Goals:
(1) Compare designed and current volumes of flood-control debris basins to USGS sediment yield predictions for post-fire debris flow events, as part of recent disaster recovery and future planning efforts in Santa Barbara County, California.
(2) Develop framework for the use of drones (sUAS – small unmanned aerial systems) to aid flood infrastructure monitoring among local government, emergency management and academic geoscience communities.

Motivation: Recovery and preparation for future “one-two punches” of severe wildfires and debris flows.

How does 1960s-70s era infrastructure capacity compare with current debris flow hazards across large and small watersheds?
• Severe wildfires, such as the recent Thomas Fire (Dec 2017), leave watersheds denuded and prone to mass wasting events.
• 50-year trends of hotter June-Nov temperatures, and increasingly episodic rainfall, increase likelihood of severe fires and landslide hazards.
• Land-use, flood, and emergency managers need data on flood infrastructure and watershed conditions to mitigate and plan hazard responses.

Integration: Planning for future flood infrastructure needs based on recent extreme events
• The log-ratio of sediment yield : basin design capacity vs. USGS-sediment yields for design storms, gives a theoretical guide to how current infrastructure relates to mass wasting hazards.
• Blue stripe indicates range of maximum rainfall intensities at 3:45 AM PST. Jan 9, 2018, the time of debris flows.
• San Ysidro and Gobernador basins have largest gap, infrastructure capacity relative to sediment yields, for coming years.

Challenges for monitoring:
• Difficult to measure “true” debris flow volumes given overflow, drainage from basins.
• Large uncertainties in the way debris flows “mound” behind spillways; leads to discrepancies between design capacity and “basin-empty” volume estimates.
• Truck-reported volumes are what taxpayers pay to remove in cleanouts, but estimating cost from basin dimensions or “pile” volumes is difficult because material “fluffs”, expanding in volume, when broken up and loaded in trucks.
• Maintaining permanent survey markers in the field for repeat monitoring with sUAS over time.

Results: Drone imaging provided rapid, low-cost assessments of debris basin volumes after post-disaster clean-outs.
• sUAS basin-empty volume estimates are within ±15% of past ground survey estimates.
• Removing 70,000 m³ material quantified during cleanout of 160,000 m³ Santa Monica debris basin over two months.
• Debris volumes hauled by truck are rough “ground-truth” checks on USGS-predicted sediment yields.

Next steps:
• Codifying MOU between UCSB and S.B. County for further outreach for hazard management.
• Collaboration with others using sUAS for flood and other infrastructure assessment pre-and post-hazard.
• sUAS to inform ecological restoration

Acknowledgments and References

Methods: Measure debris basin volumes across catchments with sUAS image-based 3D models, and compare with past survey, engineering data and USGS sediment-yield predictions.

Drone imaging workflow:
• DJI Phantom 4 and Inspire 1.
• Autonomous grid flights over basin areas.
• Structure-from-Motion point cloud and volume analysis with Pix4D, Cloud Compare.

Integration with County survey and engineering data
• Worked with SB County Flood Control Surveyor for ground control points.
• Data sharing with county for basin design specifications, and volumes of removed debris.