# Modeling of Three Major Tributaries Within The Mad River: HEC-RAS versus the Proportional Area Method

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## BACKGROUND

In their list of Grand Challenges for Engineering, the National Academy of Engineering defined the quality and quantity of freshwater as one of the largest concerns facing our civilization's ability to sustain its current levels of development. Within the state of Vermont, Lake Champlain continues this trend as it struggles to maintain its water quality in its surrounding basin. Sub-watersheds, such as the Mad River, heavily contribute to the overall sediment and nutrient loadings into the lake through nonpoint sources of pollution. Understanding where these loads originate from and the level in which they are transported is essential for future land development, policy making, and conversation efforts. This research project was aimed to develop rating curves, stage versus discharge relationships, for three major tributaries within the Mad River watershed. Discharge values for base flow conditions can be determined with a pygmy meter, however for larger flows this process is not safe. The US Army Corps of Engineers' HEC-RAS software can be used to estimate discharge for much larger storm events i.e. (5, 10, 15, 100, 500 year etc.).

Utilizing the rating curves (Discharge versus Stage) and additional relationships between total suspended solids, turbidity, and stage level, comparisons can be made to predict potential loads of larger storm events. The precision of these models can be compared to methods of determining discharge, such as the proportional area method.

## MAD RIVER WATERSHED

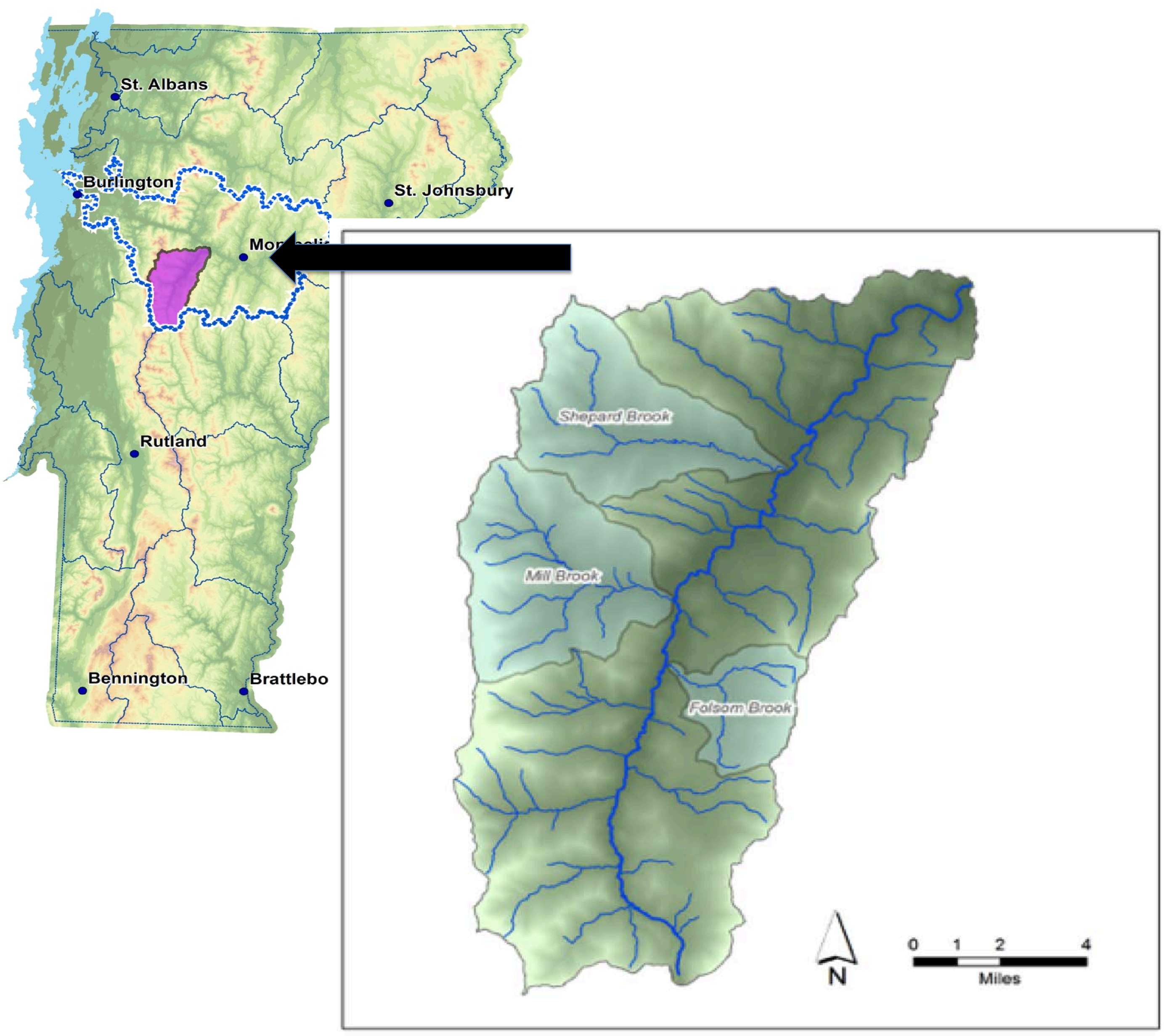



Figure 1 (Left): Location of the Winooski watershed (blue outline) and Mad River sub-watershed (purple fill) within the state of Vermont (Photo S. Hamshaw).
Figure 2 (Right): Mad River Watershed with highlighted Shepard, Mill, and Folsom Tributaries (Photo: K. Underwood).

## METHODS

Field Methods:

- Utilizing a Total Station, horizontal angles and vertical distances determined numerous stream cross sections and points of interest along each of the three tributaries.
- These measurements were then converted into relative eastings, northings, and elevation heights within Microsoft Excel.

HEC-RAS:

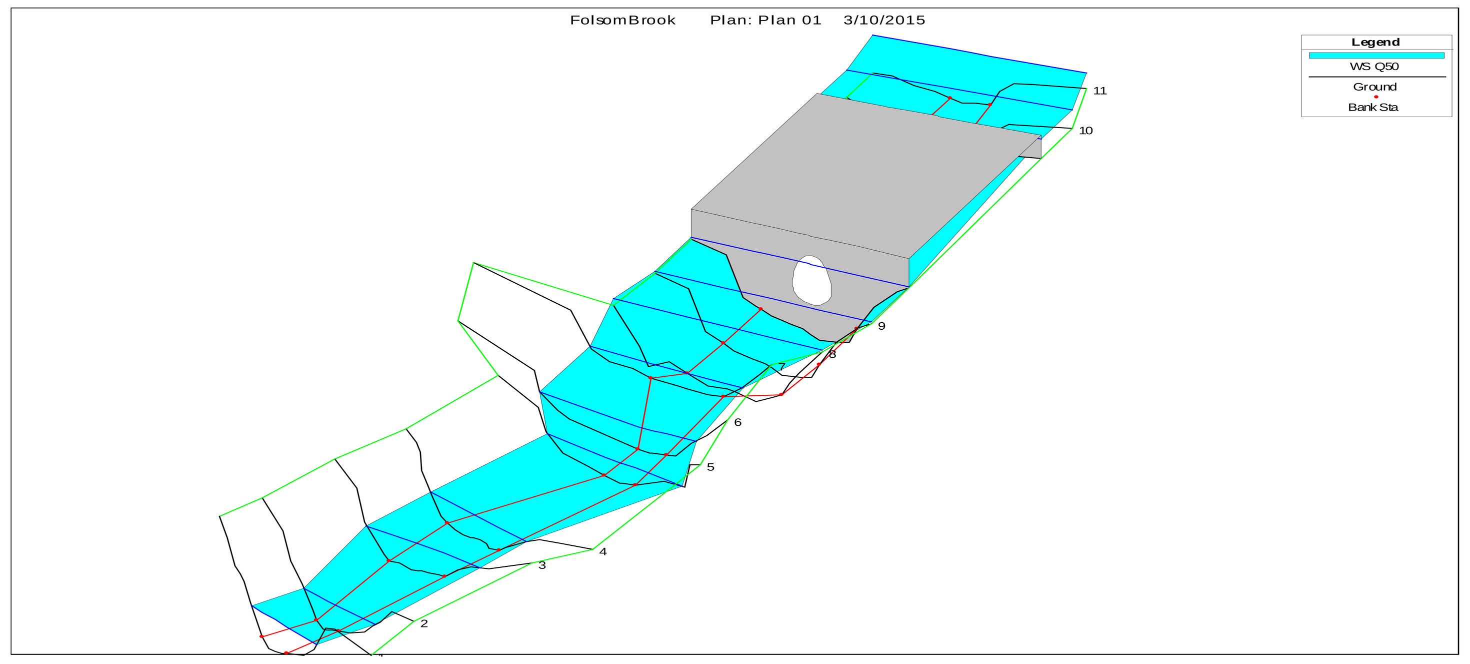
- The computed northings and elevations of cross-sectional data, bridges, culverts, etc. were input into the HEC-RAS for each tributary.
- Rating curves were produced from performed subcritical flow measurements.

Proportional Area Method:

- The three subwatersheds and Mad River watersheds' areas were calculated from Vermont Agency of Natural Resource (VTANR) Stream Geomorphic Assessment database .
- Discharges from the main stem of the Mad River can from a USGS gage station in Moretown, VT.
- Rating curves were then developed for each tributary by plotting the calculated discharges vs. stage levels (observed from each ISCO).

$$Q = \frac{A}{A_{gs}} * Q_{gs}$$

Where:
$Q$ = Estimated flow rate of interest (cfs)
$A$ = Drainage area of desired site ($mi^2$)
$A_{gs}$ = Drainage area of the gage station site ($mi^2$)
$Q_{gs}$ = Flow rate measure at the gage station (cfs)



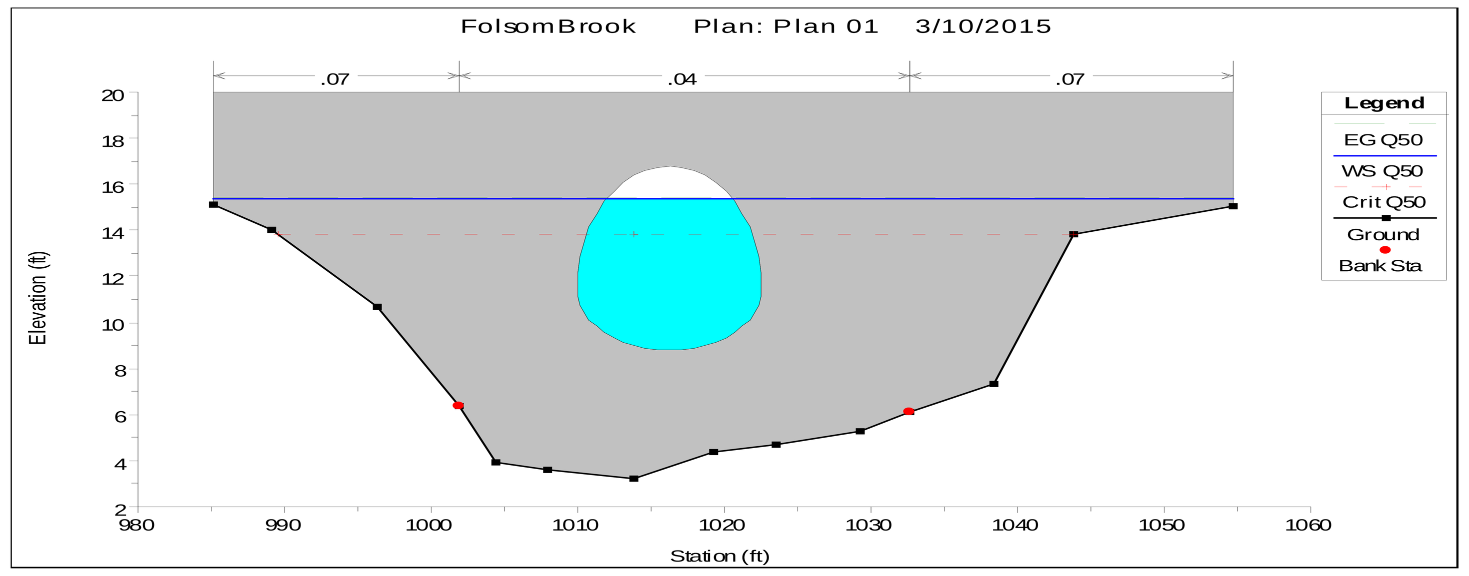




Figure 3 (Top): XYZ perspective plot of Folsom Brook (HEC-RAS).
Figure 4 (Bottom): Cross sectional plot of Folsom Brook's culvert (HEC-RAS).

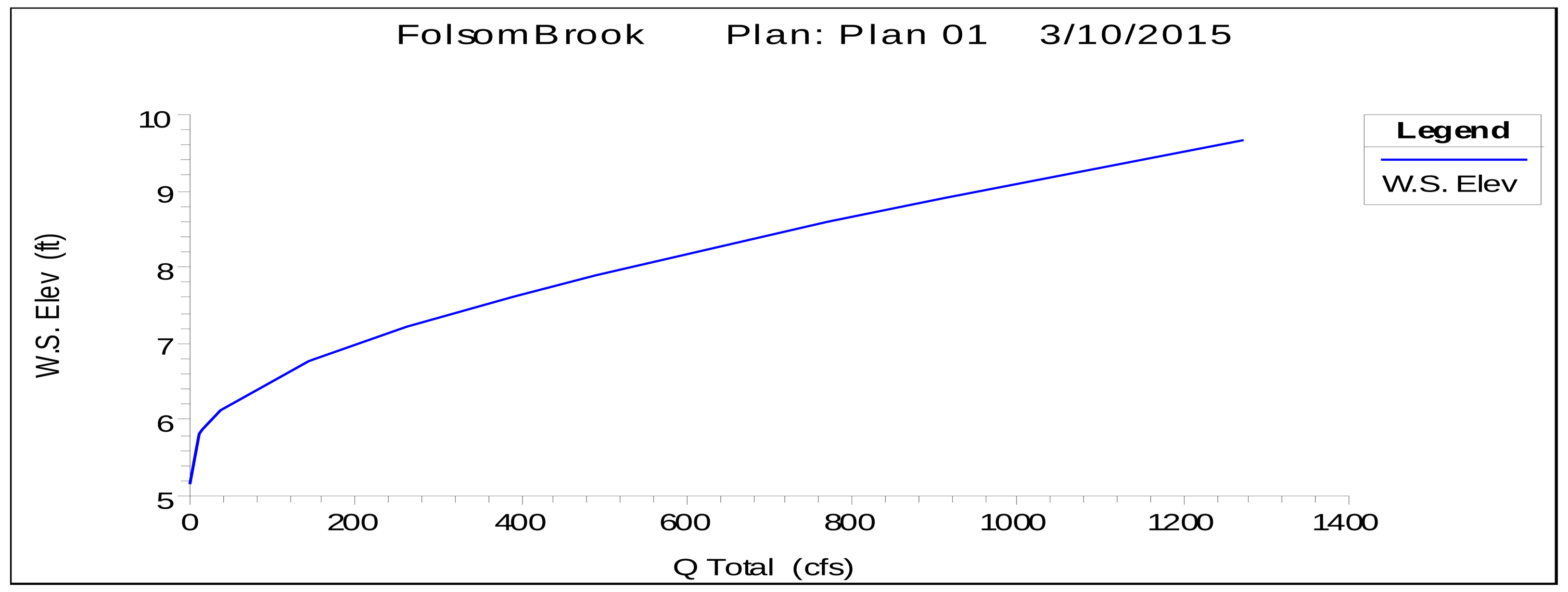
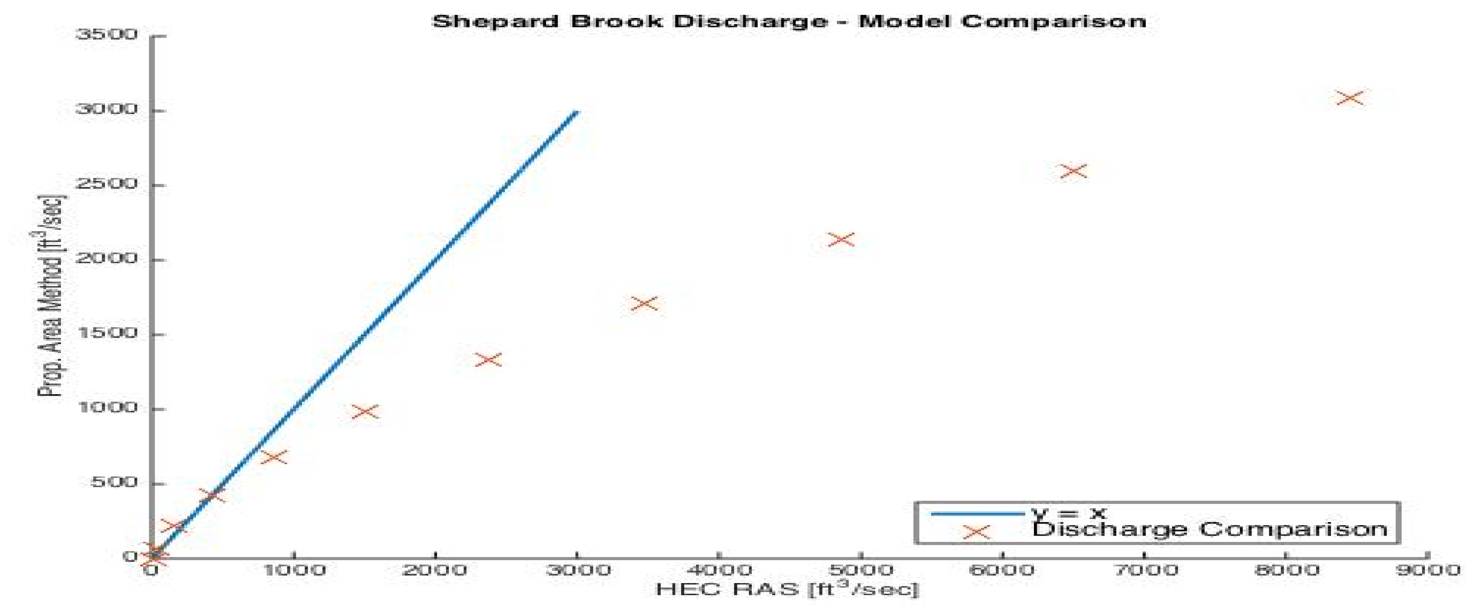
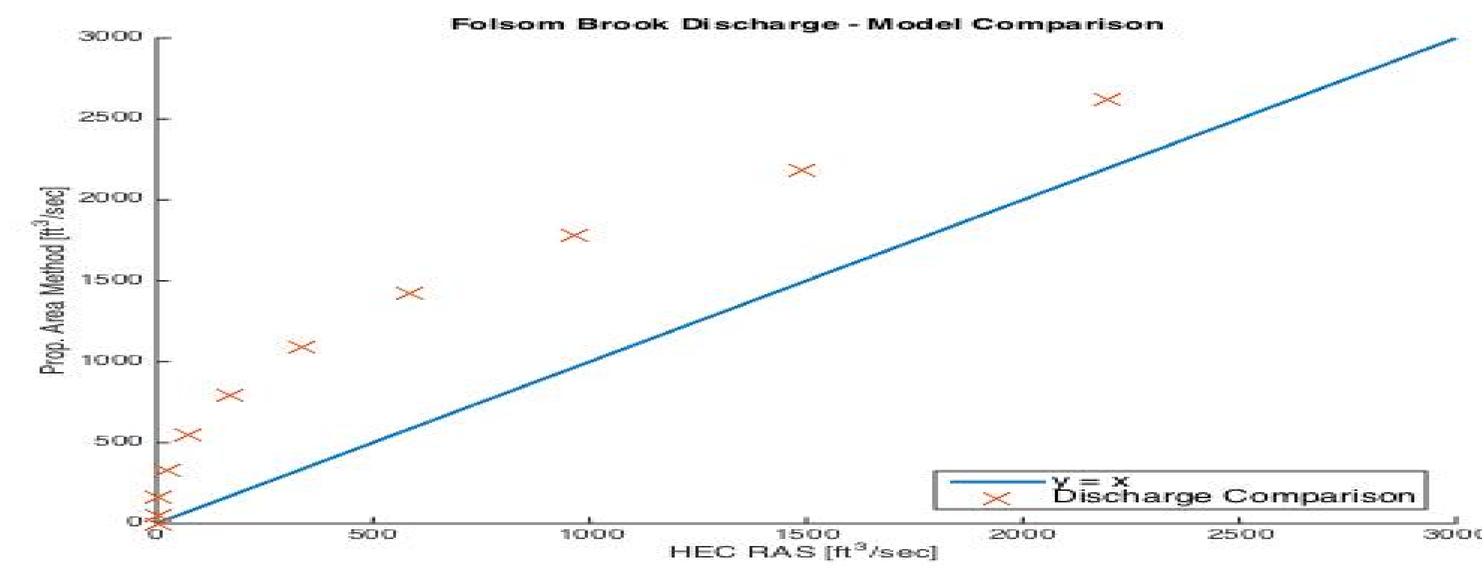


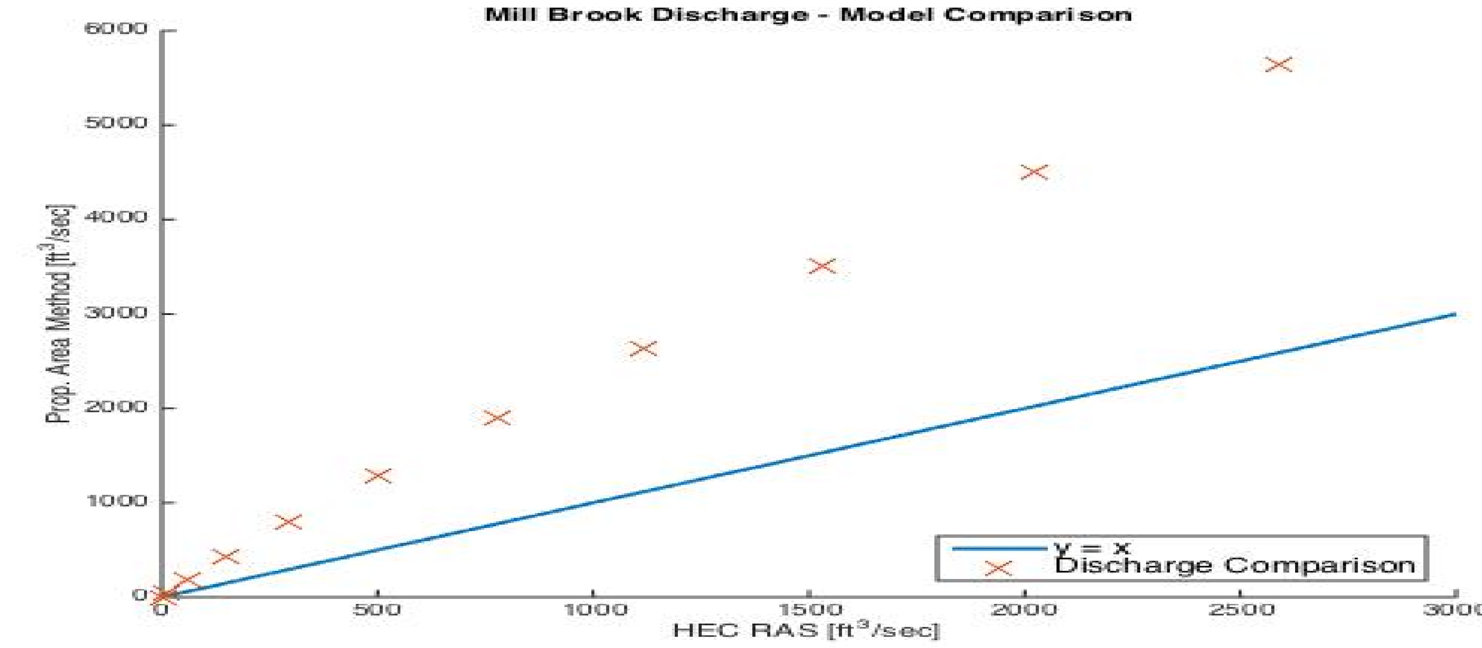

**Figure (Above): Rating curve of Folsom Brook (Hec-RAS)**

## Conclusion

- As seen by the trend of data points laying above the 1:1 line, the model comparisons for both Folsom and Mill Brook show a greater rate of increase of discharge values calculated from the proportional area method compared to the HEC-RAS model.
- Shepard Brook shows the opposite trend with an exponential growth in projected discharge from the HEC-RAS model.

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