Flooding Potential in Bloomington, Idaho

Final Report Prepared for
Civil and Environmental Engineering
GIS in Water Resources
CEE 6440, Dr. Tarboton
Utah State University

Prepared by
Taylor Stauffer

7 December 2018

Introduction

This report discusses the methodology and analysis of the flooding potential in the area of Bloomington, Idaho. How the data was collected and how ArcGIS pro was used in produce the data and present it will be discussed. The purpose and need of the study will be presented and then the results will be shown and why it is important to have completed the study.

The town of Bloomington, Idaho is becoming a popular recreational area because of the nearby Bear Lake. Development of vacation homes are increasing rapidly in the small town. Before development of homes can begin it is important to know if the property is at risk of being flooded. Bloomington is located at the mouth of Bloomington canyon which is part of the Bear River Range in southeast Idaho (See Figure 1). The Bloomington Creek and the annual snow pack run off are the major factors which influence flooding.

Figure 1. Bloomington basin

Table of Contents

List of Figures

Page

Objectives

The Bloomington Creek is a mountain stream and the water source comes from the snowpack in the catchment region. Each year in the spring the Bloomington Creek has its highest flowrates due to the warmer air temperatures melting the snowpack in what is called the spring runoff. There are many parcels of land which are of interest to be developed. The results of the project provided the area which may be affected by certain flood events. The factors which affect flooding are mainly the amount of snowpack and the temperature which causes the snow to melt. A look at the historical data of snow water equivalence and temperature for the area was used to know for what conditions will cause a certain flood event.

The project objectives were

- Create an inundation map for Bloomington
- Create a rating curve for the catchment in town most affected by flooding
- Analysis historical snowpack, precipitation, and temperature data
- Associate an inundation stage height to certain conditions and probabilities

Methods

Inundation Methods

Data of the elevation was obtained from the National Map which is created by the United States Geological Survey (USGS) and used to map a digital elevation model (DEM). The DEM for the Bloomington catchment has high resolution of 10 M x 10 M which is the most accurate available. Before the DEM could be used to find catchments, streamlines, and an inundation map the DEM needed to be conditioned by filling pits and removing artificial barriers.

A major artificial barrier in the catchment was highway 89 which runs north to south through Bloomington. The road is an artificial barrier because the DEM does not identify culverts under the roadway which would allow flow to pass under the road. Conditioning the DEM by using TauDEM toolbox and etching the stream by using vector stream information aligns the natural flow of the stream through the artificial barrier (Tarboton, 2018). Dr. Tarboton provided much assistance in the etching of the stream.

After the DEM is conditioned to the natural hydrologic conditions then using the National Hydrography Dataset (NHD) a raster can be created from the flow lines. With the DEM model and the NHD flow lines an inundation map can be created.

Rating Curve

A rating curve was created for the catchment shown in Figure 2. This catchment was selected because it is the part of town that is close proximity to the Bloomington Creek and where it is observed to have a higher population density. The rating curve was created by using the inundation map to find the number of flooded cells associated with a stage height. The wetted bed area was obtained by finding the average slope of each grid cell from a flow direction calculation. Applying Manning's equation (Equation 1) a flowrate can then be calculated that is associated with the given stage height.

Figure 2. Catchment selected for rating curve

$$Q = \frac{1}{n} * \sqrt{Slope} * \frac{Area}{Wetted\ Perimeter}^{\frac{2}{3}} * 448.831 \qquad \text{Equation 1}$$

The Bloomington Creek does not currently have a USGS stream gauge but historical data of the stream was found from years 1960-1986. It was determined to be applicable to the current conditions of the project. The stream gage provided a discharge estimate which was then compared to the rating curve found using the HAND method.

Snowpack and Temperature

An important part of the project was to conduct an analysis of the historical data for snowpack and air temperature for the catchment. The data was collected from the Natural Resources Conservation Service (NRCS) SNOTEL stations. The nearest SNOTEL station was located in the Franklin Basin, Idaho which is at a similar elevation as the Bloomington Basin and is less than five miles away. The snow water equivalent (SWE) is a common snowpack measurement and is the amount of water contained in a snowpack. It is the depth of water that would theoretically result if the snowpack melted instantaneously (NRCS, n.d.)

The historical SWE data for the catchment was analyzed in month increments. The data showed how the snow pack accumulated through the winter months. The SWE amount is recorded as a depth and can be multiplied by the catchment area to measure the volume of water that will run off into the stream.

In the spring months the snowpack will melt depending on the air temperature. The historical data of temperature in the region was collected from the National Oceanic and Atmospheric Administration (NOAA) and used to predict a range of possible temperatures during the spring months. It was then predicted how the flowrates would increase with the predicted snowpack runoff.

Results

SNOTEL and Temperature

The data collected from the USGS stream gauge was plotted to show the monthly peak flow rate which has happened in the Bloomington Creek. Figure 3 has the months numbered on the x-axis and the discharge in cubic feet per second (CFS) on the y-axis. The time of year where flow rates are the highest is in May and June. The peak flow rates are associated with the time of spring runoff and for that reason the SWE and temperature data in May and June were used in the analysis.

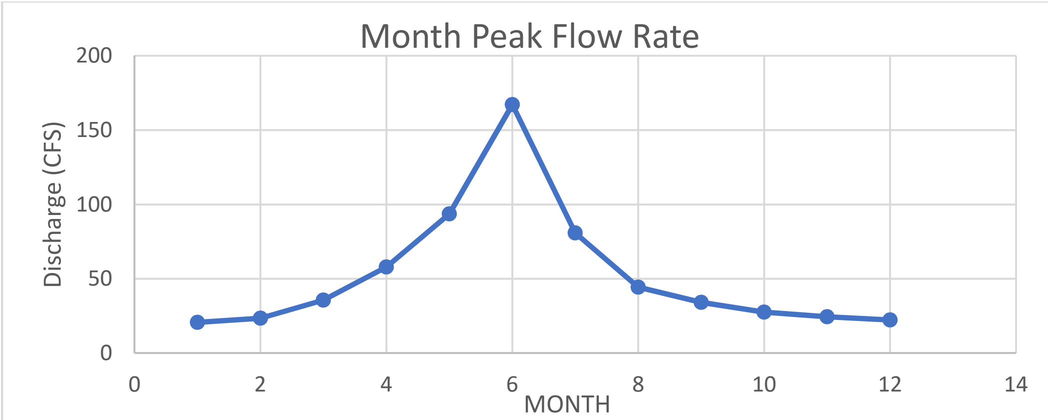

Figure 3. Monthly peak flow rate

The data retrieved from the NRCS SNOTEL station gives the measurement of snowpack in the amount of SWE. Figure 4 gives the SWE for the water year of 2011 and the precipitation accumulation. Figure 5 shows the cyclical pattern of the snowpack and runoff. 2011 is the peak snowpack levels which is on record for the SNOTEL station. The water year starts in November and is when the area begins to receive snow and the snowpack continues to increase into May. By looking at Figure 4 the snowpack begins to decrease between May and June and which shows the relationship between peak flow and snowpack melt.

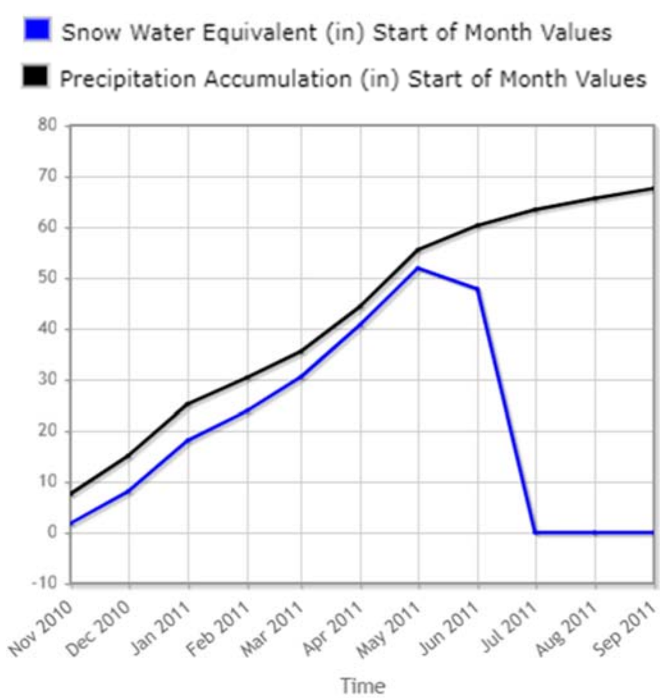

Figure 4. Snow water equivalent for 2011 water year

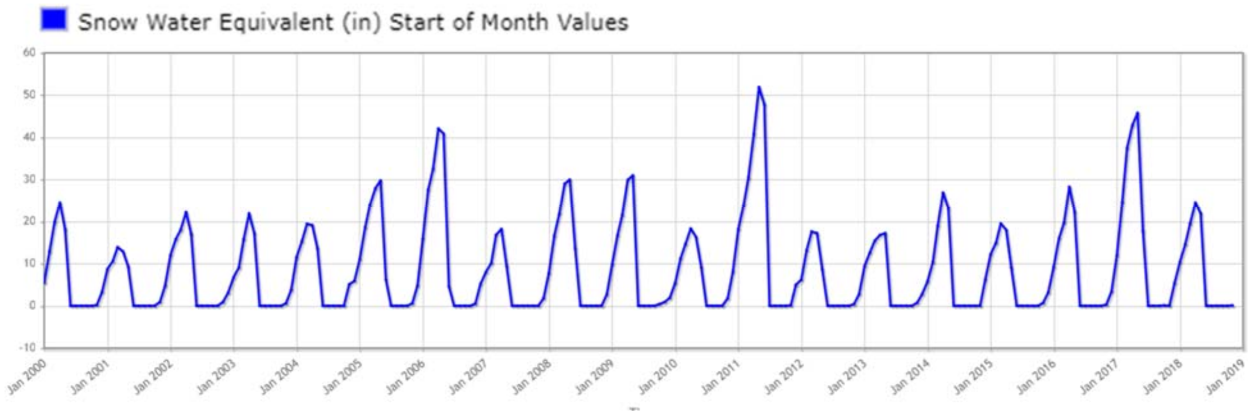

Figure 5. Historical data of snow water equivalent

Predicting the volume of runoff is done by multiplying the area of the basin by the amount of SWE. The area of the Bloomington basin was measured by delineating the drainage basin using ArcGIS and found to be 112.6 kilometer squared. The peak SWE record by SNOTEL is 52.4 inches. The calculated volume of water in the snowpack for 2011 was approximately 121,500 acre-feet of water (5.3 billion cubic feet).

Temperature data collected by NOAA gave the maximum and minimum daily temperatures for the period of record. The calculations of run off looked at the rate in which the SWE decreases and the average daily maximum temperatures for that time period. For the 2011 water year the SWE decreased at a rate of approximately 1.5 inches per day. The average daily maximum temperature for that time period was 72.5 degrees Fahrenheit. For the period of record the 2011 water year showed the largest rate of snowpack melt.

Inundation Map

An inundation map was created to show the height above the nearest drainage (HAND) for the catchment. The inundation map shows which areas would be affected if the water surface would get to a certain height above the stream (Figure 6). The areas most affected are agriculture land, which are frequently affected by normal amounts flooding. A rating curve was produced to find what discharge is associated with a stage height for the selected catchment (Figure 7).

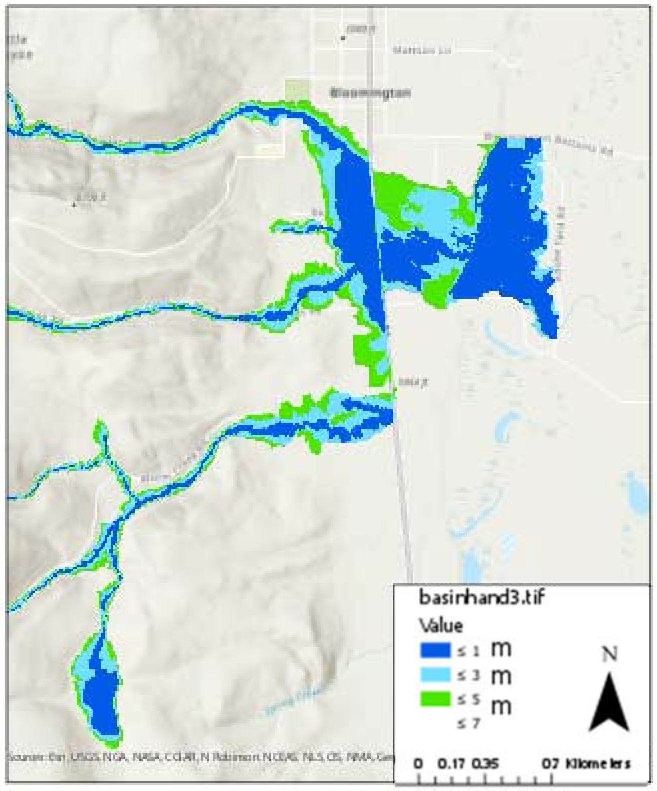

Figure 6. Inundation map

Stage h	1	1.5	3	5
stage (ft)	3.28	4.92	9.84	16.40
Cell size (m^2)	100	100	100	100
flooding cell num	1,825	2,330	3,481	4,795
sb	1.00	1.00	1.73	2.24
As (m^2)	182,500	233,000	348,100	479,500
Ab (m^2)	182,591	233,198	603,289	1,074,080
inundation depth (m)	0.64	0.80	1.91	3.10
Vol (m^3)	116,928	186,400	663,583	1,488,800
Length m	4,223	4,223	4,223	4,223
z1 (m)	1,867	1,867	1,867	1,867
z2 (m)	1,855	1,855	1,855	1,855
A (m^2)	27.7	44.1	157.1	352.6
P (m)	43.2	55.2	142.9	254.4
R(m)	0.64	0.80	1.10	1.39
S	0.002723	0.002723	0.002723	0.002723
n	0.05	0.05	0.05	0.05
Q mannings m^3/s	21.5	39.7	174.8	457.5
Q cfs	758.3	1,401.4	6,172.2	16,155.9

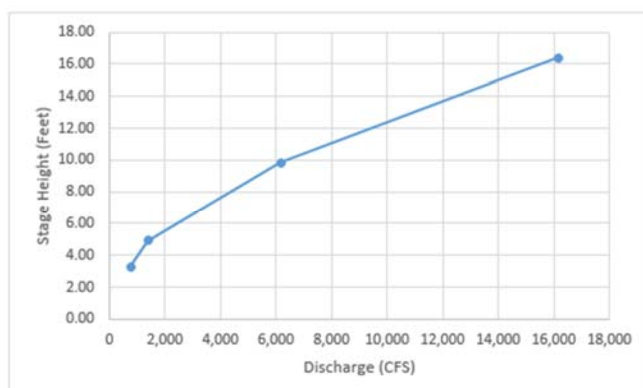

Figure 7. Rating curve and calculations

The removal of the artificial barrier caused by the highway is shown in Figure 8 and allows flow through the barrier. The road is elevated above the surrounding surfaces and it can be seen how there is a break in the elevated roadway which allows flow passage. There was only a small difference in the inundation map once the barrier was removed. The effect of the flooding was slightly decreased once the artificial barrier was removed.

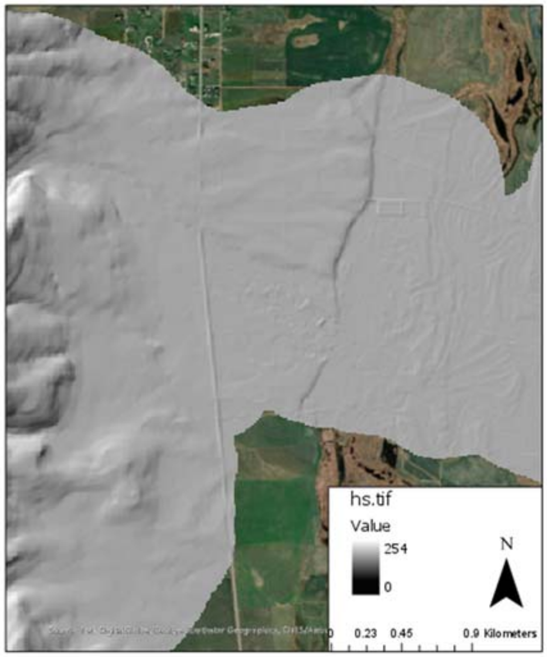

Figure 8. Hill shade map after artificial barrier was removed

According to the USGS Stream Stats data, the 25 year flood event has a discharge of 755 CFS. The rating curve in Figure 7 shows that for a discharge of 758 CFS the stage height would be 1 m. The 100 year flood event has a discharge of 1000 CFS according the USGS Stream Stats. By looking at the rating curve, for the stage height to increase to 1.5 m, there would need to be a flow rate of 1400 CFS, which is greater than the 100 year flood event.

Discussion

The HAND method was used to create an inundation map for Bloomington, Idaho. There may not be a large effect due to flooding because the town is located at the mountains base and has large elevation changes. There is a small amount of area close to Bloomington Creek which is likely to experience flooding for a 25year storm event. For a flow rate surpassing the 100 year storm event, there would be similar amounts of flooding compared to the 25 year storm.

After looking at the historical data that was measured from SNOTEL the peak water volume and the largest rate of snow melt was used to predict a flowrate. It was predicted that the peak flow rate during the spring runoff would be approximately 1000 CFS. The predicted peak flowrate would cause a small amount of flooding in the area.

There are uncertainty and limitations in the modeling of the methods used in the project and should be considered. A high resolution DEM was used to find to determine stream bed locations and elevations. A finer resolution would result in more accuracy in the results. The model to predict snowpack and temperature was determined based off historical data. There is a possibility that the snowpack or air temperatures exceed that of historical data and would result in flowrates much higher than predicated.

Conclusion

Bloomington, Idaho is a small town located at the base of mountains in the Bear River Range. Each year there are increased flows in the Bloomington Creek due to spring runoff. The spring runoff increases the probability of property flooding near the creek. An analysis looked at several factors which affect flooding such as elevation, snowpack, and temperature. There is a small amount of area near the Bloomington Creek which would be affected by flooding associated with a 25 year flood event. The area which is affected by flooding increases at a small rate as the flowrate increases at a large rate.

References

National Oceanic and Atmospheric Administration. "Climate Data Online". (n.d.) Retried from https://www.ncdc.noaa.gov/cdo-web/

Natural Resources Conservation Services. "What is snow water equivalent" (n.d.) Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/or/snow/?cid=nrcs142p2_046155

Tarboton, D.G. (2018). "GIS in Water Resources, "Using Digital Elevation Model Derived Height Above the Nearest Drainage for flood inundation mapping and determining river hydraulic geometry Lecture". http://hydrology.usu.edu/dtarb/giswr/2018/ (October 23, 2018).