1927 Flood: Then and Now

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Abstract: This study surveys the 1927 flood effects in Bethel, Cambridge, Montpelier, and Winooski, Vermont. This was done through re-photographing original flood photos. A brief history of the causes of the flood is given. Also, Manning's n was calculated for the Winooski River (USGS site 04290500) using United States Geological Survey records of discharge and blueprints of the Winooski riverbed from Winooski One Hydro. A combination of factors caused the 1927 flood, including deforestation. In conclusion the landscape has rebounded since the flood, with re-stablilization of slopes and man made structures such as bridges and dams.

I. Introduction:

The landscape change that has taken place over the past seventy-five years is immense. Since the 1927 flood, Vermont has been greatly re-forested, river channels have changed course, and development has altered the countryside greatly (Misinger, 2003). This project aims to record the changes that have occurred since the 1927 flood through the comparison of photographs taken at the time of flooding and photographs taken today, focusing on the history and causes of the flood, flood damage, and the changes that have taken place since the flood. This case study concentrates on four locations in Vermont: Bethel, Cambridge, Montpelier and Winooski (Figure 1), with the most time spent in Winooski, and Bethel. Also, a calculation of Manning's n, or roughness coefficient, will compare the Winooski River at the time of flooding with today. Manning's n is defined as the roughness coefficient, or how rough a river is. That is how much friction is acting upon the water from the materials on the stream bed. Manning's n values are extremely low, often ranging from 0.010 for very smooth surfaces such as glass, to 0.041 for mountain streams and rivers.

II. Methods:

Photographs:

The main focus of this investigation was photography. Twenty photographs were collected from Special Collections at the Bailey / Howe Library at the University of Vermont. It was our aim to then go to the places they were originally taken and re-take them. Doing this, we accumulated nine photo pairs. We used a Sony digital still camera, with a side 3.5 inch floppy disk drive.

Manning's N:

We calculated Manning's n using the slope, wetted perimeter, and cross-sectional area from surveying records (Figure 2). These records were obtained from Winooski One Hydro, the company which controls the dam. Also, velocity is needed for this calculation,

something that is impossible to obtain for the 1927 flood. We instead used the value Q, or discharge, as these are readily obtainable from the United States Geological Survey (Figure 3). Due to this change in variables we had to alter the equation slightly, making sure to multiply both sides of the equation by the area of the river.

Mannings's Equation: $V = R^{2/3} \times S^{1/2} / n$

V = average velocity, m/second. R = hydraulic radius (area/wetted perimeter), m^2/meter. S = slope of water surface, no units. n = roughness coefficient.

Modified Manning's Equation to Calculate for Today and Flood:

$Q = (R^{2/3} \times S^{1/2} / n)$ (Area), Q = discharge, m^3/second. Area, m^2.

III. History:

The flood occurred on November 2, 3, and 4 of 1927 (NOAA, The Flood of 1927). Rainfall averages over this period of time range from four to nine inches total (NOAA, The Flood of 1927). Had this been an isolated event of extreme rain the effects would not have been so severe. The month of October, 1927 saw one hundred-fifty percent more rain than normal (NOAA, The Flood of 1927). In Northern and Central Vermont there was nearly three hundred percent more; this completely saturated the ground. Since the periods of heavy rainfall in October were spaced apart flooding did not occur. These factors, combined with the fact that it was autumn, a season where most vegetation was already dead or dying, lead to what is still known as Vermont's greatest disaster. (Misinger, 2003) The lack of plants and the deforestation of Vermont may have played a minor role in the grounds ability to absorb water. For the soil to be able to hold on to some amount of water it has to have plants which can consume that water, and with no plants or trees and heavy rain, the excess runoff has no other place to go than into the rivers.

A cold front moved into the area from the West, and the rain started the evening of November 2. The convergence of the cold front, with a low pressure system that was

moving up the Northeast coast caused a strong southeast air current forcing the storm into Vermont. When it reached the Green Mountains moist air was forced to rise, causing torrential downpours on November 3. The rain was most intense in Central Vermont, East of the mountains, and the highest recorded rainfall was 9.68 inches in Somerset (Figure 1). (Walter, 1928)

IV. Data Presentation:

Photographs: See Figures 4 through 12.

Manning's N:

Slope was calculated from surveying records (Figure 2). From the same records we created a cross-section, from this cross-section we were then able to determine the wetted perimeter and cross-sectional area (Figure 13).

Winooski River Calculations:

Today- $535 = [(149.57 / 48.77)^{2/3} (0.04)^{1/2} / n] (149.57)$, $n = 0.017$

Flood- $3341 = [(391.35 / 73.15)^{2/3} (0.04)^{1/2} / n] (391.35)$, $n = 0.02$

V. Data Interpretation:

Photographs:

In the nine photograph pairs (Figures 4 - 16) there are varying degrees of change in the landscape and varying amounts of development. Bethel's landscape has changed the most due to reforestation, this can be noted best in the image of the river with the bridge fallen in (Figure 4). The development of the area has changed so little that the houses seen in the original photograph are still there, but cannot be seen because of the new trees that have grown on the riverbanks. The most striking of the similarities in pictures is that of the railroad bridge (Figure 5), where there is still a landslide on the failing slope.

Winooski has probably changed the most, because the flood completely destroyed both the bridge and the dam, and a large rebuilding effort took place. The landscape change

around the bridge and dam is mostly human-induced. The bridge that was rebuilt is much larger and higher than the first (Figure 7), and the dam has a much greater effect on the river now than it did before. When they rebuilt the dam, they cement cast the bedrock and then placed a rubber dam on top (Thompson, personal conversation, 19 November 2003). After the flood, the mills were sold, as they had been severely damaged, this caused the rebuilding effort to constrain the river using a cement wall before the dam (Figure 2). Little reforestation has taken place in Winooski, there is only one photograph showing the re-growth of trees (Figure 6).

Montpelier and Cambridge were effected in much the same way as Bethel and Winooski. The landscape has changed little since the flood, owing its major changes to development of roads. There has been some reforestation in Cambridge (Figure 11). The flood waters in Montpelier were upwards of 20 - 30 feet higher than they are today (Figure 9); this is also true for Cambridge (Figure 12).

Manning's N:

A low Manning's n (0.010) signifies a smooth surface, whereas a high value (0.040) is a rough one.The two values calculated were 0.017 for today, and 0.02 at the time of flooding. Since the Winooski river has changed little over the course of the past seventy-five years the closeness in values of coefficients is to be expected. According the United States Geological Survey during the 1927 flood the Winooski was discharging 160,00 Cubic Feet per Second (CFS) (Figure 3) (USGS Website, November 2003). On November 20, 2003 the discharge was 18,900 CFS (Figure 3), a change of 141,100 CFS (USGS Website, November 2003).

VI. Conclusions:

The cause of the 1927 flood cannot be attributed to one single factor, but a combination of many. The excess rain during the month of October saturated the soil to the point where it could not hold anymore. The final factor, the excessive rain culminating

on November 4, pushed the landscape over the edge. The water ran into the already high rivers, causing mass flooding all over the state. The flood greatly changed the landscape, causing failing on slopes, destruction of homes and bridges, and forcing a mass rebuilding effort in all counties. (American National Red Cross, 1929)

The Manning's n values observed are to be expected for the amount of water that has been observed both during the flood and today. These relate to the photographs in that the height of the water during the flood can be estimated from the height observed in the pictures. At the observed locations the flood waters were anywhere from 15 to 30 feet above normal levels, depending on the channel geometry. Over time the landscape and people effected have healed, and reverted back to a state of stability.

VII. References:

Abair, Joseph G. Flood, November 3 and 4, 1927, Montpelier, Vermont. Capital City Press, 1928

Johnson, Luther B. Flootide of 1927. Roy L. Johnson Company, Randolph, VT 1927

Misinger, William Elliot The 1927 Flood in Vermont and New England, November 3 - 7, 1927: An Historical and Pictorial Summary. Blue Hill Meteorological Observatory nd Science Center, 2003

New England Flood Disaster, November 1927, Official Report of the Relief Work. American National Red Cross, 1929

The Flood of 1927 <http://www.erh.noaa.gov/btv/html/27flood.shtml>

Thompson, Colm. Conversation with at Winooski One Hydro dam

United States Geological Survey <http://nwis.waterdata.usgs.gov/>

Walter, Charles T. Lights and shadows of the flood of 1927; Vermont at its worst, Vermonters at their best. The Cowles Press, 1928

All original photos courtesy of Bailey / Howe Special Collections

Location Map

Figure 1. Location map showing the four locations of case study and Somerset the location of the heaviest rainfall seen during the flood.

Blueprint of Winooski Riverbed

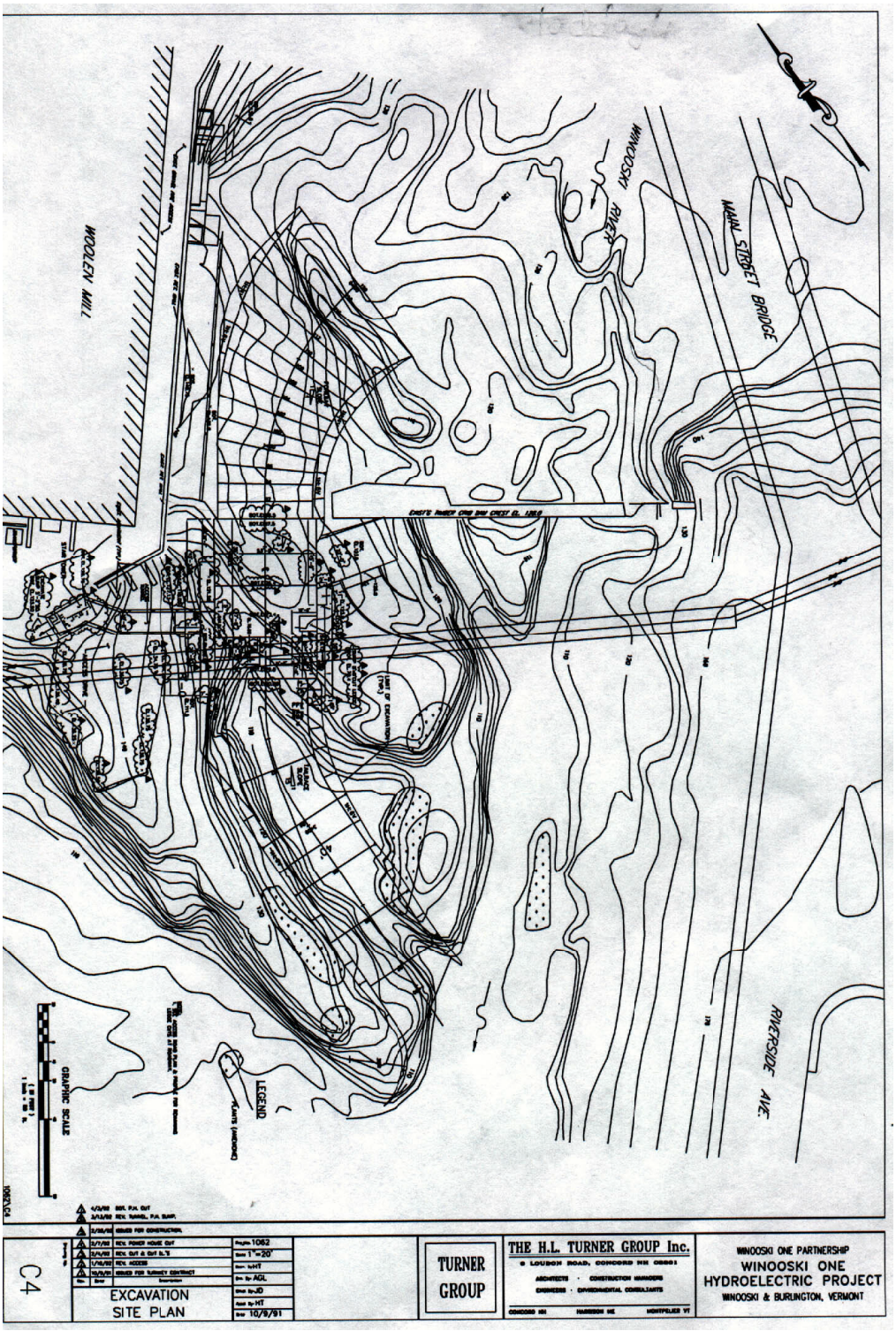


Figure 2. This blueprint shows the Winooski Riverbed and the complete schematics of the dam. Courtesy of Winooski One Hyrdo.

Discharge Graphs

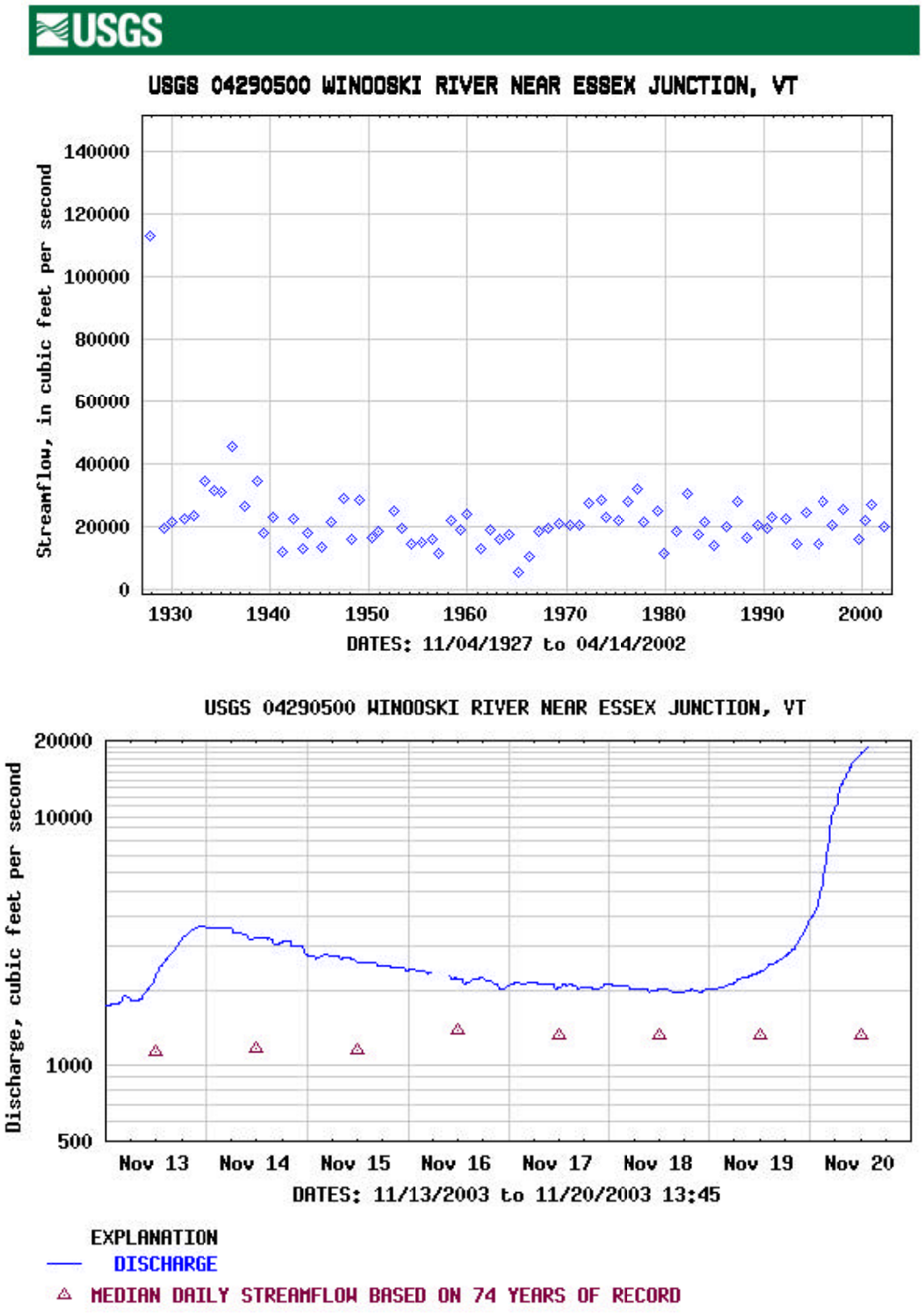


Figure 3. These graphs depict the discharge in Cubic Feet per Second (CFS) of the Winooski River. Courtesy of United States Geological Survey.

Bethel Photograph Pair 1

Original

Re-Photo

Figure 4. Since the flood the area has been greatly reforested, and the bridge re-built. Many of the homes seen in the original are still there, but are obscured by the trees.

Bethel Photograph Pair 2

Original

Re-Photo

Figure 5. Aside from the rebuilding of the bridge little has been changed at this site. The houses still remain, there has been some reforestation. Note: The landslide is still there.

Winooski Photo Pair 1

Original

Re-Photo

Figure 6. There has been extensive change since this photo was originally taken. A much wider bridge has been built in place of the original, and many trees have grown back around the bridge.

Winooski Photograph Pair 2

Original

Re-Photo

Figure 7. The Winooski-Burlington bridge was completely destroyed in the flood. The bridge seen in the re-photo was built in 1928 to replace the first. The flood also obliterated the dam, that too has since been rebuilt.

Winooski Photograph Pair 3

Original

Re-Photo

Figure 8. One of the many mills on the Winooski that was destroyed during the flood. It has since been rebuilt, sold, and turned into apartments.

Montpelier Photograph Pair 1

Original

Re-Photo

Figure 9. The re-photo of this location is not exactly the same because the original photo was taken on top of a building. While little has changed at this location it gives a good idea of how high the water was.

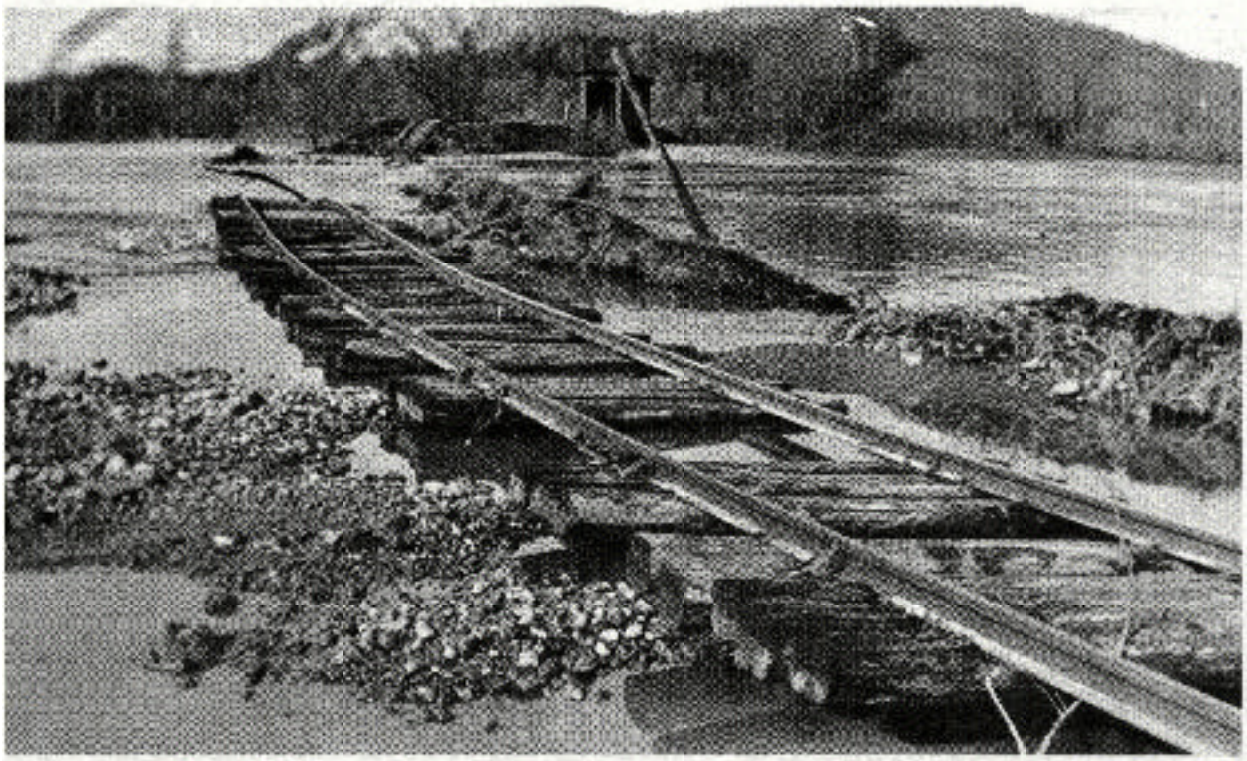
Montpelier Photograph Pair 2

Original

Re-Photo

Figure 10. The original and re-photo are virtually the same. There are minor diffrences such as the parking meter, and the building in the background has been torn down since.

Cambridge Photograph Pair 1



' flood caused extensive destruction to the Saint Johnsbury and Lake Champlain trackage. This ıken at Cambridge Junction shows how the Lamoille River washed out everything but the covered bridge.*

Original

Re-Photo

Figure 11. After the flood the railroad seen here was not repaired, it was later turned into a road. The bridge is now in the process of being rebuilt.

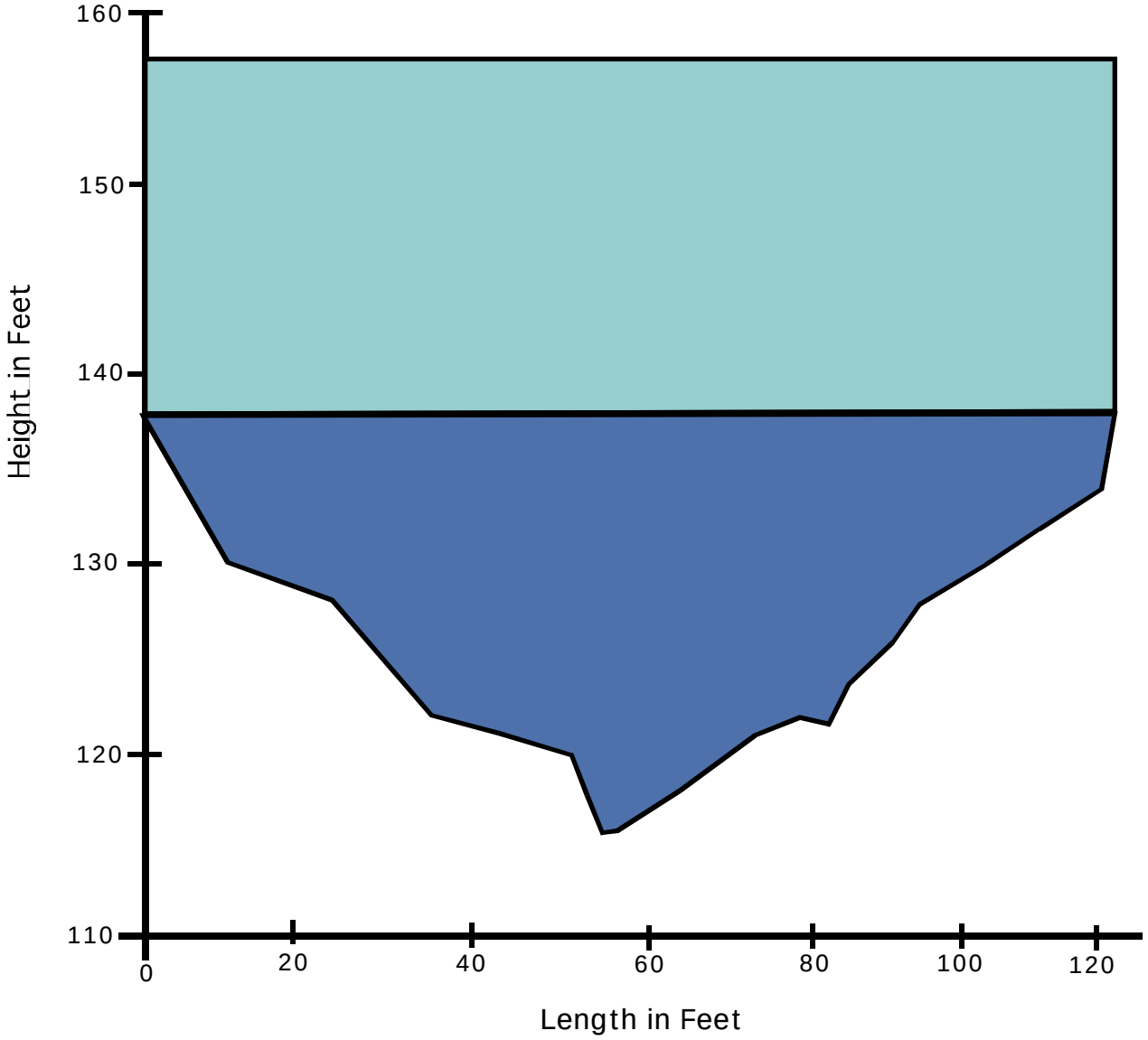
Cambridge Photograph Pair 2

Original

Re-Photo

Figure 12. Very little has changed since this photo was originally taken. The road has been paved, and a few of the trees have been cut down.

Winooski River Cross-Section



Key

Water Today

Water at Flood

Figure 13. This cross-section was approximated used the surveying records from the dam (Figure 2).