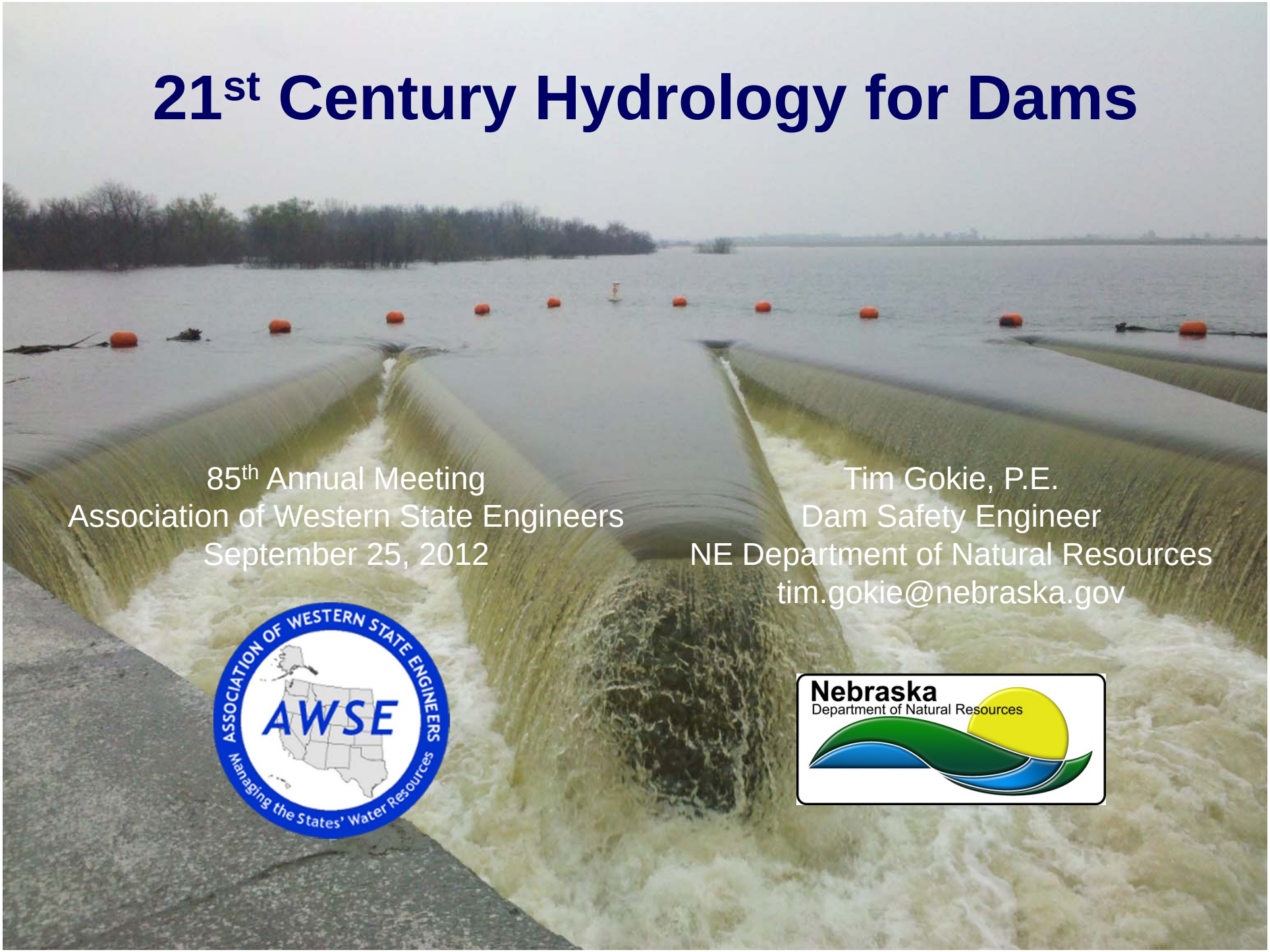
21st Century Hydrology for Dams



85th Annual Meeting
Association of Western State Engineers
September 25, 2012

Tim Gokie, P.E.
Dam Safety Engineer
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Emerging Methodologies

- Incremental Design Analysis

Emerging Methodologies

- Incremental Design Analysis
- Risk Analysis

Emerging Methodologies

- Incremental Design Analysis
- Risk Analysis
- Physical Based Model for Embankment Overtopping and Erosion

Emerging Methodologies

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21st Century Technology

- Geographic Information Systems (GIS)

21st Century Technology

- Geographic Information Systems (GIS)
- LiDAR

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21st Century Technology

- Geographic Information Systems (GIS)
- LiDAR
- 2D Hydrology

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21st Century Technology

- Geographic Information Systems (GIS)
- LiDAR
- 2D Hydrology
- 2D Hydrualics

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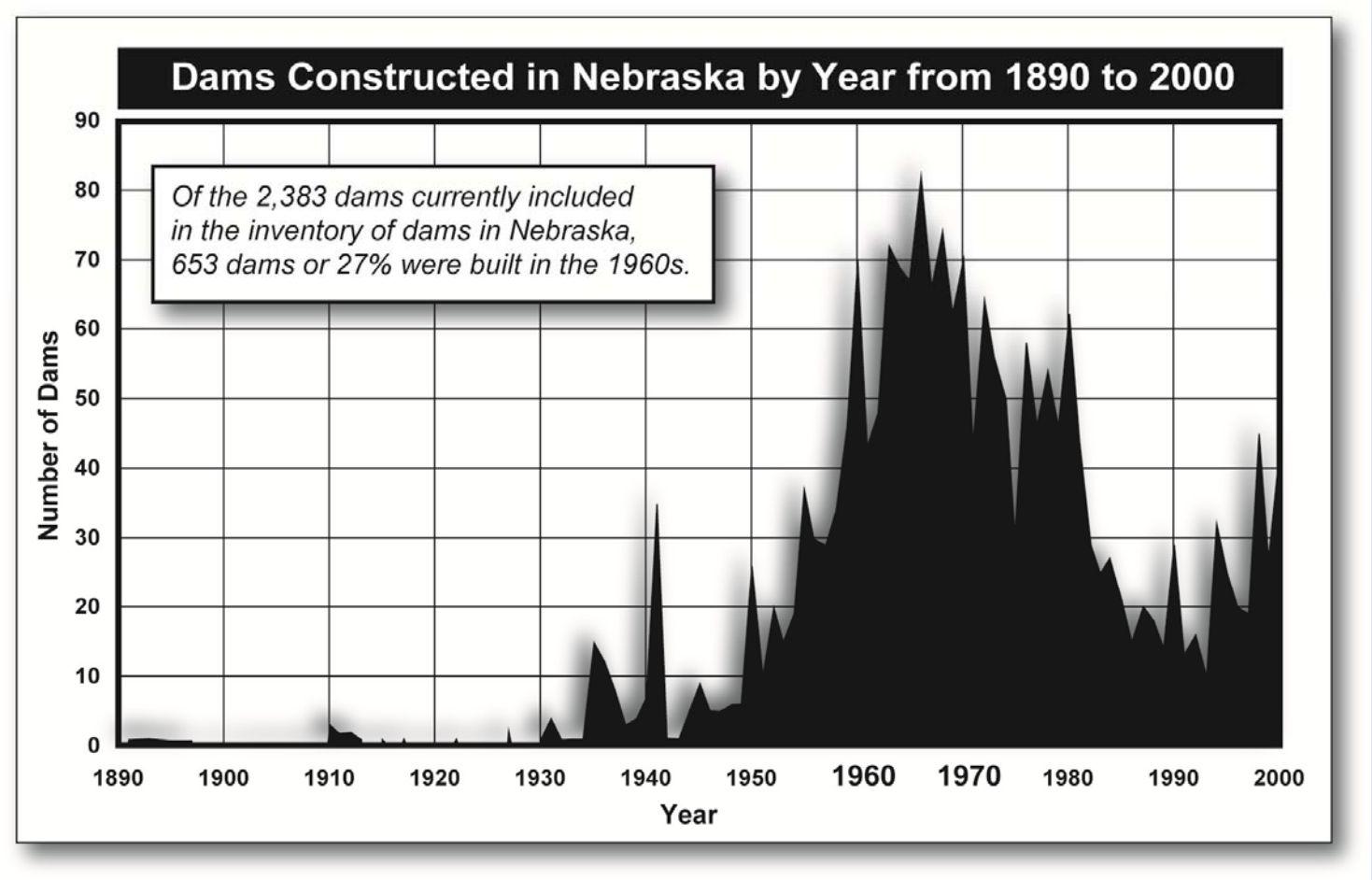
Current Issues



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Current Issues

WATER AND ENVIRONMENT

DAMS 2009 GRADE D

RAISING THE GRADES

SOLUTIONS

THAT WILL WORK **NOW**

- ★ **ENCOURAGE** or require effective state dam safety programs that provide adequate funding, staff, and statutory authorities;
- ★ **DEVELOP** emergency action plans for every high hazard dam by 2011;
- ★ **ESTABLISH** a national funding program and parallel state programs to repair nonfederally owned dams;
- ★ **INCLUDE** dam failure inundation mapping as part of the National Flood Insurance Program;
- ★ **EDUCATE** the public about dam safety risks;
- ★ **ENCOURAGE** individuals to educate themselves on the location and condition of dams in their area.

A = Exceptional
B = Good
C = Mediocre
D = Poor
F = Failing

AMERICA'S INFRASTRUCTURE G.P.A. **D**

ESTIMATED 5-YEAR FUNDING REQUIREMENTS FOR **DAMS**

Total investment needs **$12.3 BILLION**

Estimated spending **$5.05 BILLION**

Projected shortfall **$7.45 BILLION**

Facts About **DAMS** www.asce.org/reportcard 15

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Current Issues

"Over the past six years, for every deficient, high hazard potential dam repaired, nearly two more were declared deficient."

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Current Issues

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Current Issues

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Current Issues

21st Century Technology

- Geographic Information Systems (GIS)
- LiDAR
- 2D Hydrology
- 2D Hydrualics

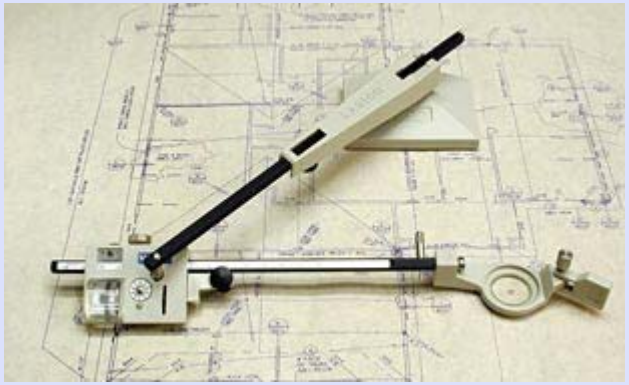
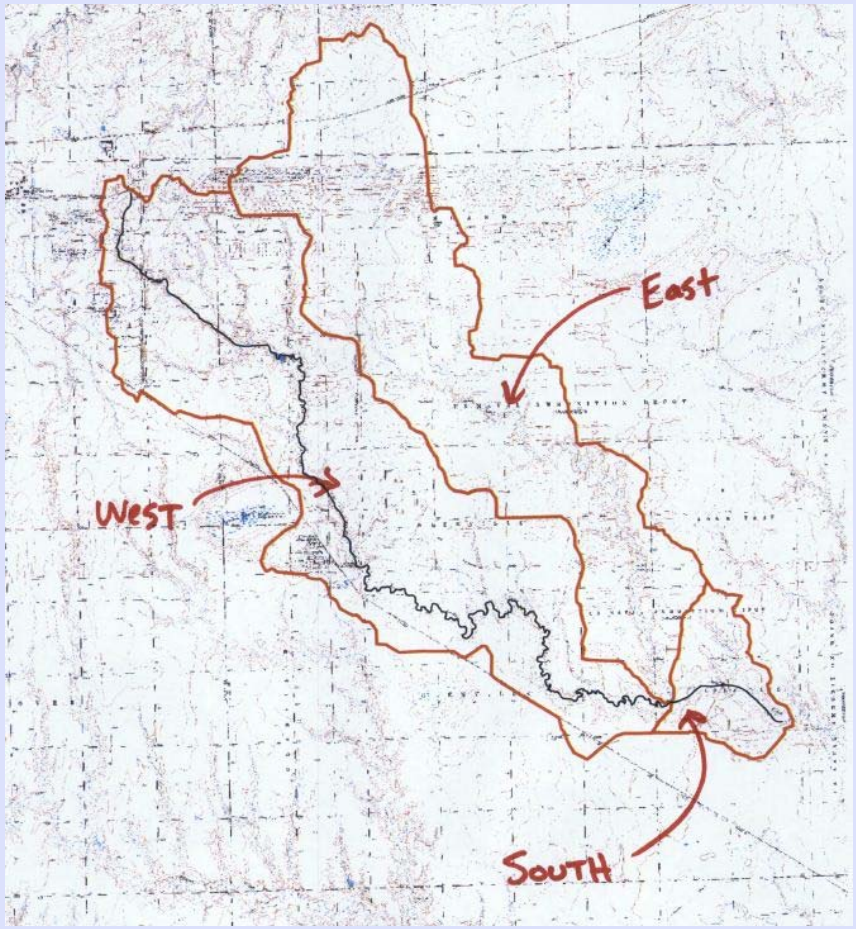
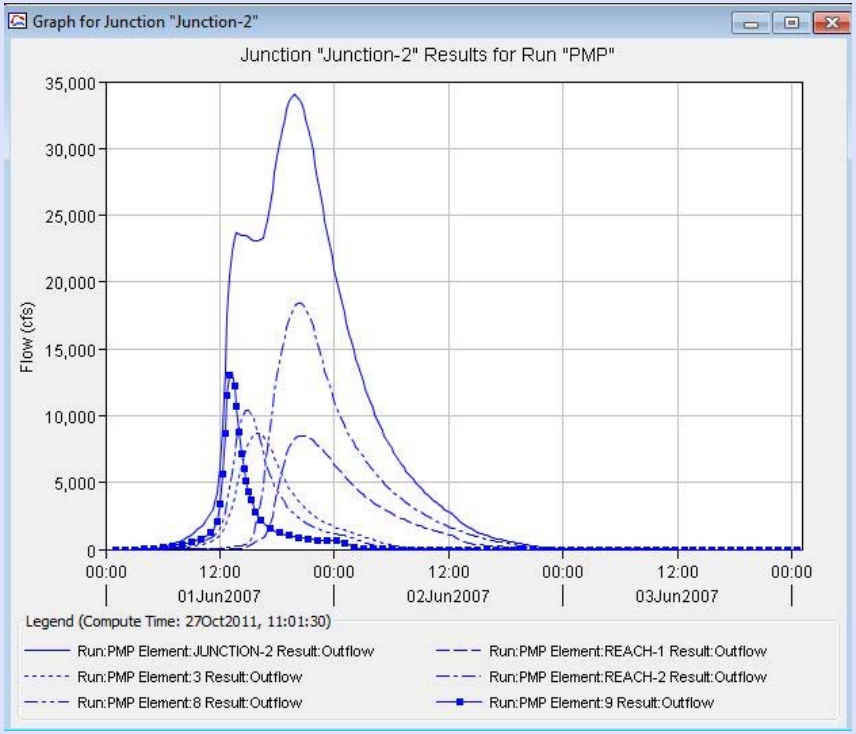


Photo courtesy Lasico

Photo courtesy Geoslopes

20th Century Hydrology





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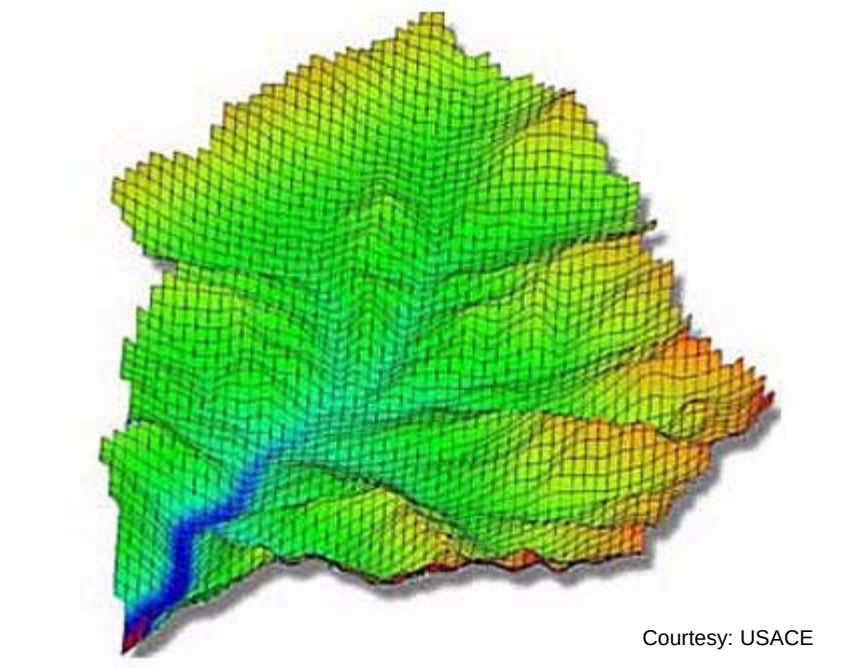
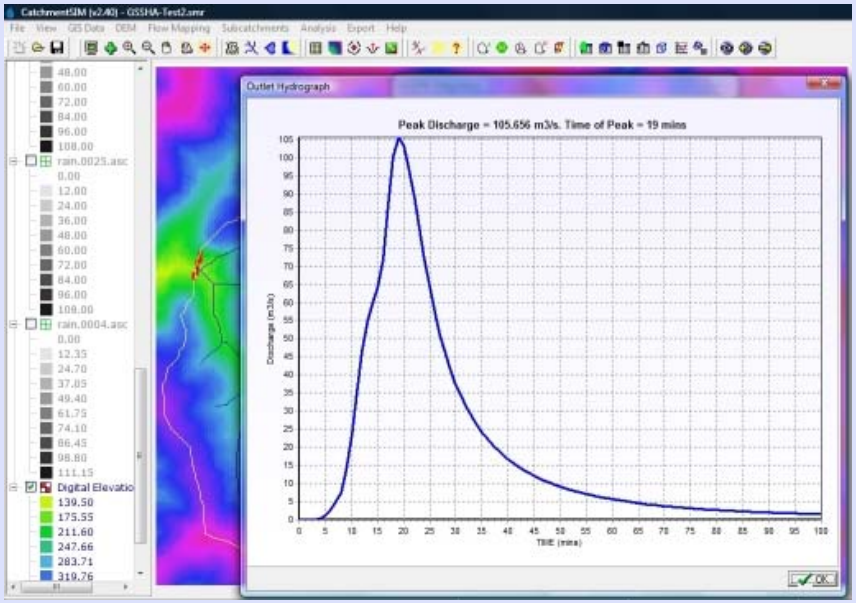
21st Century Hydrology



Courtesy: USACE



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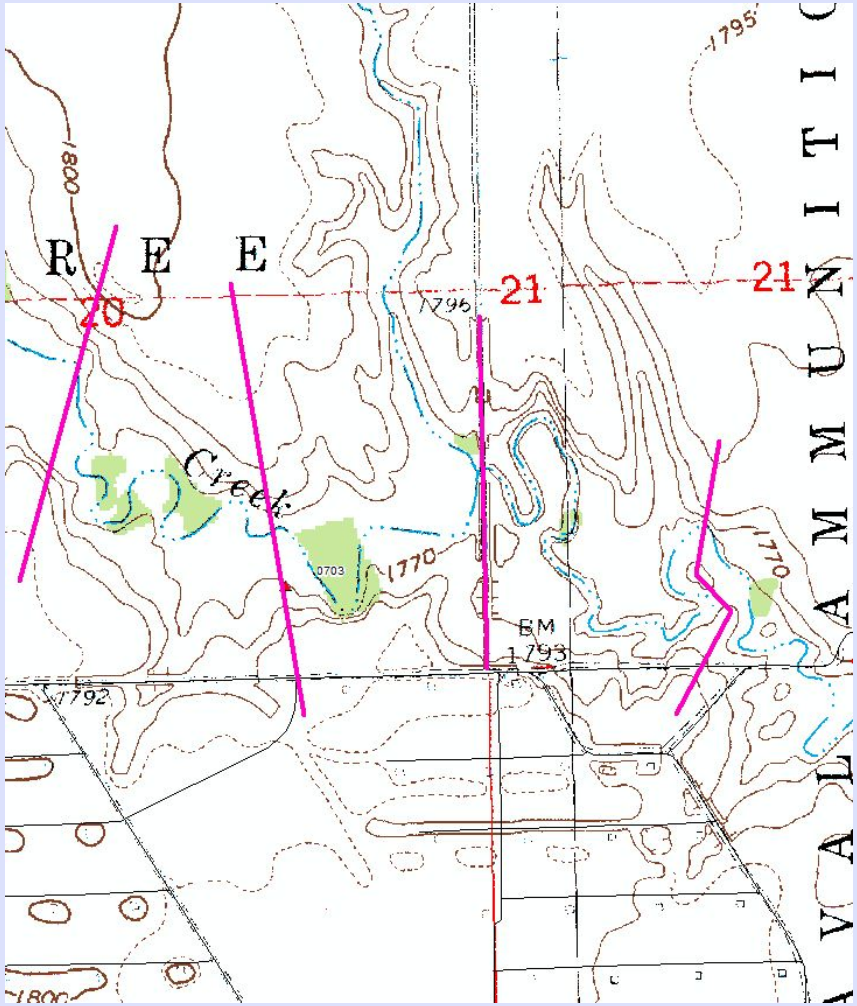
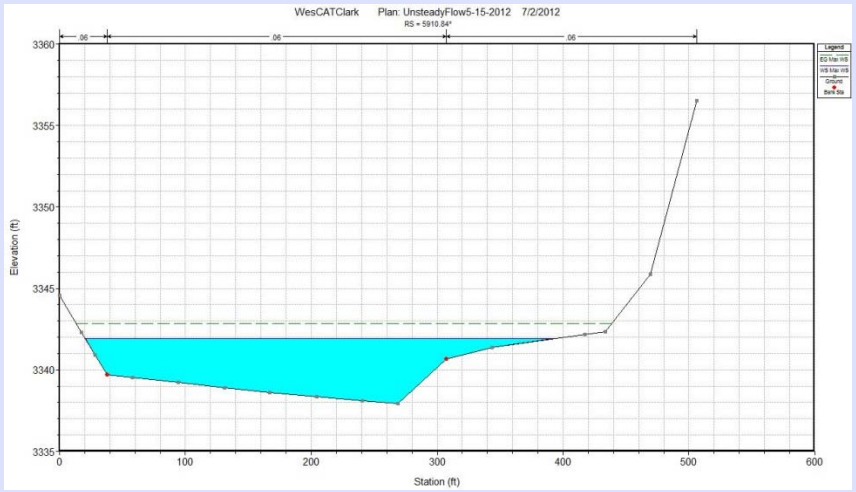
20th Century Hydraulics





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21st Century Hydraulics

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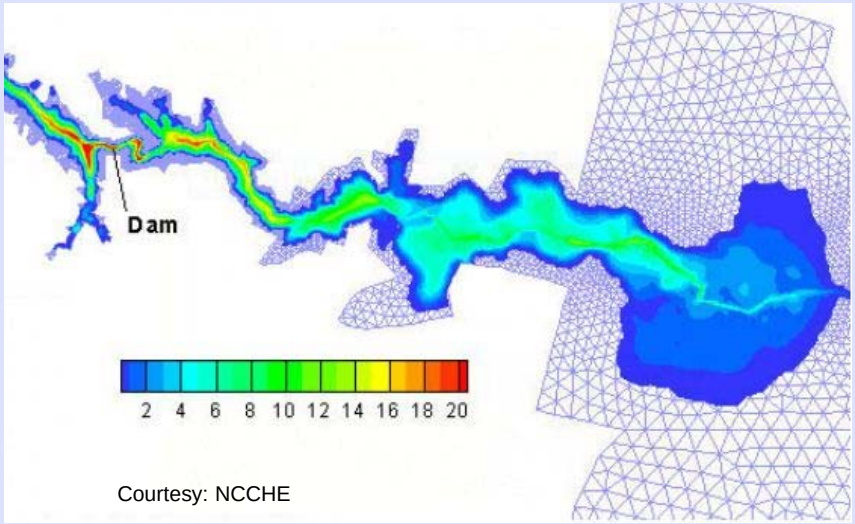

Courtesy: NCCHE

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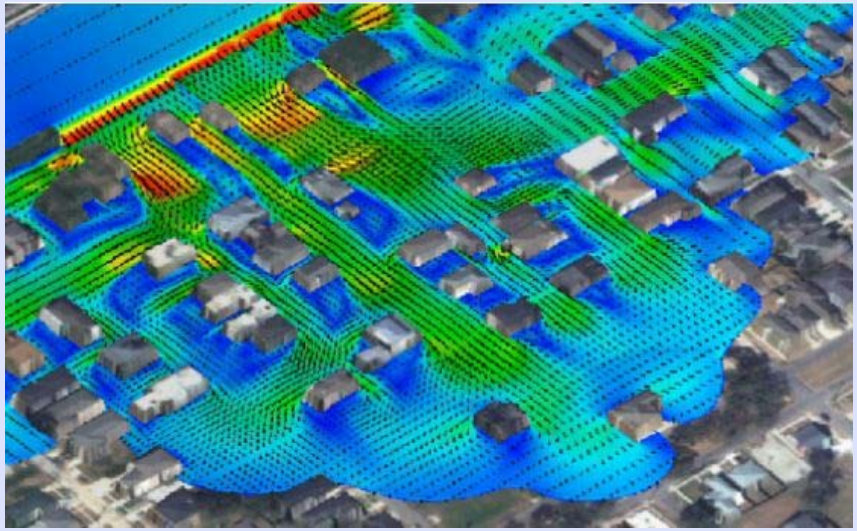
2D Hydraulics



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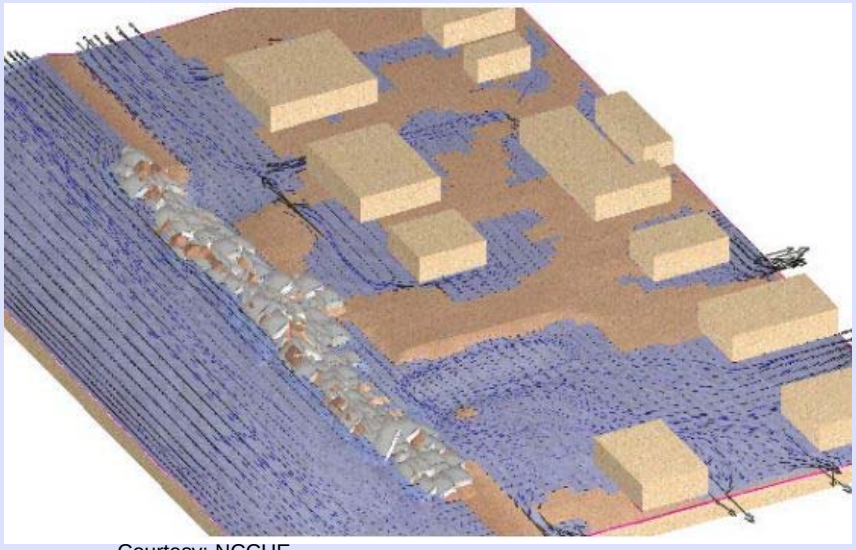

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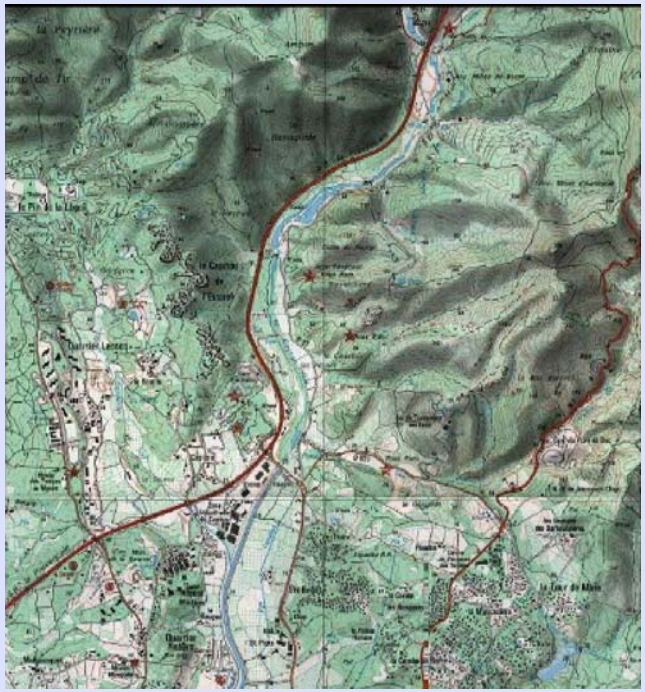

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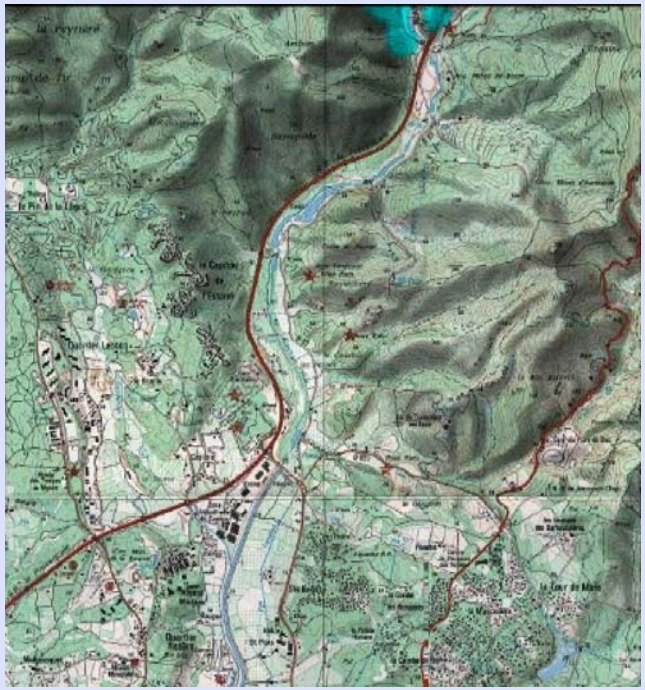

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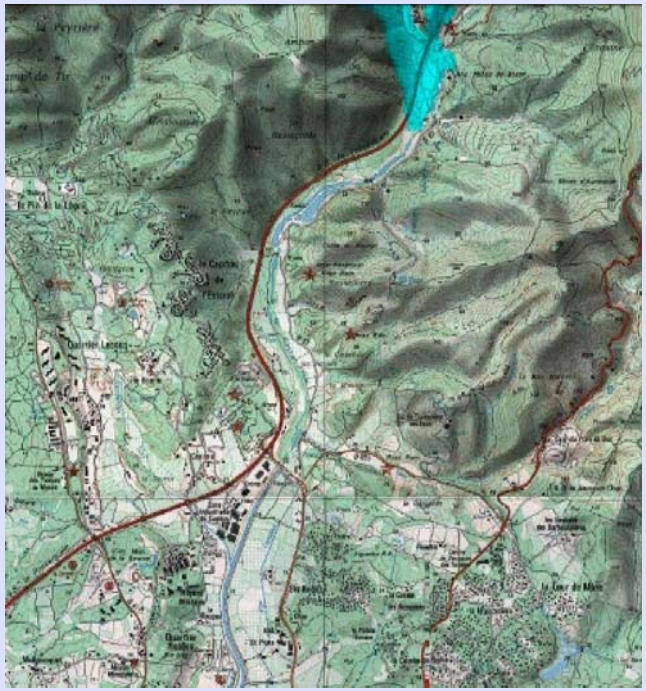

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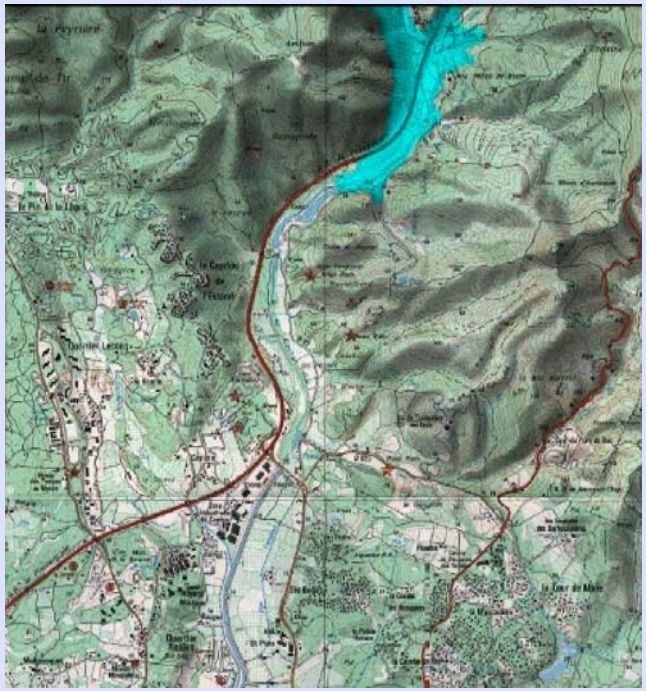

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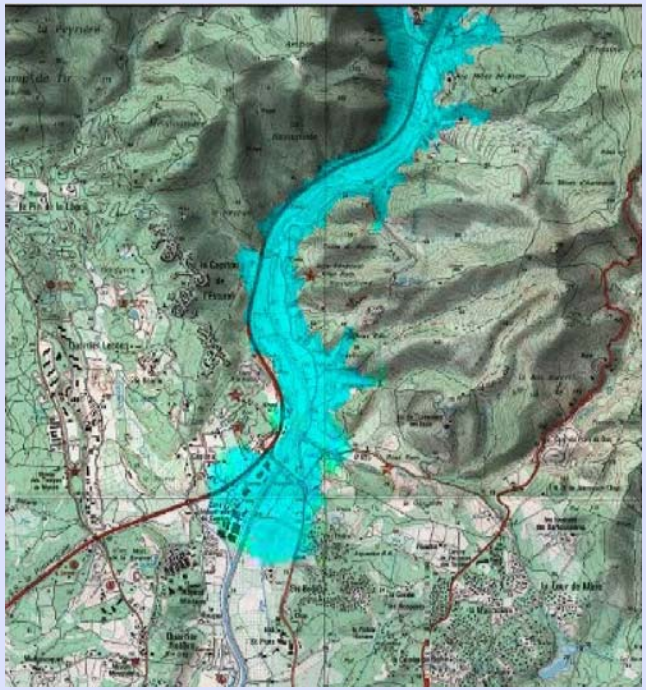

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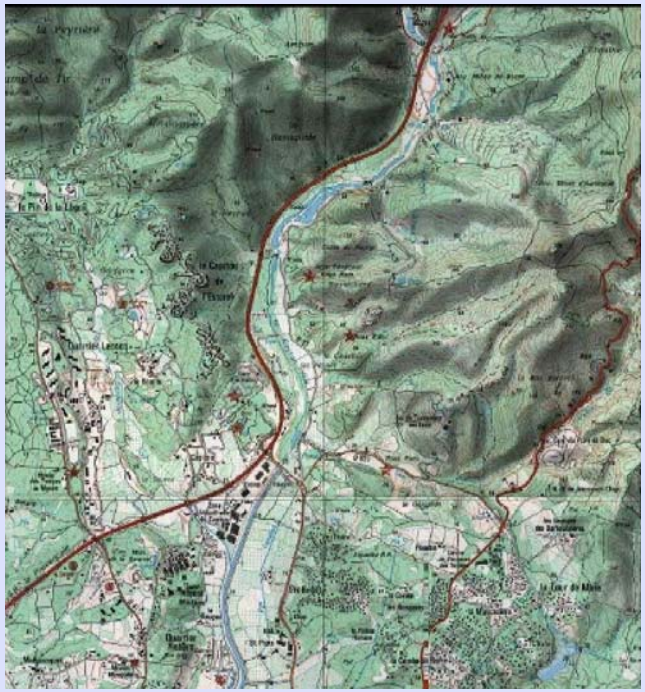

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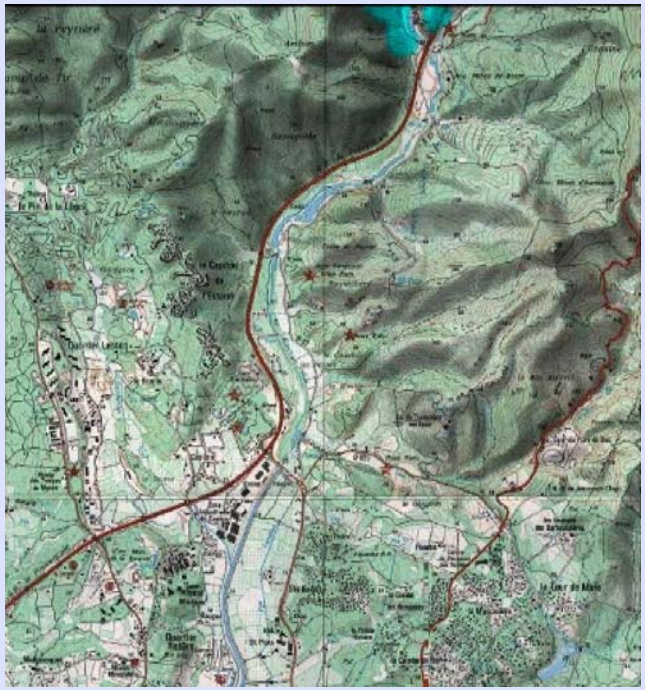

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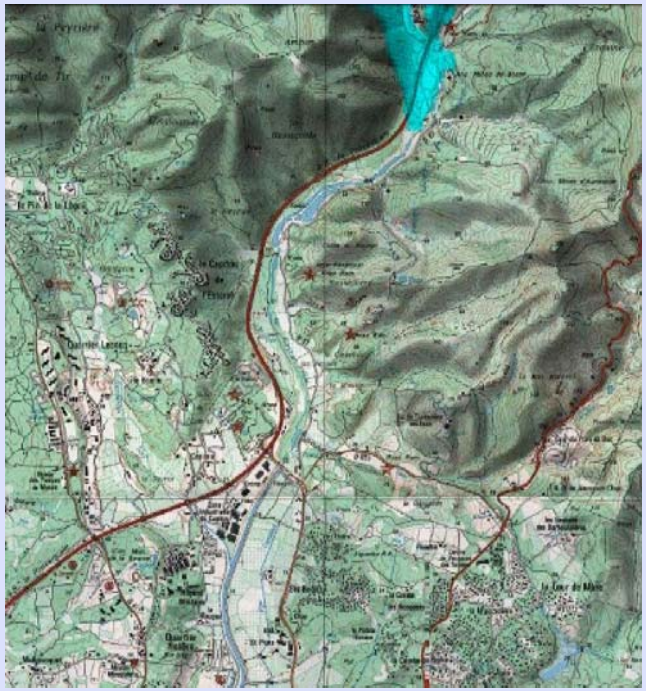

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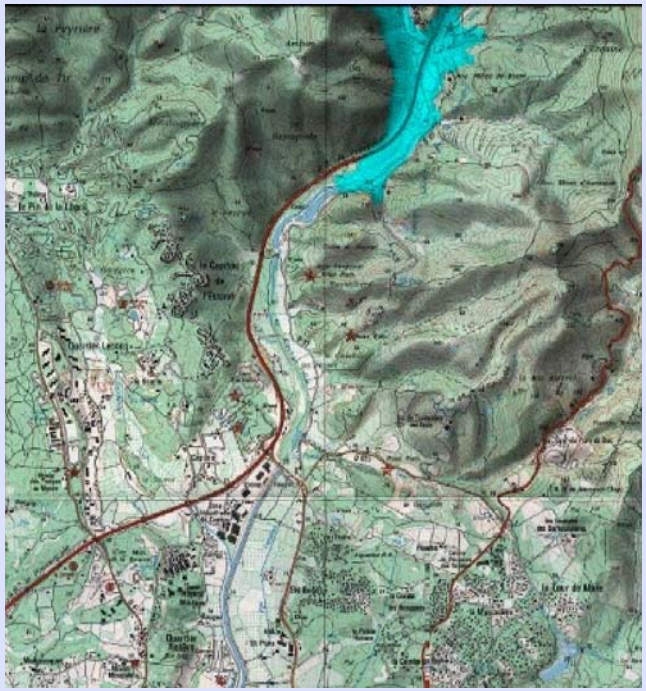

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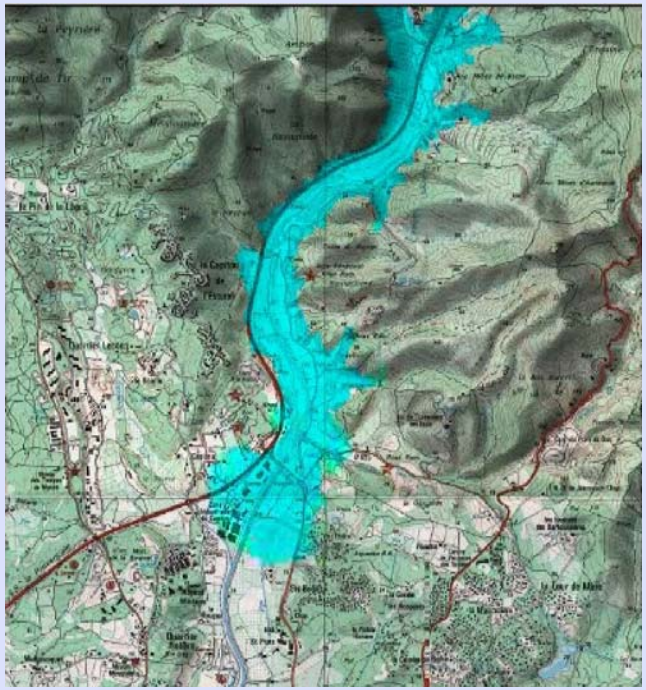

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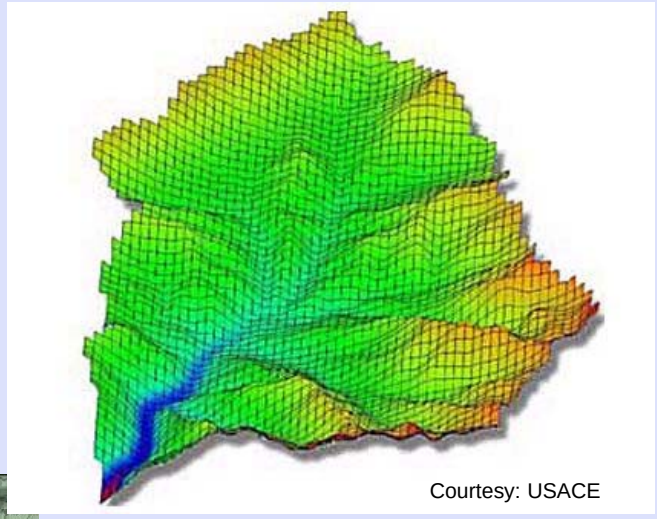
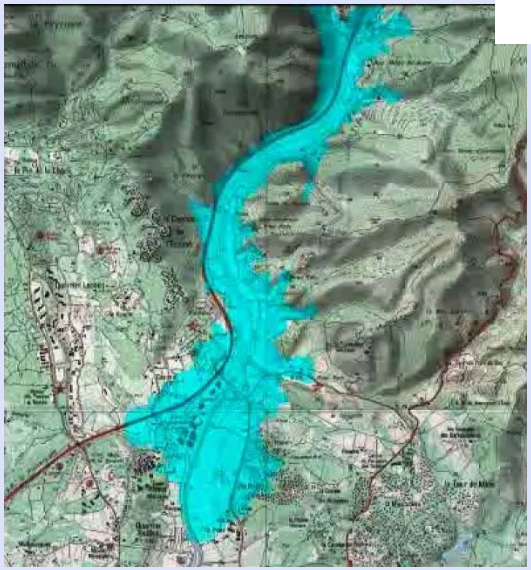


Courtesy: USACE



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- Incremental Design Analysis
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Emerging Methodologies

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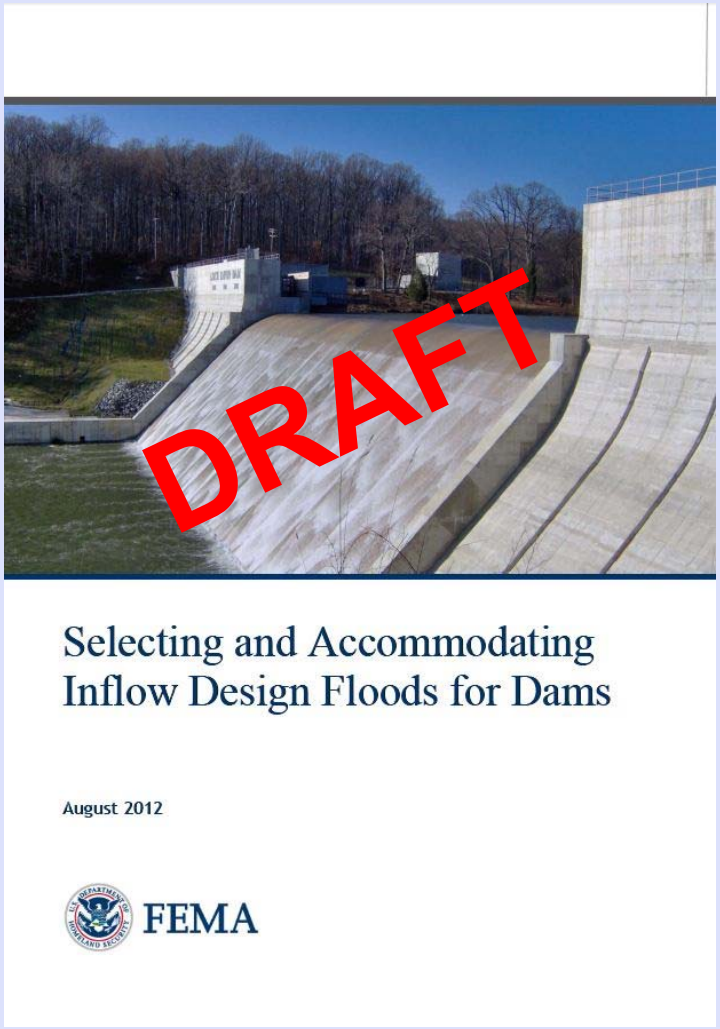
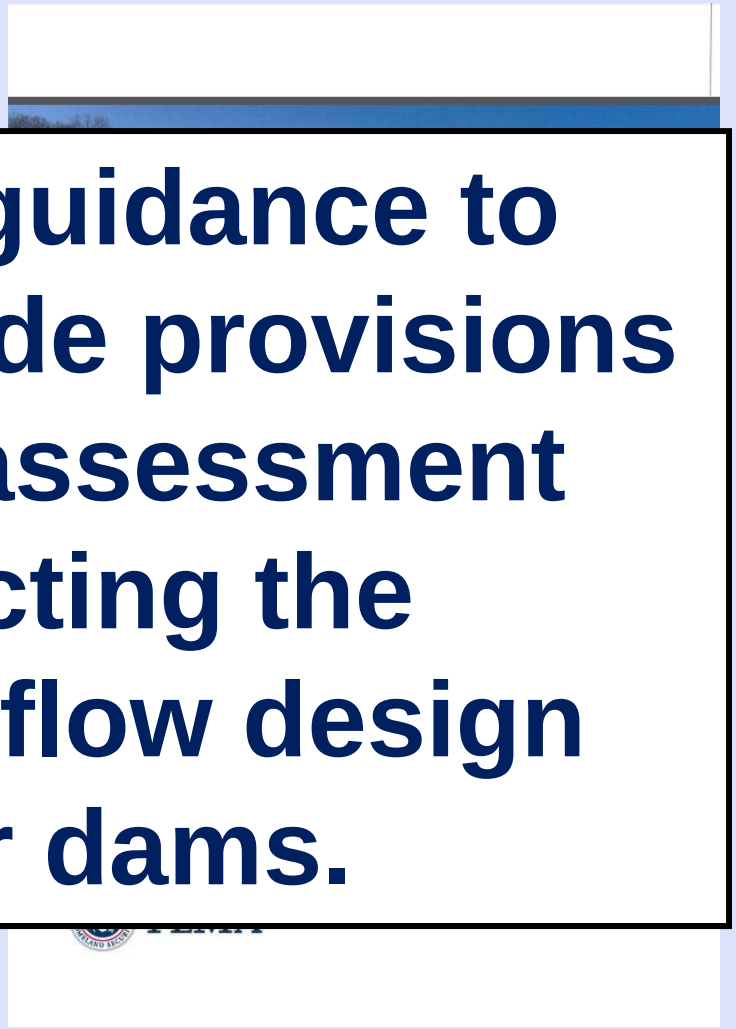
Risk Analysis

- Primary Authors
  - Dr. Arthur Miller, P.E. (AECOM)
  - Schweiger, Hess, Holderbaum, Kline, Raorabaugh, Dickey, and Richards (Gannett Fleming)
- Steering Committee:
  - James Gallagher, P.E.
  - Shyang-Chen S. Lin, P.E.
  - Brian Long
  - Dan Mahoney, P.E.
  - John H. Moyle, P.E.
  - Laurence Siroky, P.E.
- Reviewed by Research Work Group (National Dam Safety Review Board):
  - Brian Becker
  - Jason Boyle, P.E.
  - Robert H. Dalton
  - James Demby
  - Patrick Diederich, P.E.
  - Greg Hanson
  - Lisa Krosley
  - Dan Mahoney, P.E.
  - John Ritchey
  - Michael K. Sharp
  - Hal Van Aller
  - Eugene P Zeizel



Risk Analysis

- Primary Authors
  - Dr. Arthur Miller, P.E. (AECOM)
  - Schweiger, Hess, Holderbaum, Kline, Raorabaugh,
- **FEMA's new guidance to states will include provisions to allow risk assessment when selecting the appropriate inflow design floods for dams.**
  - Michael K. Sharp
  - Hal Van Aller
  - Eugene P Zeizel



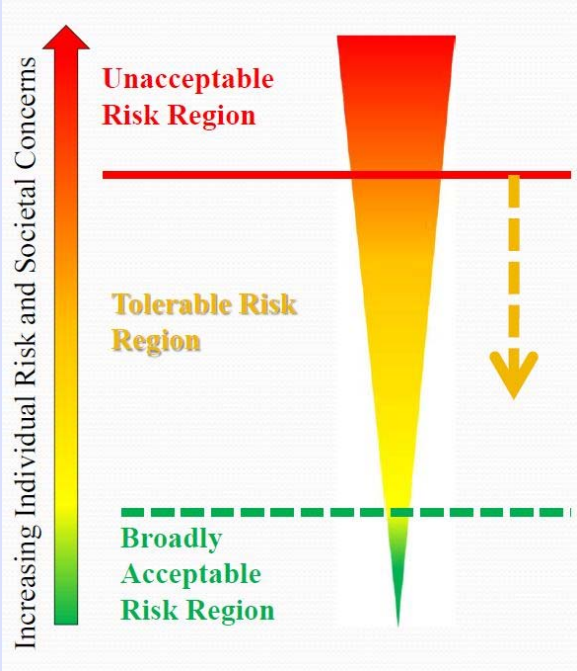
Risk Analysis

Annual Risk of Death

- Any Accident (1 in 2,500)
- Hospital Infection (1 in 3,000)
- Car Accident (1 in 8,000)

Broadly Accepted and Tolerable Risk

- **Broadly Acceptable Risk**
- **Tolerable Risk** - People are prepared to accept risk to secure benefits
  - Risks are properly assessed and managed
  - Risks are reduced to as low as reasonably practicable (ALARP)
  - Risks are periodically reviewed
  - Requires ongoing review and management



courtesy USACE

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Risk Analysis

Risk

=

Probability of Event

X

Probability of Failure Given Such an Event

X

Consequences

Risk Analysis

Risk

=

Probability of Event (1 in 100)

X

Probability of Failure Given Such an Event

X

Consequences

Risk Analysis

Risk

=

Probability of Event (1 in 100)

X

Probability of Failure Given Such an Event (1 in 10)

X

Consequences

Risk Analysis

Risk

=

Probability of Event (1 in 100)

X

Probability of Failure Given Such an Event (1 in 10)

X

Consequences (100 lives lost)

Risk Analysis

Risk (1 in 1,000 chance of 100 lives lost) (0.1 lives per year)

=

Probability of Event (1 in 100)

X

Probability of Failure Given Such an Event (1 in 10)

X

Consequences (100 lives lost)

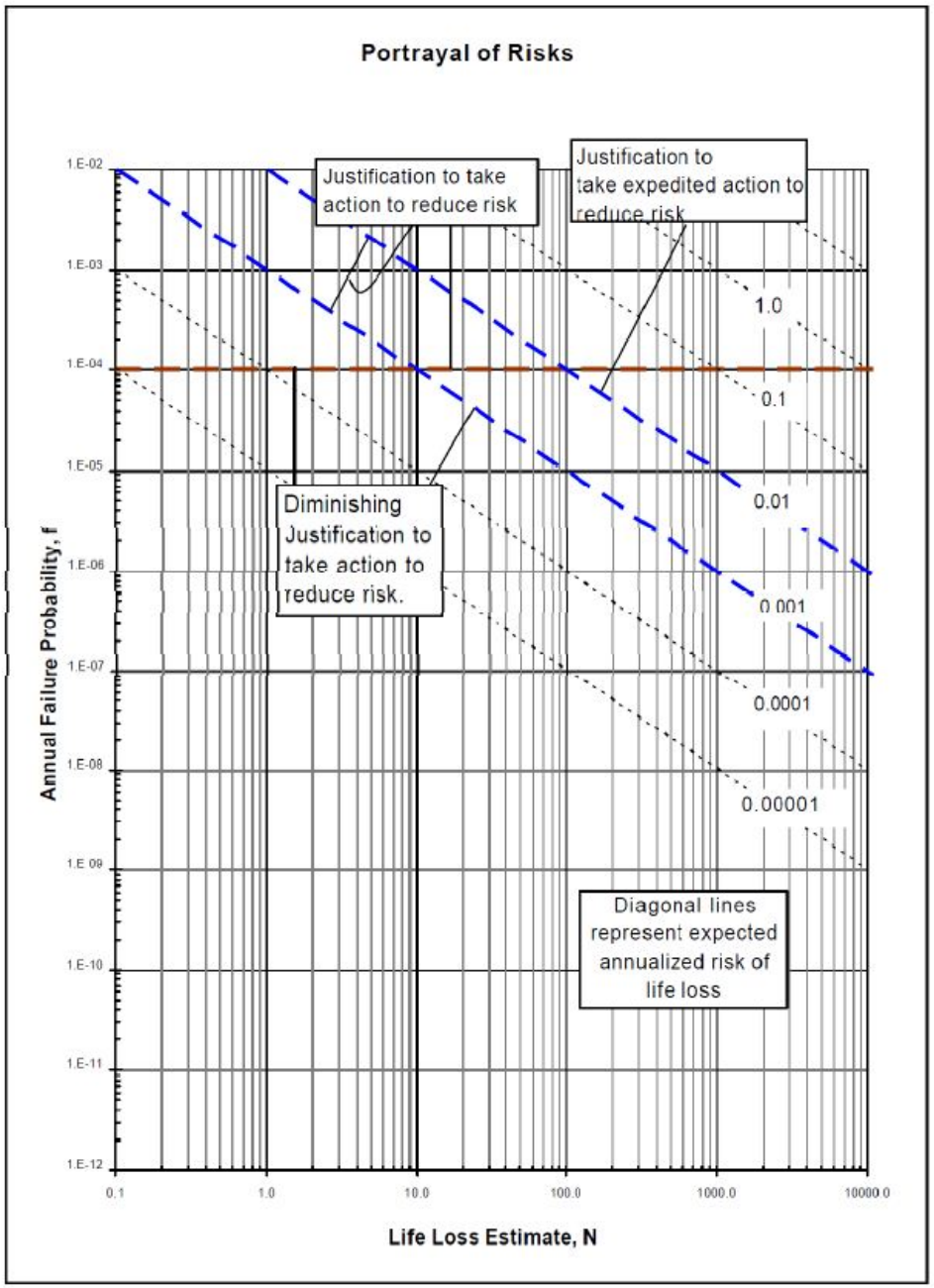
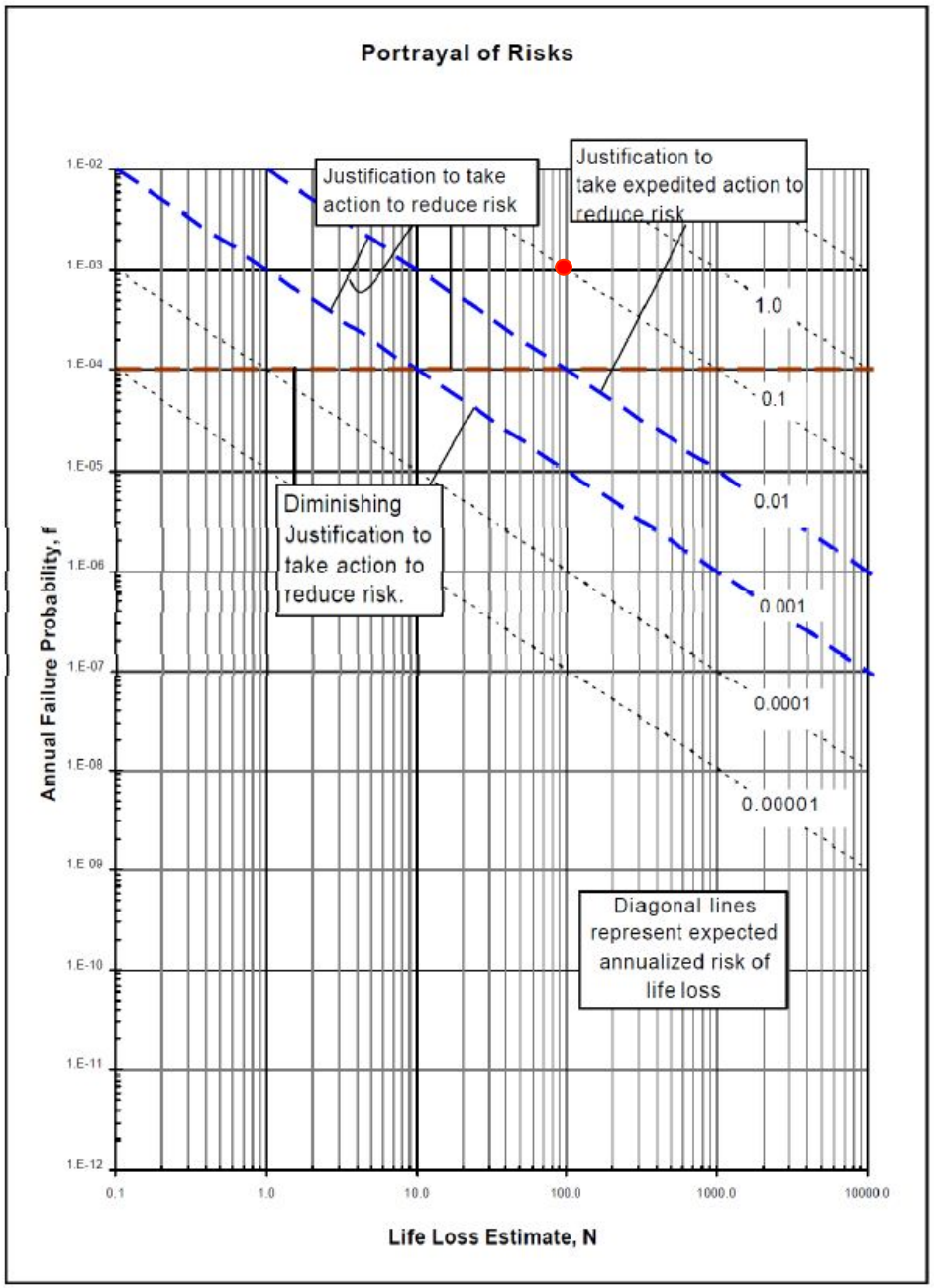


Figure 8.1 Reclamation f-N Chart for Displaying Probability of Failure, Life Loss, and Risk Estimates [Reclamation, 2003]



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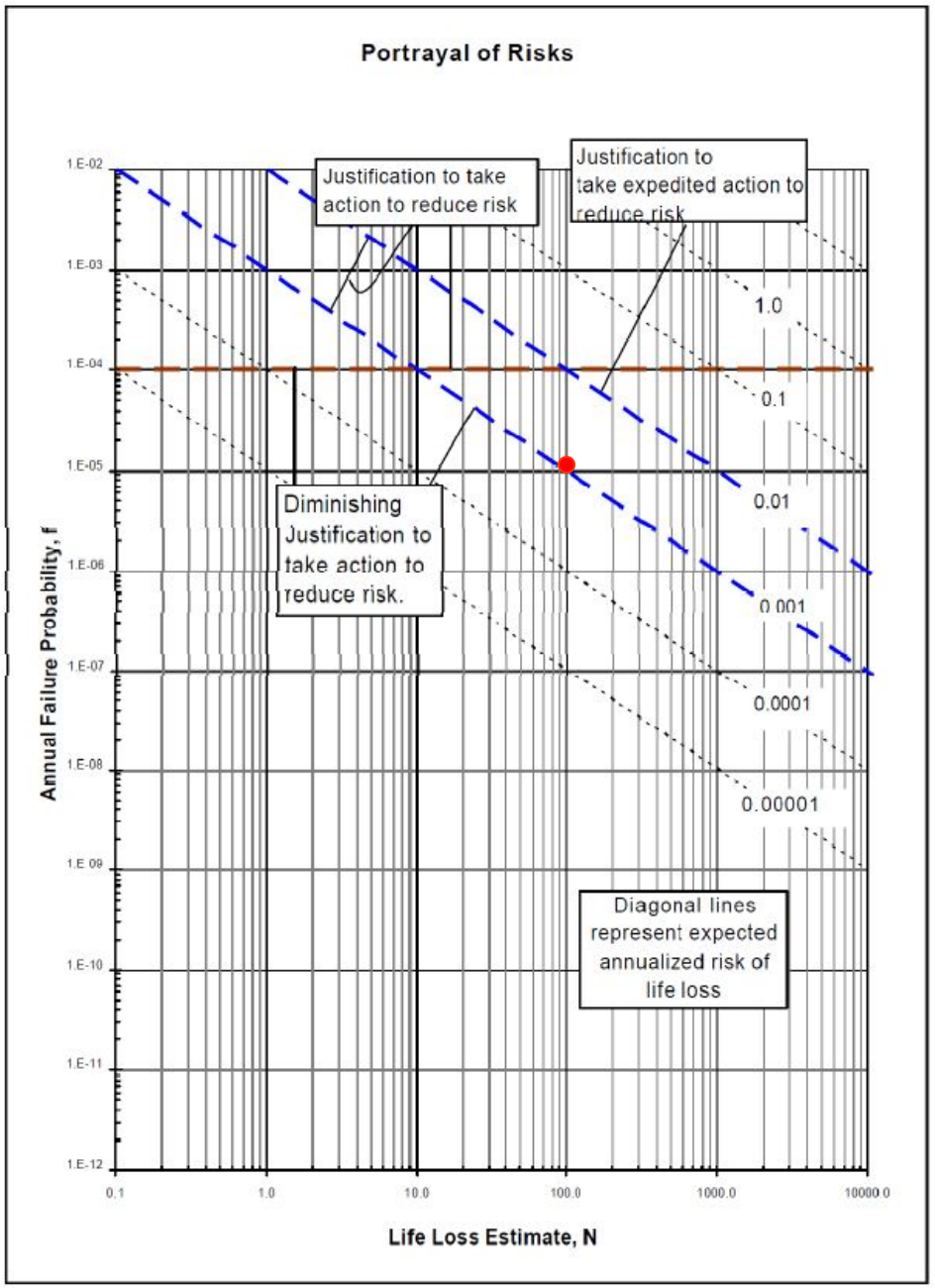

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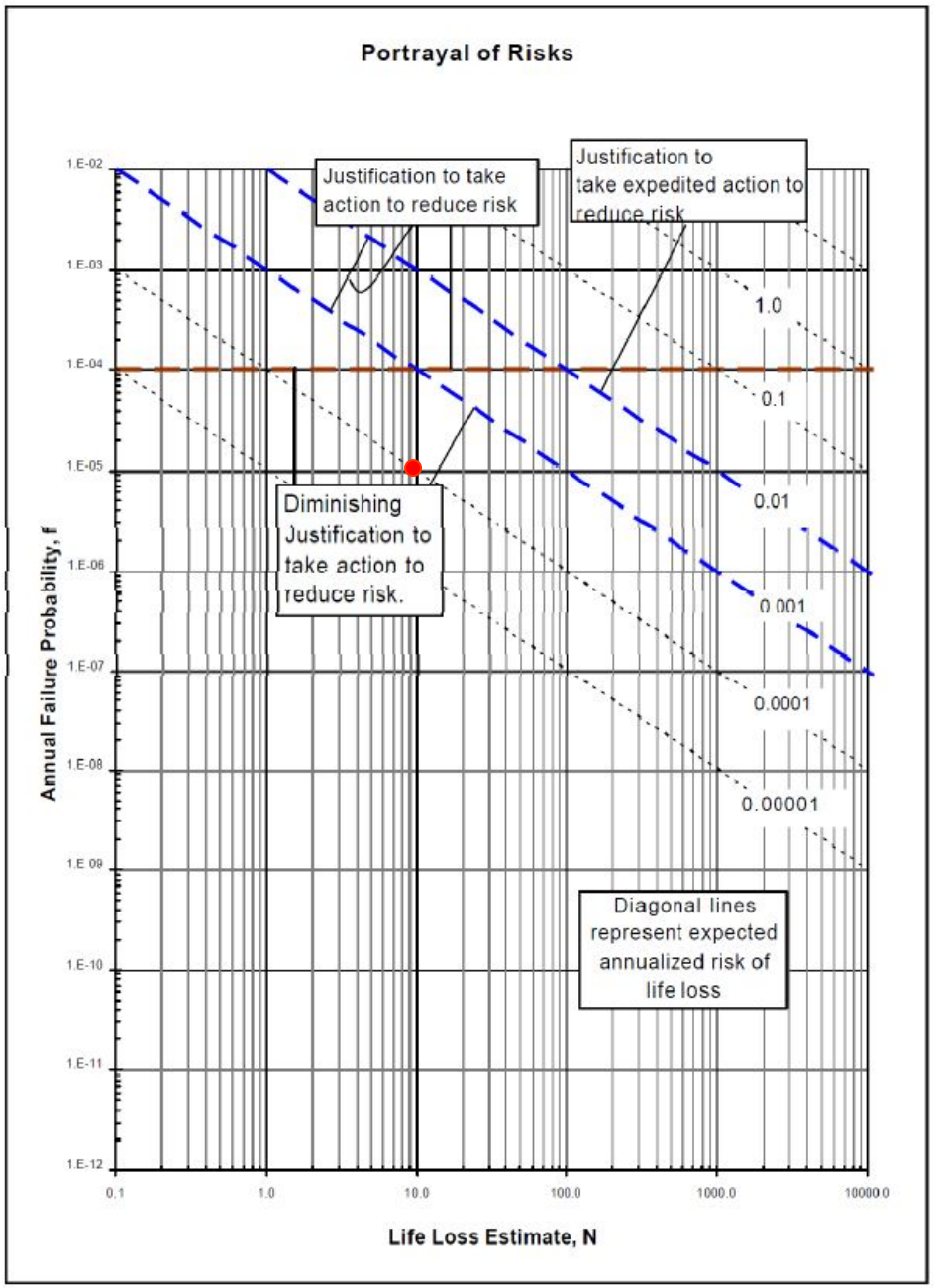

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Embankment Erosion Analysis

- Agriculture Research Service (ARS)
- NRCS

Courtesy: ARS

Embankment Overtopping

Dam Breach

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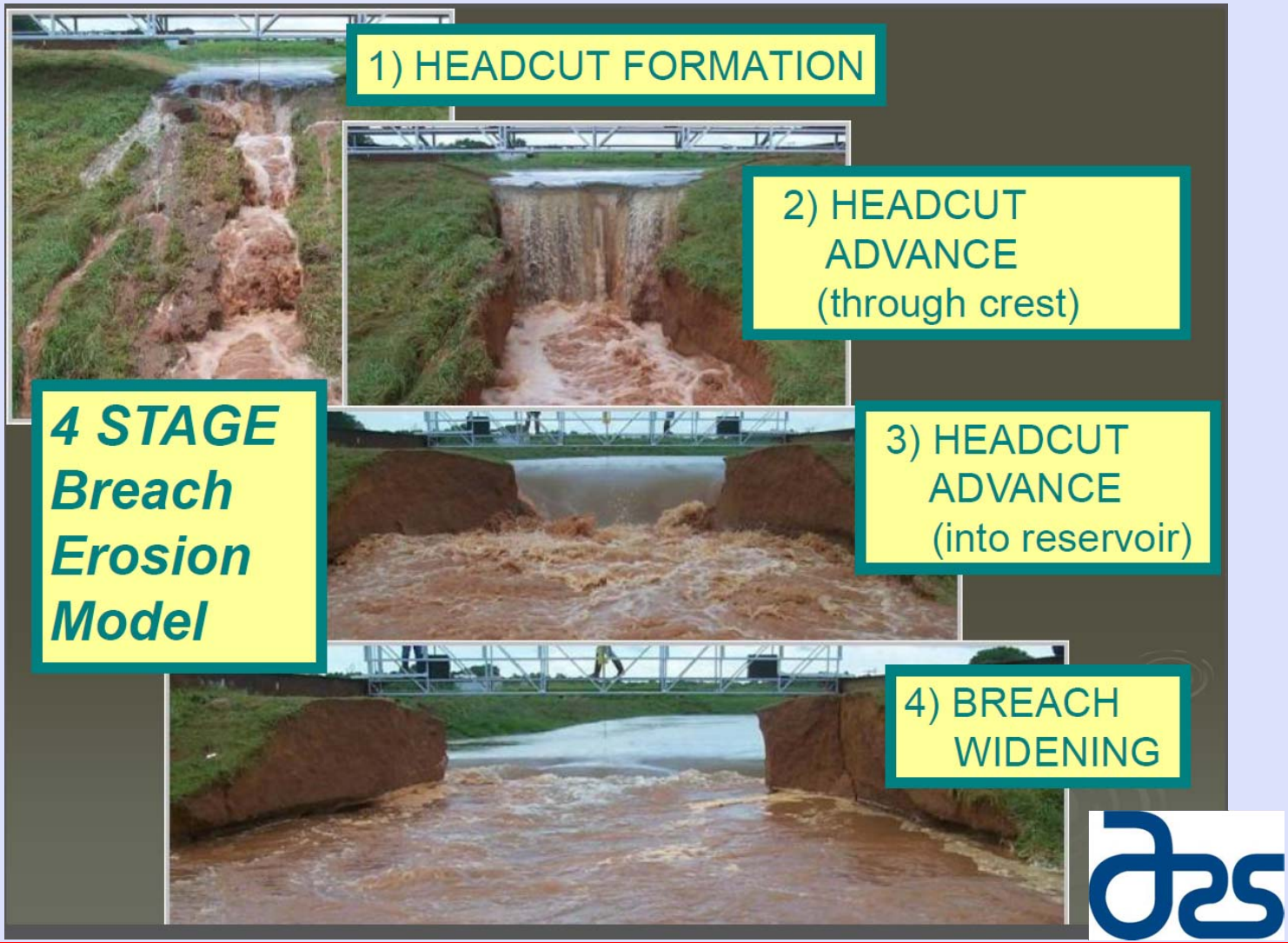
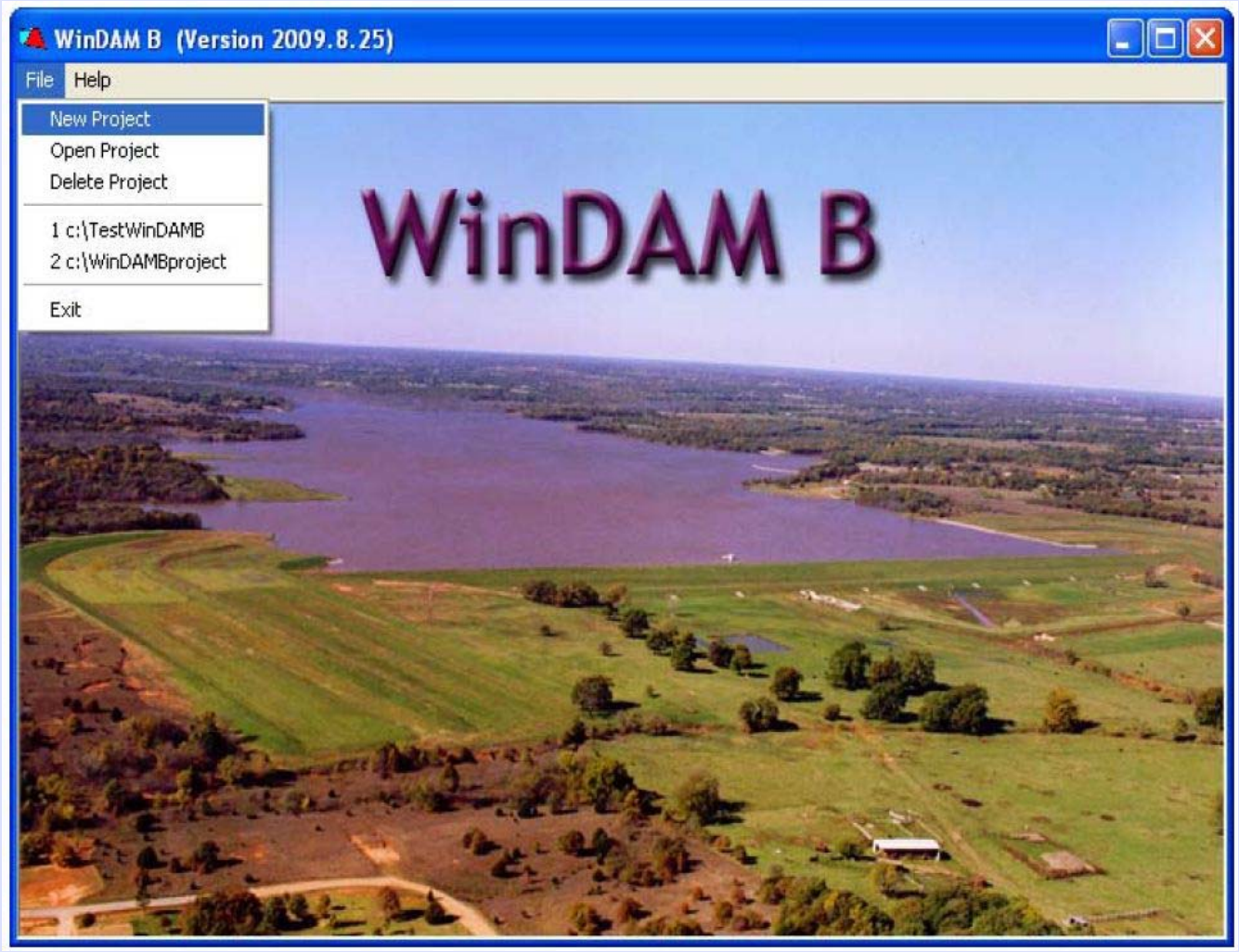
Breach Erosion Model



Embankment Erosion Analysis



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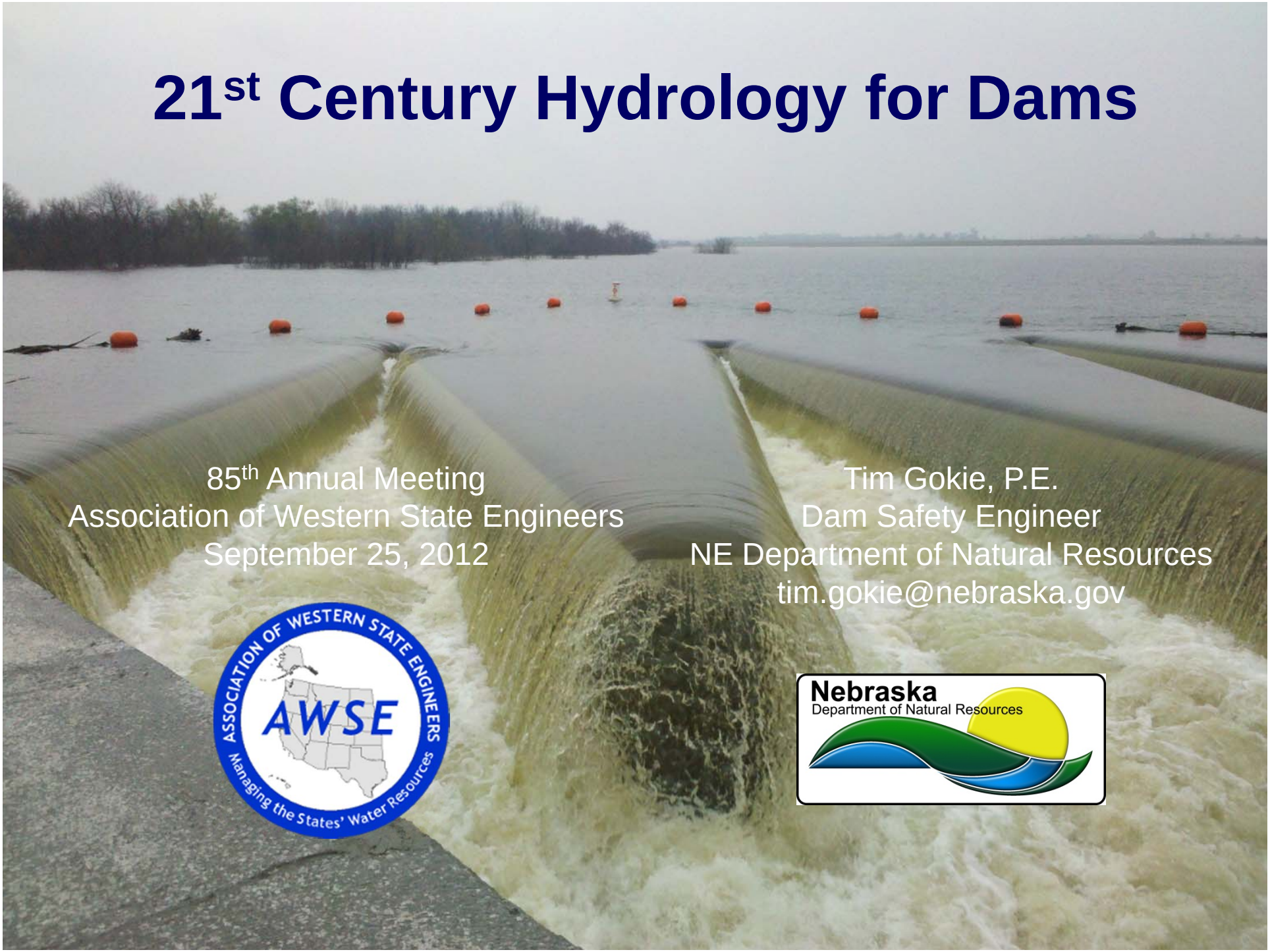

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