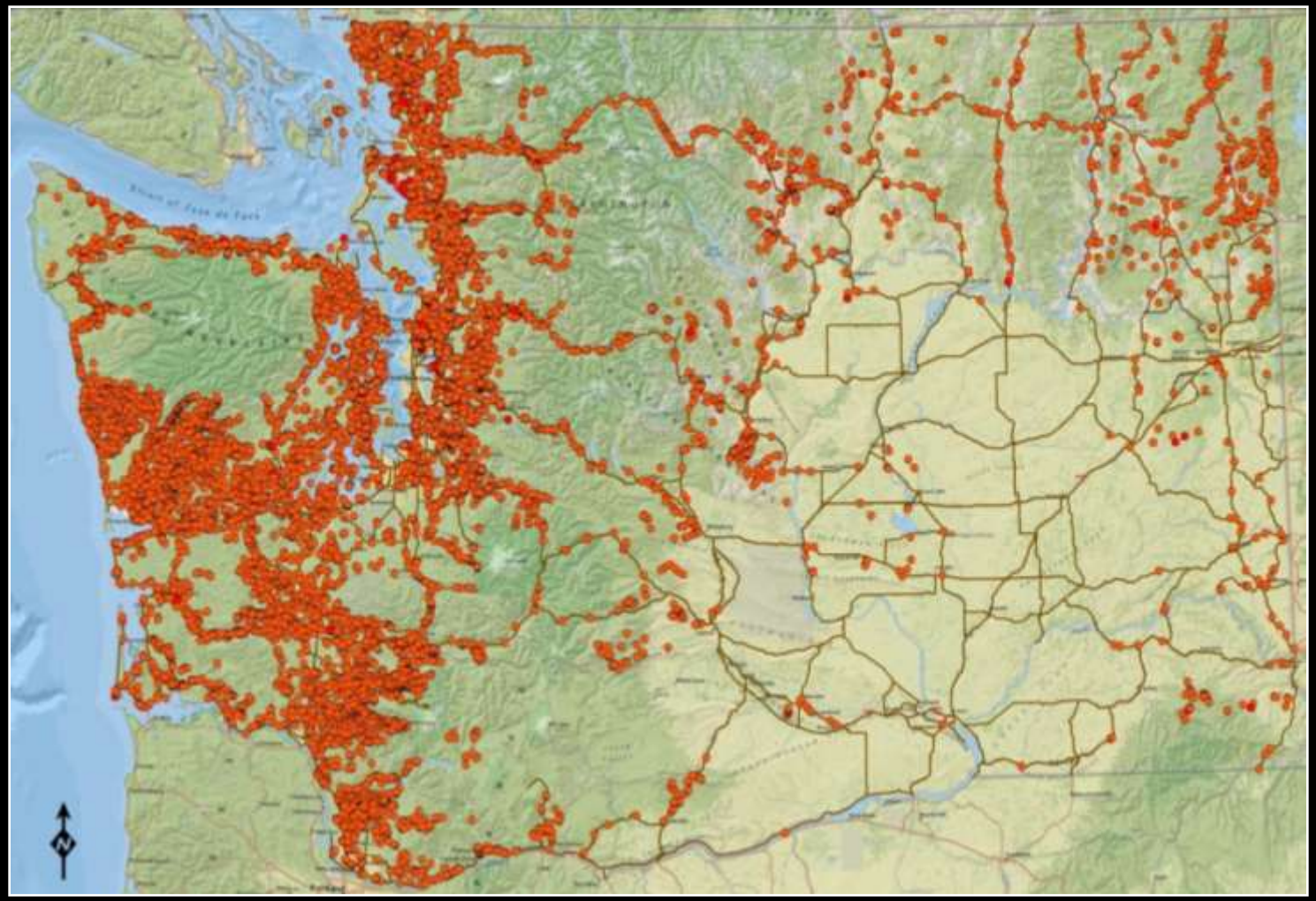
Structure from Motion Use in Culvert Monitoring

Jane Atha

14,000 known culvert barriers in database

35,000 estimated culvert barriers state-wide



$25 to $100 billion to replace ~25,000 culverts

WDFW's role in water crossing structures

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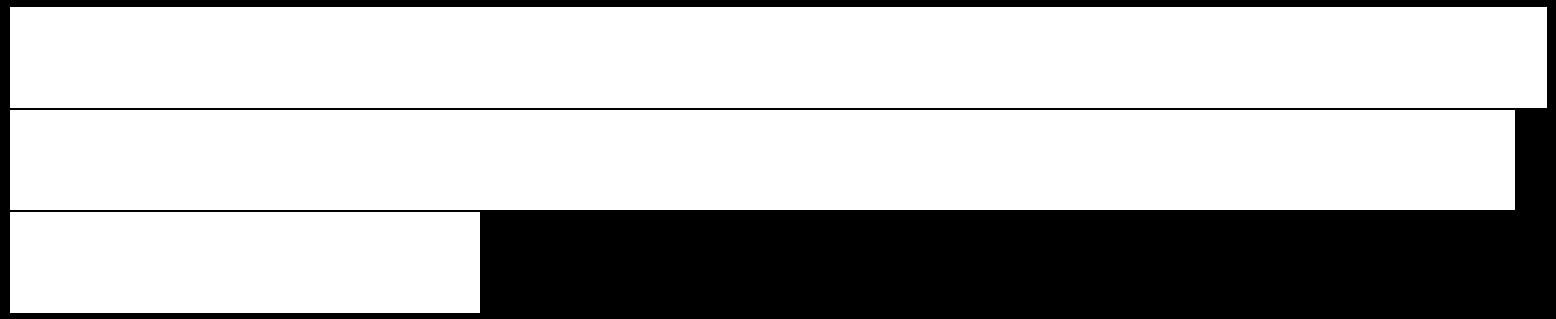
Culvert Issues

2011

2014

Good Culverts Gone Bad

Culvert Effectiveness Monitoring

- 
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Culvert Effectiveness Monitoring: Considerations for Choosing Methods

1. Ability to estimate change

2. Time/money

Current Methods

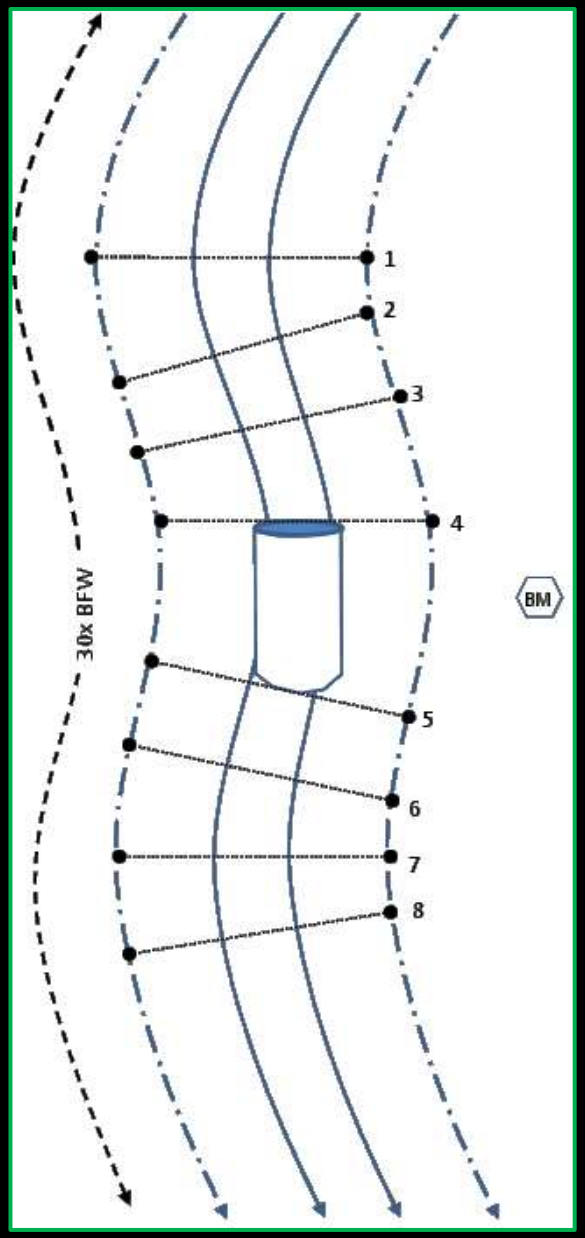
1. Eight cross-section measurements
   - Each ~2 bankfull widths (BFW) apart us/ds of culvert
   - Rotating laser level
   - Elevations taken at ~ 13 locations

1. Long profile within culvert interior

2. Long profile ~30x BFW

4. Substrate size

Time/site: ~3 hours



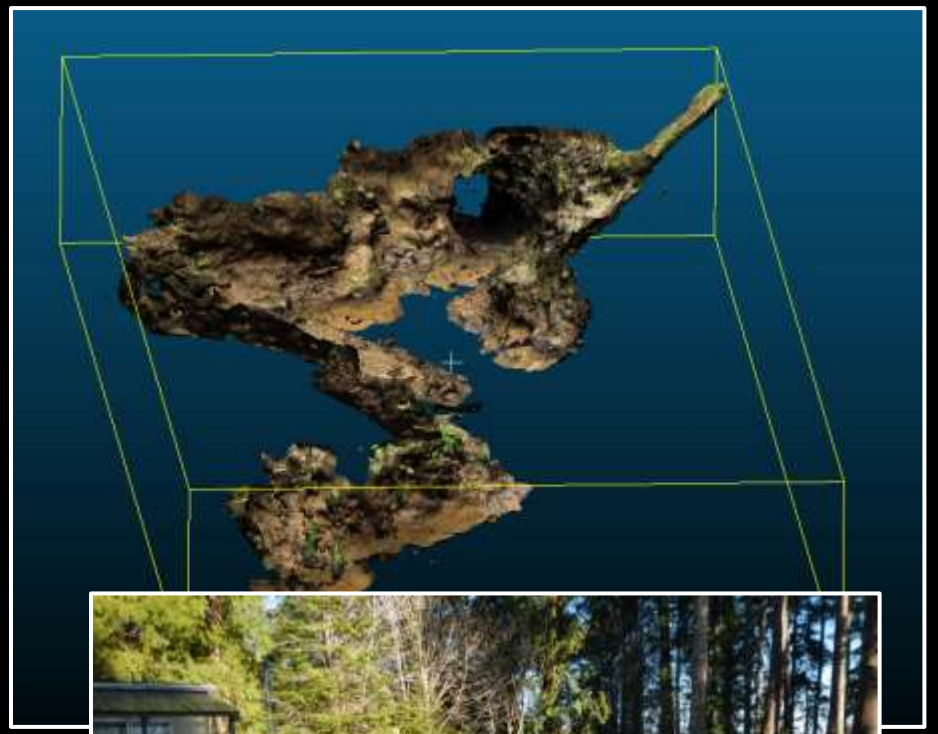
SfM Methods

1. 3D scene reconstruction upstream and downstream of culvert
   - ~200 photos

2. Year 1 ground control points with Total Station

3. Depth measurements with stadia rod in wetted areas

4. Long profile ~30x BfW



Overview

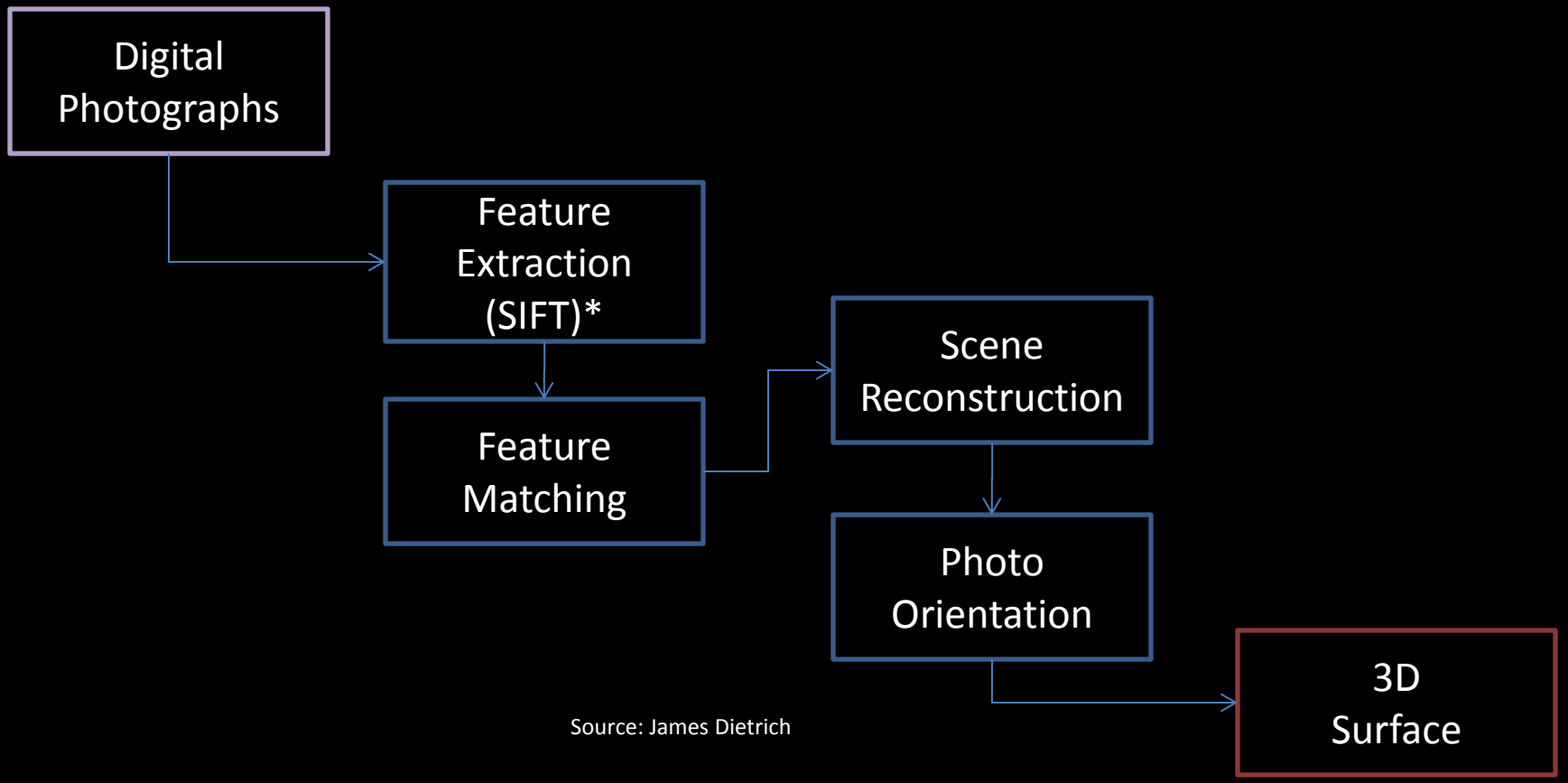
Structure from Motion (SfM)
- 3D structure from overlapping offset images
  - Calculates scene geometry (structure) and camera positions (motion) to reconstruct a 3D scene

Inexpensive 3D mapping system
- Easily deployable
- Comparatively low equipment costs

Uses
- High resolution topographic mapping
- 3D environmental change estimates

Cartoon Source: James Dietrich

SfM: Photogrammetry meets computer vision



Source: James Dietrich

*Scale-invariant feature transform

Lowe, DG. 1999. Object recognition from local scale-invariant features. Proc. of the International Conference on Computer Vision.

Structure from Motion

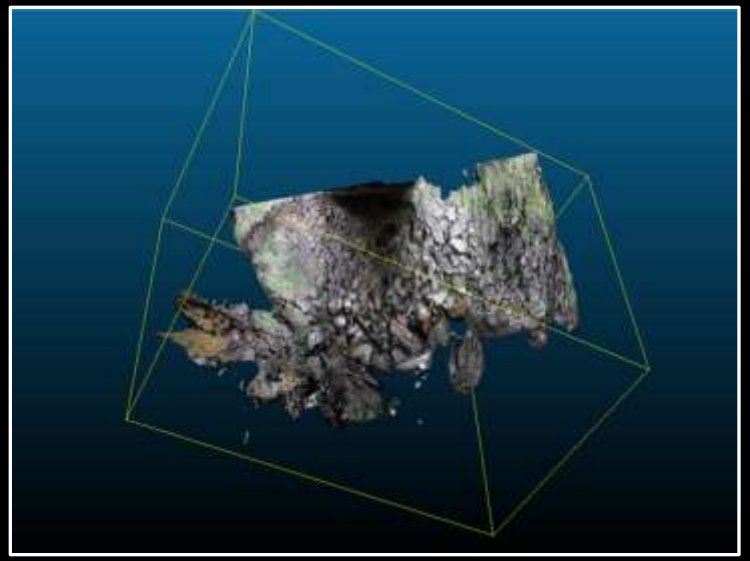
- Photogrammetry
  - Calibrated Camera(s)
    - Position
    - Parameters
  - GCPs
    - Several for each photo pair

- SfM
  - Un-calibrated camera
    - Positions and parameters solved in processing
  - GCPs
    - Several for entire model
      - Used post-bundle adjustment

Agisoft Photoscan

Image-based modeling with Structure from Motion

- Photogrammetric triangulation
- Dense point cloud creation and editing
- Georeferencing from GCPs
- Digital elevation model export
- 3D and 4D modeling
- Multispectral imagery processing



Costs

- Agisoft Photoscan Professional Edition: $3500 (not time limited)
- Total Station and/or RTK GPS: $4,000-$22,000 (ish)
- Digital Camera: $100-$1,000
- Painter's pole: $15

Repeat costs:

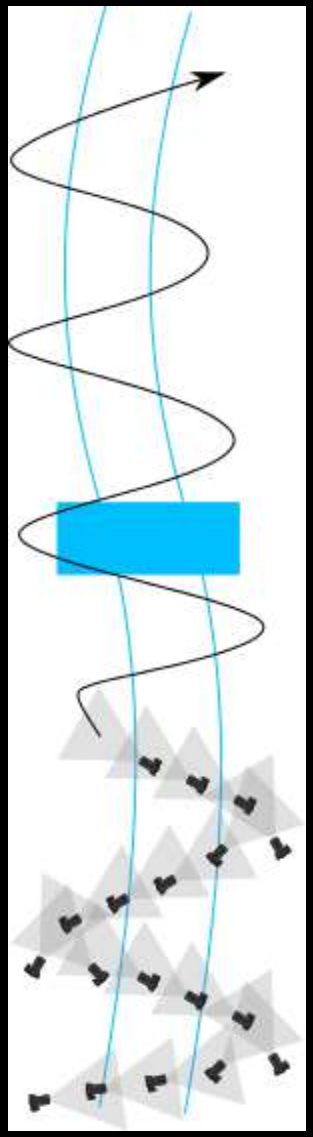
- Labor: 2 people for data collection, 1 person for processing

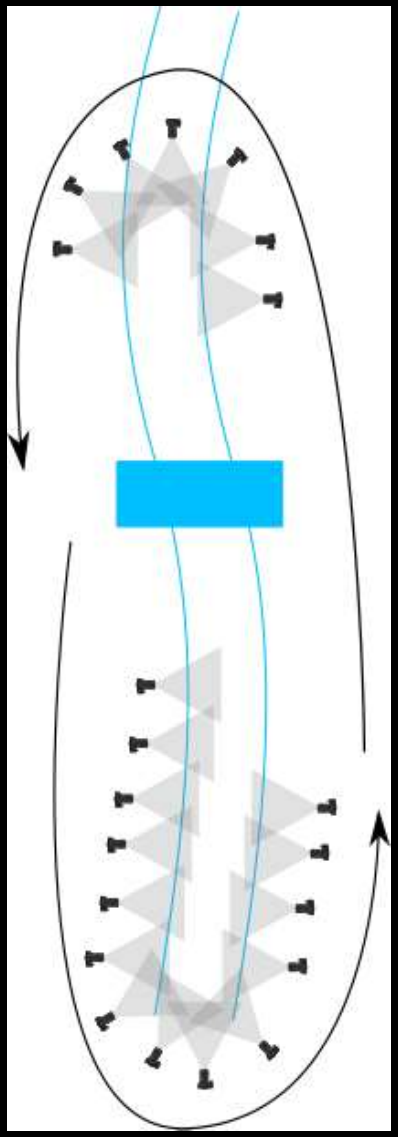
Next Steps

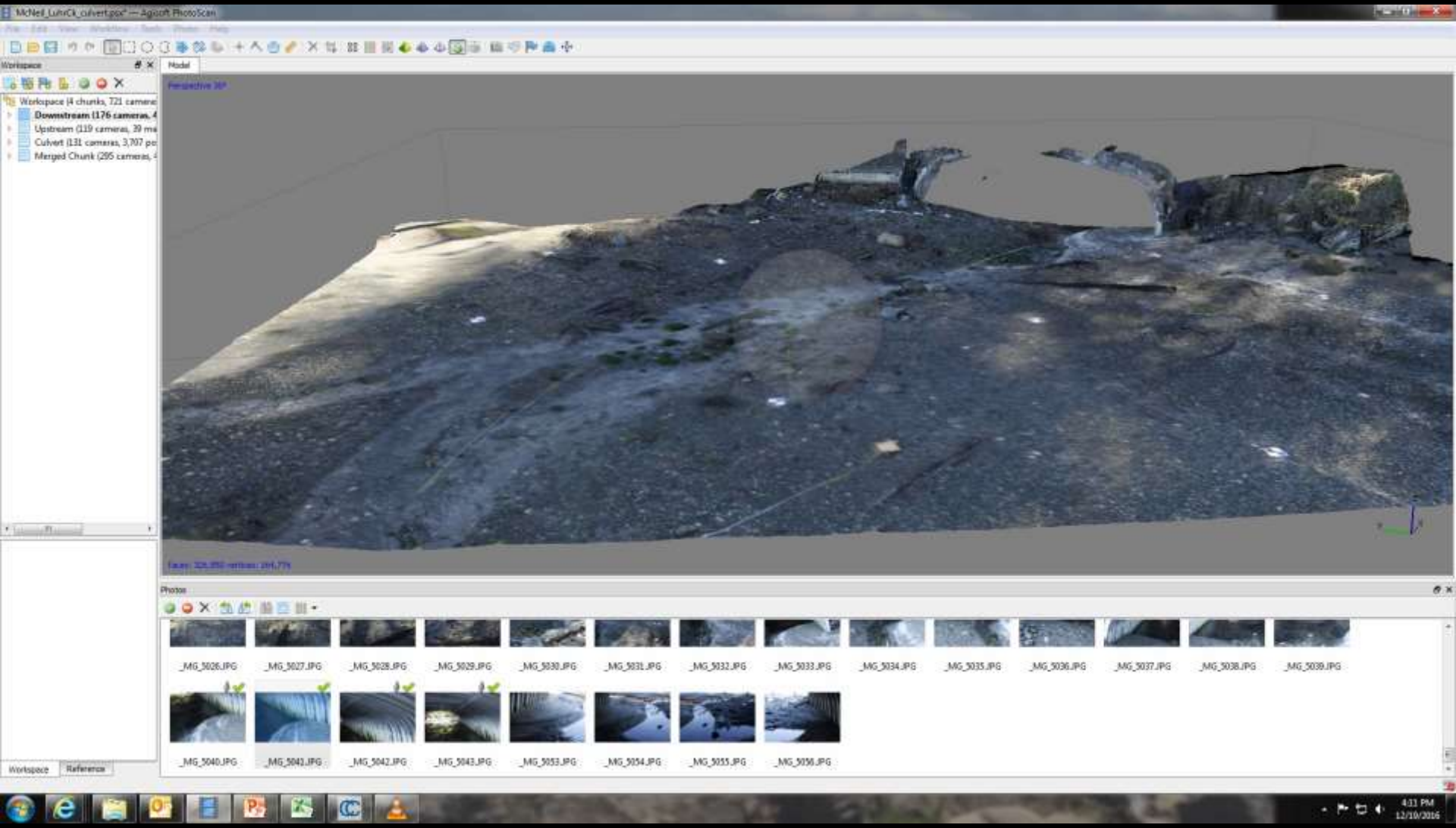
1. Refine workflow
   - Patterns for taking photos
   - Number and position of control points
   - Vegetation strategies
   - Culvert design channel strategies

2. Projected coordinates

3. Test against existing methods
   - Where is SfM most useful






McNeil_LutnCk_culvert.psx* — Agisoft PhotoScan
Workspace
Model
Perspective 30°
Photos
_MG_5026.JPG
_MG_5027.JPG
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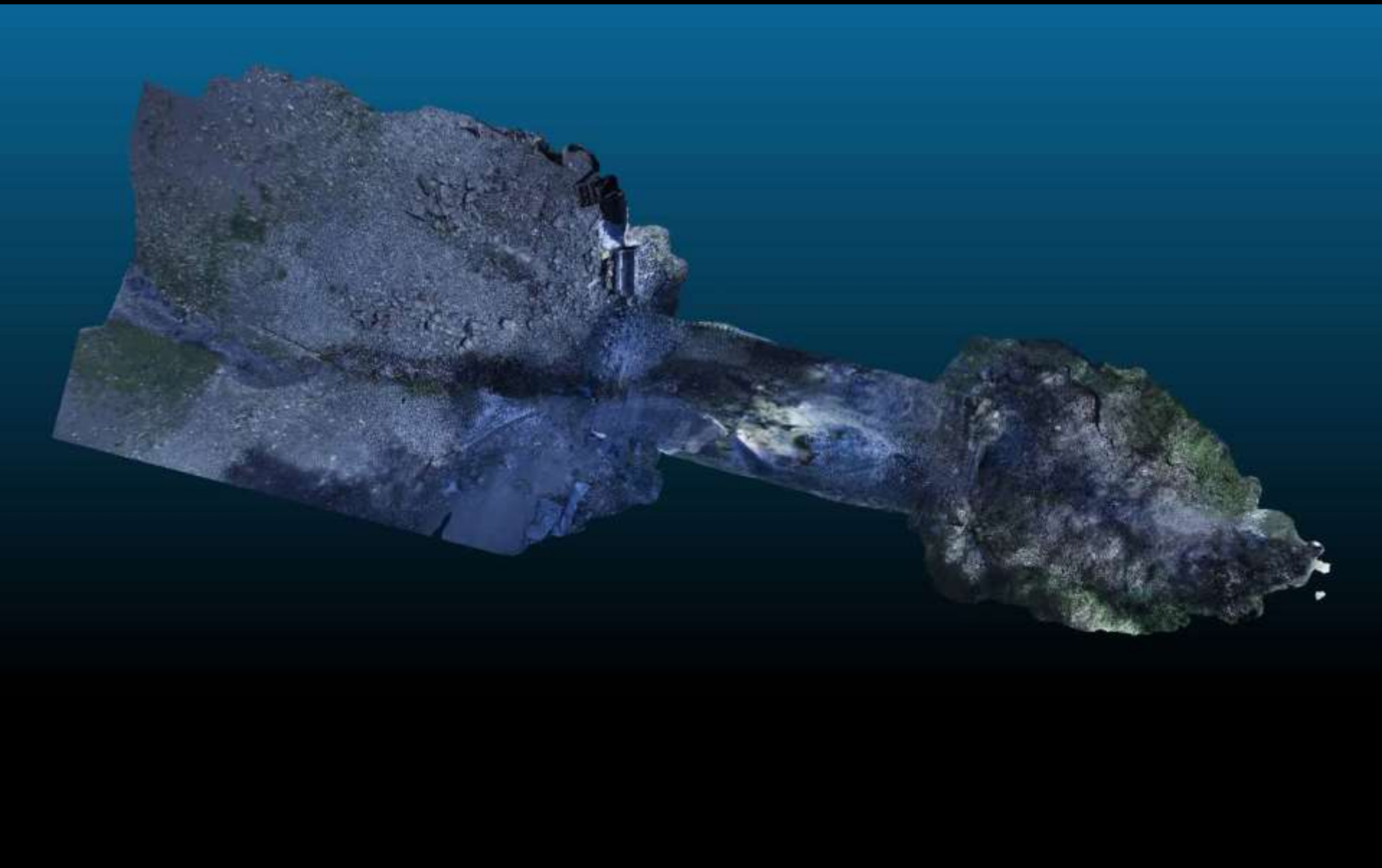
_MG_5056.JPG
Workspace
Reference
4:11 PM
12/19/2016

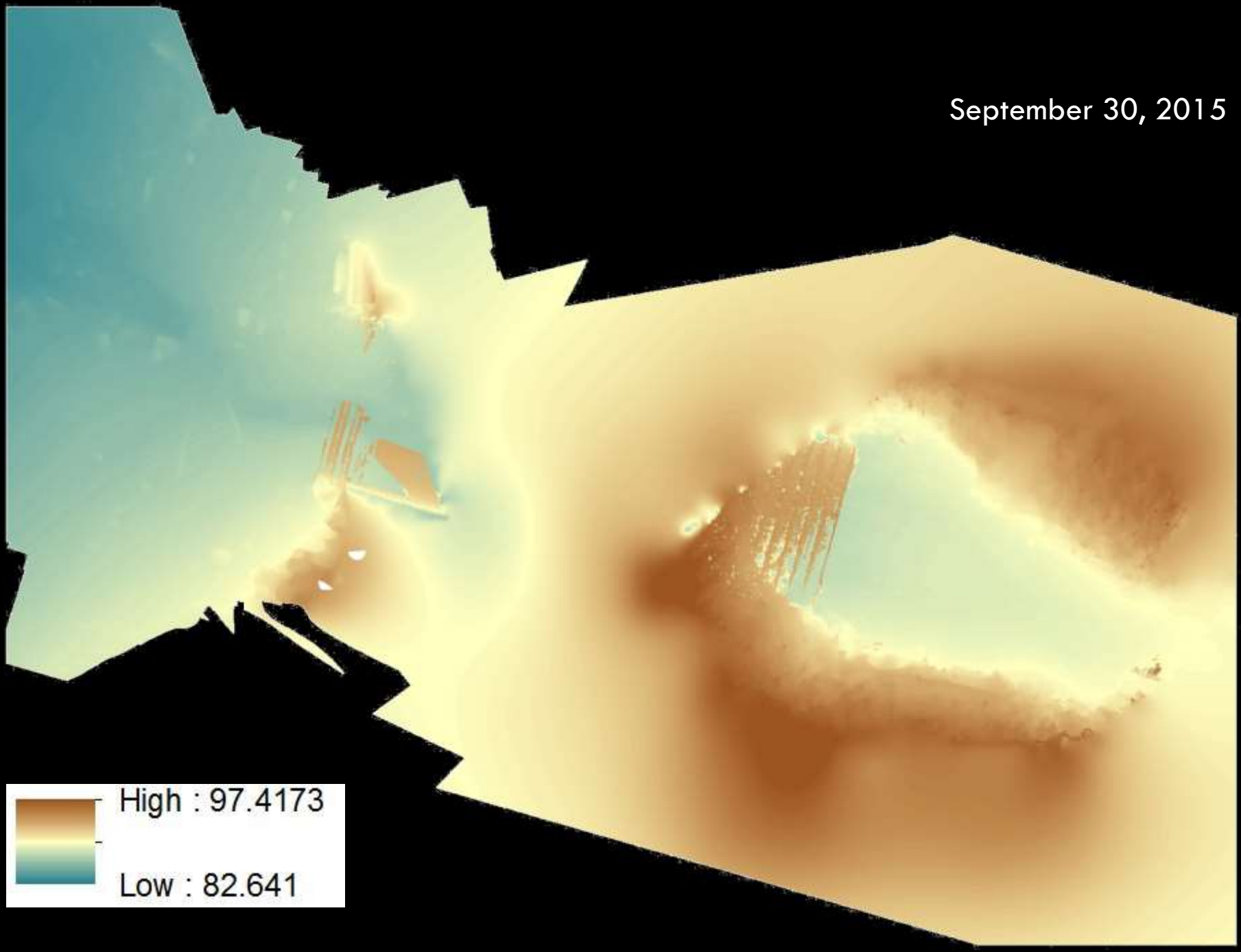
A New Culvert in Clark County

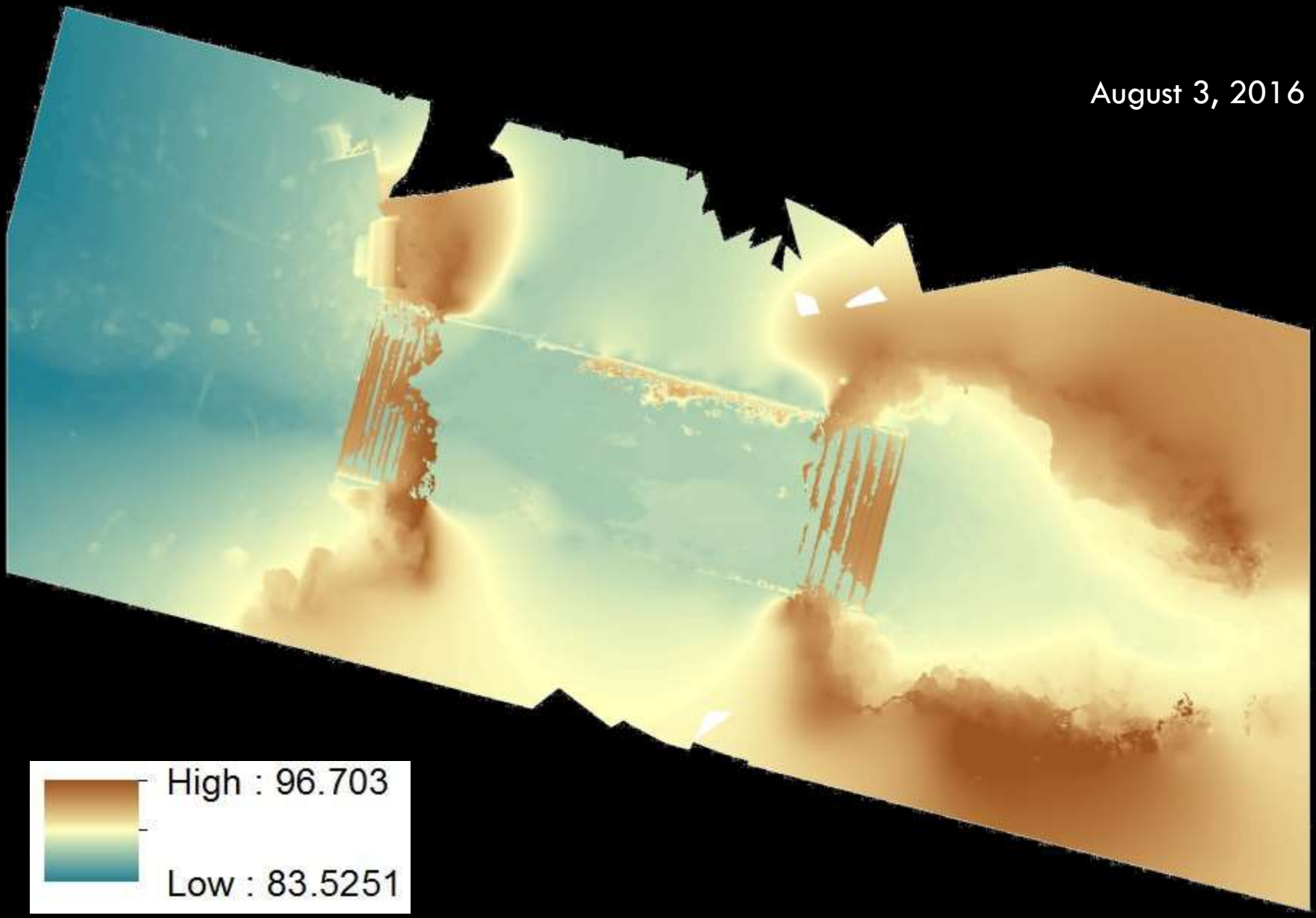
Luhr Ck. Culvert, McNeil Island

September 30, 2015

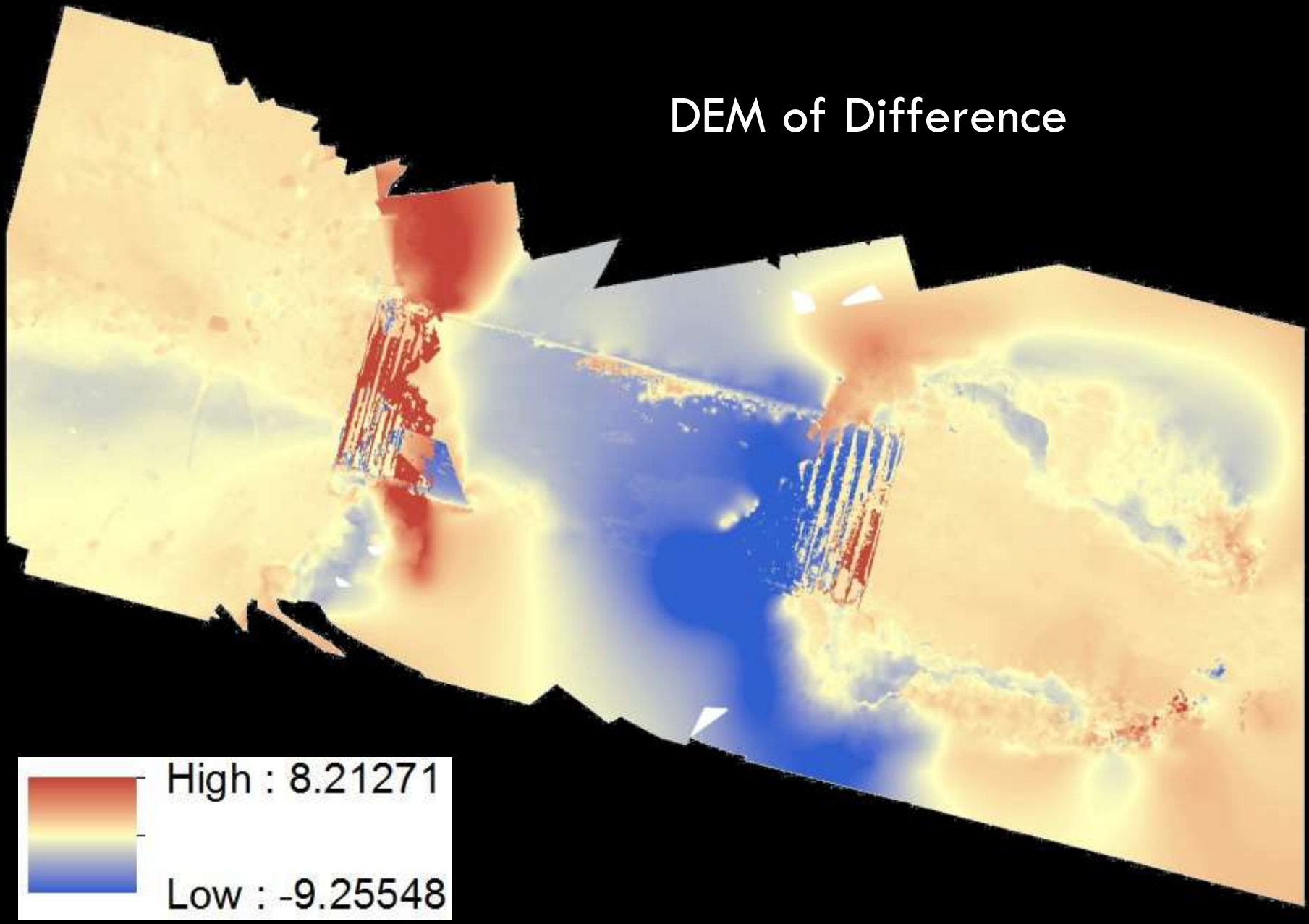
August 3, 2016




September 30, 2015
High : 97.4173
Low : 82.641


August 3, 2016
High : 96.703
Low : 83.5251

DEM of Difference



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