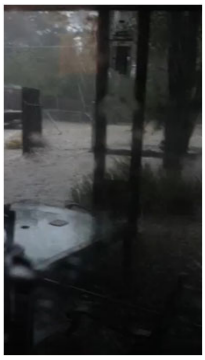
Modeling a Railroad Embankment Failure as a Dam Breach

Gerald E. Blackler, PhD, PE, DWRE, M.ASCE
David Williams PhD, PE, DWRE, PH, CFM, CPESC, F.ASCE, F. EWRI

Scenario

- On October 30th, 2015 a large rainfall event (frequencies have been debated) around the Arroyo Doble Neighborhood, (South of Austin, Texas)
- A Railroad Embankment upstream of the neighborhood, that had no drainage infrastructure, failed.
- This sent a gush of water into the downstream neighborhood and flooded many homes.



Scenario

Image of Railroad Embankment after Failure

Items to note from Image

1. laydown of vegetation.
2. Movement of Ballast Material (rock, gravel).
3. Functions like a low head dam (less than 10 feet), or embankment, and its failure caused a massive flood wave

Home Owners' Claimed Damages

- Railroad Denied any Fault
- Experts Dr. Blackler and Dr. Williams were hired to help the Homeowners'.
- Work involved,
  - ✓Modeling the Embankment Failure.
  - ✓Modeling the Floodwater. (Forensic Analysis)
  - ✓Calibrating that model to observed events.
  - ✓Presenting a design solution to the Railroad Standards
  - ✓Presenting what may have happened if the Railroad had followed their own standards.

3D CFD (Computational Fluid Dynamic Model) of Floodwave on houses from Breach

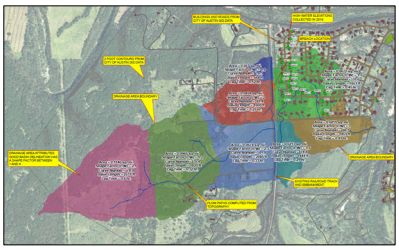
Hydrologic Analysis

Basin delineation, land use, soils, lag time, and time of concentration.

Rainfall:
- IDW from NOAA Gages
- Eventually used opposing expert's analysis to strengthen our position.

Runoff: SCS Methodology, with AMC I, and II tested.

Frequency:
Debates over frequency occurred, we concluded just over a 100-year event, railroad said so large nothing could be done, act of god.

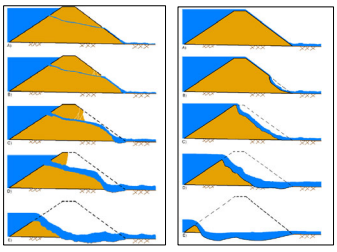


Hydrologic map developed by Dr. Blackler

Breach Analysis

Storm Type	Breach Type	Peak Discharge (cfs)
6 Hour	Piping Linear	2,446
	Piping S Curve	3,493
	Overtopping Linear	2,214
	Overtopping S Curve	3,996
12 Hour	Piping Linear	1,173
	Piping S Curve	3,686
	Overtopping Linear	1,127
	Overtopping S Curve	1,120
24 Hour	Piping Linear	2,050
	Piping S Curve	2,975
	Overtopping Linear	1,519
	Overtopping S Curve	2,904
Max		3,996
Min		1,120
Average		2,392

Overtopping and Piping Failure Analysis



Criticisms to Breach Analysis

- ➢One Expert stated it was overtopping flow, and estimated the amount of flow over a weir, and denied any breach occurred.
  - ✓We used his math to show this could not have happened. (Awkward Deposition)
- ➢Next Expert did not criticize the general analysis, but instead commented that the timing, and selection of breach timing between linear and sinuous breaching is very sensitive.
  - ✓We did not dispute and rebutted that we provided a range for that very reason.

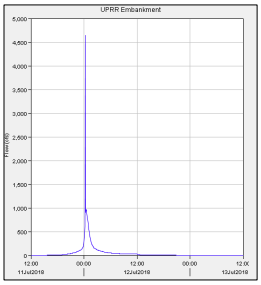


Image of Discharge and Breach Hydrographs

Findings From Forensic Analysis

- Opposing Experts Denied Breach All Together,
  - Our Rebuttals completely dismissed that theory, that opposing expert was no longer used in the case and the railroad hired a different expert.
- Railroad also hired a rainfall (meteorologist). We had very little, to no disputes between each other.
- In fact, we used the metrological data form the opposing expert to support our analysis.
- We modeled the
  - Depth, Velocities, and Damages, and also
  - "what if scenario" asking, what if the Railroad had satisfied their own design standards, and the rainfall from their own experts occurred?

Findings From Forensic Analysis

- Mapped each structure, with depth, velocity, and energy.

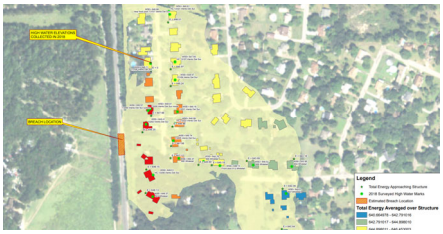
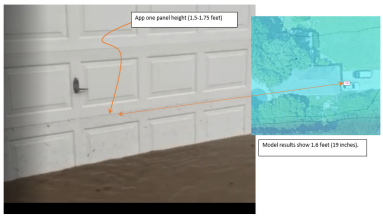


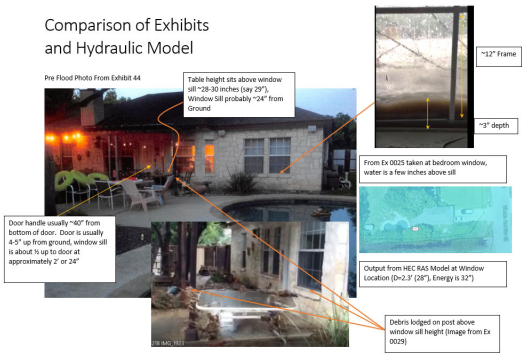
Image from one of the many GIS Maps produced as Evidence

Calibration (“Check”) on the Analysis

- A lot of information was available to calibrate our model, we had videos, highwater marks, and location of moved vehicles.

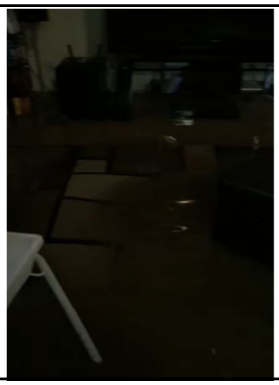


Comparison of Exhibits and Hydraulic Model



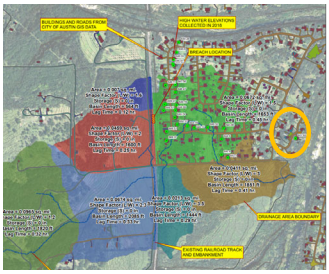
What's the Manning's Roughness or Energy Loss Through a house?

Some argue "blocked" but video evidence shows, people open doors, water goes through windows, certainly not high, but not zero.



Motions for Summary Judgements (MSJ)

- Only one MSJ was allowed by the Judge
- One MSJ, that houses on the far east end (to the right), did not accrue damages and were taken out of the case.



Conclusions

- Applying unsteady breach analysis and unsteady flow using 2- and 3-dimensional software (2D and 3D) can be very effective in forensic analysis for cases involving flooding and flood damages to structures.
- Publicly and Privately available software can make this task reasonable in time and budget for retaining attorneys. (Public software is preferred for Legal Work).
- Calibration of the models fit well with observed data.
- Visual aids help tell the story to non-technical people such as attorneys, judge and jurors.
- The Case Settled, the homeowners got paid for damages, the railroad admitted no fault and paid if the homeowners absolved them of any fault, preventing case precedence.

Thank you for your Time,
Questions?