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Risk Assessment Framework

Levee Ready Columbia

November 23, 2015

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Today's Discussion

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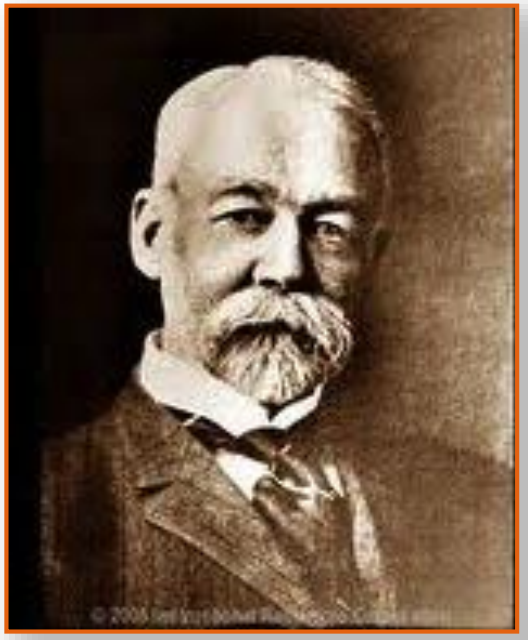
Levees and Level of Protection

When it comes to levees, there are two types:



William Hammond Hall, 1895

Those that have been overtopped by floodwaters

And those that will be overtopped by floodwaters

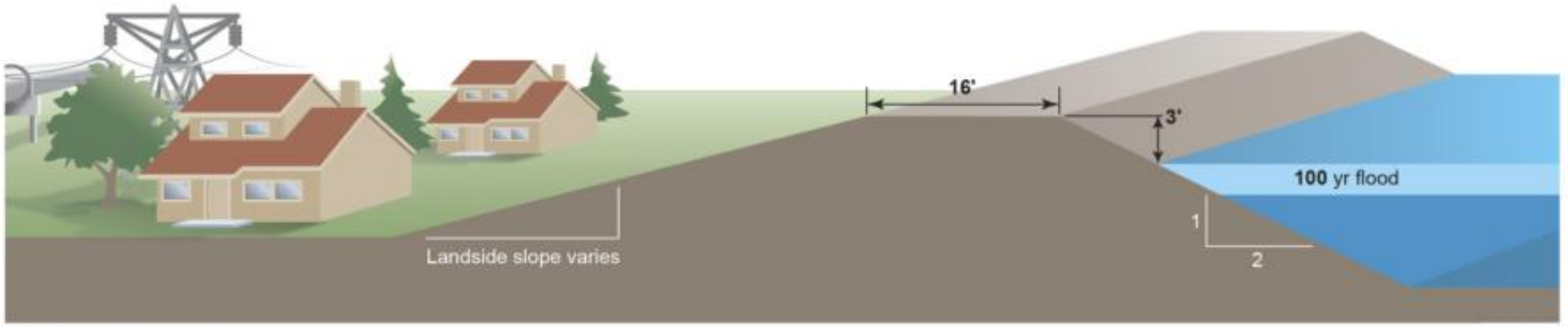
If there are consequences from flooding, then the risk is real

Current guidance

One percent AEP – NFIP (44FR 65.10)

100-year level-of-protection (LOP)

Basis for certification and FEMA accreditation



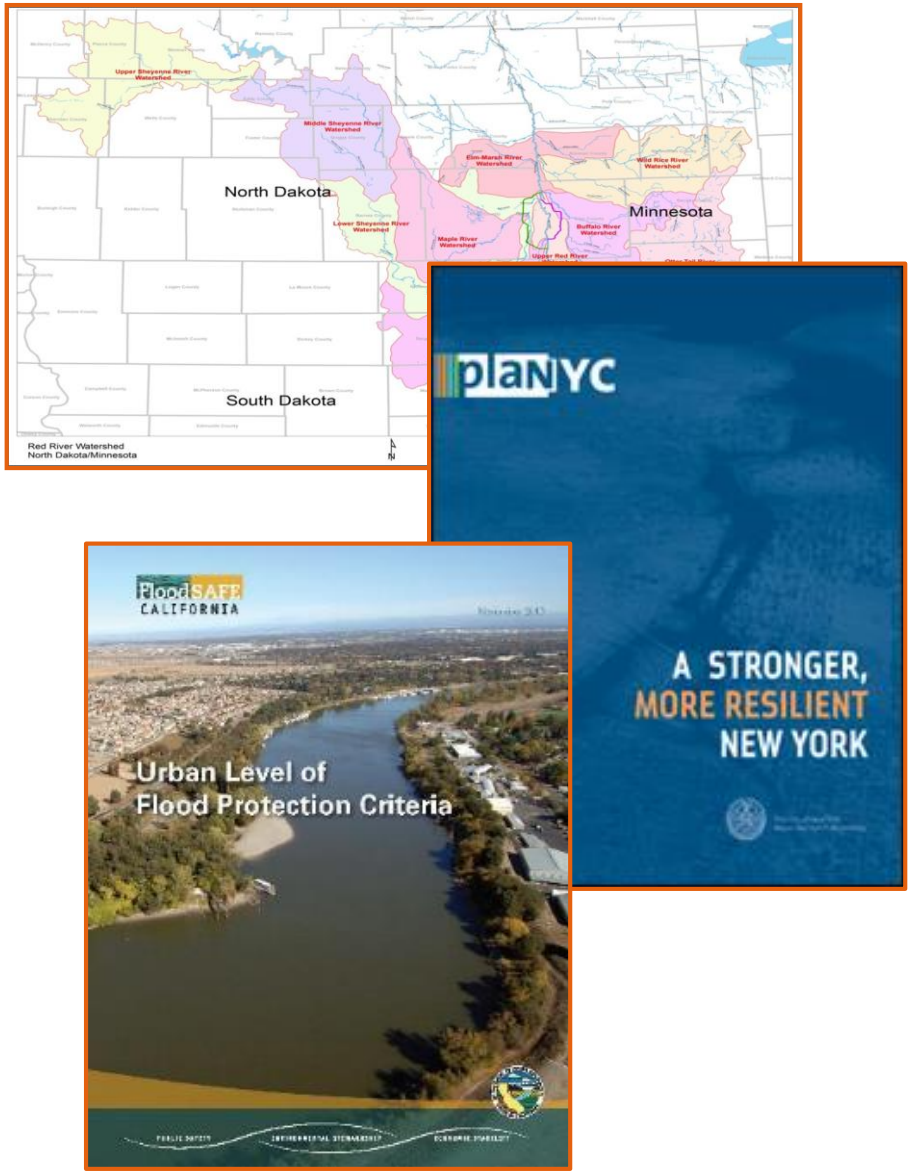
FEMA - 100 year

Increased LOP

Red River Basin, US and Canada: *1 in 500 to 1 in 750*

New York City: *1 in 500 for critical infrastructure*

California: *1 in 200 for urban areas*



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Using LOP, the focus is on the hazard

Basically an insurance standard

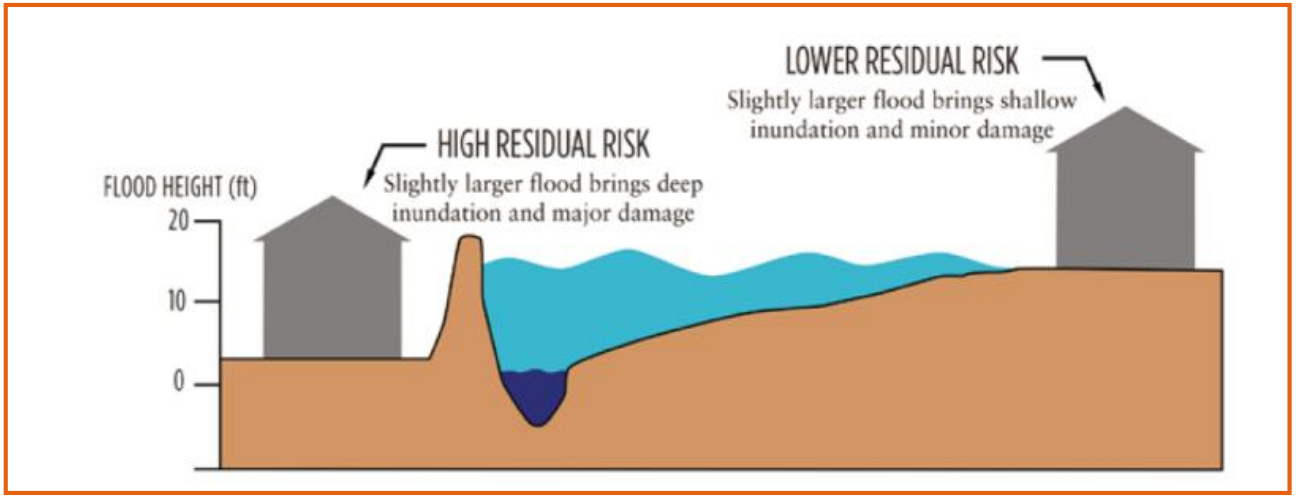
Ignores consequences

Implies risk can be eliminated

Hard to measure cost-effectiveness

Favors structural solutions

Ignores residual risk



LOP is <u>not</u> a safety standard.

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Levees and Risk

What is risk?

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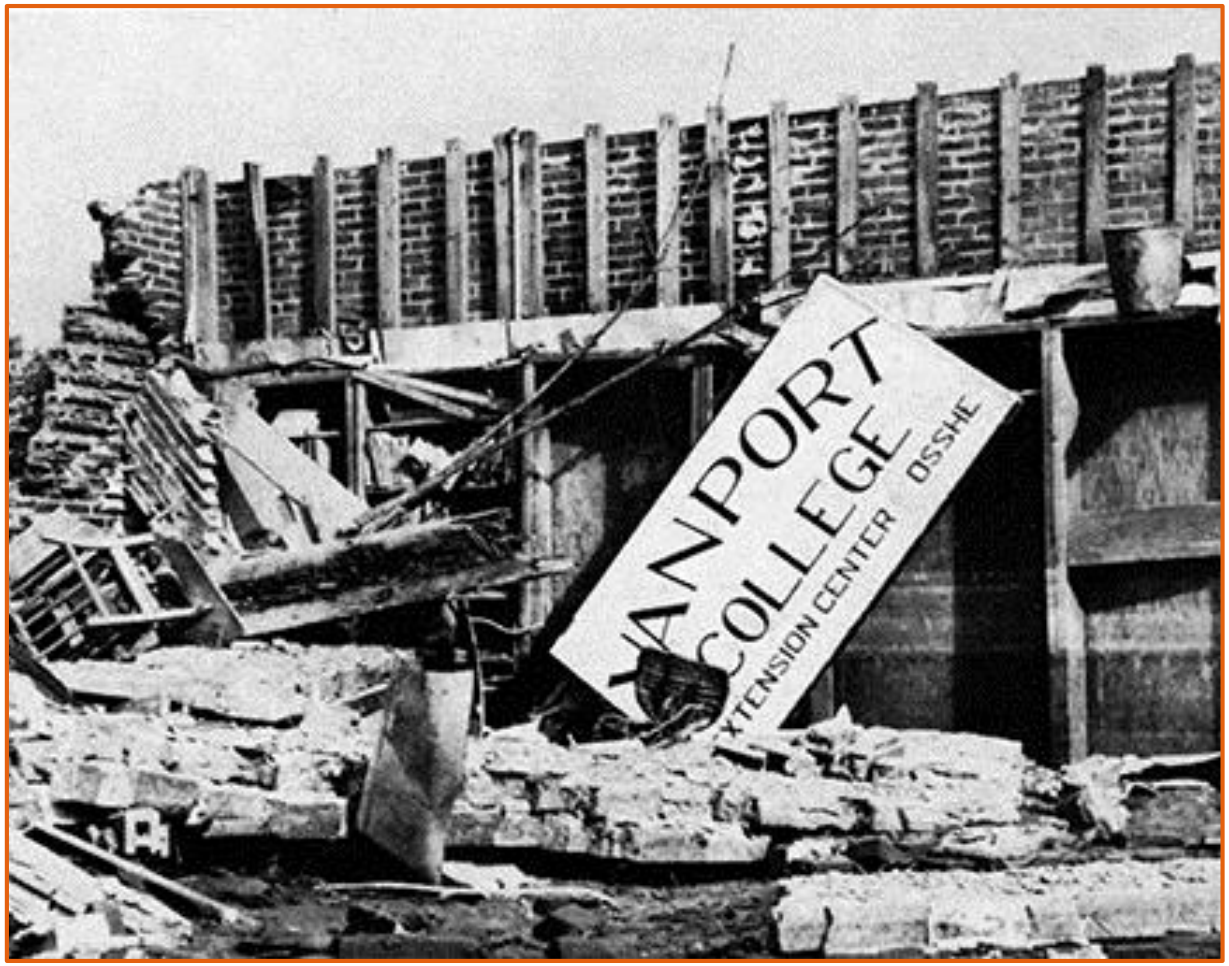
Risk = Probability x Consequences



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Risk cannot be eliminated

Jones Island, CA, June 2004

Mississippi River, 2011

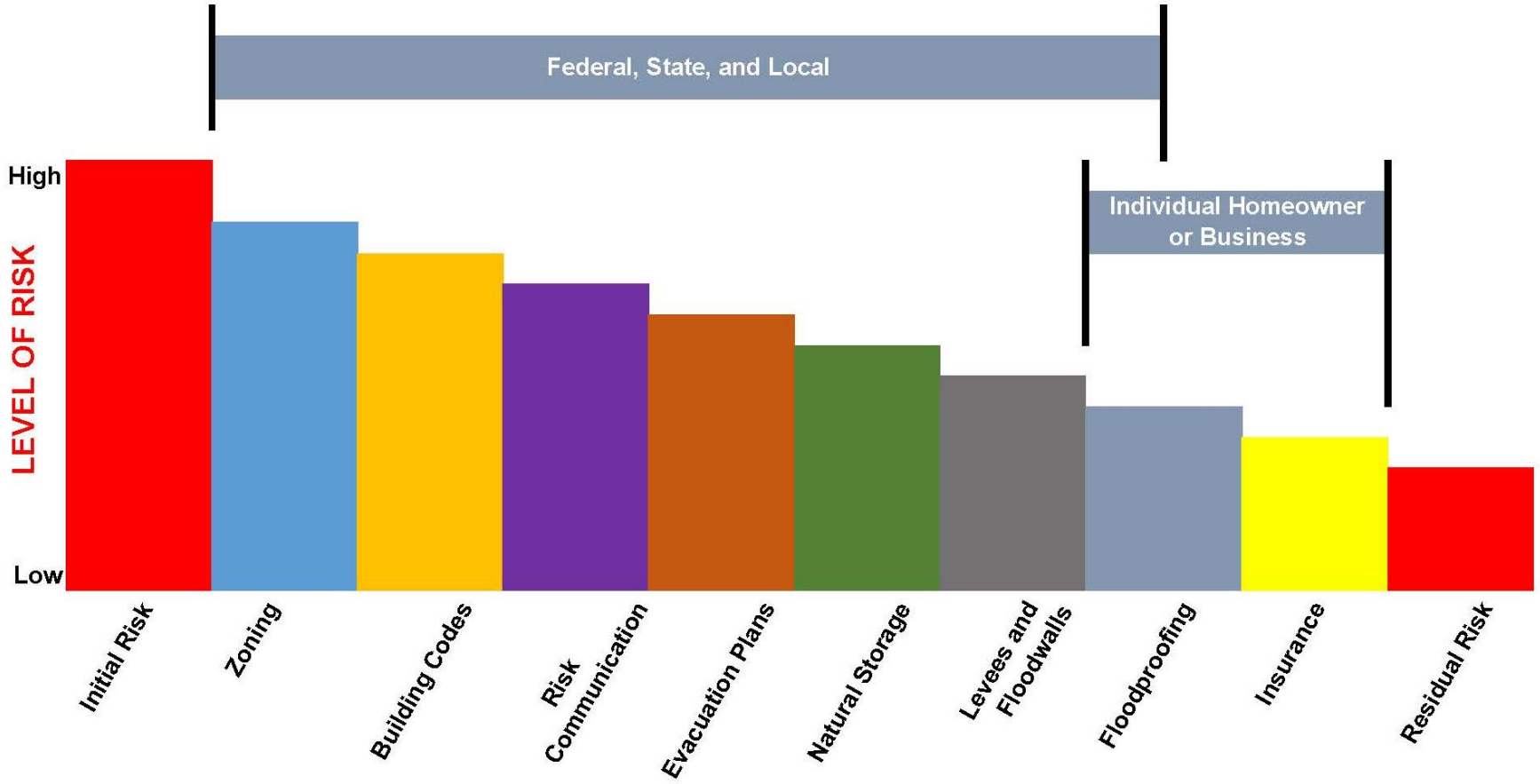
Katrina, Aug 2005

Superstorm Sandy, Oct 2012

Houston, May 2015

South Carolina, Oct 2015

BUYING DOWN RISK



How do we measure risk?

Expected Annual Fatalities (EAF)

- Percentage of fatalities among the population who will come in contact with floodwaters
- Dependent on many factors (warning time, water depth and velocity, rate of rise, water temperature, etc.)

How do we measure risk?

Expected Annual Damages (EAD)

- Annual cost of flooding
- Integrates the product of the probability of flooding and the potential economic damage over all flood levels

What level of risk is tolerable?

Nuclear Power Plants

Commercial Aviation

Dams

Hazardous Occupations

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Tolerable Risk Guidelines

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We make decisions everyday on what level of risk is tolerable to us

We cannot eliminate risk

Unacceptable **Tolerable** **Broadly acceptable**

Risk cannot be justified except under extraordinary circumstances

No further actions required. Risk regarded as insignificant

Tolerable Risk **is the level of risk people are willing to live with in order to secure certain benefits.**

Principles of *Tolerable Risk*

Life safety is paramount

Risk cannot be ignored

Absolute safety cannot be guaranteed

Goal = Risk should be As Low As Reasonable Practicable, or *ALARP*

ALARP **is what can be reasonably done without spending an inordinate amount of time, money, or resources relative to the risk reduction benefits.**

Tolerable Risk vs. LOP

Facilitates:

- Understanding risk
- Managing risk
- Communicating risk

Recognizes

- Risk cannot be eliminated
- Absolute protection is not possible

Accounts for structural vs. non-structural options

Enables:

- Evaluation of trade-offs
- Assessment of cost-effectiveness
- Efficient use of resources
- Establishing priorities
- Fair treatment

If you can measure risk, you can measure the cost-effectiveness of efforts to reduce risk.

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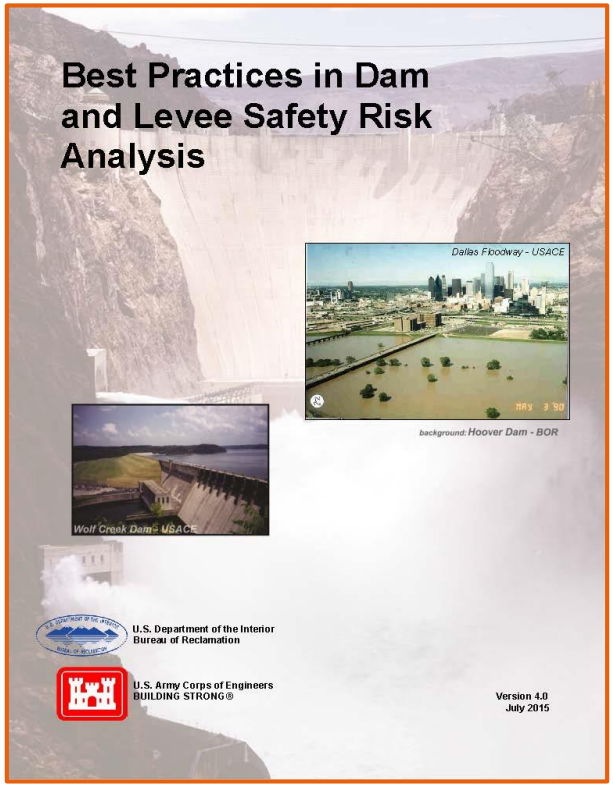
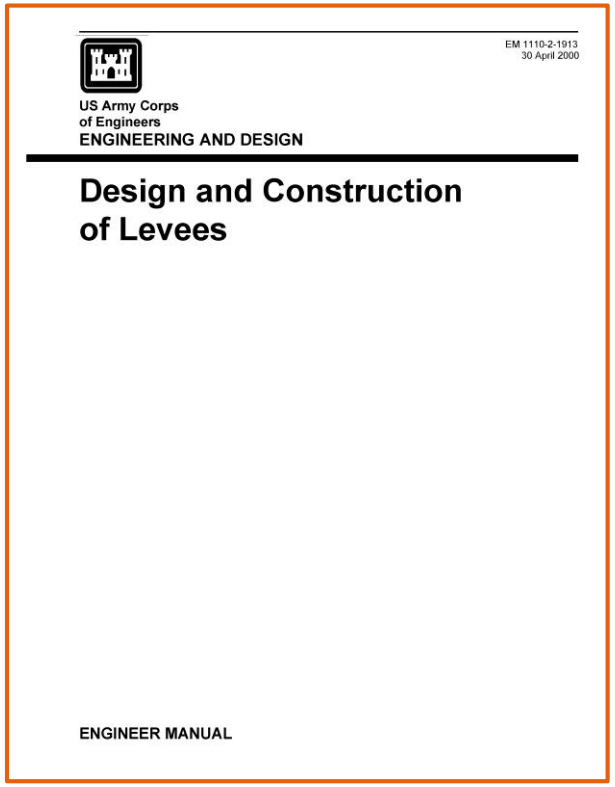
Applying Tolerable Risk

Applying Tolerable Risk Guidelines

Best practices identified by USACE and USBR (2015)

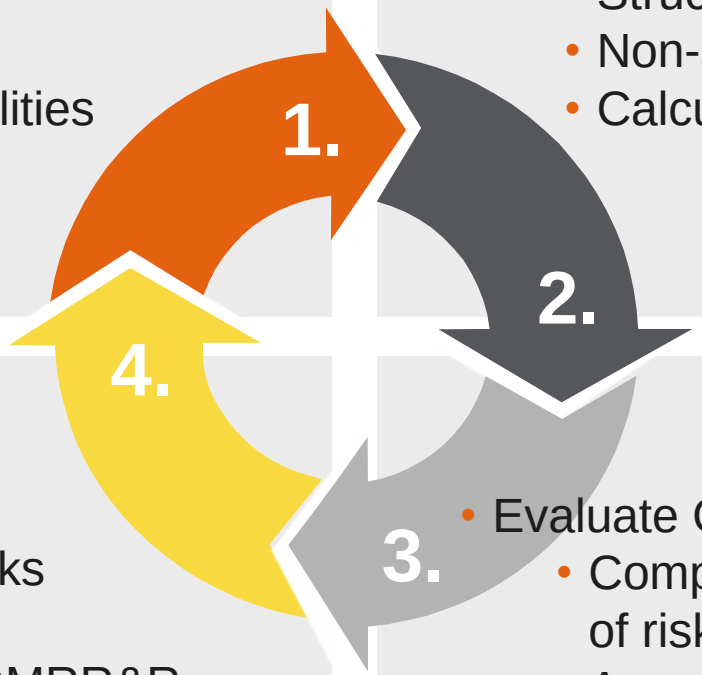


USACE *Design and Construction of Levees* (2016) will encourage risk assessment procedures



Applying Tolerable Risk Guidelines

- Characterize Risk
  - Inventory assets
  - Identify Hazards
  - Assess vulnerabilities
  - Calculate risk



- Identify Options to Reduce Risk
  - Structural
  - Non-structural
  - Calculate risk reduction

- Evaluate Options
  - Compare cost-effectiveness of risk reduction measures
  - Assess residual risk

- Continuously Review
  - Communicate risks
  - Adapt to change
  - Perform robust OMRR&R

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THE NETHERLANDS

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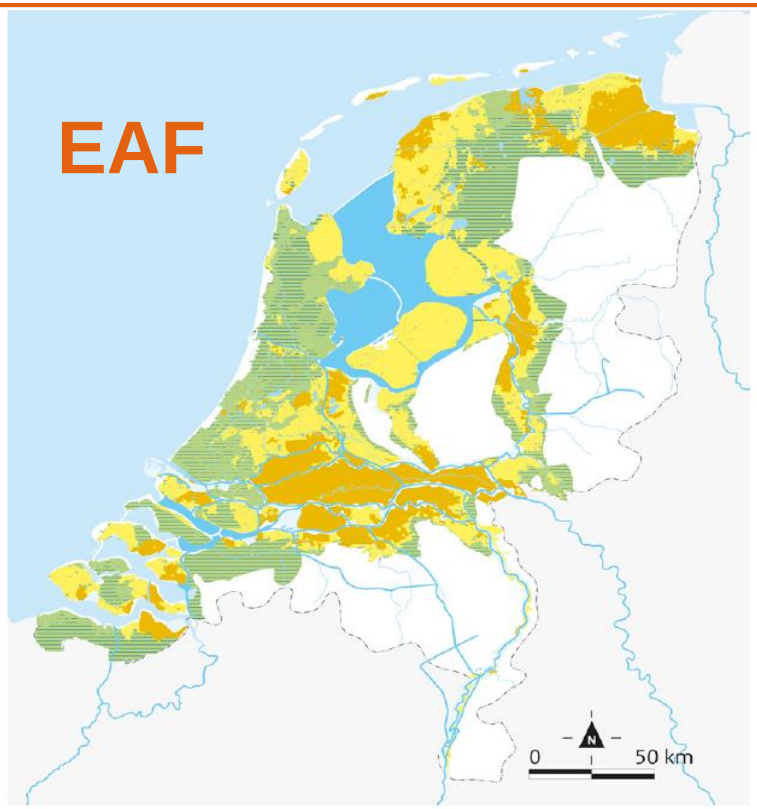
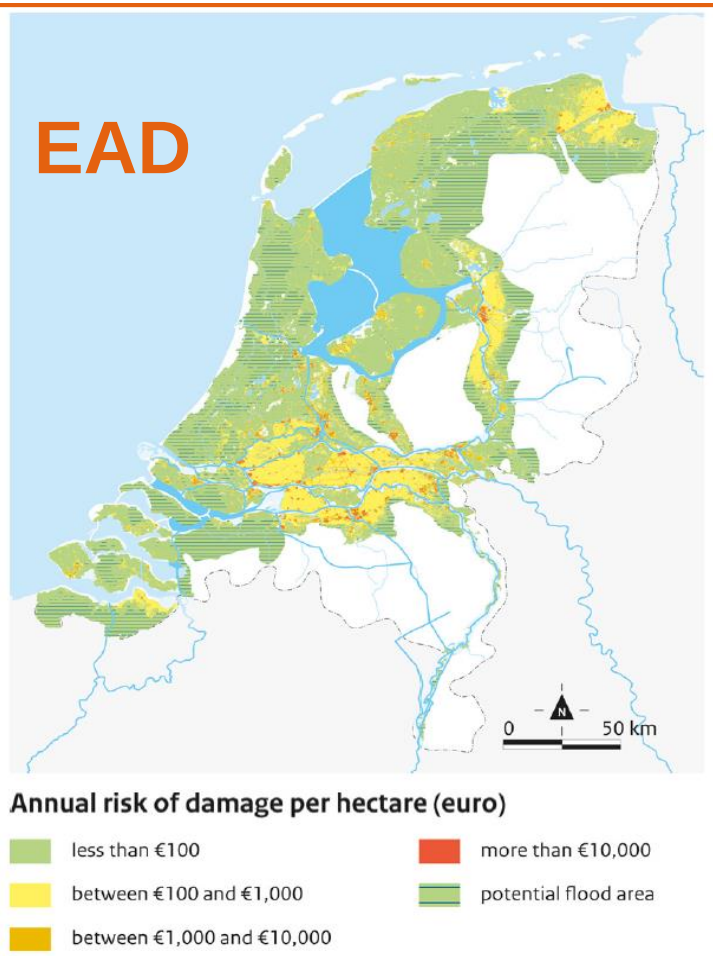
Risk mapping using TRG

The Netherlands

EAF



EAD



No Dutch person has greater than 1 in 100,000 chance per year of dying in a flood.

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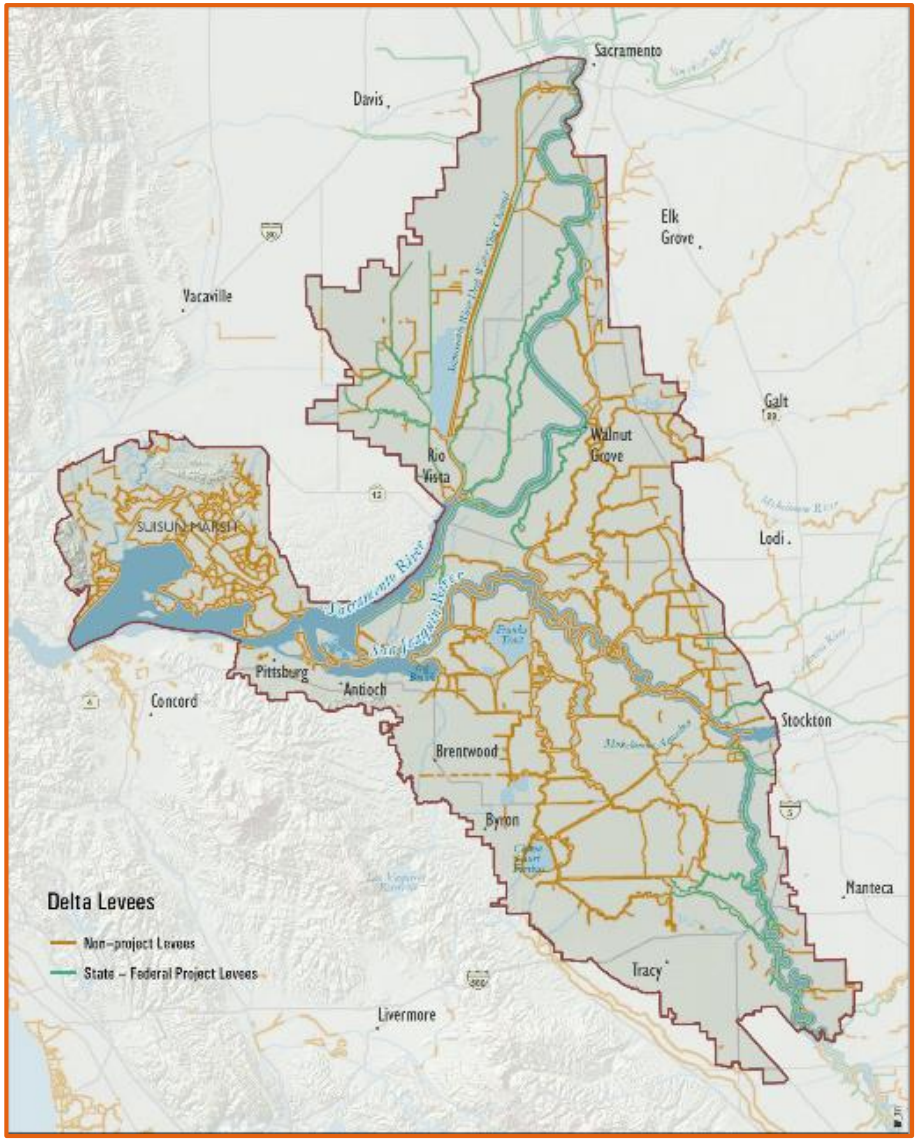
CALIFORNIA DELTA



California Delta

Largest estuary on west coast of the Americas

>60 major islands comprising 1300 sq. mi.

1,100 miles of levees

Main source of water for 27M people and 4M acres of farmland

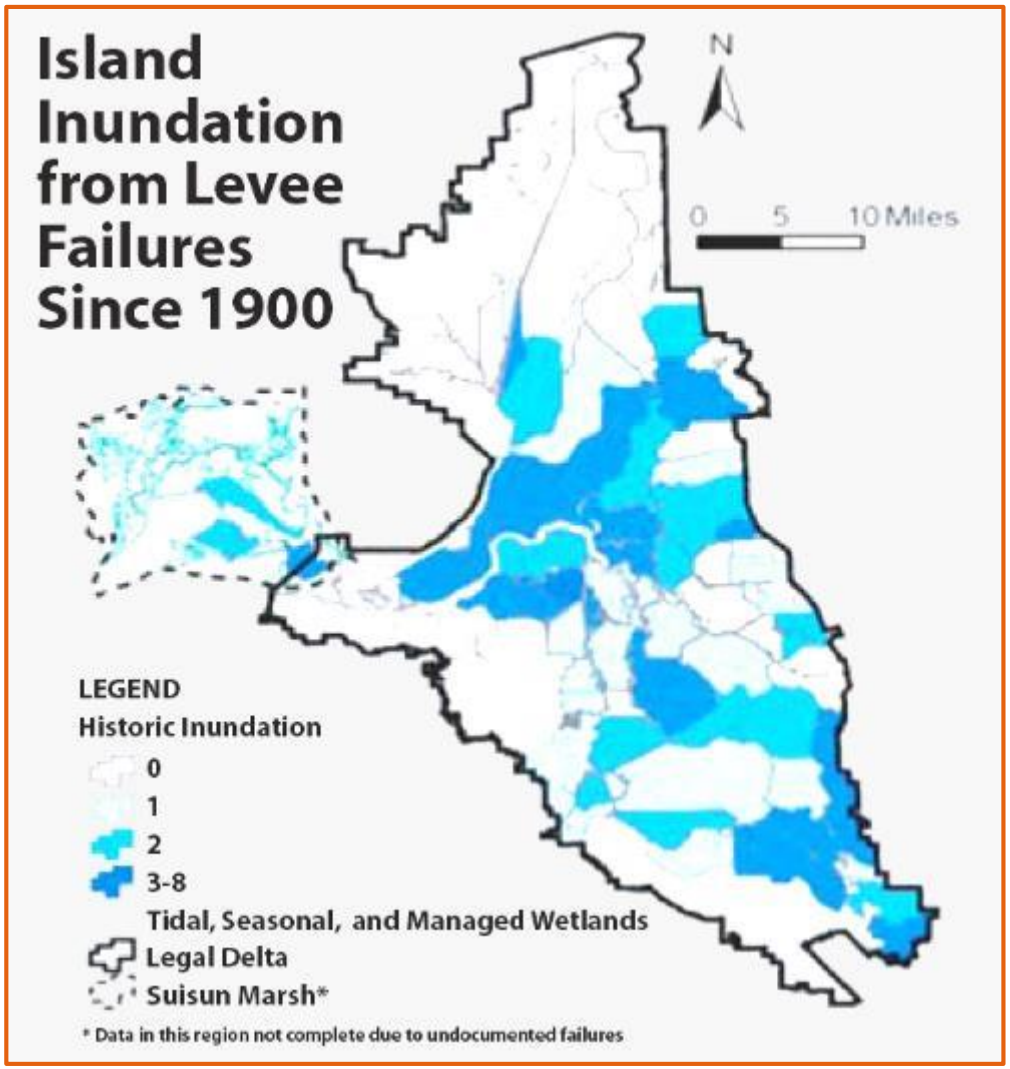
160 levee failures since 1900

Hazards

- Floods
- Earthquakes
- Subsidence
- Seepage
- Sea-level rise

Threats to

- People, property, and infrastructure
- Water supply
- Ecosystem
- Delta as a place



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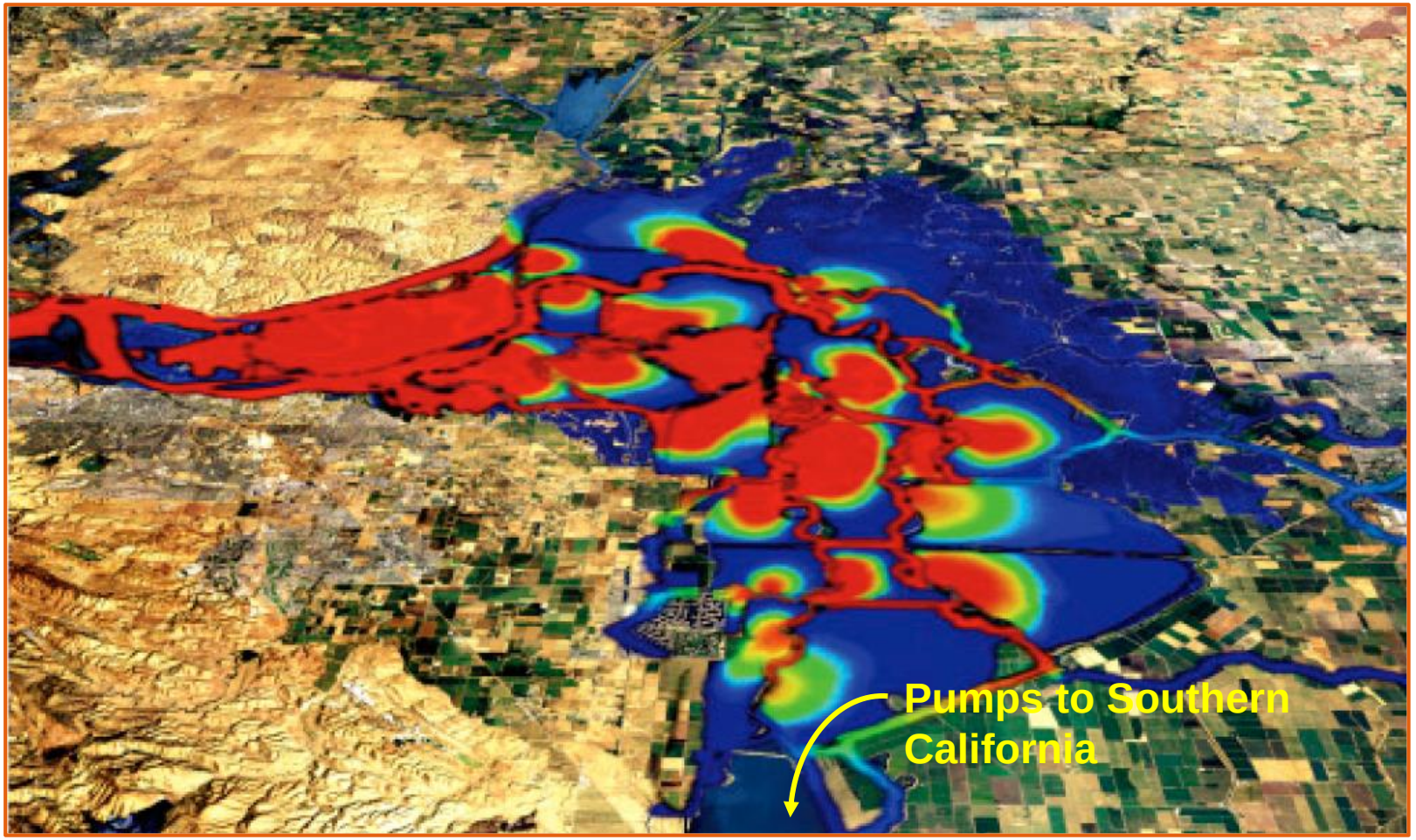
Water Supply Disruption



Risk Metrics

Expected Annual Damage (EAD)

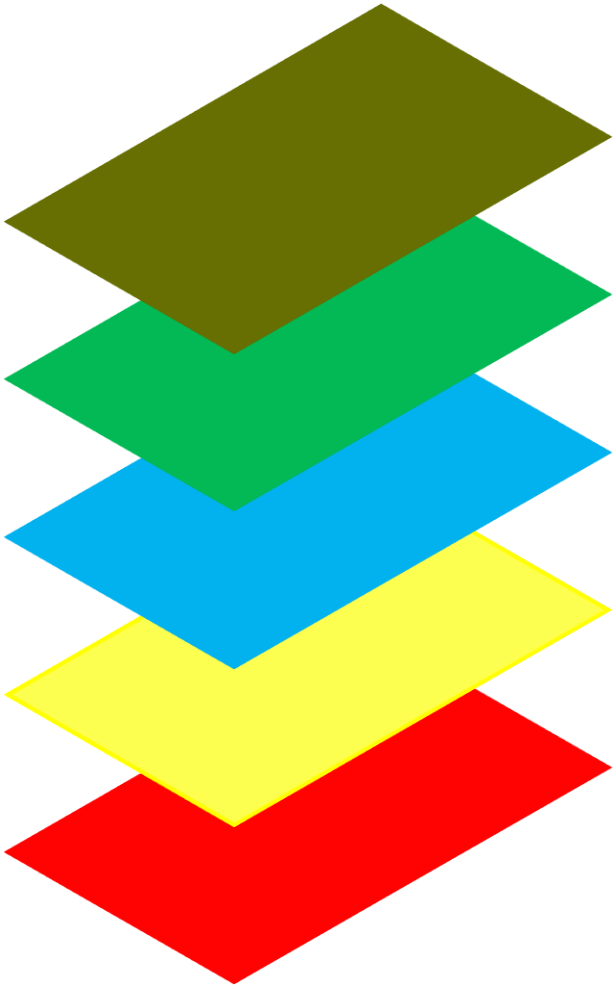
Harm to the Ecosystem

Expected Annual Fatalities (EAF)

Harm to Delta as a place

Water Supply Disruption

Delta Risk Maps



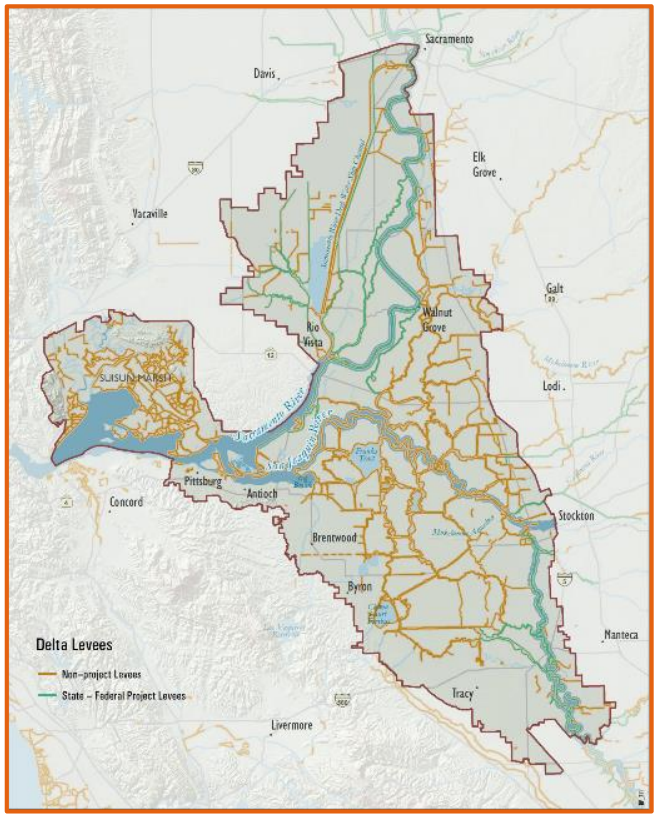
RISK TO DELTA AS A PLACE

ECOSYSTEM RISK

WATER SUPPLY RISK

FLOOD DAMAGE RISK (EAD)

LIFE LOSS RISK (EAF)



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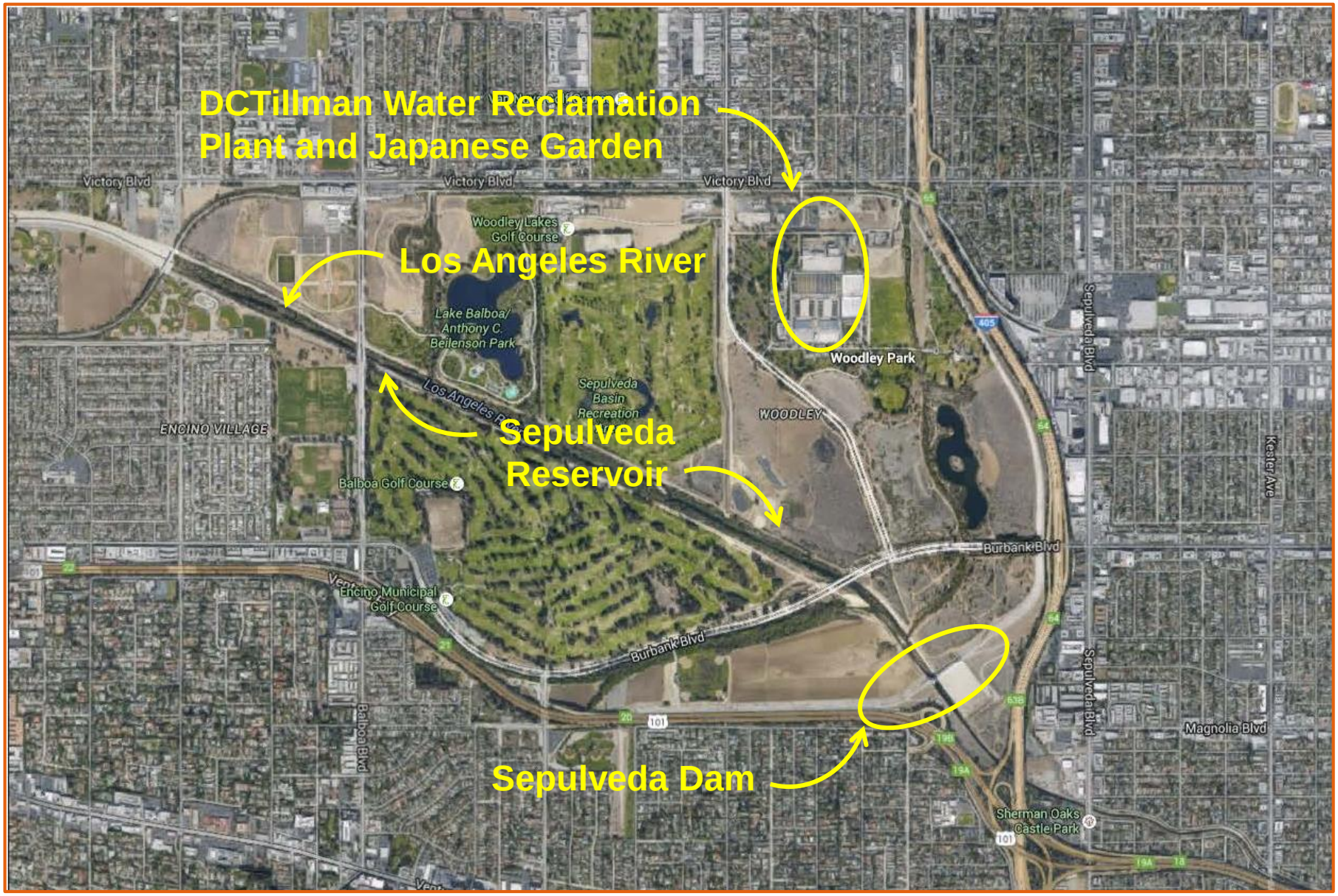
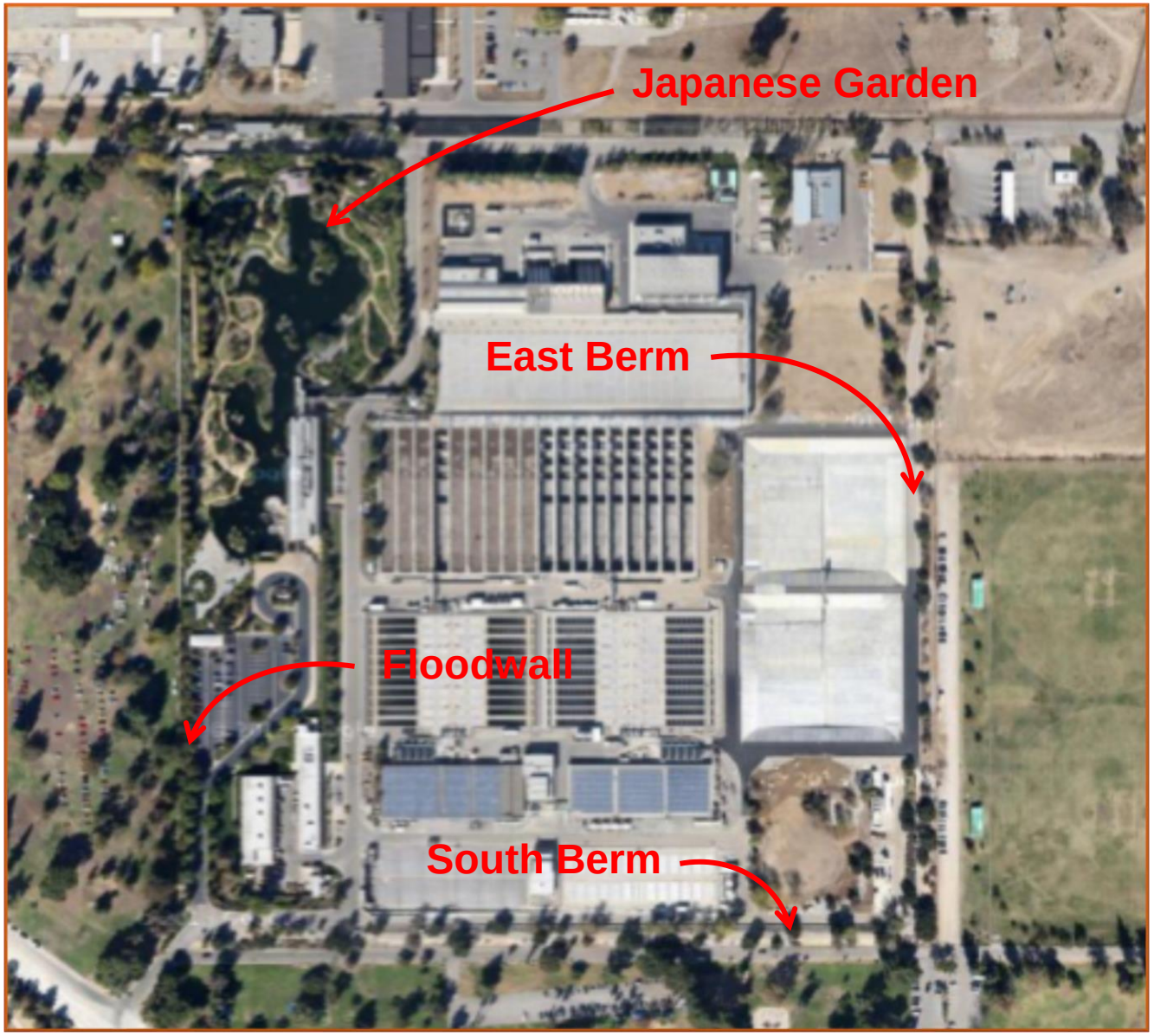
DC TILLMAN WATER RECLAMATION PLANT



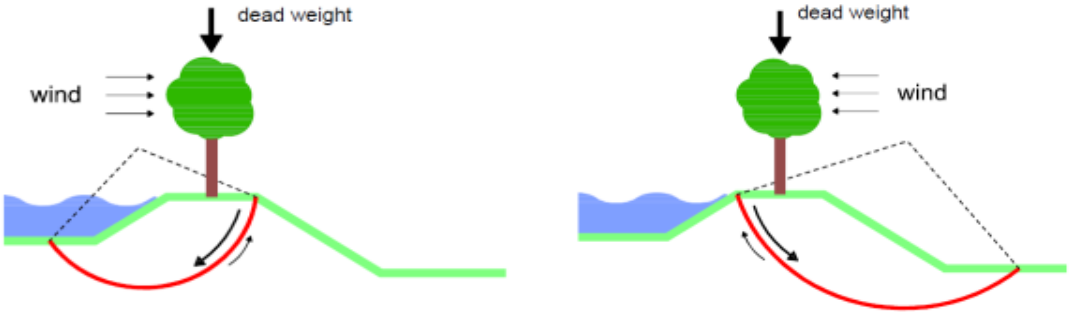


Berms and floodwall at DCTWRP

Berm

Floodwall

Hazards posed by vegetation



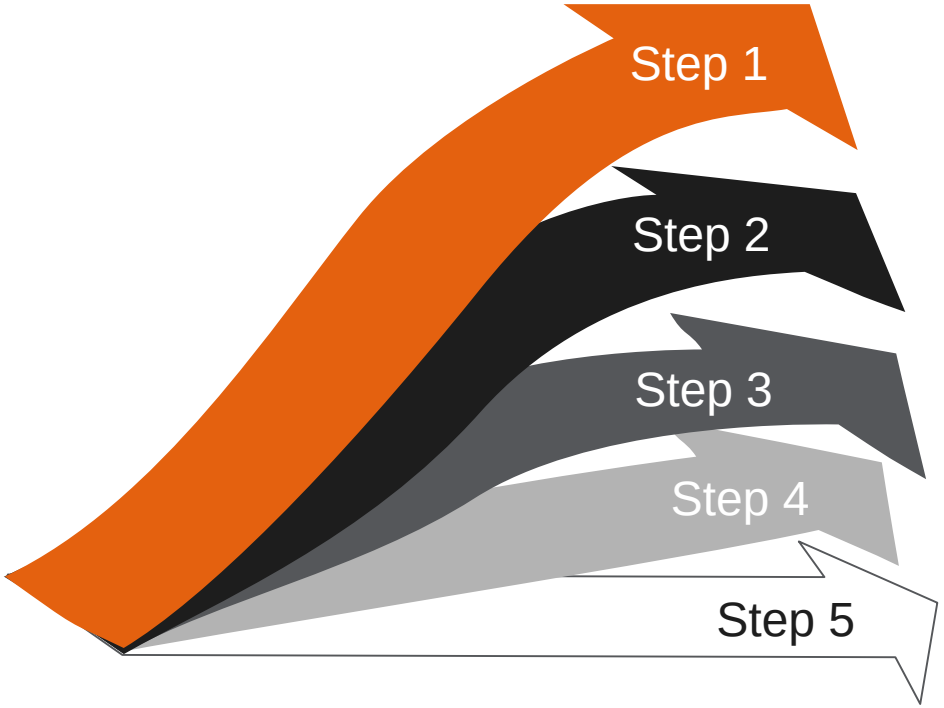
Stability assessment with wind forces and dead weight

Stability and seepage/piping assessment with root void

- Presents stability and seepage problems
- Obstructs flood fighting
- Obscures inspection and monitoring
- Shelters burrowing animals
- Can exacerbate erosion in flowing water

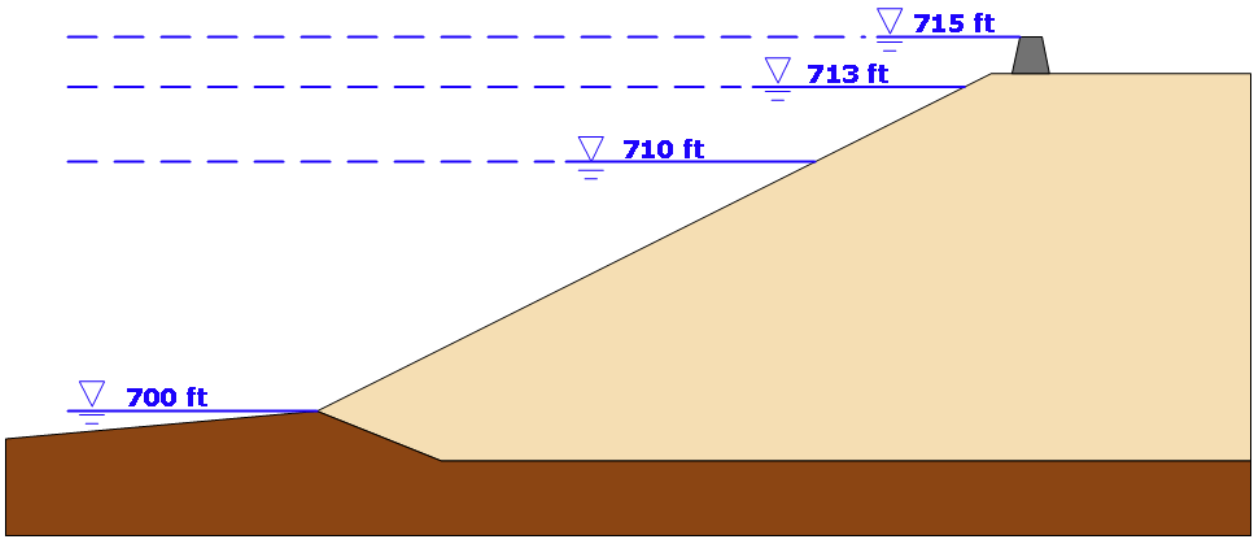
Does vegetation materially increase the risk from flooding?

Overview of the process

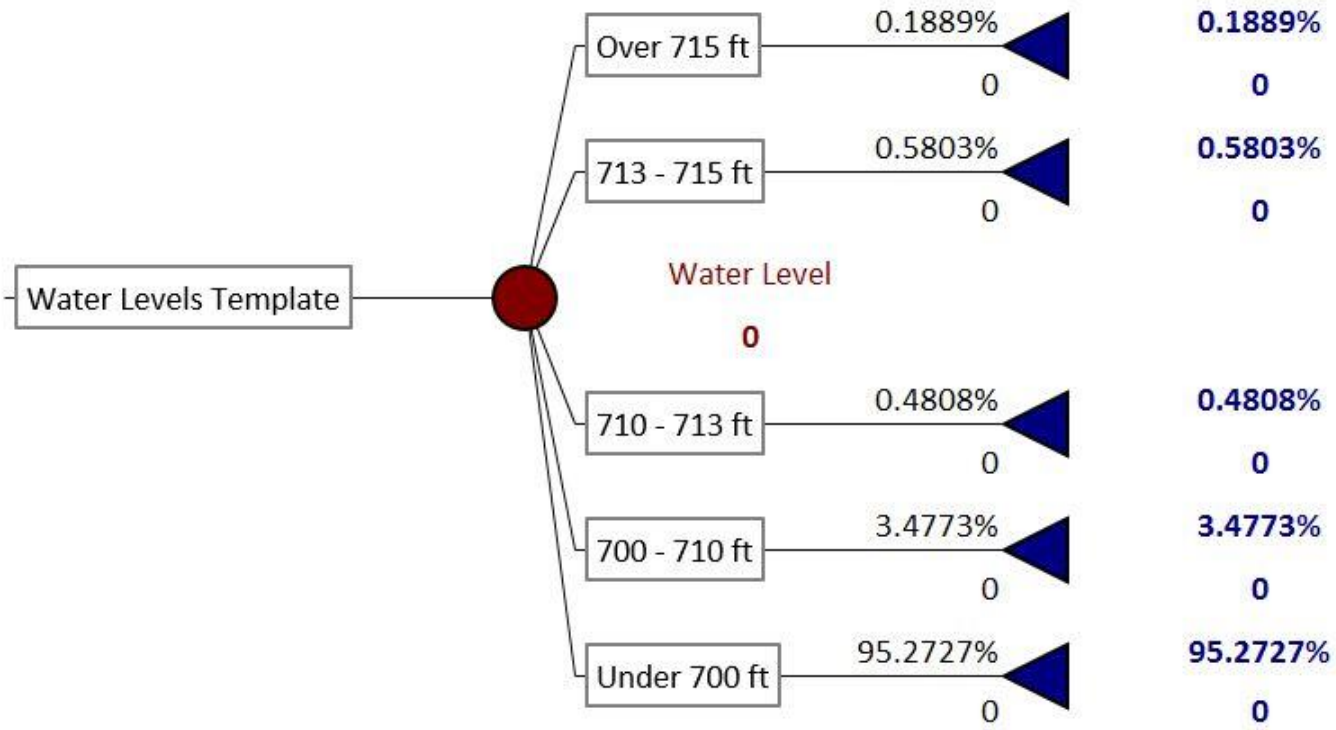


- Collect and review background information
- Review loading conditions and baseline consequences
- Brainstorm potential failure mechanisms (PFMs)
- Discuss and evaluate risk drivers
- Develop event trees for PFMs

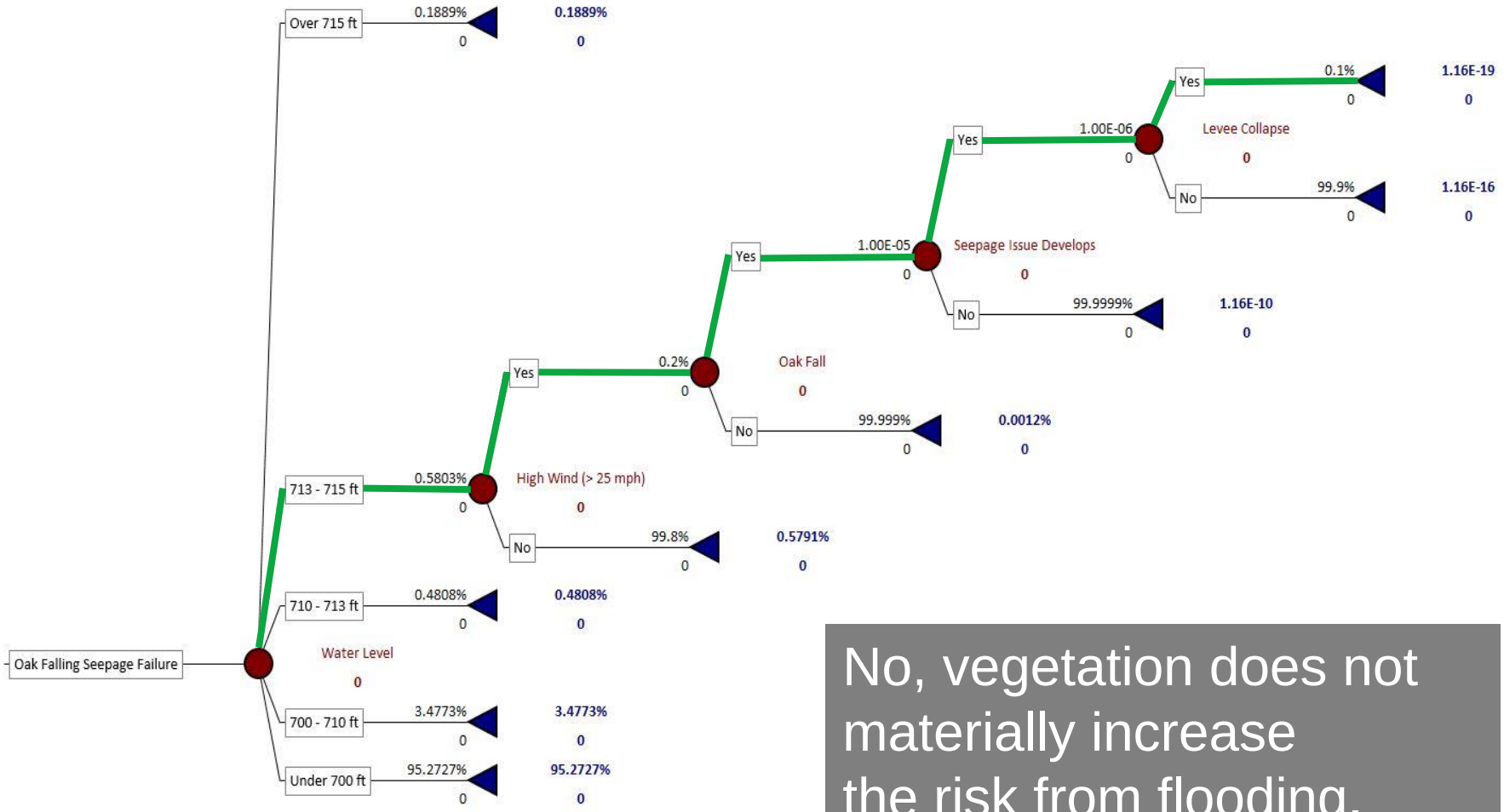
Flood loading



Initiating event



Building the event tree



No, vegetation does not materially increase the risk from flooding.

Risk assessment enables

Understanding risk

- Life, property, infrastructure, the environment, and features of interest

Calculating the amount of risk reduction

- Structural alternatives
- Non-structural options

Prioritizing actions to reduce risk

Comparing alternatives and evaluating trade-offs

Determining cost-effectiveness of alternatives

Clear communication of risk to stakeholders and to those most affected

Thank you!

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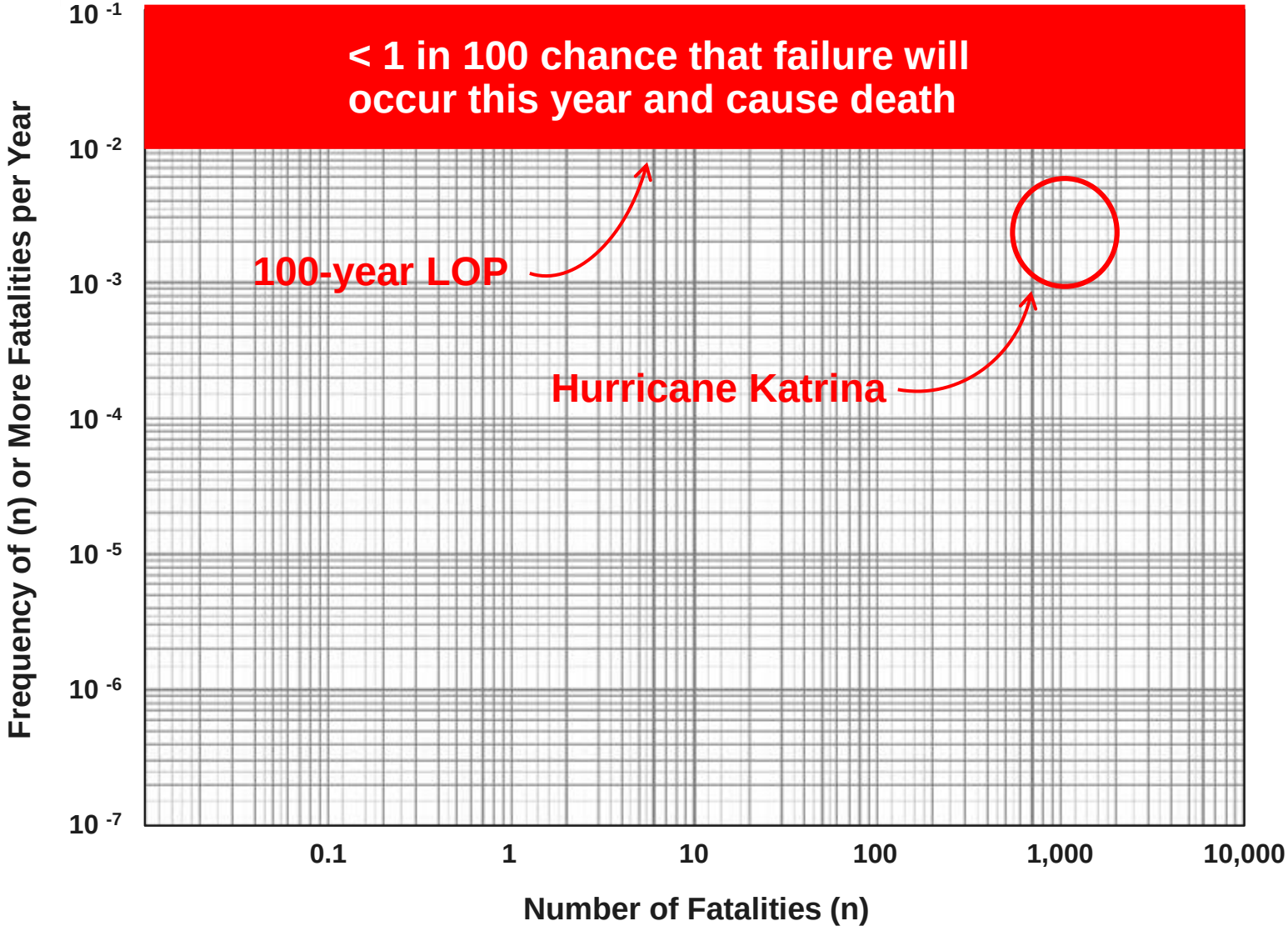

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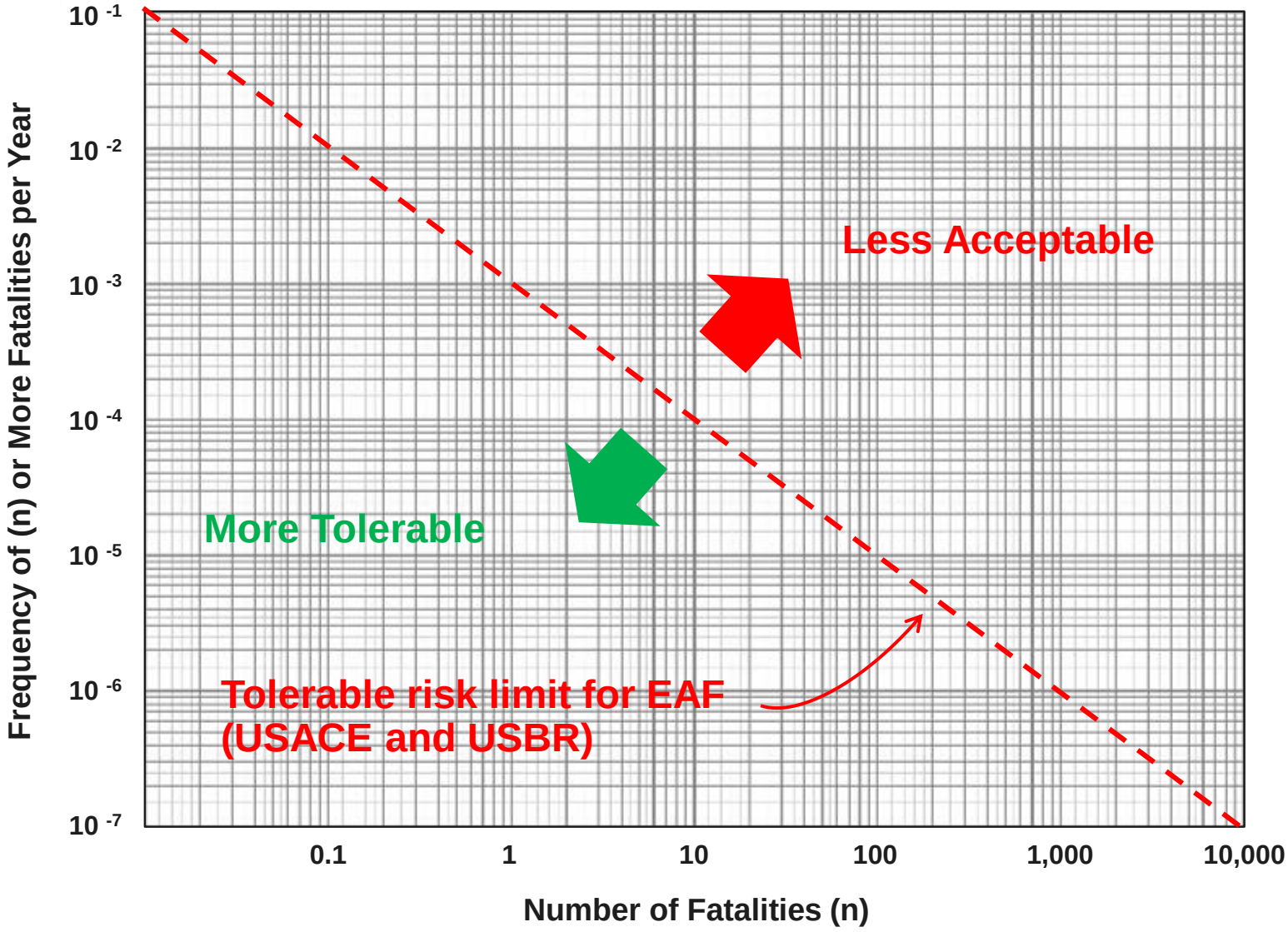

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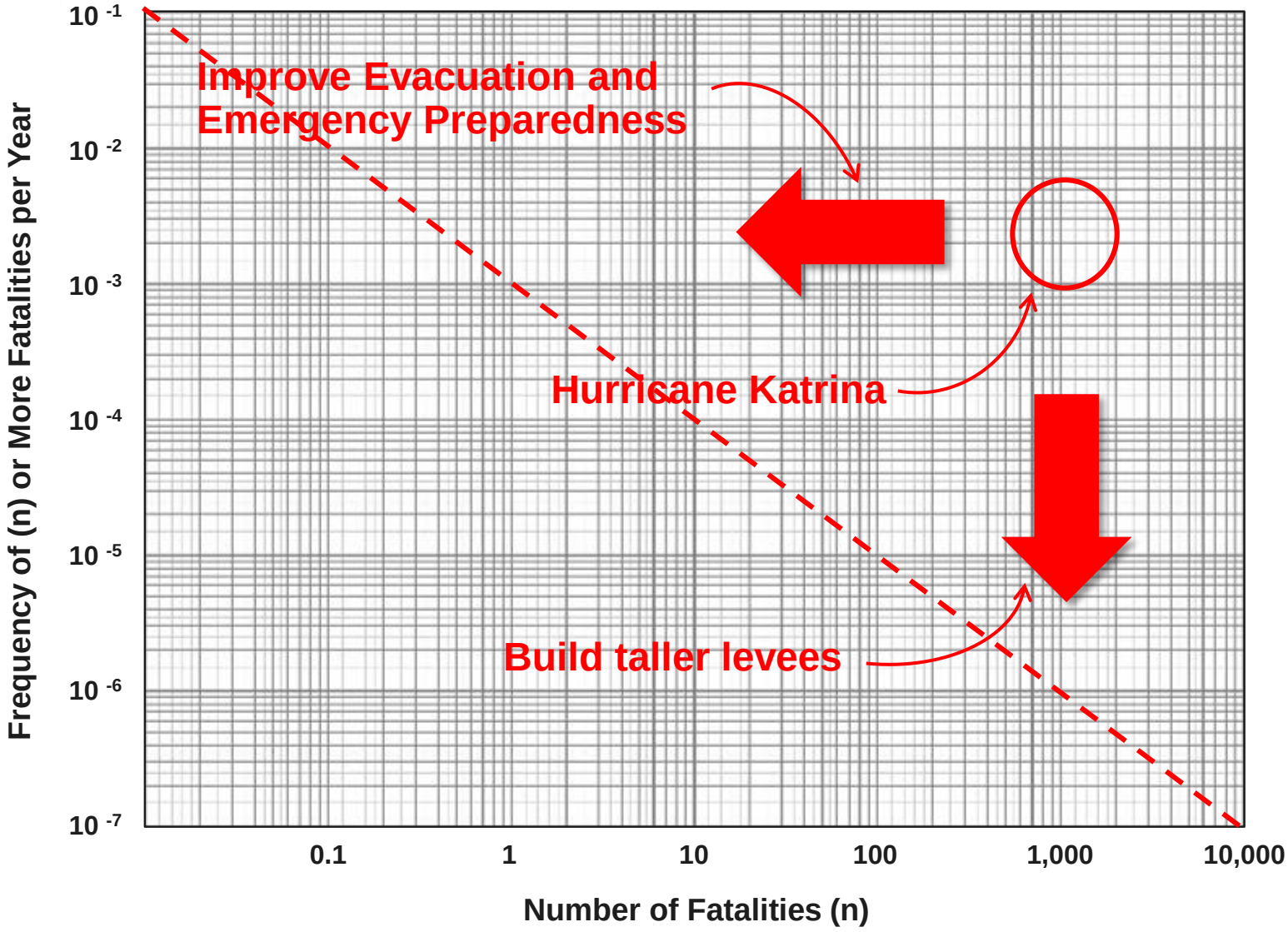

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