Analysis of the Snow Water Equivalent (SWE) in the Logan River Watershed

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Introduction

During the spring of 2011 many parts of Utah experienced a longer and wetter precipitation more than usual. As a result flooding and water control became a large issue as spring runoff was affecting many parts of the state including the Logan River Watershed. The maximum daily flow for 2011 was peaked at around 1650 cfs on (June 25th) which is 220% above normal (Source: USGS). The purpose of this project is to show that Snow Water Equivalent (SWE) that is measured at SNOTEL stations throughout the country can be related elevation and maximum daily flow. Originally for this project eight SNOTEL station data was used. However because five of the stations only have SWE data for no longer than ten years it was decided to only use the three stations that have data going back many years. This will prevent any kind of a bias that the newer station may impose. Delineation of the Logan River Watershed in ArcMap will be the first step in this project. After Delineation the Snow Water Equivalent data from the Nation Resources Conservation System (NRCS) will be imported into excel and will be used to find a linear regression that relates elevation with SWE. Then a relationship between the SWE and the Maximum daily flow will be analyzed in this project.

Data Sources

In this project a Digital Elevation Model (DEM) is needed to create the Logan River Watershed. The DEM was obtained through Seamless data source online that the USGS provides. The DEM requested needed the 1/3 second Digital Elevation Model. Also in this project the SWE in or near the watershed will be contained at the SNOTEL stations will be needed. At first eight station data was used, however due to some stations having shorter data than other only three stations were used that had data longer than 20 years. The maximum daily flow for the Logan River was found through USGS.

ArcGIS Watershed Delineation

The first part of the project is to create a Logan River Watershed through delineation. To do this a Digital Elevation Model (DEM) obtained from the Seamless Data Warehouse through the United States Geological Survey (USGS). Once the DEM is imported in ArcMap the DEM is subjected to a FILL tool to create a more accurate DEM that has no pits.

The next step in the Delineation process is to bring in the stream flowlines from NHDPlus Online. The total data included covers most part of the state of Utah. Figure 1 below shows the stream network in correlation to the DEM. Once this is completed an outlet indicating the Logan River start is placed through the editor tool function. The outlet is listed as a point feature and is needed to delineate the watershed.

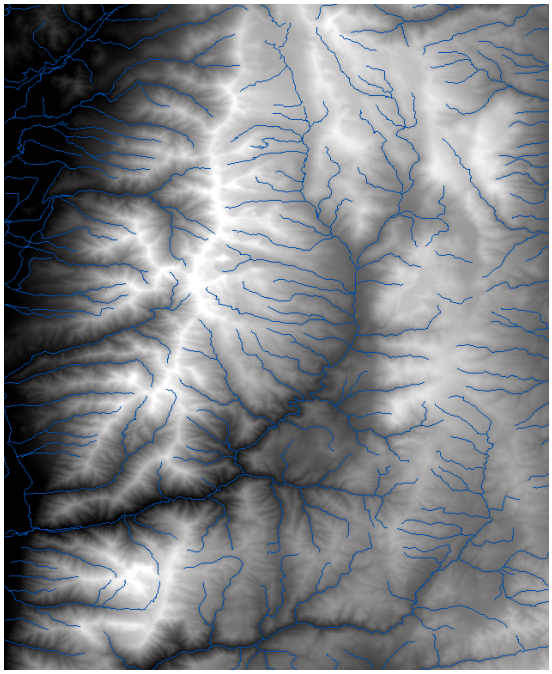

Figure 1 - DEM and Streamflow Lines

The watershed can now be created using the ArcMap tool Watershed. The first outcome will produce a raster grid of the catchment. After that is done a raster to polygon command is used to indicate the watershed boundary. Figure 2 below shows the completed Logan River Watershed. Using math algebra in ArcMap the total area found in the watershed was found to be 211 Miles^2.

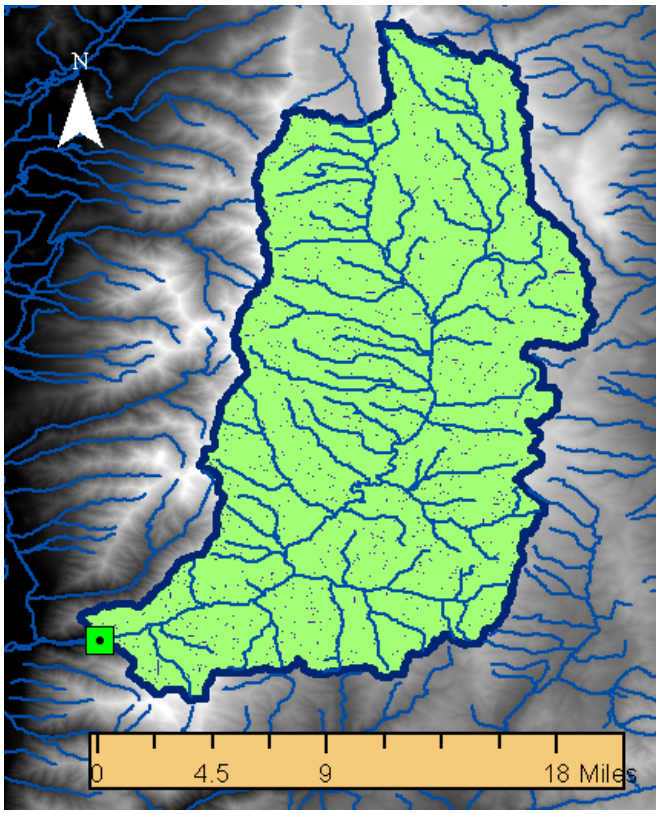

Figure 2 - Delineated Watershed

SWE and Elevation

Data for the SNOTEL stations used in this exercise was found online through Natural Resources Conservation Service (NRCS). Originally eight SNOTEL station data was going to be analyzed. However after much trial and error is was discovered that since five of the stations used had SWE data for less years it was determined that only three SNOTEL station data would be used to prevent any kind of a bias in the analysis. Table 1 below shows the names of these stations. The stations highlighted in green will be used in the analysis.

Table 1 - SNOTEL Stations

Location	Latitude	Longitude	Elevation (ft)
Tony Grove Lake	41.90	-111.63	8540.02652
USU Doc Daniel	42.05	-111.52	8451.44384
Franklin Basin	42.90	-111.60	8205.38084
Bug Lake	41.68	-111.42	7949.47532
Garden City Summit	41.92	-111.47	7700.13148
Temple Fork	41.80	-111.55	7290.02648
Klondike Narrows	41.97	-111.60	7273.62228
Tony Grove RS	41.88	-111.57	6325.45952

MS Excel was used heavily to import the data then changed before being exported into ArcMap to be used in the project. For this project the total daily SWE for each year for each station was averaged to find a mean daily SWE for the three SNOTEL stations used. In seeing how SWE changes over time the average SWE bimonthly was taken to show this relationship. A linear regression was then created that related SWE to elevation. Figure 3 below shows the relationship between all of them at the same time.

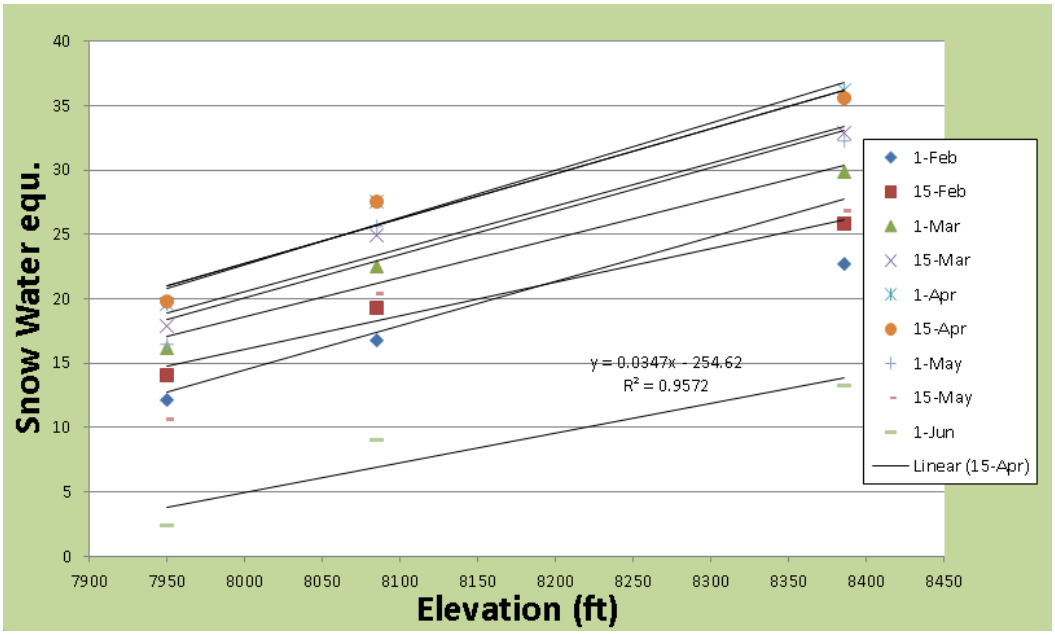

Figure 3 - Elevation vs. Snow Water

Since each time period produces a different linear equation the equation that will be used will be the April 15th. The reason why is because this is approximately the SWE peak for each of the SNOTEL stations. SWE = -245.62 + 0.0347x shows the relationship between SWE and Elevation. From this we can determine the SWE for the entire Logan River Watershed that has been created through interpolation.

Adding the SWE data for each time period was a difficult process but was finally figured out. Figure 4 below shows the Stations in regards to where they are on or near the Watershed

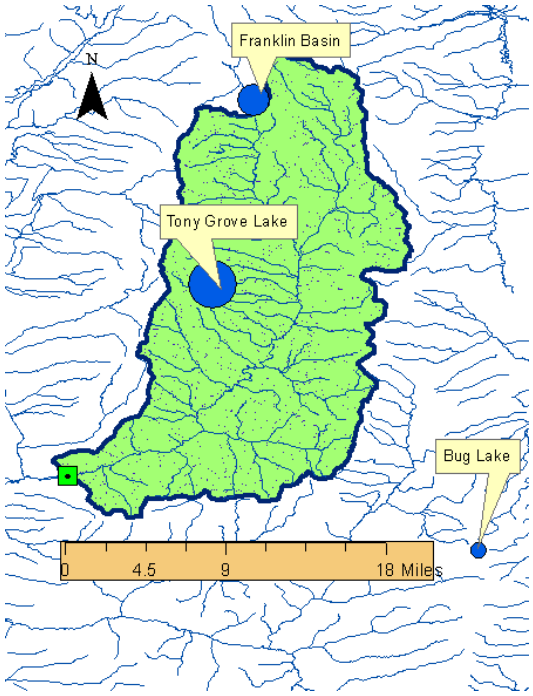

Figure 4 - SNOTLE Stations

To show how elevation of each station relates to SWE a spline function through ArcMap was used to display the SWE relationship over the watershed. Figure 5 below shows the spline interpolation map.

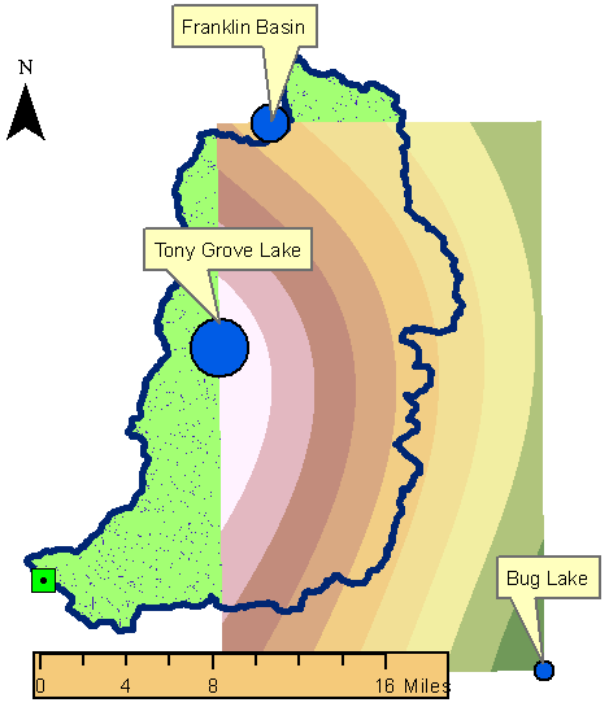

Figure 5 - Spline Interpolation

Stream Flow Correlation

In this part of the project an analysis will be made to show the correlation to stream flow with Snow Water Equivalent. Average daily flows for the Logan River above the state dam was obtained through the USGS online. The maximum daily flow for the Logan River is 751 cfs that occurs about June 6th. The figure below shows the correlation between the average daily flow from Logan River with the average SWE storage. Figure 6 below shows how the two curves are in proportion to each other.

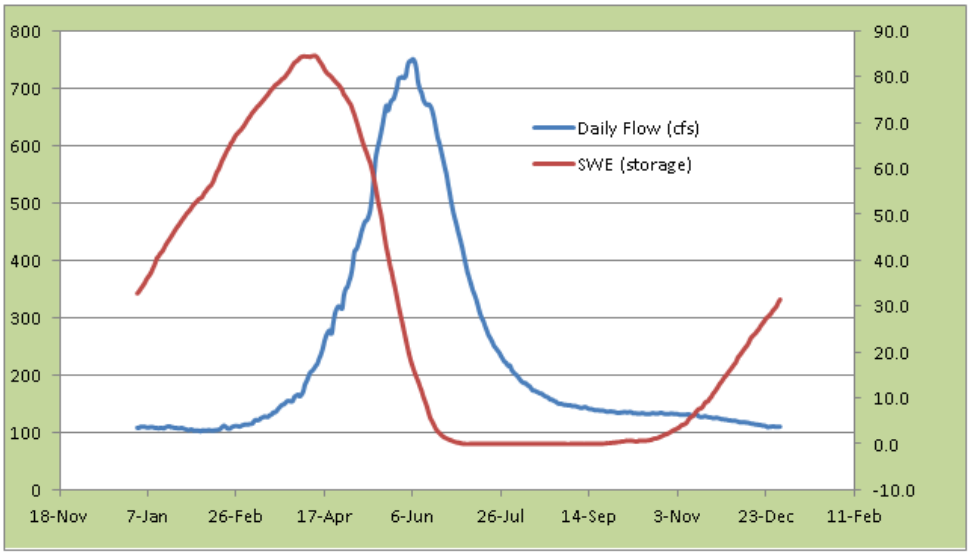

Figure 6 - SWE Storage vs Daily Flow

Conclusion

According to the SWE data there is a correlation between the elevation and Snow Water Equivalent. This means as the elevation increases the more Snow water Equivalent builds up over the course of a winter. It was interesting to see how not only they all increased at the same rate but also decreased at the similar rate as well. There is also a correlation between the SWE storage and Daily maximum flow. When the SWE peaks at around the middle of March is when the flow in the Logan River dramatically increases. This has a lot due to temperature and less snowfall precipitation.

References

National Hydrography Dataset plus (2011) – Great basin Region 16 b

< http://www.horizon-systems.com/nhdplus/HSC-wth16.php>

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< http://www.wcc.nrcs.usda.gov/snotel/Utah/utah.html>

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< http://seamless.usgs.gov/>

United States Geological Survey (2011) – USGS 10109000 Logan River about State Dam,

< http://waterdata.usgs.gov/nwis/dv/?site_no=10109000&agency_cd=USGS&referred_module=sw>