US Army Corps of Engineers New Mexico Silver Jackets

Alluvial Fans

Please add your name and email address to the chat to receive a CEC Certificate for this webinar.

USACE Silver Jackets

- USACE Silver Jackets is a component of the National Flood Risk Management Program (NFRMP)
- State (NM Department of Homeland Security and Emergency Management) Led Teams with regular meetings
- Interagency Program to Reduce Flood Risk throughout New Mexico
- Interagency Projects
  - Competitive Project Proposals
  - 12 to 18-month Projects

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New Mexico Department of Homeland Security and Emergency Management

New Mexico Post-Fire Flood Risk Education

Fill gaps for post-fire technical support to understand flood risk post-fire, possible mitigation strategies, and resources and programs to provide long-term fire recovery support. Topics will inform and address risks associated with:

- **Dam Safety**
- **Floodplains**
- **Flood After Fire**
- **Alluvial Fans**

The New Mexico Post-Fire Flood Risk Education project will empower communities in New Mexico to be better prepared for flood events after wildfire season.

New Mexico Flood Risk Webinar Series

Please join us for a webinar series about different types of **Flood Risks** across the State of New Mexico.

DAM SAFETY	FLOODPLAINS	FLOOD AFTER FIRE	**ALLUVIAL FANS**
21 OCT 2025	18 DEC 2025	19 FEB 2026	**23 APR 2026**
			9:00-10:00AM

Continuing Education Credits (CECs) will be offered through the US Army Corps of Engineers upon completion of individual sessions.

Sessions are **60** minutes, held virtually, with **30** minutes of recorded presentation and **30** minutes of question and discussion. Meeting instructions will be provided with induvial series invites.

APRIL PRESENTER: P. KYLE HOUSE, Ph.D.

UNIVERSITY OF ARIZONA

ARIZONA GEOLOGICAL SURVEY

RESEARCH SCIENTIST IV

TUSCON / FLAGSTAFF

Interagency partners will present on **dam safety, floodplains, flood after fire,** and **alluvial fan** risks.

ARIZONA GEOLOGICAL SURVEY AZGS

US Army Corps of Engineers. Albuquerque District

New Mexico Flood Risk Webinar Series

Alluvial Fans

P. Kyle House, Ph.D.
University of Arizona, Arizona Geological Survey

Alluvial Fan Flooding

Geomorphology, Hazard Recognition, and Risk in Arid Landscapes

P. Kyle House | Arizona Geological Survey | April 23, 2026

Talk Overview

01 **What is an Alluvial Fan?**

Formation, morphology, and common setting

02 **Getting to Know Alluvial Fans**

Geologic mapping, Aerial imagery, and LiDAR interpretation

03 **Fan Mapping & Hazard Assessment**

Tools, methods, for geologic mapping

04 **Case Examples and Approaches**

Real events and lessons learned

What is an Alluvial Fan?

The ~ubiquitous landform where Mountains meet the valley floor

Alluvial Fan: Definition & Origin

- Cone-shaped sedimentary deposit formed where a stream exits a confined canyon onto an open valley
- Apex at the canyon mouth; fan spreads radially downslope toward the toe
- Common in arid and semi-arid environments with episodic, high-energy runoff
- Sediment sizes range from boulders (proximal/apex) to fine sand and silt (distal/toe)
- Individual fan or part of a coalescing bajada — a continuous apron of fans

Key terms: Apex · Mid-fan · Toe · Bajada · Piedmont

Figure: Google Earth, 2013 image of the Lucy Gray alluvial fan in Ivanpah Valley, along the border or NV and CA.

How Alluvial Fans Form

1 Uplift, Incision, sediment transport

Tectonic activity steepens mountain fronts; streams cut deep canyons with abundant sediment supply

2 Flash Floods and Debris Flows

Intense rainfall (often convective storms) mobilizes sediment; high-velocity flow exits the canyon

3 Hydraulic Expansion

Flow abruptly widens and decelerates at piedmont; sediment rapidly drops out of transport, distributary channels form

4 Repeated Avulsion

Channel shifts laterally over time, distributing sediment across the fan surface in successive lobes.

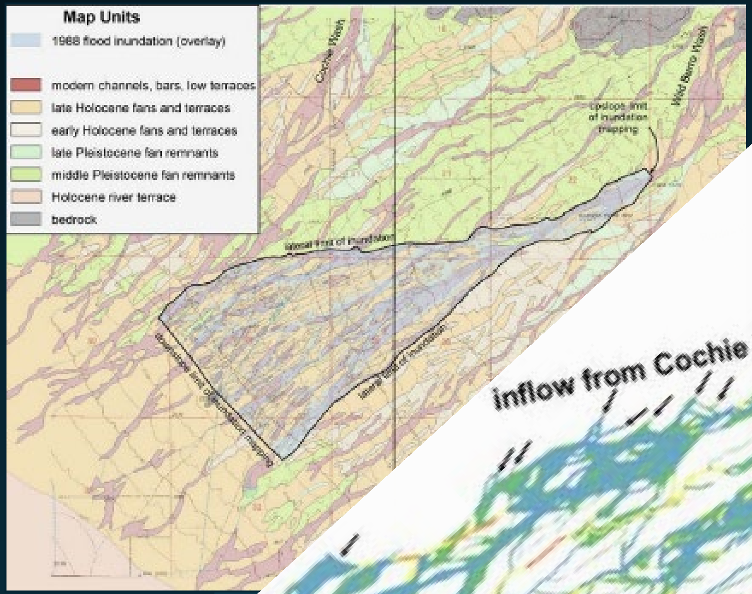
Sheetfloods & Streamfloods

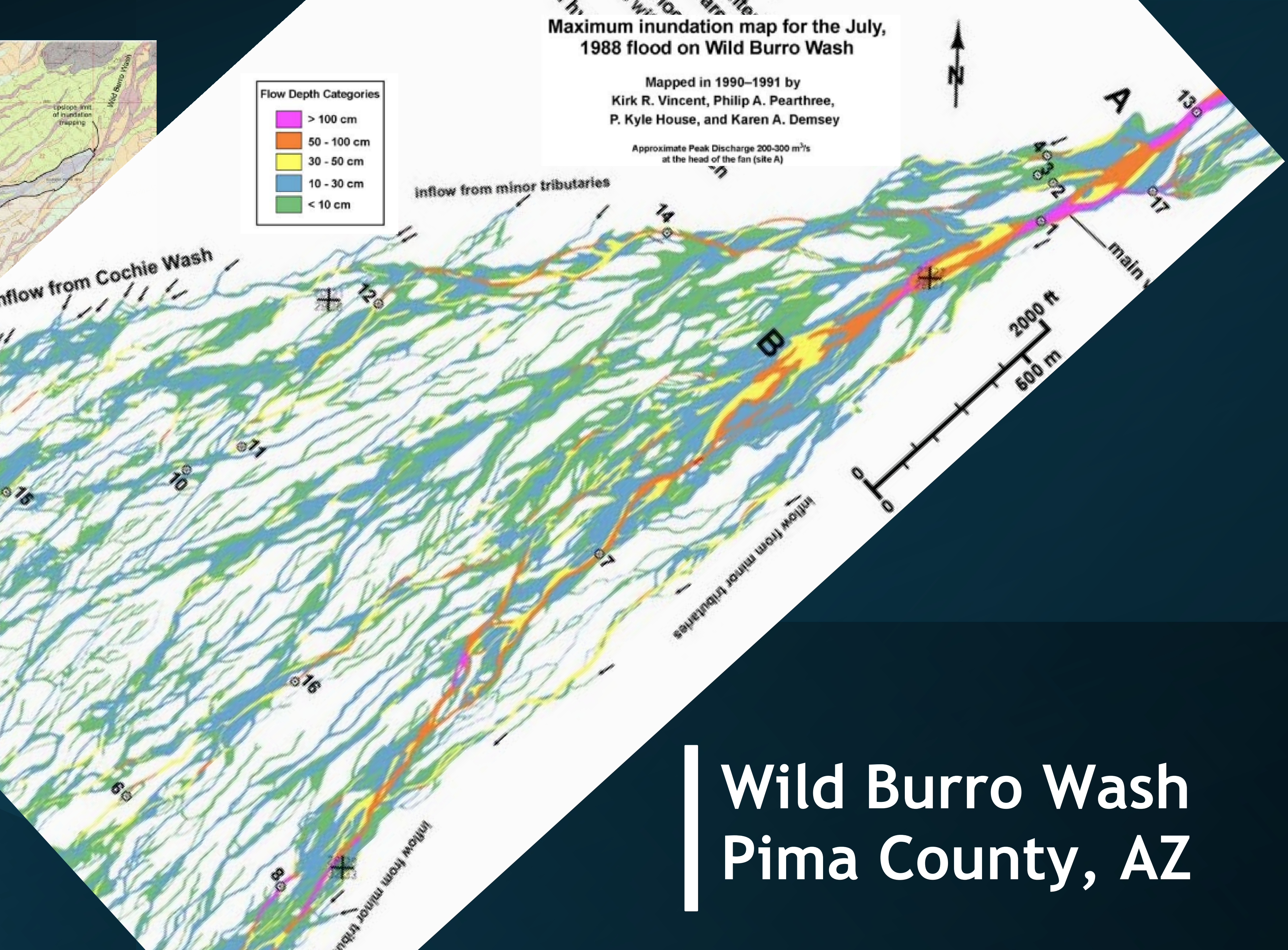
SHEETFLOOD

- Unconfined, thin sheet of water over fan surface
- Occurs when flow exceeds channel capacity
- Deposits thin, well-sorted sand and gravel sheets
- Common on distal (lower) fan
- Lower sediment concentration than debris flows

STREAMFLOOD

- Channelized flow with defined banks on the fan
- Higher discharge, lower sediment concentration
- Can incise into earlier fan deposits
- Common on proximal (upper) fan or after entrenchment
- More predictable flow paths than sheetflood





Vincent, K.R., Pearthree, P.A., House, P.K., and Demsey, K.A., 2004, Inundation Mapping and Hydraulic Reconstructions of an Extreme Alluvial Fan Flood, Wild Burro Wash, Pima County, Arizona. Arizona Geological Survey Open File Report, OFR-04-04, 2 map sheets, map scales 1:6,000 and 1:15,000, 51 p.

Wild Burro Wash
Pima County, AZ

Getting to Know Alluvial Fans

Debris flows, sheetfloods, and the mechanics of fan-building events

Fan Anatomy--Aerial Overview of Ideal Fan

Apex / Fan Head

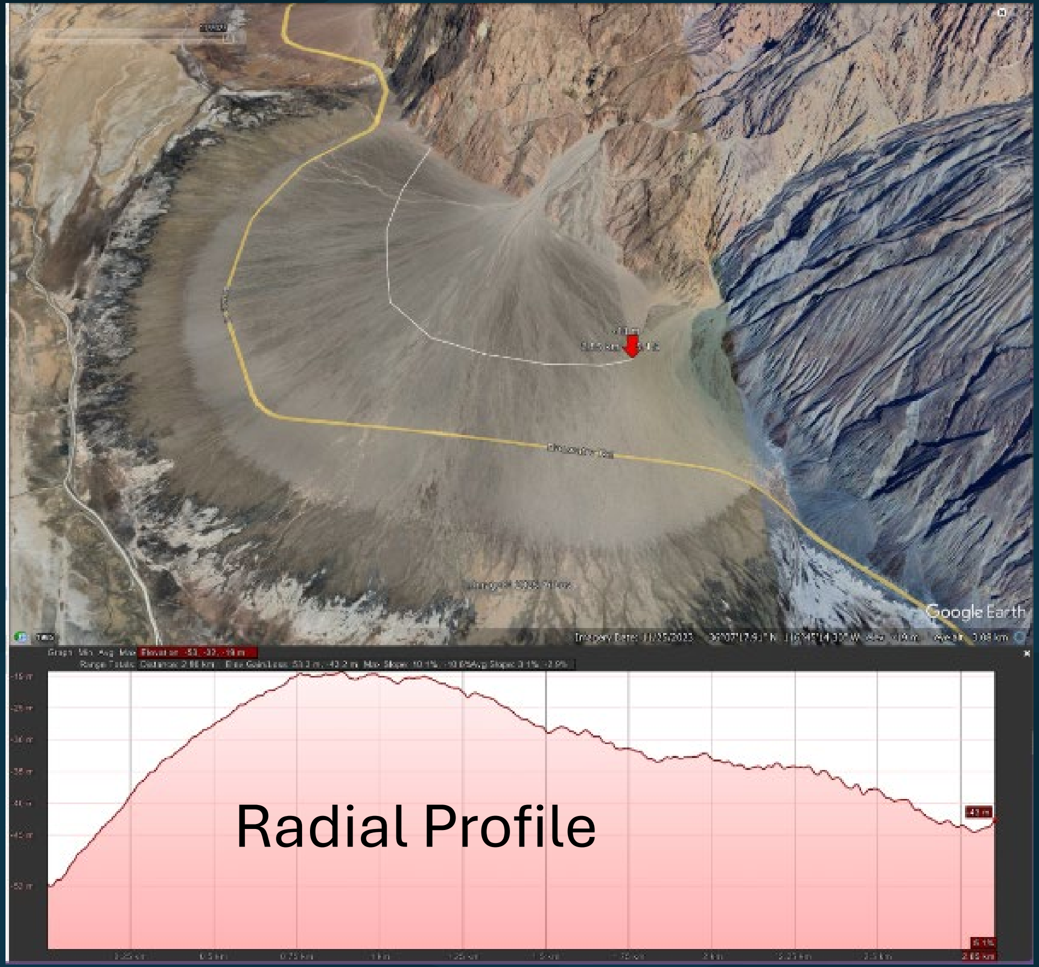
Active Distributary Channels

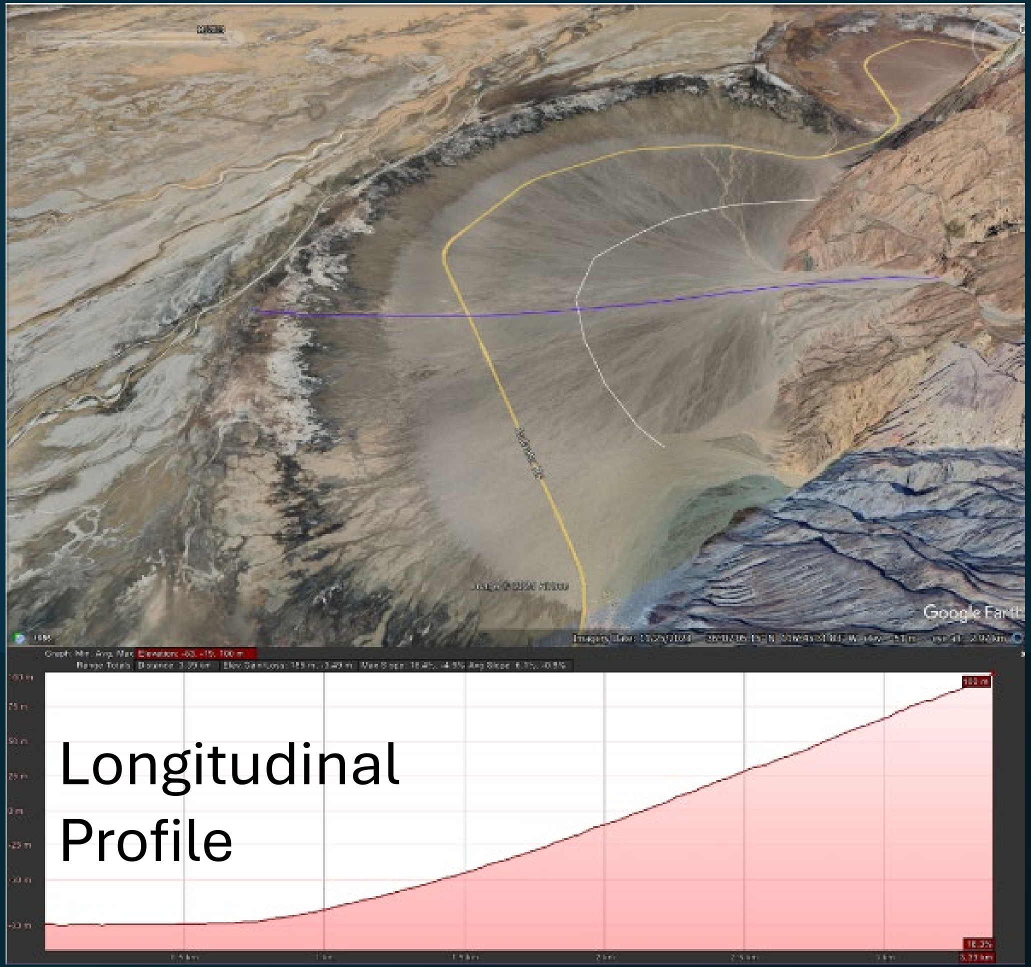
Abandoned Lobes

Distal Toe

Basin Floor/Playa

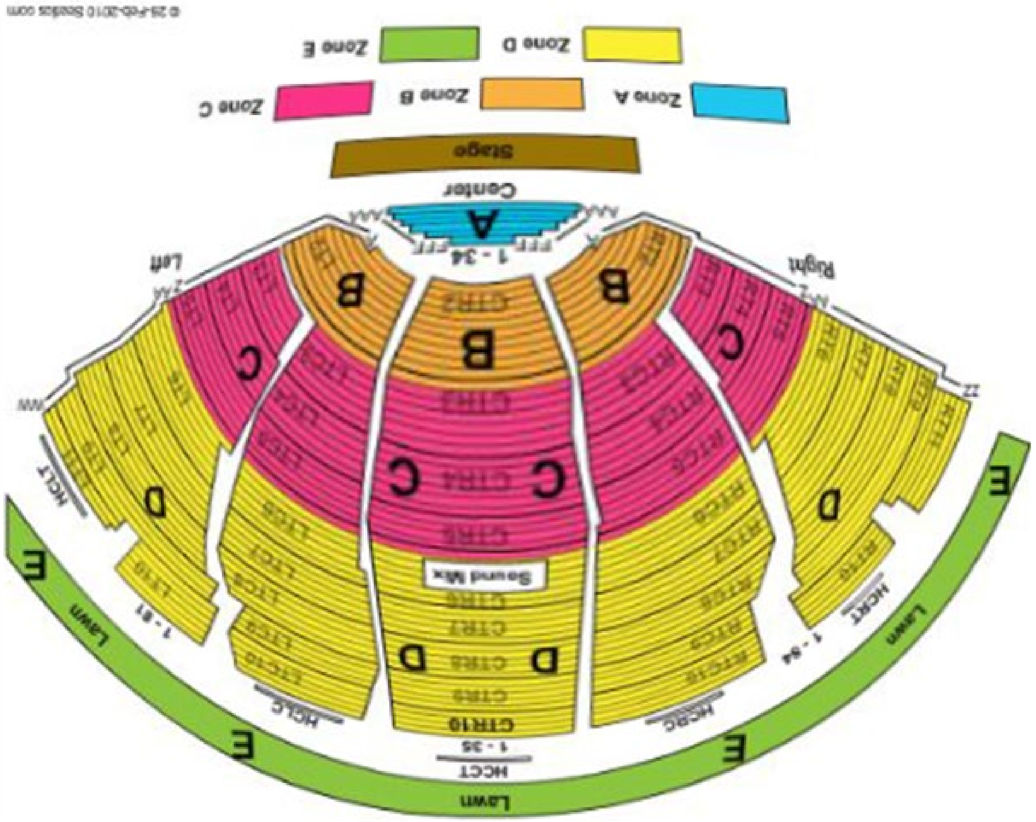
Fan Anatomy: Radial and Longitudinal Profiles





Copper Canyon Alluvial Fan, Death Valley National Park, California

Fan Anatomy: Radial and Longitudinal Profiles



Unnamed 'perfect' alluvial fan in Baja California Norte, Mexico

Fanatomy: Reading Aerial Imagery

Bright/Light Tone

Young, unvegetated active surface

Dark Tone / Desert Varnish

Older, stable pavement surface

Linear Features

Channels, levees, distributary network

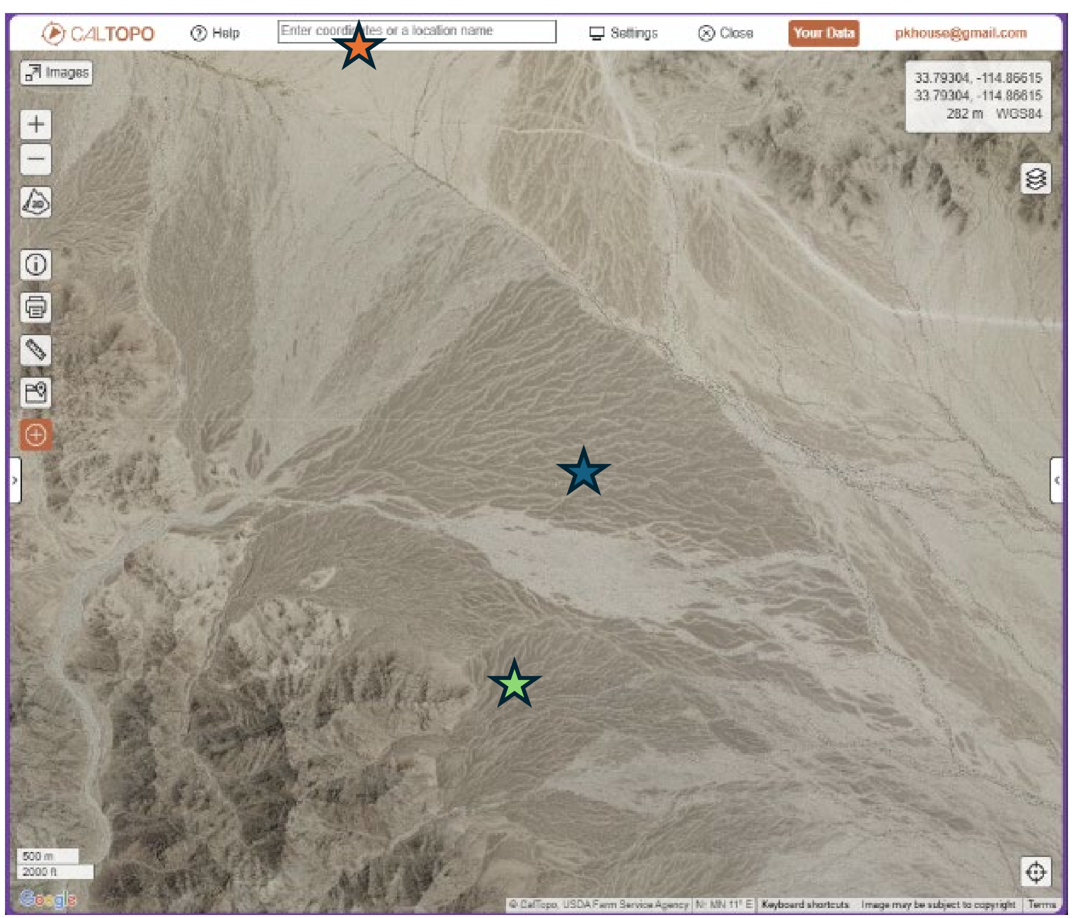
Cross-cutting Features

Indicate relative age

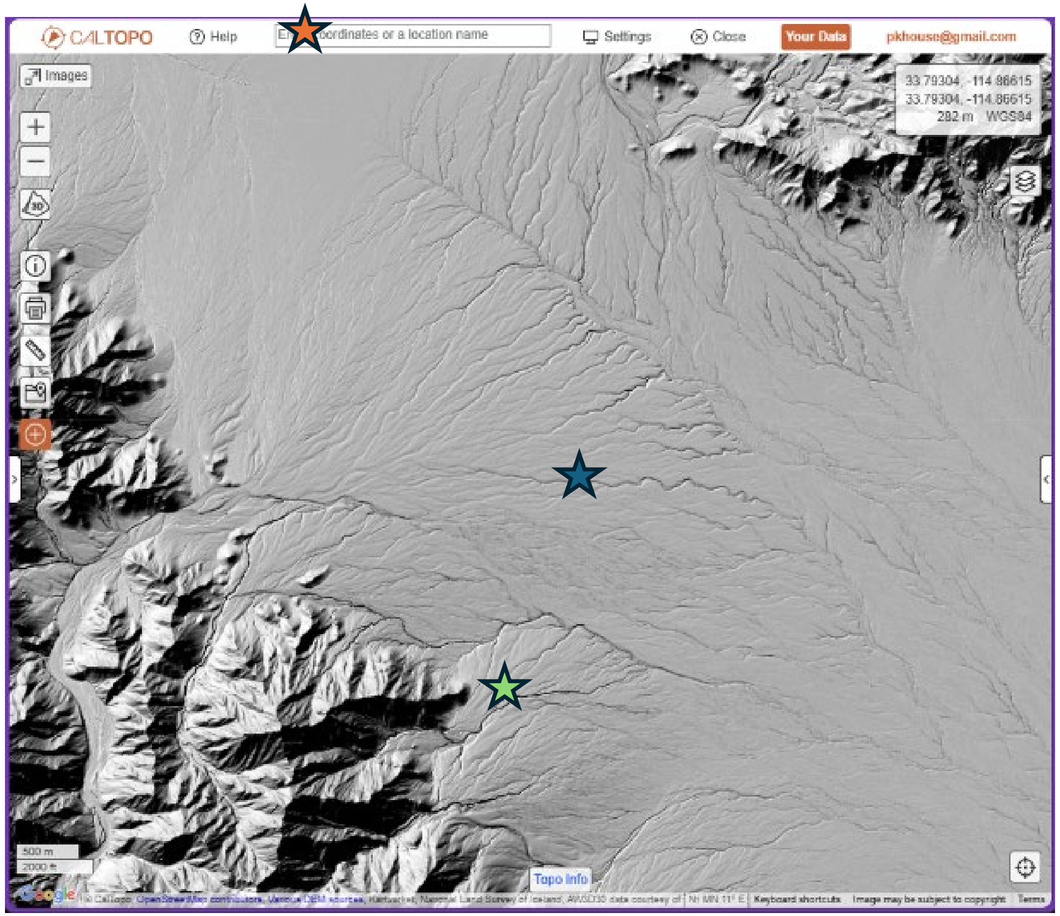
Expanding flow swaths

Individual debris flow or flood deposits

LiDAR: Seeing Through Vegetation & Shadow



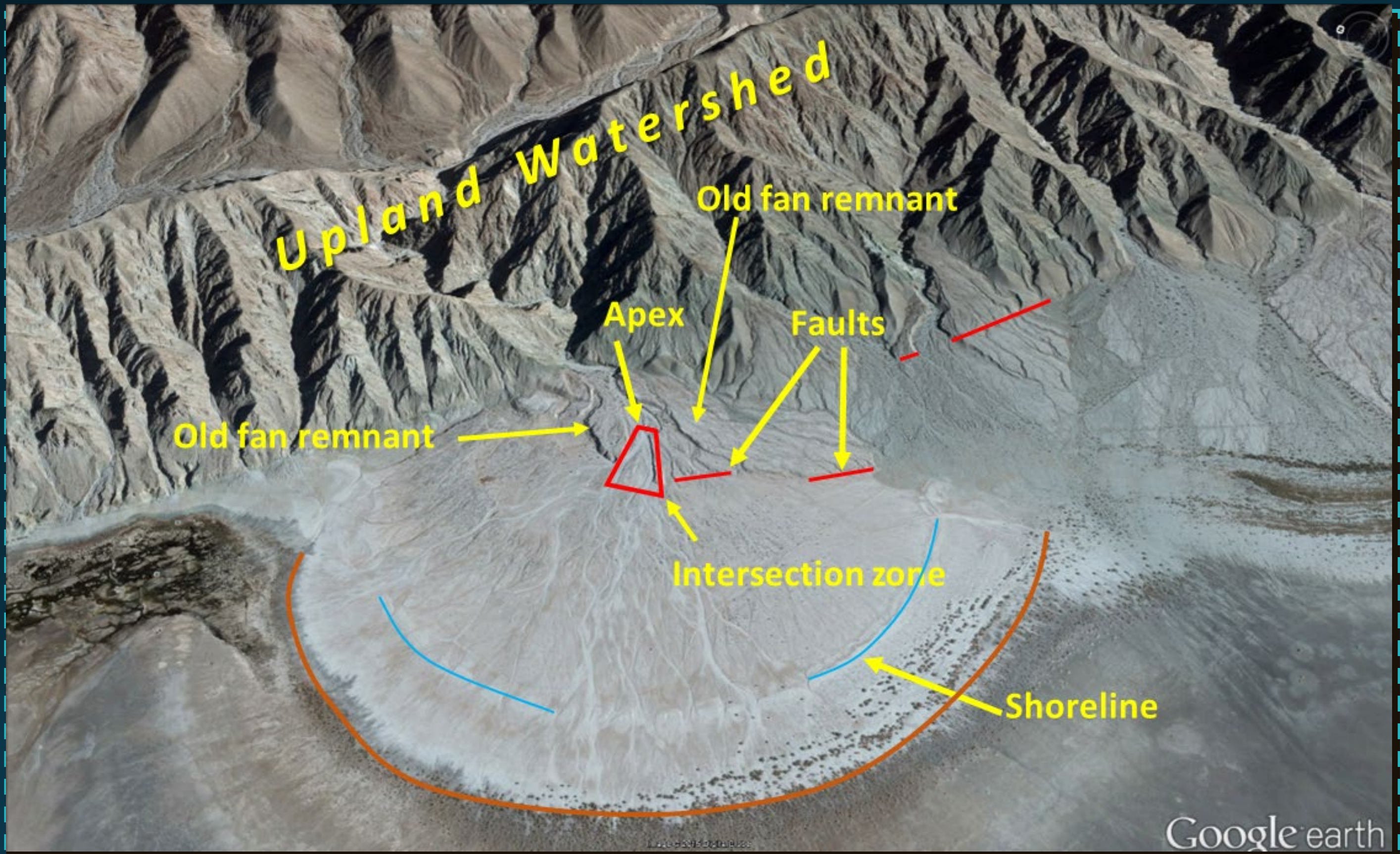
AERIAL PHOTO



LiDAR HILLSHADE

LiDAR reveals subtle topographic features invisible in photography — critical for geologic mapping

LiDAR Representation of mixed processes on fans



Fluvial Scarps

Hallmarks of interruptions in river down-cutting. Indicate complete abandonment. One of many indicated on map

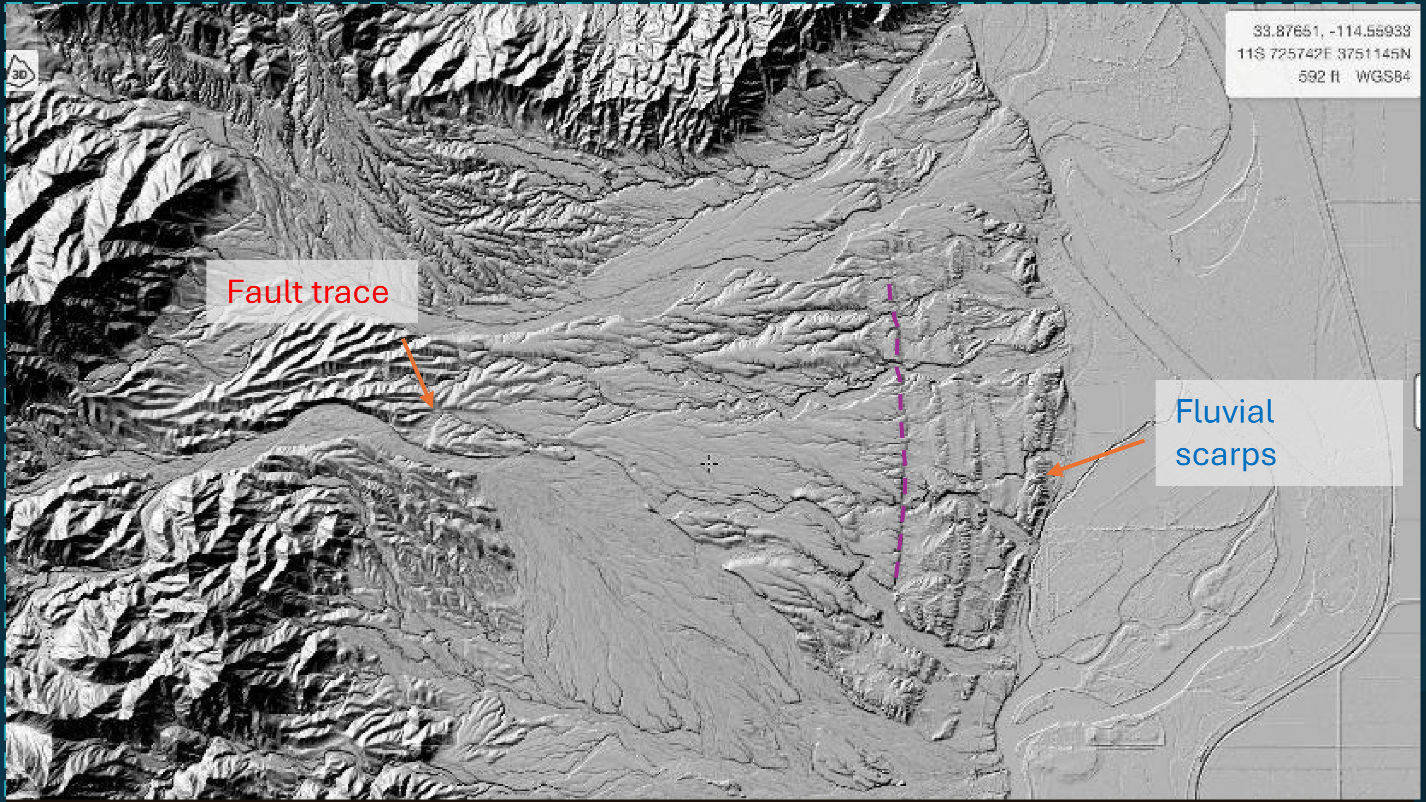
Shoreline / Wave-Cut Scarps

The Colorado River floodplain is the terminal point for fans

Fault Scarps

Scarps from surface rupture created by earthquakes

LiDAR Representation of mixed processes on fans



Slaughter Tree Wash Alluvial Fan. Where the Big Maria Mountains meet the Colorado River floodplain.

This fan has communicated with the Colorado River for 100,000s of years.

Fluvial Scarps

Hallmarks of interruptions in river down-cutting. Indicate complete abandonment. One of many indicated on map

Floodplain

The Colorado River floodplain is the terminal point for fans

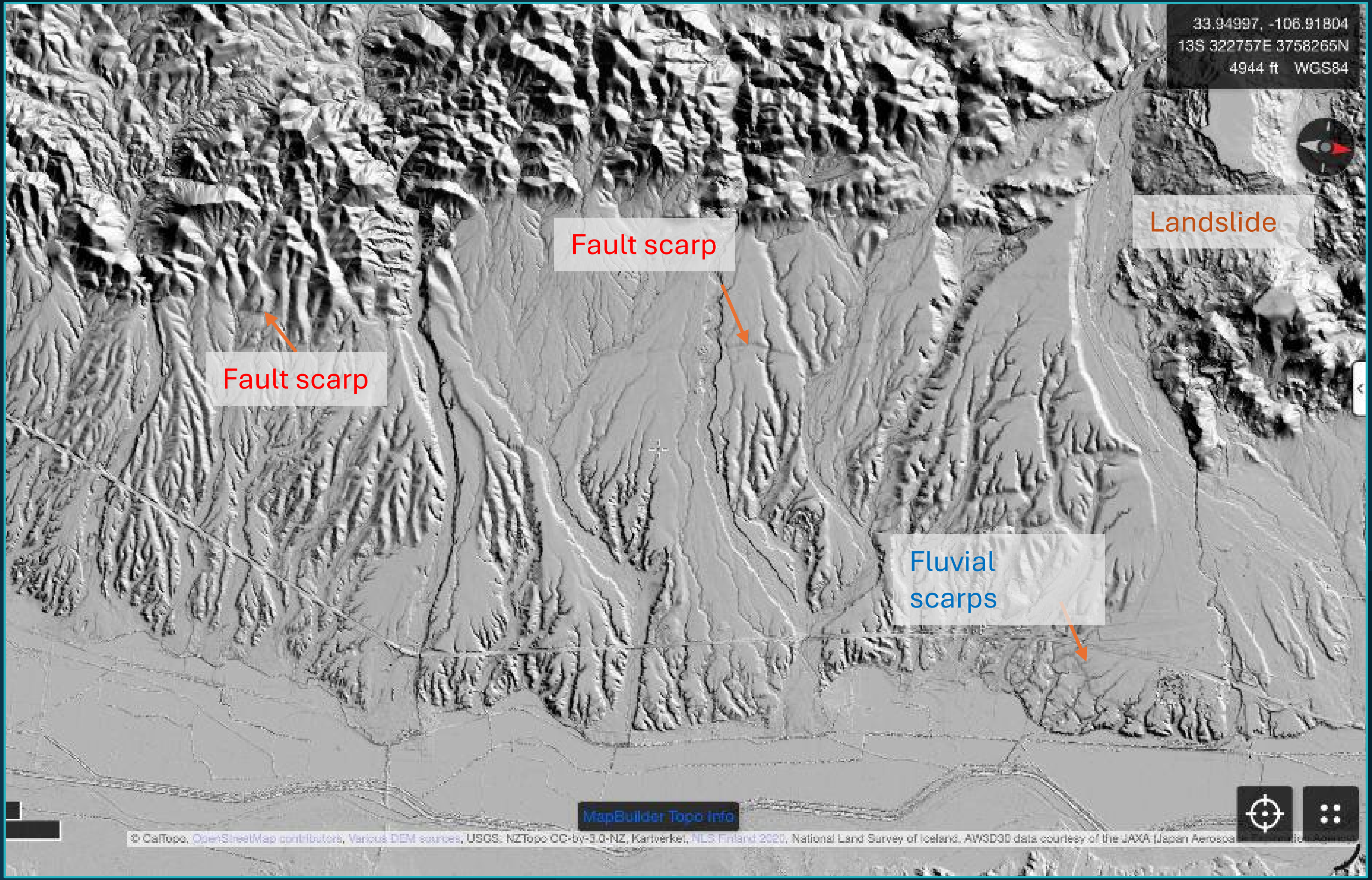
Inset Relations

These fans follow the river. The incise when it incises and they grow when the river shifts position

Qa4 (Old)

Lower but NOT zero risk

LiDAR representation of mixed processes on Fans New Mexico, Chupadera Mtns



Deeply Incised old alluvial fans

Young fans graded to Rio Grande

Earthquake-fault Rupture Scarp

Fluvial scarps from the Rio Grande

Surface Age Zones

Avulsion Nodes

LiDAR derivatives: hillshade, slope, roughness, and TPI each reveal different fan features

Alluvial Fan Flooding: Unique Characteristics

⚡ Channel Mobility

Flow can occur anywhere on the fan surface — traditional floodplain concepts do not apply

🔀 Avulsion

Channels abruptly shift mid-event; structures outside mapped zones can be inundated without warning

🪨 Debris & Sediment

High sediment loads cause rapid burial, impact damage, and clog drainage infrastructure

⏱️ Flash Onset

Events triggered by distant upstream storms; little to no lead time at the fan surface

📐 Upslope Source

Fan flood hazard is driven by the upstream watershed — the fan itself is just the depositional record

🏘️ Development Pressure

Fans are flat, attractive for development; risk is often underestimated or not communicated

Fan Mapping and Hazard Assessment

Tools, methods, and approaches for evaluating alluvial fan flood hazards

Field Indicators of Active Fan Hazard

Fresh Scour & Deposition
HIGH

Unvegetated gravel sheets, fresh debris lobes, newly exposed boulders

Fanhead Incision
HIGH

Entrenched channel at fan apex with steep eroding walls; avulsion potential

Lack of Desert Pavement
MODERATE

Absence of varnished clast pavement indicates young, active surface

Channel Morphology
HIGH

Multiple distributary channels, bifurcations, and abandoned channels visible

Vegetation Patterns
MODERATE

Sparse or pioneer species on active lobes; dense desert shrubs on older surfaces

Debris Flow Levees
HIGH

Paired ridges flanking flow paths; bouldery, poorly-sorted deposits

Mapping Methods: Remote Sensing to Field

1

Aerial & Satellite Imagery

Identify fan extent, surface age zones, channel network

Tools: Google Earth Pro, NAIP, historical photography

2

LiDAR Analysis

Map subtle topography, channels, scarps, lobe boundaries

Tools: 1m or sub-meter bare-earth DEM derivatives

3

Field Reconnaissance

Verify surface ages, characterize deposits, ground-truth mapping

Tools: GPS, hand lens, sediment description

4

Hydraulic Modeling

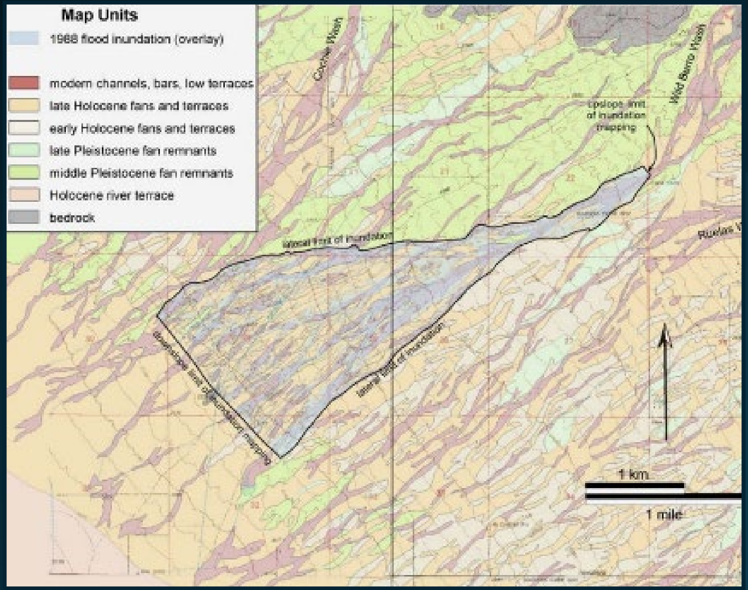
Quantify flood depths, velocities, and extent across fan

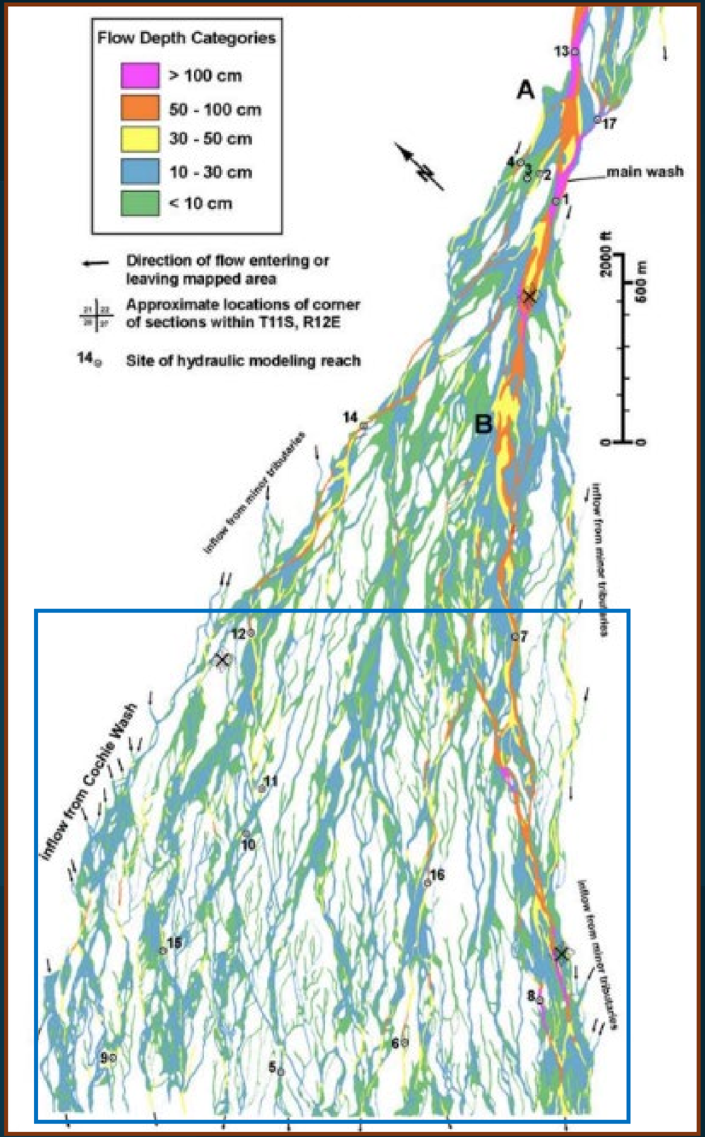
Tools: HEC-RAS 2D, FLO-2D, RAMMS

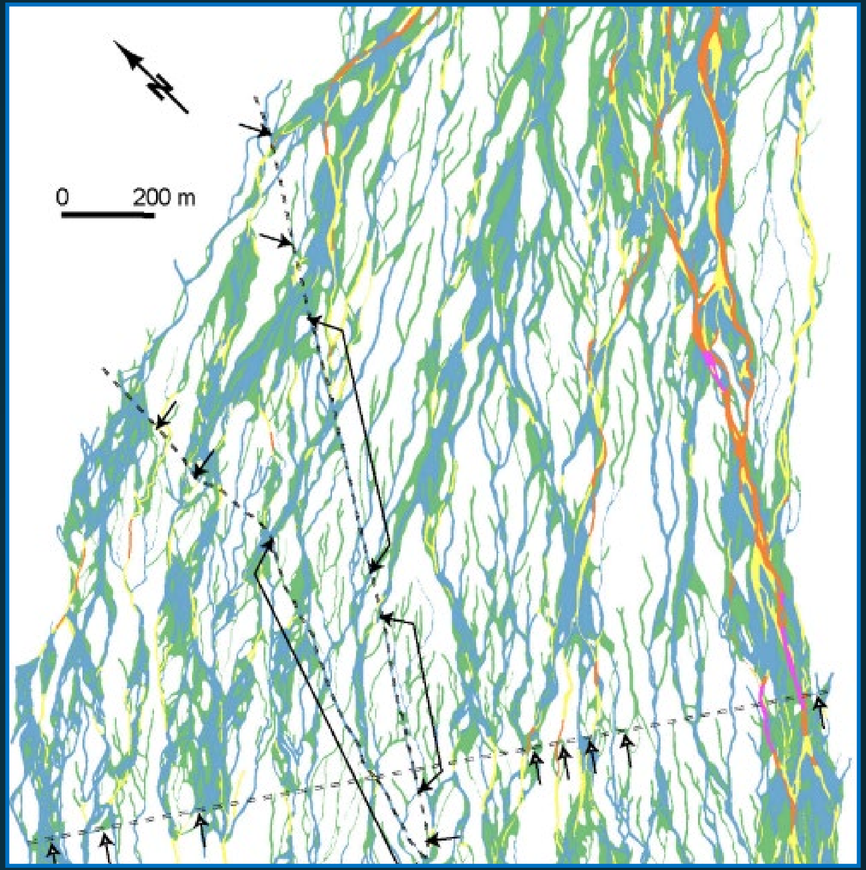
SECTION 06

Case Examples and Approaches

Events that shape our understanding of alluvial fan flood hazard







Alluvial Fan Flood: Wild Burro Wash Tucson, AZ

Figure: Google Earth, 2013 image

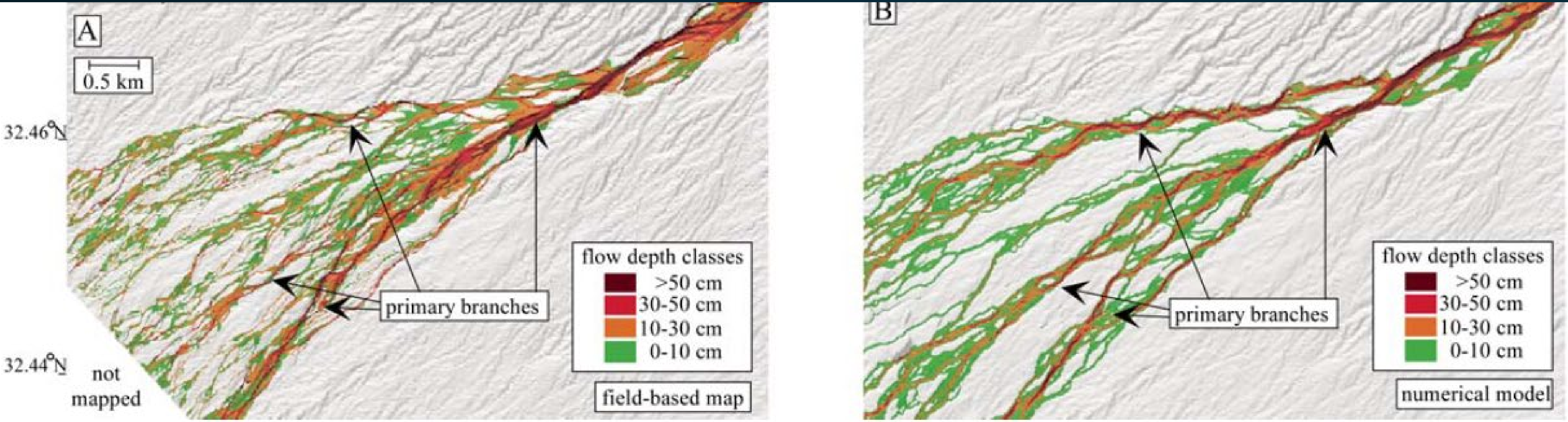
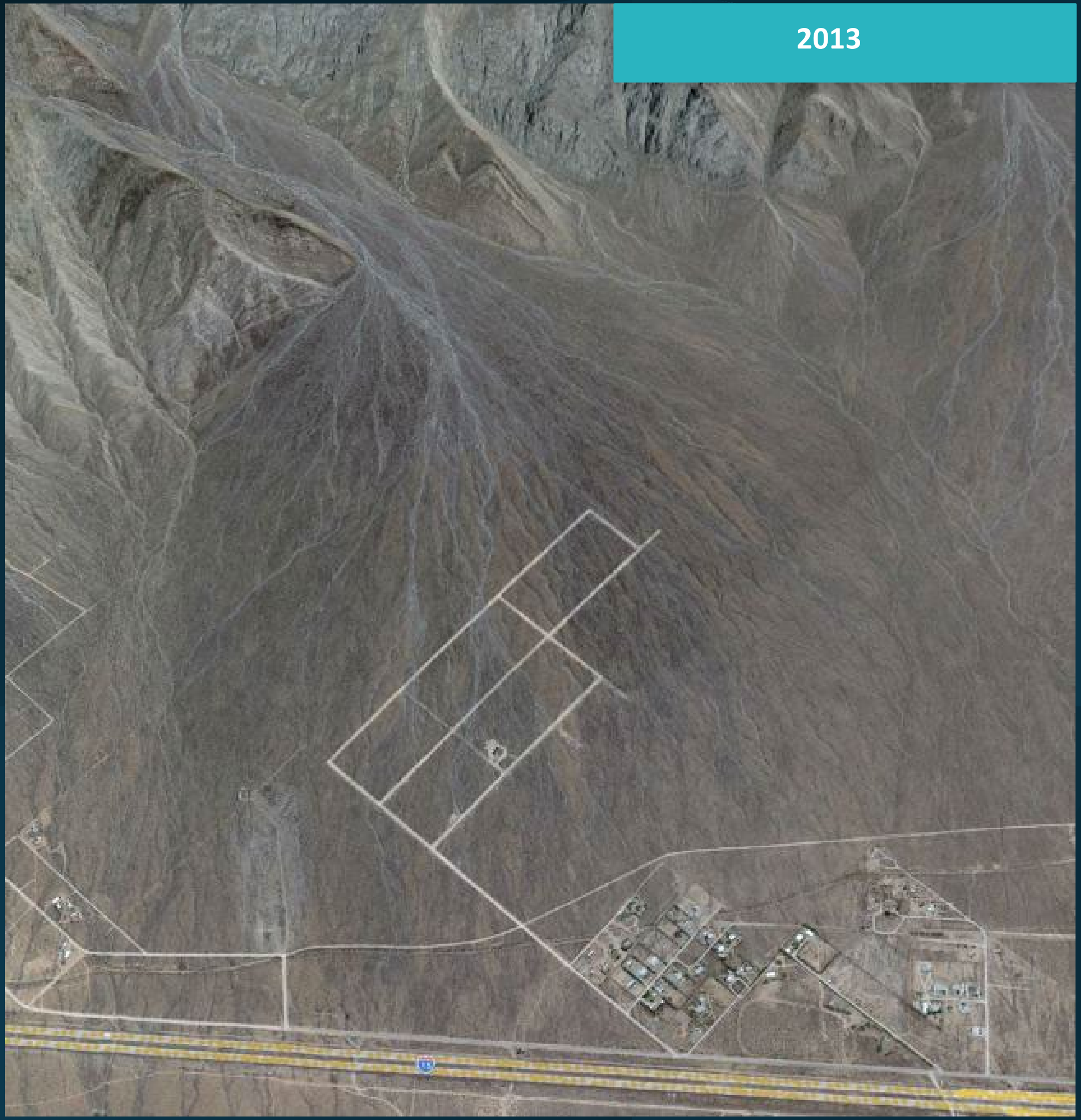


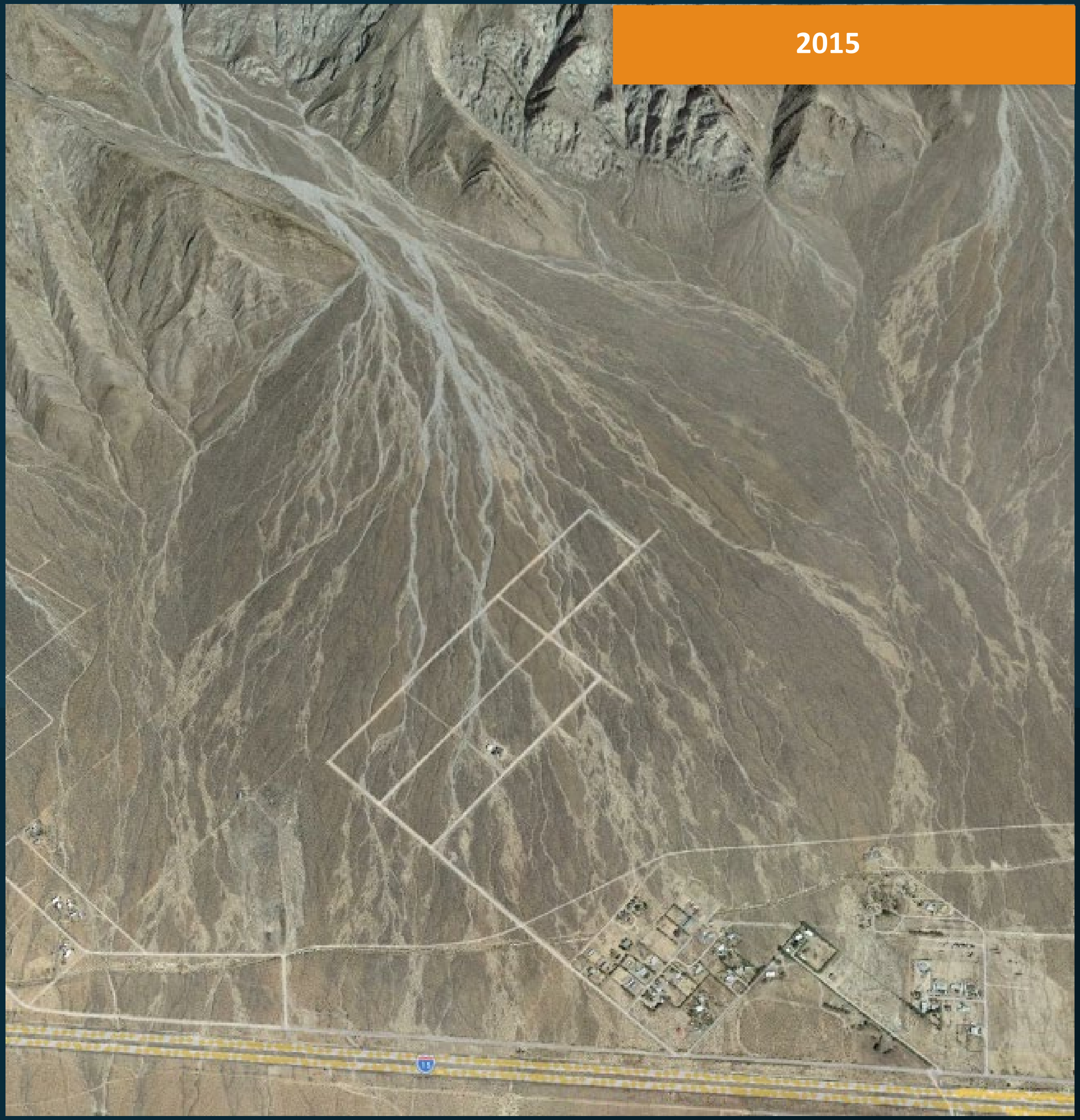
Figure 5. Comparison of (A) field-based inundation map with (B) color map of flow depths predicted from hydrological model for the 27 July 1988 flood in Wild Burro Wash, Tortolita piedmont. The model input included flow depths observed in the field corresponding to a peak discharge of Q = 250 m^3/s. The locations and flow depths of the primary flow branches match each other closely in the two images.

1988 Wild Burro Flood Map vs. Flood Model

CASE STUDY 02

Before and After: The “Figure 5” Alluvial Fan, Mesquite, NV





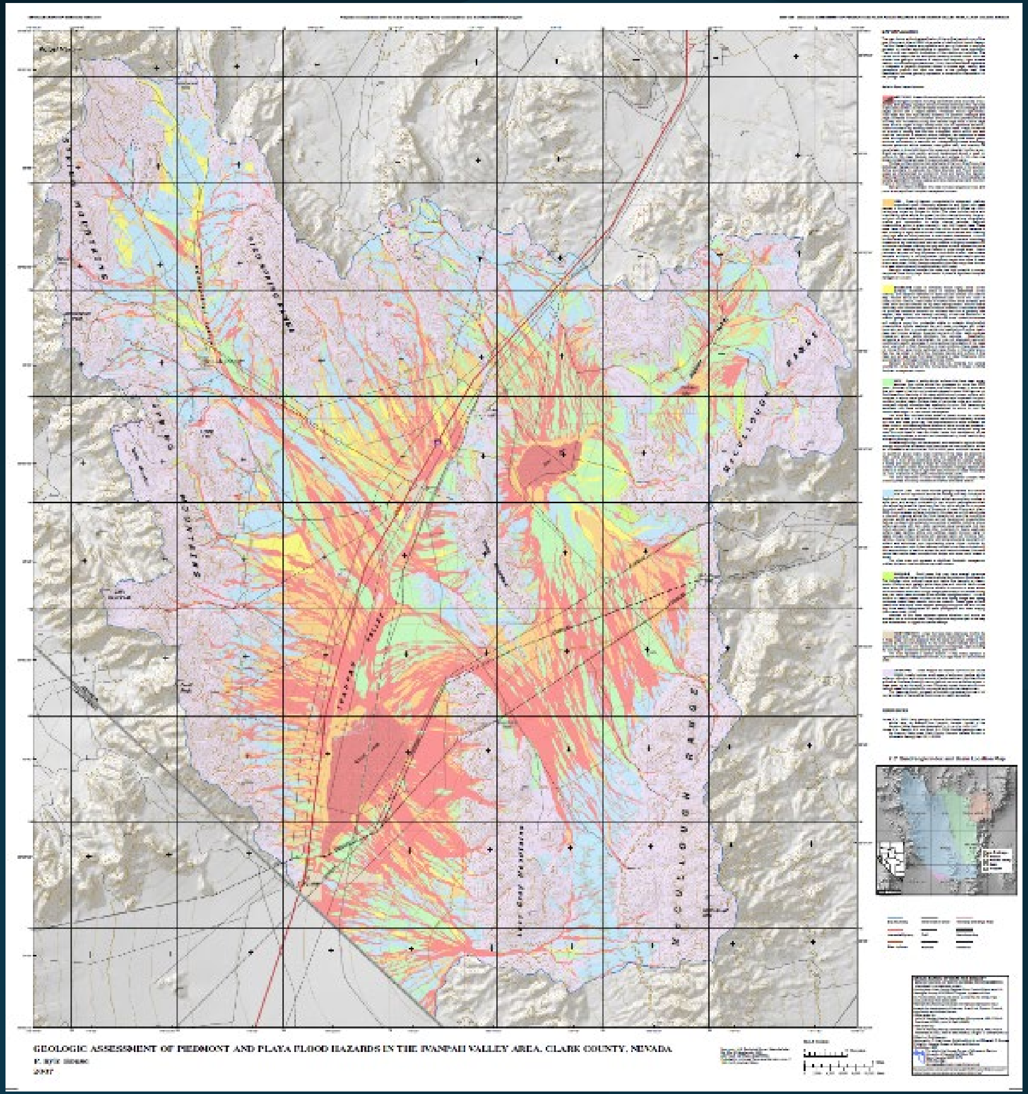
CASE STUDY 02

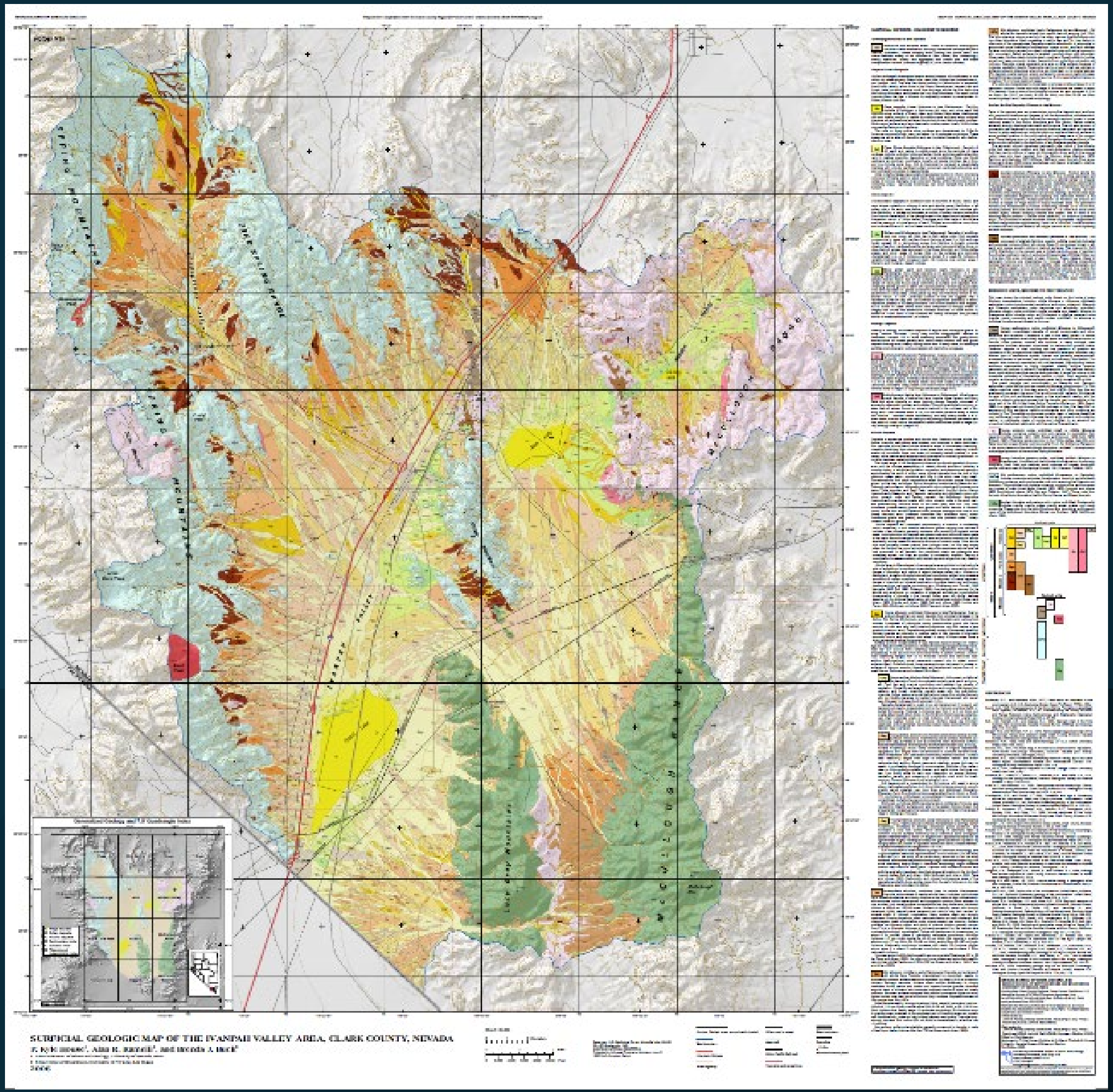
Before and After the Sept. 8, 2014, Flood: Impact to the "Figure 5" Alluvial Fan, Mesquite, NV

2013

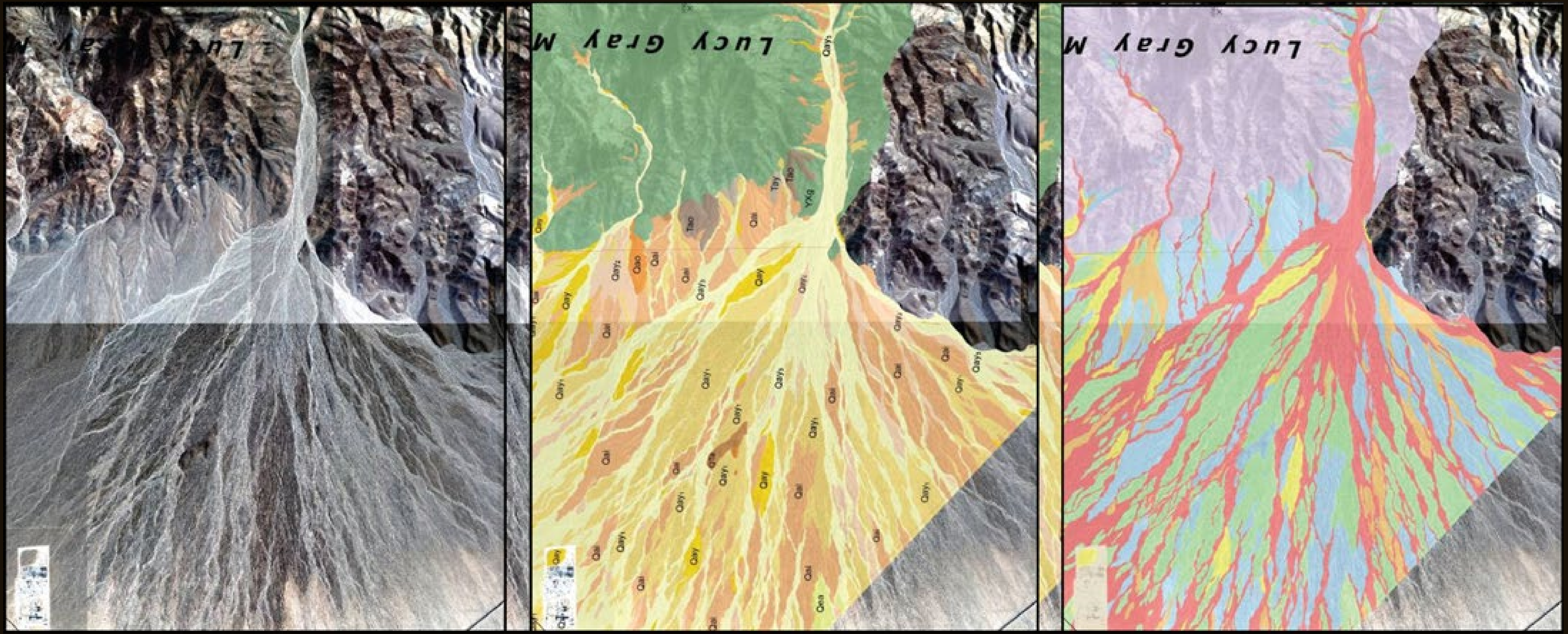
2015

Geologically Defined Fan-Flood-Hazard Zones: Ivanpah Valley, Nevada and California





Fan Flood Hazard Zones



Lessons Learned from Historical Fan Flood Events

- Flow paths cannot be reliably predicted from prior event history alone — avulsion resets the system
- Development on fan surfaces treated as 'inactive’ can be inundated by avulsion flows on certain parts of the fan
- Debris flow events cause disproportionate damage relative to their discharge volume
- Emergency response is complicated by the lack of fixed channel geometry — where will flow go?
- Pre-event geomorphic mapping dramatically improves post-event interpretation and future / continuing hazard assessment
- LiDAR-based mapping consistently reveals hazardous conditions missed by conventional survey

Communicating Fan Flood Risk

Audience	Focus
General Public / Residents	Emphasize unpredictability, rapid onset, and the fact that no part of a fan is truly 'safe'
Planners & Floodplain Managers	Focus on FIRM limitations, avulsion probability, and need for site-specific studies including geologic mapping
Engineers & Designers	Water and debris flow volumes, velocities, deposition modeling, uncertainties, and infrastructure vulnerability
Emergency Managers	Event triggers, early warning gaps, response challenges, evacuation constraints

Key Messages: Alluvial Fan Flooding

- Alluvial fans are dynamic landforms — the entire surface of an active fan is potential floodplain
- Widespread flow can occur anywhere on the active fan
- Avulsion is a fundamental process and is a primary hazard driver
- LiDAR and multi-temporal aerial imagery are essential tools for hazard assessment
- FEMA FIRMs often misrepresent true fan flood hazard — site-specific analysis is required
- Understanding fan processes equals meaningful risk communication