Lake Mansfield Debris Fan

Written by:

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ABSTRACT:

A debris fan was studied near the Trout Club at Lake Mansfield in Stowe, VT. Using surveying equipment and various hand made and existing maps, a volume of sediment from the debris fan was calculated. The volume was determined to be about 5600m_. Points were used, paying particular attention to elevation, in order to construct a contour map that was then used to determine fan shape, slope, and volume. Slope of the fan from top to bottom was determined to be 0.147 with a slope percent of 14.7%. Average boulder diameter was measured and established to be 6.3ft. The feature studied was determined a fan because of observations such as; steep slope, available moisture consisting of the present day stream beds and precipitation, source of boulders in the form of an exposed outcrop, fan shape, vegetation on and around perimeters of fan, and unsorted sediment especially boulders seen at the site.

INTRODUCTION:

This project determined the sediment volume of a debris fan found near the Trout Club at Lake Mansfield in Stowe, VT (Figure 1). A debris fan, as suggested by Schumm (1977), is also termed a dry fan, which is created by a temporary flow and is described on the basis of the type of sediment being deposited. Deposits tend to be fan shaped and are often illustrated as a segment of a cone radiating away from a point (Kochel et al 1995). Debris fans are usually the result of a debris flow, which is gravity induced rapid mass movement of various rock types and grain sizes (Kochel et al 1995). Flows can originate in multiple ways, such as an abundant source of moisture, abundant supply of fine-grained sediment, and relatively steep slopes (Kochel et al 1995). We attempted to pin point the source of rock debris that was transported by a debris flow that created the Lake Mansfield debris fan. Our goals also included mapping the perimeter of the fan and calculating the volume of sediment it contains.

METHODS:

To identify the potential rock source of the debris flow, we hiked the nearby streambed. While climbing upward along the streambed, we continuously marked coordinates by using a GPS system. We later plotted these points on a topographic map in order to trace the path of the streambed (Figure 2). The goal of hiking the streambed was to search for a large outcrop that contained rocks similar to those found in the fan (Figure 3a and Figure 3b). Next we used survey equipment to determine the topography of the fan. In order to accomplish this, one person held a marker on or near the point we wished to survey. In the meantime, the other person aimed the machine containing a laser at the marker and recorded the data. Using the survey equipment, numerous points were taken that formed the topography of the fan. These were in the form of x, y, and z with x equal to north, y equal to east, and z equal to elevation. This information was all recorded in meters. With these data, a contour map was constructed as well as several plots containing the recorded x and y values (Figure 4 and 5). From the contour map, the slope of the fan was easily calculated along with the volume of sediment load. Points of interest while surveying included the fan boundaries and the largest boulders located on the fan. To determine which boulders were the largest, we measured the diameter with a tape measure and then excluded those with the lesser values. Also, we used several observations and factors to establish the boundaries of the fan (Figure 3c and Figure 3d). For instance, the streambed served as the east boundary, whereas a change in vegetation, a raise in land, and a change in quantity of boulders marked the west boundary. Again, observable changes in vegetation and rock size were used as characteristics for distinguishing top and bottom boundaries.

DATA:

Streambed and Outcrop:

During the initial ascent of the streambed, we observed a gradual change from large scattered boulders lining the channel to water flowing over sheer rock (Figure 3e and Figure 3f). In addition, the streambed became progressively steeper the higher up we went. There were also many dry channels surrounding either side of the current streambed. Approximately three quarters of the way up the streambed, an immense outcrop was exposed to the northwest of the existing channel. The slope of the outcrop was extremely steep and all the trees growing along the side appeared to be sloping in a downward direction. From what could be deciphered, the exposed rock was consistent with the boulders found on the fan bottom. By following the channel further, the outcrop turned out to be a continuous ridge. Another ridge was flanking the east side of the streambed; however, it was not exposed. Therefore, the streambed is flowing along the valley between these two ridges.

Fan:

To find the slope of the fan, height and length were calculated from the contour map (Figure 4). Height was found by taking the difference of the highest and lowest elevation whereas measuring the distance from the top of the fan to the bottom and scaling that number yielded length. The height was 9.66 meters and the length was 66.5 meters. By using the Pythagorean theorem, a distance measurement was calculated to be 65.79 meters. In turn, the slope was found by dividing the height by the distance, which came out to be 0.147.

The volume of a cone is determined by the formula:

$$\{[(\pi \text{ r\_h})/3] * \text{sweep angle}\} * (1/2)$$

The r-value equals radius and was found by measuring the distance between the top and bottom of the fan, which is equivalent to the length. The sweep angle was roughly estimated to be approximately 45º. This number was then further converted into a decimal by dividing it by 180º. After incorporating all of these values into the formula the volume was calculated to be about 5600 meters_. By measuring the diameters of the boulders that were chosen to survey, an average boulder size was found to be around 6.3 feet.

DISCUSSION:

Most of the rocks found on the fan and along the streambed contained mica and quartz and appeared to be schist. This rock type coincides with the rocks seen in the large outcrop, implying that this was in fact the source of boulders for the debris fan. In addition, the slope of the streambed and the land itself was steep enough to carry these boulders down gradient. According to Costa (1988) for the ground to be steep enough to transport debris the percent slope should be between 5.8 and 47; the slope above the fan is 14.7% and thus falls directly within this range. There appeared to have been a large amount of water running through this valley at one point due to the number of ephemeral streambeds in and around this area. This source of moisture could have aided in mobilizing debris flows. All of our calculations were derived from our constructed contour map; as a result, some error might have occurred in the form of experimental error and scaling inaccuracy. Overall, our calculations of the sediment volume of the debris fan seem to be correct and make sense in comparison to other studies. Another study by Mazza and Wieczorek (2001) on the Kinsey Run debris fan in Virginia showed the same type of information but on a much larger scale. Their debris flow yielded a sediment load of 5.7*10^4 m_ with boulders averaging 23ft in length. Clearly this shows the vast range of possible debris fans compared to what we thought was a large sediment yield of the Lake Mansfield fan.

SUMMARY:

There is evidence suggesting that this is a debris fan resulting from debris flows. Such evidence consists of: a source of boulders for the debris flow in the exposed outcrop that was discovered; a steep enough slope for the propagation of the debris flow; a moisture source in the form of the streambed/s and precipitation; a contour map revealing a fan shape; dense vegetation around the parameters of the fan with only sparse vegetation on the actual fan; and unsorted sediments, especially seen as the large boulders on the surface of the fan. The volume of the sediment load deposited by debris flows was about 5600 m_, which is a fairly large volume yet expected due to the large nature of the boulders. This area is prime for a debris flow because of its potential for a heavy winter snow pack followed by a cool spring and rapid late spring melt. These flows can occur on slopes with shallow cover over weathered metamorphic rocks in which slides can be initiated by increased pore pressure of water in the soil (Kochel et al 1995). Again, metamorphic rock was found at the site of the point source and we have already seen at Jeffersonville that pore pressure contributes to slope failure (Nichols et al 2001).

REFERENCES:

Costa, J.E. (1984). Physical geomorphology of debris flows. In Costa, J.E., and Fleisher, J.P., eds., *Developments and applications of geomorphology*, pp. 268-317. New York: Springer-Verlag.

Kochel, C.R., Miller, J.R., Ritter, D.F. (1995). Process Geomorphology "3rd ed.", 117-119, 247.

Mazza, Nilah A., Wieczorek, Gerald F. (2001). *A Volumetric Sediment Analysis for Kinsey Run Debris Flow, Triggered During an Extreme Storm Event, Madison County, Virginia.* http://landslides.usgs.gov/html_files/nlic/Virginia/Madison/debrisflw.htm

Nichols, K.K., Bierman, P.R., Klepeis, K., Wright, S.F., Peavey, M., McGee, M. (2001) *Long Run Out Mass Movements in Glacially Conditioned Landscapes.*

Schumm, S.A. (1977). *The Fluvial System*. New York: John Wiley & Sons.

NAME	18T	UTM
Fan B	0674698	4926535
Fan 2	0674763	4926601
Fan 3	0674738	4926728
Fan 4	0674730	4927022
Fan 5	0674758	4927079
Out 1	0674699	4926906

Appendix 1: GPS coordinates taken along the fan and outcrop. These points were then plotted on a topographic map to show the path of the streambed and location of the outcrop.

X	Y	Z	Notes
Fan Data			
1015.682	1017.243	997.912	Bottom of fan where stream bed turns
1016.253	1005.871	999.552	Along side of fan and streambed, still turning
1017.674	1001.251	1000.068	Sharpest turn in streambed
1022.494	994.454	1000.897	Upward along streambed
1024.737	988.98	1001.769	"
1024.909	981.866	1003.163	"
1027.755	975.52	1004.714	"
1032.693	968.932	1006.16	Along streambed, into deeper tree coverage
1043.039	966.661	1008.354	Going steeper up streambed, shear rock in streambed
1051.122	962.857	1013.574	Steeper up streambed, shear rock, little waterfall
1058.09	957.595	1014.771	Steeper up streambed, slight turn to the right
1064.165	954.971	1017.278	Up streambed, lots of trees, still slightly turning
1001.171	1015.908	997.435	Along road on same side as surveyor, to the right
996.405	1017.398	997.509	Other side of the road, directly across from previous point
991.802	1006.869	998.444	Other side of road, middle of fan, to the left of surveyor
996.428	1004.317	998.569	Along road on same side as surveyor, directly across from previous point
990.654	986.618	999.267	Along road on same side as surveyor, more left of surveyor, extreme left side of fan
985.488	988.792	999.201	Directly across from previous point, other side of road
996.684	989.13	1000.54	Boundary of left side of fan
1003.314	982.304	1001.66	Behind big boulder on left side of fan
1007.638	982.828	1002.551	Upward along left side of fan
1009.956	981.203	1002.393	"
1012.546	977.696	1002.787	"
1016.625	974.475	1003.496	On raised section of land, probably extreme left boundary
1020.918	970.562	1004.387	Left side, approaching streambed
1028.509	964.3	1006.918	"
1023.82	979.677	1003.924	"
Fan on other side of Road			
982.901	988.562	999.076	Next to rock, on left most side of fan
984.405	1002.073	997.917	One of the larger boulders
986.715	1012.554	997.159	Another rock
995.247	1024.911	996.5	Big pile of rocks closer to right side of fan
Big Boulders			
1000.997	997.444	1000.163	3.5ft diameter
998.091	997.321	1000.005	4ft
1002.758	994.859	1000.596	5ft
1005.951	996.72	1000.115	5.5ft
1014.822	995.95	1000.109	9ft
1016.169	993.872	1000.816	6ft
1017.997	992.008	1001.153	7.5ft
1019.779	994.37	1001.379	6ft
1020.179	989.034	1002.046	10ft
1017.185	988.869	1001.863	4ft
1013.445	989.786	1001.093	6ft
1012.871	987.55	1001.574	9.5ft
1015.546	982.942	1002.728	9.5ft alongside rock in next point
1015.791	980.372	1003.184	8ft alongside rock in previous point
1011.466	983.341	1002.324	4ft
1003.338	983.125	1001.571	6.5ft
1004.297	984.358	1001.49	5ft
998.965	987.46	1001.135	4.5ft
995.669	990.857	1000.141	6.5ft

Appendix 2: Table of all measured points taken from surveying machine including a description of each point.

Average boulder size: 120ft / 19 boulders = 6.3ft

Volume Calculation:

Height (change in elevation from top to bottom) = 1006.16 - 996.5 = 9.66m

Radius = 1016.5 – 950.0 = 66.5m

Sweep angle = 45º / 180º = 0.25

{[(π r_h)/3] * sweep angle}* (1/2) = 5591m_ = approximately 5600m_

Slope Calculation:

a_ + b_ = c_

(66.5)_ - (9.66)_ = (4328.9344)^(1/2) = 65.79m

Slope = height / distance = 9.66 / 65.79 = 0.147

Appendix 3: Calculations including average boulder size, volume and slope.

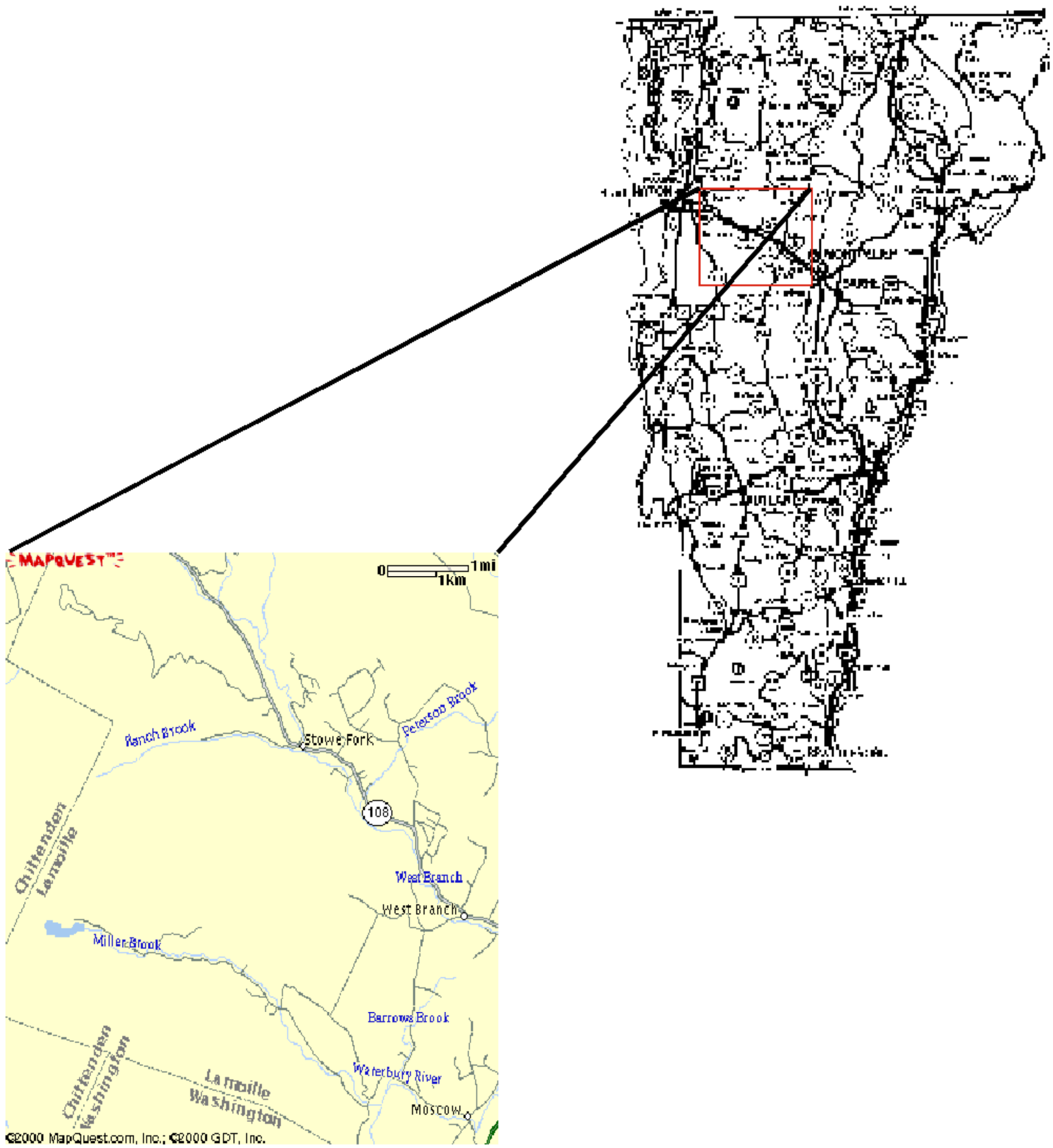
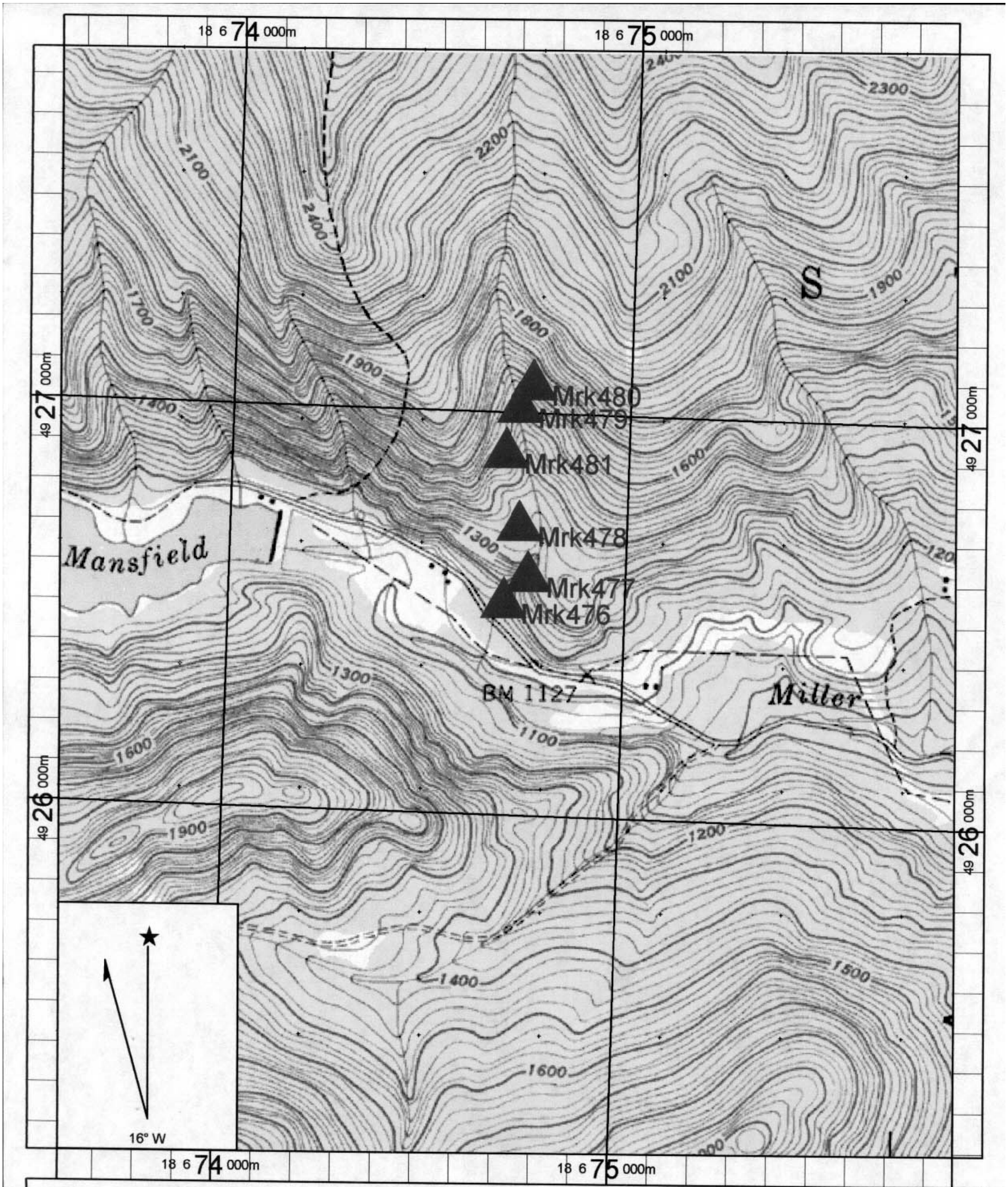


Figure 1: Location map of the Lake Mansfield debris fan in Stowe, Vermont. The area chosen to study was off of route 108 near the Lake Mansfield Trout Club.



Name: BOLTON MT
Date: 11/28/2001
Scale: 1 inch equals 1000 feet

Location: 18 674705 E 4926529 N
Caption: Figure 2: Topographic map with markers to indicate path of streambed. Mrk 481 indicates location of the outcrop.

3a

3b

Figure 3a and 3b: View of outcrop at the Trout Club at Lake Mansfield in Stowe, Vermont. The outcrop was located approximately three quarters of the way up the streambed. The rock type is metamorphosed schist.

Figure 3c and 3d: Pictures show vegetation change on boundary's of the fan. The top picture is a view looking just to the left of the fan. A vegetation difference can be seen. The bottom picture shows a view looking down the fan. Increased vegetation is seen on the right.

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Figure 3e and 3f: The top picture is a view looking down on the fan. Some vegetation can be seen on the fan. The bottom picture is a view looking up the fan. The streambed can be seen as a boundary on the east again along with a vegetation change on the east side.

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FIgure 3g and 3h: Bottom view of streambed containing large boulders lining the channel. Top picture shows how the streambed changes as elevation increases. Slope of the channel is very steep and the water is running over sheer rock.

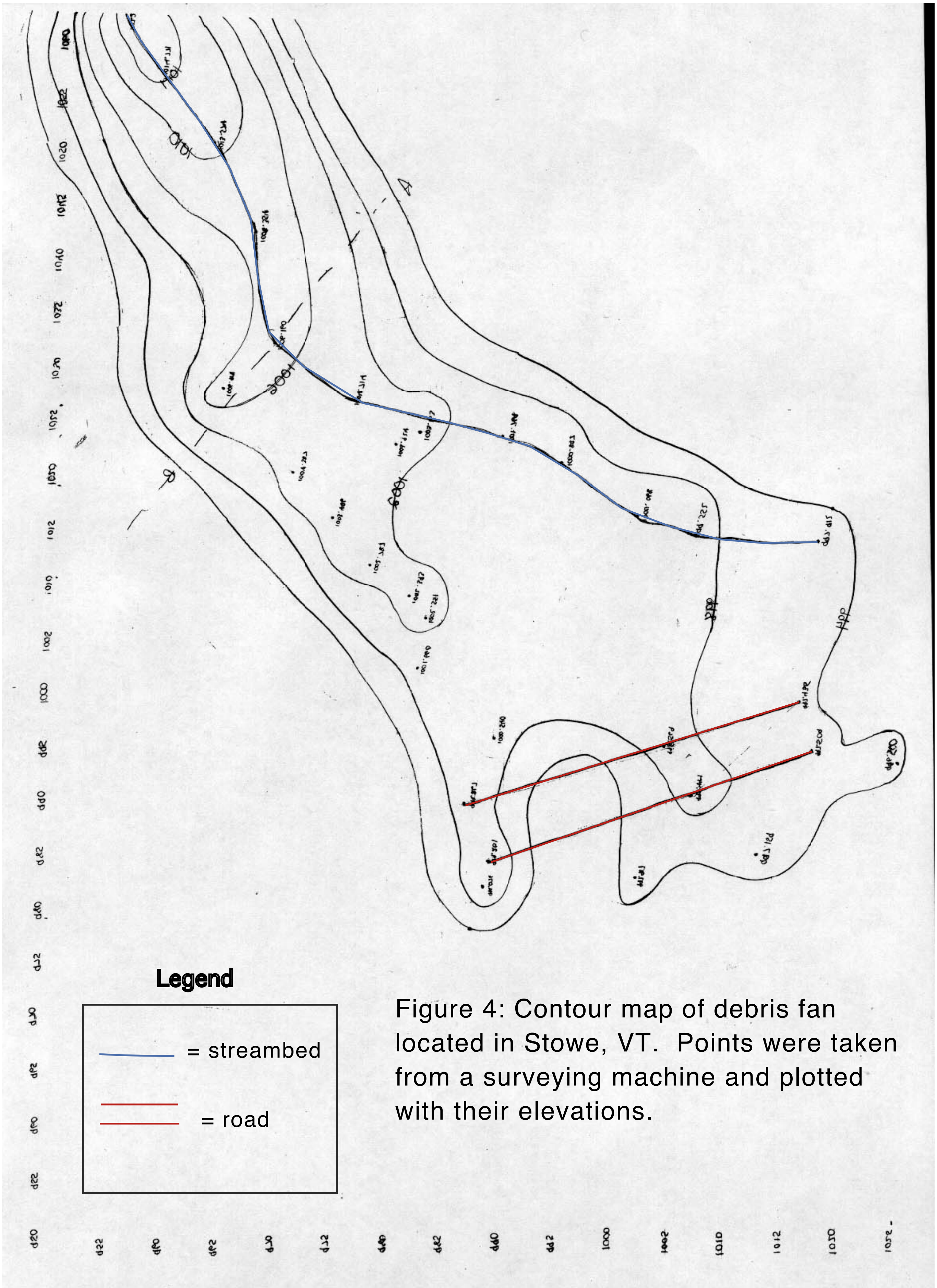
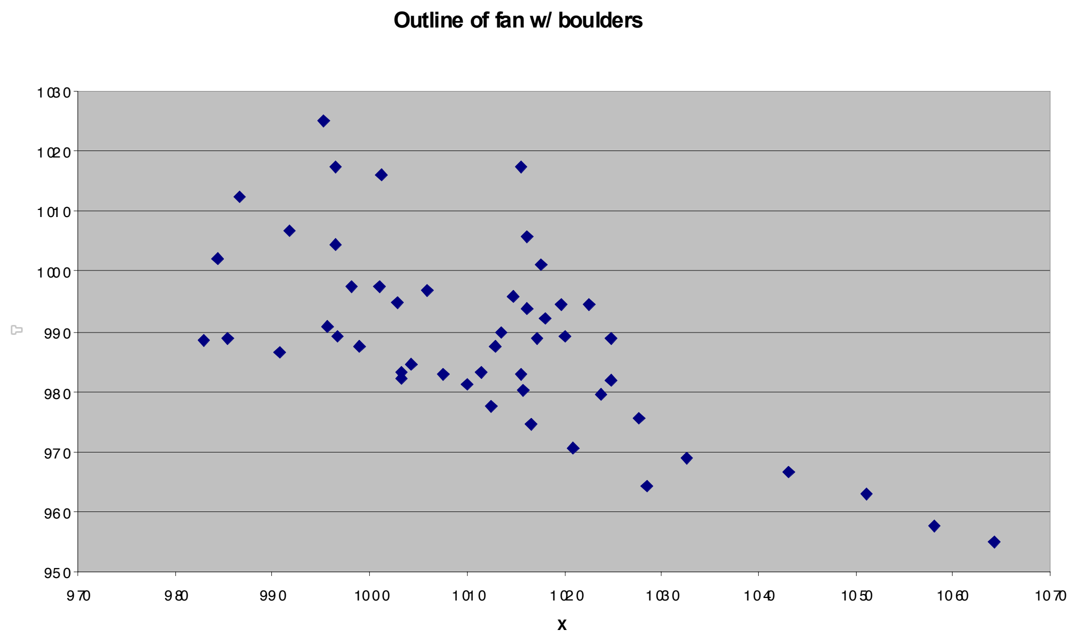
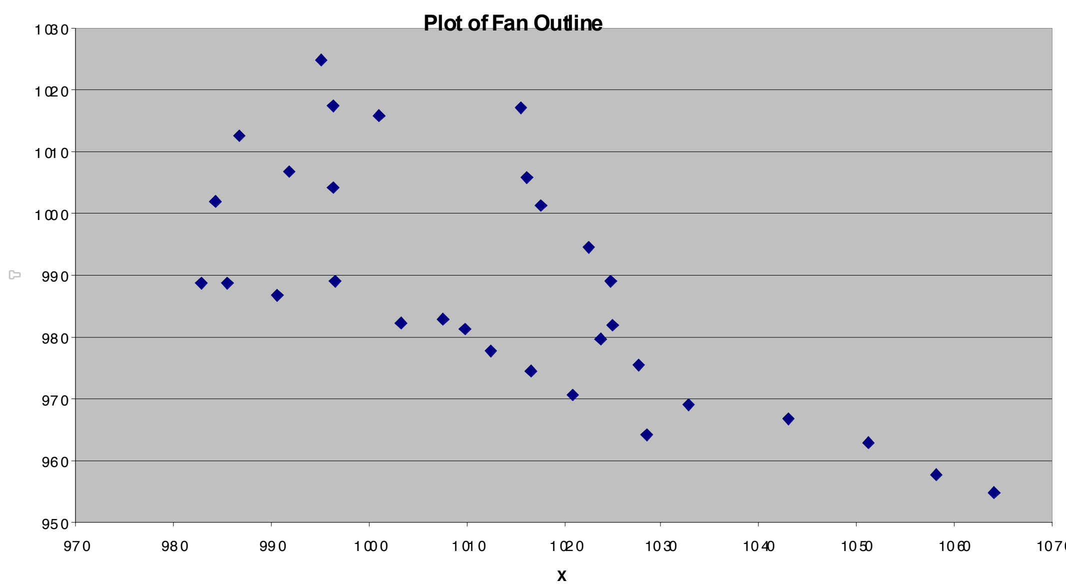


Figure 4: Contour map of debris fan located in Stowe, VT. Points were taken from a surveying machine and plotted with their elevations.





Figures 5a and 5b: Graphs of outline of fan. 5a includes large boulders that were found on the fan while 5b includes only the perimeter of the fan. These points were taken from the surveying machine.