The New Cedar River and Turtle Creek Hydrologic and Hydraulic Model

Model Roll Out Meeting
January 10, 2012
Agenda

1. Introduction and Background
2. Building the model and the GIS Data Files
3. Ensuring Model Accuracy (Calibration)
4. Possible Model Uses

Our presentation will be placed on the Cedar River Watershed District’s web site
Background

- CRWD was established in 2007
- Purpose: Reduce flooding and improve water quality throughout the watershed
- Need to understand how the water flows through a watershed
- Needed to establish an accurate existing conditions flow model
Existing Conditions Flow Model

- Project was funded by CRWD, TCWD, MPCA, and Hormel
- The model will be a tool for watershed districts, counties, townships, MnDOT, and SWCDs
- Used to design projects and/or evaluate impacts of potential projects on flood reduction
Building the Model and the GIS Data Files
Cedar River and Turtle Creek Watersheds

Cedar River Watershed District

Turtle Creek Watershed District
What goes into a model?

- Subwatersheds
- Land use information
- Soils information
- Topography
- Rainfall Depths/Distributions
- Flow control devices (bridges, culverts)
Subwatershed Divides

- 646 Subwatersheds
  - 517 Cedar River
  - 129 Turtle Creek
Land Use – to evaluate percent impervious and flow resistance
Soil Type – to determine infiltration
Topography – to determine drainage patterns and speed of runoff
Rainfall Depth and Duration

100-YEAR 24-HOUR RAINFALL (INCHES)
Existing Flow Control Structures

648 Structures Surveyed
- Mower SWCD
- NRCS
- JHS
Using the GIS Inventory – Flow Control Structures
Using the GIS Inventory – Structure Photos
### LIMITED DETAIL STUDY
**HYDRAULIC STRUCTURE DATA WORKSHEET**

<table>
<thead>
<tr>
<th>Date</th>
<th>Stream Name</th>
<th>Time</th>
<th>Road Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-6-06</td>
<td></td>
<td>9:40 AM</td>
<td>540 A 5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taken By</th>
<th>Structure Number</th>
<th>GPS Point Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKE</td>
<td>F 18</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>County</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Moore</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Structure</th>
<th>Bridge</th>
<th>Culvert</th>
<th>Weir</th>
<th>Dam</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>HydWd (ft)</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HydWd (ft) (Cont.)</td>
<td>(Length from US side to DS side of structure)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approx Skew (°)</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approx Skew (Cont.)</td>
<td>(Angle btwn structure CL &amp; road CL. 0-90°. 90° = 90)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railing Hgt (ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railing Hgt (Cont.)</td>
<td>(Height of railing on bridge or culvert)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deck THck (ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deck THck (Cont.)</td>
<td>(Distance from top of road to top of culvert or low chord of bridge)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Culverts: (See back of sheet for descriptions, diagrams, and sketch space if required)

<table>
<thead>
<tr>
<th>Barrel</th>
<th>Barrel #1</th>
<th>Barrel #2</th>
<th>Barrel #3</th>
<th>Barrel #4</th>
<th>Barrel #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrel Type</td>
<td>BEP</td>
<td>BEP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inlet Type</td>
<td>Box</td>
<td>Concrete</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rise or Diameter (ft)</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span (ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invert Elevation (ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upstream/Downstream</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Blocked</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using the GIS Inventory – Structure Photos
<table>
<thead>
<tr>
<th>Taken By</th>
<th>Deck Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axp</td>
<td>3.2'</td>
</tr>
<tr>
<td>Stream Name</td>
<td>Rail Height</td>
</tr>
<tr>
<td>Turtle Creek</td>
<td>2.65'</td>
</tr>
<tr>
<td>Road Name</td>
<td>Number &amp; Pier Type</td>
</tr>
<tr>
<td>230 st</td>
<td>2 - Round</td>
</tr>
<tr>
<td>Structure Number</td>
<td>Pier Width</td>
</tr>
<tr>
<td>FP 7</td>
<td>20''</td>
</tr>
<tr>
<td>Location</td>
<td>Low Member Elev</td>
</tr>
<tr>
<td>8 12 Cole 25-103-19</td>
<td>1201.87</td>
</tr>
</tbody>
</table>

Diagram:

- **Flow**
- **Span**
- **Width**
- **Low Member**
- **Deck Thickness**
Now the model is built, but how accurate is it?
Ensuring Model Accuracy (Calibration)

• First step with model building is to input suggested starting value within a published range of values for model hydrologic parameters
  - Infiltration Rates
    (example range: 1in/hr to 5in/hr → starting point 3in/hr)
  - Depression storage and vegetation interception
    (example range 0.1 in to 0.5 in → starting point 0.2)
• NEXRAD rainfall data obtained for two storms (intensity and amount) – September 2004, September 2010
• Run the model using the published starting values and recorded NEXRAD rainfall
Ensuring Model Accuracy (Calibration)

- Then compare model results against actual measured flow gage data at various points in the watershed
- The published starting values typically need adjustments to make the modeling results more closely match the measured data
- These model adjustments are typically known as “calibration”
Model Adjustments

• We continue to adjust model inputs within the published range
• After each adjustment, modeled data is compared to measured flow gage data
• Additional adjustments are made until modeled flow data accurately resembles measured flow data
Five Gage Locations

- Cedar River Gage
  - MnDNR

- Turtle Creek Gage
  - MnDNR

- Cedar River Gage
  - USGS

- Dobbins Creek Gage
  - MnDNR
Gage 48027001 (Turtle Creek) – September 2004 Stage
Calibrated Results – with and without tile simulated

Gage 48027001 (Turtle Creek) – September 2004 Stage

- Monitor Data
- Calibrated Results with tile simulated
- Calibrated Results without tile simulated
Model Applications

- Designing flood reduction and water quality improvement projects
- Help townships, counties, and MnDOT design and evaluate new road crossings and their proposed changes
- Simulate land use changes or development impacts
- Determine the effect of upstream watershed changes on flood elevations anywhere in the watershed
- Aid in FEMA “No Rise” determinations in areas where FEMA DFIRMs exist
- Aid in levee certifications
Example 1: Red Rock Township Road Crossing (250\textsuperscript{th} Street)
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- 250th Street was overtopping during large storm events
- Construction options discussed with township
  - Double culvert capacity
  - Raise the road
  - Restrict culvert capacity and raise the road and potentially see flood reduction benefits downstream
- Model results showed that road raise only was the best option.
- The analysis took about 10 hours
- Cost for this evaluation was about $1,000
Example 2: Wetland Restoration along Murphy Creek

• Mower SWCD wanted to evaluate four projects’ impacts on flood reduction along Murphy Creek
• Restoration involved breaking tile, adding storage capacity, and restoration of the cropland to native grasses
Example 2:
Wetland Restoration along Murphy Creek
Example 2: Wetland Restoration along Murphy Creek

BEFORE – soybean field

AFTER – restored wetland and native prairie
Example 2: Wetland Restoration along Murphy Creek
Example 2: Wetland Restoration along Murphy Creek
Example 2:
Wetland Restoration along Murphy Creek
Example 2: Site Restoration along Murphy Creek

- Volume of runoff from the watershed was reduced by 8% from 460 acre-ft to 420 acre-ft during the 100-year storm event.
- Peak runoff rate in Murphy Creek was reduced by about 10% (approximately 40 cfs reduction) during the 100-year storm event.
- The analysis took 7 hours per site.
- Cost for this evaluation was $800 per site or $3,200 for all four sites.
Questions?

Cedar River Watershed District Web Site

www.cedarriverwd.org