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

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**Recommended Citation**
Successful Approaches to Change: MaineDOT’s Experience

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presented at
Our Changing Bay 2015
Casco Bay – State of the Bay Conference
Double Tree – Hilton, South Portland, ME
13 October 2015
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
* 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
Some Ideas

* 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
Depth Damage Functions for Each Candidate Structure

<table>
<thead>
<tr>
<th>Elev.</th>
<th>Damage</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<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

D = 7’

Waterway

Base Elevation

Courtesy of Sam Merrill
Transformation of Hydrologic Probabilities to Damage Probabilities

Log-Normal Probability Plot

Return Period (yrs)

$Q_T$ (ft$^3$/s)
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

Log-Normal Density Function

Performance Curve - Inlet Control

LN Density Function
Transform Depth PDF to Damage 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