Improvement of rating curve through Manning's Equation and LiDAR

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Disaster Risk Exposure and Assessment for Mitigation (DREAM) Project

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### Philippines and flooding

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haiyan (Yolanda)</td>
<td>2013</td>
<td>2.02 billion</td>
</tr>
<tr>
<td>Bopha (Pablo)</td>
<td>2012</td>
<td>1.04 billion</td>
</tr>
<tr>
<td>Rammasun (Glenda)</td>
<td>2014</td>
<td>871 million</td>
</tr>
<tr>
<td>Parma (Pepeng)</td>
<td>2009</td>
<td>608 million</td>
</tr>
<tr>
<td>Nesat (Pedring)</td>
<td>2011</td>
<td>333 million</td>
</tr>
<tr>
<td>Fengshen (Frank)</td>
<td>2008</td>
<td>301 million</td>
</tr>
<tr>
<td>Megi (Juan)</td>
<td>2010</td>
<td>255 million</td>
</tr>
<tr>
<td>Ketsana (Ondoy)</td>
<td>2009</td>
<td>244 million</td>
</tr>
<tr>
<td>Mike (Ruping)</td>
<td>1990</td>
<td>241 million</td>
</tr>
<tr>
<td>Angela (Rosing)</td>
<td>1995</td>
<td>241 million</td>
</tr>
</tbody>
</table>
Meteorological Sensors in the Philippines

Only baseflow discharge is available!
Surveyed Flow Data
Dipalo Bridge, Pangasinan

\[ y = 2E-165e^{4.293x} \]

\[ R^2 = 0.8297 \]

Discharge (\text{cms})

Stage (MSL), m

```
<table>
<thead>
<tr>
<th>Stage (MSL), m</th>
<th>88.46</th>
<th>88.48</th>
<th>88.5</th>
<th>88.52</th>
<th>88.54</th>
</tr>
</thead>
</table>
```

Dipalo Bridge Hydrometry
September 19-20, 2014

Max Q: 1,834,234 cms
Min Q: 2.15 cms

Rainfall, mm

Discharge, cms

Date & Time

```
<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>19/09/2014</th>
<th>20/09/2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00</td>
<td>15:00</td>
<td>6:00</td>
</tr>
<tr>
<td>21:00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Unrealistic!
River Measurements for Rating Curves

Problem with baseflow measurements only

- In-situ river discharge measurements during high flows are dangerous and expensive to capture.
- The opportunities to gather field measurement are rare.

Nonetheless, this is required to develop a good elevation-discharge relationship, or rating curve.
Agusan River Basin

- Typhoon Yolanda Date: November 10-16, 2013
- Typhoon Yolanda Total Precipitation: 73mm (Mat-I Rain Gauge)
- Agusan River Watershed Size: 10,921 km²
- Location of discharge measurement: Dankias, Las Nieves (8°45'1.55"N, 125°35'14.52"E)
Hydrograph of TS Yolanda
Problem

Using only baseflow data of the Agusan River Basin, which procedure for extending the rating curve will best fit the actual river hydrograph?
## Techniques for extending the rating curve

<table>
<thead>
<tr>
<th>1. Simple hydraulic technique</th>
<th>Bankfull discharge estimated using Manning's Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Computational hydraulic technique</td>
<td>Discharge estimated at every point of the cross-section using Manning's Equation</td>
</tr>
<tr>
<td>3. HECRAS, using LiDAR</td>
<td>Rating curve tool; a hybrid cross-section is used</td>
</tr>
</tbody>
</table>
Manning’s Equation

\[ Q = AV = A \frac{1}{n} R^{2/3} S^{1/2} \]

Where:
- \( Q \) = Discharge (m\(^3\)/s),
- \( A \) = Cross-sectional area of flow (m\(^2\)),
- \( n \) = Manning’s roughness coefficient,
- \( R \) = Hydraulic radius (m),
- \( S \) = Slope of the hydraulic grade line
Equation (2). Manning’s Equation (Manning’s $n$ and slope are constant)

$$Q = \frac{A^{5/3}}{P^{2/3}} \times k$$

Where:

$$k = \frac{1}{n} S^{1/2}$$
Equation (3). Manning’s Equation for bankfull discharge

\[ Q_{\text{full}} = k_{\text{ave}} \frac{A_{\text{full}}^{5/3}}{P_{\text{full}}^{2/3}} \]
Simple hydraulic technique

\[ y = 107.86e^{0.3503x} \]

\[ R^2 = 0.0476 \]
Computational hydraulic technique

\[ y = 31.848e^{0.9539x} \]

\[ R^2 = 0.5373 \]
HECRAS, using LiDAR

\[ y = 567.87e^{0.3314x} \]

\[ R^2 = 0.9603 \]
Results

R-squared

<table>
<thead>
<tr>
<th></th>
<th>Manning’s with Bankfull</th>
<th>Manning’s with Bankfull and Cross-section Points</th>
<th>HECRAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared</td>
<td>0.888</td>
<td>0.851</td>
<td>0.890</td>
</tr>
</tbody>
</table>
Recommendations:

• Possible validation can be done by comparing actual flood events and the result of a watershed-floodplain model calibrated using discharge generated rating curve.