

EDMONTON
2018  **ite**
June 3-6

CITE Edmonton 2018
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Resilient Infrastructure Planning Risk-Based Analysis Process



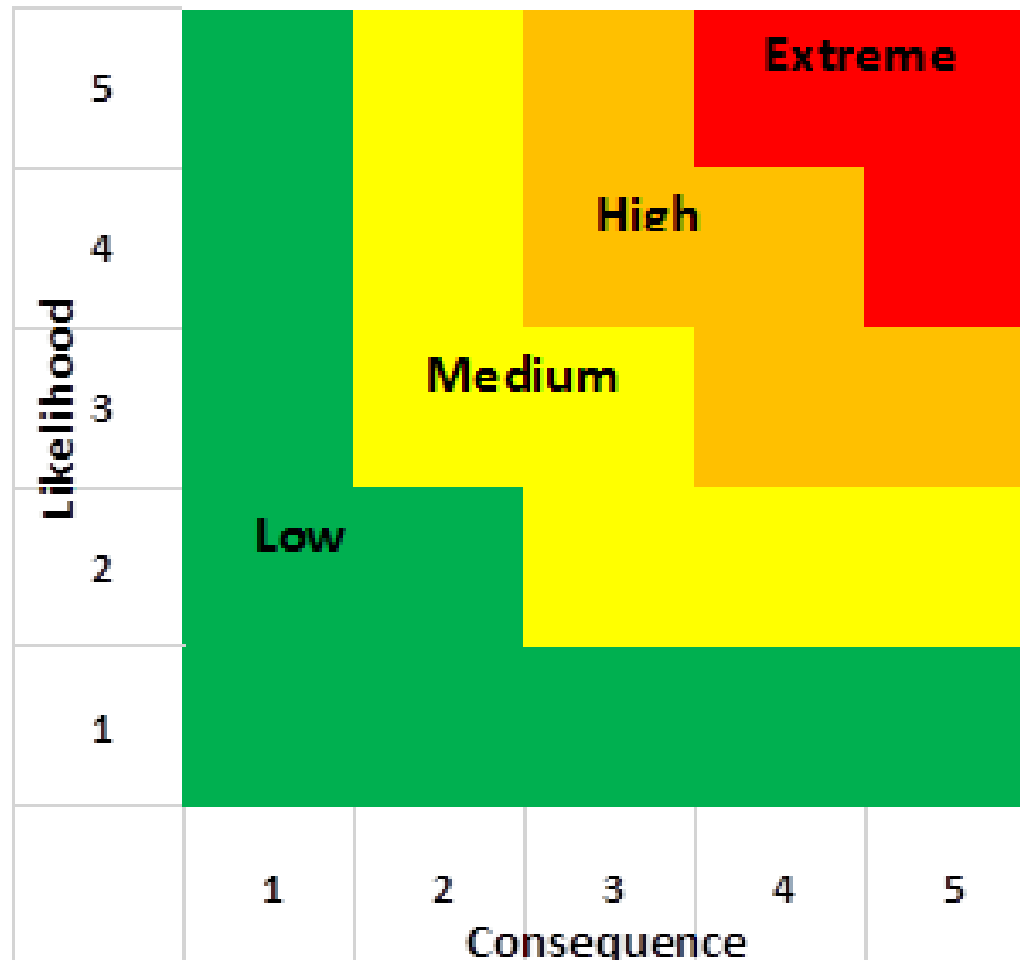
High Probability – Low Consequence



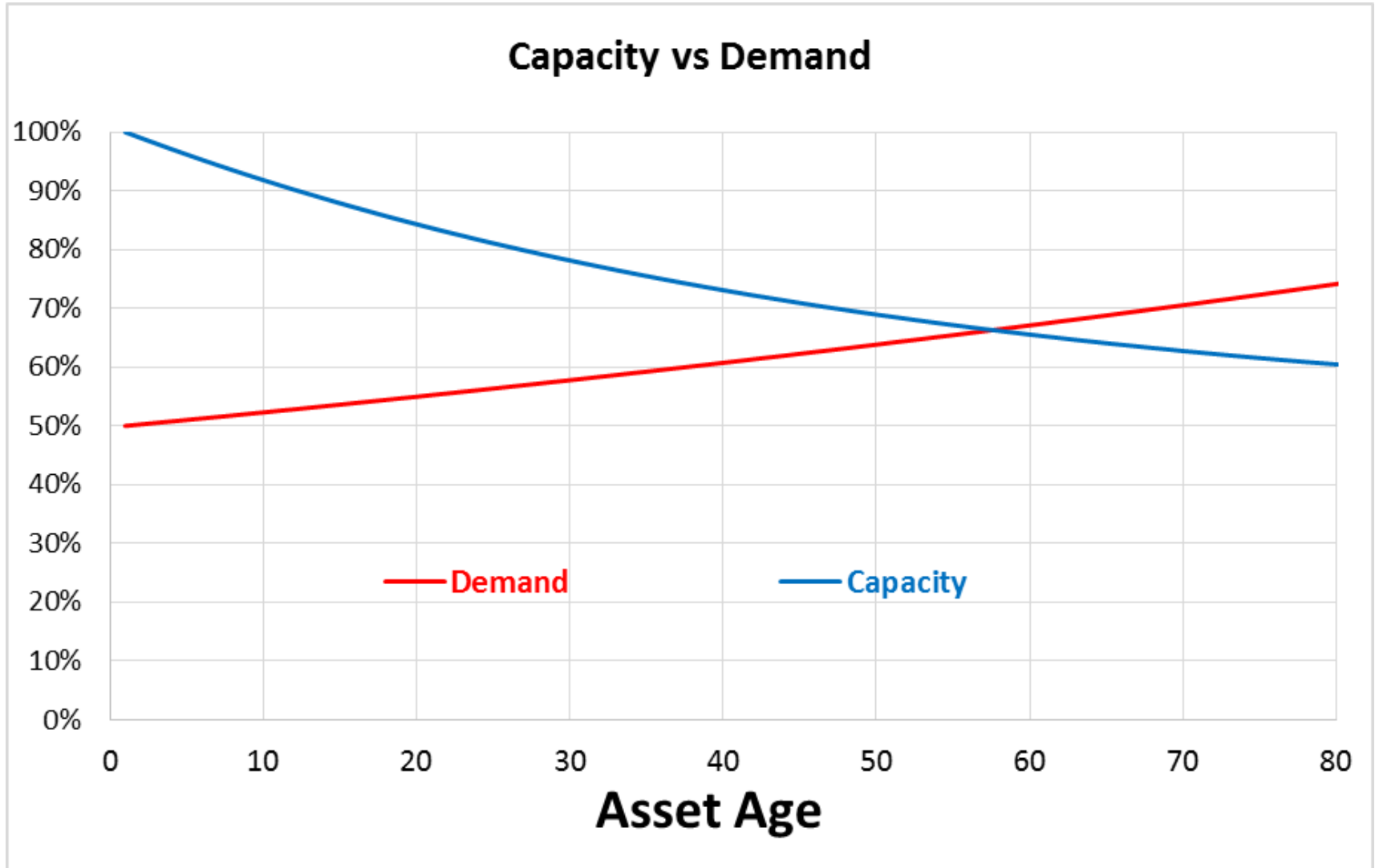
Low Probability – High Consequence



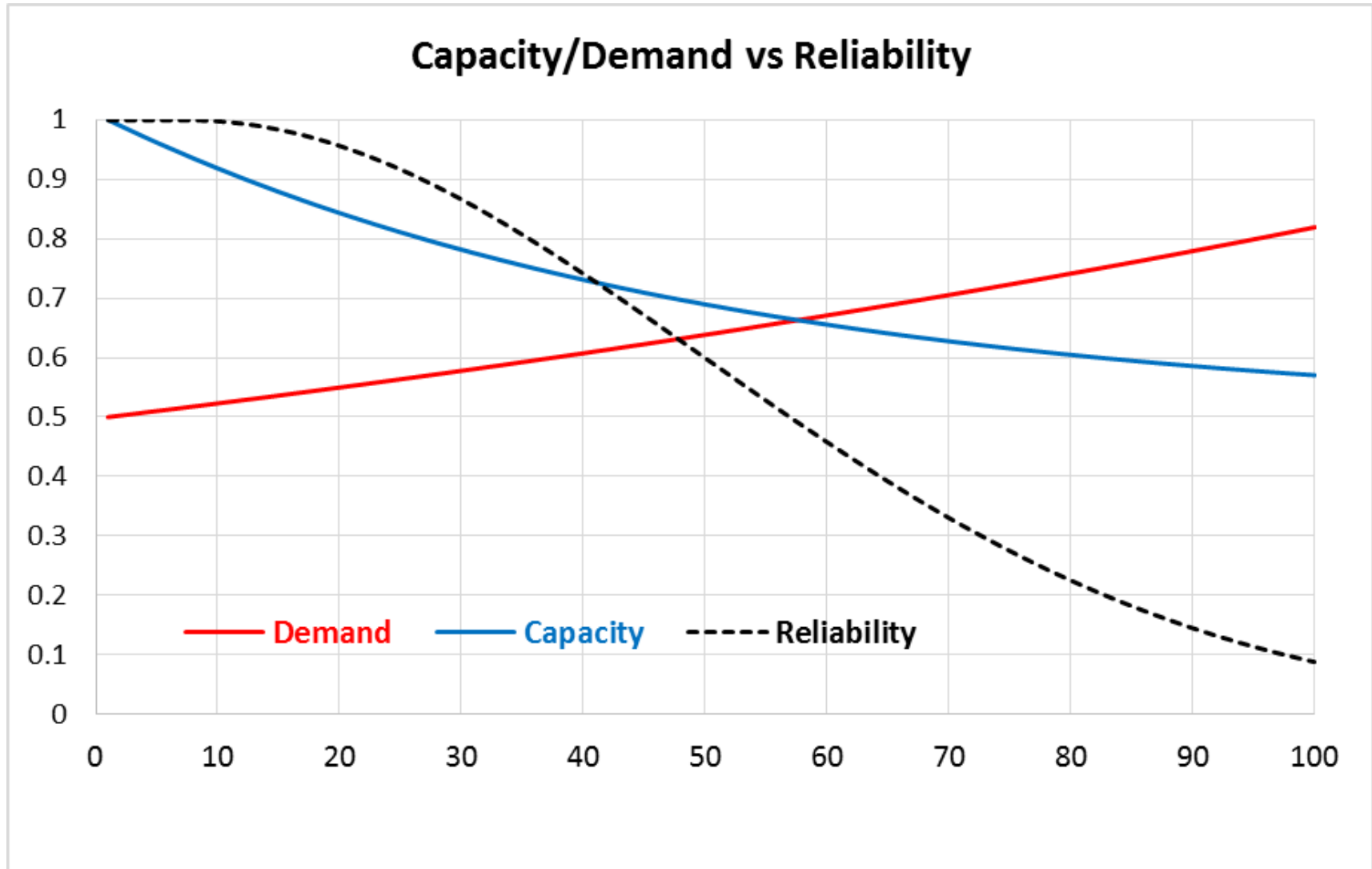
Defining Risk



Capacity and Demand

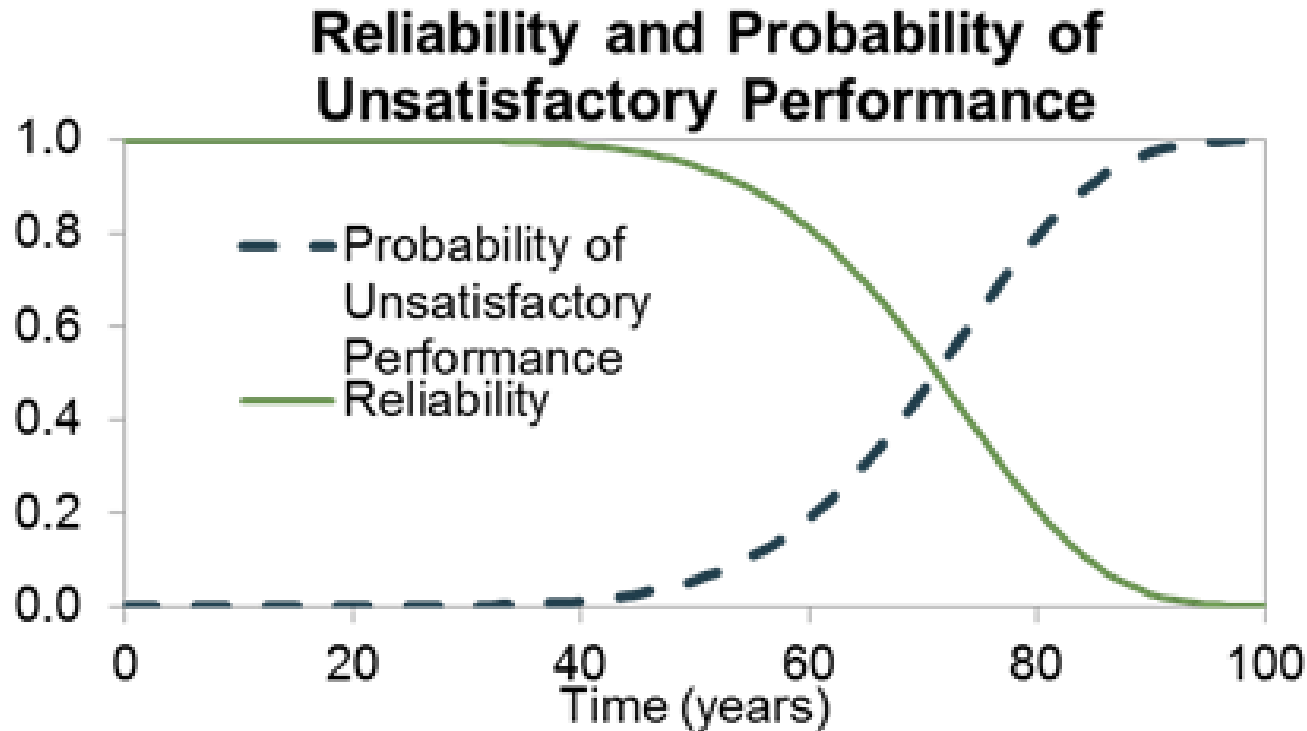


Asset Adequacy



US Army Corps of Engineering

EC 1110-2-6062



$$\text{\$Risk} = \text{PUP} \times \text{\$Consequences}$$

Consider a Culvert



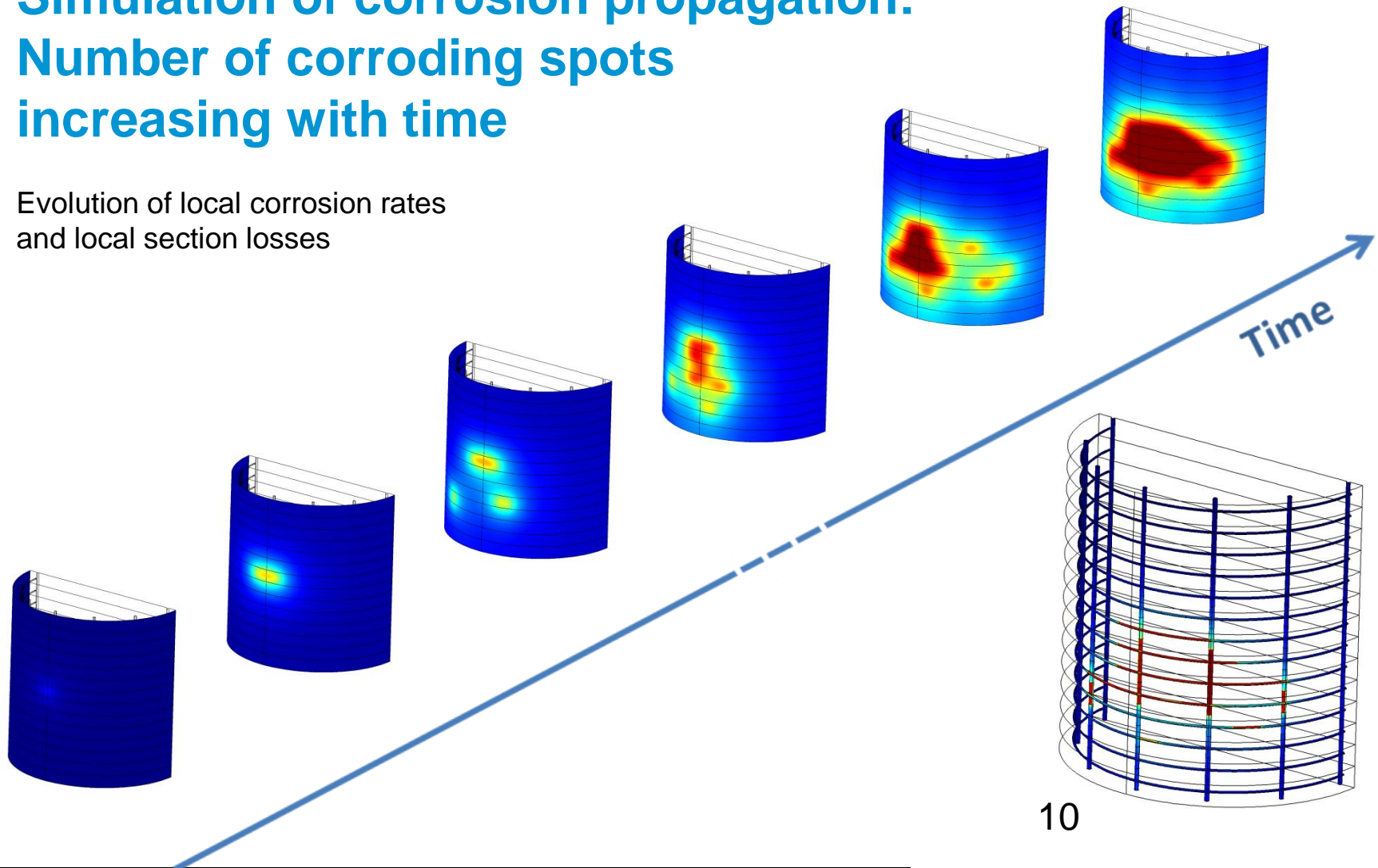
Two Failure Modes



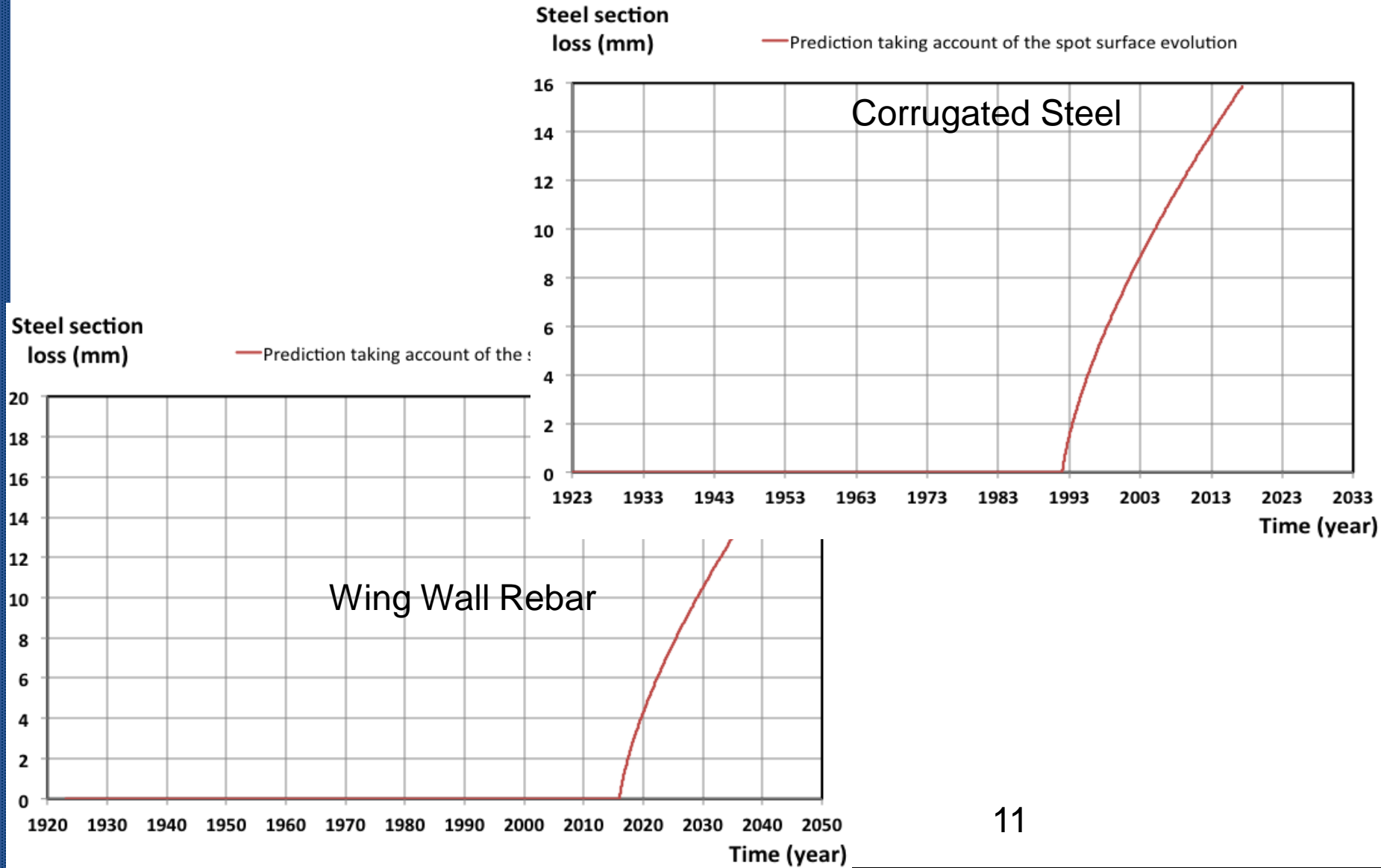
Corrosion Simulation

**Simulation of corrosion propagation:
Number of corroding spots
increasing with time**

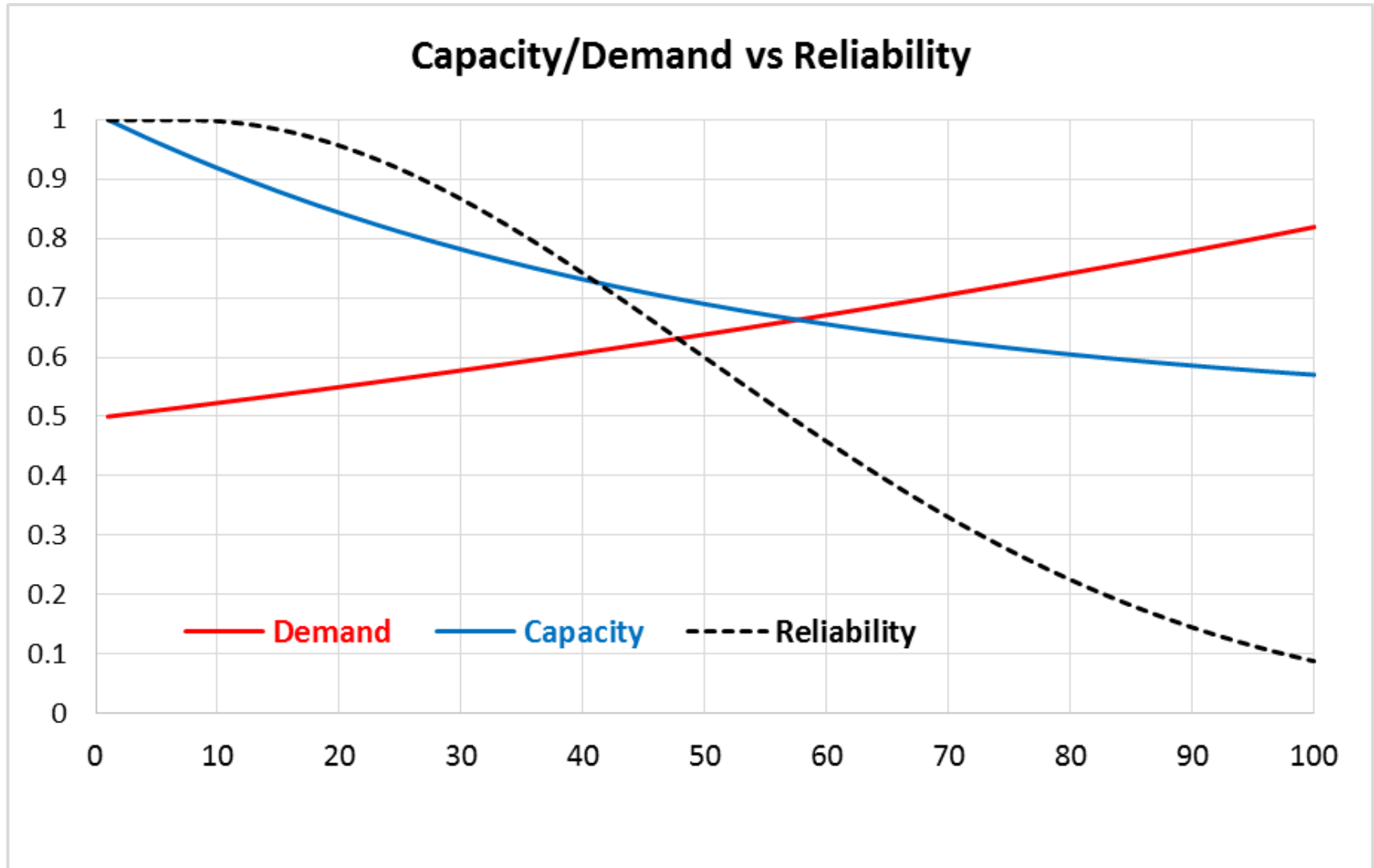
Evolution of local corrosion rates
and local section losses



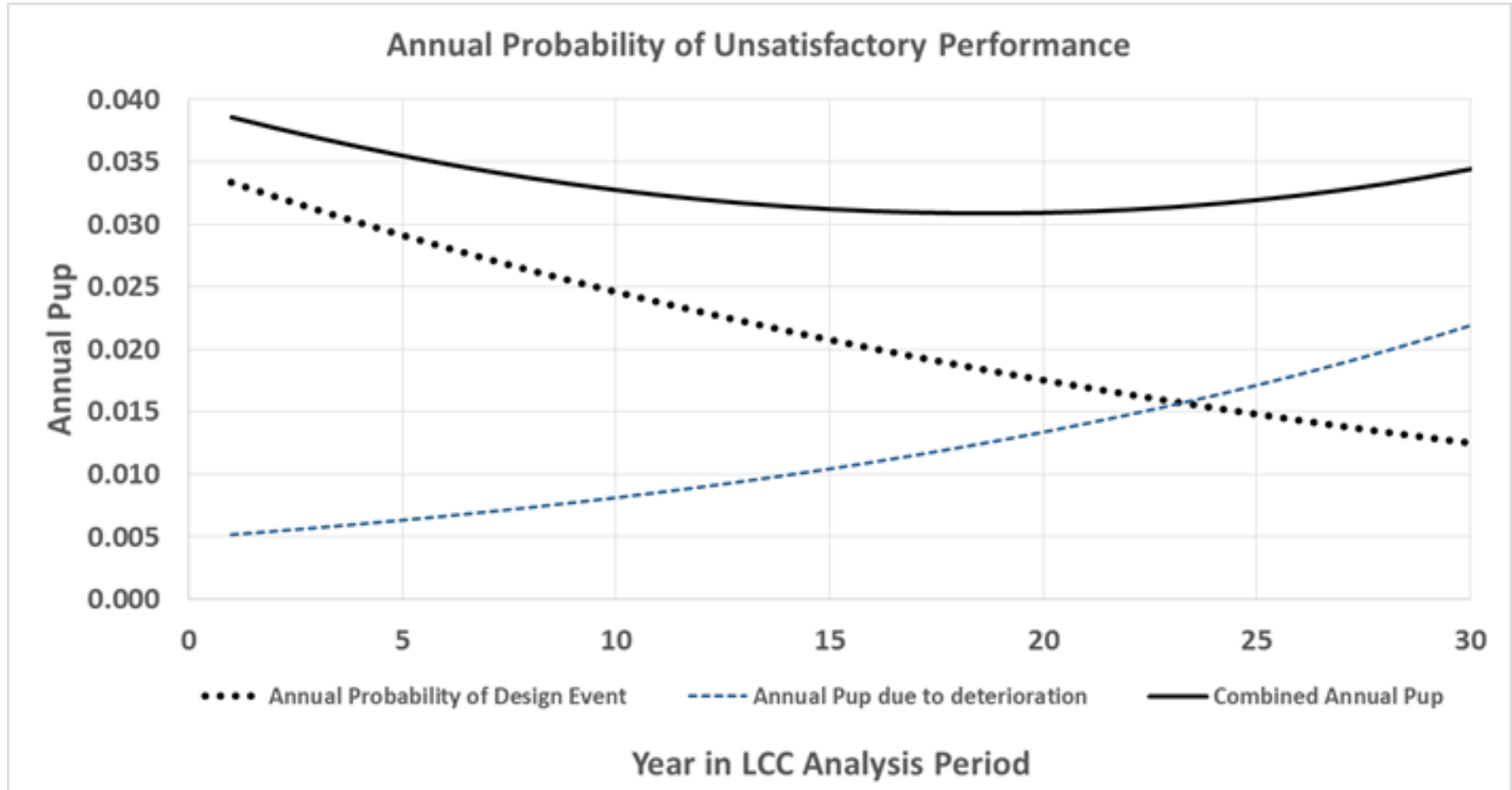
Rebar Section Loss Simulations



Predicted Asset Reliability



Both Material Degradation and Design Event Contribute to Pup



Consequences of Failure?

- Direct Consequences – replace culvert, embankment, pavement.
- Addition detour based travel costs: 465 AADT, 1% Growth, 460km detour, 15 day replacement period
- In this example Consequences = \$3.225 m

$\text{\$Risk in year 1} = 0.0333 \times \$3.225 \text{ m} = \$130\text{K}$
over 30 years $0.64 \times \$3.225\text{m} = \2 m

Life Cycle Cost for Replacement

Return Period	Initial Cost	Present Value Cost Replacement in 60 Years ¹	Present Value Cost for 100 Year Analysis Period
50	\$ 621,000	\$ 63,000	\$ 684,000
100	\$ 689,000	\$ 70,000	\$ 759,000
200	\$ 757,000	\$ 77,000	\$ 834,000
500	\$ 847,000	\$ 86,000	\$ 933,000
1000	\$ 915,000	\$ 93,000	\$ 1,008,000

What Should Be Done?

- What Storm Event would be designed for?
- What can be economically justified?

LCCA !!

Multi-strategy LCCA Informs Design Decision

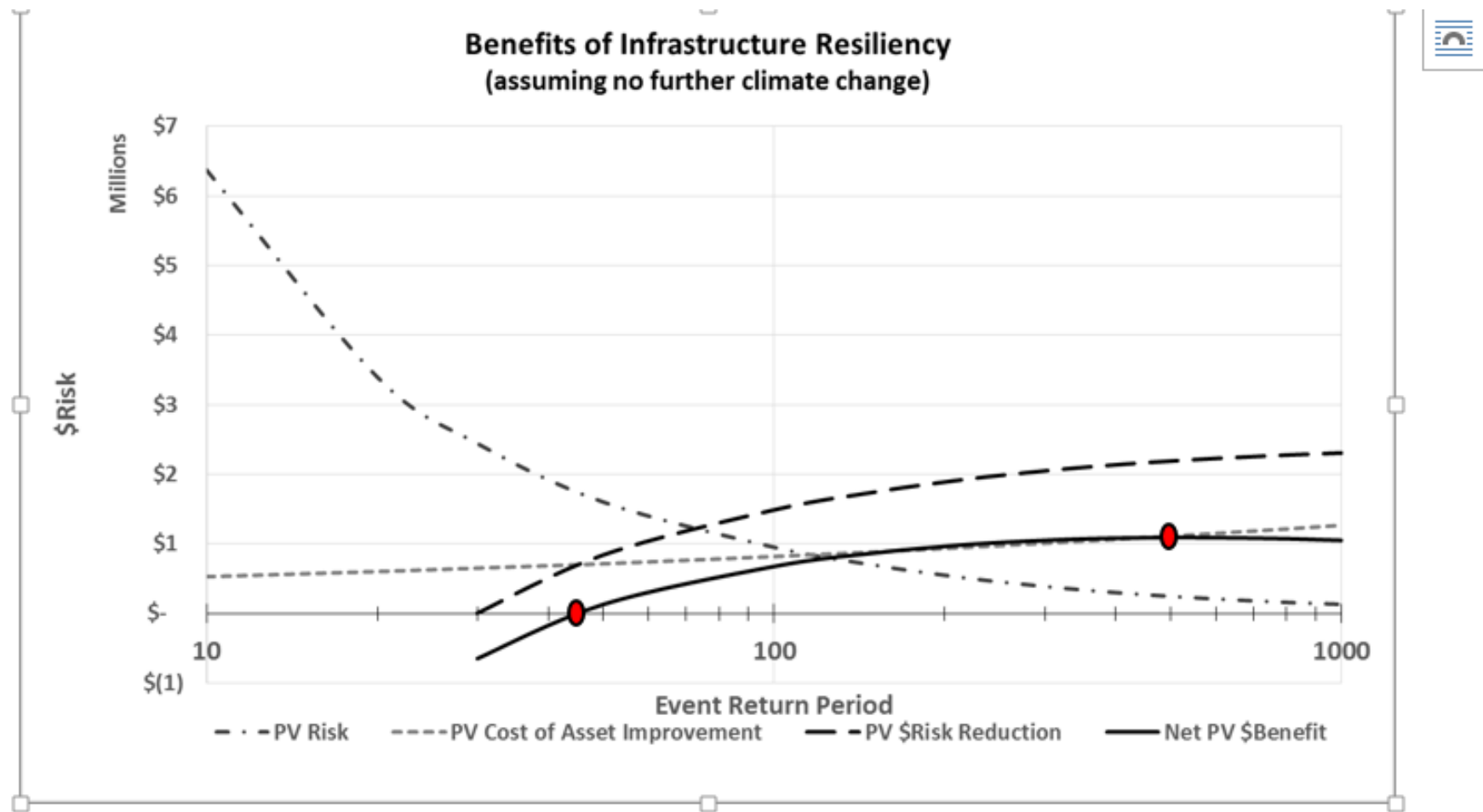
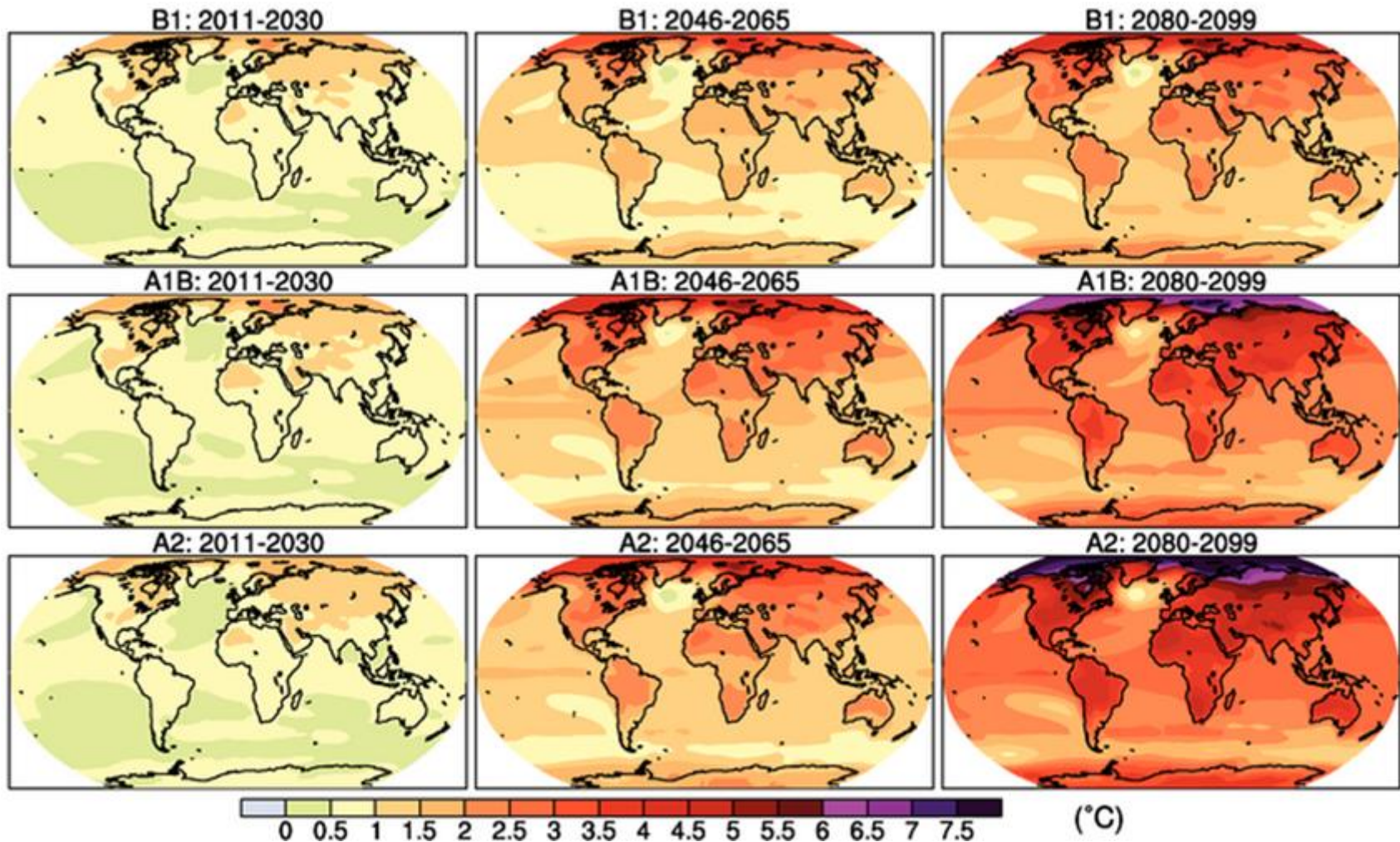
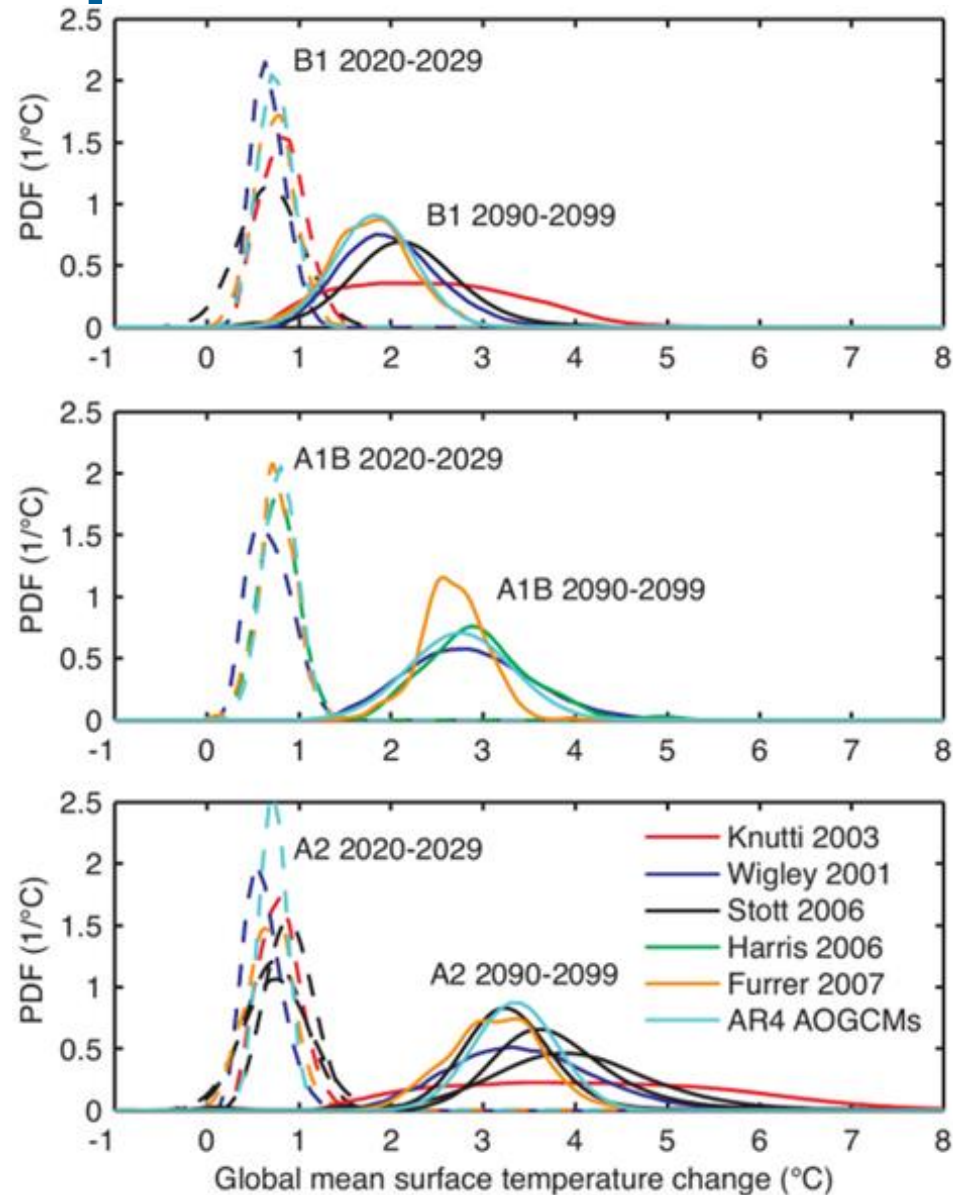


Figure 5 – PV Asset Strategy Costs Compared to PV \$Risk at Different Return Periods

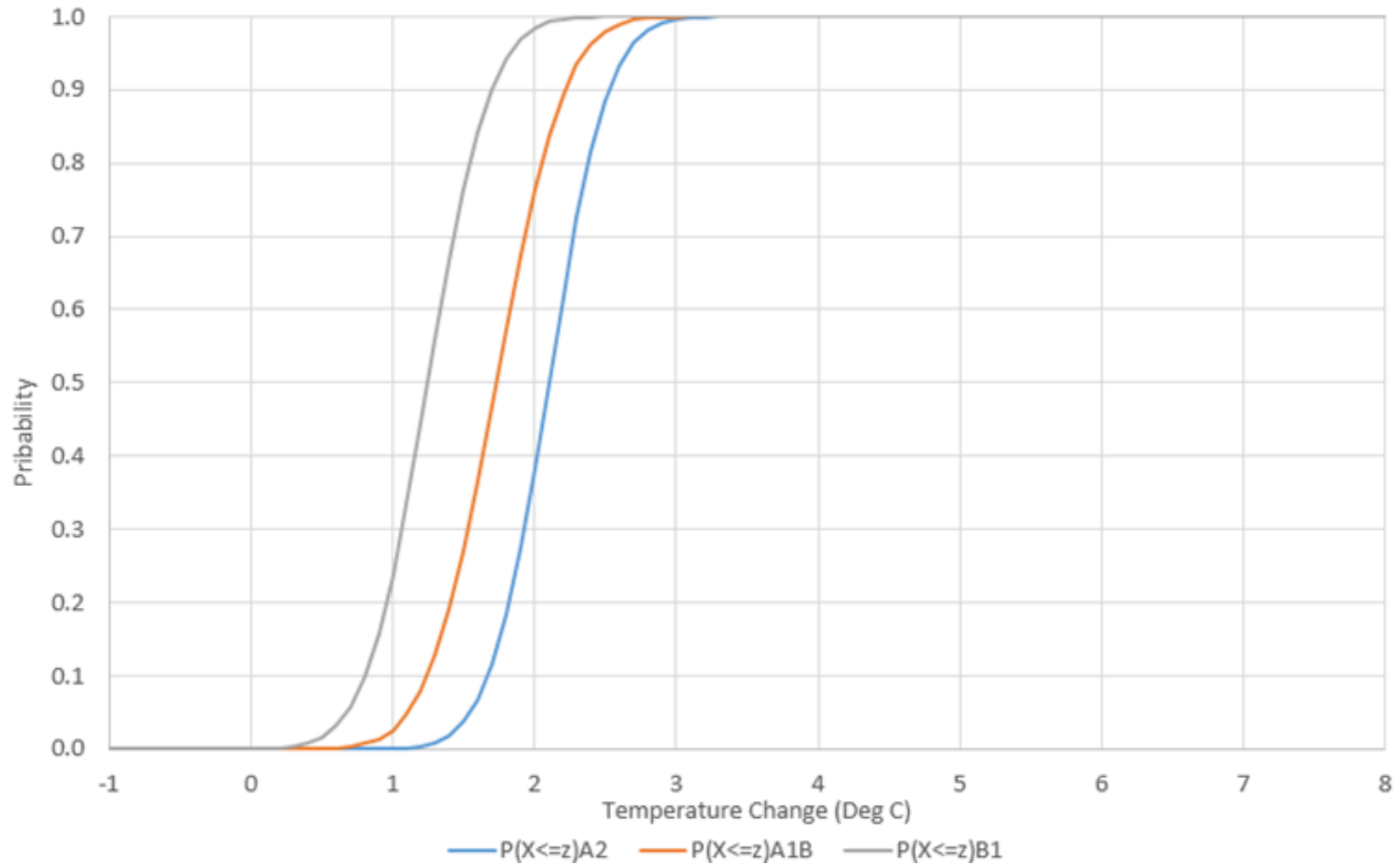
Add future climate change



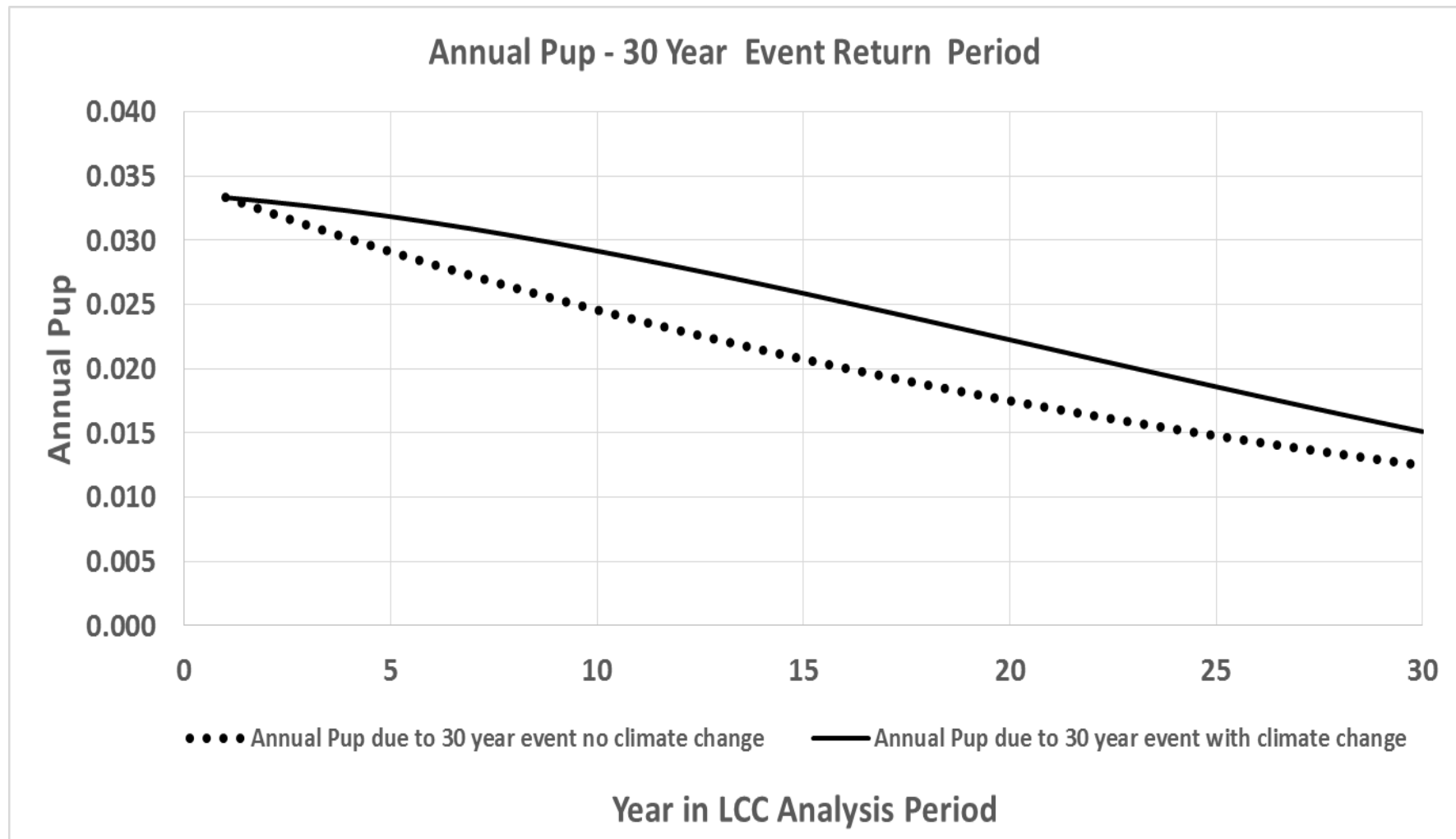
Using Multiple Climate Models



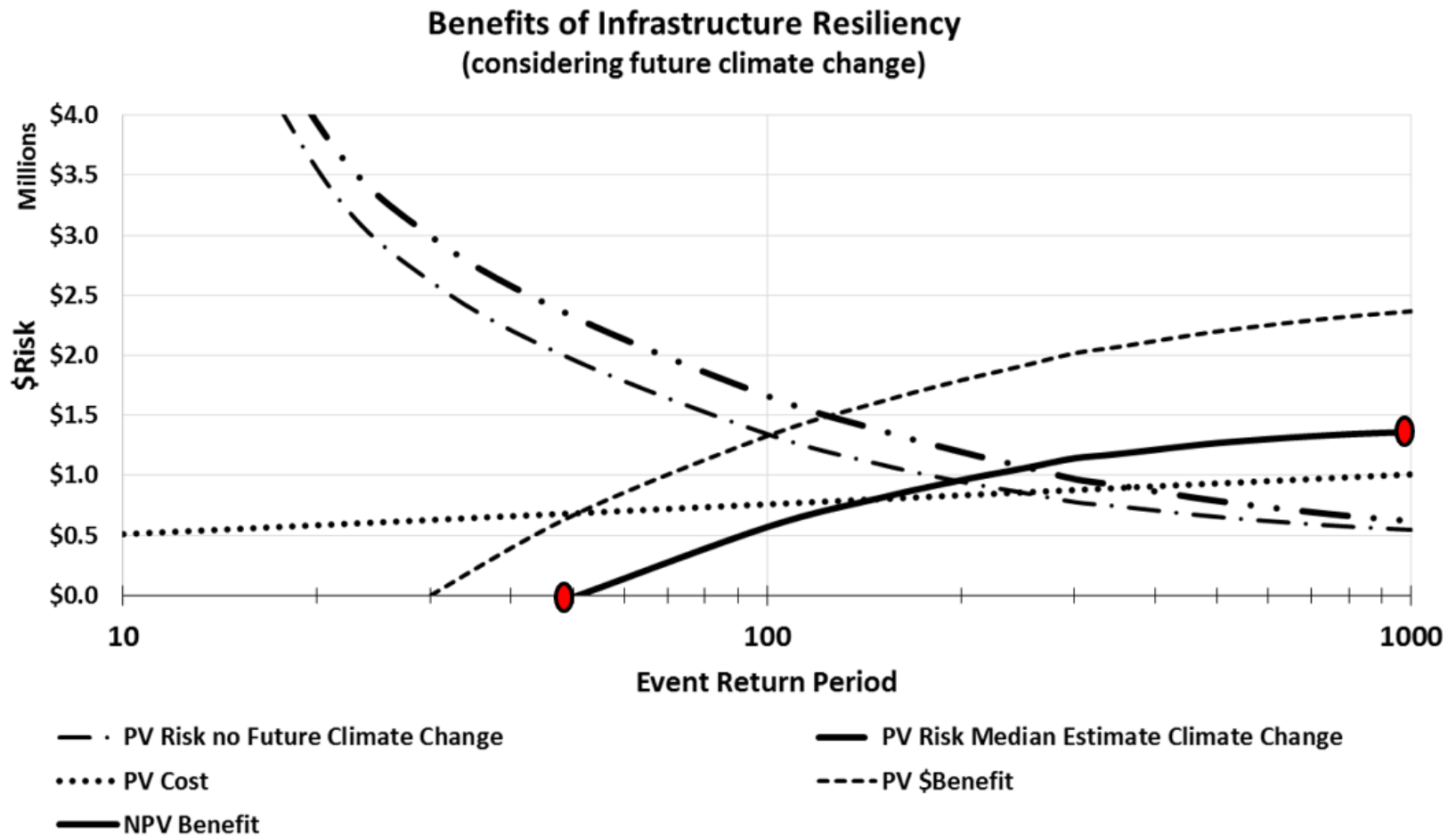
And Monte Carlo Simulations to produce Probability of an event return period



Change in Event Probability as Climate Evolves



LCCA informs Asset Managers



Summary

- Requires monetizing \$Risk
- Justifies Capital Expenditure
- Applicable to Geo-hazards, Avalanches and Seismic events
- Forms the Basis for LCCA Comparisons Across a Portfolio of Assets