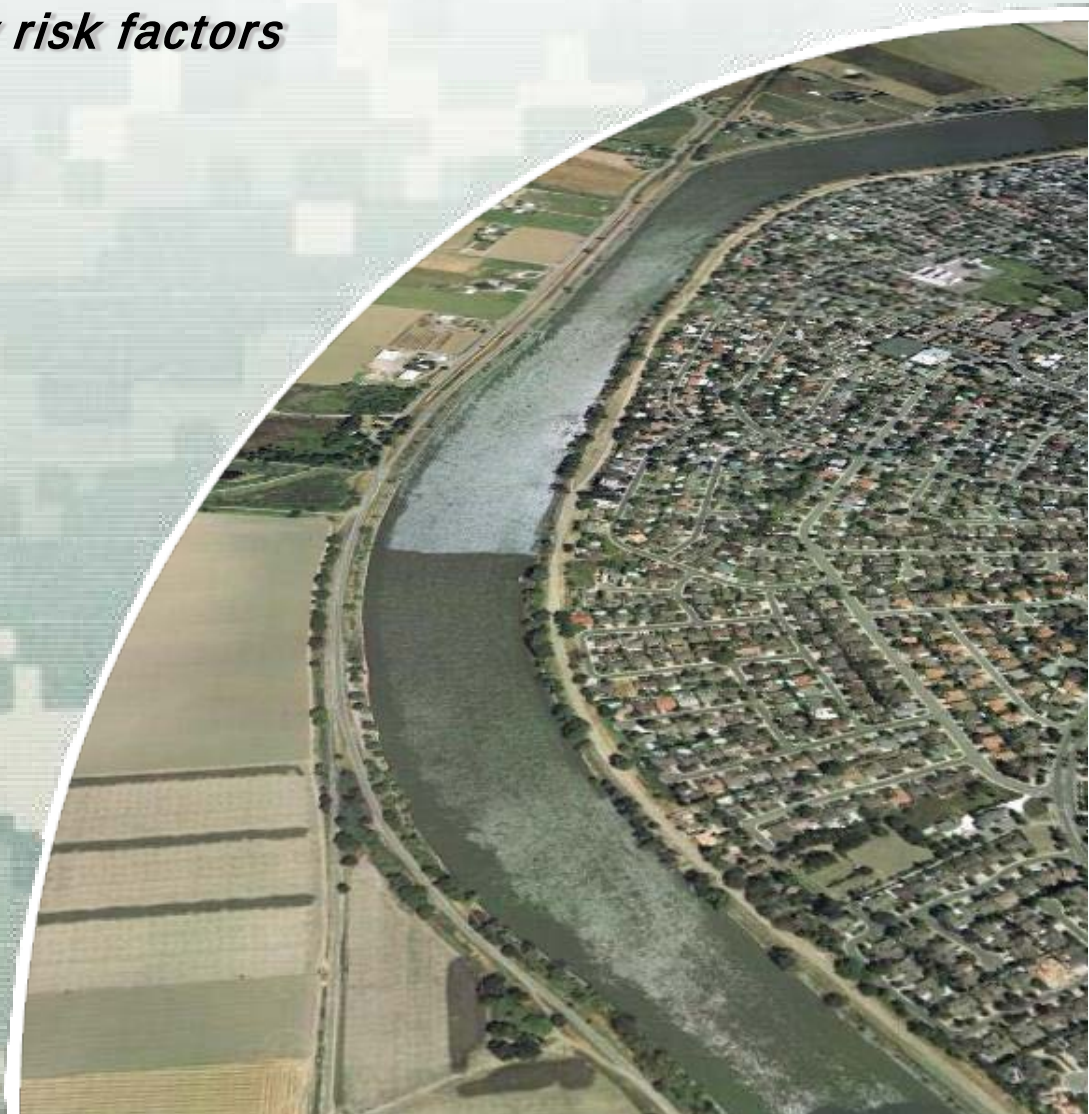
FLOOD RISK MANAGEMENT
Life Safety Hazard Index
Quantification of life and safety risk factors



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BUILDING STRONG®

Purpose and Agenda

- Purpose
  - Overview of the “Life Safety Hazard Index” Its use and calculation
  - Application of the index for feasibility & construction projects
  - Application of the index to inform the budget prioritization
- Outcomes
  - Understanding of the application of the Life Safety Hazard Index in the budget process
- Agenda
  - Definition of Flood Risk Management (FRM) Life Safety Hazard Index
  - Description of Risk Factors
  - Calculation of Life Safety Hazard Index
  - Risk Factors and Budgeting
  - Discussion

Life Safety Hazard Index

The Life Safety Hazard Index represents the "relative" potential loss of life caused by a design level flood for the without project condition.

- Uses selected "risk factors" for a relative assessment of the potential loss of life associated with a proposed FRM project in feasibility or construction phase
    - Population at Risk (PAR)
    - Warning time available to the PAR
    - Depth of flooding in the project area
- Used as a relative evaluation of non-monetary (life) aspects of planned FRM projects during the budget prioritization process.
- The Life Safety Hazard Index is not a true risk calculation or assessment!
- Is not an attempt to estimate an absolute loss of life for a specific flood event or level of protection which requires a detailed understanding of many factors related to the PAR and flood characteristics

Life Safety Hazard Index
Risk Factors

- Population at Risk (PAR) = Represents the # of people residing, working, transiting within the study inundation area (studies) or design level flood inundation area for the recommended project (construction)

- Warning time available to the PAR = The amount of warning time available to the PAR from when a flood warning is issued.

- Depth of flooding in the project area = The average (500 yr) depth of flooding in the study inundation area (studies) or design level flood inundation area (construction)

  Study inundation area = representative of the average flood condition (~500 yr) in the study area that represents the maximum risk potential that a project may be designed to (without project condition)

  Design level flood = the elevation up to which the proposed project would reduce flood impacts in the inundation area if it performs as designed (NED recommended alternative)

Life Safety Hazard Index Formulation

Equation # 1 – Computes a factor that represents the % of the original PAR that will not mobilize prior to being inundated

$$PAR_{Exposed} = PAR * \left[1 - \left[\frac{1}{1 + e^{4.825 - 0.0425(WarningTime)}}\right]\right]$$

- $PAR_{Exposed} >= 0.02*PAR$
  - *Equation #2 transforms population at risk (PAR) to Exposed PAR, using average assumptions for how quickly a warning would spread and how quickly people would respond to a given warning*
  - *$PAR_{Exposed}$ cannot be less than 2% of PAR. This accounts for generally accepted notion that a small percentage of the population will not comply to warning due to either not understanding the nature of the danger or consciously deciding to take action other than evacuation.*
  - *WarningTime is in MINUTES*

Equation # 2 - Computes a factor that represents a fatality rate for the % of the original PAR that does not mobilize prior to inundation

$$Fatality\ Rate = \Phi\left(\frac{\ln(Depth * 0.3048) - 5.2}{2}\right)$$

- *Index represents a relative life risk that is computed using a similar methodology that is contained within the Levee Screening Tool (LST).*
- *Research from TU Delft illustrates that life risk can generally be represented as a function of depth and that fatality rate follows a lognormal distribution of the depth.*
- Φ represents a normal distribution.
- This computation can be setup easily in Excel using the following syntax: =normaldist(ln(Depth*0.3048),5.2,2)
- Depth is in feet

Life Safety Hazard Index Formulation

Combination of factor equations results in a relative “Life Safety Hazard Index”

$$Index = PAR * \left[1 - \left[\frac{1}{1 + e^{4.825 - 0.0425(WarningTime * 60)}}\right]\right] * \Phi\left(\frac{\ln(Depth * 0.3048) - 5.2}{2}\right)$$

% of people not evacuated

Fatality Rate

- Life Safety Hazard Index
  - Is a relative assessment of the potential loss of life associated with a proposed FRM project in feasibility or construction phase
  - Used during the budgeting process to consider projects and studies from a non-monetary (life safety) aspects
  - Simplified assessment using specific factors contributing to life loss

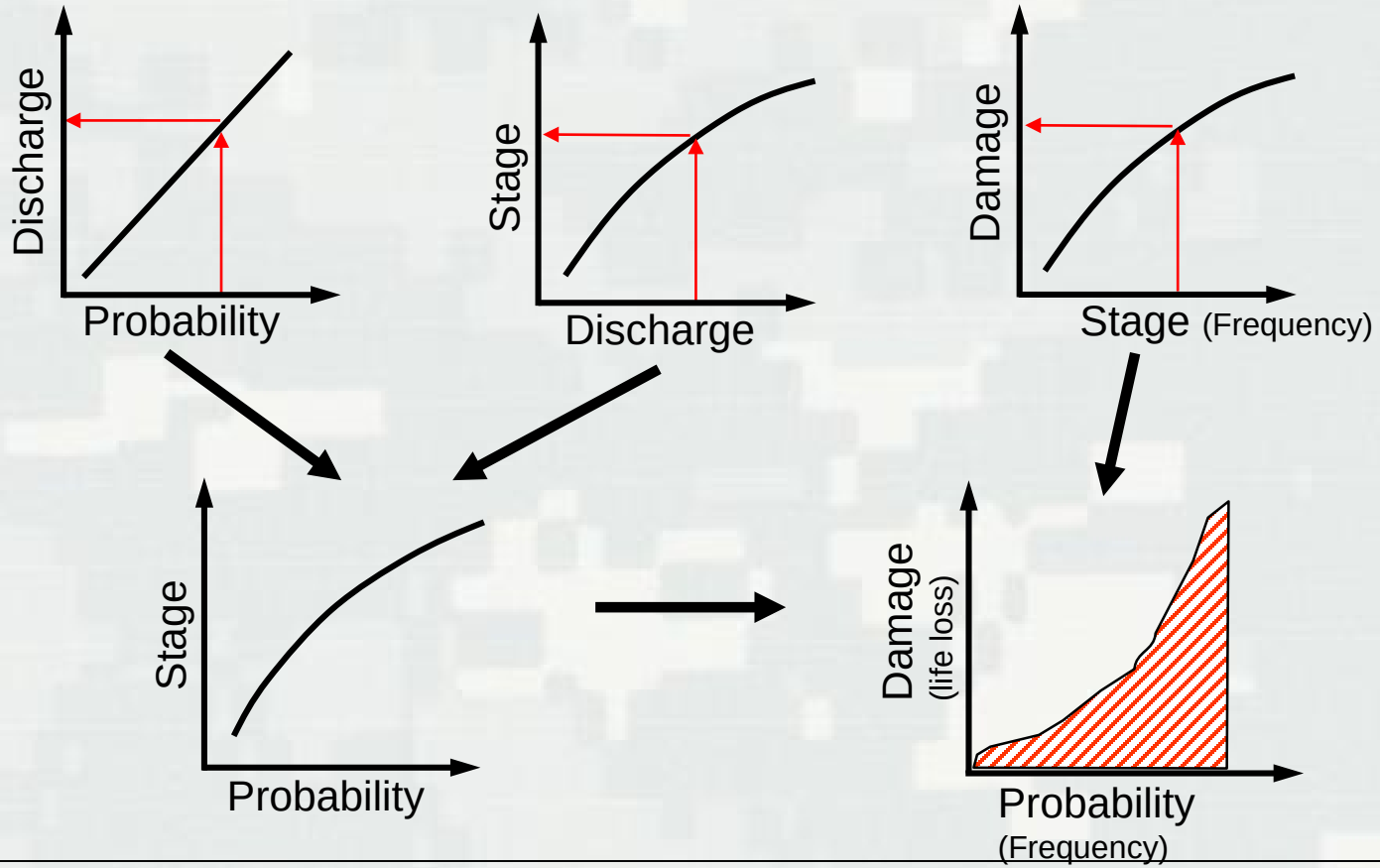
LSHI and Budgeting Process

- FRM Feasibility Studies
  - Study funding recommendations based on greatest NED and/or LRHI (life project)
- FRM Construction
  - Construction funding recommendations based on greatest NED and/or LRHI (life project)
- Implementation
  - Supports National Goals and Objectives for the Nation to realize the benefits (economic & life risk) from flood damage reduction projects

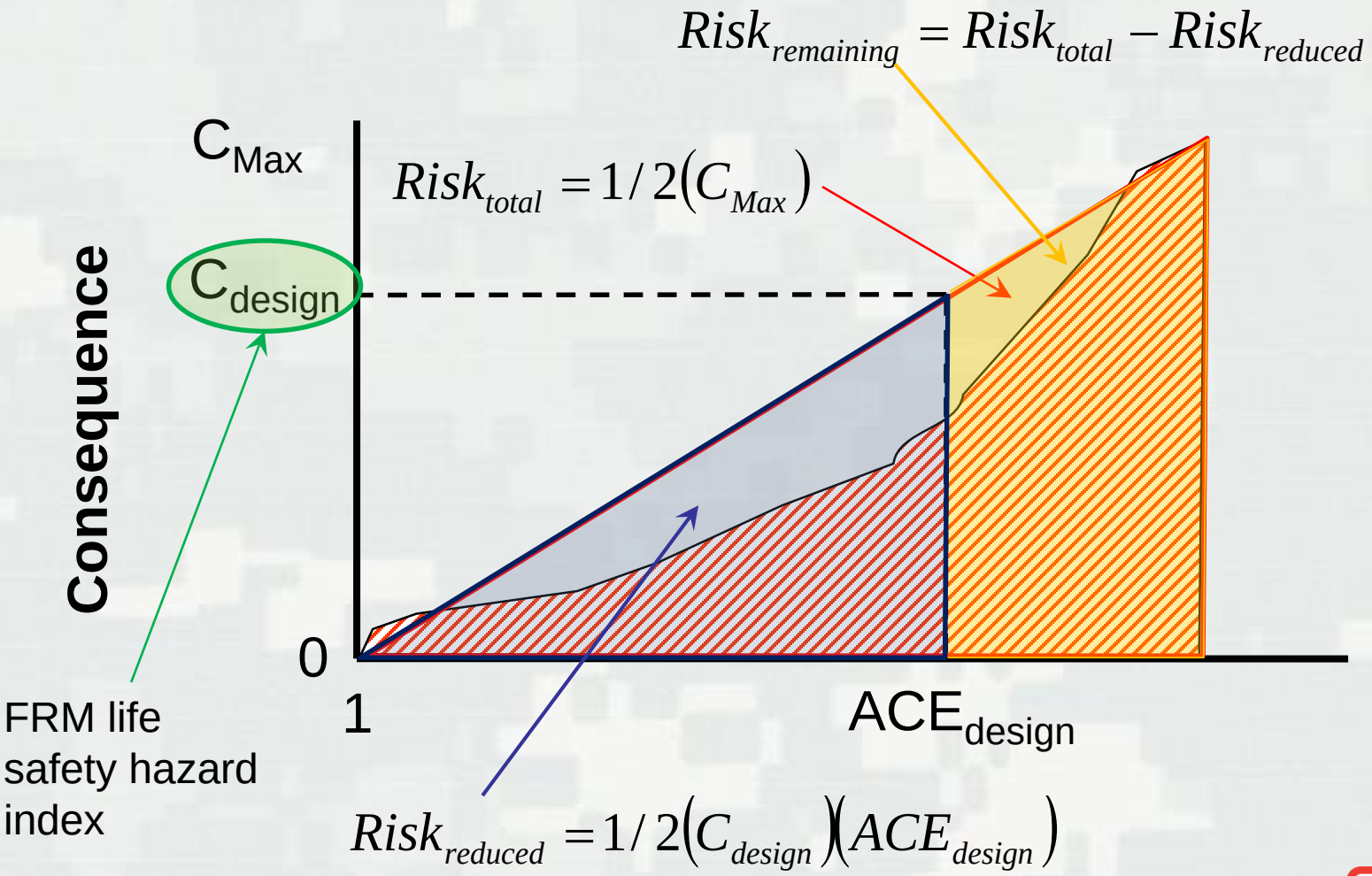
Life Safety Hazard Index as a "Risk Framework"

Risk = (probability of an event) X (consequences associated with the event)

(Frequency) (relative potential life loss)

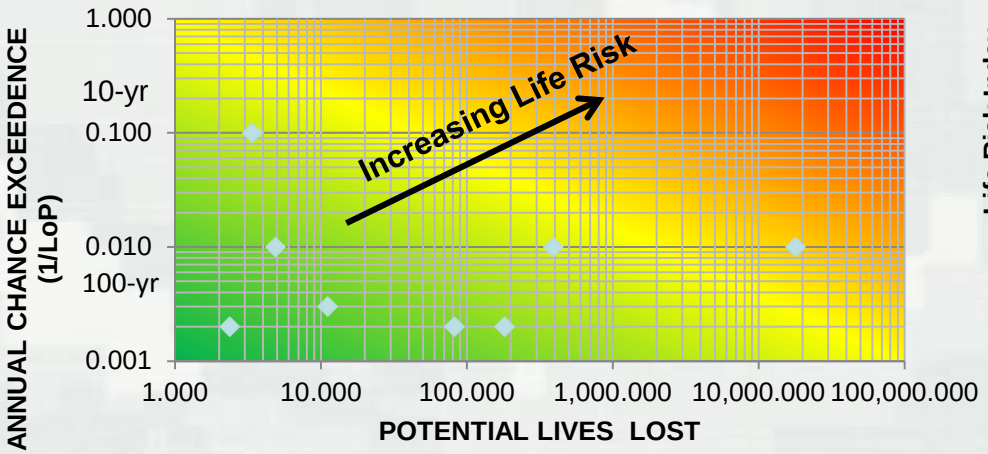


Life Safety Hazard Index as a "Risk Framework"

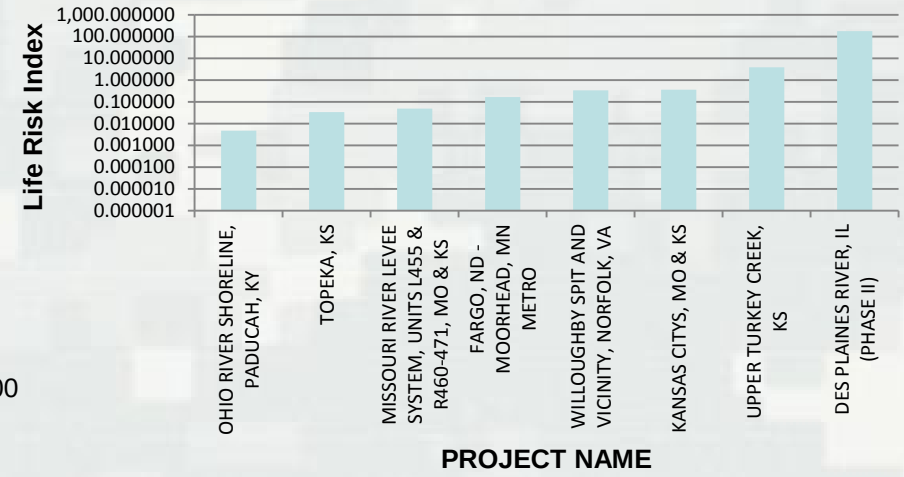


Annual Probability = Annualized Life Loss Estimate

Life Safety Hazard Index
PED



Life Risk Index
PED



PHASE	PROGRAM NAME	LEVEL OF PROTECTION [###]	POPULATION AT RISK [###,###]	RISK-DEPTH [FT]	RISK-WARNING [H]	ANNUAL CHANCE EXCEEDENCE (1/LoP)	PAR EXPOSED [PEOPLE] PAR EXPOSED	LIFE SAFETY HAZARD INDEX (PEOPLE) POTENTIAL LIVES LOST	LIFE RISK INDEX Annualized Life Risk = [(1/LoP) * (LSHI)]
P	OHIO RIVER SHORELINE, PADUCAH, KY	500	14,000	5	120	0.002	280	2	0.0047
P	TOPEKA, KS	333	27,000	10	24	0.003	540	11	0.0333
P	MISSOURI RIVER LEVEE SYSTEM, UNITS L455 & R460-471, MO & KS	100	8,000	14	24	0.010	160	5	0.0487
P	FARGO, ND - MOORHEAD, MN METRO	500	200,000	10	24	0.002	4,000	82	0.1643
P	WILLOUGHBY SPIT AND VICINITY, NORFOLK, VA	10	20,000	5	24	0.100	400	3	0.3376
P	KANSAS CITYS, MO & KS	500	175,000	23	36	0.002	3,500	182	0.3636
P	UPPER TURKEY CREEK, KS	100	10,000	18	0.5	0.010	9,726	391	3.9058
P	DES PLAINES RIVER, IL (PHASE II)	100	4,810,000	3	1	0.010	4,370,604	17,865	179

Questions / Discussion

FRM Risk Index

$$Index = \frac{Velocity * Depth * PAR}{WarningTime}$$

Risk Factors

- Velocity - for the design level and the without condition what is the average velocity (fps) affecting most of benefit area.
- Depth – for the design level and the without condition, what is the average depth (ft) affecting most of the benefit area
- PAR – the number of people (1000s) living, working, and transient in the floodplain without the project in place.
- Warning Time - for the design level and the without condition, what is the average warning time (hrs) affecting the most of benefit area.

Limitations

- Index is not intuitive (units are meaningless)
- Relative weight of each parameter (velocity, depth, PAR, and warning time) not supported by research or physics