Combining Coincident Frequency Analysis with Risk Analysis in a Tidal Zone

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Estudillo Canal Project

Zone 2 Line A Plan
Estudillo Canal Project

Zone 2 Line A Profile
Risk Analysis

Risk and uncertainty (R&U) concepts have been used in water resources for decades.

**ER 1105-2-101**: “Risk Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies”

**EM 1110-2-1619**: “Risk-based Analysis of Flood Damage Reduction Studies.”
Risk Analysis

Estudillo Canal: Risk and Uncertainty for Hydraulics only

Channel Roughness (Manning’s ‘n’):

The distribution of the resulting water surface elevation due to a low and a high “n” value is assumed to be as shown.

This is based upon the assumption that the range of water surface elevations is divided by four to obtain the standard deviation.
Coincident Frequency Analysis

Joint Probability of Multiple Events
Coincident Frequency Analysis

Joint Probability of Multiple Events depends on Relationships of Events to each other

Completely Coincident \quad \Rightarrow \quad Independent \quad \Rightarrow \quad Completely Non-Coincident

Astronomical & Storm Surge
Coincident Frequency Analysis

Flow in Estudillo Canal (with Probability $P_Q$) + 
Stage in San Francisco Bay (with Probability $P_H$) = 
Water Surface Elevation with Probability 

Probability of Water Surface Elevation = 
$P_Q \times P_H$
### Coincident Frequency Analysis

Flow in Estudillo Canal (with Probability $P_Q$) + Stage in San Francisco Bay (with Probability) = Water Surface Elevation with Probability $P_H$

<table>
<thead>
<tr>
<th>YEAR 0 C</th>
<th>B, Stages in feet</th>
<th>Tide (b)</th>
<th>b1</th>
<th>b2</th>
<th>b3</th>
<th>b4</th>
<th>b5</th>
<th>b6</th>
<th>b7</th>
<th>b8</th>
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</thead>
<tbody>
<tr>
<td>Flow (a)</td>
<td></td>
<td>0.87</td>
<td>2.93</td>
<td>4.22</td>
<td>5.51</td>
<td>7.09</td>
<td>9.14</td>
<td>11.34</td>
<td>11.95</td>
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<td>$a_{(0.99)}$</td>
<td>266</td>
<td>1.42</td>
<td>2.99</td>
<td>4.22</td>
<td>5.49</td>
<td>7.06</td>
<td>9.10</td>
<td>11.30</td>
<td>11.91</td>
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<td>$a_{(0.5)}$</td>
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<td>1.46</td>
<td>3.03</td>
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<td>5.53</td>
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<td>4.37</td>
<td>5.58</td>
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<td>4.47</td>
<td>5.63</td>
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<td>4.24</td>
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<td>5.83</td>
<td>7.23</td>
<td>9.19</td>
<td>11.36</td>
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<td>$a_{(0.004)}$</td>
<td>4663</td>
<td>4.25</td>
<td>4.48</td>
<td>5.02</td>
<td>5.91</td>
<td>7.26</td>
<td>9.20</td>
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<td>7.30</td>
<td>9.21</td>
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</table>
Original Coincident Frequency Analysis

Performed at Downstream End by USACE
Original Coincident Frequency Analysis

Results
Review of USACE Coincident Frequency Analysis

Tidally Influence ‘Zone’
HEC-RAS Runs Required

- Five Cross Sections
- Year 0 and Three Year 50 Sea Level Rise Scenarios
- Eight Tide Stages (w/ Prob) and Eight Flows (w/ Prob)
- Ten Alternatives

Number of HEC-RAS Runs = 5 x 4 x 8 x 8 x 10
= 12,800
Sensitivity Analysis

Alternative Approach Recommended by USACE
# Results

## 1% Annual Chance Exceedance Water Surface Elevation @ Section 112+80

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Year 0</th>
<th>Year 50, NRC Curve III</th>
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</thead>
<tbody>
<tr>
<td>CFA Complete Independence</td>
<td>12.20</td>
<td>12.93</td>
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<tr>
<td>HEC-RAS Complete Coincidence</td>
<td>12.86</td>
<td>14.04</td>
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Risk Analysis

Coincident Frequency Analysis

Engineering Judgment