Successful Approaches to Change-MaineDOT’s Experience (2015 State of the Bay Presentation)

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Successful Approaches to Change: MaineDOT’s Experience

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As a famous climate scientist once said ... 

The future ain’t what it used to be.
Some DOT Challenges
Hydraulic Structures

* Assets:
  * Thousands of bridges (span $S \geq 10$ ft)
  * Thousands of large culverts ($5 \leq S < 10$ ft)
  * Many thousands of cross-culverts ($S < 5$ ft)

* Exposures:
  * Coastal: seal-level rise (SLR)
  * Inland: riverine runoff peak flow events

* Projects:
  * Individual assets
  * Corridor reconstruction

* Design Life of New Structures
  * 100 YRS +
Some Very Simplistic Starting Assumptions

- **Bridges:** they are generally big, climate change not a worry
- **Culverts:** existing structures tend to be undersized by current standard
- **Sea Level Rise:** elevation is the issue, not capacity
- **Inland Peak Flows:** asset capacity is the primary issue
- **Asset Replacement:**
  - Due to poor condition or chronic hydrologoc failure
  - Not according to some *prediction* of future failure
MaineDOT Efforts

- Data & Engineering Methods
  - Cooperative projects with USGS
  - Internal design policy
- Planning, Research & Pilot Studies
  - FHWA sponsorship
  - Catalysis & GEI projects (Sam Merrill & collaborators)
  - Decision Support Tool for Enhanced Early Project Scoping and Program / Project Risk Identification
Major Change to MaineDOT Culvert Design Standard

* Cross Culverts ($S < 5$ ft)
  * Design Flow $Q_{50}$
  * Allowable Headwater $H_{w}/D \leq 1.5$
  * (former standard for all culverts)

* Large Culverts ($5 \leq S < 10$)
  * Design Flow $Q_{100}$
    * $Q_{100} 20\% > Q_{50}$
  * Allowable Headwater $H_{w}/D \leq 1$
  * Result: bigger structures

- Complemented by environmental “bankfull sizing” for fish passage.
- Protection against $Q_{100}++$.
- Relatively few culverts on “real streams” sized purely for hydraulic capacity.
Benefits of New Standard

- Enhanced protection of assets
  - Protection against increased flows due to climate change
  - Design for $Q_{100}$ now, get $Q_{50}$ protection 50 – 100 yrs from now
- Most useful, biggest impact on “production work”
  - Smaller structures, routine work – lots of them!
- Improved fish passage
  - Reducing & eliminating undersized culverts
- “We’re doing something!”
- Better than interim standard – strong first step - but not final story
  - Ideally – still need to capture future climate expectations
    - Which change scenario plays out?
    - Uncertainty in predictions within that scenario
  - Address MaineDOT system in some fashion
Total DOT asset base too big for meaningful assessment
- Break it up into digestible portions
- Corridors
- Vulnerable geographic settings
- Leverage local experience and staff knowledge
  - Efficient, effective screening

Risk-Based Design *(vs current Frequency-Based Design)*
- **Goal:** Balance Underdesign against Overdesign in a Rational Manner
- Minimize total expected project cost over asset lifetime

Challenges & Limitations:
- Data
- Models
Corridor Selections

Route 2 - Mercer

Courtesy of Sam Merrill

Route 4 - Berwicks
Courtesy of Sam Merrill
Depth Damage Functions for Each Candidate Structure

<table>
<thead>
<tr>
<th>Elev.</th>
<th>Damage</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
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<td>14-16’</td>
<td>Extreme</td>
<td>= $E/event</td>
</tr>
<tr>
<td>12-14’</td>
<td>Severe</td>
<td>= $E/event</td>
</tr>
<tr>
<td>11-12’</td>
<td>Serious</td>
<td>= $D/event</td>
</tr>
<tr>
<td>8-11’</td>
<td>Moderate</td>
<td>= $C/event</td>
</tr>
<tr>
<td>7-8’</td>
<td>Slight</td>
<td>= $B/event</td>
</tr>
<tr>
<td>0-7’</td>
<td>Negligible</td>
<td>= $A/event</td>
</tr>
</tbody>
</table>

**Depth-Damage Function**

- **Negligible** = $A/event
- **Slight** = $B/event
- **Moderate** = $C/event
- **Serious** = $D/event
- **Extreme** = $E/event

**Elev. Stage**: $D = 7’$

**Waterway**

**Base Elevation**

*Courtesy of Sam Merrill*
Transformation of Hydrologic Probabilities to Damage Probabilities

![Log-Normal Probability Plot](image)
Sort of like the Cumulative Distribution Fn – CDF “showroom product”

Probability Density Fn – PDF “under the hood”

Alternative Representations of the Same Underlying Probability Function
Culvert Performance Curve
Flow – Depth Function

For D = 7’
Transform the Flow PDF to a Depth PDF
Expected (Avg) Damage = $62
Challenges to Application

* Models
  * Depth-damage functions
    * Identify **ALL** costs
    * Get good estimates (relative? absolute?)
  * Flood frequency curves
* Data
  * Basic asset data
    * Size (capacity)
  * Elevations
  * Real construction costs
  * Screen for vulnerable, at-risk assets