

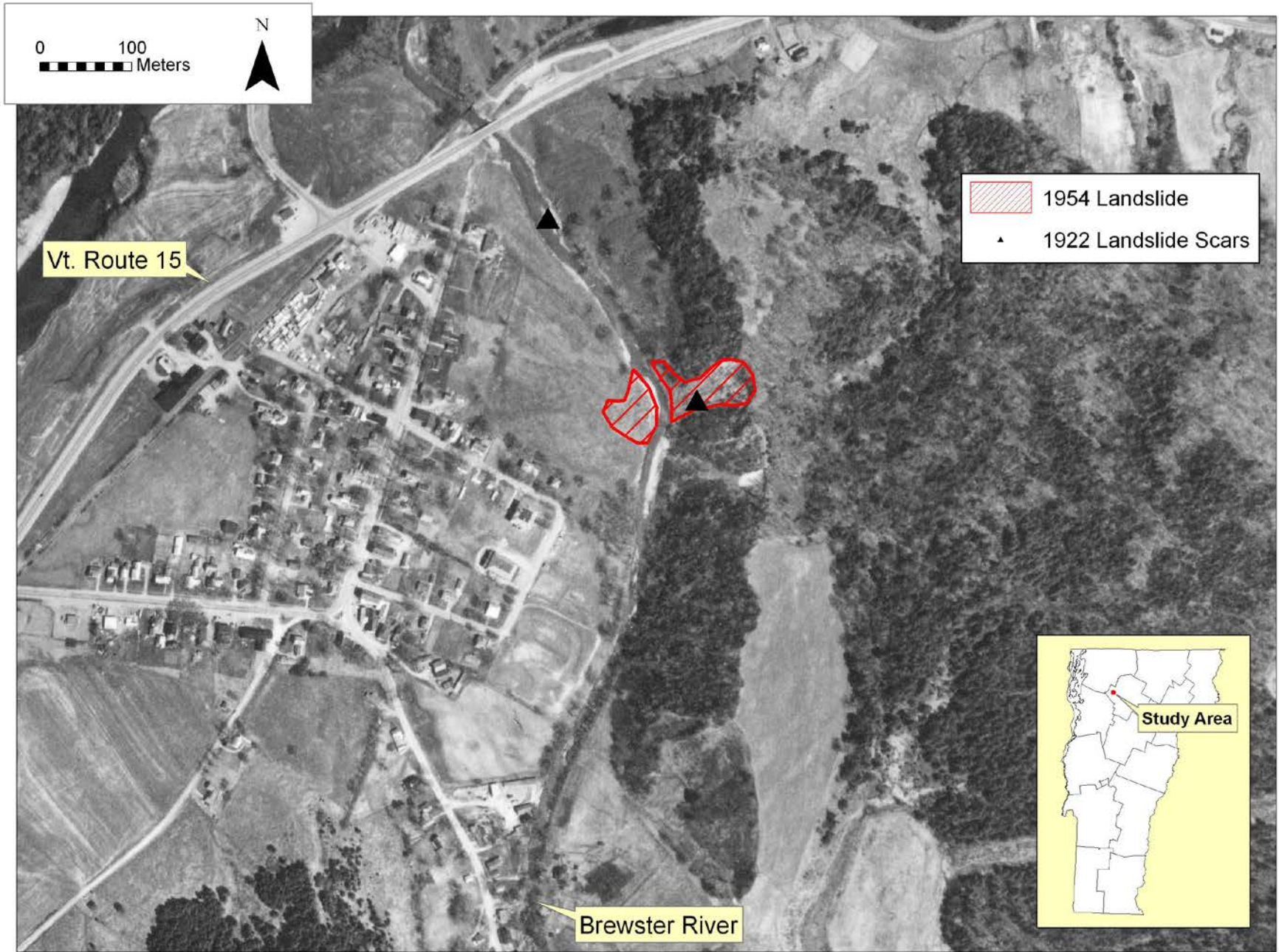


1942 Aerial Photo

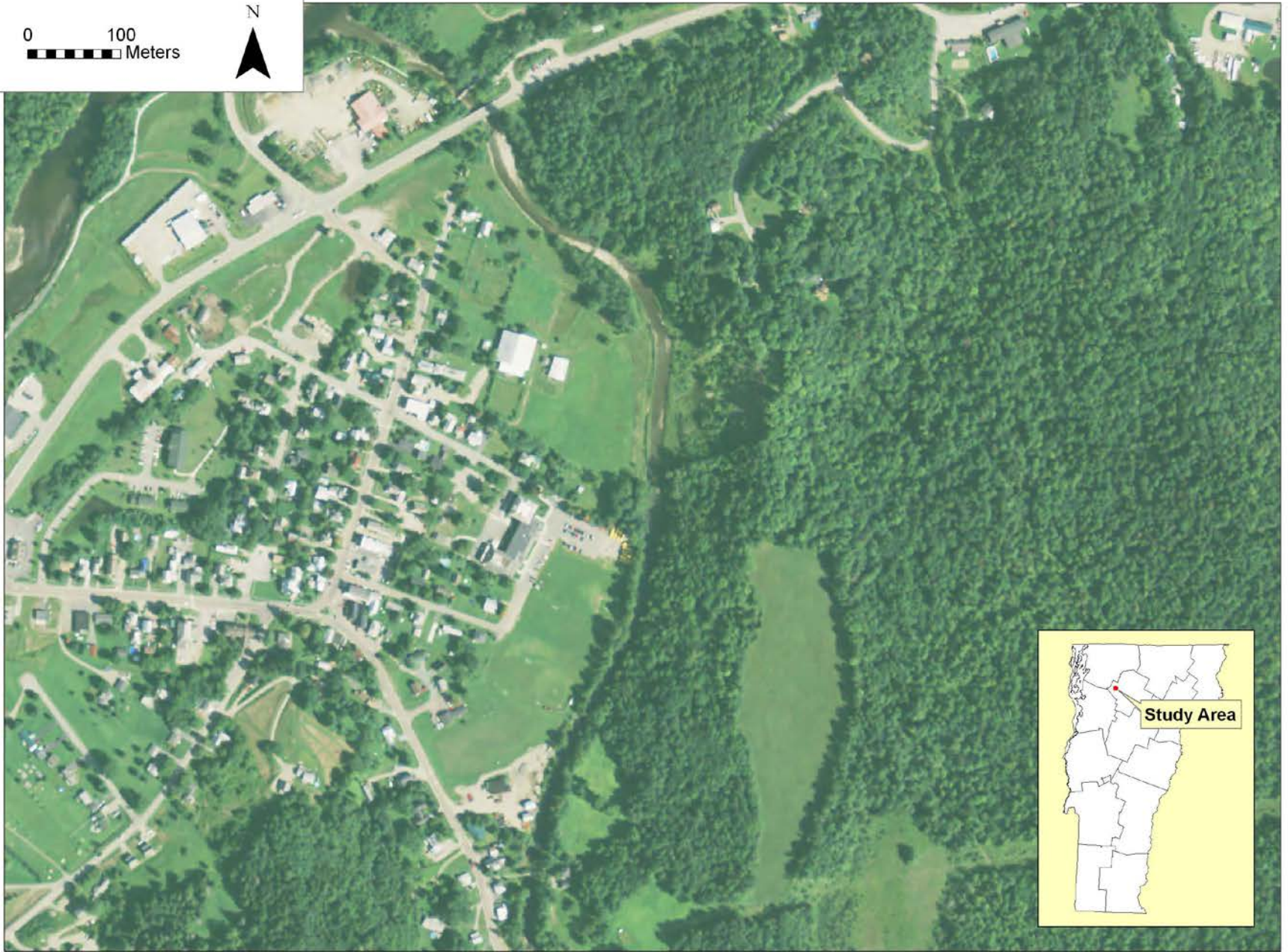
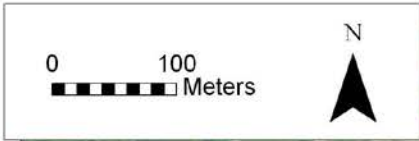
Jeffersonville Landslide, May, 1954



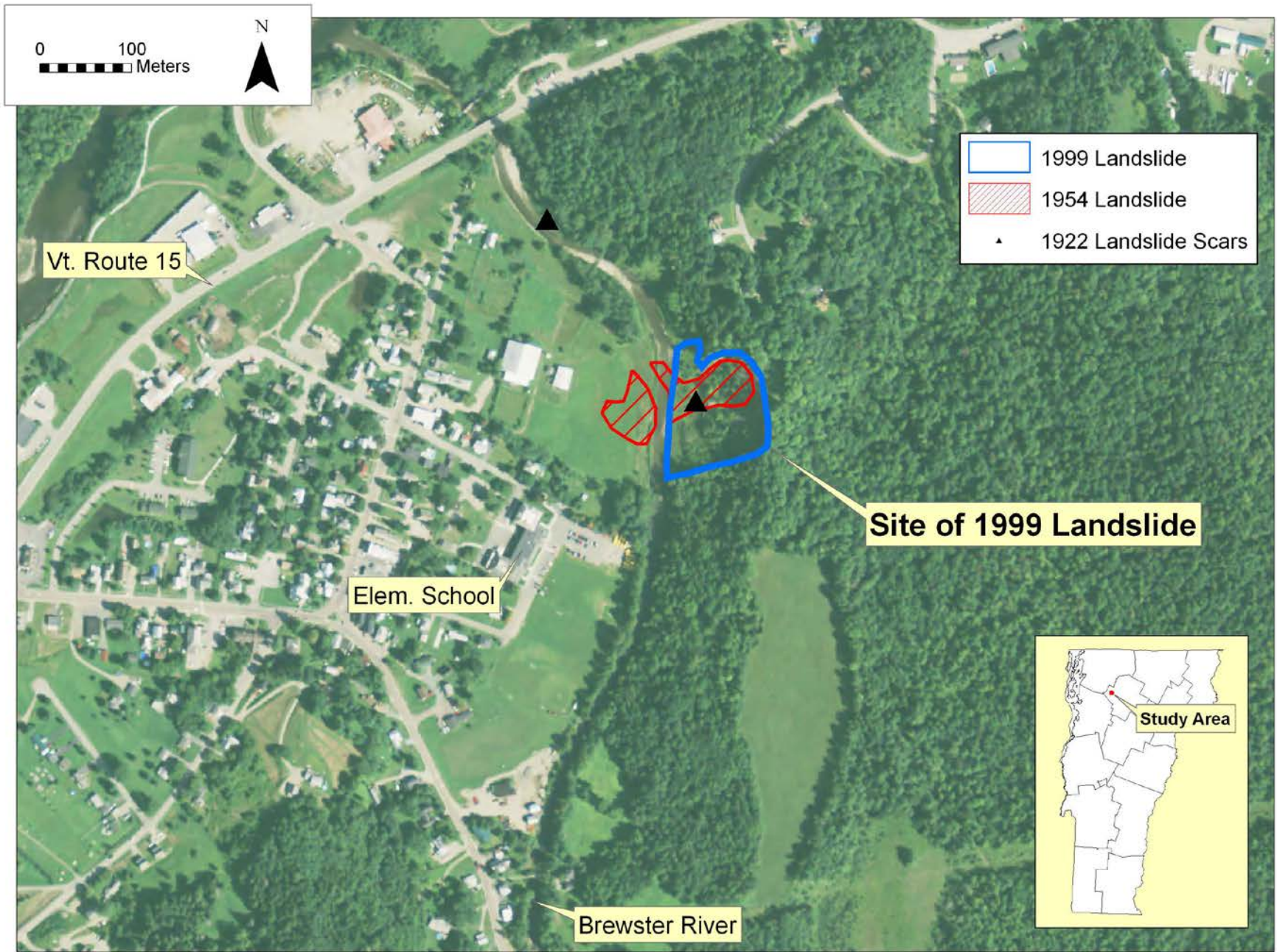
Photos by Harold Thomas
from collection of Stub
Wells, Jeffersonville.



1962 Aerial Photo



2008 NAIP Orthophoto



2008 NAIP Orthophoto.

**Rough location of
Farara slide**

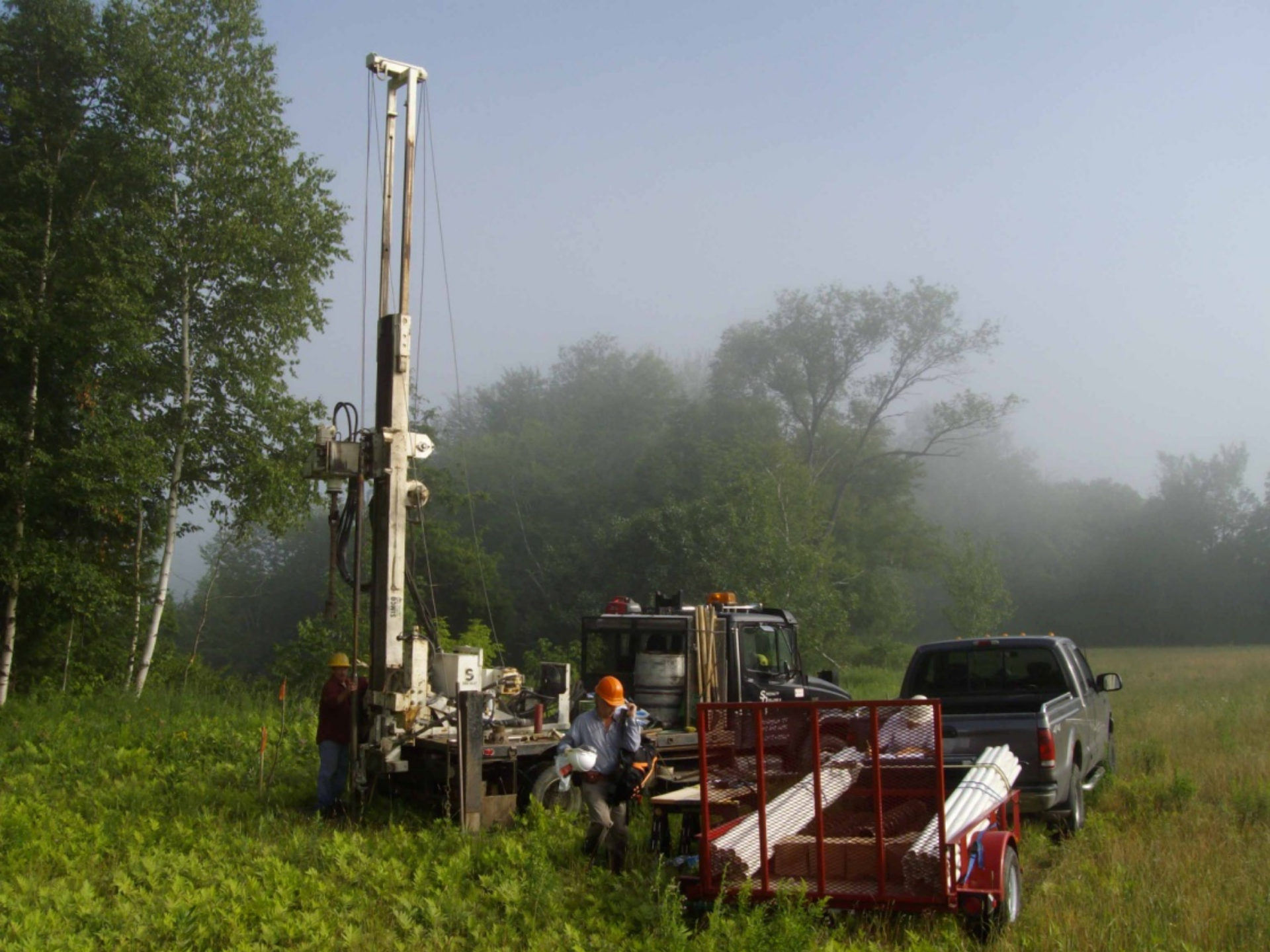


1999



Figure 3. Looking east
across Brewster River at
1999 slide on right and
Farara slide in wooded
section.

G. Springston
Photo 1819
7/13/2006





Ziploc
FREEZER
QUART

Ziploc
FREEZER
QUART

Handwritten notes and a grid on a spiral-bound notebook.

Swiss Army knife and blue pen.

Yellow ruler.

Handwritten notes on a white sheet of paper.

Acknowledgements

- All projects: Vt. Geological Survey staff: Laurence Becker, Marjorie Gale, Jon Kim
- Mad River – Rick Dunn and Fred Larsen of Norwich University, Nathan Donahue, Mike Blazewicz of the Friends of the Mad River
- Vermont Highway Rockfall Hazards – Tom Eliassen of VTrans
- Smugglers Notch – Tom Eliassen of VTrans
- Jeffersonville – Dave Severance, (Village of Jeffersonville), Leslie Kanat and students from Johnson State College, Adam Sevi and students from Norwich University



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**Vermont Geological Survey,
Laurence Becker, State Geologist**