CARSON WATER SUBCONSERVANCY DISTRICT ALLUVIAL FAN MAPPING STUDY

March 10, 2020

Lew Hunter, Ph.D., P.G. – Sr. Geologist, Army Corps of Engineers

Ed James, General Manager, Carson Water Subconservancy District

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Courtney Walker, CFM – Stormwater Program Manager, Douglas County Public Works

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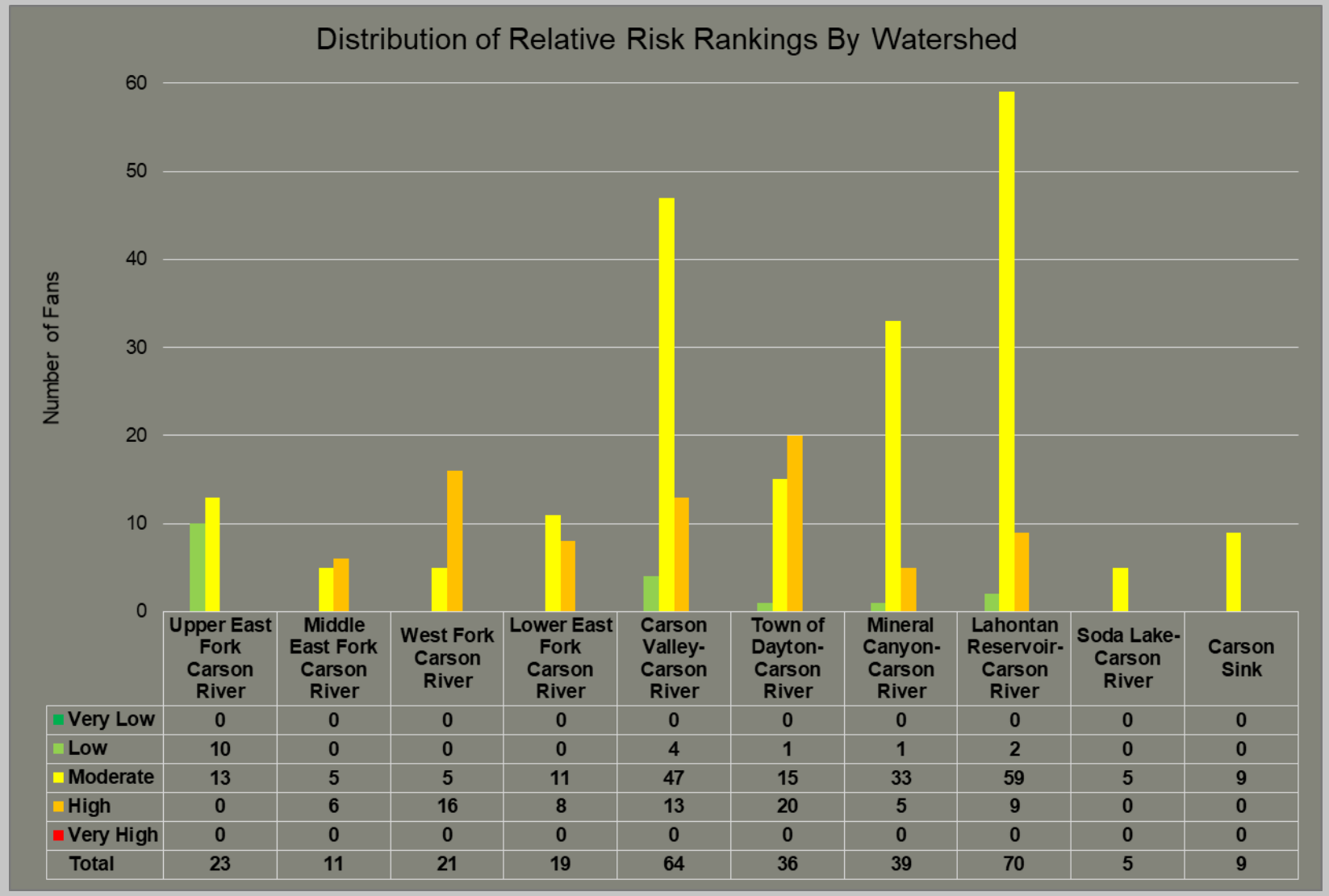
OVERVIEW

- Study History (Phase 1 & Phase 2)
- Geologic Assessment
- Hydraulic Assessment
- What’s Next?

PHASE 1 RESULTS: DISTRIBUTION OF RISK RANKING

- A majority of the fans were classified as moderate risk
- No fans were classified as very high risk or as very low risk
- The Town of Dayton-Carson River watershed had the most high risk fans at 20
- West Fork Carson River watershed had the highest proportion of high risk fans at 76%

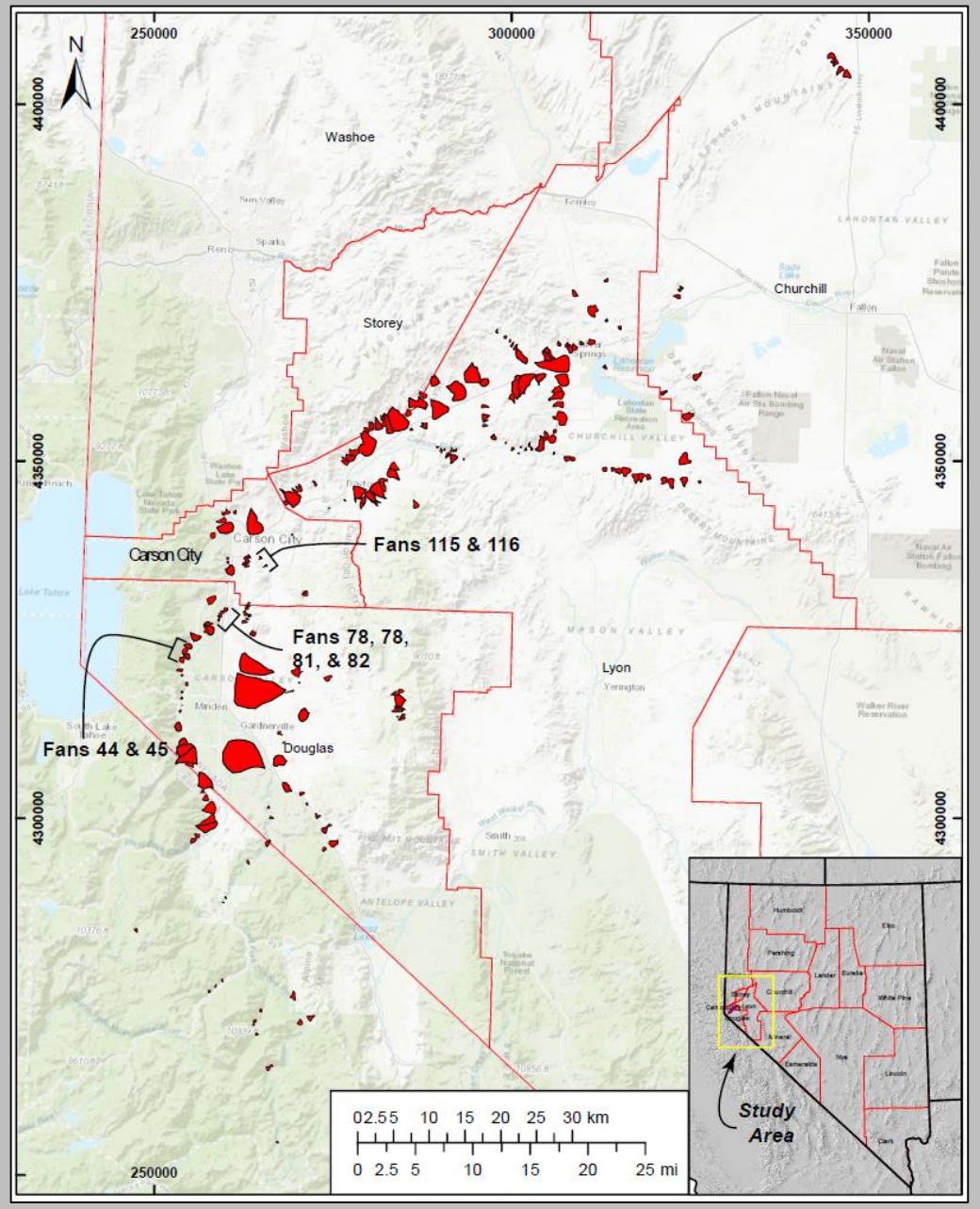
	Very Low	Low	Moderate	High	Very High	Total
Number of Fans	0	18	202	77	0	297
Percent	0%	6%	68%	26%	0%	100%



	Upper East Fork Carson River	Middle East Fork Carson River	West Fork Carson River	Lower East Fork Carson River	Carson Valley-Carson River	Town of Dayton-Carson River	Mineral Canyon-Carson River	Lahontan Reservoir-Carson River	Soda Lake-Carson River	Carson Sink
Very Low	0	0	0	0	0	0	0	0	0	0
Low	10	0	0	0	4	1	1	2	0	0
Moderate	13	5	5	11	47	15	33	59	5	9
High	0	6	16	8	13	20	5	9	0	0
Very High	0	0	0	0	0	0	0	0	0	0
Total	23	11	21	19	64	36	39	70	5	9

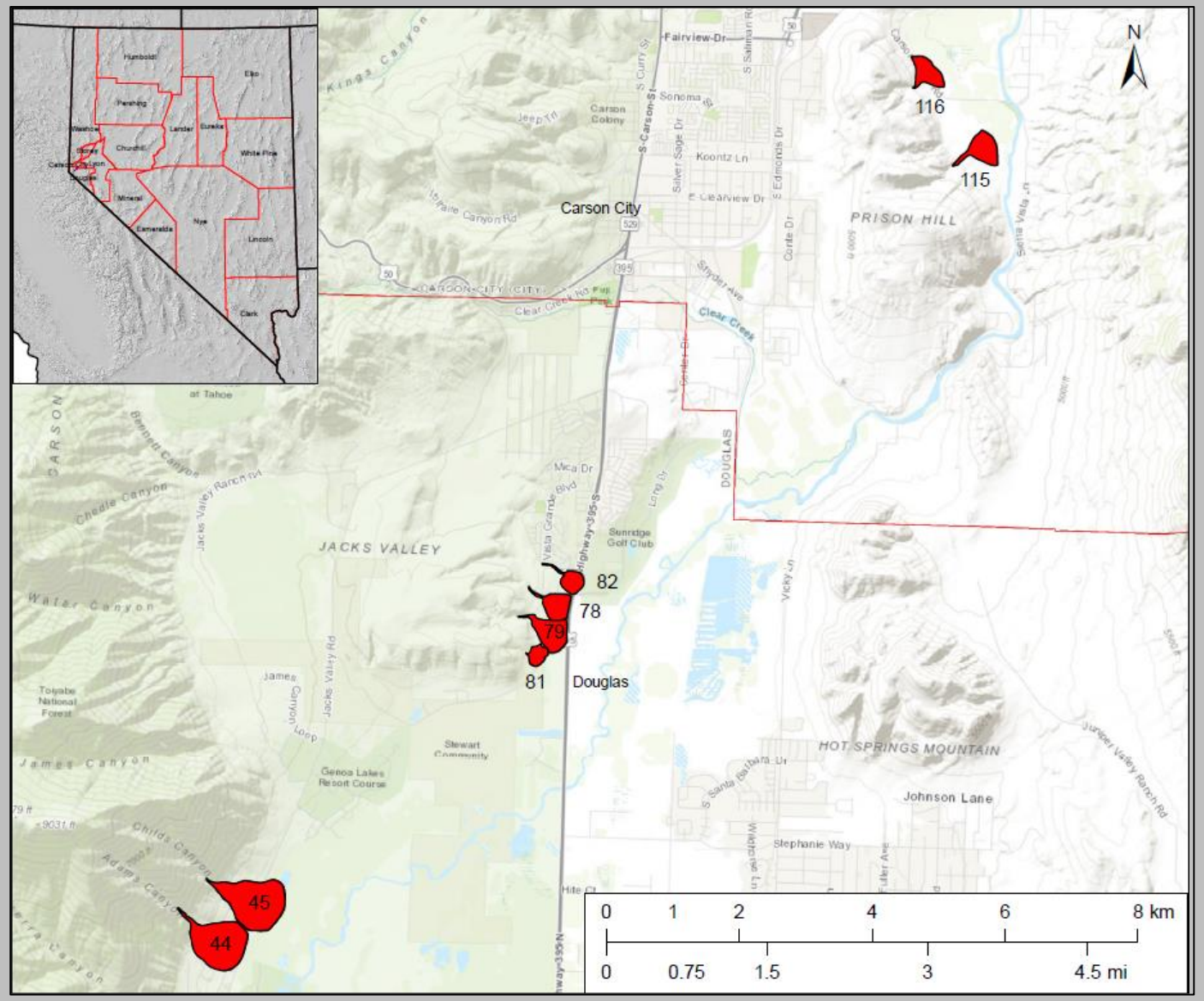
PHASE 2: APPROACH

- Phase One completed in 2017
    - Mapped and classified 297 alluvial fans based on apparent risk within the Carson River Watershed
- Phase Two identified specific alluvial fans for further geologic and hydraulic analyses



GEOLOGIC ASSESSMENT

- **Goal**
  - Evaluate geohazards (floods/debris flows)
- **Methodology**
  - 8 fans selected by County
    - Round 1 – 6 fans (78, 79, 81, & 82 in Douglas County & 115 & 116 in Carson City County)
    - Round 2 – 2 fans (44 & 45 in Douglas County)
- **Fans had to have LiDAR data available**
  - LiDAR data downloaded from USGS
  - 3DEP Elevation Data (https://viewer.nationalmap.gov/basic/)



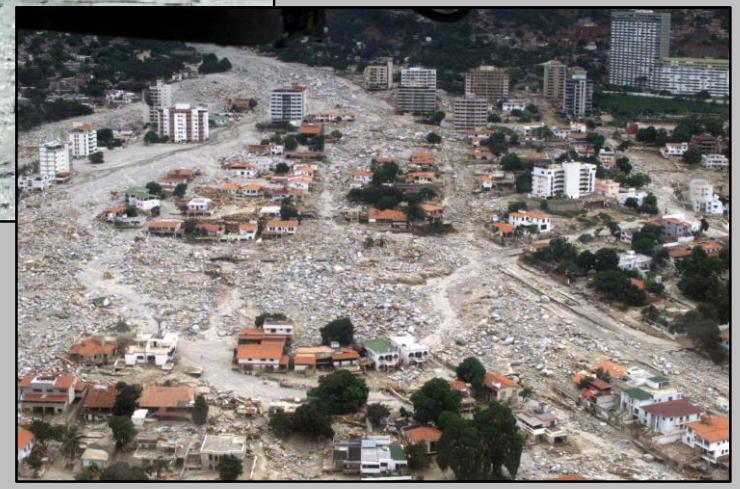
GEOLOGIC ASSESSMENT

Terminology

Geohazards

- **Hyperconcentrated flows** (Pierson 2005)
  - High concentration flows
  - Sediment concentration 5 - 60% by volume
- **Debris flows**
  - Flow has reached a critical shear strength when large particles suspended indefinitely

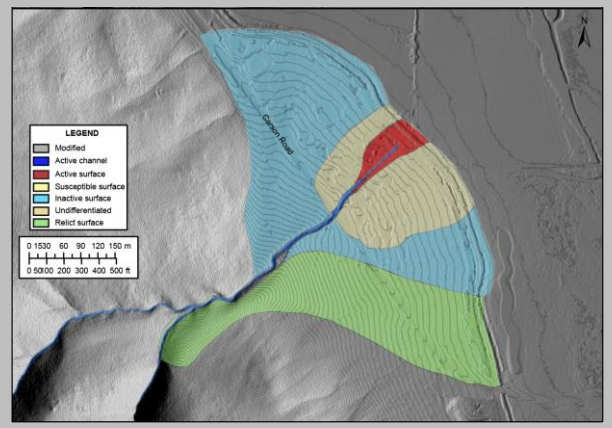
From Schneider et al. (2013). Advances in Geoscience, 35, 145-155.



From https://www.universetoday.com/wp-content/uploads/2010/10/debris_flow_damage.jpg

Mapping

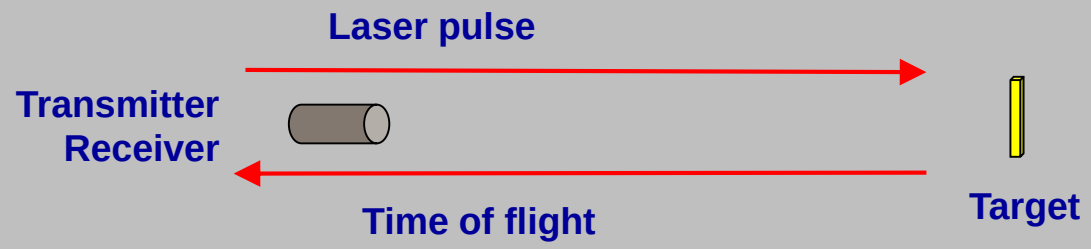
- **Active channel(s):** primary channel(s) transferring water/sediment
- **Active**: Portions of fan surface that show evidence of recent (<50 yrs) activity
- **Susceptible**: areas typically downgradient of active areas that are likely to see activity
- **Inactive**: areas of fan surface currently unlikely to see fan activity under current conditions
- **Relict**: ancient (abandoned) portions of fan

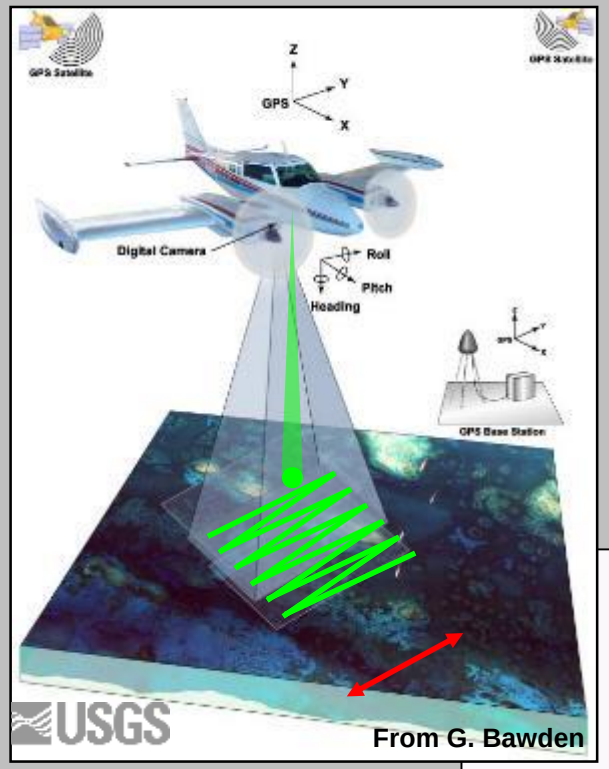


GEOLOGIC ASSESSMENT

- **LiDAR** (Light Detection and Ranging)
  - Integrates: Laser, GPS, Internal Navigation System
  - Platform (Plane)

- **Measure 2-way travel time to calculate distance**
  - Aircraft to ground

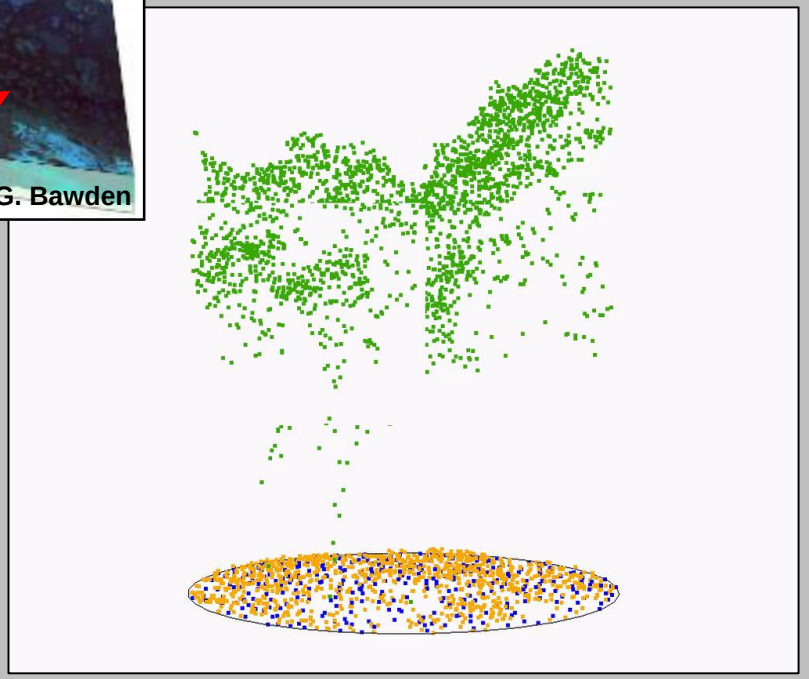




Laser sweeps back and forth to cover ground

Generates a point cloud dataset

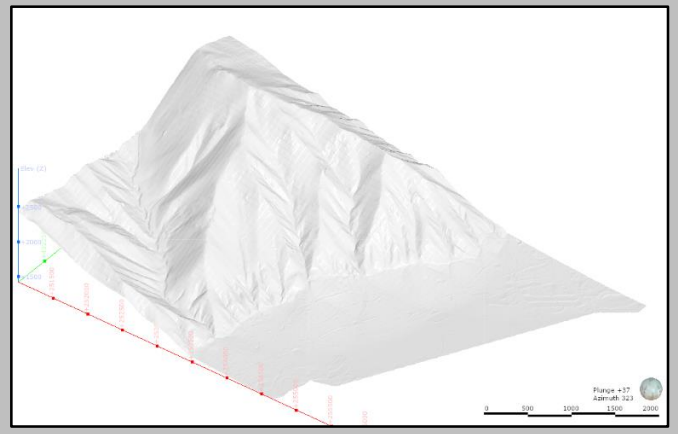
- Vegetation (Trees)
- Low vegetation (grass)
- Ground (bare earth)



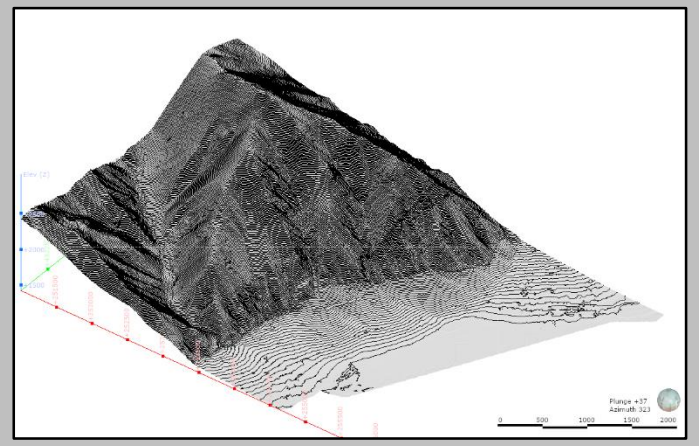
GEOLOGIC ASSESSMENT

- **LiDAR Assessment:**
  - Only use bare earth data
  - Digital elevation models
  - Generated contours (1m, 2m, & 5m)
  - Slope maps
    - Surface morphology
    - Calculate gradients
    - Define outer toe (distal edge) : 1° - 2°

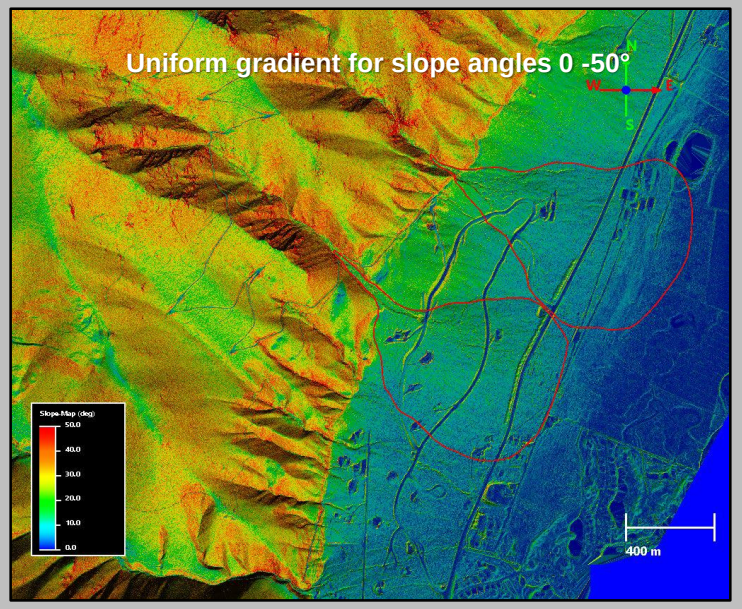
Digital elevation model

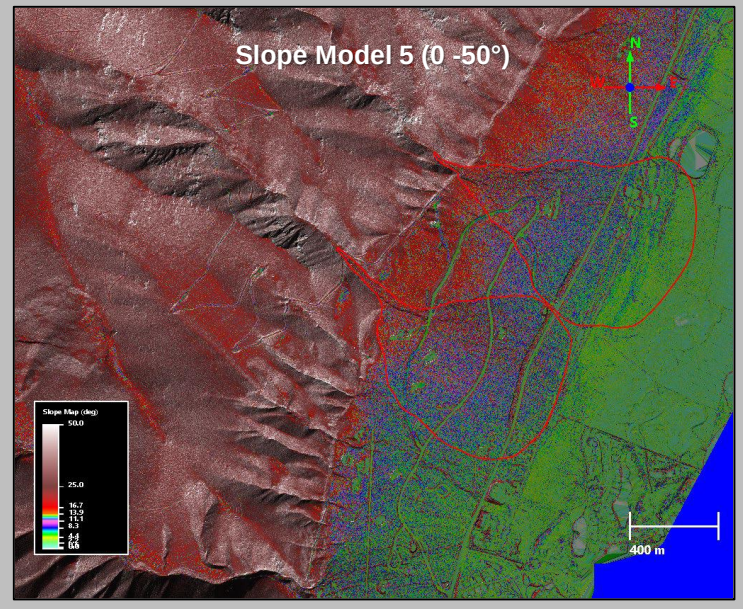


LiDAR Derived Contours (5 m)



Slope Model Examples

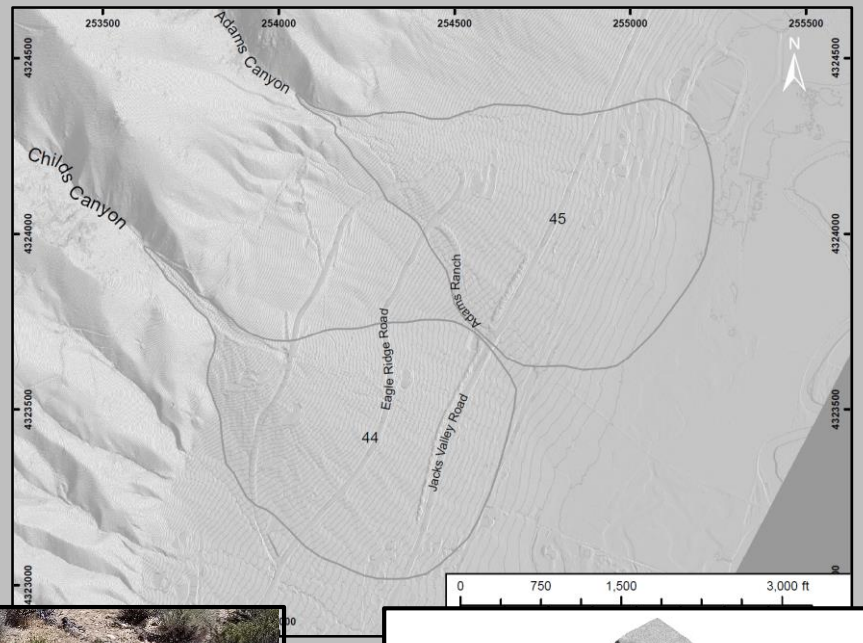


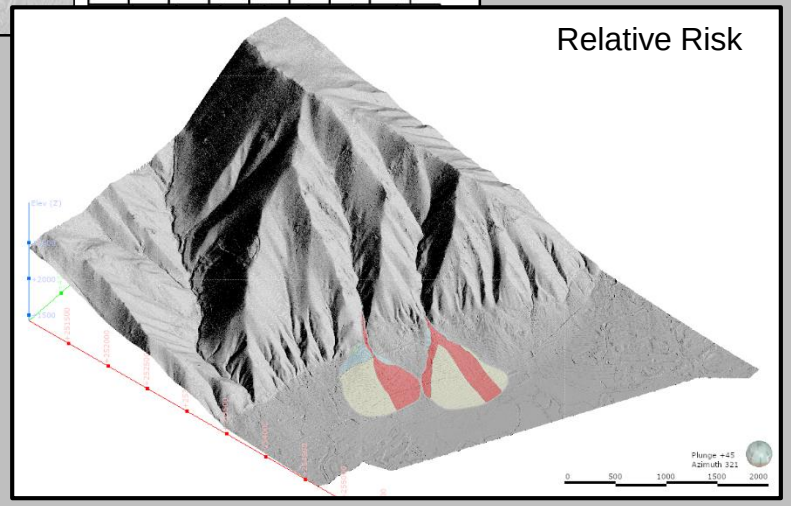


GEOLOGIC ASSESSMENT

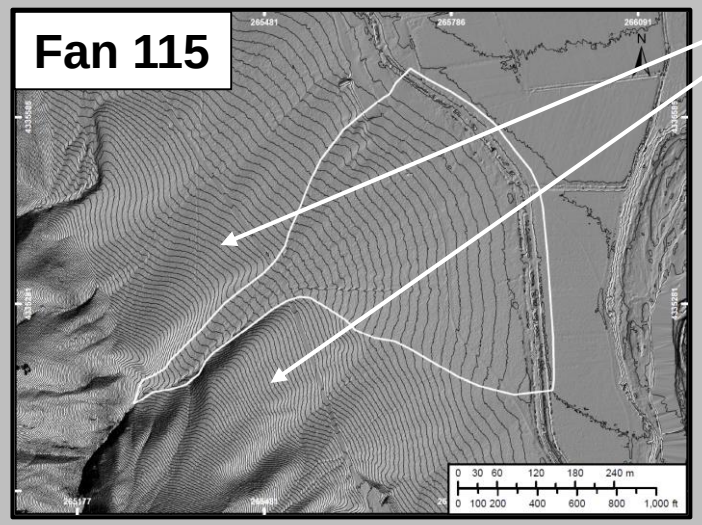
- **LiDAR Assessment (cont.):**
  - Fan boundaries
    - Contours superimposed on LiDAR hillshade
    - Slope maps
    - LiDAR Hillshade
    - Aerial photography
  - Site visits
  - Evaluate Geohazards

LiDAR Derived Contours (5 m) on hillshade map

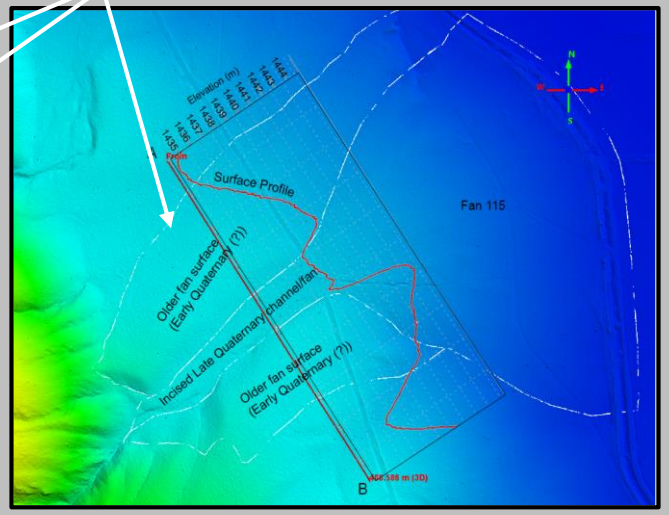


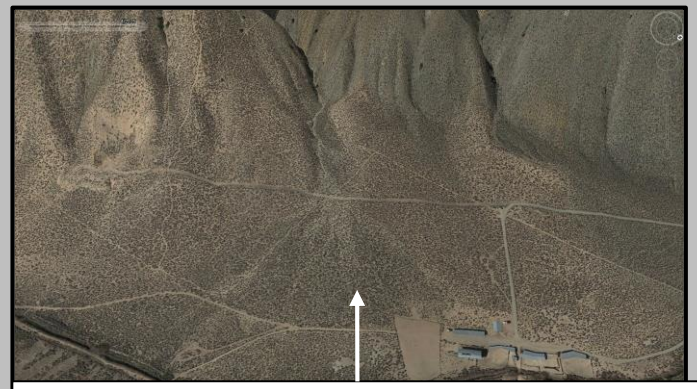


GEOLOGIC ASSESSMENT

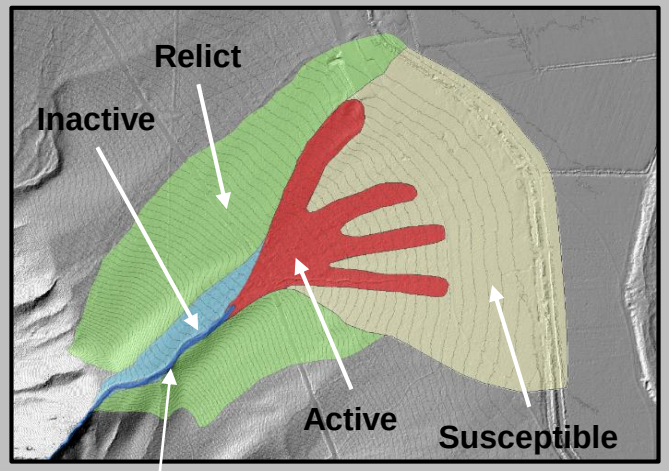


Relict fan surfaces





Light coloration inferred as zones where recent deposition has occurred



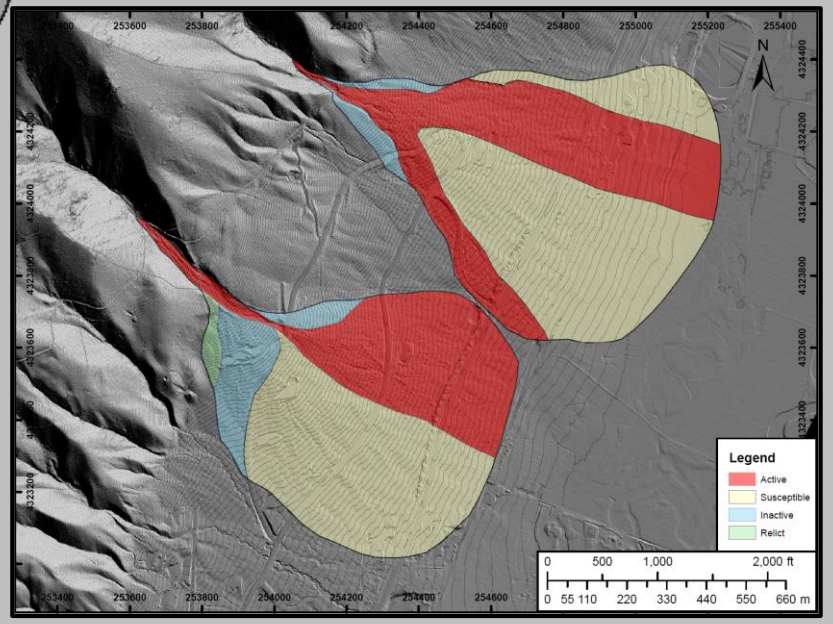
Incised channel where it exits mountains and cuts relict fan surfaces

Sheet flow deposits downgradient of where channel exits confined reach

Old, weathered boulders. Not deposited under current conditions

- Relict
- Channel lag
- Old debris flow deposits

GEOLOGIC ASSESSMENT



Fan	Surface		Process		Avulsion Potential	Development	Geohazard
	Texture	Slope	Alluvial	Debris Flows			
44	Rough	>10*	Mod - Hi	Mod - Hi	Hi	Mod***	Hi
45	Rough	>10	Mod - Hi	Mod - Hi	Hi	Low***	Hi
78	Smooth-moderate	6 - 8**	Mod - Hi	Low	Low	Mod	Low
79	Smooth	6 - 8	Mod	Low	Low	Mod	Low
81	Smooth-moderate	4 - 9	Mod	Low	Mod - Hi	Low - Mod	Low
82	Moderate	4 - 6	Low - Mod	Low	Low	Mod	Low
115	Smooth	4 - 9	Mod	Low	Low - Mod	Low	Low
116	Smooth-moderate	6 - 9	Mod - Hi	Low - Mod	Low	Mod	Mod

* Consistant slope

** Near topographic apex

*** Undergoing development

GEOLOGIC ASSESSMENT

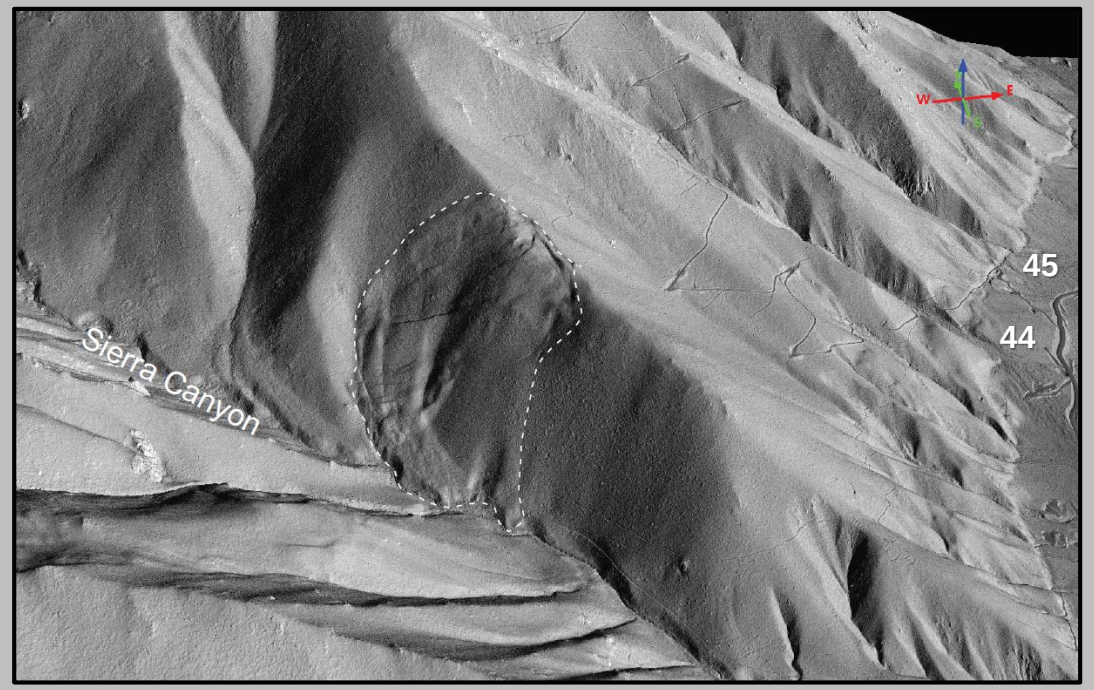
- **Summary:**
  - Reconnaissance observation
    - No active process monitoring
  - Primary land form development in Quaternary
    - Colder, wetter climate
  - All fans are active (varying degrees)
    - #79 & 82 pretty benign
    - #44 & 45 very active
  - Alluvial transport & deposition occurring
    - Channel & sheet flow deposits common
    - Fresh deposits along road during site visit
  - Debris flow possible
    - #44 & 45 most susceptible
    - Steep sections near fan apex (#81 & 116; maybe #78)

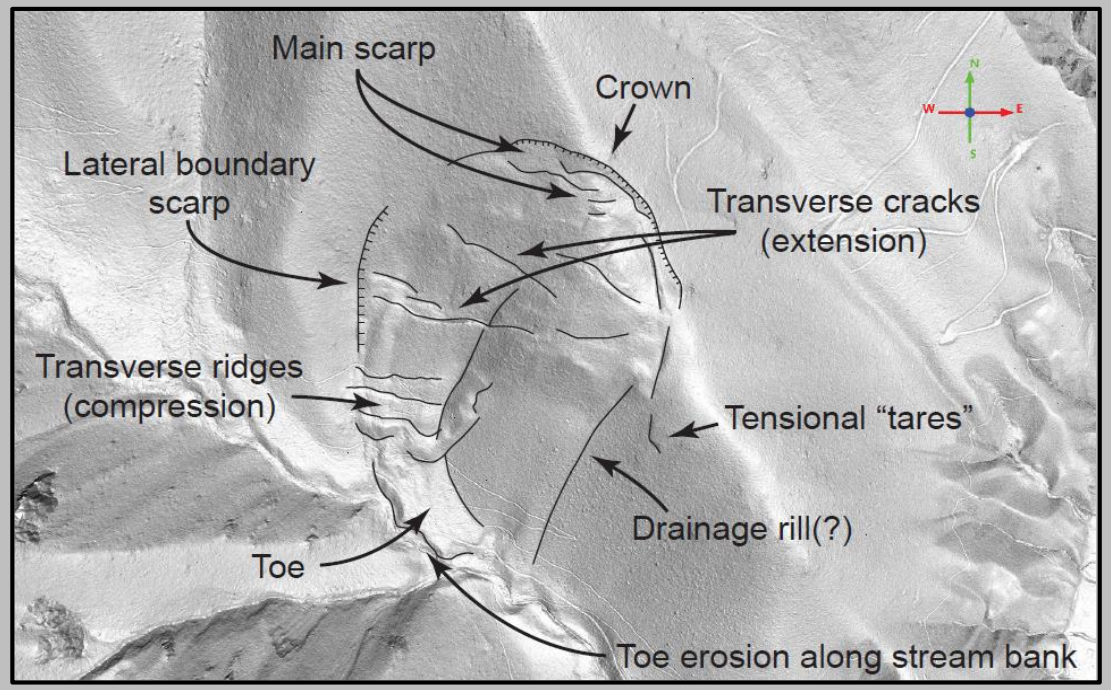
2014 Flooding Event Fan 116: Carson River Road

- Culvert inundated/ overwhelmed by discharge
- Became blocked and road flooded
- LiDAR data & aerial photo review channel looked like it should pass flow
- Hydrologic modeling suggests culvert too small

GEOLOGIC ASSESSMENT

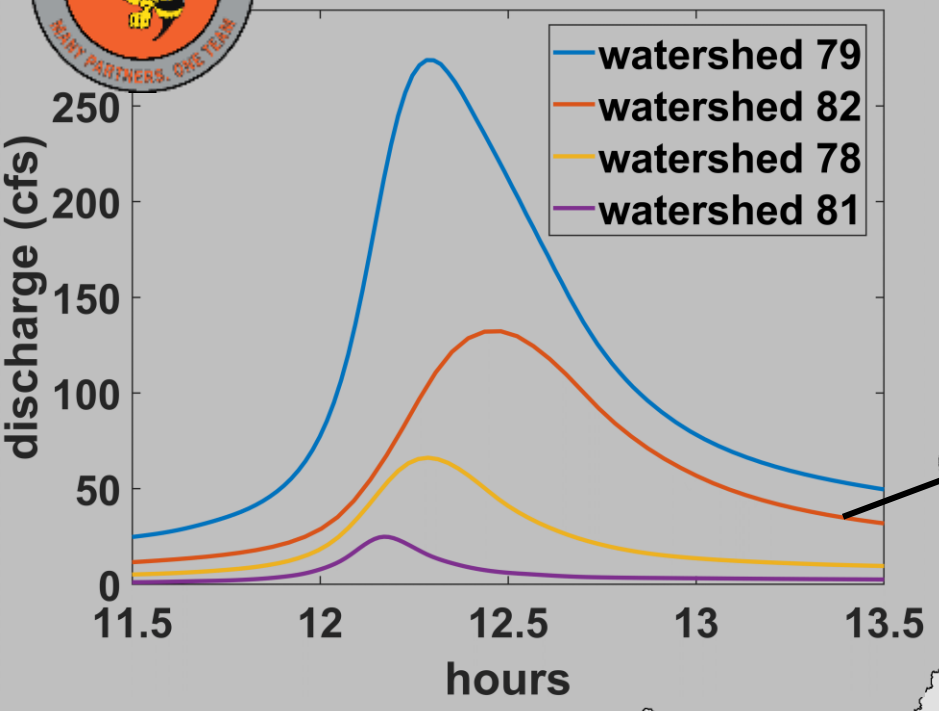
- **Sierra Canyon**
  - Well defined slide scar
  - Failure already initiated
  - Potential to close off canyon
  - Debris flow/slide hazard to Genoa, NV

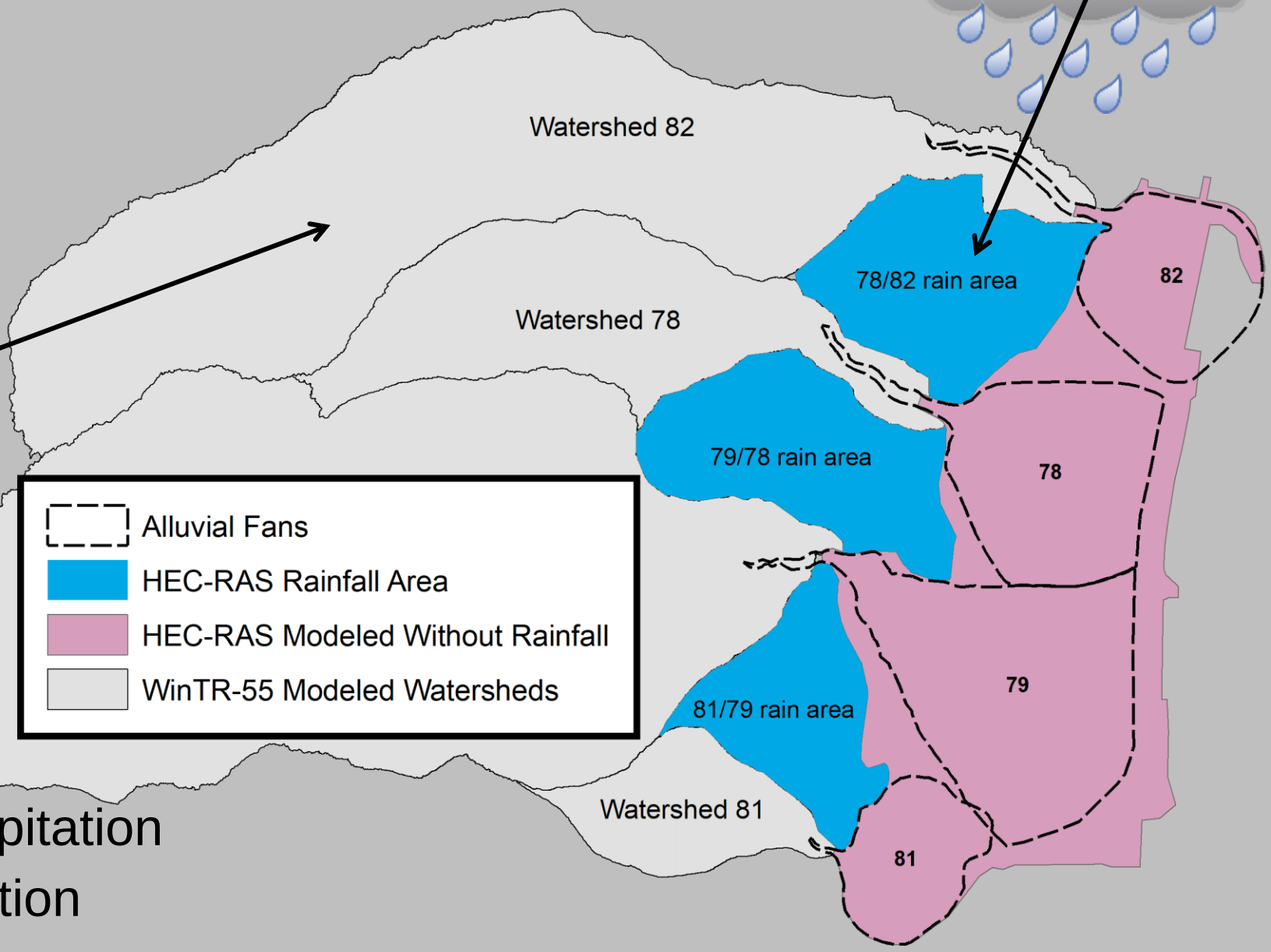




Rain cloud image source: https://ya-webdesign.com/image/raining-clipart-rainy-sky/1678401.html

HYDRAULIC ASSESSMENT



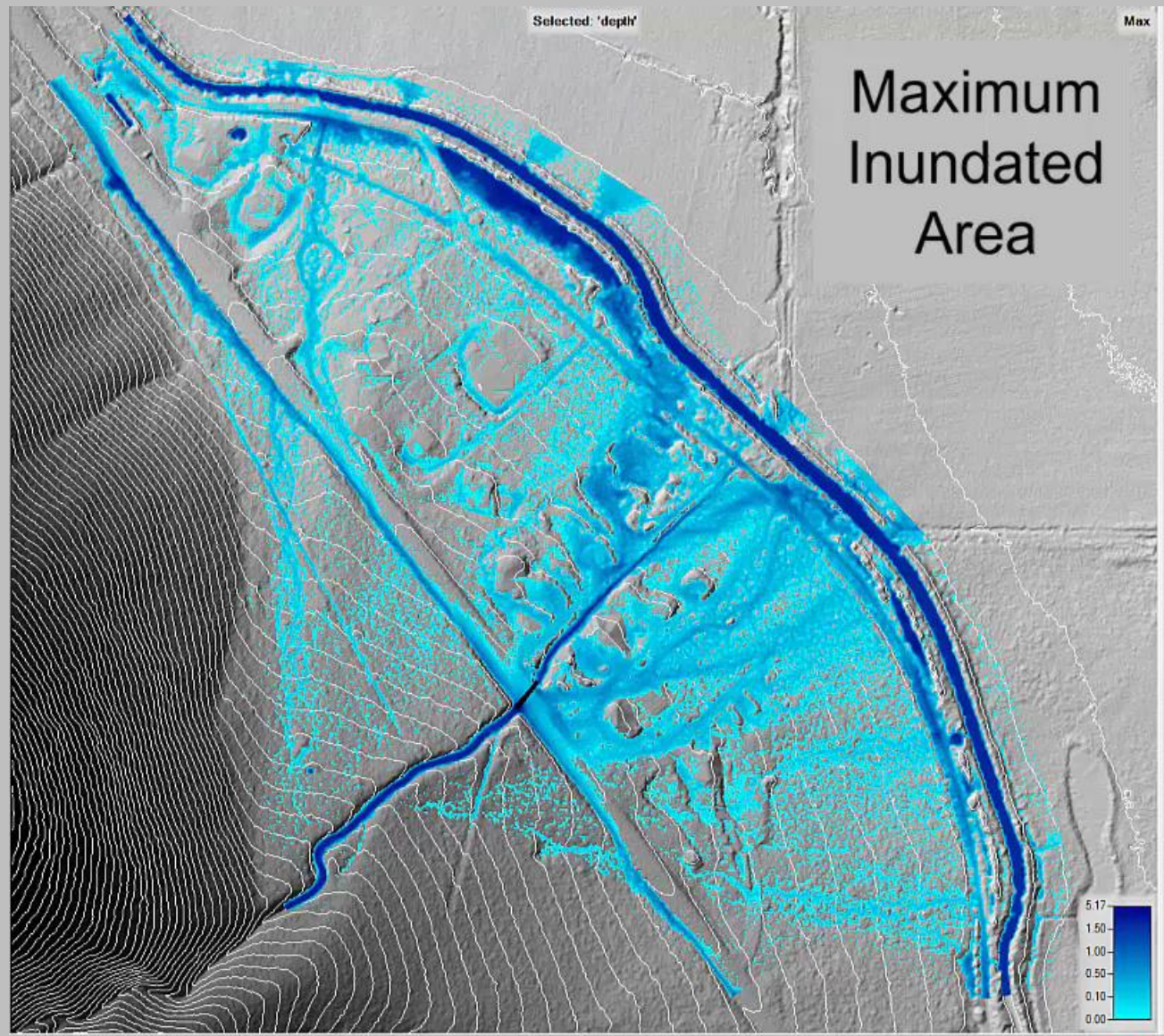


- Curve Number Method
- 100-yr rainfall event
- NOAA Atlas 14 gridded precipitation
- Nevada West rainfall distribution

HYDRAULIC ASSESSMENT

HEC-RAS 2D Hydraulic Model

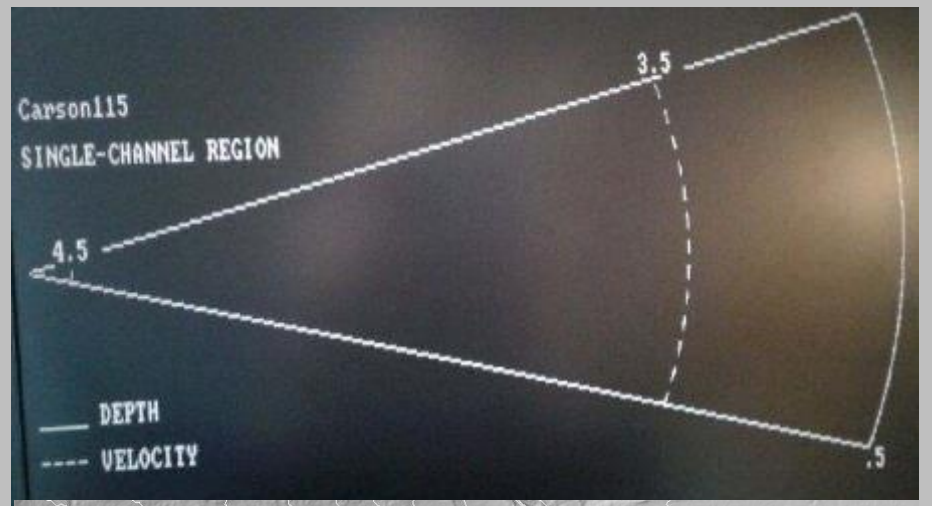
- Flow depth
- 2D velocity
- Direct rainfall
- Hydrograph inflow
- Culverts
- No erosion or deposition
- Not capable of modeling hyperconcentrated flow
- Sediment bulking factor of 1.35

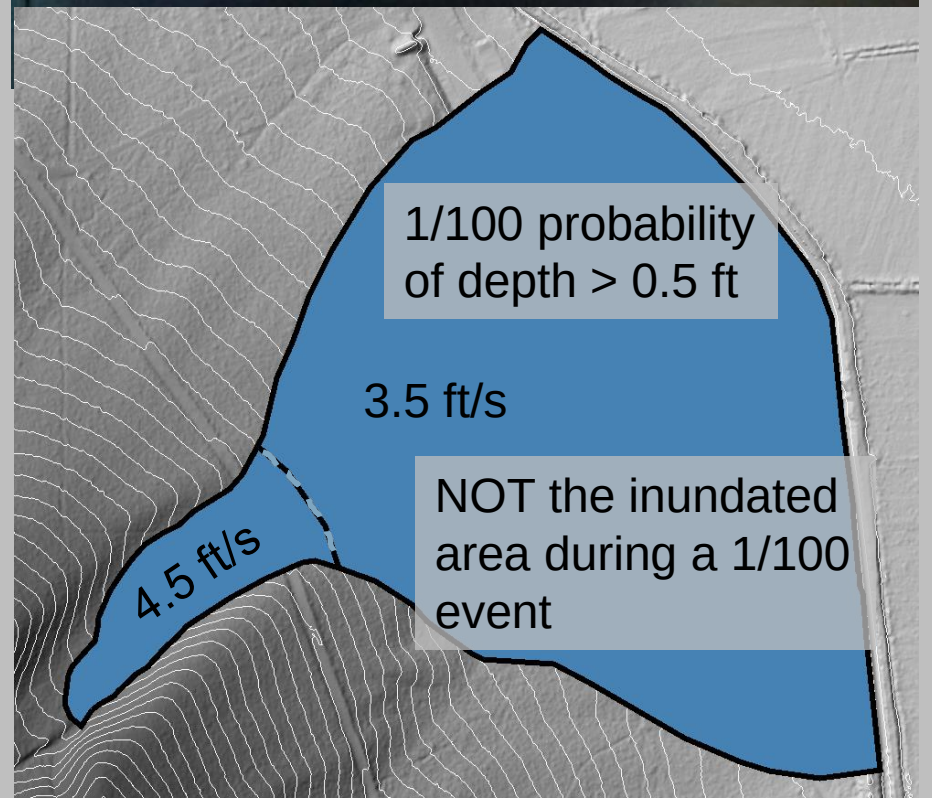


HYDRAULIC ASSESSMENT

FEMA FAN Program

- Any location in the zone has a probability of 1/100 of being inundated at the specified depth, or greater, during any given year
- Program solves for the contour length of the depth and velocity boundaries



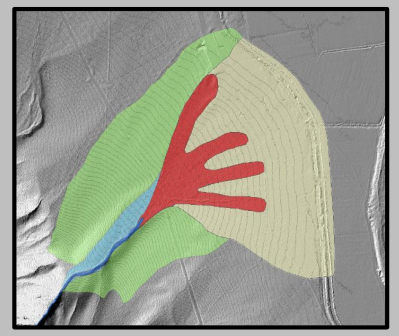


Assumptions

- Highly active alluvial fans
- Flow paths are allowed to move randomly
- Simple relationship between depth and flow
- Not valid for debris flow
- Negligible urbanization

HYDRAULIC ASSESSMENT

Geologic Assessment



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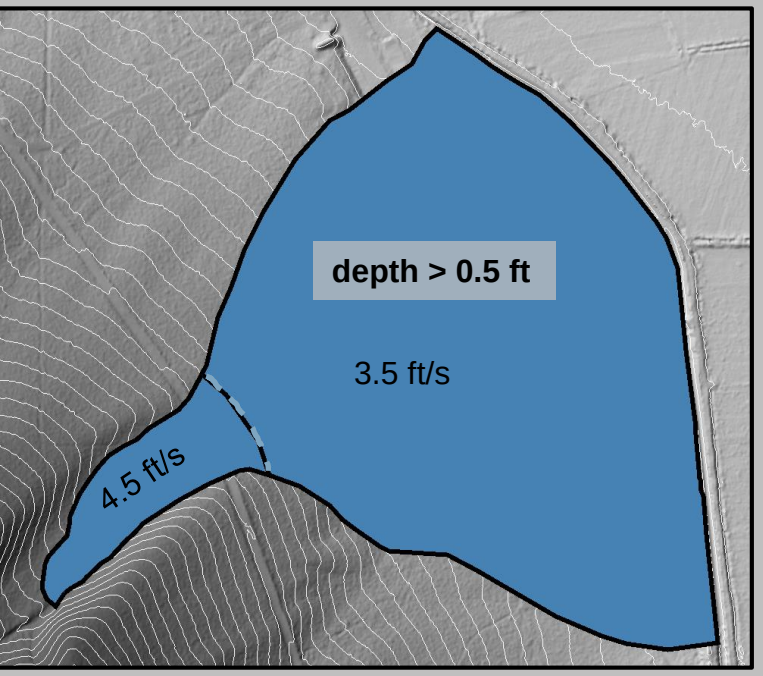
FEMA FAN



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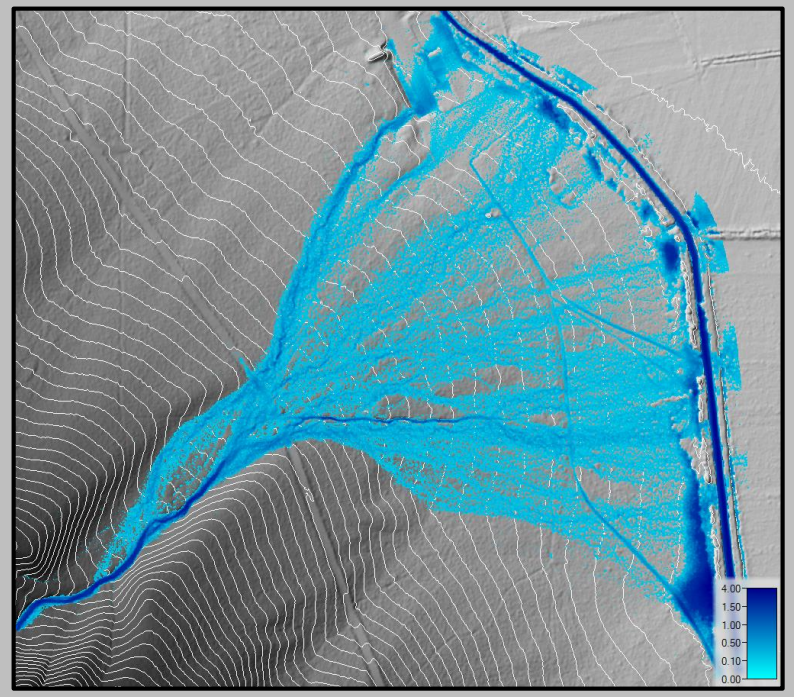
2D HEC-RAS



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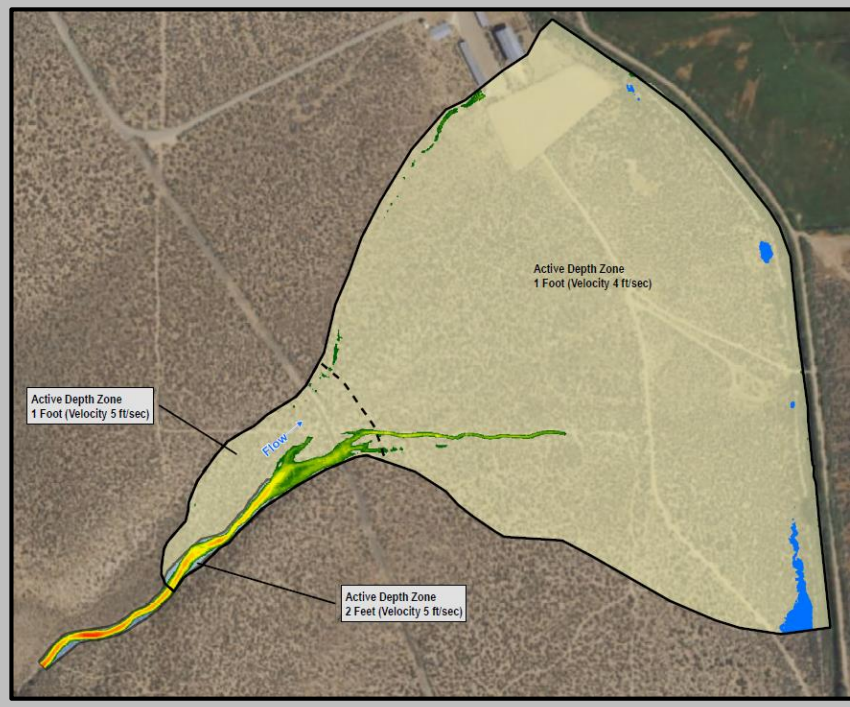
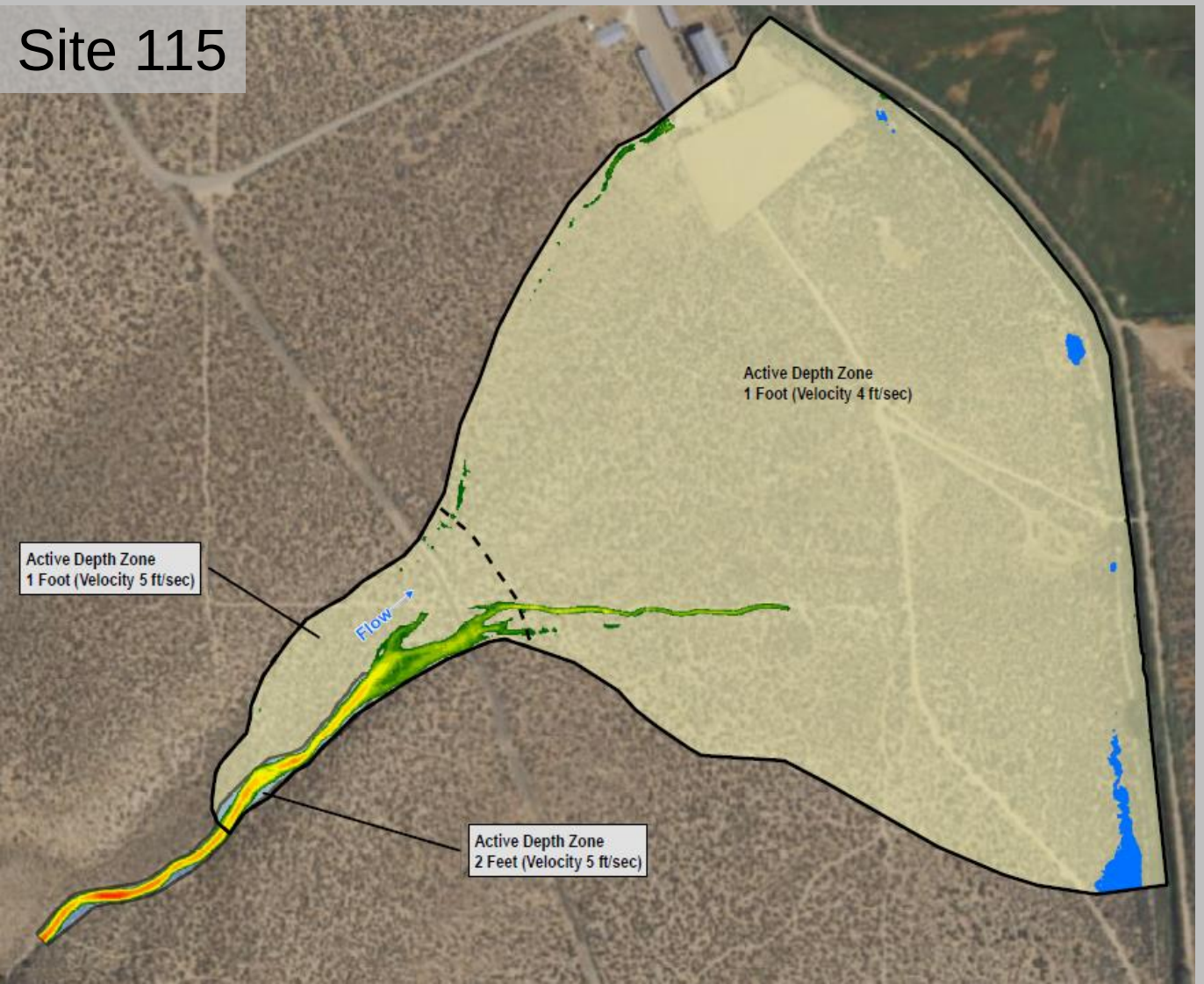
Inundation Map



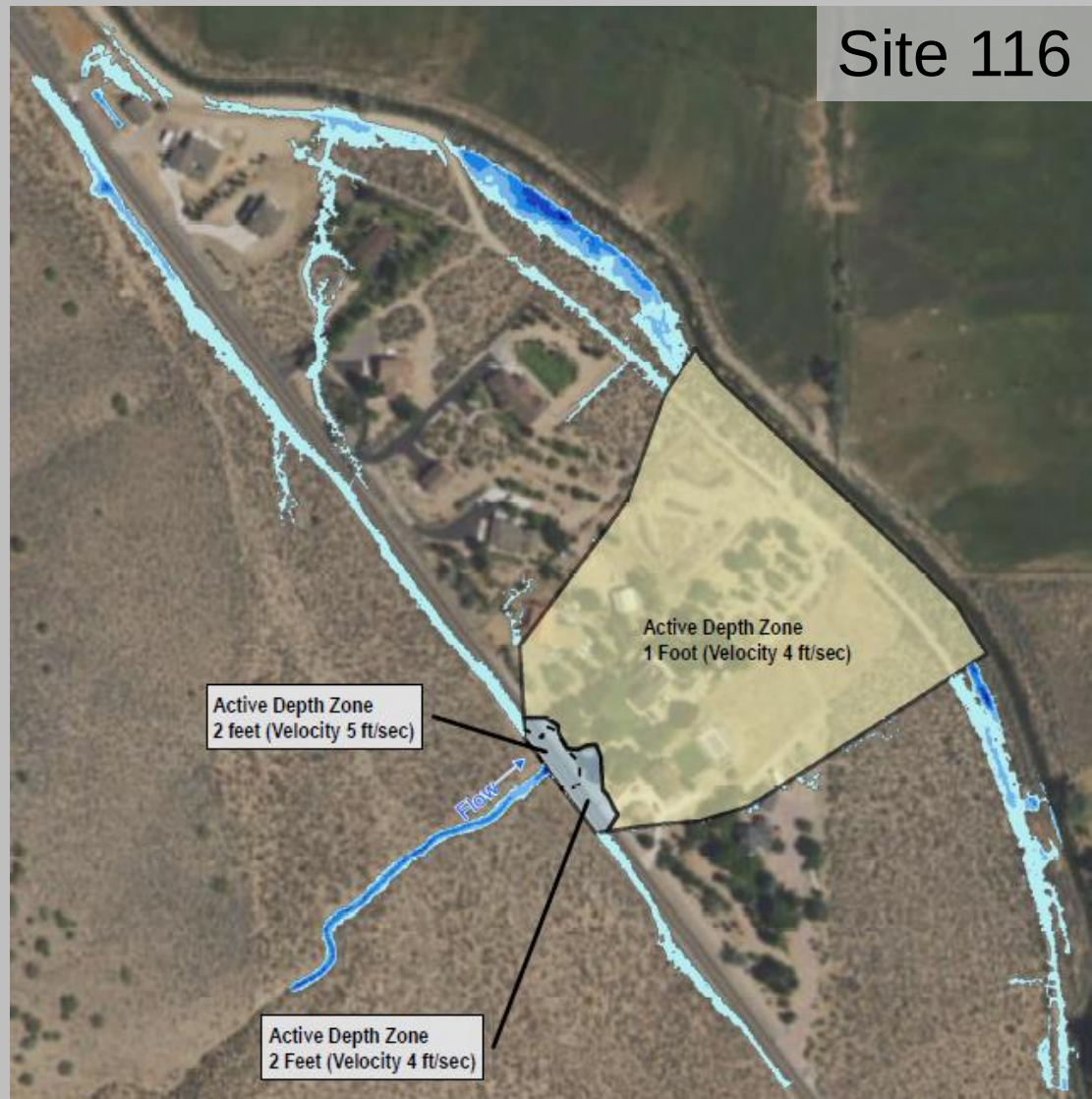
HYDRAULIC ASSESSMENT

Inundation Maps

Site 115



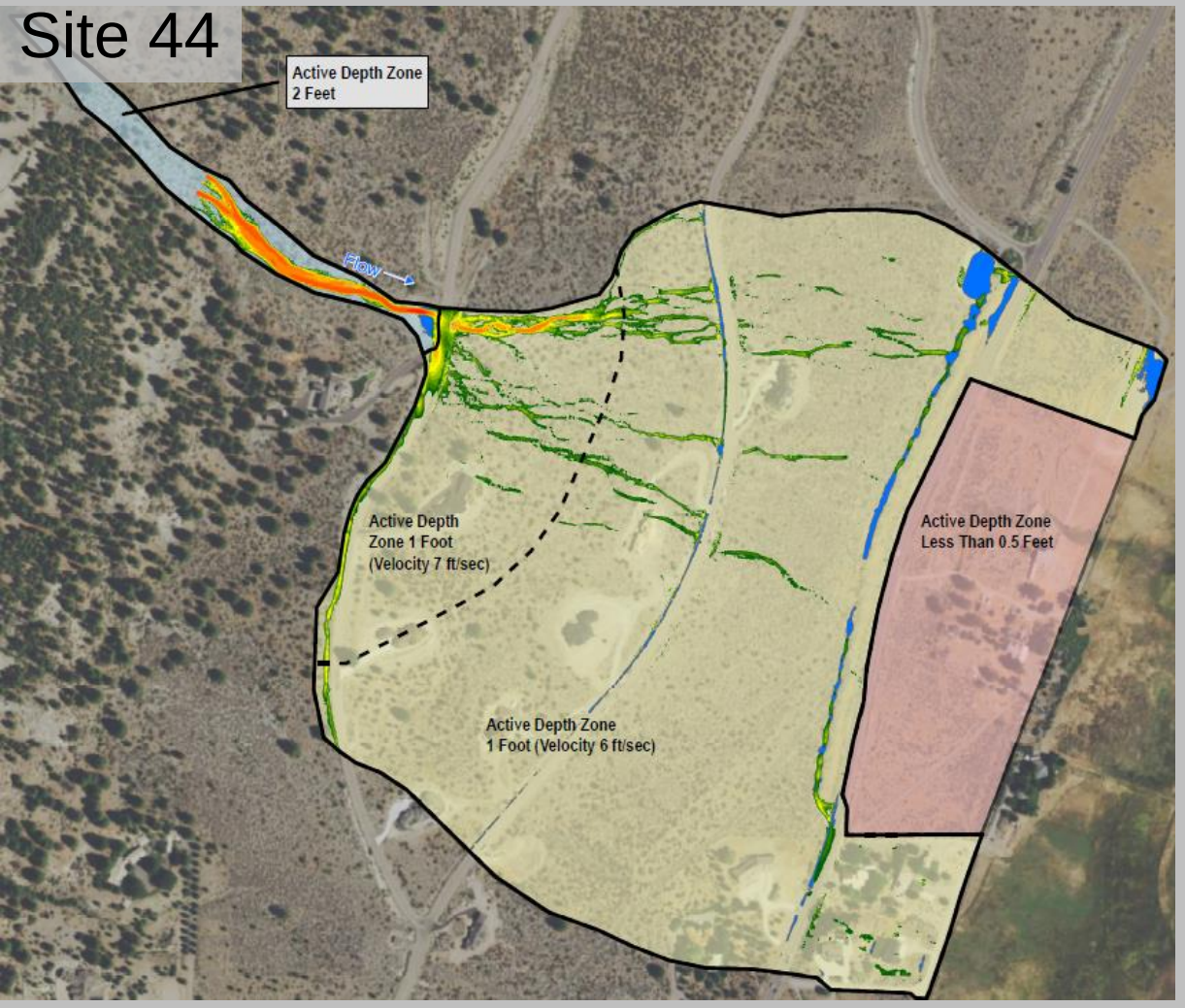
Site 116



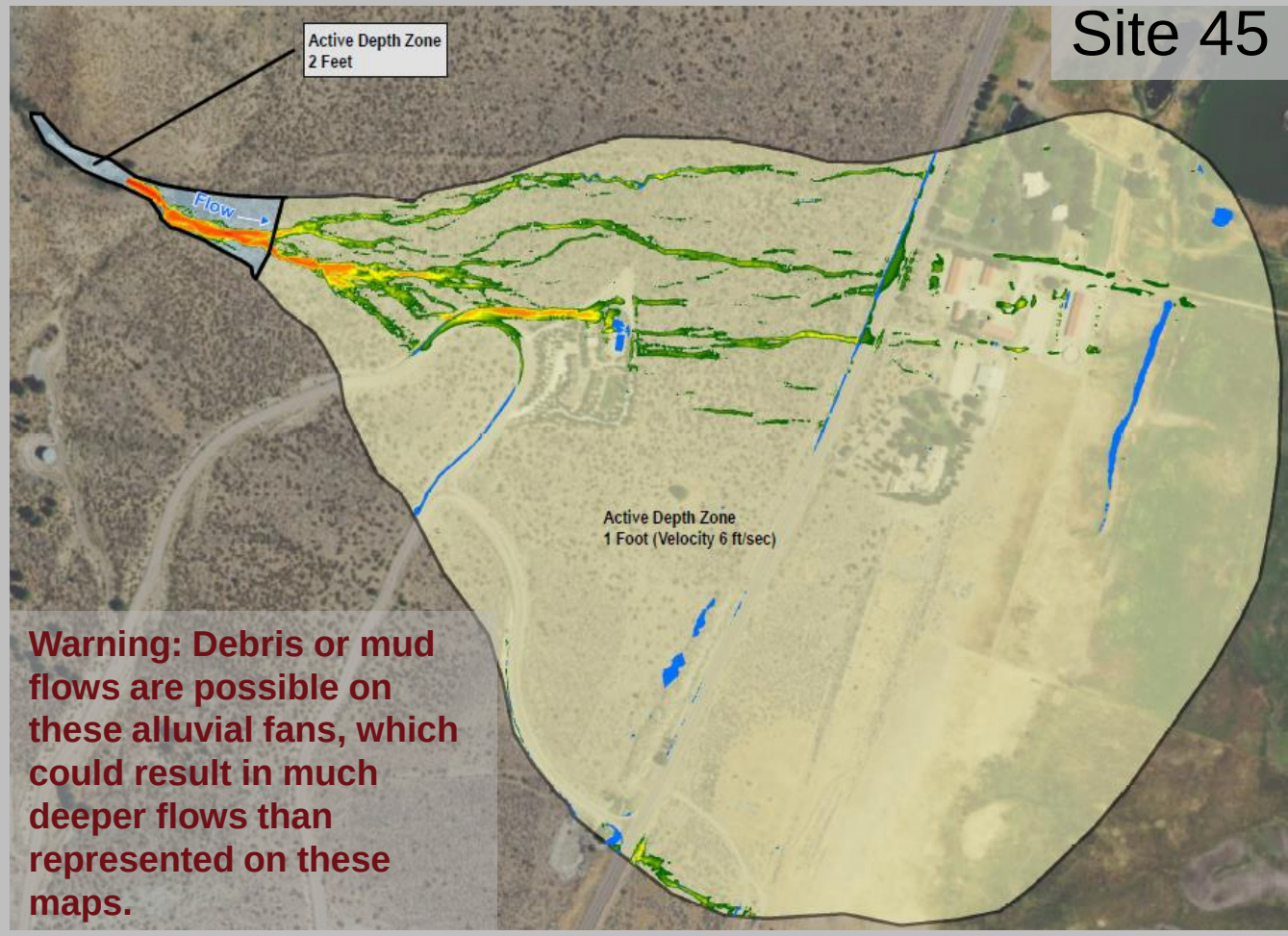
HYDRAULIC ASSESSMENT

Inundation Maps

Site 44



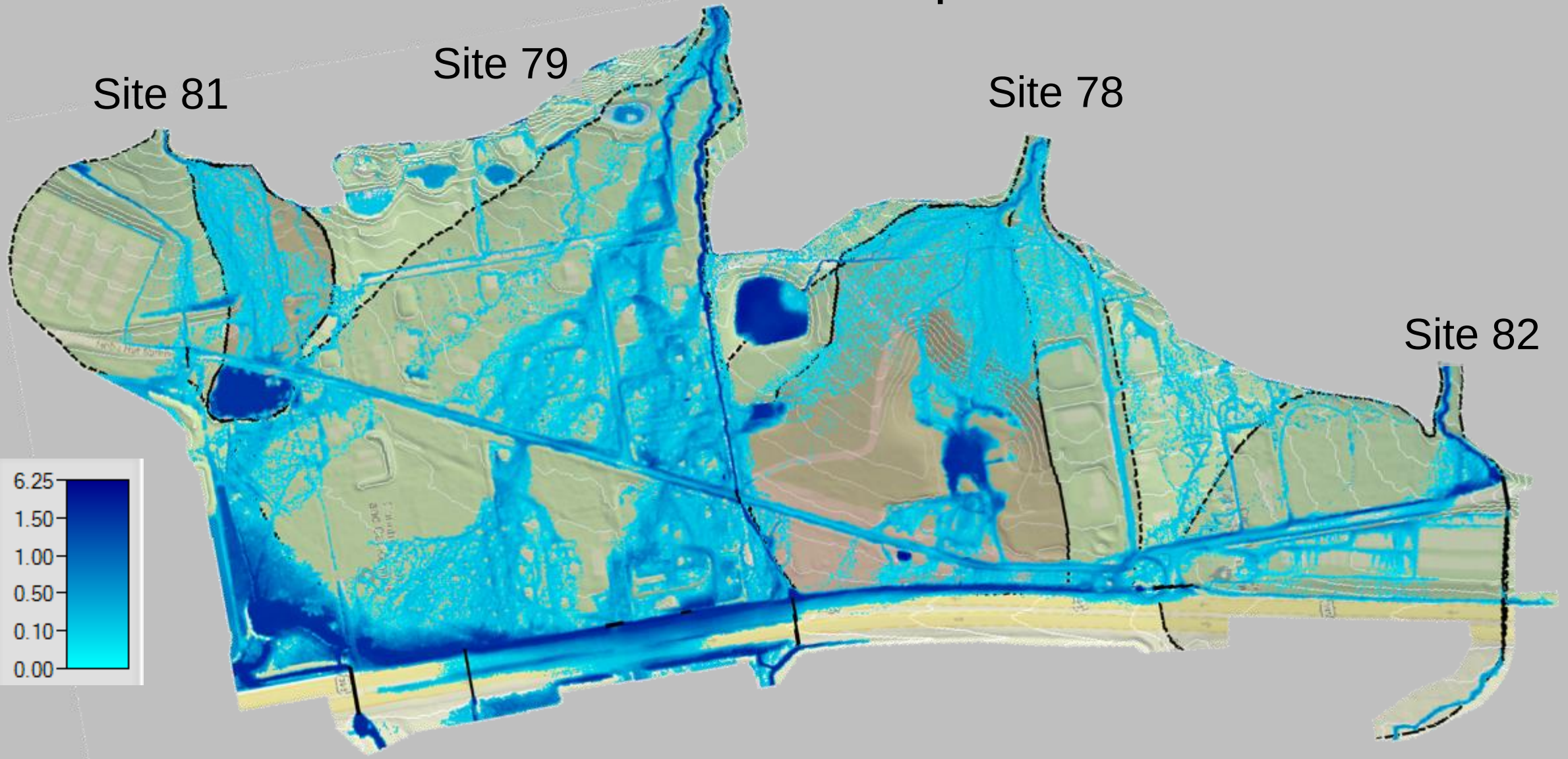
Site 45



Warning: Debris or mud flows are possible on these alluvial fans, which could result in much deeper flows than represented on these maps.

HYDRAULIC ASSESSMENT

Inundation Maps



WHAT'S NEXT?

- Understanding impacts to existing and future development
- Prioritizing watershed risk and develop strategies to minimize that risk
- Utilizing identified alluvial fan areas and associated risk in development review

Source: esri.com

QUESTIONS?

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