Arizona DOT Infrastructure Resilience
Blending Risk/Science/Technology/Engineering
ADOT/USGS Pilot - Laguna Creek Bank Protection

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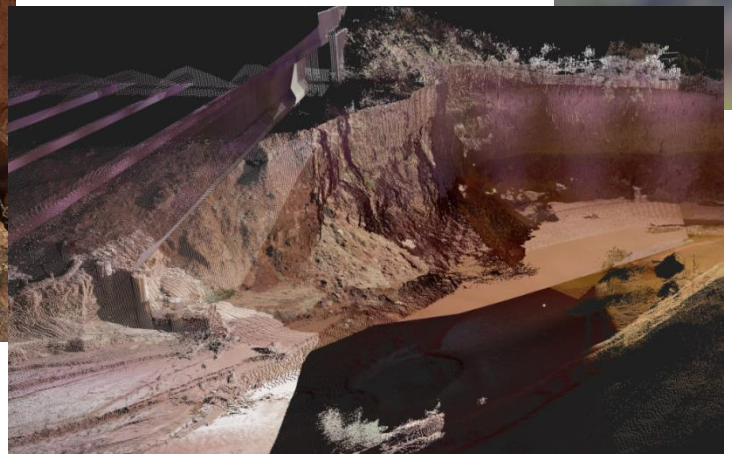

11th International Bridge and Structures Management Conference

April 25, 2017

ADOT

Laguna Creek Bridge Bank Protection

Laguna Creek Bridge Bank Protection

Jacobs

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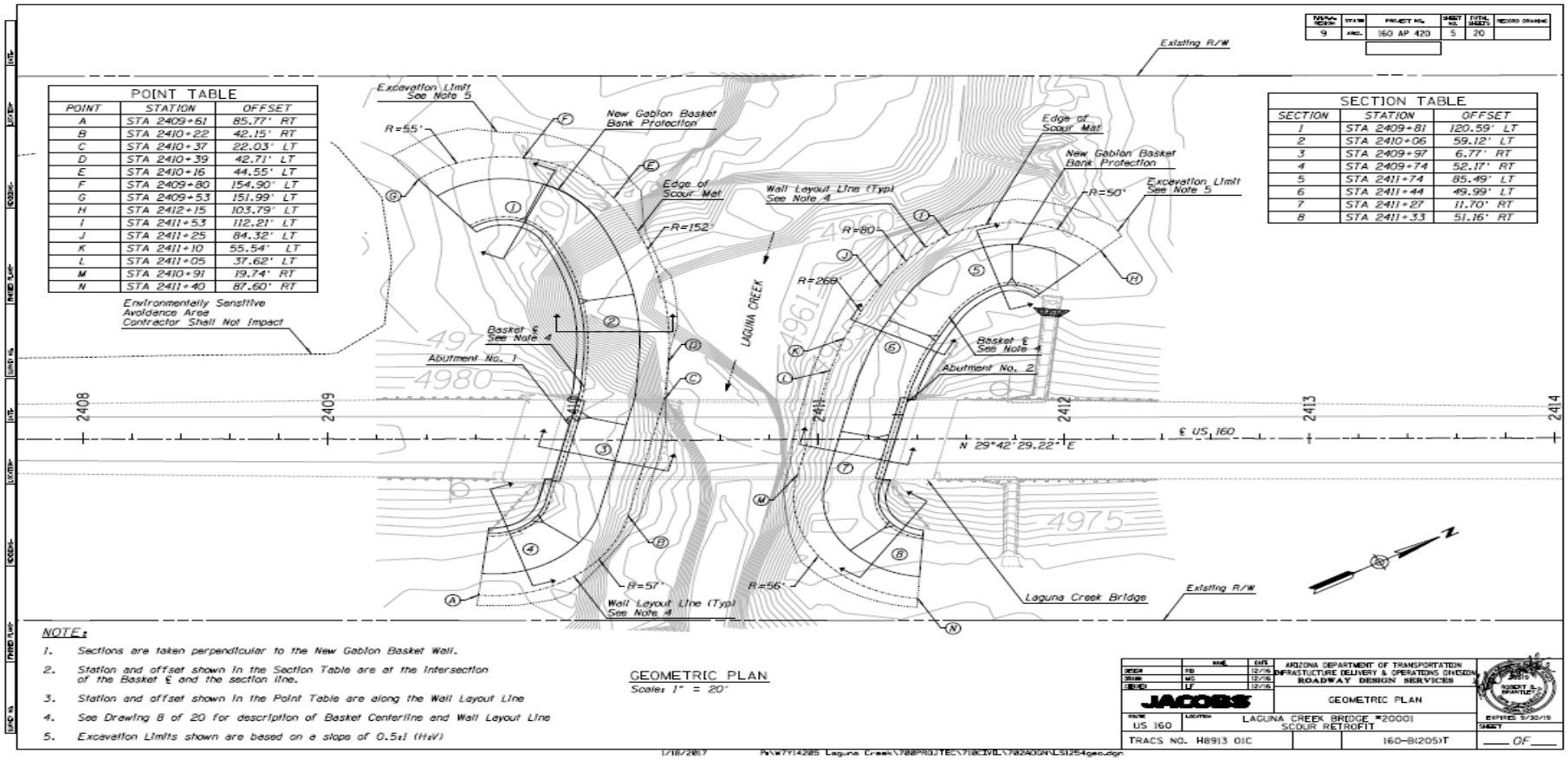
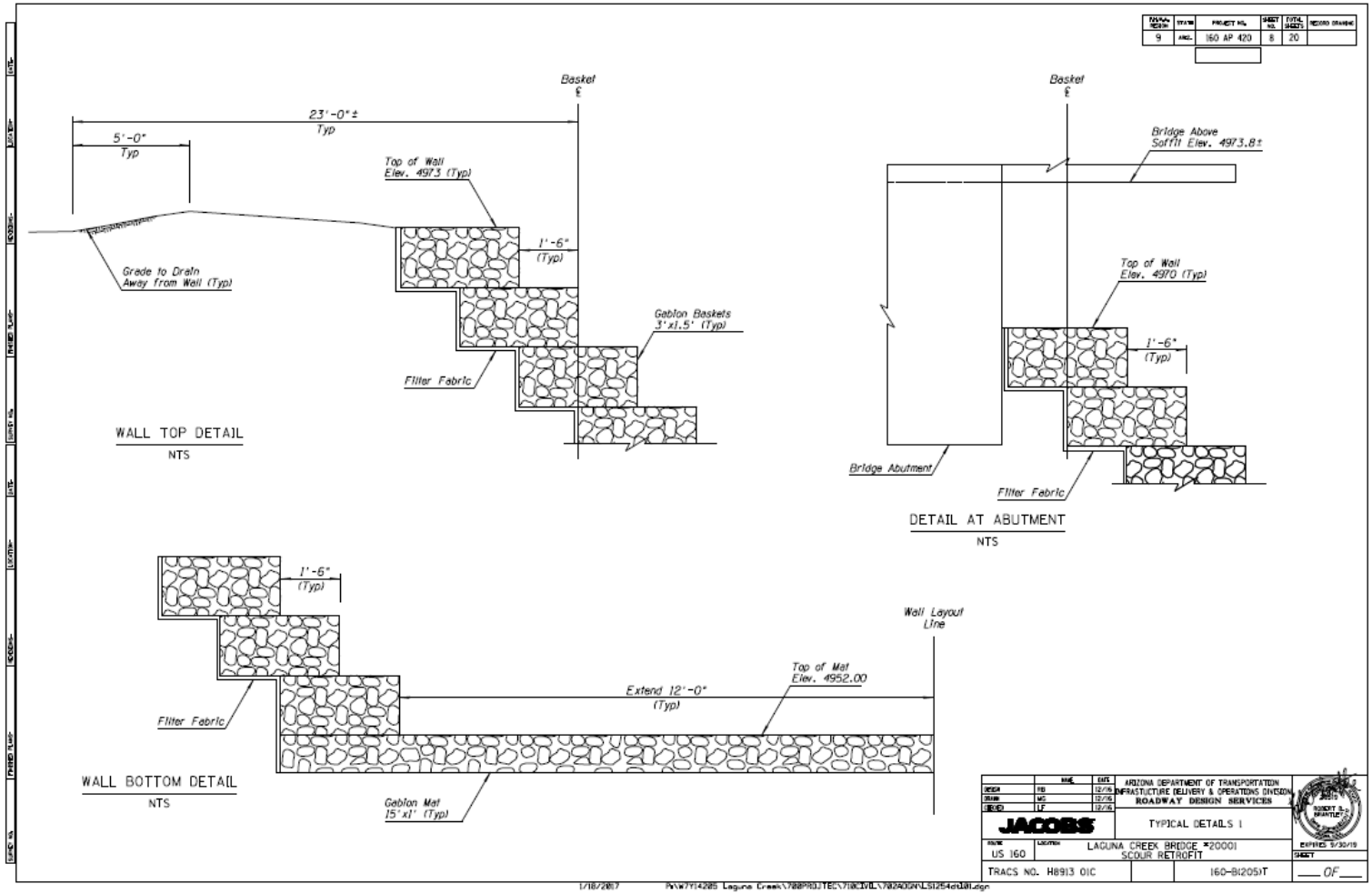


Laguna Creek Bridge Bank Protection

Jacobs



Arizona Asset Universe

Arizona

140,000 maintenance lane miles
7,250 bridges
1 International border

ADOT

30,000 maintenance lane miles connecting those 140,000
4,750 bridges
7 maintenance and construction districts
1,500 facility buildings

Spread over 114,000 square miles
Our assets operate from sea level to over 6,000 feet
Temperatures below 0°F to over 120°F

Impacts

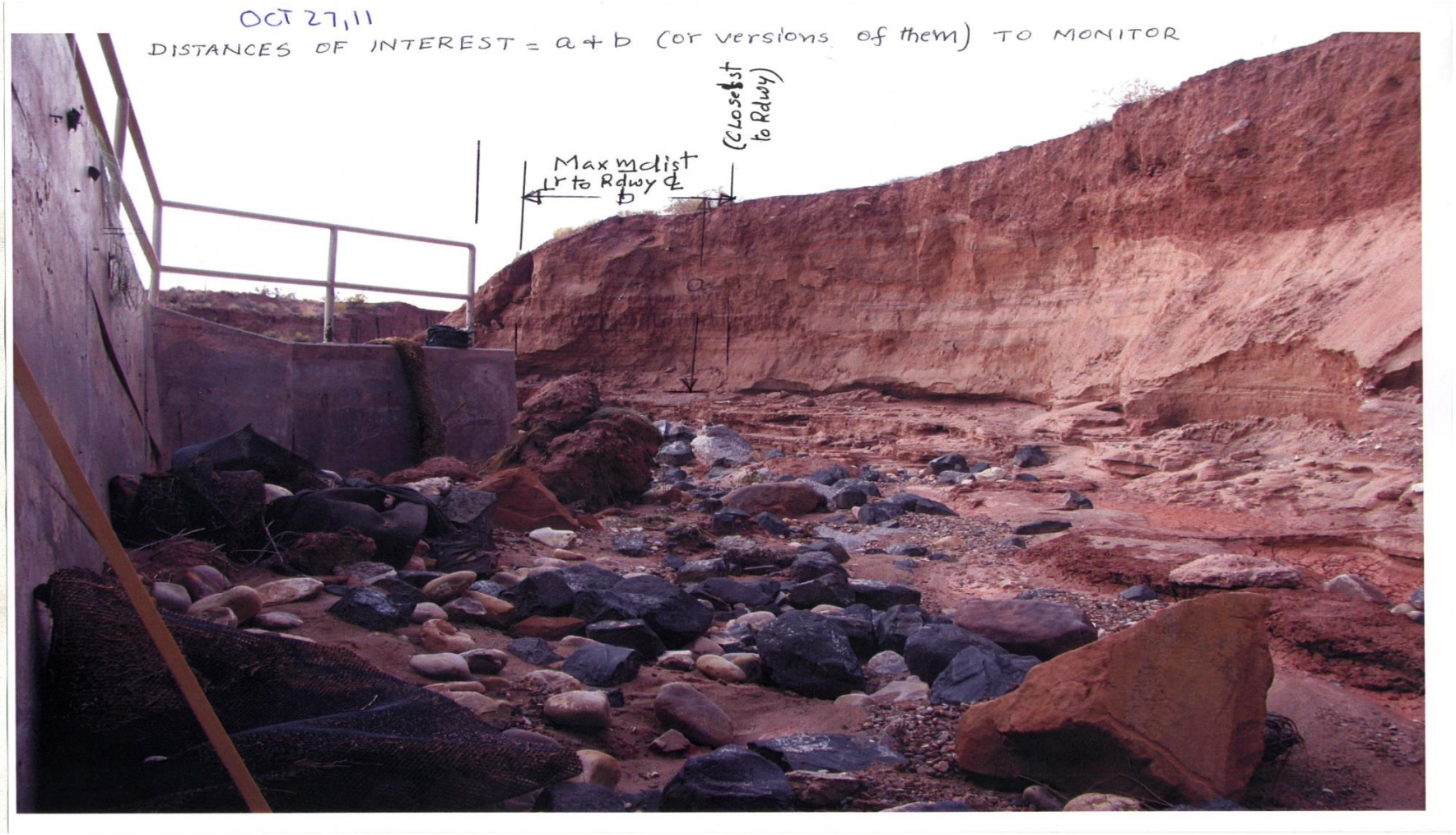
Impacts

Impacts

Impacts

Impacts

Impacts


Oct 27,11
DISTANCES OF INTEREST = a + b (or versions of them) TO MONITOR
Max mdist ⊥r to Rdwy ℄
b
(Closest to Rdwy)
a

Impacts

Impacts

Risk-based Approach

Stressor considerations on infrastructure / future design criteria, construction, and maintenance activities

- Shortened pavement life (heat, freeze-thaw, snow plowing)
- Culverts - design capacity, maintenance frequency
- Bridges - design capacity, maintenance frequency
- Roadside erosion
- Road closures from flooding/fire/rockfall/dust/low water crossings
- Shifting periods for paving operations
- Winter storm maintenance costs
- Stormwater structure design and locating
- Other

Risk-based Approach

The challenge – Continue considering the balance between predictable asset deterioration curves, the sudden and unpredictable nature of flooding, hydraulic-related failures, extreme weather events and long term climate trends.

- Develop asset subsets that reflect an accurate picture
- Identify and evaluate relevant asset/maintenance datasets
- Assess availability and accuracy of asset spatial information
- Collect data that is necessary to scope and objectives
- Engage local experts on data gaps
- Develop clear data management strategy

Risk-based Approach

How do we shift from a deterministic preset design frequency basis and statistical risk of failure

To a probabilistic analysis approach that inputs additional vulnerabilities, considerations, and current conditions not previously considered

For ADOT - as they relate to incidents of stormwater, flooding, hydraulic-related failures, extreme events, forest fires - flows, debris, sediment, roadside

What is ADOT after – Identification of a reasonable universe <u>not previously considered or required in design</u>

Risk-based Approach

OK Great – Helpful – But what constitutes a reasonable universe

Implement a new probabilistic end-to-end engineering-based asset adaption process and ensure that it incorporates:

- Current design requirements
- Extreme event data / modeling where appropriate
- Stakeholders
- Constructability flexibility
- Life cycle cost considerations (operations and maintenance)
- Prioritization characteristics for TAMP / Performance Measures
- Environmental review connectivity
- And lends confidence and validity to funding constraint

Catalyst to take this on?

The Arizona DOT Resilience Program

ADOT's mission to provide a safe, efficient, cost effective transportation system can be compromised from the effects of extreme weather effects and climate change adaptation - heat extremes, dust storms, wildfires, flooding, landslides, rockfall incidents, and slope failures. In order to cope with the ever-growing cost of these threats, ADOT set out to develop a resilience program that could:

- Incorporate existing planning, design, construction, operations, and maintenance criteria
- Identify a strategic and systematic framework
- Take advantage of available technologies, tools, and partnerships
- Build upon their 2014 *Preliminary Study of Climate Adaptation for the Statewide Transportation System in Arizona* and the 2015 *Extreme Weather Vulnerability Assessment Final Report*
- Contribute to the national conversation surrounding these topics

ADOT

Catalyst to take this on?

The Arizona DOT Resilience Program (initial focus)

Since ADOT has had a long history considering the balance between predictable asset deterioration curves and the unknown, erratic, and abrupt incidents of flood, overtopping, system hotspots, hydraulic-related failure, and extreme weather impacts, these topics were identified to make up the core of the pilot program. Three areas of vexing concern for state DOTs and the main catalyst for developing an ADOT Resilience Program involve how to:

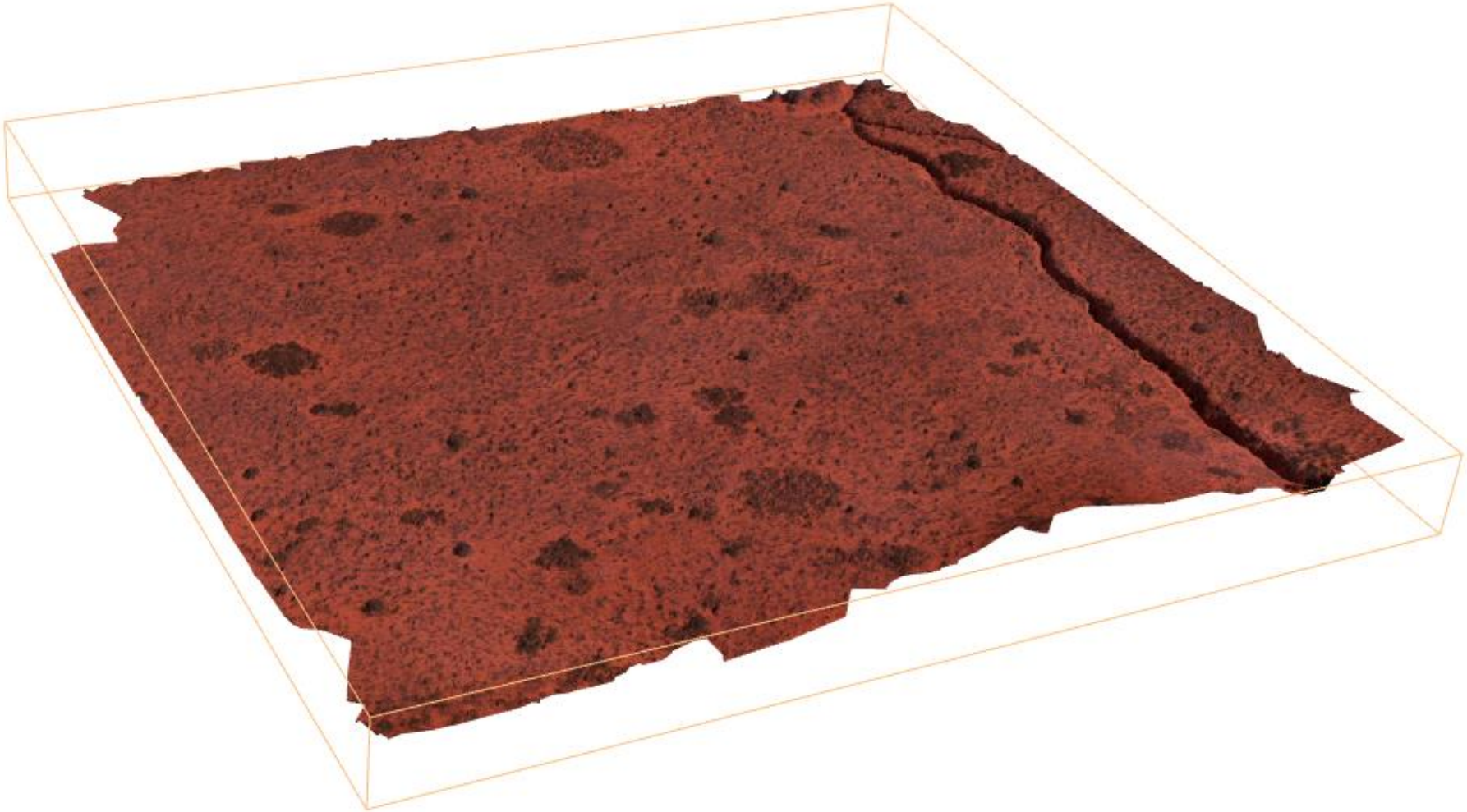
- Centralize to one operating area the unknown, erratic, and abrupt incidents of stormwater and its contributors of flooding, overtopping, system hotspots, hydraulic-related failures
- Introduce extreme weather adaptation to agency and engineering design processes and establish transportation asset sensitivity to extreme weather
- Handle scientifically-informed climate data downscaling as it relates to transportation systems

Science - ADOT/USGS Partnering Project

ADOT Goal: Incorporate USGS Arizona Water Science direct (real-time) storm monitoring and data collection, indirect (post-storm event monitoring and data collection), and next generation hardware, software, and surface water flow data collection capabilities. This effort would directly and meaningfully contribute to expediting and improving ADOT's efforts in planning and responding to incidents of flood, over-topping, system hotspots, hydraulic-related failure, and extreme weather events in connection with:

1) NEPA jurisdictional and wetland delineation expediting and streamlining **2)** Highway stormwater runoff management **3)** Evaluating scour potential and countermeasure development at water crossings **4)** Drainage structure siting, design and construction **5)** Response to Federal extreme weather regulatory activities.

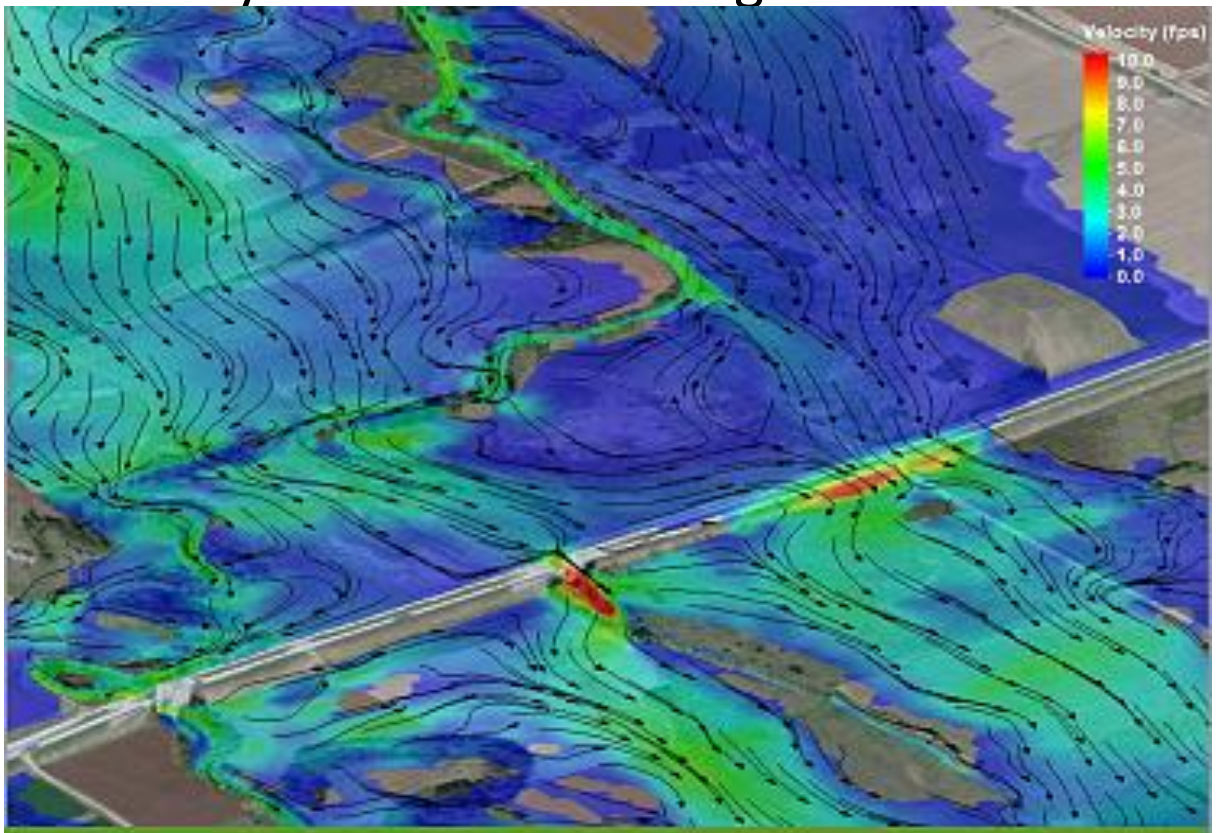
Technology - 3-D Modeling



Technology - every day counts

An Innovation Partnership with States

CHANGE - Collaborative Hydraulics: Advancing to the Next Generation of Engineering



The latest 2D hydraulic modeling tools offer better representations that provide planning and design teams with better data, leading to improved project quality.

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Pilot #1 – Laguna Creek Bridge (Ground based LiDAR project)

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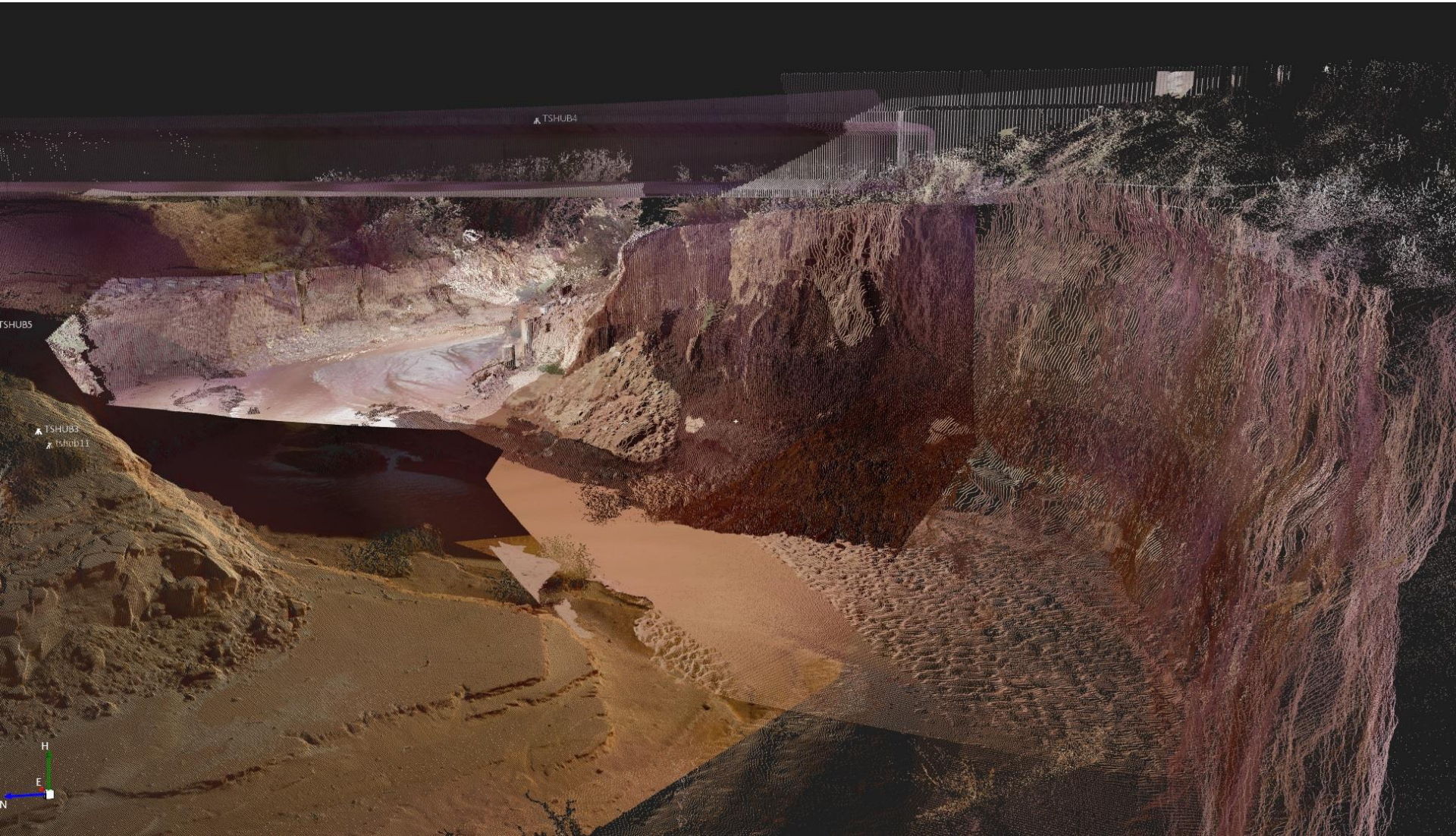

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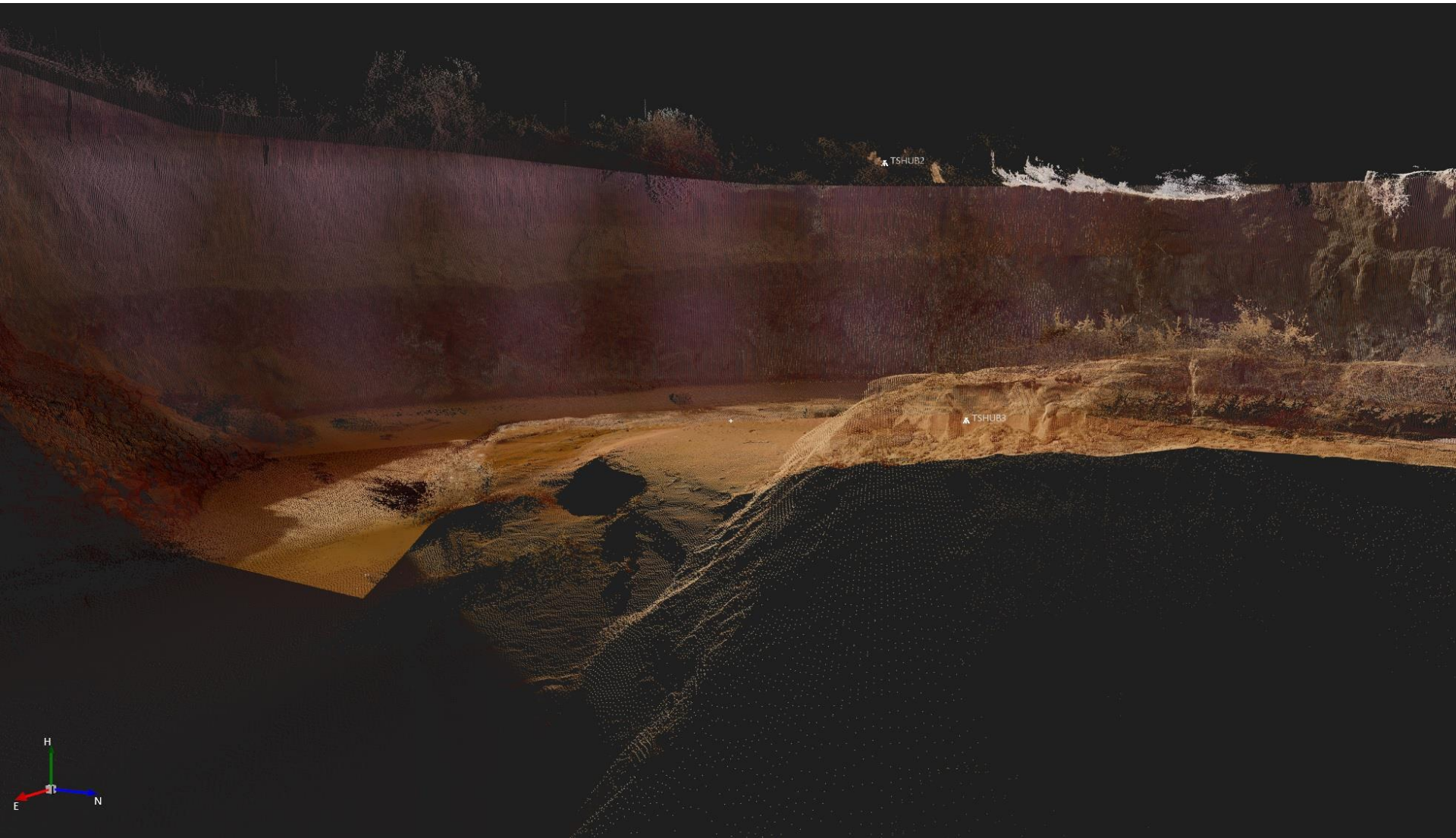

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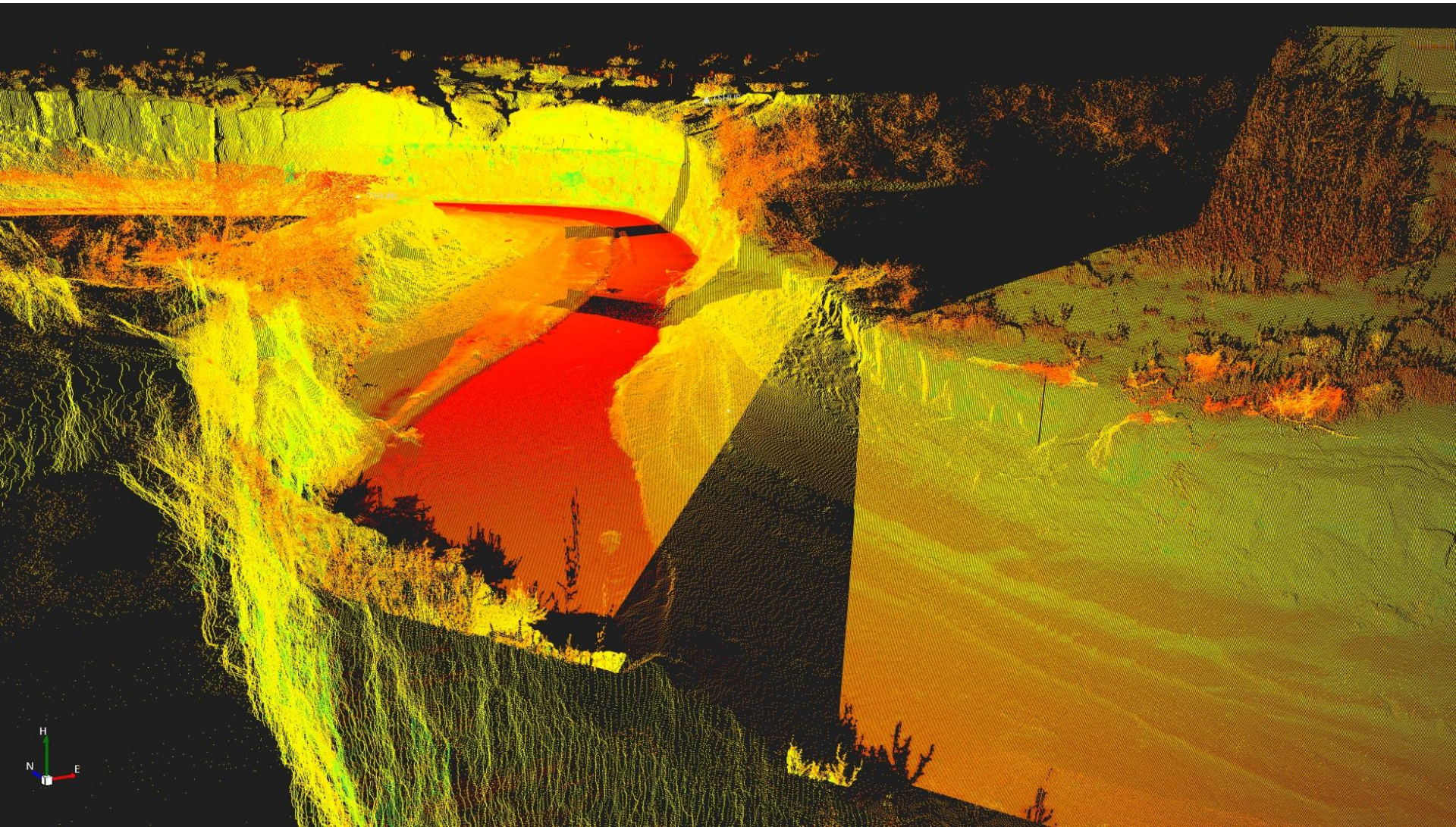
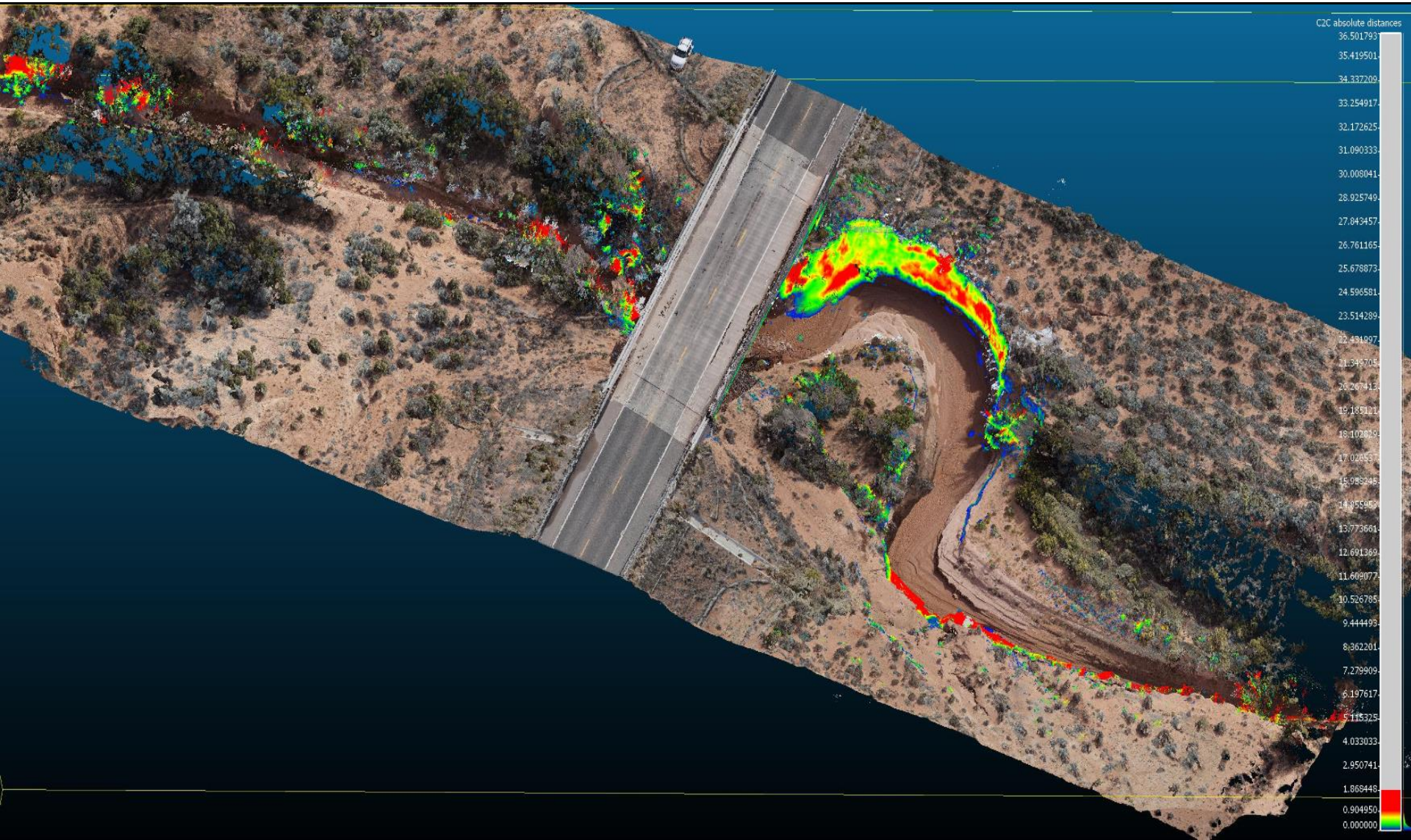
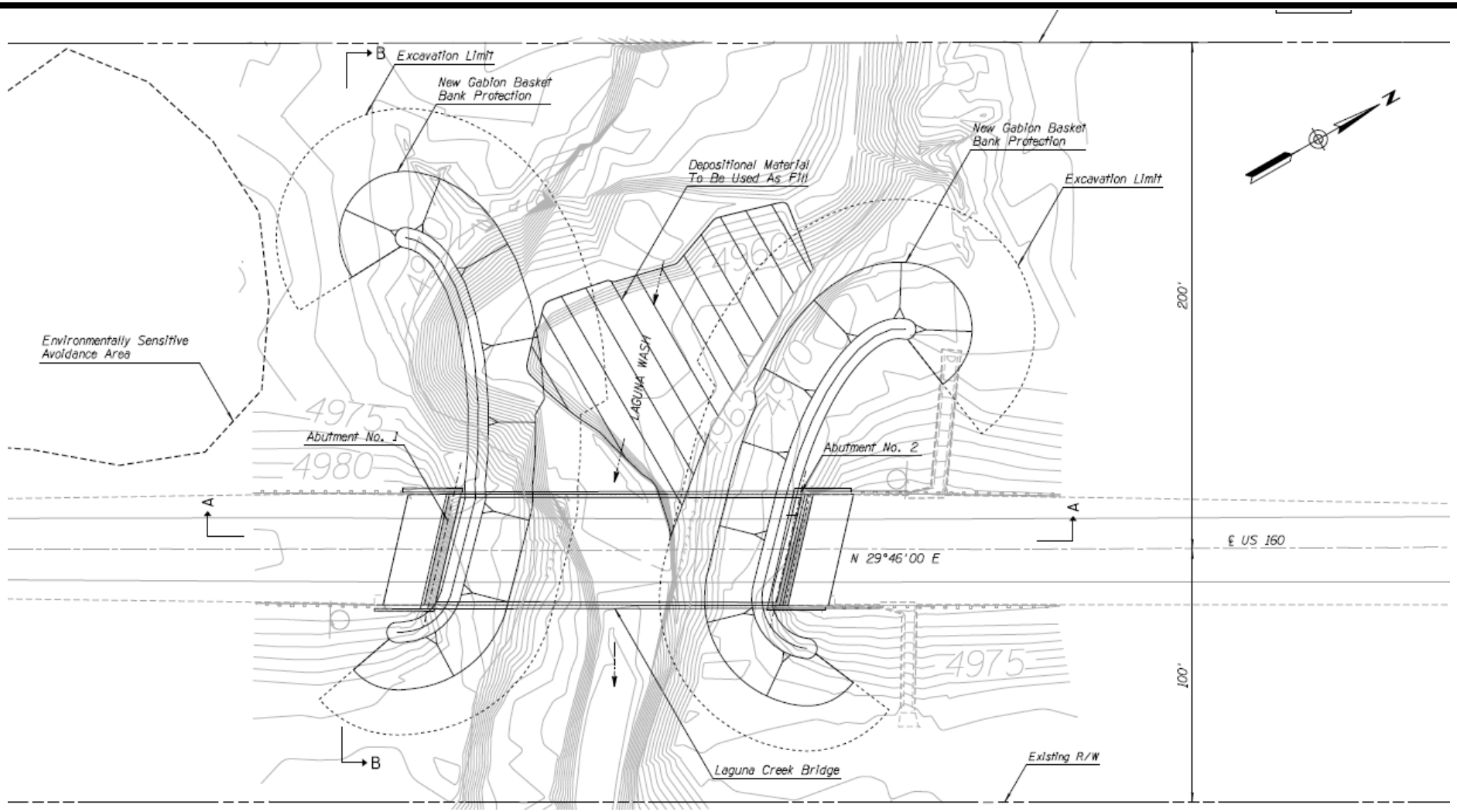


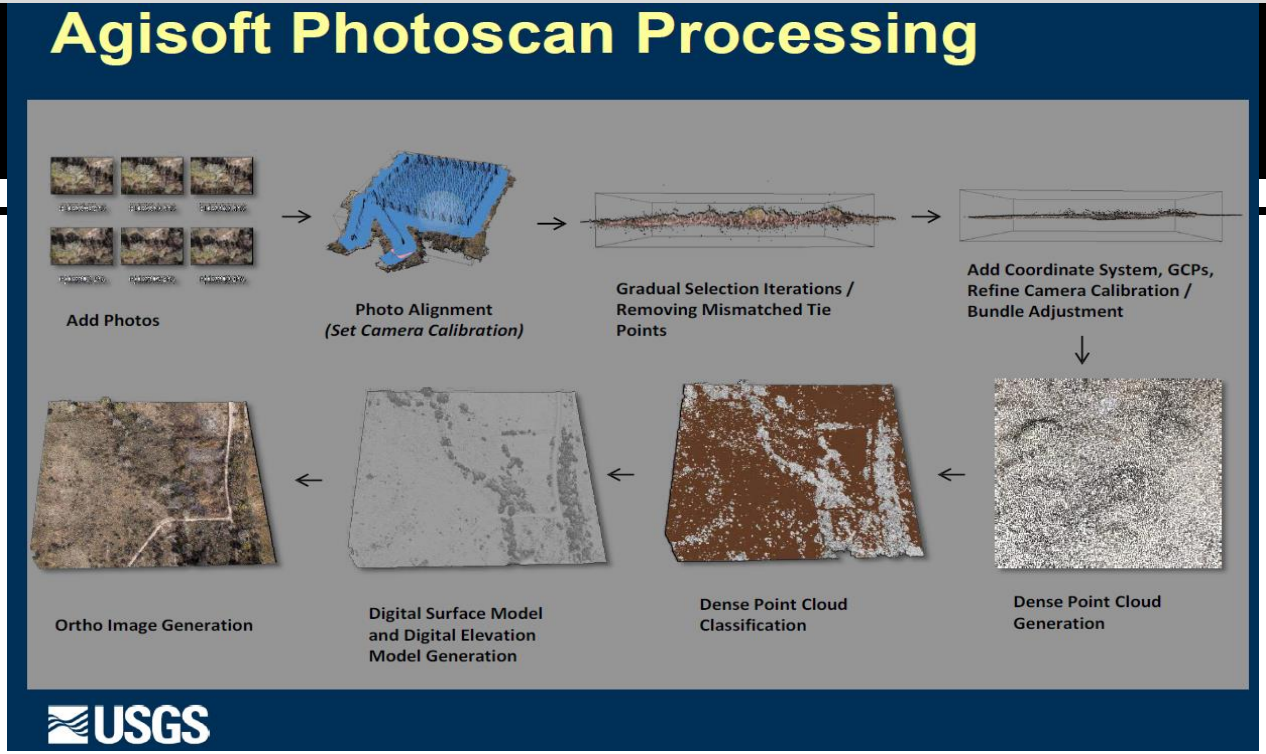
3-D Erosion Change Detection Mapping

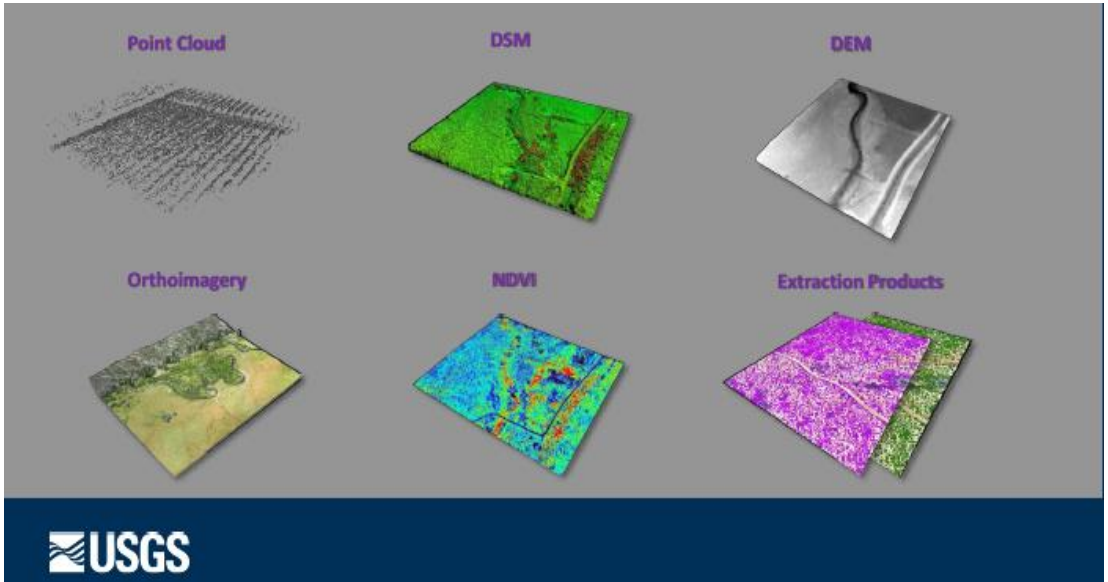


3-D Erosion Change Detection Mapped to Design



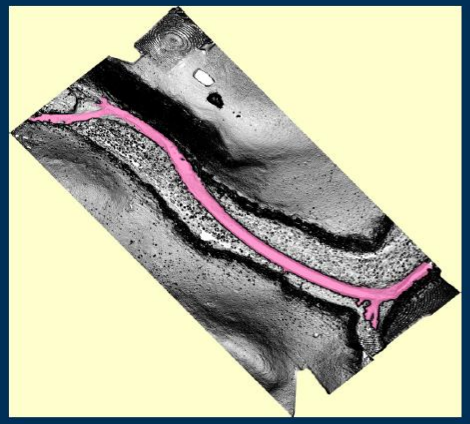
Products

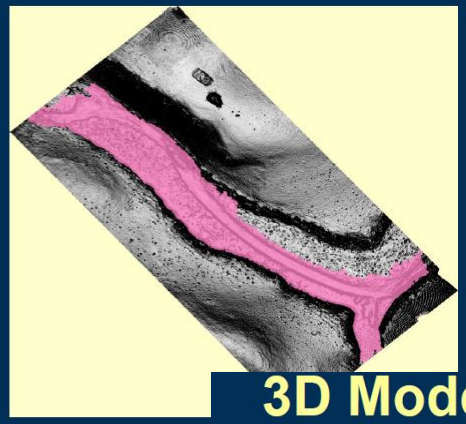

Agisoft Photoscan Processing
Add Photos
Photo Alignment
(Set Camera Calibration)
Gradual Selection Iterations / Removing Mismatched Tie Points
Add Coordinate System, GCPs, Refine Camera Calibration / Bundle Adjustment
Dense Point Cloud Generation
Dense Point Cloud Classification
Digital Surface Model and Digital Elevation Model Generation
Ortho Image Generation
USGS


Point Cloud
DSM
DEM
Orthoimagery
NDVI
Extraction Products
USGS

Hydraulic Modeling

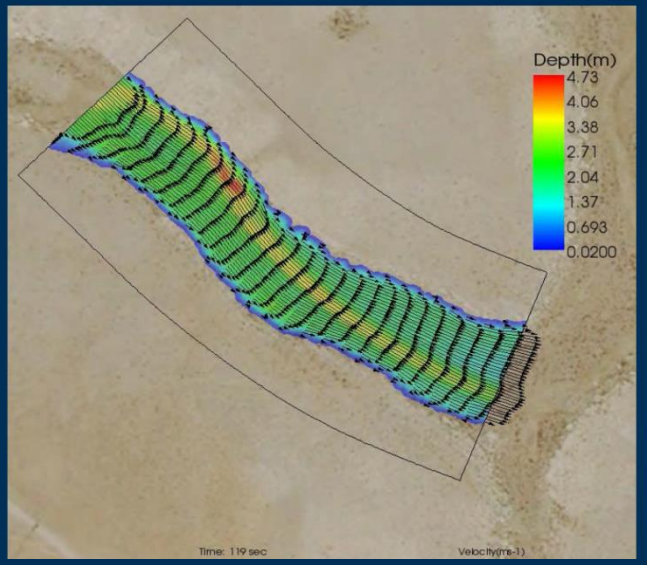
- Simple “Bath Tub” Inundation Model
  - 5 feet vs 10 feet of water from low point





USGS

iRIC Flow Model 300 m^3/s ~ 10,595 ft^3/s

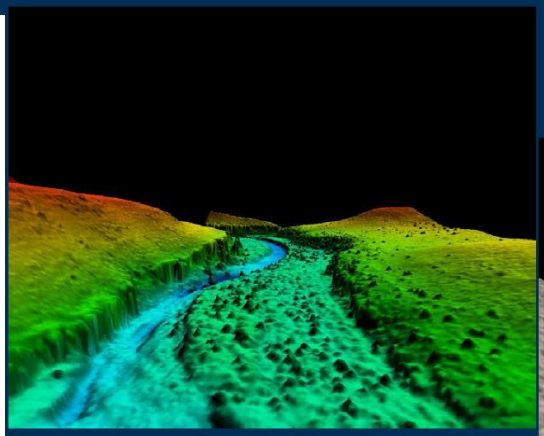


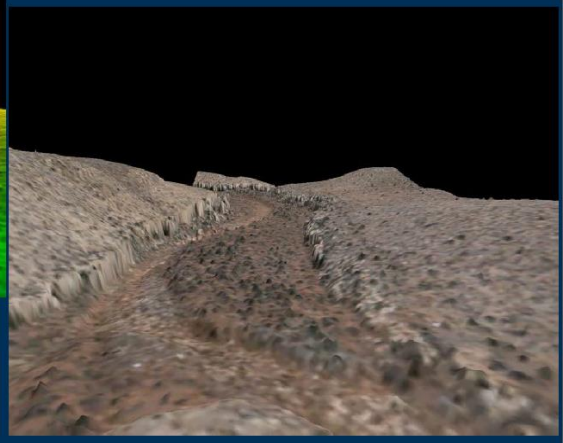
3D Modeling

USGS

Visualization

Calculation results developed for creation of vector, contour, and other diagrams, as well as creation of graphs. Can be output to file in graphic formats such as 3-D PDF, GIS, LAS, CAD, M-Station





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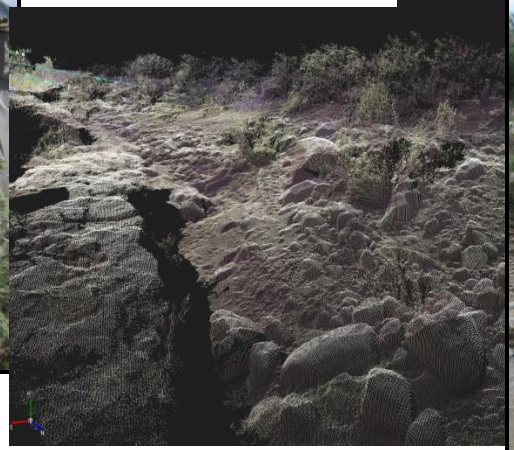
USGS

USGS - Reach Monitoring at New Gages

Future rating development tools

Reaches scanned with ground-based LiDAR

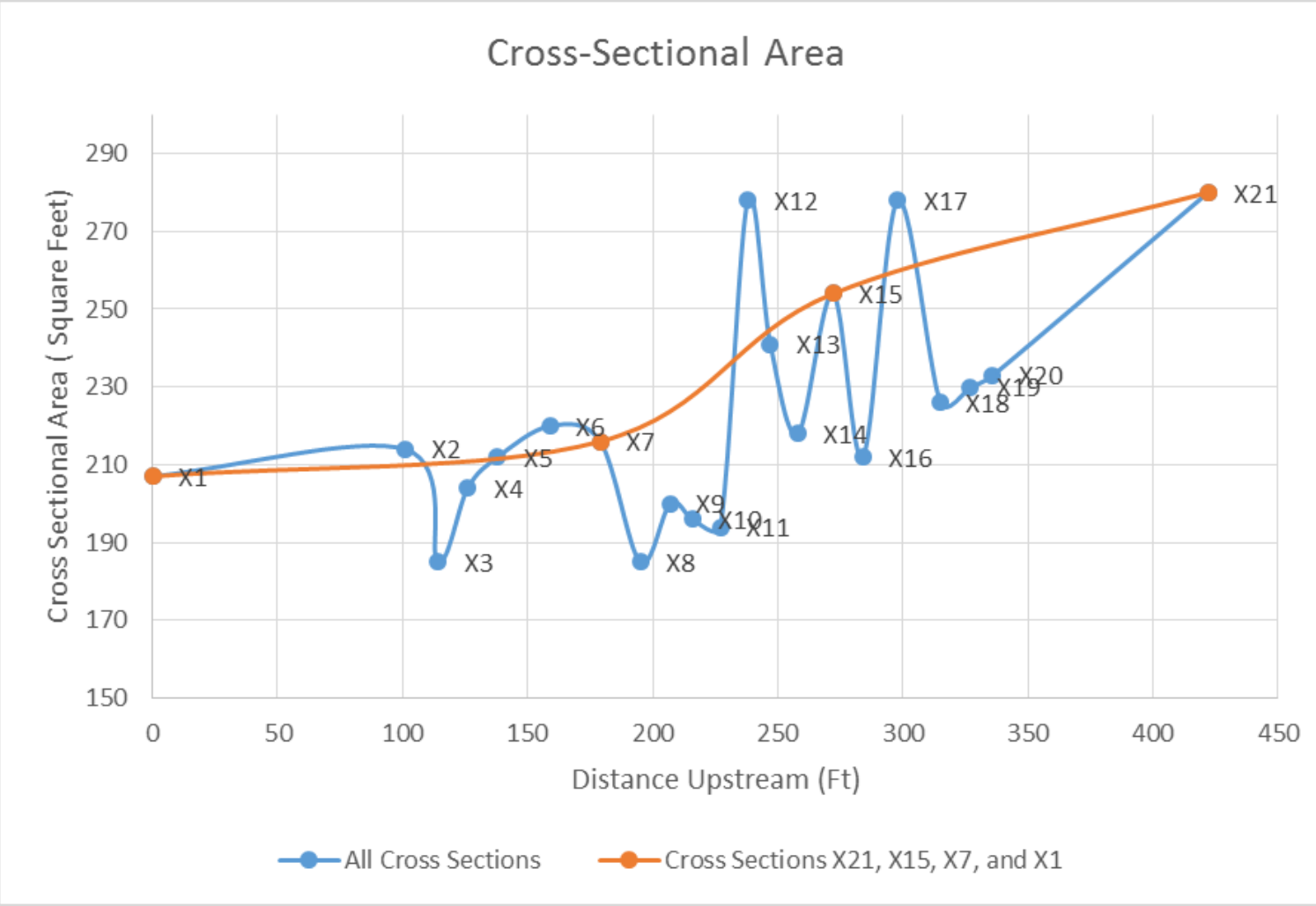
Addressing rating development needs



ADOT

USGS - Reach Monitoring at New Gages

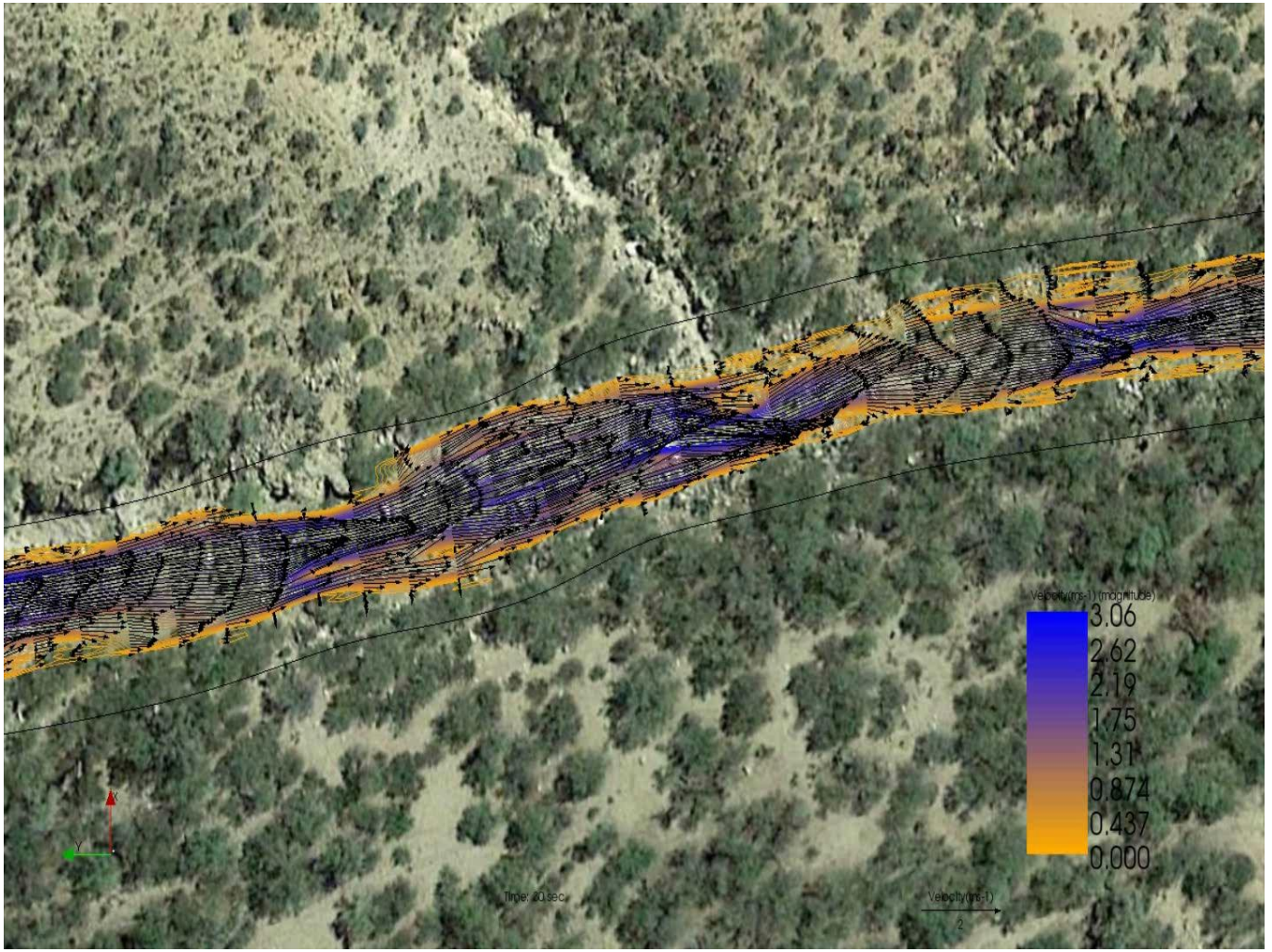
Future rating development tools - Identify optimal cross section locations



USGS - Reach Monitoring at New Gages

Future rating development tools - Identify optimal cross section locations

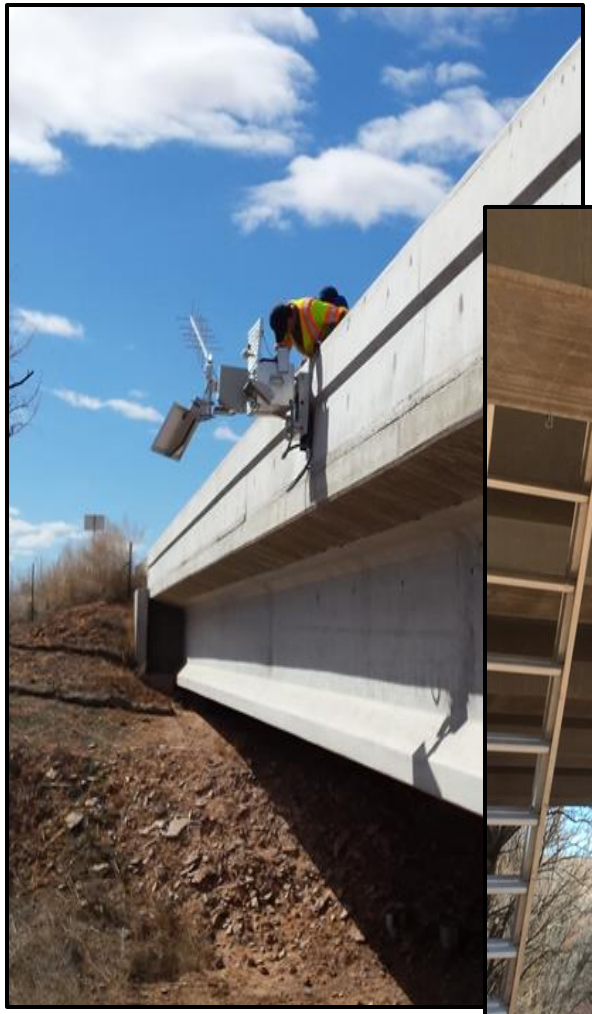
(USGS - iRIC model)



Reach Monitoring in Dynamic Channels
Understanding bank erosion and impacts to infrastructure

Laguna Creek Reach Monitoring:

- Rapid deployment streamgage
- Surface velocity radar sensor
- Particle tracking video cameras
- Indirect discharge measurements
- Repeat LiDAR scans of bridge structure and surrounding channel
- sUAS (drone) survey

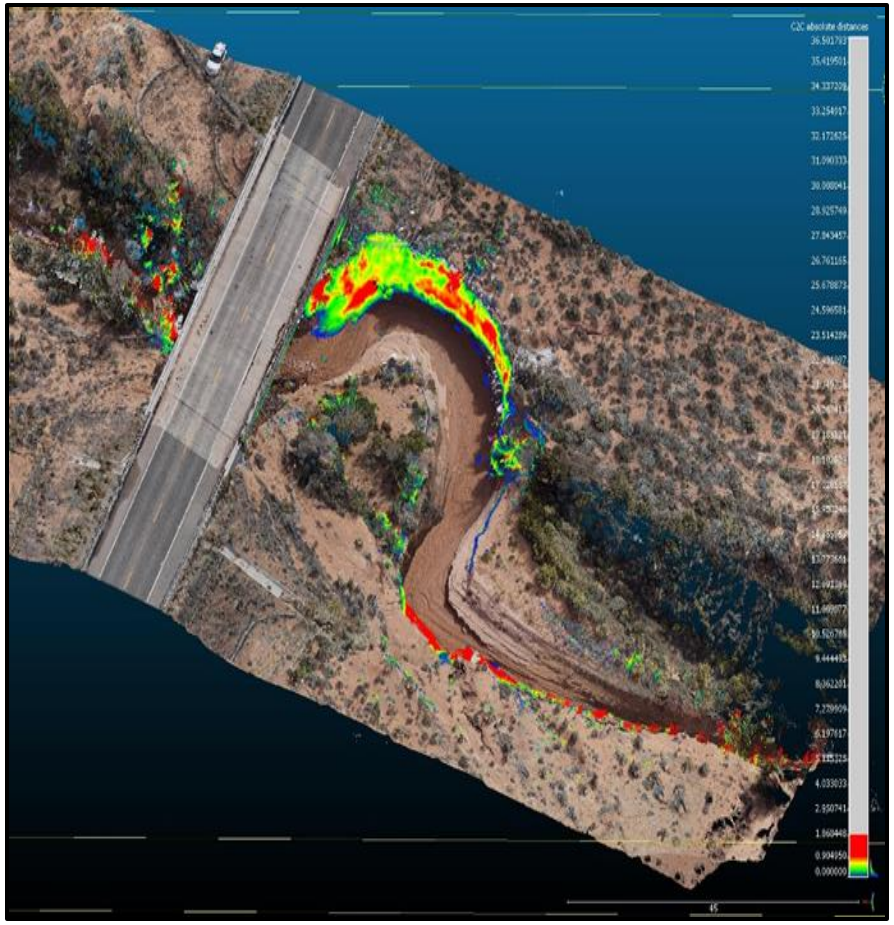


USGS

Reach Monitoring in Dynamic Channels

Understanding bank erosion and impacts to infrastructure

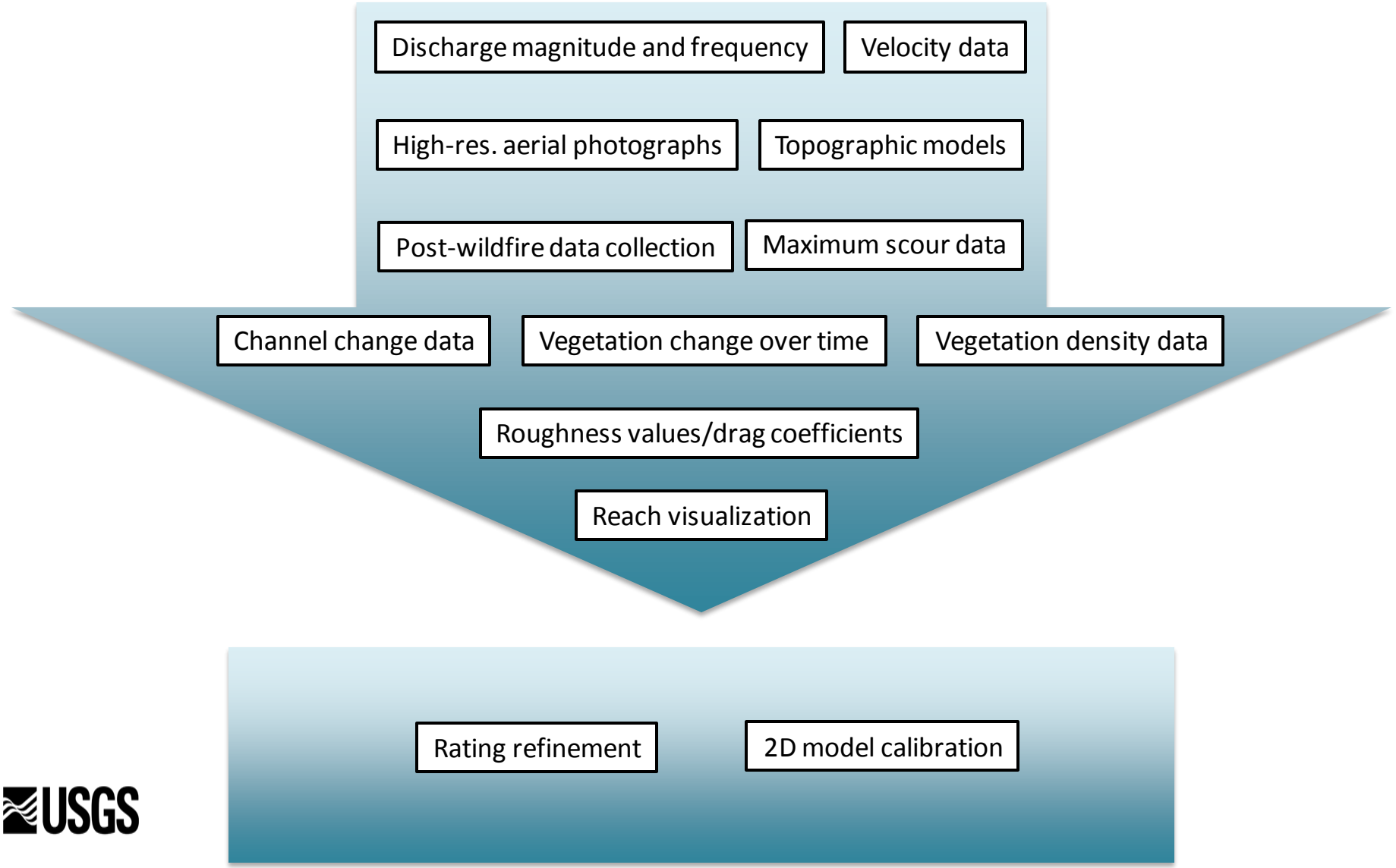
Laguna Creek Reach Monitoring: ADOT Perspective



USGS

Reach Monitoring Products

Collecting data for the future



USGS

Where does this feed into the Agency?

- Create project scoping/development process utilizing 2-D/3-D modeling
- This is an SEO supported effort to introduce digital data capture technologies into our project development process
- Introduce the general concepts and get input from the data and engineering disciplines on what deliverables would be desired/useful
- Develop a national DOT model for projects that are precip event and flow control puzzles
- Develop change detection Protocols - Bridge Scour, Erosion, Channel Fill/Scour vegetation growth/release
- Identify hydrologic and hydraulic modeling inputs
- Activities help the long game – EX W & CC
- ADOT/USGS Partnership funded to 2020
- FHWA AZ Division Office contributing State Transportation Innovation Council funding

ADOT

Questions?

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Arizona Department of Transportation

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