return to baseflow. For the specific storms from 2015, actual dates and times for the storm were used in the model.

Time-series data and paired data was added to the model as needed during the calibration process and when modeling possible future BMPs.

Calibrating a hydrologic model helps improve its accuracy. In order to do this, actual data from the creek was retrieved and compared to the results from the HEC-HMS model. Then the variables such as the CN values, time of concentration, and storage coefficient were adjusted for the basins so that the model more closely matched the data. There were several steps and calculations performed through this process.

At the beginning of the summer 2015, faculty and students strategically installed 16 leveloggers throughout the watershed, mostly in streams upstream of culverts. These locations were selected due to their close proximity to a sub-basin outlet and their accessibility in order to install the leveloggers and later, collect data. Leveloggers are installed at the thalweg of the creek and log the pressure observed. As the depth of flow changes, so does the pressure at the levelogger. This pressure is converted to a flowrate using a known barometric pressure, as collected on a barologger, located at the Calvin College Green House on Lake Drive, and a rating curve for the stream. A rating curve is a table of data that lists the flow rate in the stream at various depths of flow. Each Levelogger has its own rating curve based on the configuration of the stream and culvert. The rating curves were determined using HY-8, a culvert analysis program designed by the Federal Highway Administration (FHWA). Using the rating curve, the hydrology team converted the levelogger data into a hydrograph for each location. This data was added to the HEC-HMS model as set of time-series data called άdischarge gageφέ

In addition to observed flow rates in the stream, actual precipitation data is needed to complete the calibration. For this process, data was retrieved from the Internet from the MesoWest website which provides the precipitation data as recorded by the National Weather Service at the Gerald R. Ford International Airport in Kent County, Michigan at station KGRR. This data was added to the model as a set of time-series data called άprecipitation gageφέ The selected storm used for calibration occurred on August 2, 2015 with a total rainfall of 0.79 inches.

Using Excel, the hyd to a

recommendations for the best values for the parameters, engineering judgement was used to determine which parameters in the model (CN values, time of concentration, and storage coefficient) to adjust to make the hydrographs match, making sure that any changes made were reasonable and still represented the model accurately. In most cases, the CN values were increased a little. Often, the peak of the runoff as shown from the levelogger data hydrographs was quicker than the peak from the model so the values for time of concentration were reduced. In many places upstream in the watershed, there are a lot of wetlands or flat areas where water ponds. These are modeled by the storage coefficient and as expected, this coefficient was often increased in the upstream basins during calibration.

In some cases, it was obvious that the calculated data could not ever match the observed data. There are several possible reasons that could explain this. One reason may be that the rain event for the calibration process did not fall evenly throughout the watershed. In some cases downstream, in the more urbanized areas, the observed hydrographs went very high, very quickly. This could be explained by the amount of impervious pavement. One possible improvement for future use would be to decrease the size of the basins. This would require additional time, but would improve the accuracy for the model. A third reason for the hydrograph discontinuities could be an error in the rating curve for the streams at some of the Levelogger locations. Better survey data of the cross sections where the leveloggers are located could improve these calculations.

This model is intended to help plan locations for future Best Management Practices (BMPs) and quantify the potential impacts on the downstream hydrograph. There are several tools built into HEC-HMS that could be used to model BMPs. The diversion tool could be set up in the model to simulate diverting a portion of the flow to an infiltration bed, or sink. Additionally, the detention pond tool could show the impacts of detaining the flow and releasing it slowly into the creek. Sometimes, in order to add these tools to the model, it is beneficial to add sub-basins or adjust the existing ones. Future users will need to continue using the standards established in this document when making changes to the basin models. Adding additional sub-basins to the model could increase the accuracy of the model.

It is likely that after several BMPs are installed the watershed, another round of calibration would benefit the model and also help to show the actual benefit received by the BMPs instead of modeling the anticipated improvements.

In the winter of 2016, research assistant Dena Dekryger spent time identifying potential locations for future BMPs and modeling their impacts. She summarized her process and results in a paper called, άRunoff Volume Reduction from Sub-Basins in Plaster Creek Watershed, Kent County, MIΦέ

The following table lists the various useful άrunsέ set up on HEC-HMS. At this time, there is not a basin model that accurately depicts the historic scenario for the watershed. A rough estimate of the historic scenario has been started in the model, but it should be adjusted at a later time for design and planning purposes if that will be helpful. All of these listed runs use the 2-Year SCS Storm because that is often the storm that engineers use for planning BMPs and by using the same storm, one can easily see the improvements expected by BMPs.

Run Name	Basin Model	Meteorologic Model	Control Specifications

2-Year GIS	PCW_Initial_GIS, uses all basin information calculated directly from GIS before any calibration	2-Year SCS Storm, depth = 2.37 inches	Time, 01 Jan 2016 @ 00:00 to 08 Jan 2016 @ 00:00
2-Year Historic	HistoricPlasterCreek, adjusts PCW_Initial_GIS to estimated historic values by changing CN values and time of concentration (Note: this is not completed)	2-Year SCE Storm, depth = 2.37 inches	Time, 01 Jan 2016 @ 00:00 to 08 Jan 2016 @ 00:00
2-Year Cal_Aug2	Cal_Aug2, PCW_Initial_GIS basin model calibrated to rainfall on August 2, 2015	2-Year SCS Storm, depth = 2.37 inches	Time, 01 Jan 2016 @ 00:00 to 08 Jan 2016 @ 00:00