Risk Assessment in Hydrology and Hydraulics

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Lessons Learned from the Analysis of the El Aguacate River, Guatemala

Presented by Travis Haas, CFM

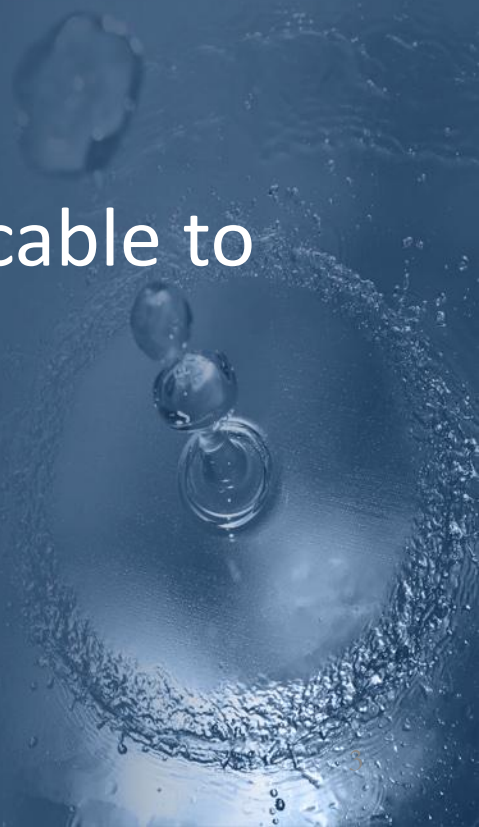
Presentation Overview

- Project Background
- Hydrologic and Hydraulic Risk Assessment Techniques
- Project Photos

Objectives:

- Summarize the application of three techniques used in the hydrologic and hydraulic risk assessment of a rural bridge design.

- Show how these techniques are applicable to many H&H projects.



Project Background

- Bridge Replacement, Aguacate Guatemala
- Engineers Without Borders (EWB), WI Professional Partners

Project Background

- Existing Bridge – Built 1987
- Concrete T Beam
- 32’ Span

Project Background

- Structural Analysis Indicates Design is Inadequate – Low Quality Concrete

Project Background

- Shallow Abutments – No Footings

Hydrologic and Hydraulic Risk Assessment

QUESTIONS

- Is Existing Bridge Site the Best Location?
- Is Existing Bridge Geometry Safe?
  - Span
  - Height
  - Configuration

Hydrologic and Hydraulic Risk Assessment

CHALLENGES

- Limited Data
- Communication
- Low Budget

Hydrologic and Hydraulic Risk Assessment

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APPROACH

- Calibration of Model to Field Observations
- Iterative Approach Between Hydrology and Hydraulics Models
- Testing Catastrophic Scenarios – What If?

Model Calibration

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Options

- Stream Gauge Data
- Historic flood data
- Field Evidence

El Aguacate Model Calibration

- No Existing Models
- No Stream Gauge Data
- No Historical Flood Data
- Villagers indicate bridge has not overtopped
- Water surface has reached bridge low chord

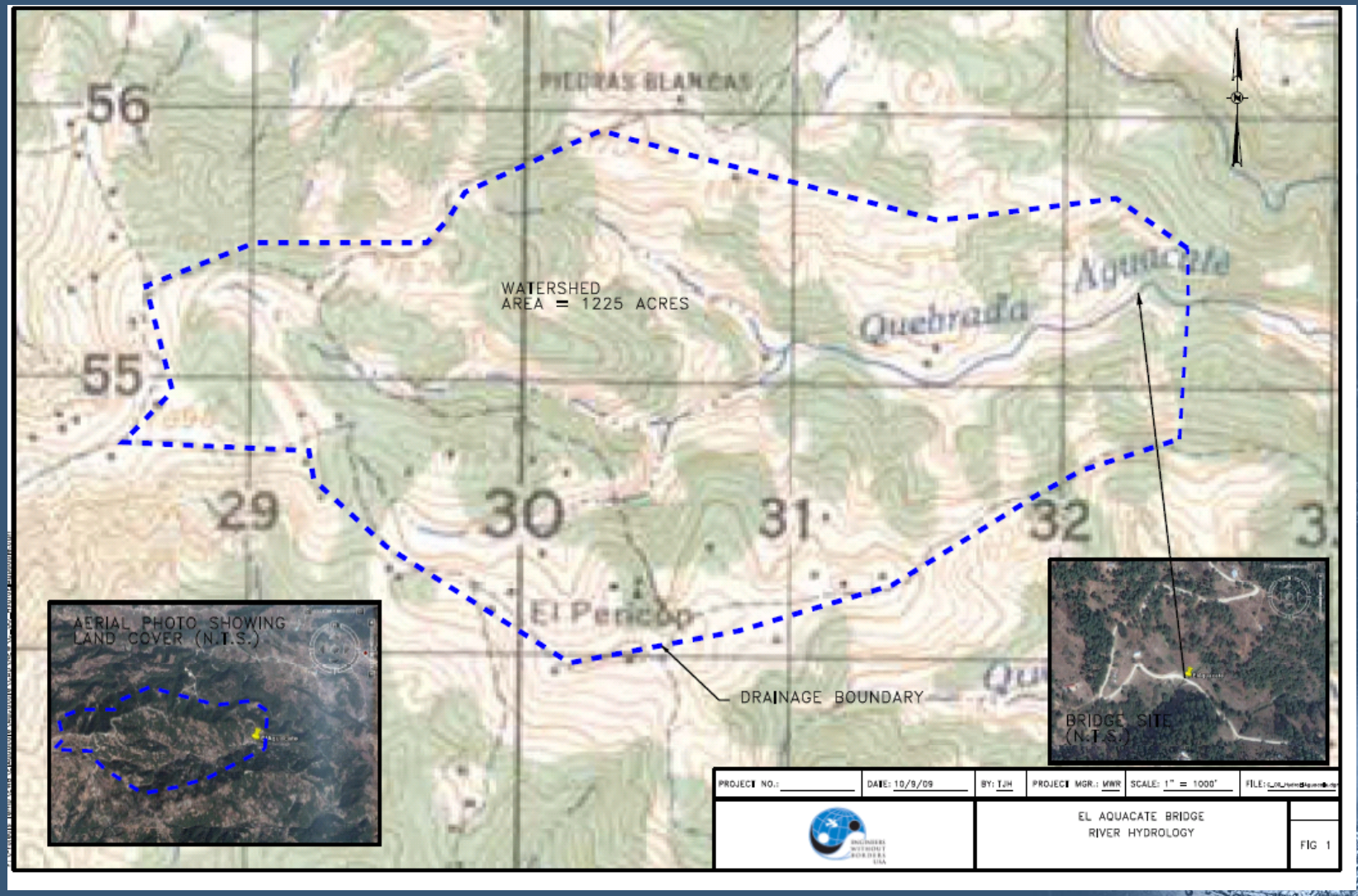
Hydrologic and Hydraulic Analysis

- Hydrologic Modeling Approach – TR-55
- Rainfall Data (INSIVUMEH)
  - 10-yr/24-hour – 4.65 in
  - 50-yr/24-hour – 5.98 in
  - 100-yr/24-hour – 6.57 in

El Aguacate Watershed

- 1225 Acres (10 M topography)
- Predominantly Woods and Grass Combination (Aerial photography)

El Aguacate Watershed

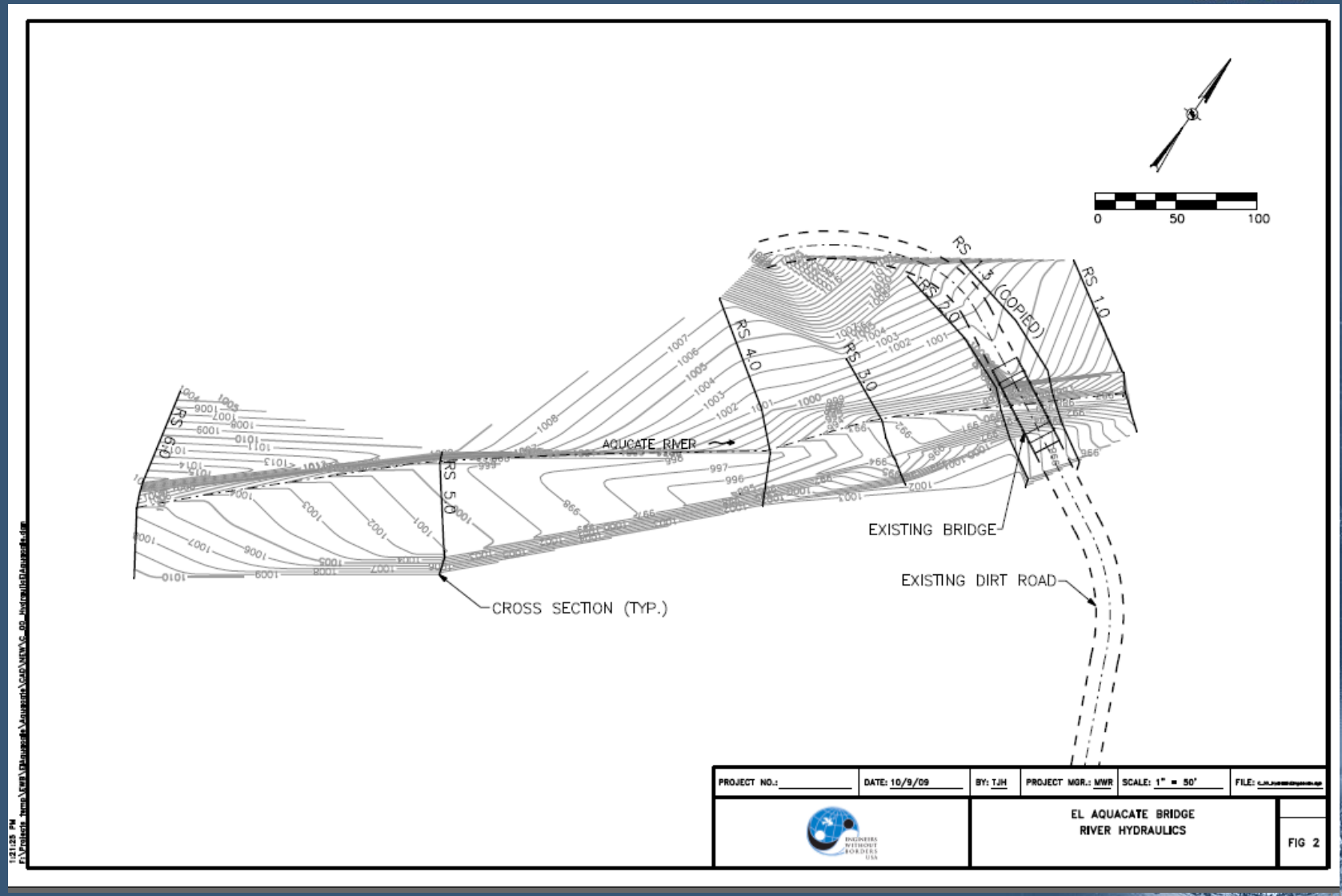


Hydrologic and Hydraulic Analysis

- Hydraulic Modeling Approach – HEC RAS
- Assumed negligent stream base flow; used flow directly from Hydrologic Analysis
- Cross section geometry - field survey
  - 6 stream cross sections
  - Bridge geometry and road profile
- Stream characteristics – site photos

Stream Characterstics

Stream Cross Sections



Model Calibration

Try to match field observation

- Model indicates water surface is more 6 feet below bridge low chord for 100 year

- Increase Mannings n

- Modified flow (2,900 cfs)

Hydrology/Hydraulics Iteration

Test Hydrologic Model using Hydraulic Results

- Test Surface Conditions
- Time of Concentration
- Watershed Area
- Rainfall Depths

El Aguacate Hydrology/Hydraulics Iteration

Tried to produce flow in Hydrology Model

- Adjusted surface conditions
- Adjusted drainage area
- Adjusted rainfall depths
- Model indicates:
  - 100% impervious doesn't produce flow
  - Rainfall Depth = 14.7 inches
  - Watershed area increased 3.5 times

Catastrophic Scenarios – What If?

- Special Geographic Conditions / Stream Debris
  - Climate
  - Topography
  - Channel Characteristics
- Bridge Overtopping

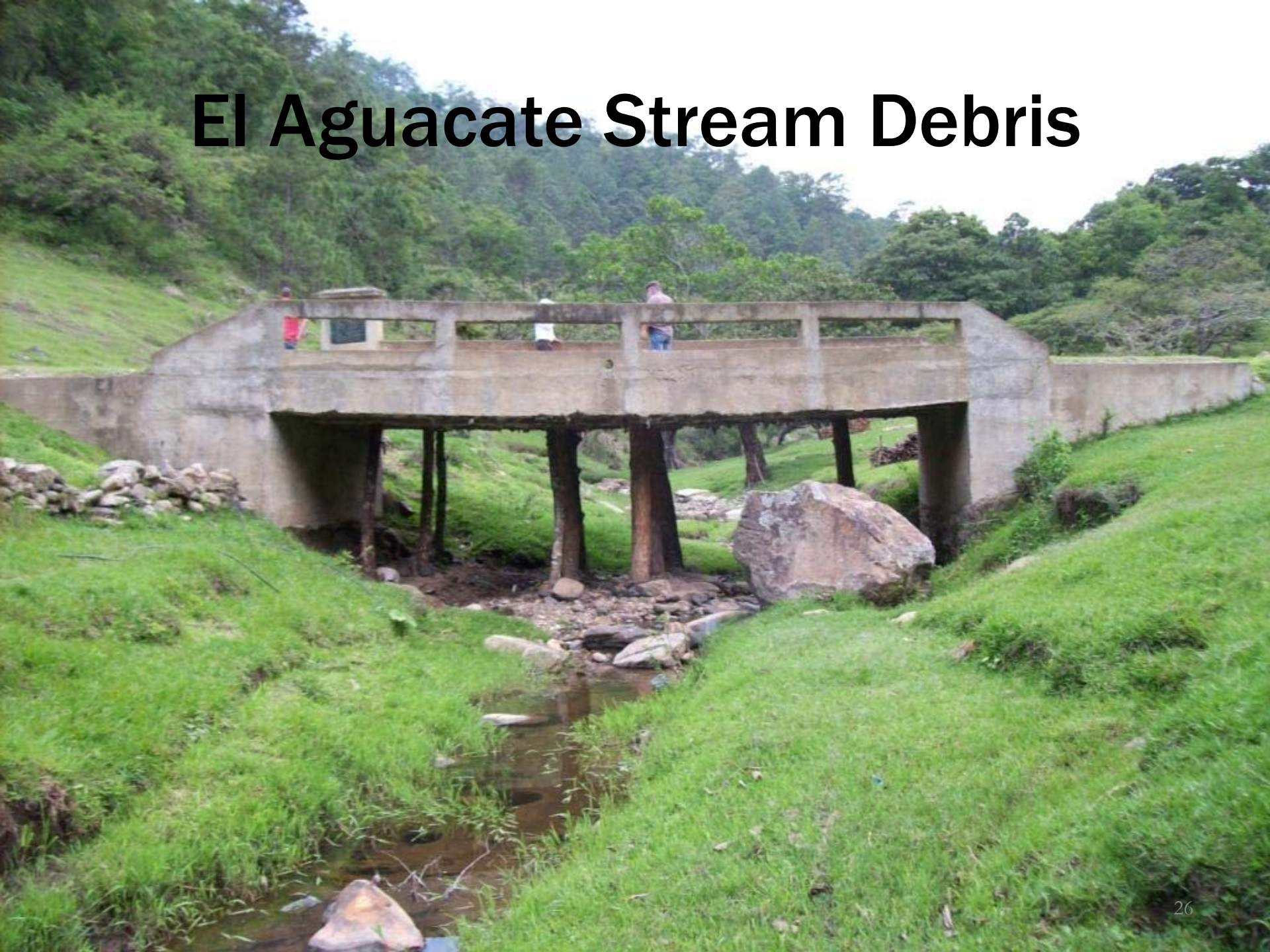
El Aguacate Catastrophic Scenarios

- Design bridge opening to pass debris
- Special Geographic Conditions – mudslides produce “Dam Break” effects

Stream Debris


Stream Debris

El Aguacate Stream Debris

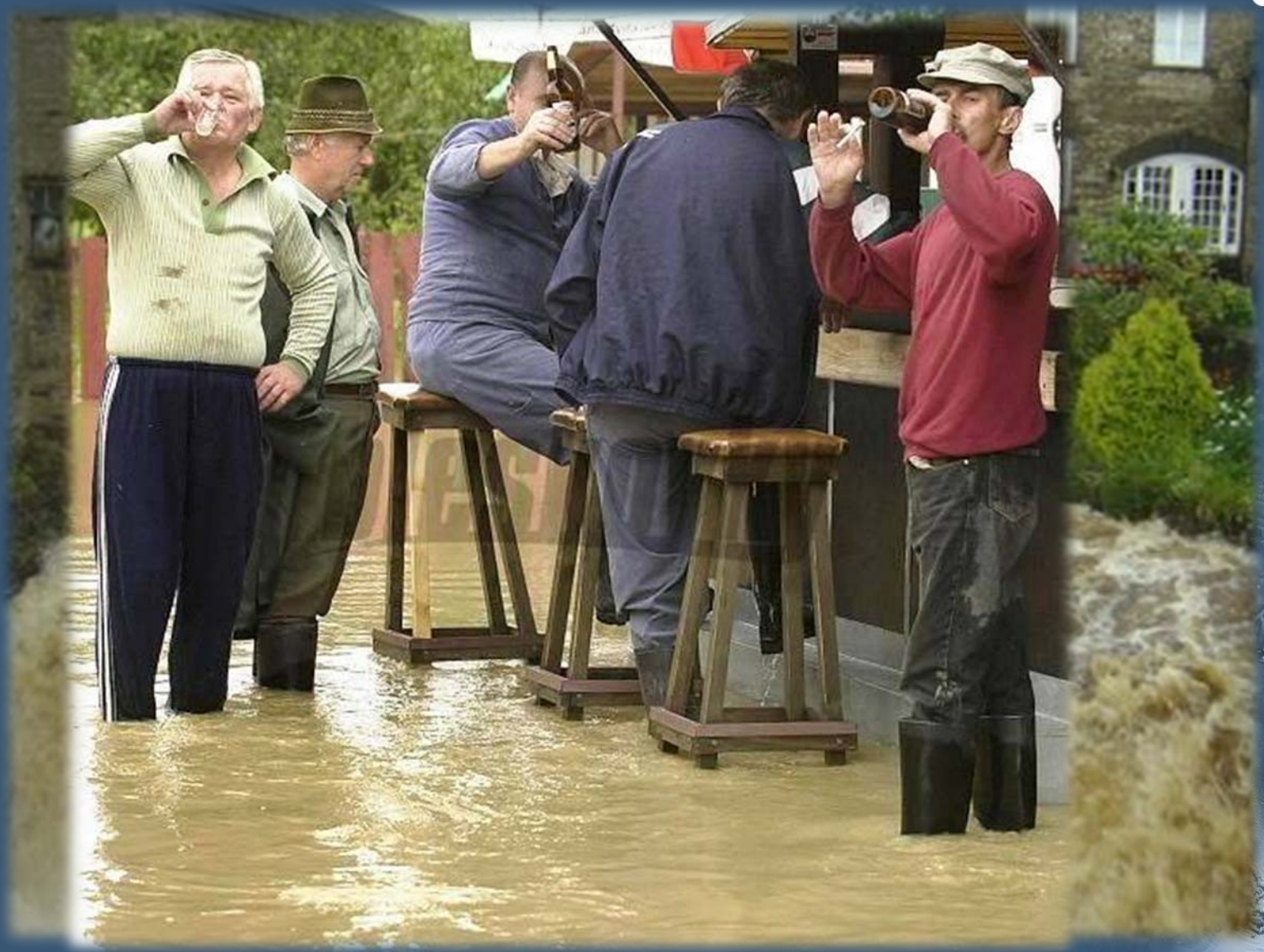


El Aguacate Catastrophic Scenarios

- Design roadway approach to prevent bridge overtopping

- Emergency Planning – Bridge/Road Closure Plan

Bridge/Road Closure Plan



Risk Assessment Lessons Learned

- Revise assessment approach as necessary
- Collaborate during assessment / Subject assessment to scrutiny – peer review

Project Photos

Bridge Construction

Bridge Construction

Bridge Construction

Bridge Construction

Bridge Construction

Bridge Construction

Bridge Construction

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