2015 APWA ANNUAL FALL CONFERENCE

DAM BREAK INUNDATION AREA MODELING AND MAPPING FOR AN EMERGENCY ACTION PLAN

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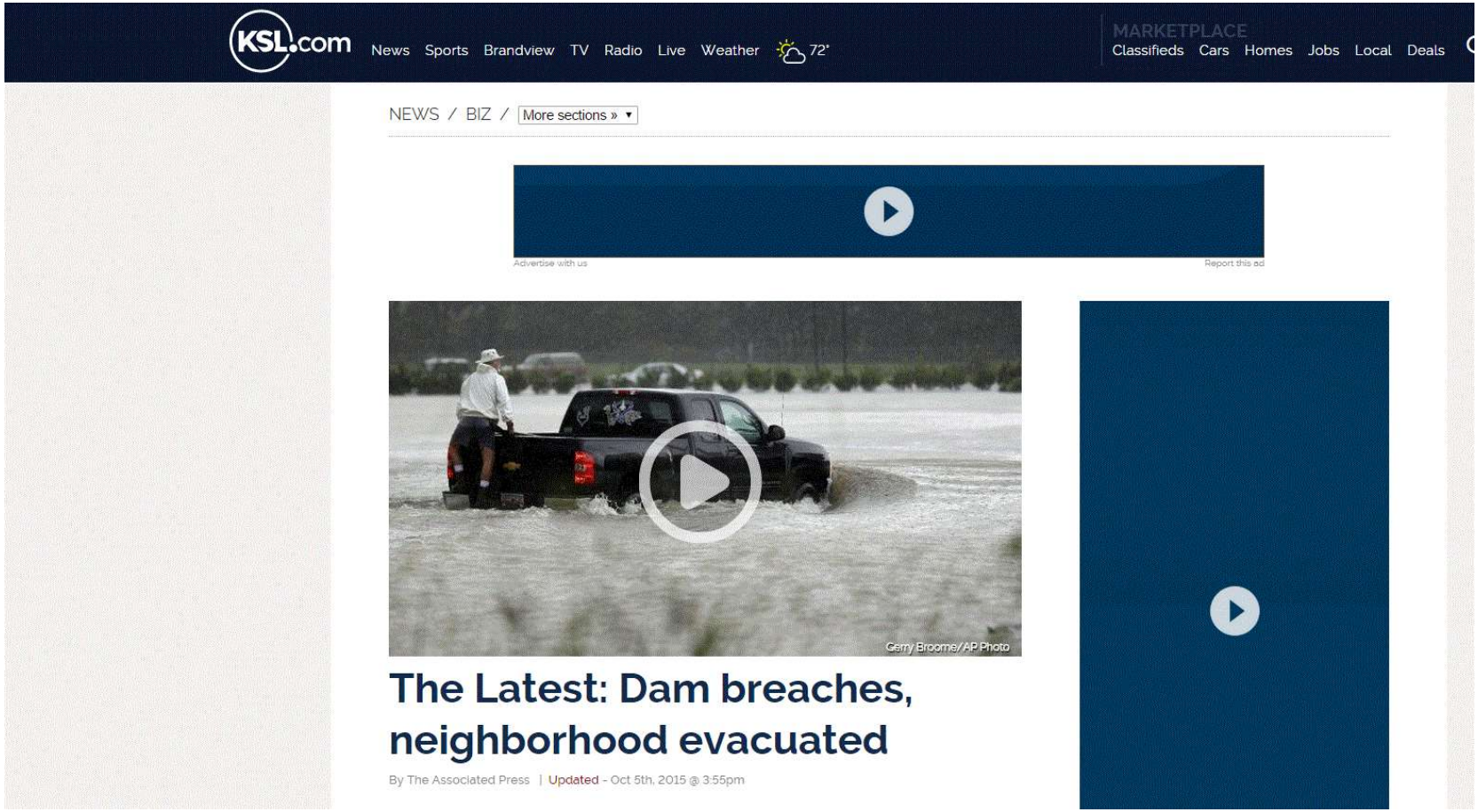
October 7, 2015

CURRENT EVENTS



Flooding and Dam Breach in South Carolina this week.

PRESENTATION OUTLINE

- Introduction
- Overview of Dams and Dam Breaks
- Key References
- Emergency Action Plans
- Inundation Mapping
- Methods and Models
- Case Studies
- Conclusions
- Questions

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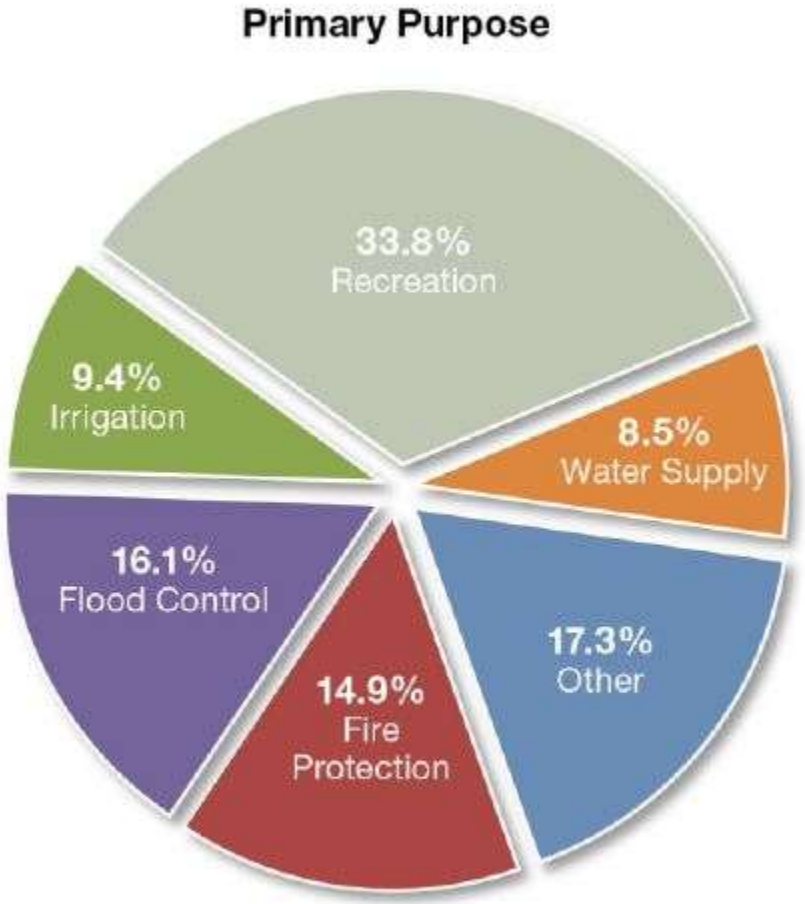
INTRODUCTION

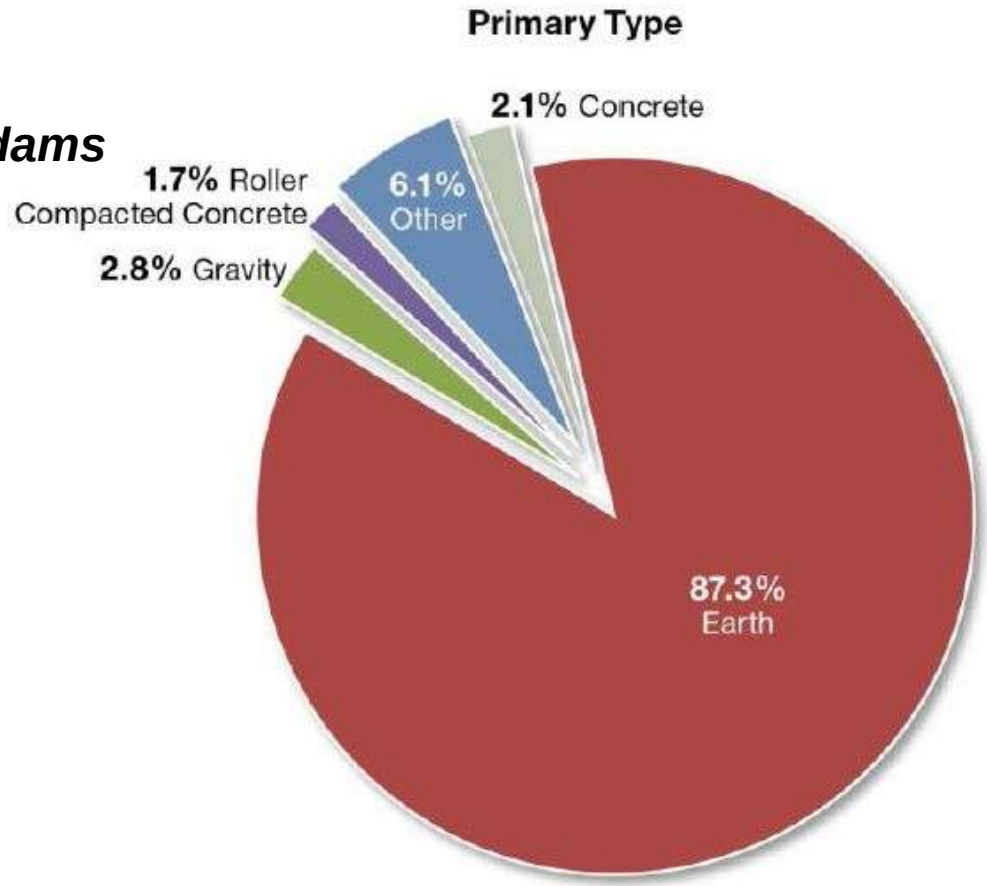
- ***Why do we need dams?***



Source: FEMA 2013

INTRODUCTION

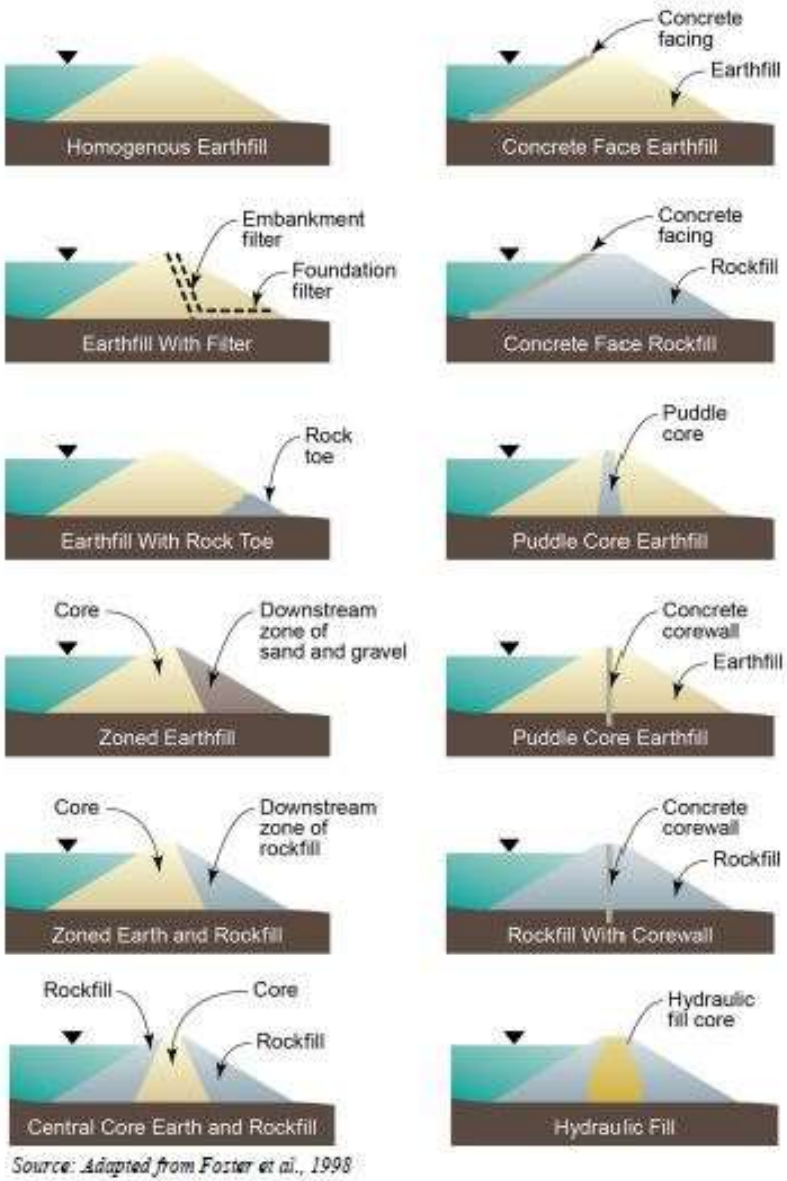
- ***What materials are dams made of?***



Source: FEMA 2013

INTRODUCTION

- ***How are dams made?***
  - ***Simple/Difficult?***



Source: FEMA 2013

INTRODUCTION

- ***UNFORTUNATELY DAMS FAIL***

Taum Sauk Dam, Missouri

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INTRODUCTION

- ***How do dams fail?***

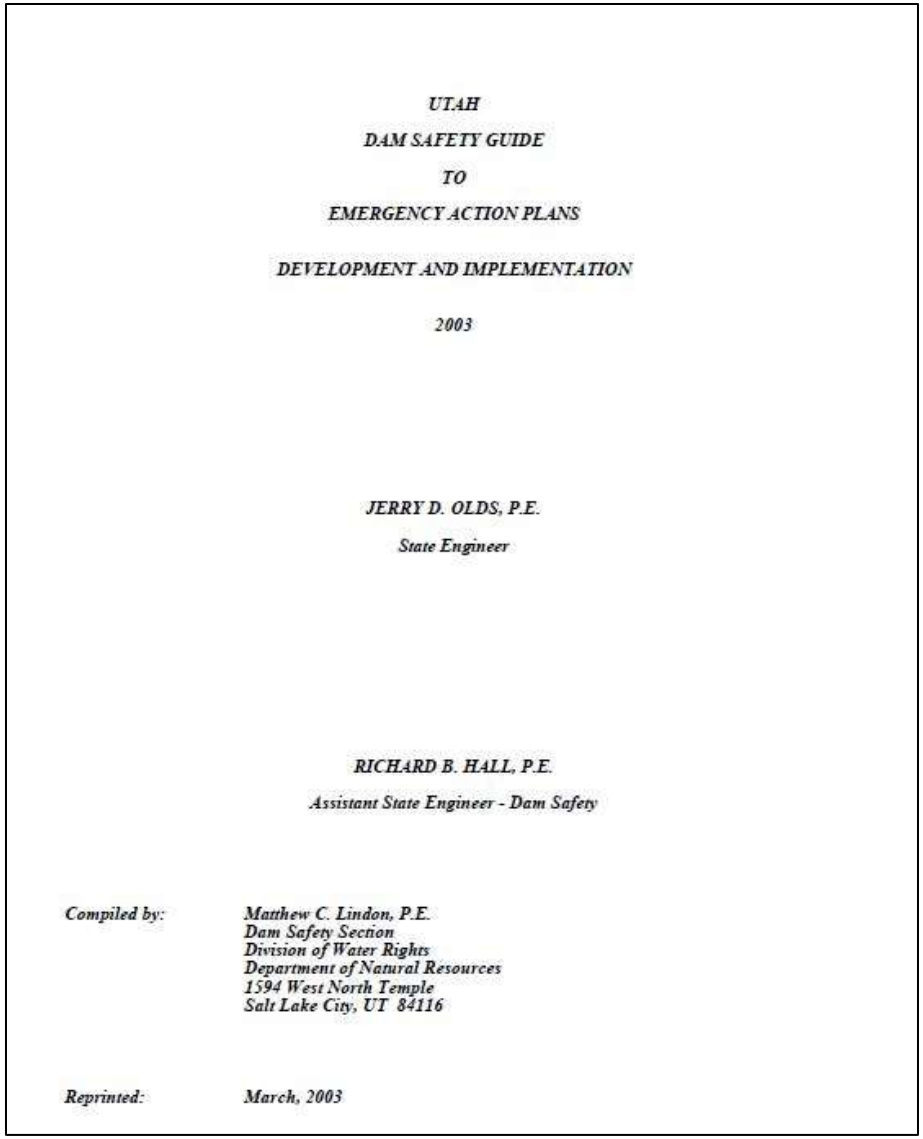
Table 4-1: Causes of Dam Failure 1975-2011

Cause of Failure	Number of Dam Failures	Percentage of Dam Failure
Flood or Overtopping	465	70.9%
Piping or Seepage	94	14.3%
Structural	12	1.8%
Human Related	4	0.6%
Animal Activities	7	1.1%
Spillway	11	1.7%
Erosion/Slide/Instability	13	2.0%
Unknown	32	4.9%
Other	18	2.7%
Total number of dam failures	**656**	

Source: FEMA 2013

KEY REFERENCE

- ***Utah Dam Safety Guide to Emergency Action Plans Development and Implementation*. Utah Division of Water Rights – Dam Safety Section. 2003**
- ***{73-5a Utah Code, Annotated}***
- ***{R655-10, 11 & 12 Utah Administrative Code}***



UTAH

DAM SAFETY GUIDE

TO

EMERGENCY ACTION PLANS

DEVELOPMENT AND IMPLEMENTATION

2003

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State Engineer

RICHARD B. HALL, P.E.

Assistant State Engineer - Dam Safety

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Dam Safety Section
Division of Water Rights
Department of Natural Resources
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Reprinted: *March, 2003*

KEY REFERENCE

- ***Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures*. FEMA. July 2013**

EMERGENCY ACTION PLANS

"An Emergency Action Plan, or EAP, is a formal plan that identifies potential emergency conditions at a dam and prescribes the procedures to be followed to minimize property damage and loss of life."

"An emergency, in terms of dam operation, is defined as a condition which develops unexpectedly, endangers the structural integrity of the dam and/or downstream property and human life, and requires immediate action."

REF: UTAH DIVISION OF WATER RIGHTS – UTAH DAM SAFETY GUIDE

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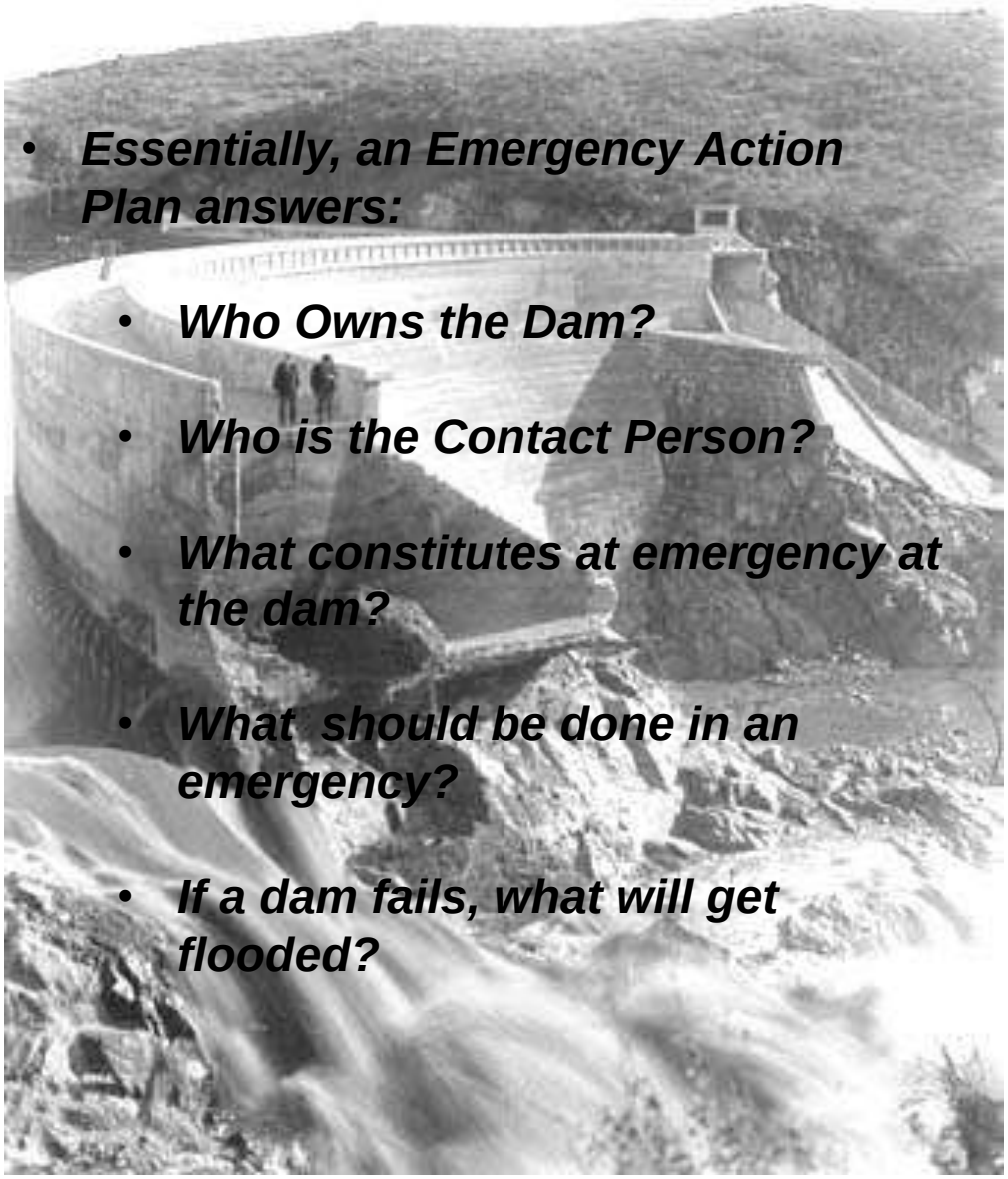
EMERGENCY ACTION PLAN



- *Essentially, an Emergency Action Plan answers:*
  - *Who Owns the Dam?*
  - *Who is the Contact Person?*
  - *What constitutes at emergency at the dam?*
  - *What should be done in an emergency?*
  - *If a dam fails, what will get flooded?*

EMERGENCY ACTION PLAN

"The EAP should address this question?"

THE DAM JUST FAILED / IS FAILING, NOW WHAT?

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EMERGENCY ACTION PLANS

4.1.1 Part I -- Introductory Section

4.1.2 Part II -- Responsibilities

4.1.3 Part III -- Emergency Procedures

4.1.4 Part IV -- Preventive Actions

4.1.5 Part V -- Inundation Maps

4.1.6 Part VI -- Appendices

REF: UTAH DIVISION OF WATER RIGHTS – UTAH DAM SAFETY GUIDE

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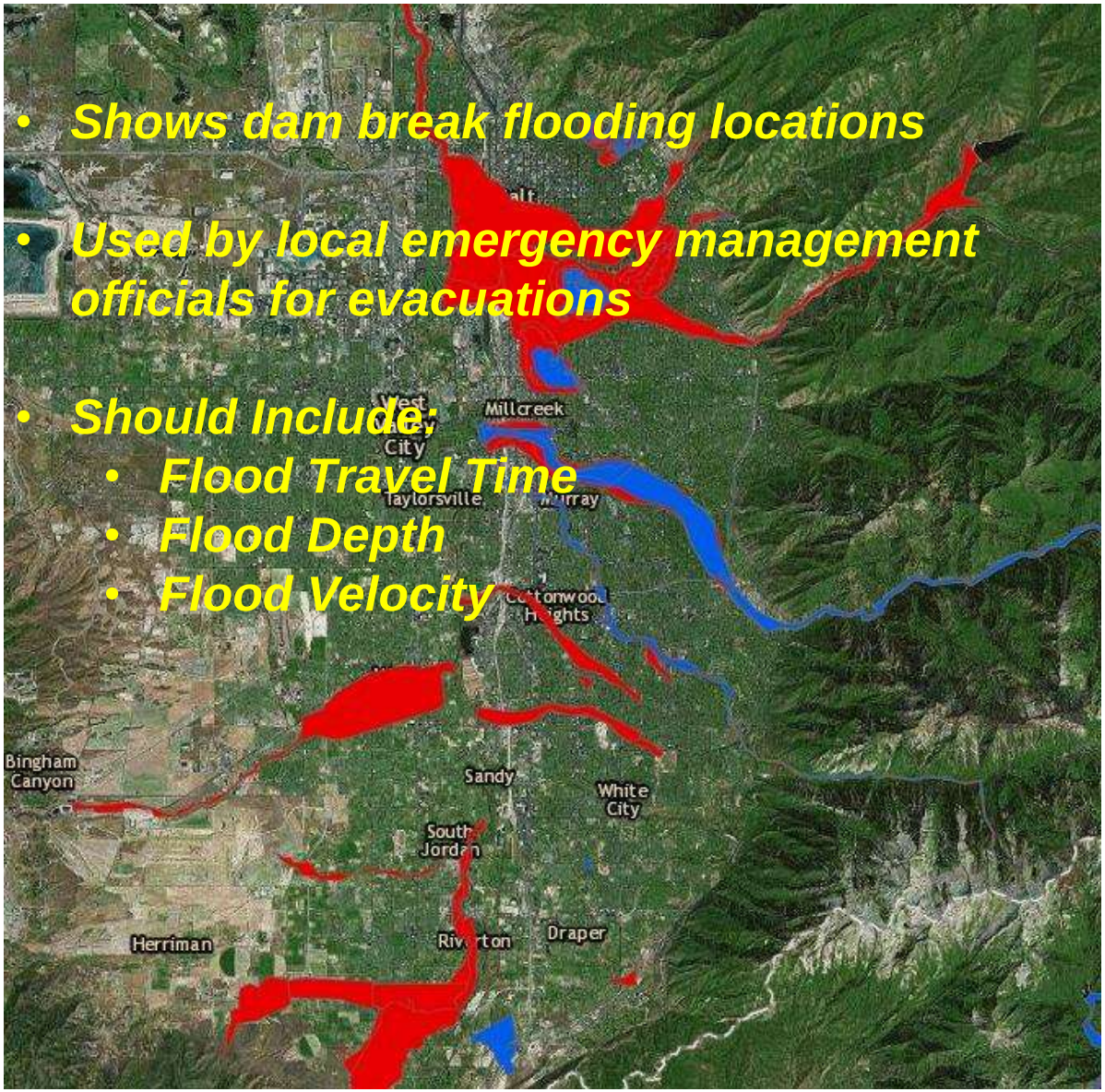
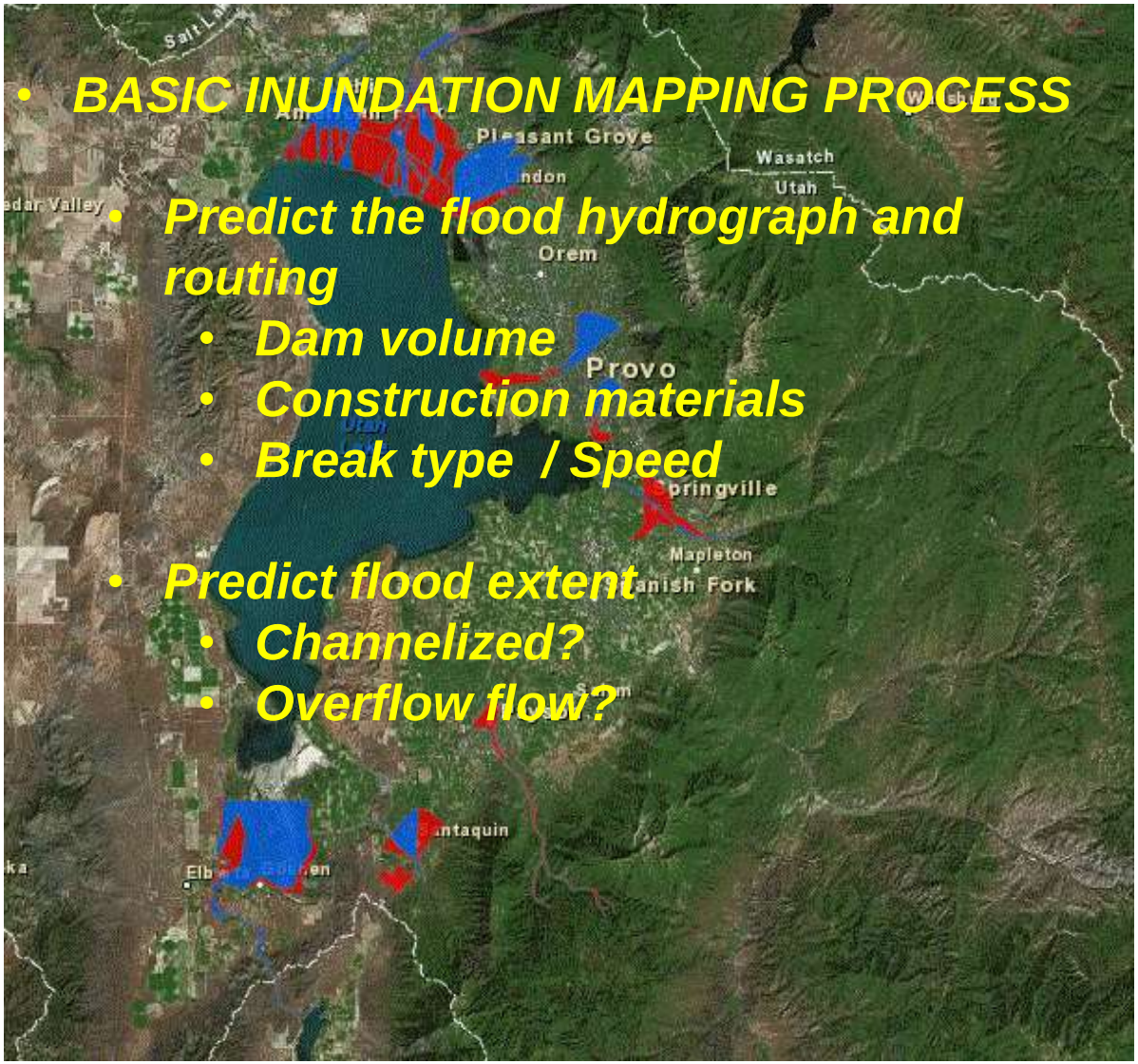
INUNDATION AREA MAP



- *Shows dam break flooding locations*
- *Used by local emergency management officials for evacuations*
- *Should Include:*
  - *Flood Travel Time*
  - *Flood Depth*
  - *Flood Velocity*

INUNDATION AREA MAP



- *BASIC INUNDATION MAPPING PROCESS*
  - *Predict the flood hydrograph and routing*
    - *Dam volume*
    - *Construction materials*
    - *Break type / Speed*
  - *Predict flood extent*
    - *Channelized?*
    - *Overflow flow?*

INUNDATION AREA MAP

- ***DAM BREAK HYDROGRAPH DEVELOPMENT***
  - ***Sunny Day Failures*** 
    - ***Hydrograph is dependent on dam's size and structure***
    - ***Consider likely modes of failure and locations / consider most severe cases***
    - ***Often associated with piping failures.***
    - ***Less warning***
  - ***Rainy Day Failures*** 
    - ***Hydrograph is dependent on dam's characteristics and on the upstream hydrology***
    - ***Often associated with overtopping failures***
    - ***Combines rainfall flooding and dam break flooding***

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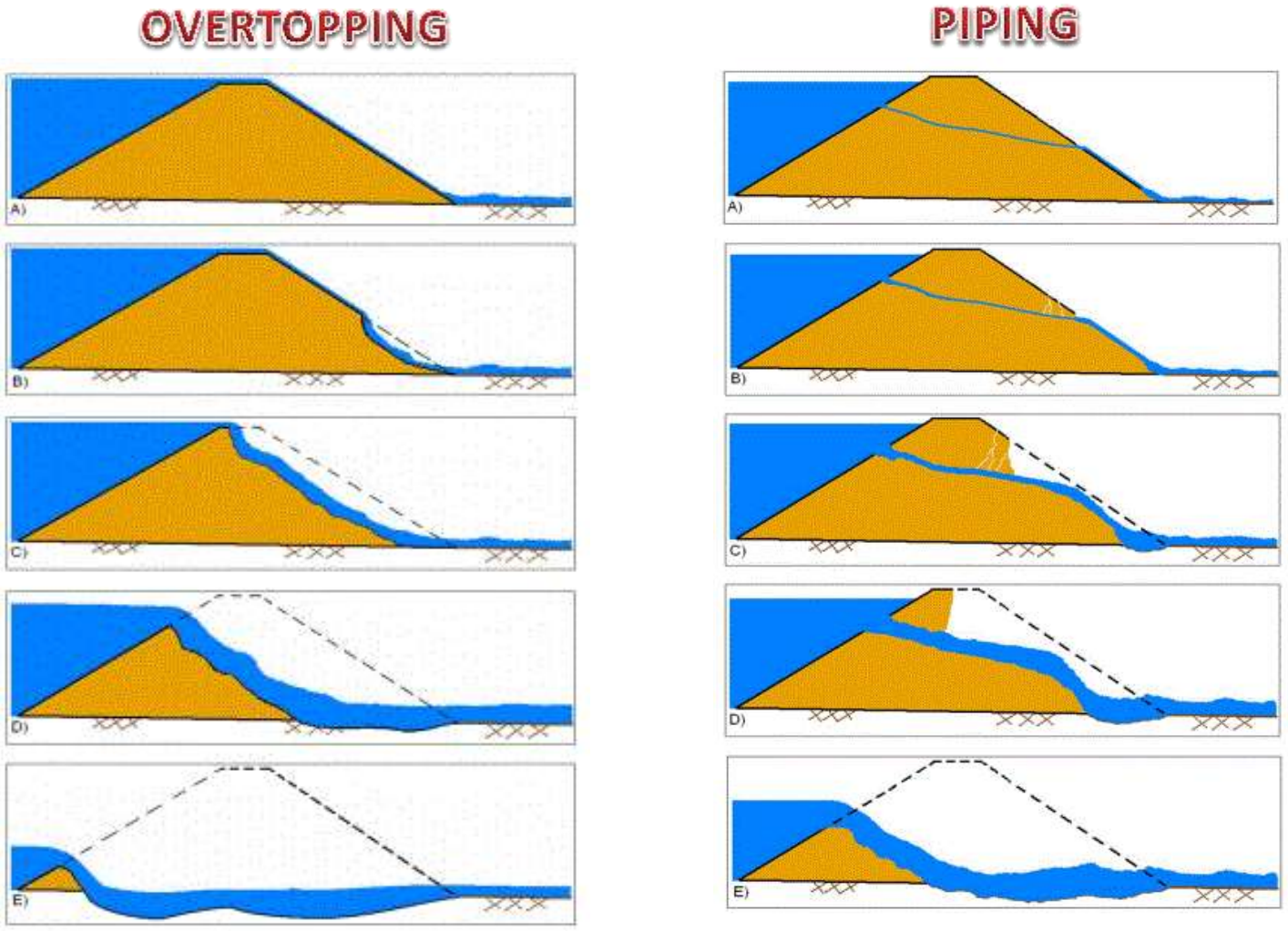
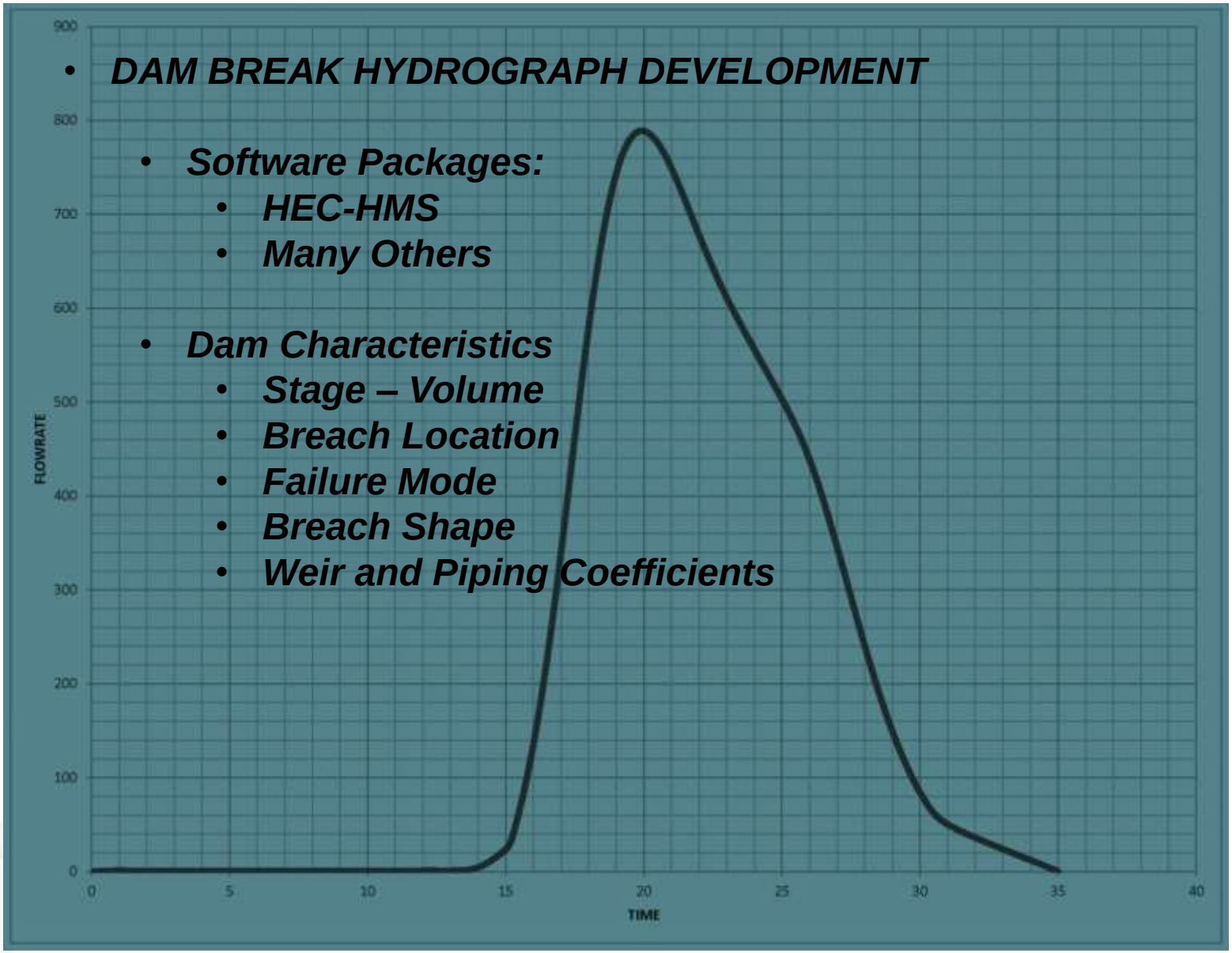
INUNDATION AREA MAP

- ***DAM BREAK HYDROGRAPH DEVELOPMENT***



METHODS AND MODELS



- ***DAM BREAK HYDROGRAPH DEVELOPMENT***
  - ***Software Packages:***
    - ***HEC-HMS***
    - ***Many Others***
  - ***Dam Characteristics***
    - ***Stage – Volume***
    - ***Breach Location***
    - ***Failure Mode***
    - ***Breach Shape***
    - ***Weir and Piping Coefficients***

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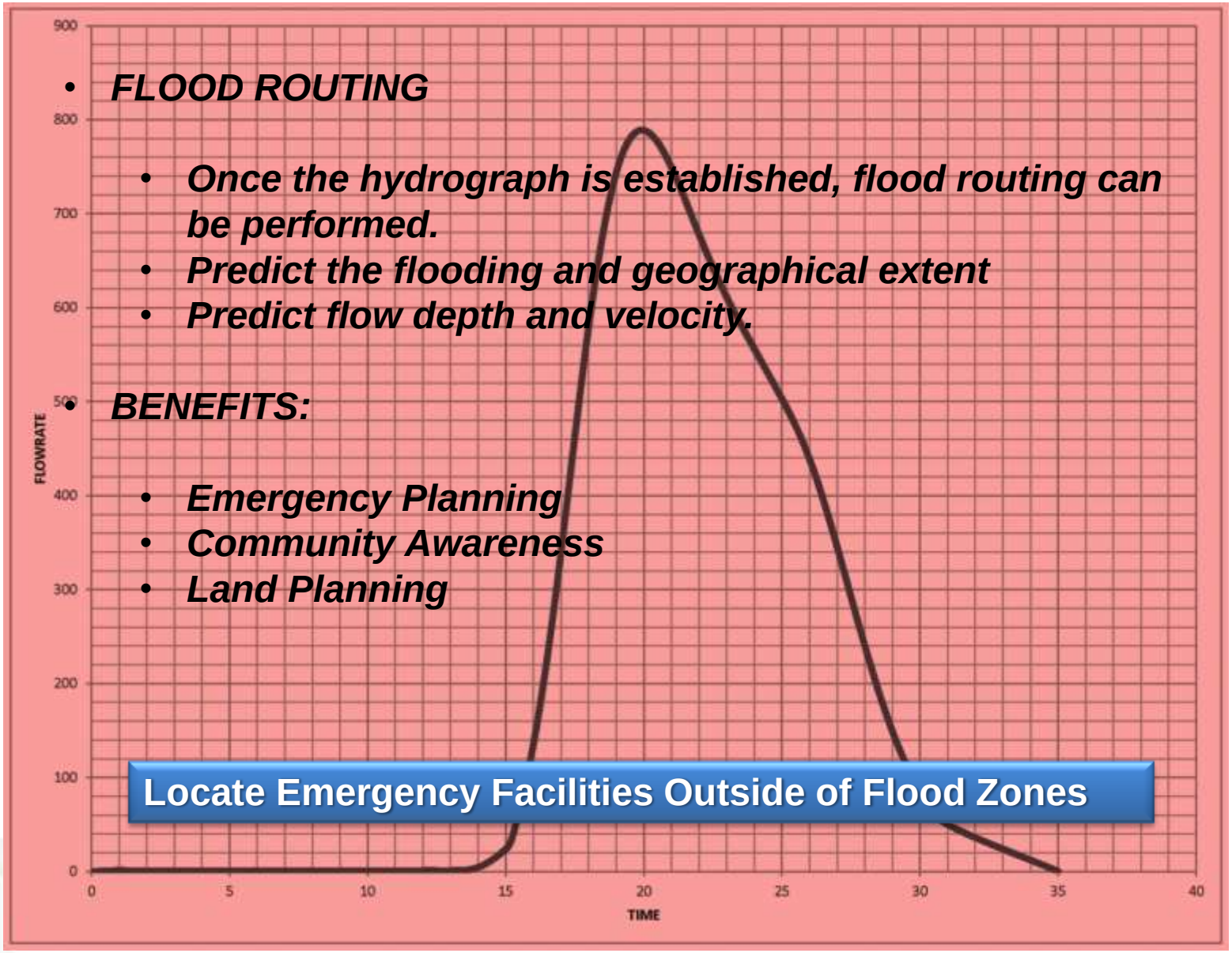
METHODS AND MODELS

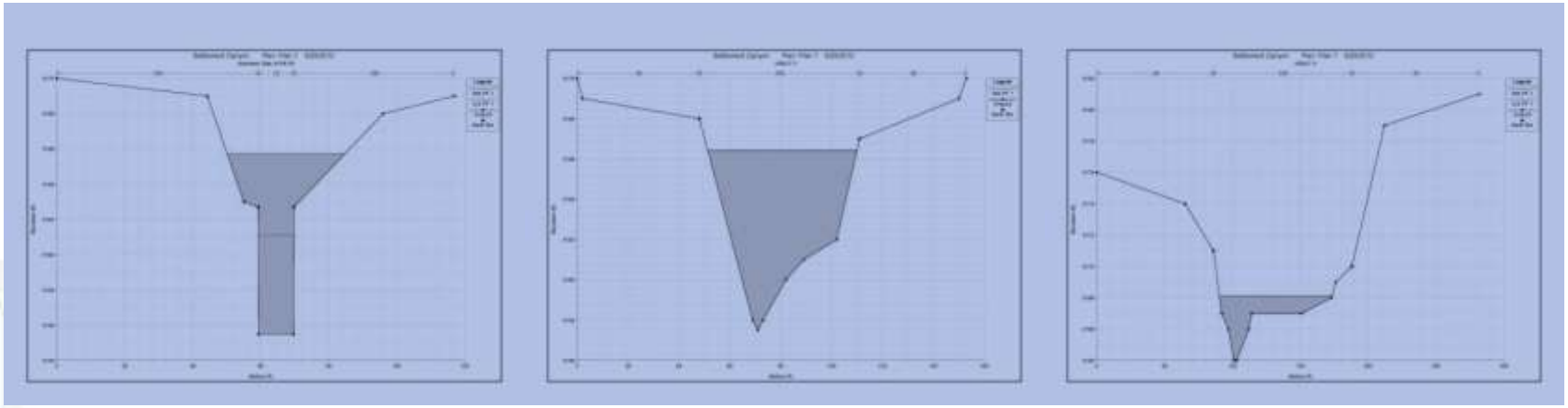


- ***FLOOD ROUTING***
  - ***Once the hydrograph is established, flood routing can be performed.***
  - ***Predict the flooding and geographical extent***
  - ***Predict flow depth and velocity.***
- ***BENEFITS:***
  - ***Emergency Planning***
  - ***Community Awareness***
  - ***Land Planning***

Locate Emergency Facilities Outside of Flood Zones

METHODS AND MODELS

- *FLOOD ROUTING – One Dimensional*
  - *Software Packages:*
    - *HEC-1 (outdated), HEC-HMS*
    - *HEC-2, HEC-RAS*
    - *Many Others*
  - *HEC-RAS*
    - *Steady and Unsteady Flow, Routing, Hydraulics*
    - *New HEC-RAS 5.0 (Beta) has 2 Dimensional Functionality*
  - *Typically Requires Well Defined Cross Sections*



METHODS AND MODELS

- ***FLOOD ROUTING – Two Dimensional Models***
  - ***Routes full hydrograph, not just peak flows (assuming unsteady flow)***
  - ***Model flows vary with time***
  - ***Volume conservation is provided***
  - ***Defined channel is not required***
  - ***Water "Flows in the Model"***

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METHODS AND MODELS

- ***FLOOD ROUTING – Two Dimensional***
  - ***Software Packages:***
    - ***HEC-RAS 5.0 (Beta) Limited Distribution***
    - ***FLO2D***
    - ***Aquaveo – WMS***
    - ***Others***

METHODS AND MODELS

- ***FLOOD ROUTING – Two Dimensional Models***
  - ***HAL Often Uses FLO2D***
    - ***Free version is available***
    - ***Client can receive model with software purchase***
    - ***Accepted by FEMA for hydraulic applications***
    - ***Accepted by Utah Division of Water Rights – Dam Safety Section (Consult with the Dam Safety Staff prior to project to ensure applicability)***

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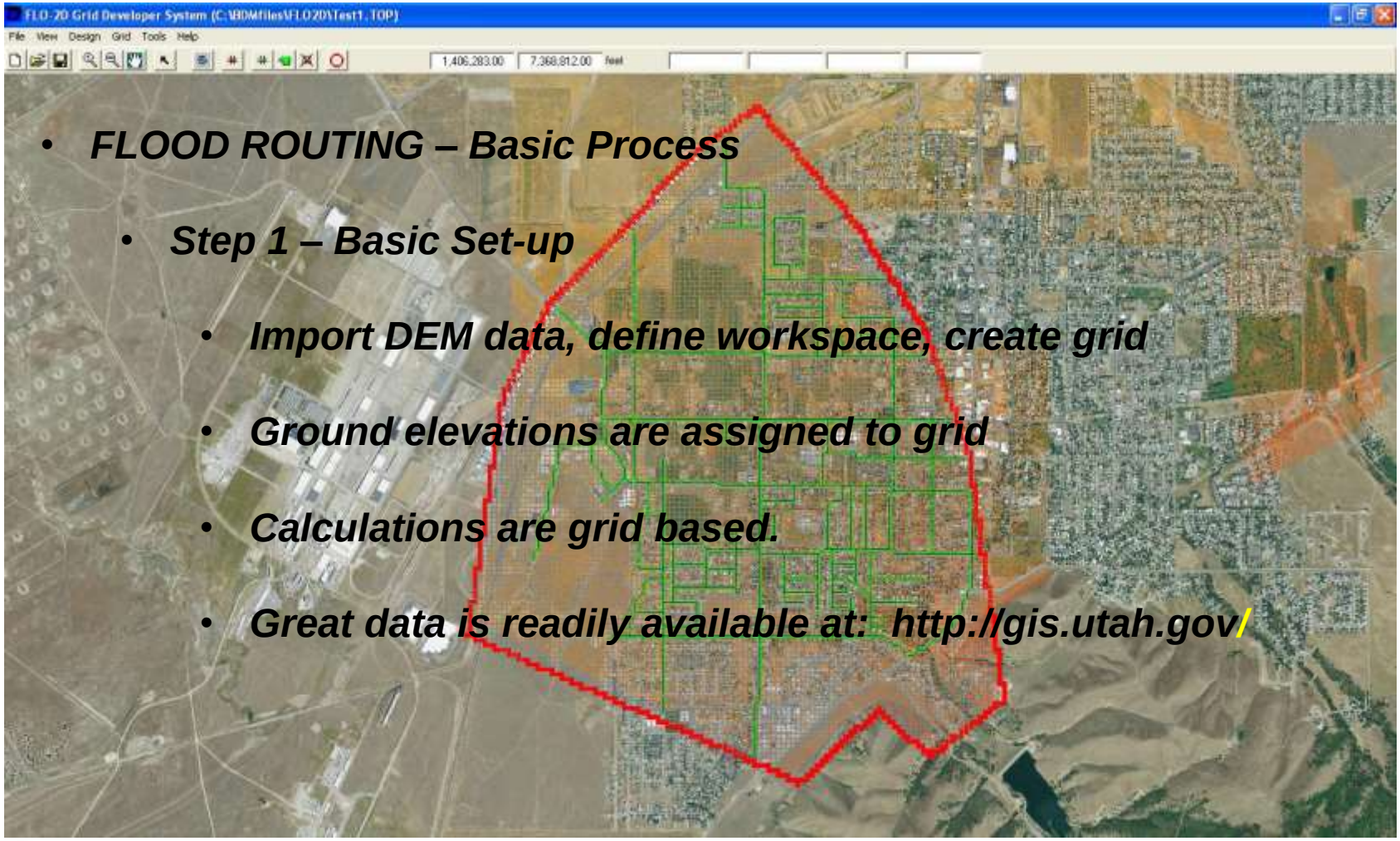
METHODS AND MODELS



- *FLOOD ROUTING – Basic Process*
  - *Step 1 – Basic Set-up*
    - *Import DEM data, define workspace, create grid*
    - *Ground elevations are assigned to grid*
    - *Calculations are grid based.*
    - *Great data is readily available at: http://gis.utah.gov/*

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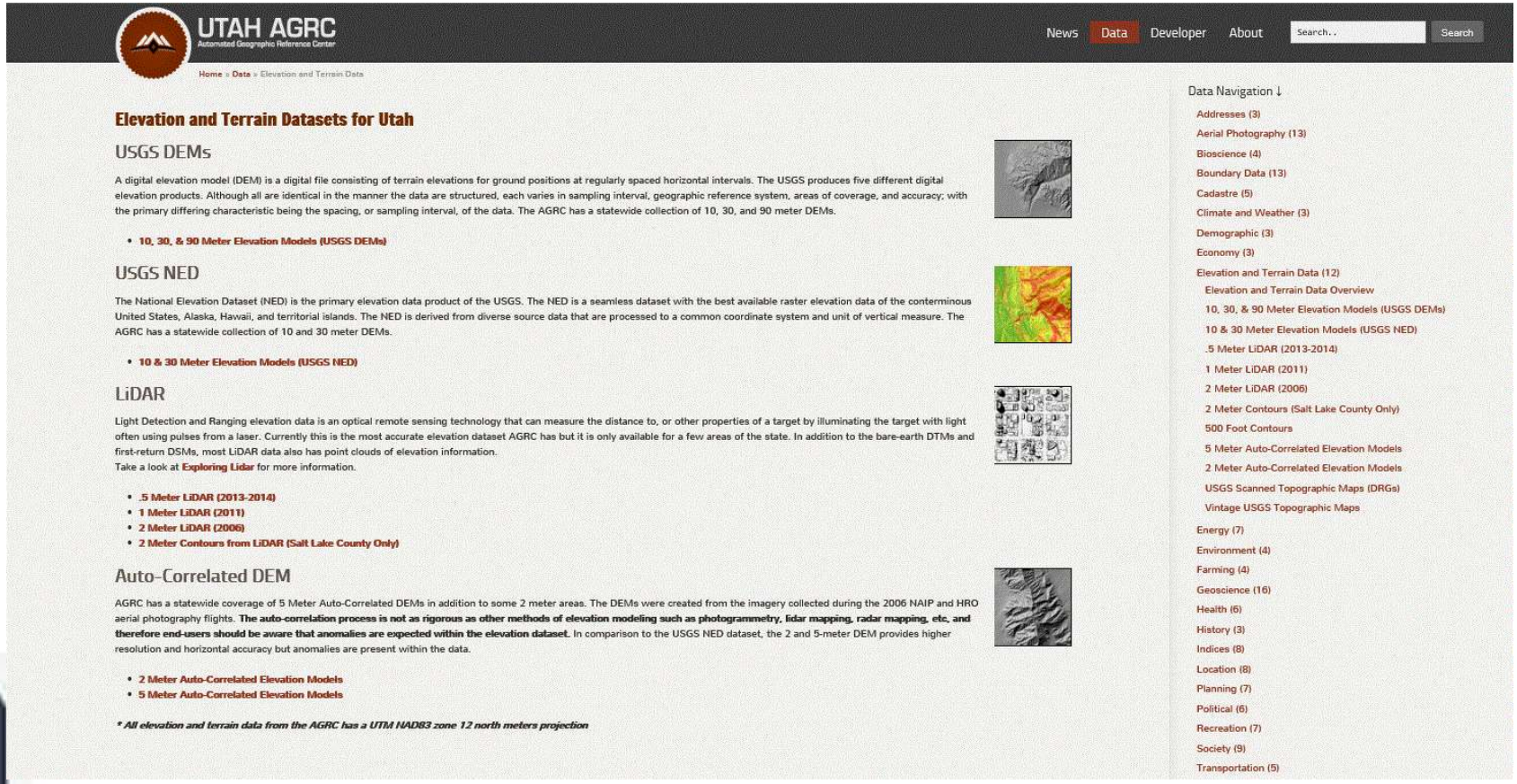
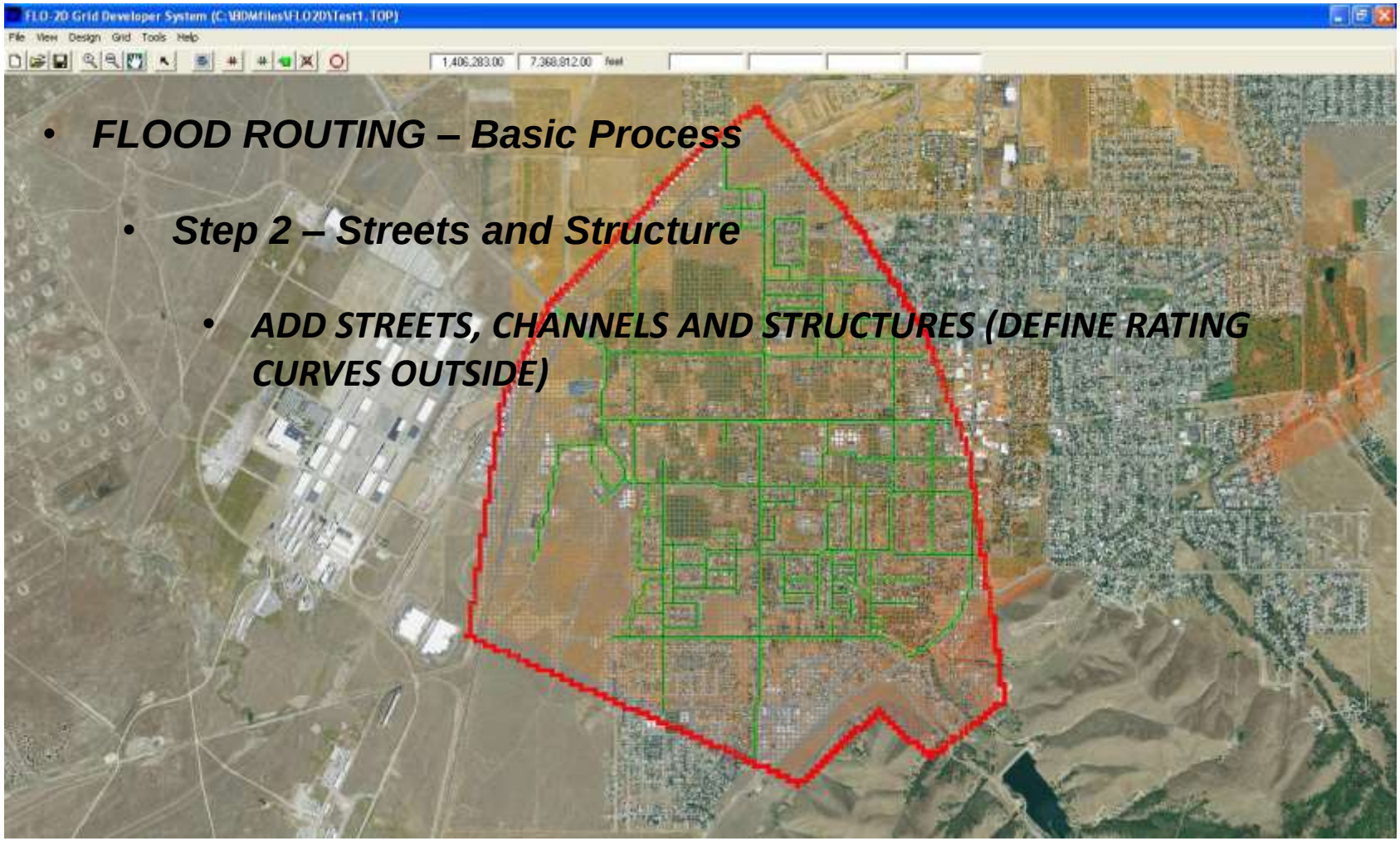
METHODS AND MODELS

- ***FLOOD ROUTING – Data***
  - ***Great data is readily available at: http://gis.utah.gov/***
  - ***Project specific land surveying***
  - ***Project specific aerial surveying***



METHODS AND MODELS



- *FLOOD ROUTING – Basic Process*
  - *Step 2 – Streets and Structure*
    - *ADD STREETS, CHANNELS AND STRUCTURES (DEFINE RATING CURVES OUTSIDE)*

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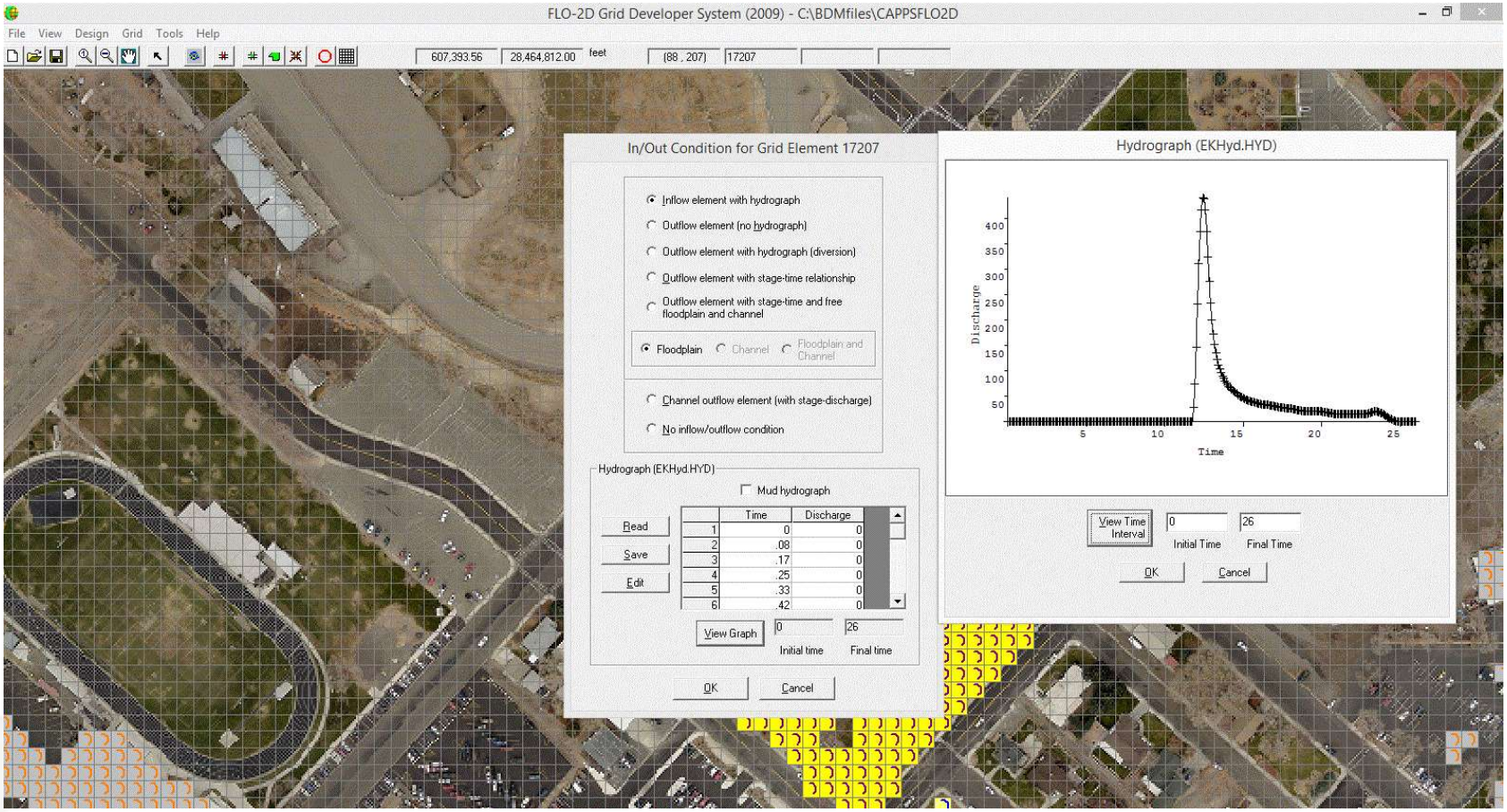
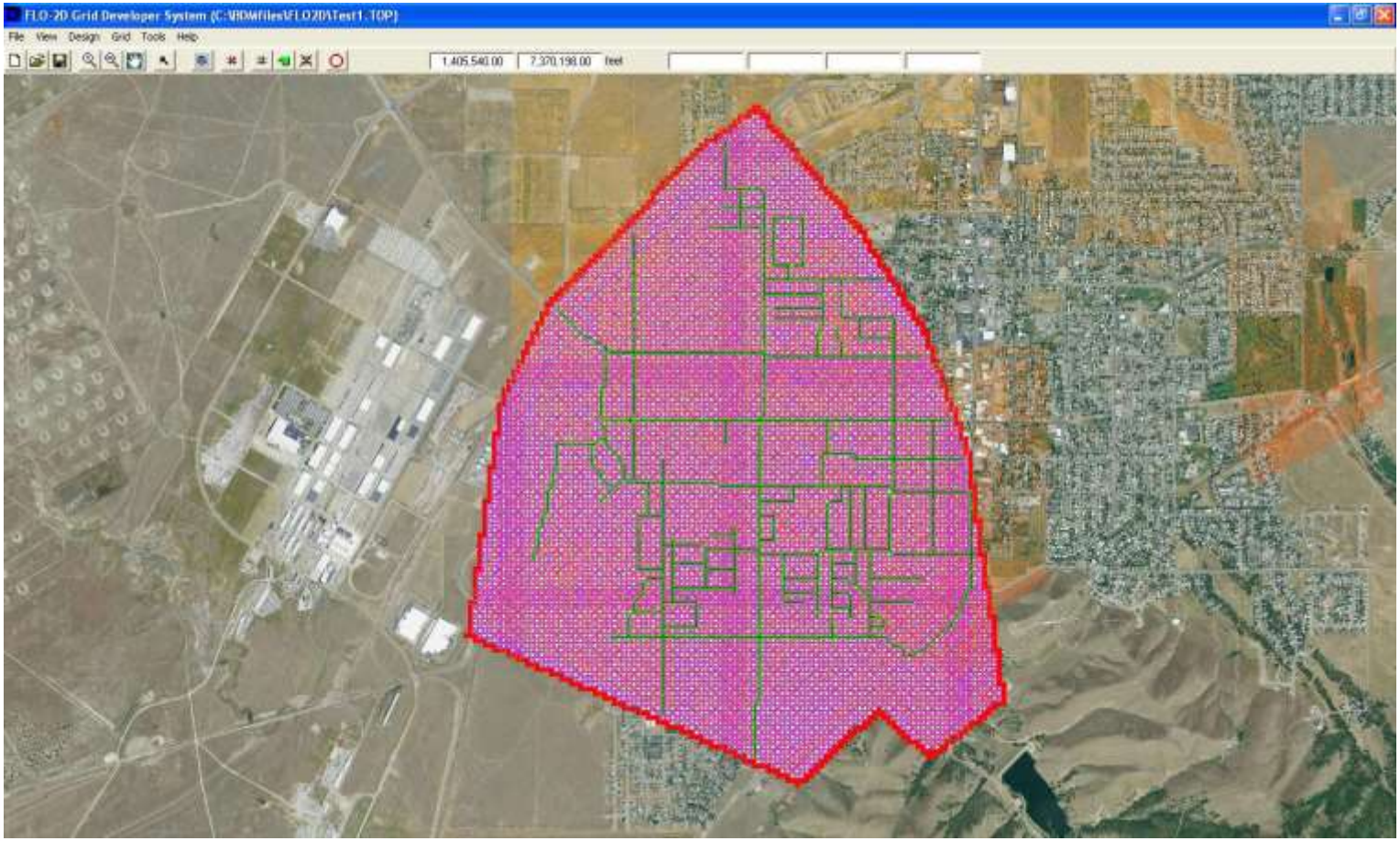
METHODS AND MODELS

- ***FLOOD ROUTING – Basic Process***
  - ***Step 3 – Add Inflows and Outflows***



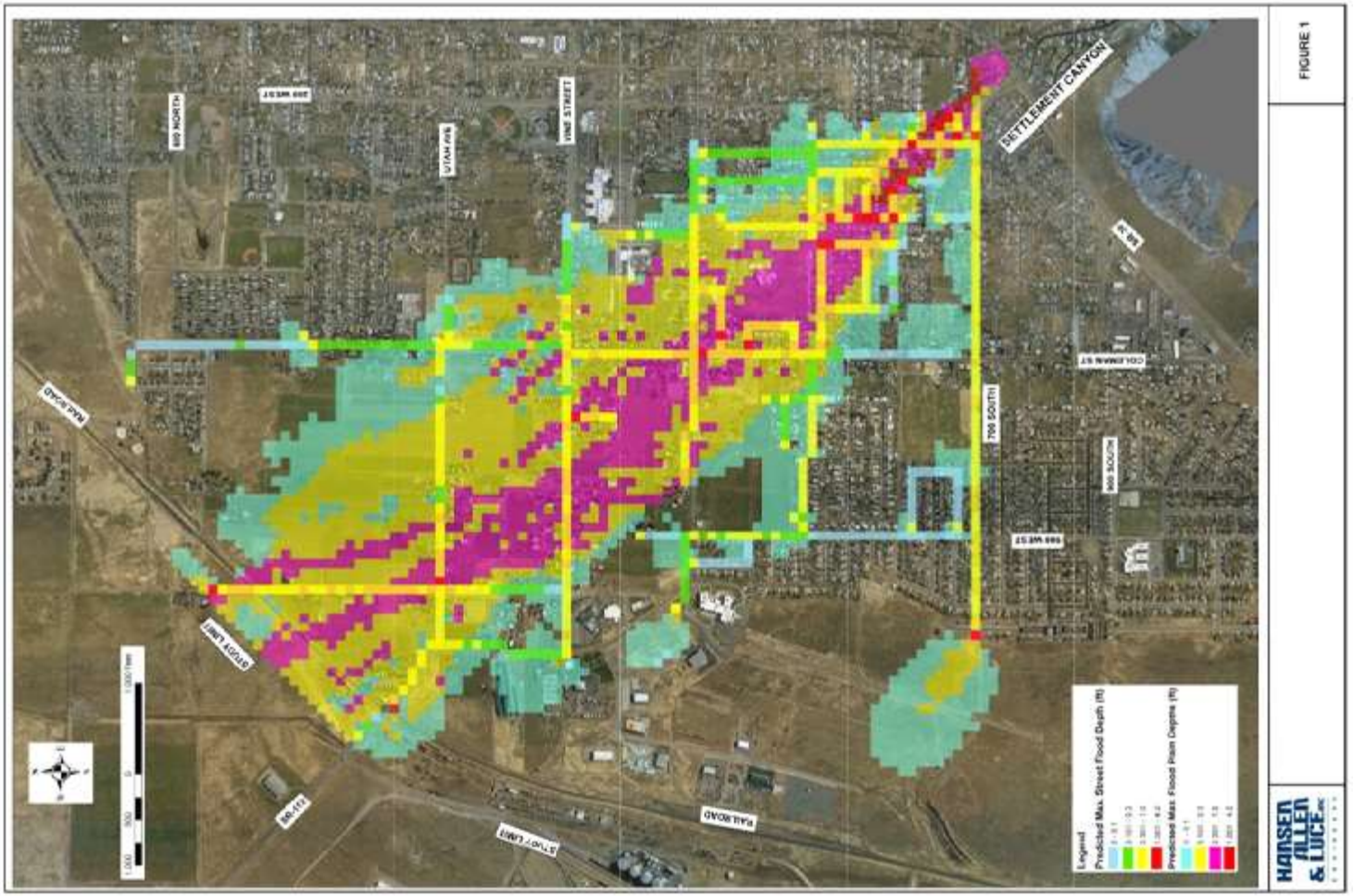
METHODS AND MODELS

- *FLOOD ROUTING – Basic Process*
  - *Step 4 – Define infiltration and blocked areas*



METHODS AND MODELS

- *FLOOD ROUTING – Basic Process*
  - *Step 5 – Interpretation and Results*



CASE STUDIES

- ***EXAMPLE DAM NO. 1***
  - ***Purpose of Dam:***
    - ***Raw Water Intake for Water Treatment Plant***
    - ***Size 550 AF***
    - ***Analysis "Sunny Day Failure"***
    - ***Breach Hydrograph Method: HEC-HMS***
    - ***Elevation Data***
      - ***2 Meter LIDAR from Utah AGRC***

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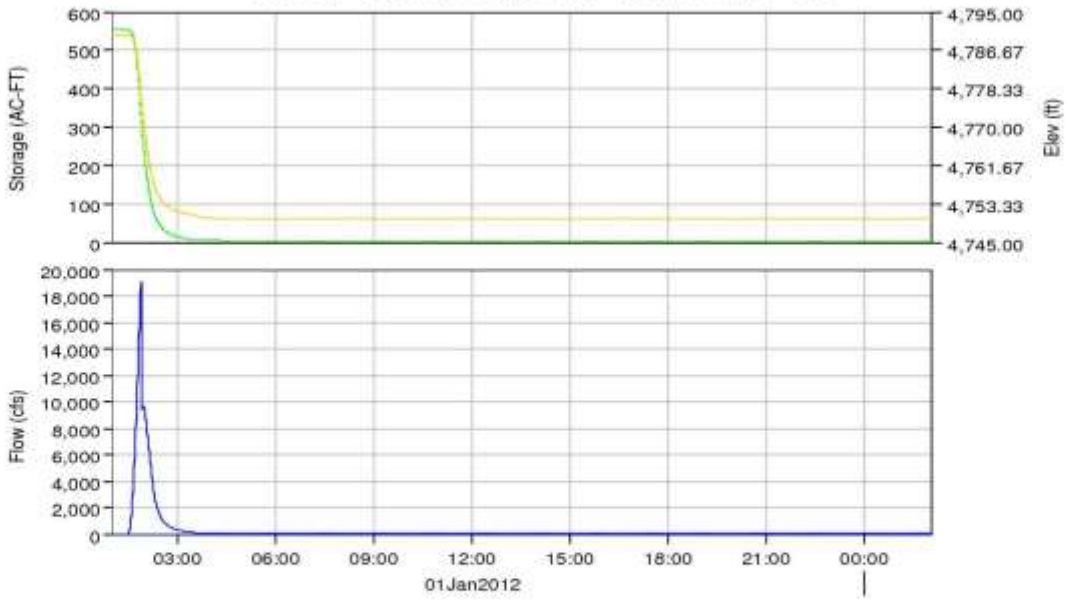
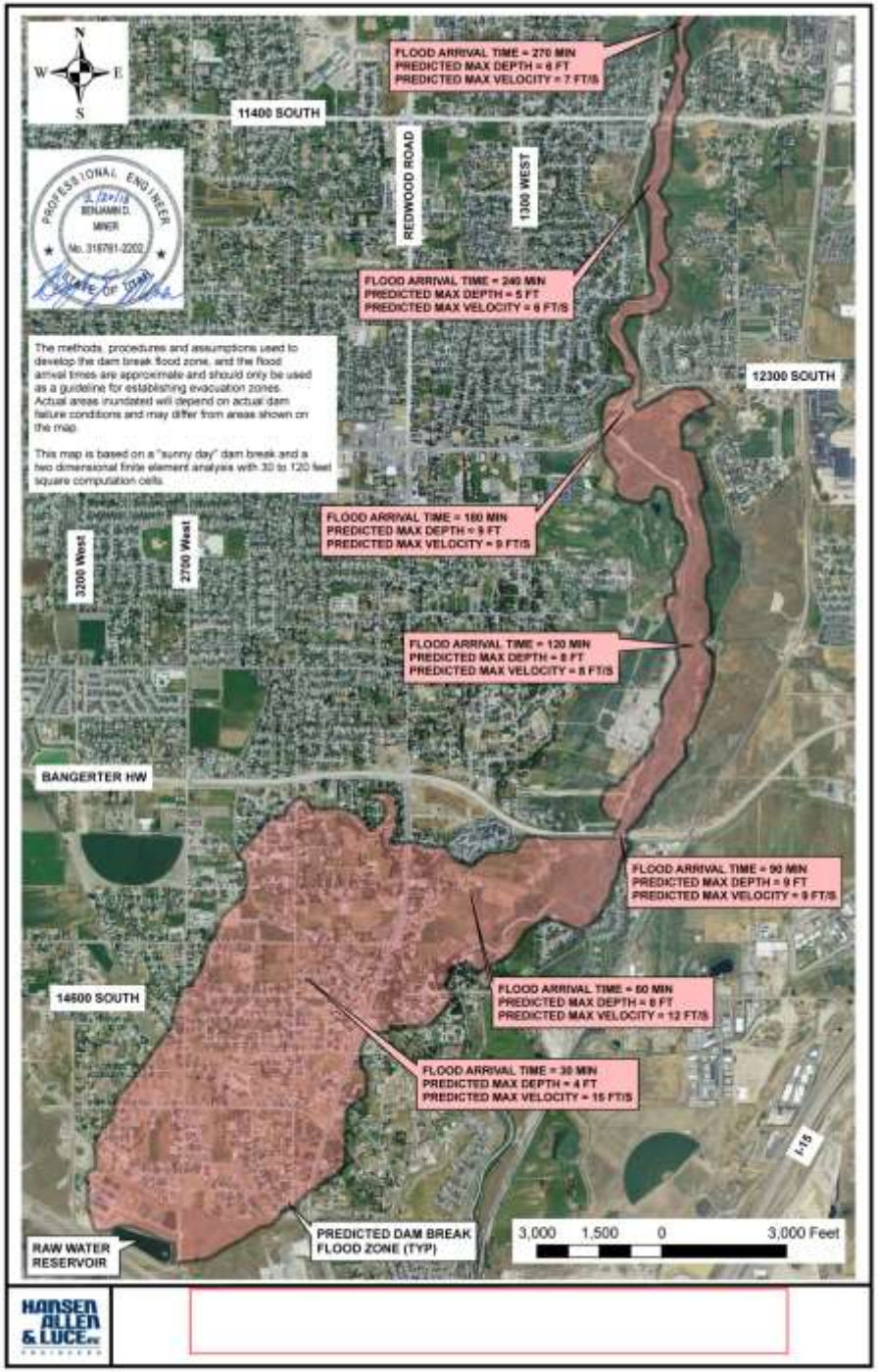
CASE STUDIES

- *EXAMPLE DAM NO. 1*
  - ***Breach Hydrograph (at Dam)***



CASE STUDIES

- *EXAMPLE DAM NO. 1*
  - ***Results***



CASE STUDIES

- ***EXAMPLE DAM NO. 2***
  - ***Purpose of Dam:***
    - ***Municipal Irrigation***
    - ***Size <20 AF***
    - ***Analysis "Sunny Day Failure"***
    - ***Breach Hydrograph Method: HEC-HMS***
    - ***Elevation Data***
      - ***10 Meter DEM from Utah AGRC***

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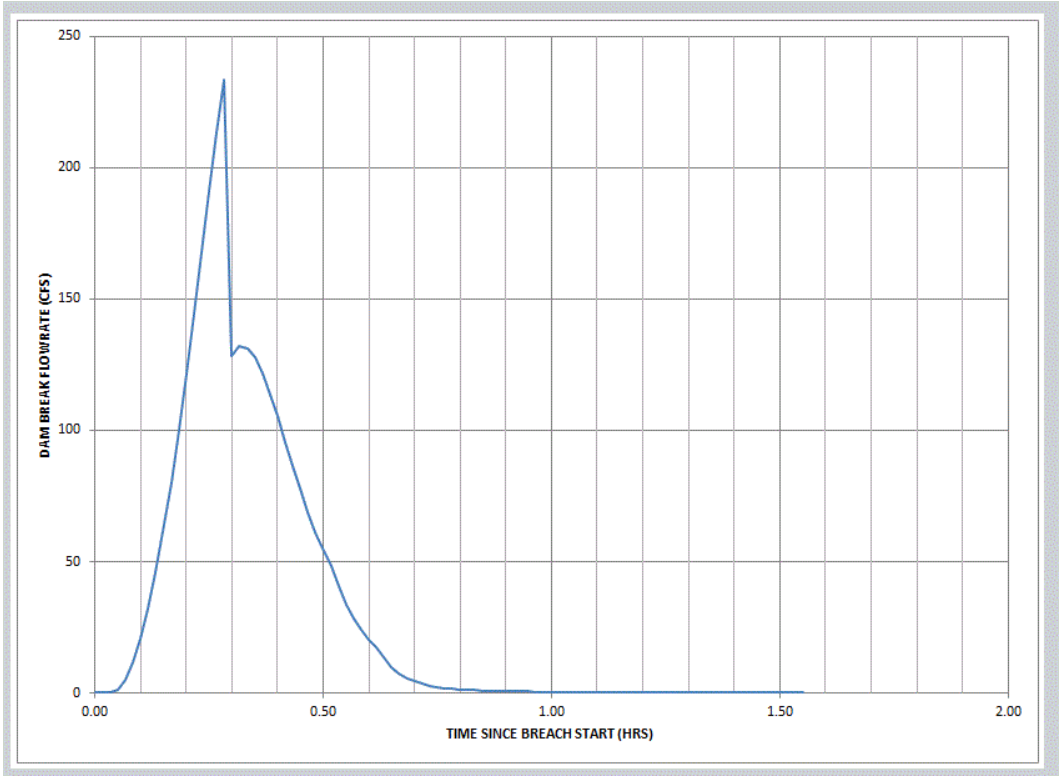
CASE STUDIES

- *EXAMPLE DAM NO. 2*
  - *Breach Hydrograph (at Dam)*



CASE STUDIES

- *EXAMPLE DAM NO. 2*
  - ***Results***

CASE STUDIES

- ***EXAMPLE DAM NO. 3***
  - ***Purpose of Dam:***
    - ***Municipal Irrigation***
    - ***Size <20 AF***
    - ***Analysis "Sunny Day Failure"***
    - ***Breach Hydrograph Method: HEC-HMS***
    - ***Elevation Data***
      - ***10 Meter DEM from Utah AGRC***

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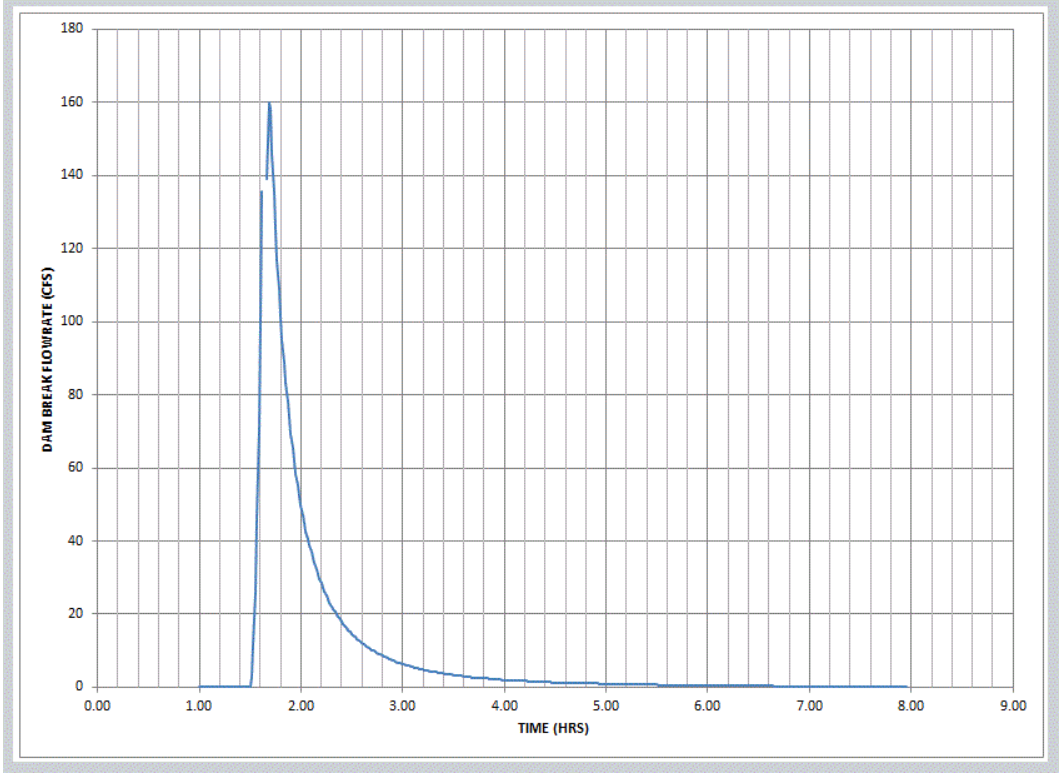
CASE STUDIES

- *EXAMPLE DAM NO. 3*
  - *Breach Hydrograph (at Dam)*



CASE STUDIES

- *EXAMPLE DAM NO. 3*
  - ***Results***

CONCLUSIONS

- ***The Emergency Action Plan relies on an accurate inundation area map.***
- ***Two dimensional models can be a cost effective approach to model complex downstream scenarios.***
- ***Two dimensional models are easily attainable and becoming easier to use.***
- ***Two dimensional models often yield better results that traditional one dimensional models.***

QUESTIONS ?