Best Practices in Dam and Levee Safety Risk Analysis

III-1. Consequences - USACE

23 June 2015

RECLAMATION
Managing Water in the West

US Army Corps of Engineers
BUILDING STRONG®

Objectives

- Participants will become familiar with USACE approach for estimating loss of life

Why the Different Approaches?

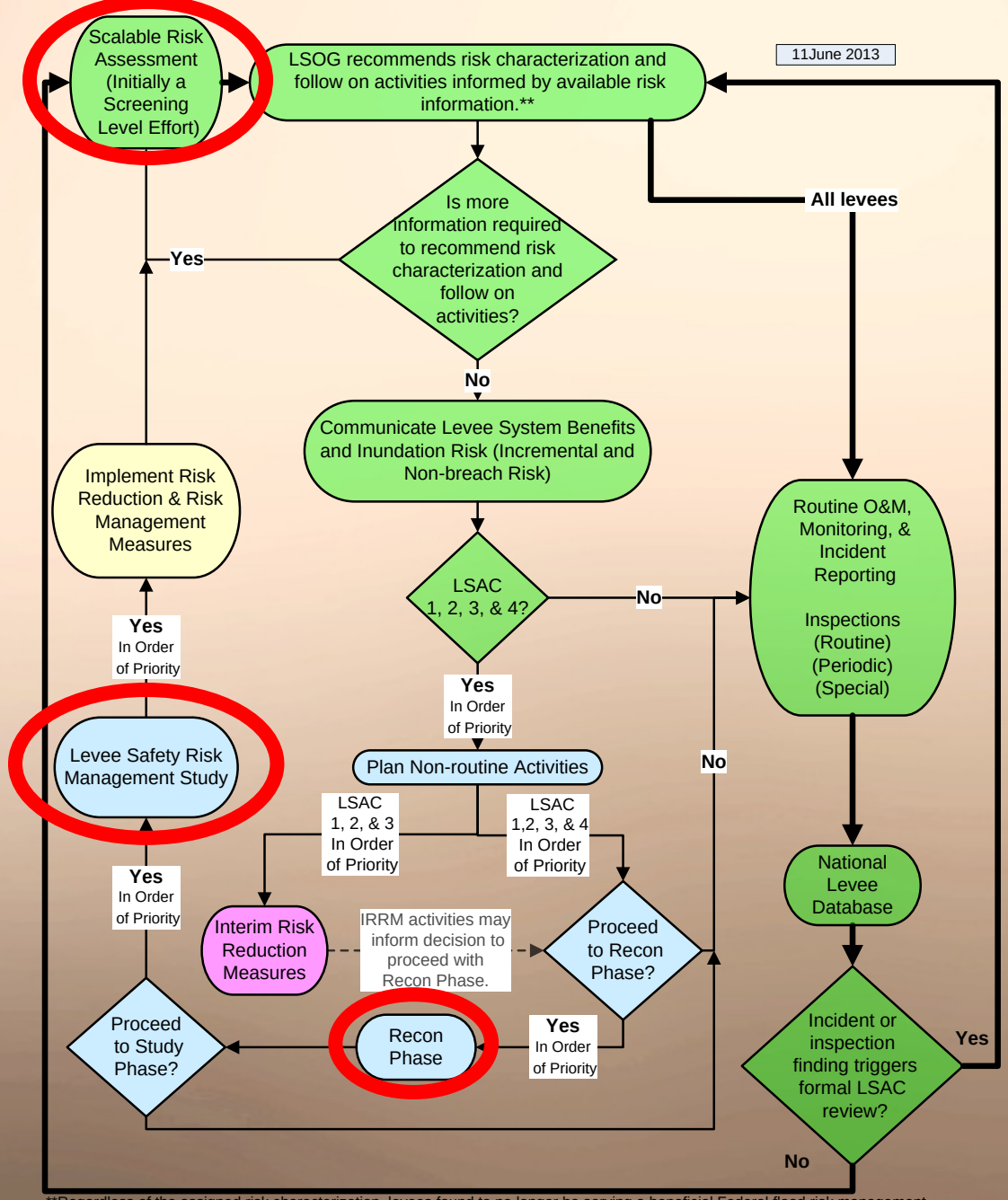
- Empirical approaches tie important parameters to historic events
  - Characteristics of built infrastructure, population, etc
  - Historic record doesn't include scenario for typical USACE flood control dam (large dam above major population center)
  - Limited number of parameters make it harder to understand risk drivers and recommend appropriate risk reduction measures
- Simulation approaches (LifeSim/FIA) consider interaction of people with water throughout event
  - Provide higher resolution for risk reduction associated with "non-structural" measures

Life Loss Estimation – Essential Elements

- Initial distribution of people
- Redistribution of people
  - Warning
  - Response
  - Evacuation potential
- Flood characteristics
  - Arrival time, depth, velocity
- Shelter provided by final location
- Fatality rates

Evacuation Effectiveness

Levee Safety Portfolio Risk Management Process



**Regardless of the assigned risk characterization, levees found to no longer be serving a beneficial Federal flood risk management purpose will be so flagged, considered to be in 'inactive status', and are exempt from the Levee Safety Portfolio Management Process.

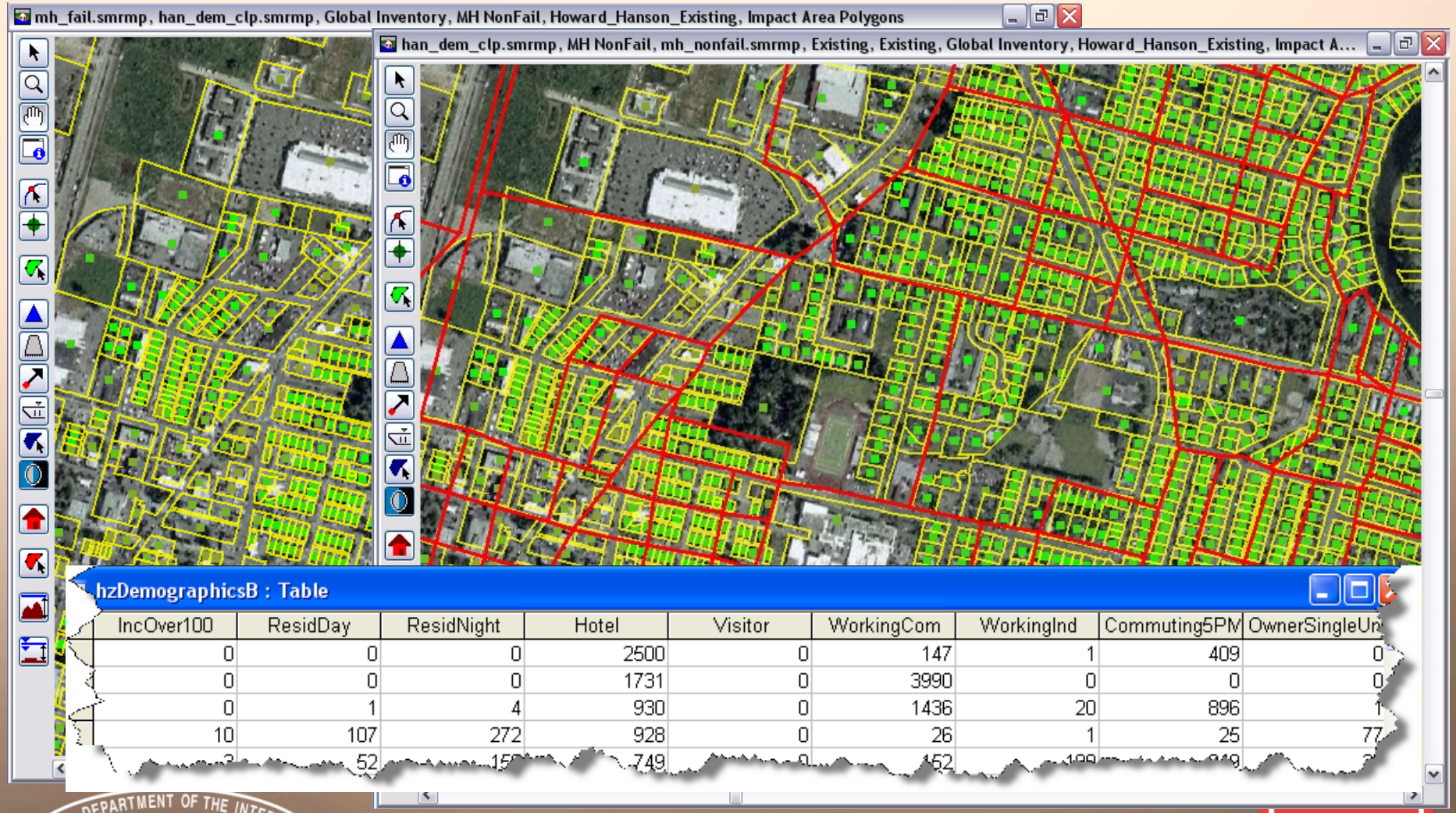
- "One size fits all approach" no good
- Decision Driven
  - Methods used dictated by available resources and potential investment

USACE Life Loss Estimation Methods – Decision Driven

- Screening - Minimal resource requirement
  - Dams - Modified DSO-99-06 Method
  - Levees - Jonkman's Method
- Higher-level Risk Assessments
  - HEC-FIA
    - Screening validation, issue evaluation and periodic assessments
    - Moderate resource requirement
  - LifeSim
    - Support studies when HEC-FIA simplifications lead to too much uncertainty
    - Larger resource requirement

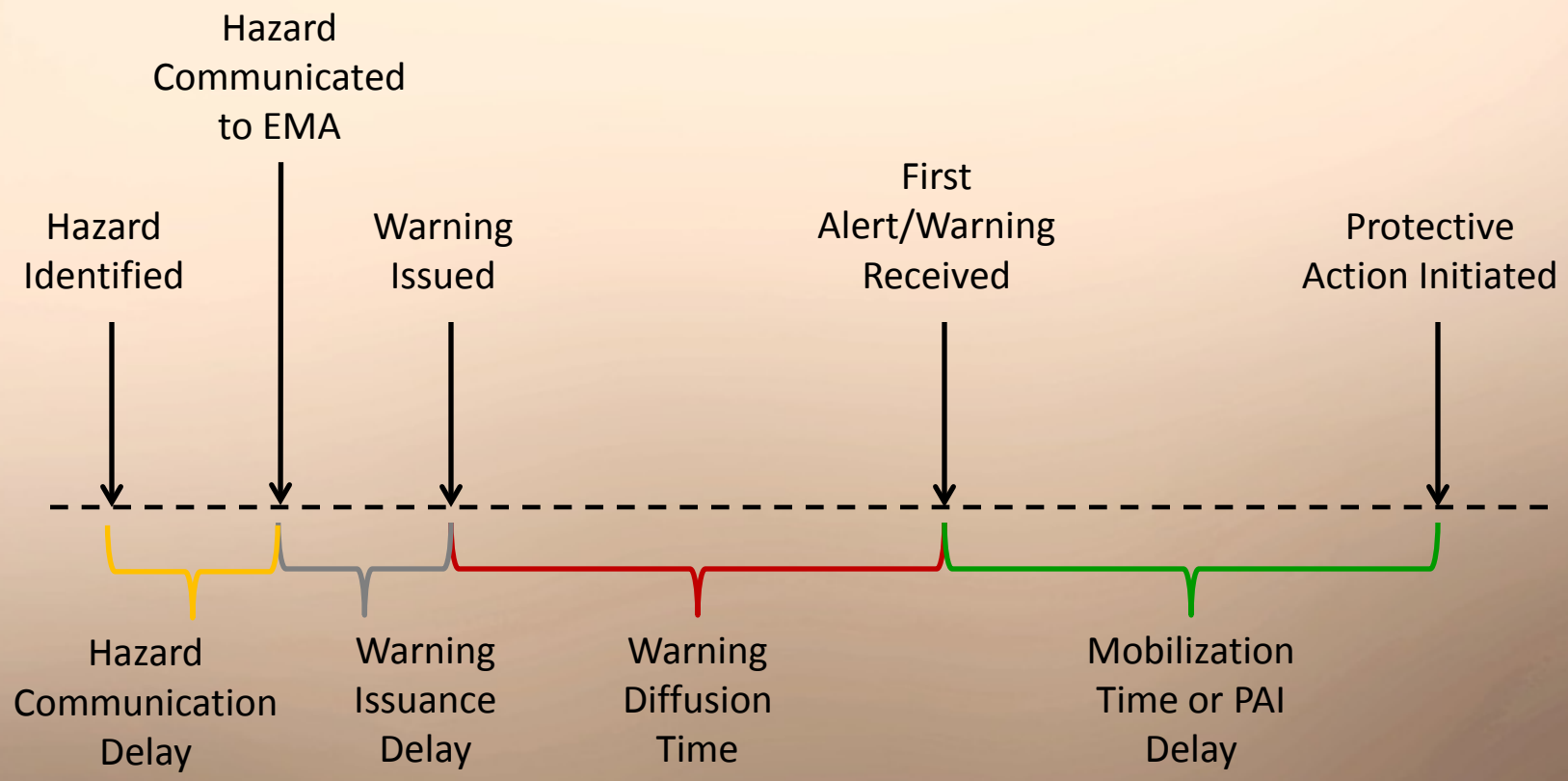
Scalable methods – effort from one applicable to more rigorous method

Initial Distribution of People



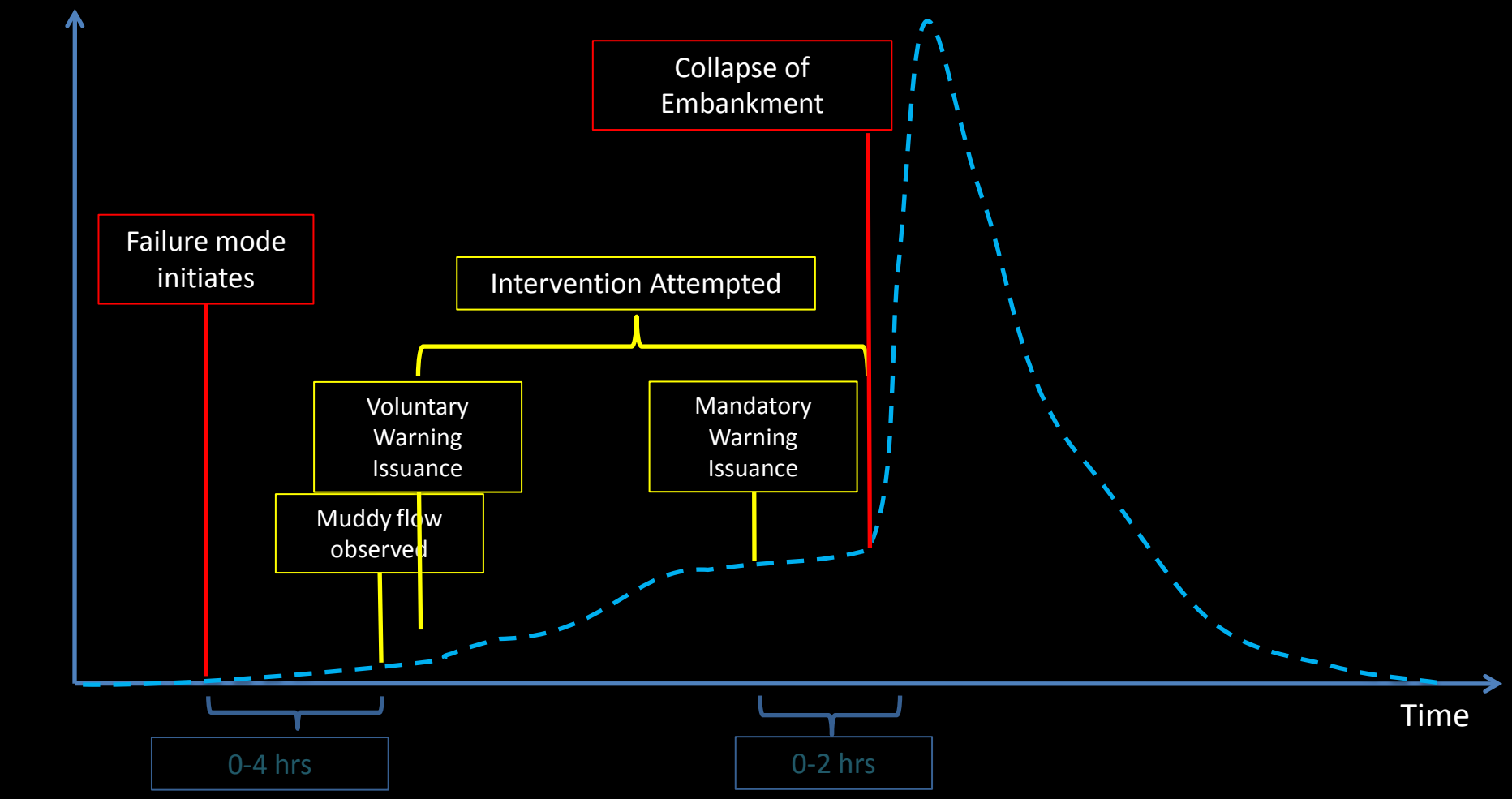
IncOver100	ResidDay	ResidNight	Hotel	Visitor	WorkingCom	WorkingInd	Commuting5PM	OwnerSingleUn
0	0	0	2500	0	147	1	409	0
0	0	0	1731	0	3990	0	0	0
0	1	4	930	0	1436	20	896	1
10	107	272	928	0	26	1	25	77
[illegible]	52	[illegible]	749	[illegible]	152	[illegible]	[illegible]	[illegible]

Redistribution of People



Redistribution of People

Step 1: Threat Recognition and Warning Issuance



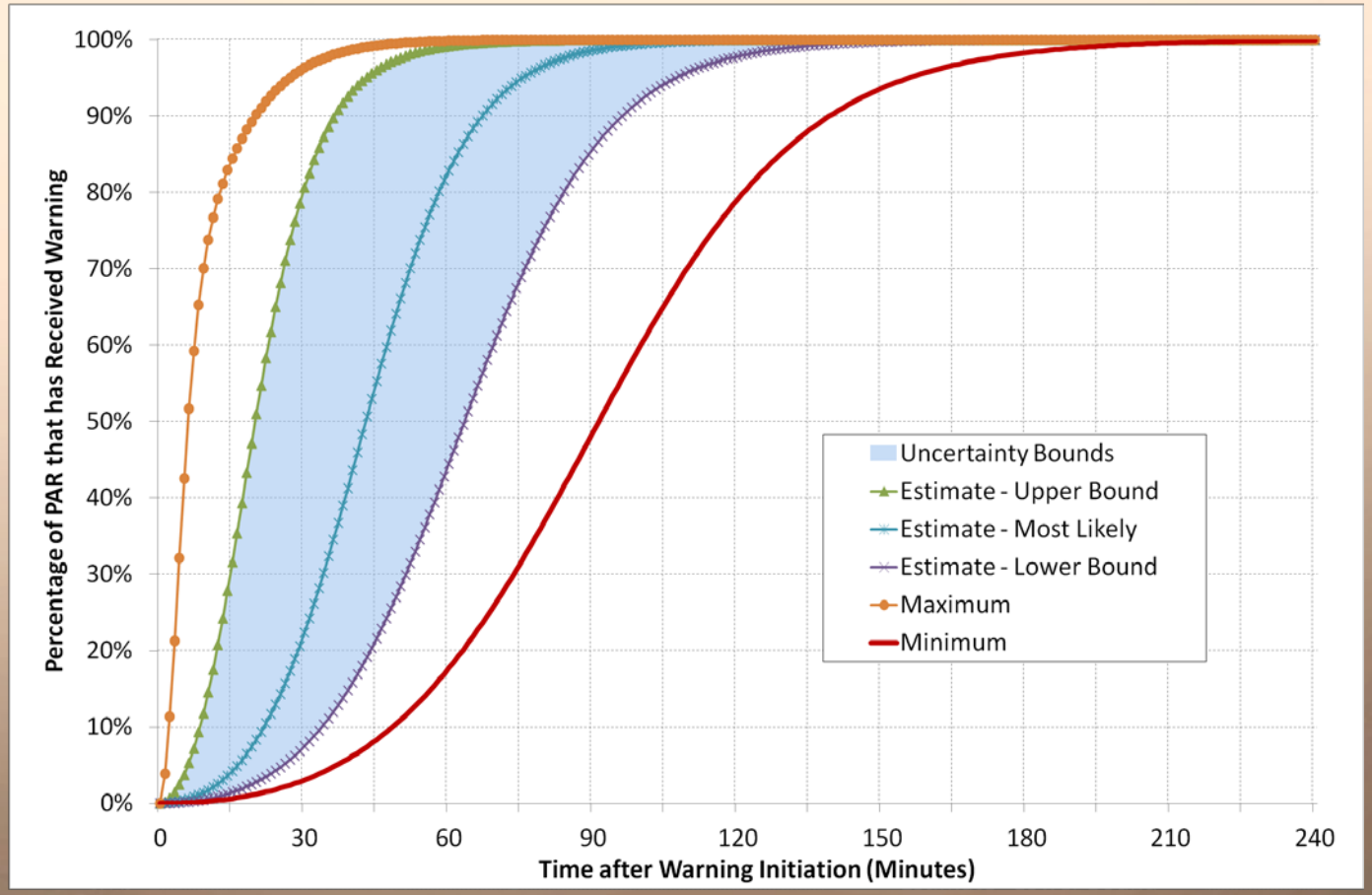
Redistribution of People

Step 2: Warning Diffusion

- What factors most influences how quickly an alert or warning spreads through a community?
  - Number and mix of warning channels
  - Frequency of distribution
  - Ability to wake people up
  - Modern technologies

Redistribution of People

Step 2: Warning Diffusion



Warning System Type (Rogers et al 1988)

Redistribution of People

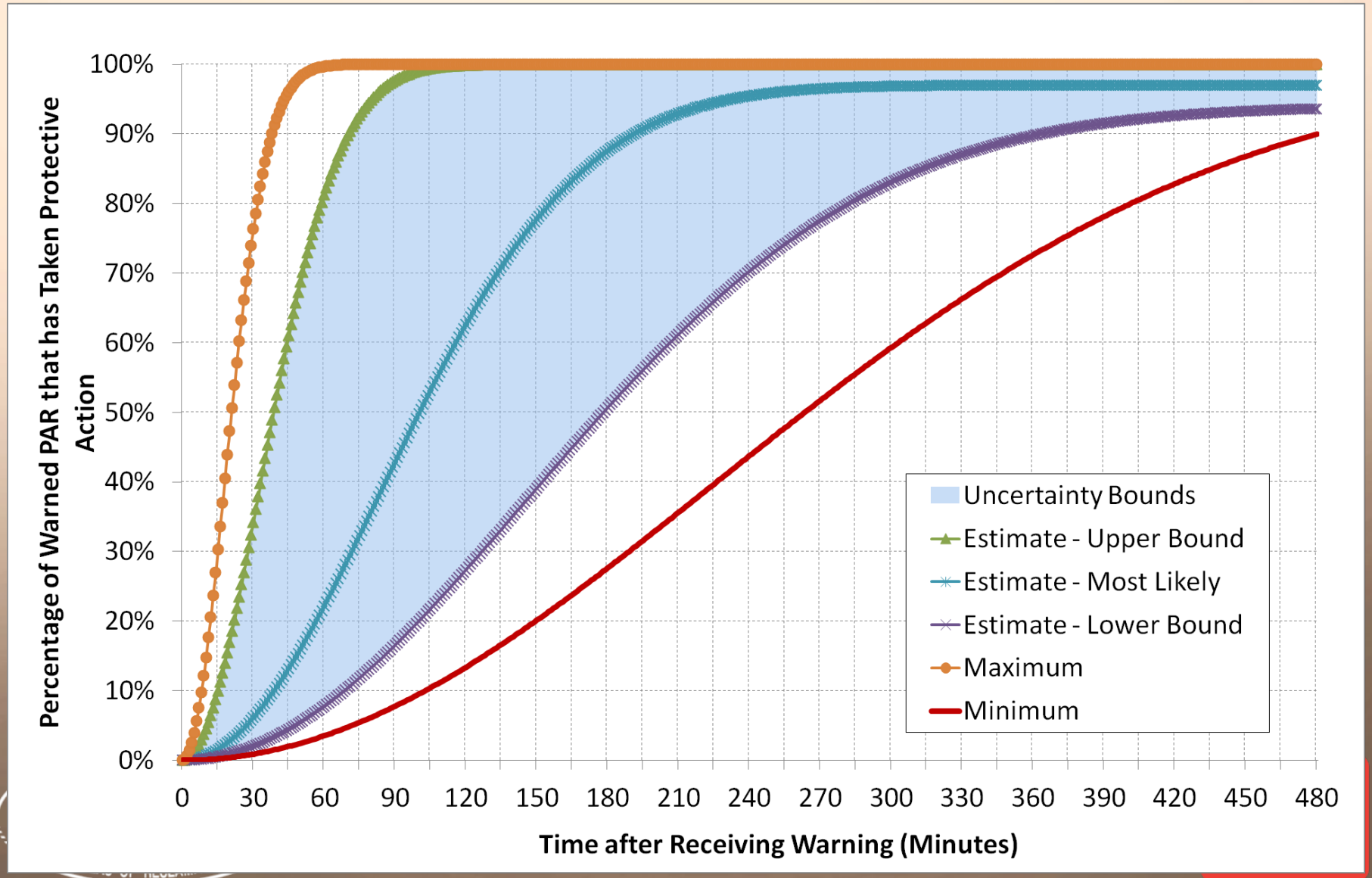
Step 3: Protective Action Initiation

- What factors most influence how quickly someone takes the recommended protective action after receiving a warning?
  - Message content and style
  - Message spoken by person
  - Messages are frequently repeated

Message Content

- Who? – Source
- What? – Threat and consequence
- Where? – Locations at risk
- How? – Action to take
- When? – Timing of when to start and finish action
- Why? – How taking action will reduce consequence

Protective Action Initiation - Uncertainty



Max Mobilization (PAI)

Initial Perception	Maximum Mobilization % (Compliance)								
	Short Warning Time (< 8 hrs)			Med Warning Time (8-24 hrs)			Long Warning Time (24-72 hrs)		
	Message Effectiveness			Message Effectiveness			Message Effectiveness		
	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Likely to impact me	51-59	81-89	94-100	81-89	81-89	94-100	94-100	94-100	94-100
Unlikely to impact me	28-34	70-76	83-89	70-76	81-89	94-100	81-89	94-100	94-100

- Message effectiveness based on results of interview with EMAs, using same scale as Protective Action Initiation

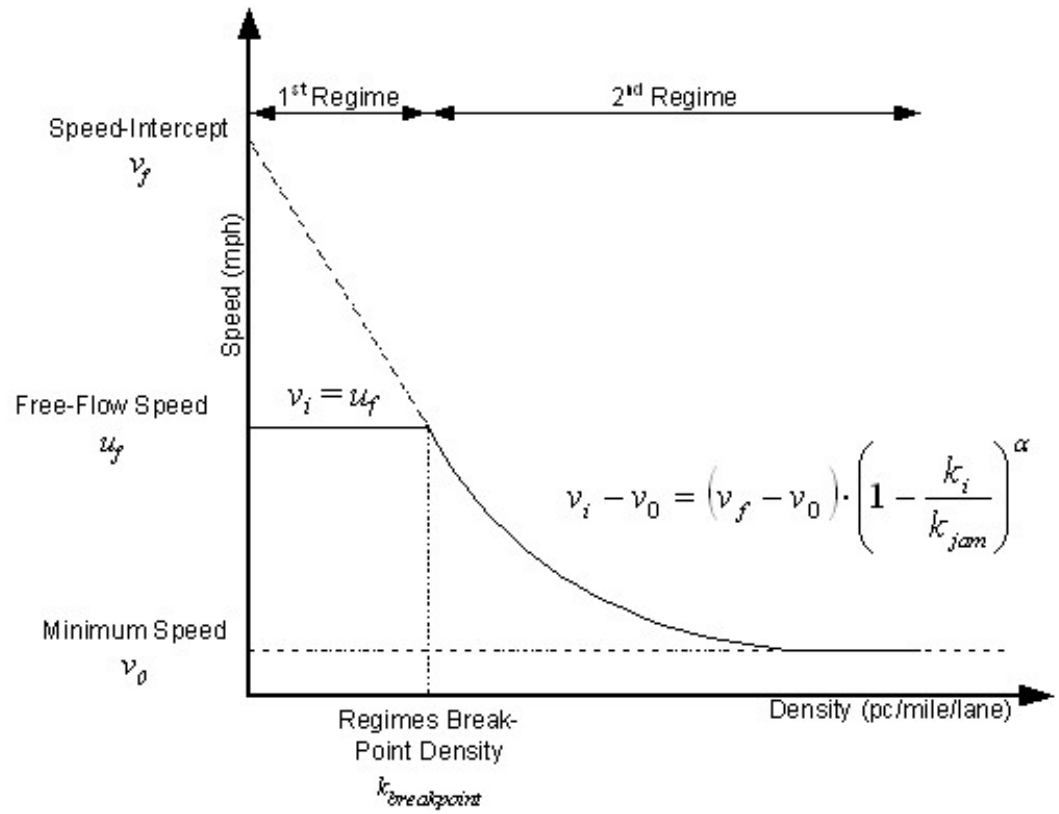
Redistribution of People

Step 4: Evacuation Potential

- Can people get to safety before water arrives?

LifeSim Methodology – Evacuation

- Dual regime modified Greenshields traffic simulation model (US-DOT).



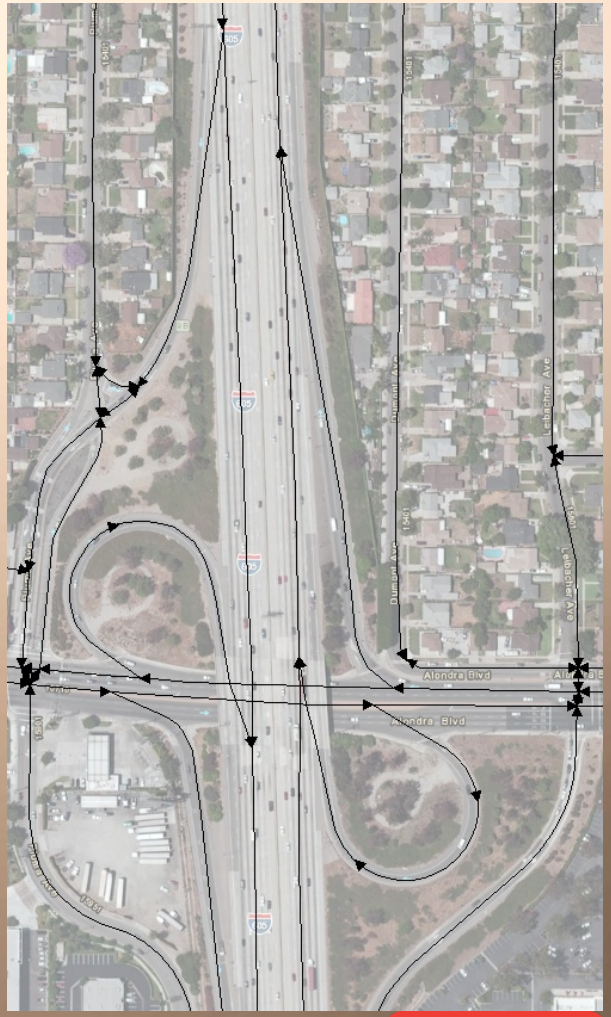
In mathematical terms, the dual-regime modified Greenshields is expressed as follows:

$$v_i = u_f, \qquad 0 \le k_i \le k_{bp}$$

$$v_i - v_0 = (v_f - v_0) \cdot \left(1 - \frac{k_i}{k_{jam}}\right)^{\alpha}, \qquad k_{bp} \le k_i \le k_{jam}$$

LifeSim Evacuation

- Destination is chosen by shortest travel time
- Allows for One-Way roads
- Allows vehicles to turn around if road is flooded
- Allows a user defined percentage of vehicles to contain system information (smarter) and re-route if traffic jam is reached.
- Traffic density based on look-ahead distance not just current segment (which could be very short or long)


Alondra Blvd
Alondra Blvd
Lakewood Blvd
Lakewood Blvd
Lakewood

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  Evacuation Effectiveness
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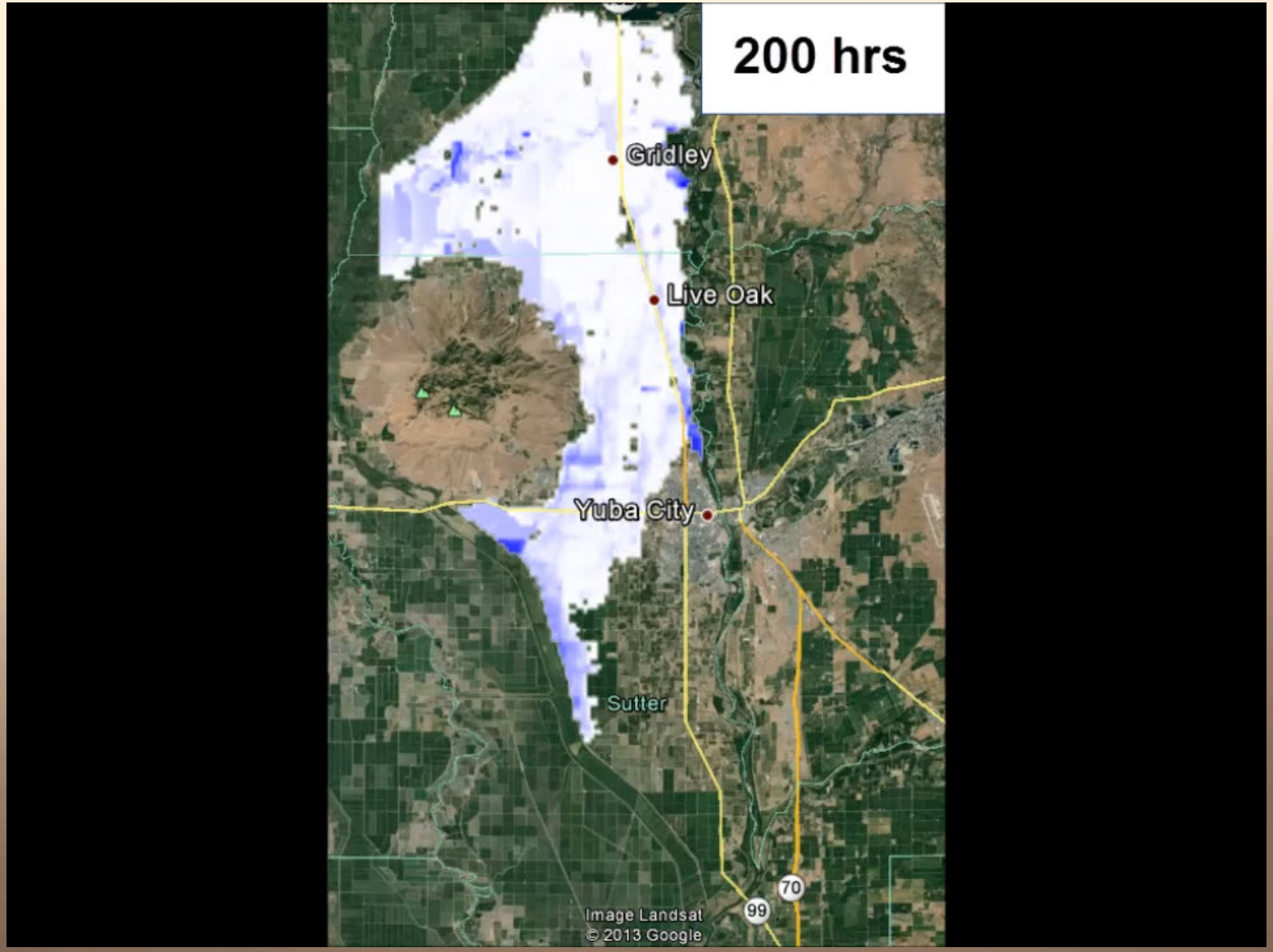
- Shelter provided by final location
- Fatality rates

Detailed Flood Characteristics



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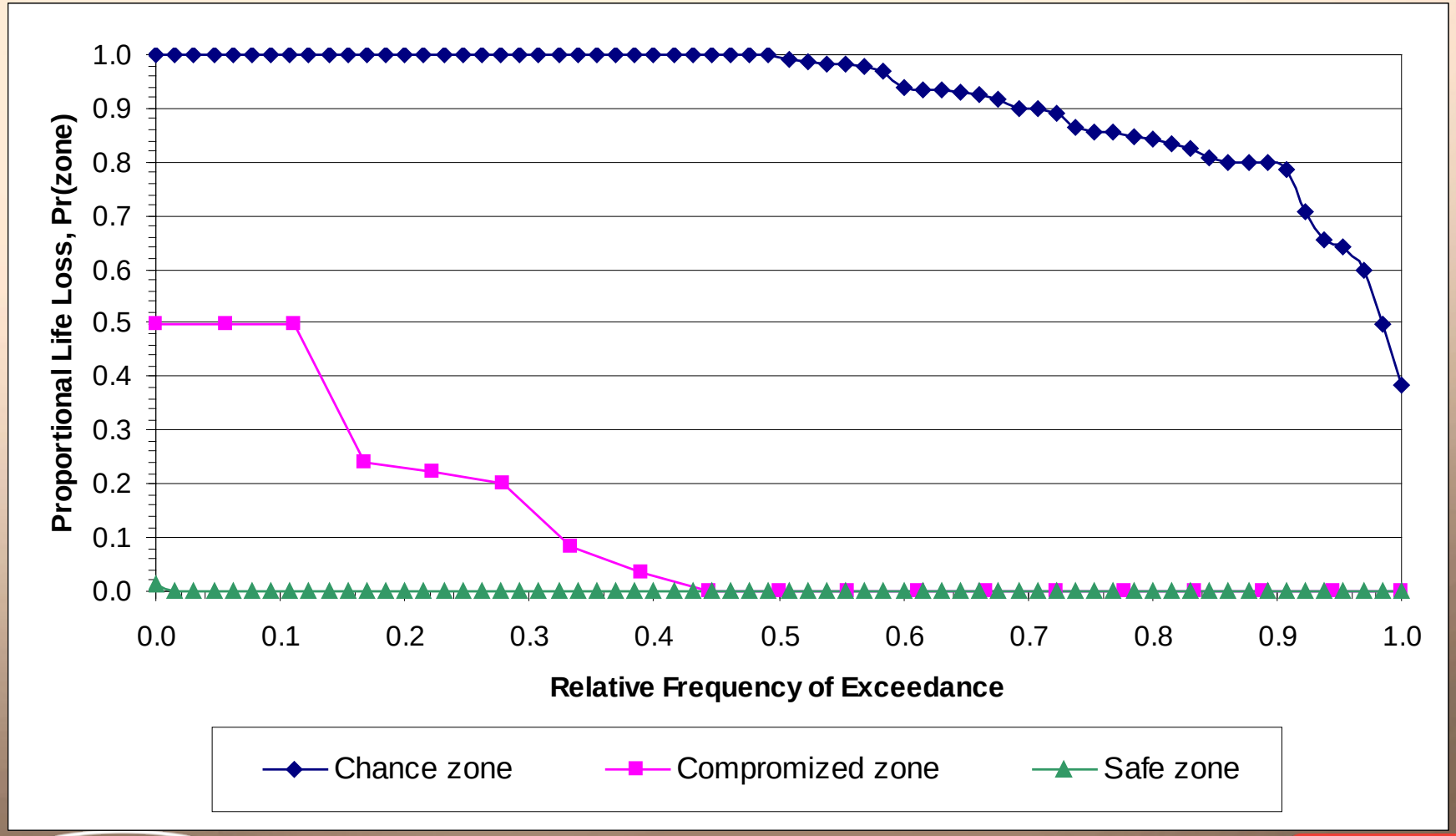
Shelter provided by final location

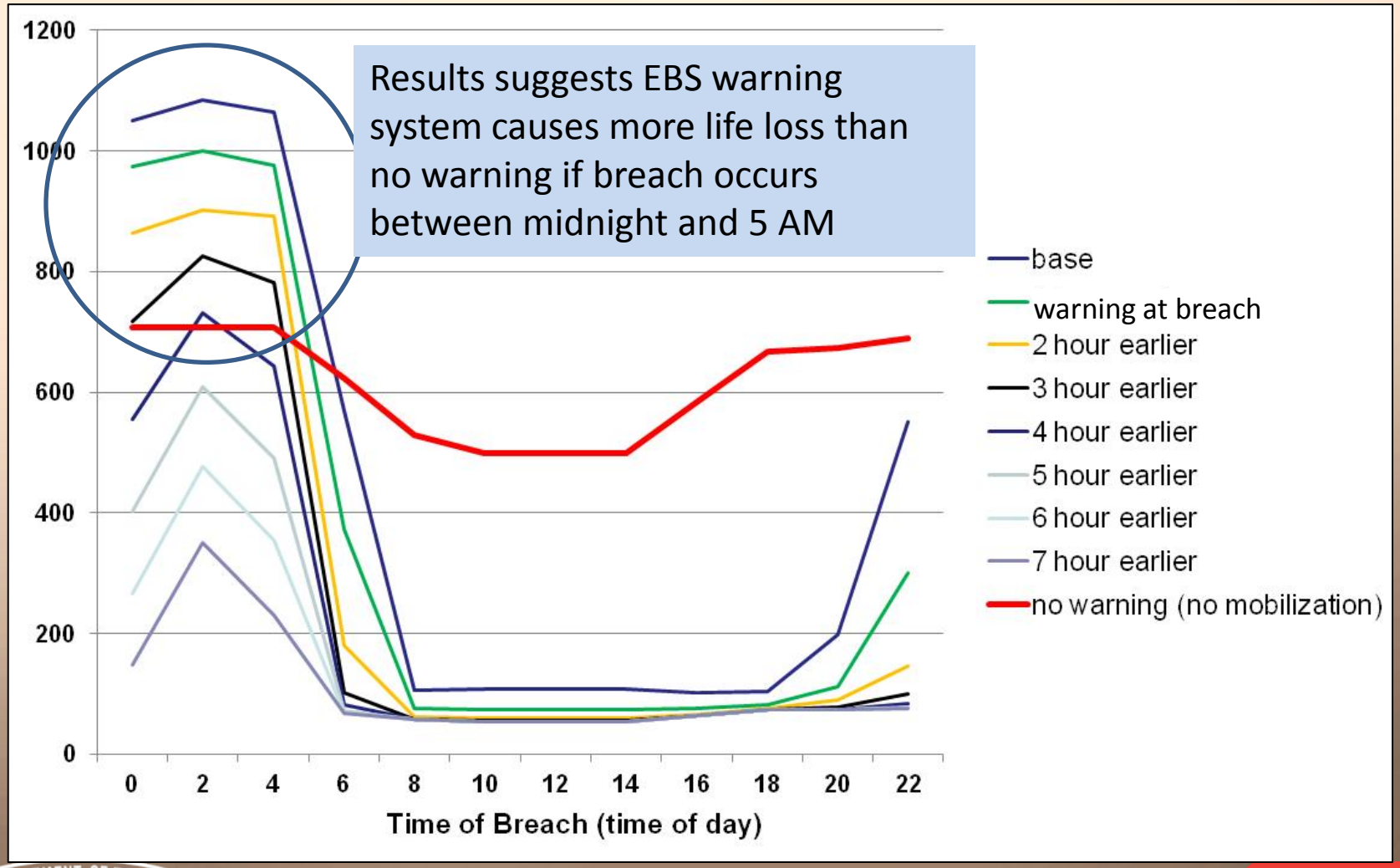
- Screening – not explicitly considered (built into fatality rates)
- Detailed – human, vehicle, structure stability criteria

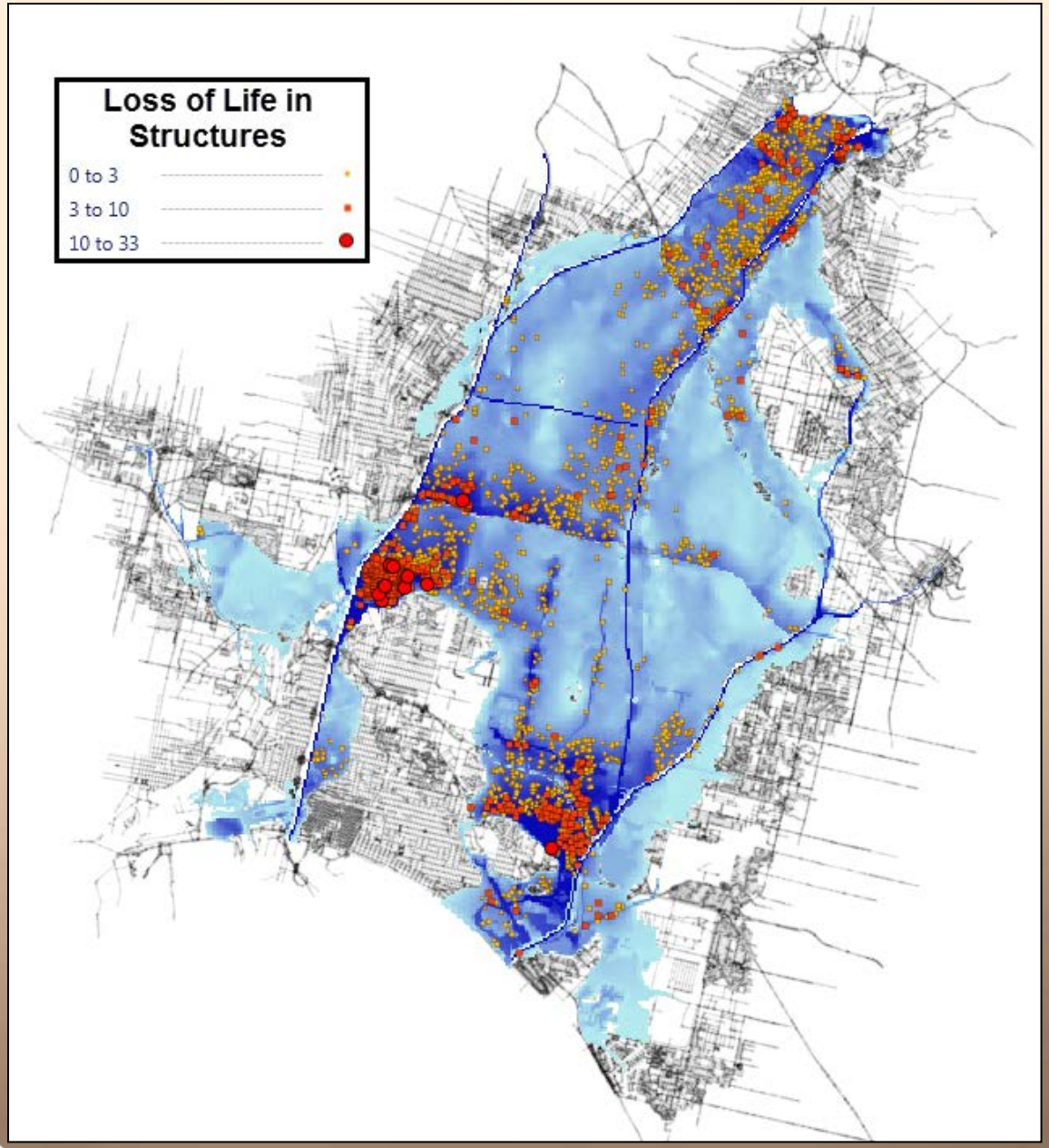
Building type	Partial damage	Total damage
Wood-framed		
unanchored	$v*d \geq 2\ m^2/s$	$v*d \geq 3\ m^2/s$
anchored	$v*d \geq 3\ m^2/s$	$v*d \geq 7\ m^2/s$
Masonry, concrete & brick	$v \geq 2\ m/s$ & $v*d \geq 3\ m^2/s$	$v \geq 2\ m/s$ & $v*d \geq 7\ m^2/s$

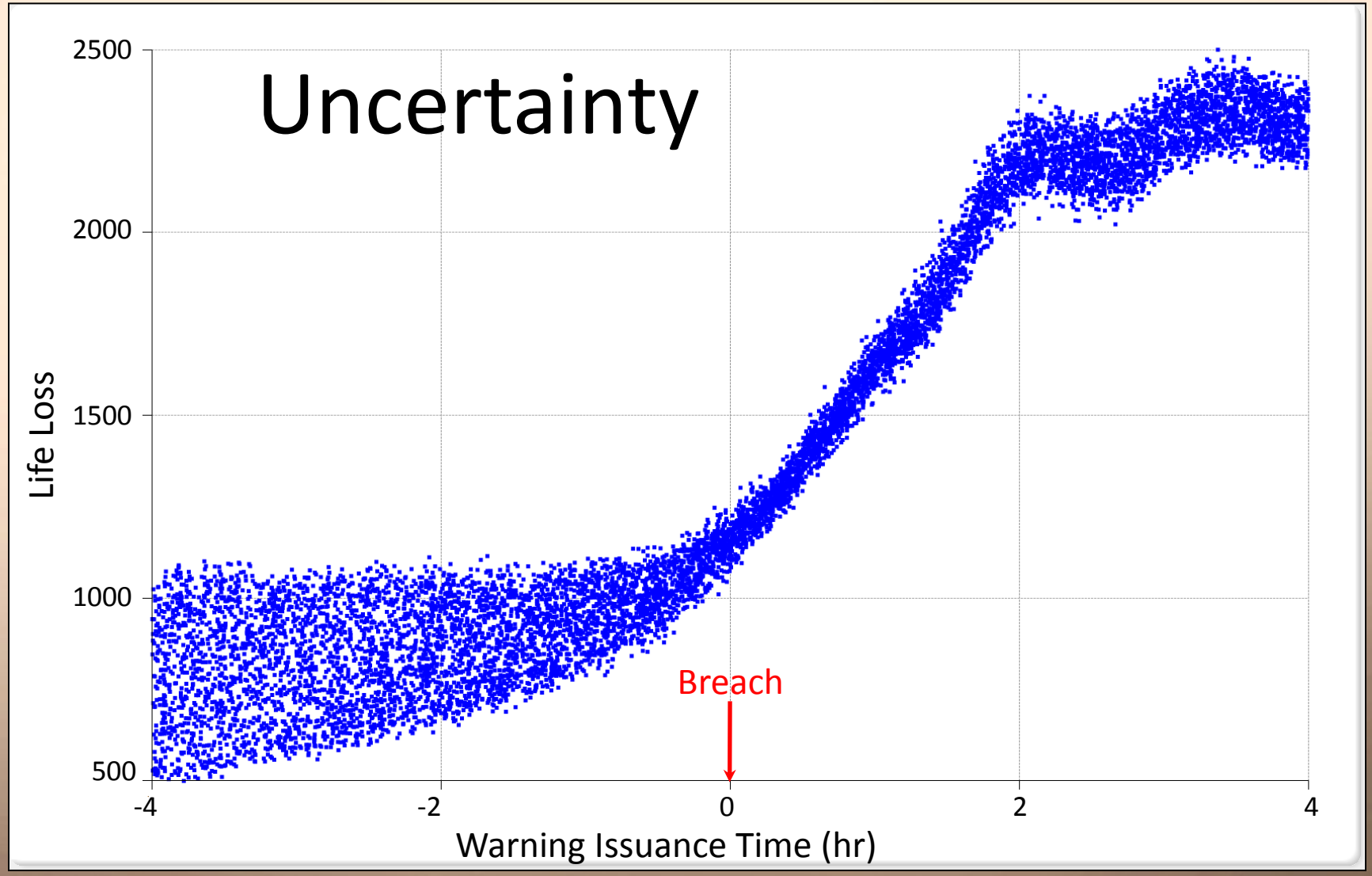
Fatality Rates - Detailed



Understanding Results




Loss of Life in Structures
0 to 3
3 to 10
10 to 33


Uncertainty
2500
2000
1500
1000
500
Life Loss
Breach
-4
-2
0
2
4
Warning Issuance Time (hr)

MYTHBUSTERS

Cry Wolf Syndrome

- Asking the public to evacuate for a flood emer[illegible] ulti[illegible] red[illegible] time[illegible]

Traffic Accidents

- Traffic accidents increase during mass evacuati

BUSTED

Traffic a de ed au
traffic is
generally single direction, and people are more cautious and more considerate.