Integrating Global Climate Model Projections into Culvert Design

Washington Department of Fish and Wildlife

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A Severe and Urgent Issue

14,000 known culvert barriers

estimate 35,000 additional barriers
WDFW’s role in water crossing structures

- Provides design guidance for the protection of fish life and fish habitat.
- Issues permits for the installation of culverts.
- Designs and co-designs culverts for its own lands and other clients.
Bankfull width (BFW) is a key parameter

No-slope
(<10 ft BFW, gradient <3%)

Stream Simulation
(<15 ft BFW)
Determining projected bankfull width changes due to climate change
Global Climate Models: Temp. and Precip.

Downscaled to Pacific Northwest

Hydrologic Model yields runoff

Estimate projected bankfull flow

Estimate bankfull width
Global Climate Models

- 1 climate change scenario: most likely
- Projections from 10 independent models
- Climate projections for 2 future time periods
- Down-scaled for Pacific Northwest Region
Key Regional Response: Less Snow and More Rain

- Same precipitation but as rain
- Higher peak flows
Mean Daily Flow Projections

Downscaled GCM output:
- Temperature
- Precipitation
Estimating Bankfull Width

Bankfull width \( = aQ^b \)

\[ Q = Q_{BF} = Q_{1.2} \text{ or } Q_{1.5} \]

\( a \) and \( b \) determined empirically

\[ r^2 = 0.76 \text{ to } 0.87 \]
Bankfull Flow Recurrence Intervals
VIC Grid Cells

1/16 degree
~30 km²
~11.5 mi²

5,270 grid cells in Washington
Percent Change in Bankfull Width

\[
\frac{\text{Future BFW} - \text{Historical BFW}}{\text{Historical BFW}} = \text{Percent Change}
\]

- Percent change allows for BFW estimates to be applied to a culvert design site.
Projections of Changes in Bankfull Width due to Climate Change
Mean % Change BFW: 2030 - 2059
Mean % Change BFW: 2070 - 2099
Implications
of
Climate Change
for
Future Culvert Function
Culverts Installed Today Likely to be too Narrow

Number of models projecting >BFW: 0
Incorporating Climate-Based Bankfull Width Projections into Culvert Design
What is a manager to do?

- Trade-off: pay-now or **maybe** pay later

- WDFW: wisest use of government resources?
Manage Risk

• Risk: how bad & how likely
  ▪ magnitude of cost or damage
  ▪ probability of cost or damage

• Risk Tolerance
  ▪ How much precaution?
  ▪ What risk is “actionable”?
Actionable Risk: 2030-2059

Magnitude

"Probability"

Number of Models per Pixel Projecting an Increase in Bankfull Width by 2030-2059
• 10 of 10 models project an increase in BFW

• range of projected change in BFW between 9.5 and 34%

• models project mean change in BFW = +18%

• 90% “probability” of change greater than 10%
hypothetical situation:

• BFW = 8 ft

• No-slope Culvert

• 10 of 10 models project an increase in BFW

• 10 of 10 models project culvert too narrow

• mean projected future BFW = 9.5 ft
Conclusions

- Bankfull width projected to increase in many areas due to climate change

- Changes may be incorporated at the design level

- Managers must decide what is ‘actionable’
1. Cost/benefit economic analysis

2. Continue discussions with management
   - Consider policy to implement internally, on department lands

3. Host discussions with stakeholders

4. Sediment transport model through culverts
Thank You

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