Acquiring and Using LiDAR-derived Products

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USDA

Advanced LiDAR Workshop August 2012

Now What?

50-100 gb/county

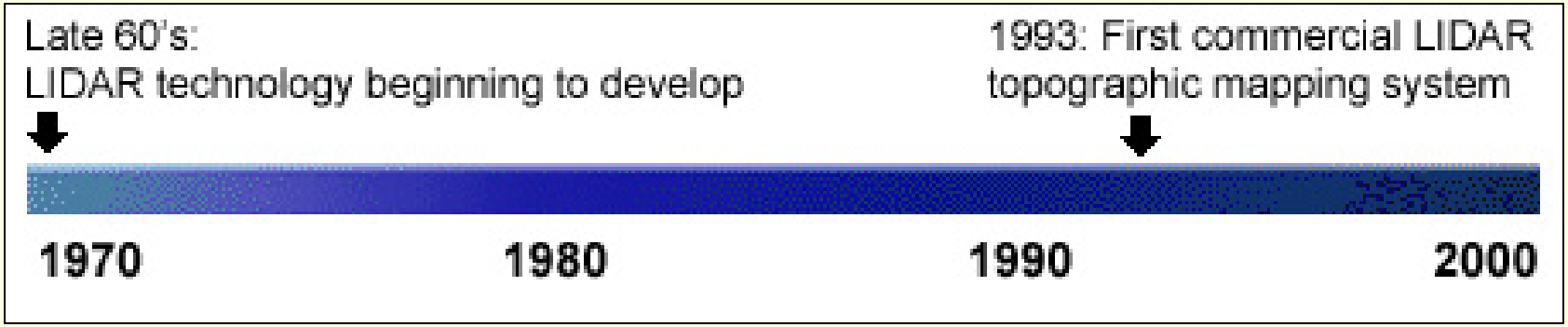
LiDAR Topics

- Airborne LiDAR Basics – What is it?
- Products – What do you get?
- Accuracy – How good is it?
- Applications – How do you use it? – Lead-in for the rest of our speakers!

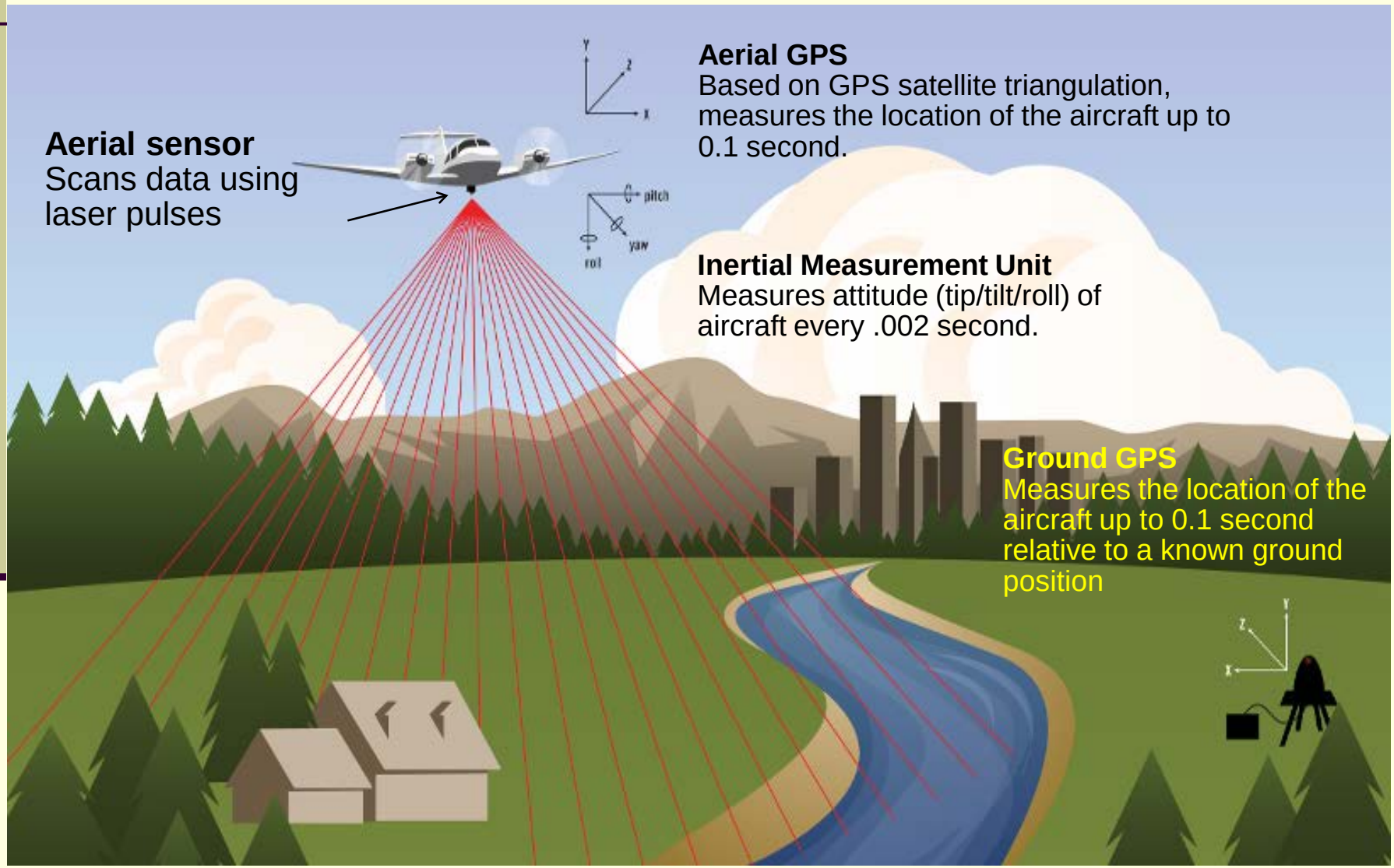
LiDAR Basics

LiDAR:
Light Detection And Ranging

The process of scanning a surface with lasers in order to map the surface's form.

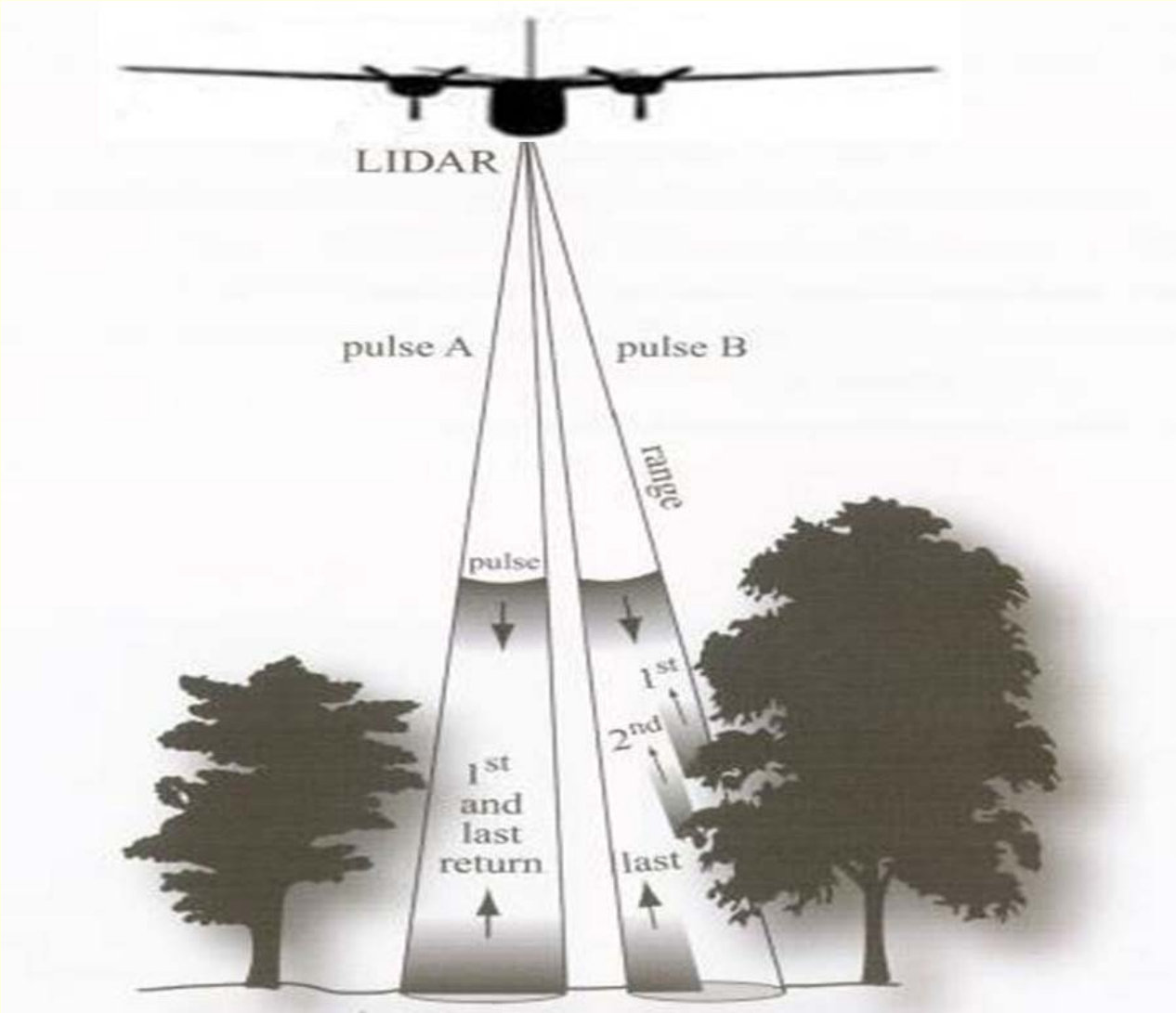


A LiDAR scan can be made of the Earth's surface from an aircraft.



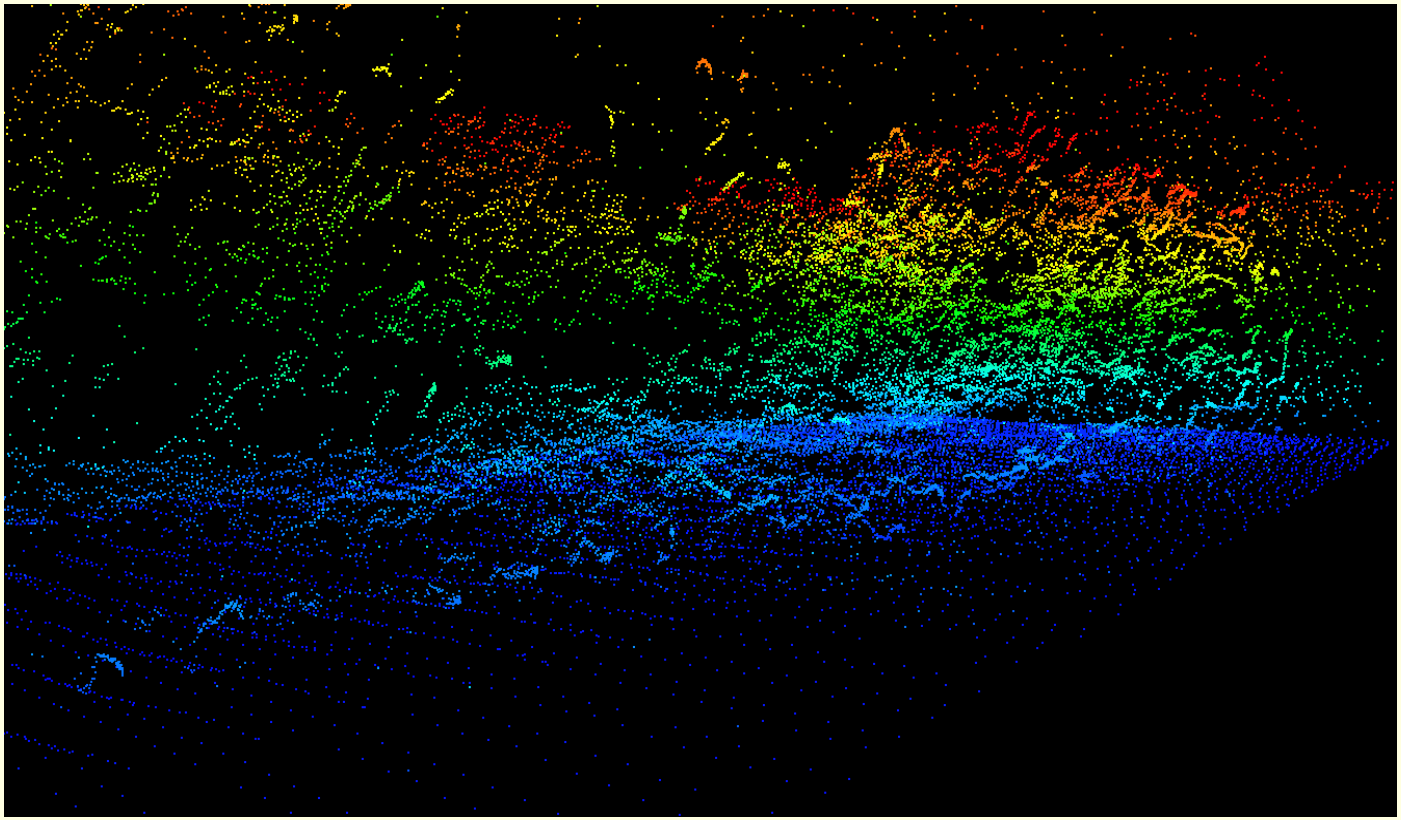
Accurately knowing the x,y,z of the aircraft and the time it takes for the emitted light to return to the sensor allows the x,y,z of the targets (ground, buildings, vegetation) to be determined.

LiDAR Basics



LiDAR Basics

Geographically referenced elevation mass points (X,Y,Z Point Cloud):

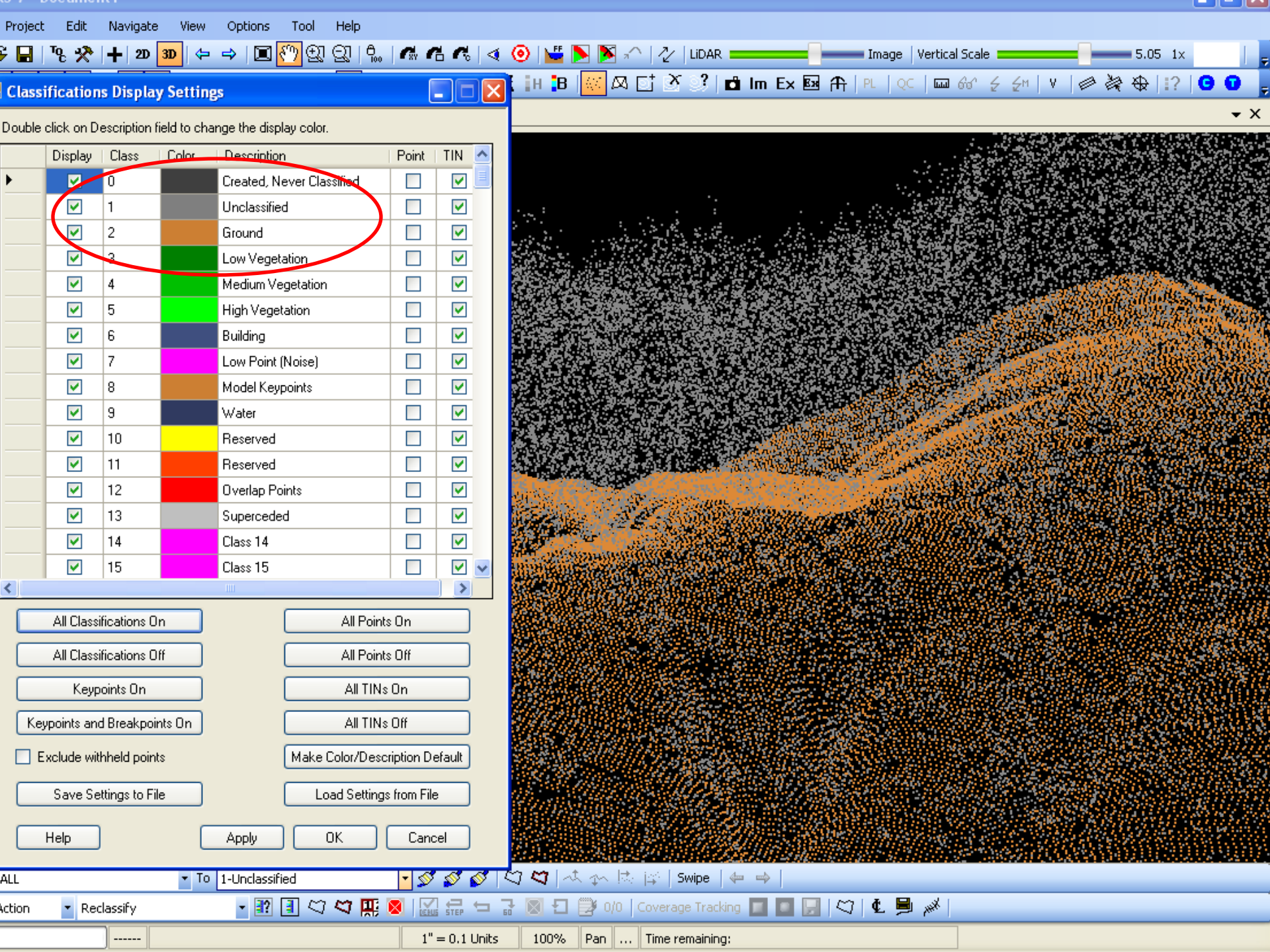


LAS Classifications

Classification Codes	Class
0	Created, never classified
1	Unclassified
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Model Key-point (mass point)
9	Water
10	Reserved for ASPRS Definition
11	Reserved for ASPRS Definition
12	Overlap Points
13-31	Reserved for ASPRS Definition

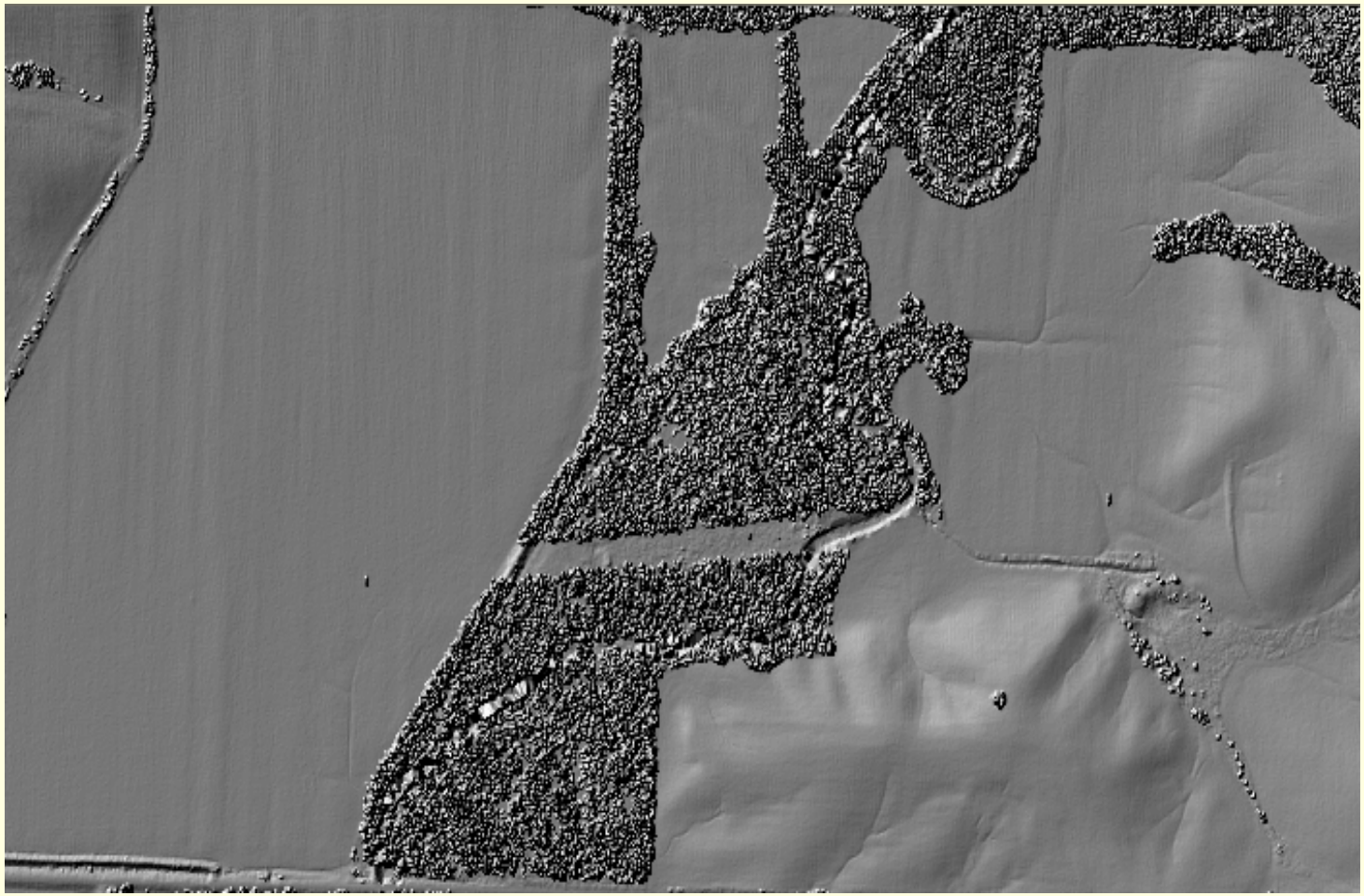
**Source: LAS Specification, Version 1.3*

http://www.asprs.org/a/society/committees/standards/LAS_1_3_r11.pdf


Project
Edit
Navigate
View
Options
Tool
Help
LiDAR
Image
Vertical Scale
5.05
1x
Classifications Display Settings
Double click on Description field to change the display color.
Display
Class
Color
Description
Point
TIN
0 Created, Never Classified
1 Unclassified
2 Ground
3 Low Vegetation
4 Medium Vegetation
5 High Vegetation
6 Building
7 Low Point (Noise)
8 Model Keypoints
9 Water
10 Reserved
11 Reserved
12 Overlap Points
13 Superceded
14 Class 14
15 Class 15
All Classifications On
All Classifications Off
Keypoints On
Keypoints and Breakpoints On
Exclude withheld points
Save Settings to File
All Points On
All Points Off
All TINs On
All TINs Off
Make Color/Description Default
Load Settings from File
Help
Apply
OK
Cancel
ALL
To
1-Unclassified
Swipe
Action
Reclassify
Coverage Tracking
1" = 0.1 Units
100%
Pan
Time remaining:

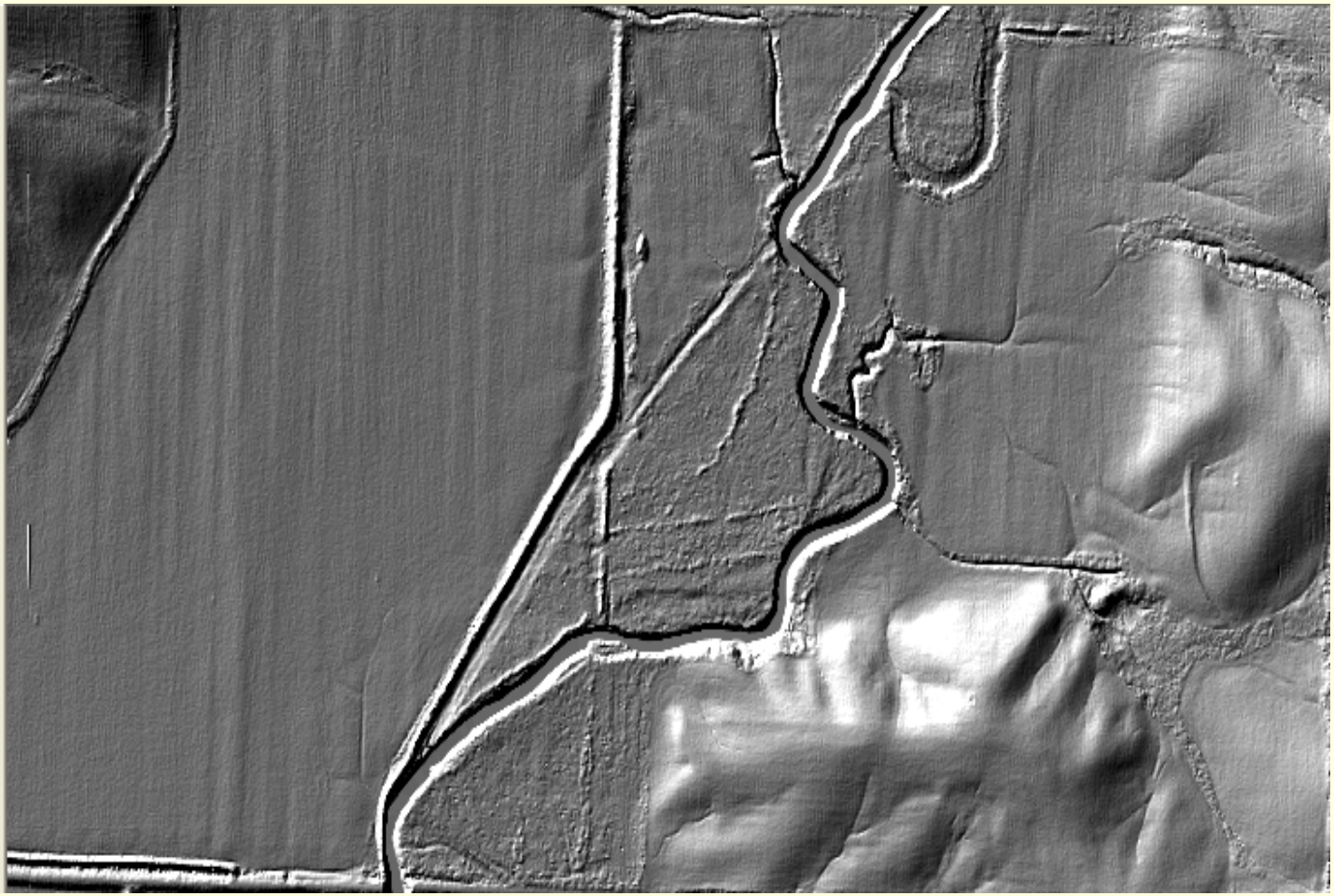
LiDAR Products

All Returns, Plotted as a Surface Model:



LiDAR Products

Bare Earth Returns, Plotted as a Surface Model:



Typical Project Deliverables

- LAS mass point files, classification of points to contract specifications, per tiling schema
- Raster (ESRI Grid, .img or other) bare-earth DEMs, per tiling schema NOTE: May become less common as GIS software improves on directly exploiting LAS files
- Control points for independent vertical QA
- Misc – tile indexes, breaklines, QA reports, metadata files

Disclaimer

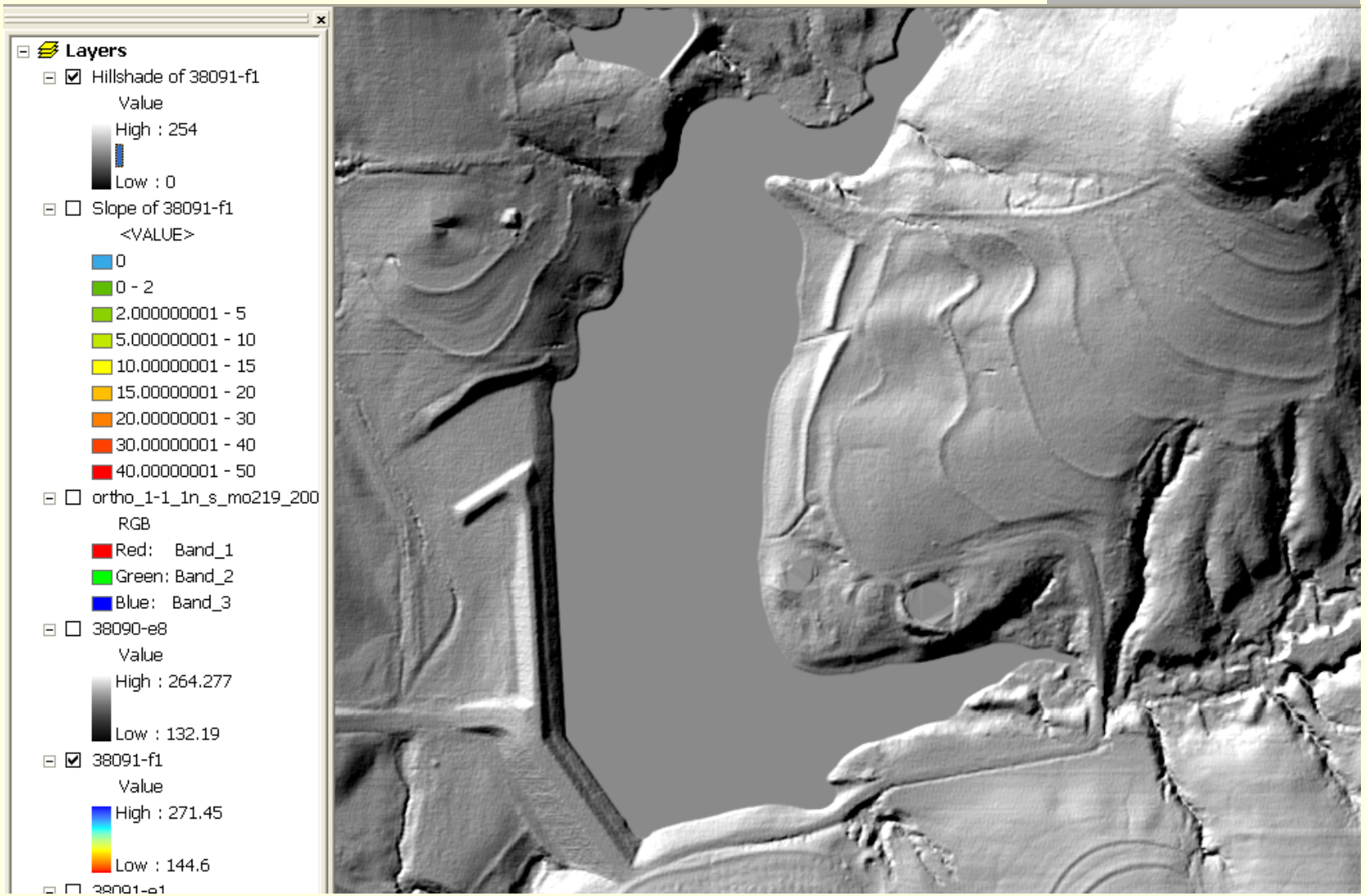
- Following slides on DEM derivatives were made using ArcGIS 9.2 (3-D Analyst). Information on basic derivatives still applies, but an update on the ESRI ArcGIS 10.1 suite of tools for working with LiDAR data will come in the 1:45pm talk by Greg Brunner

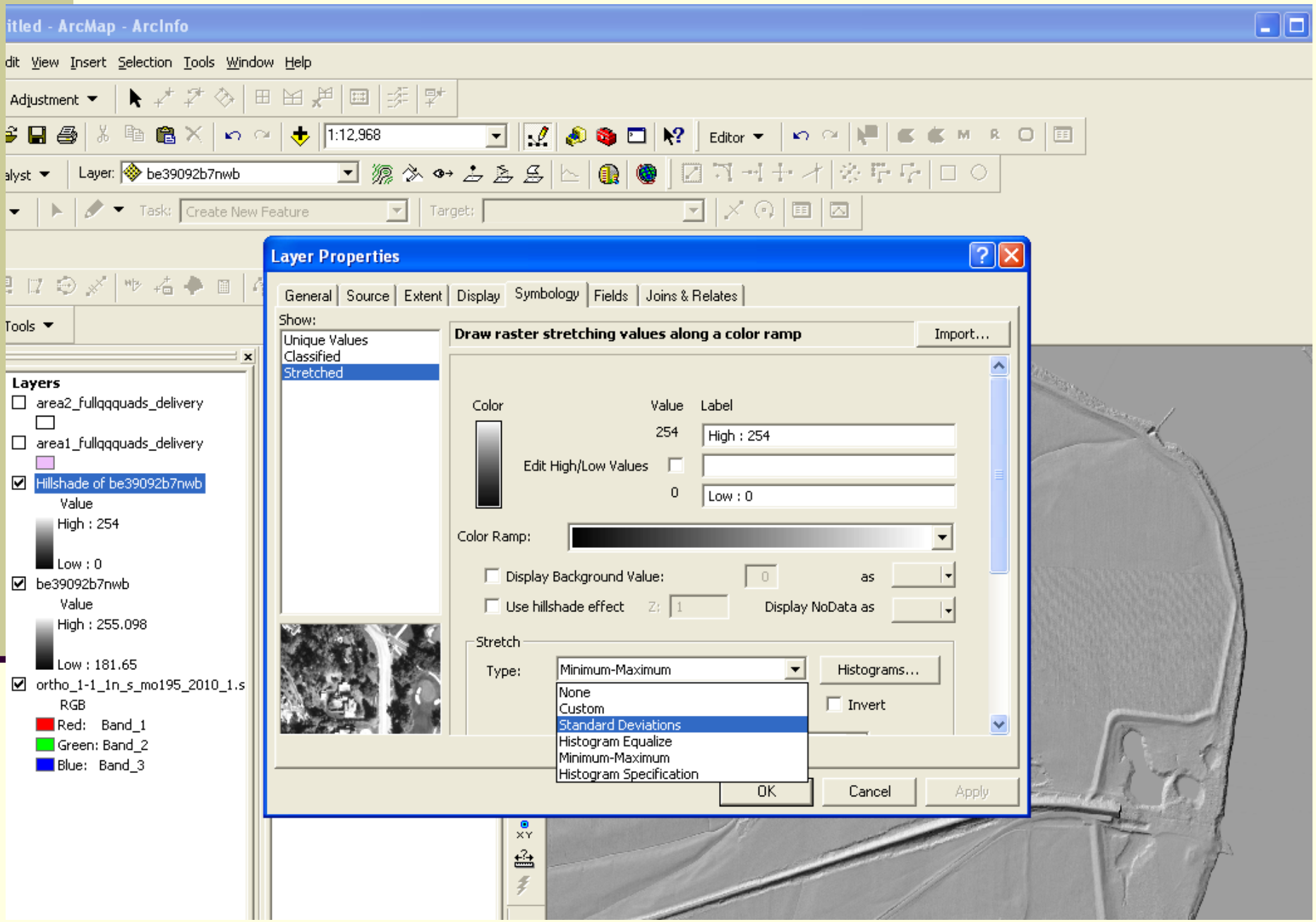
LiDAR Products

Some of the products that can be made using the LiDAR Point Cloud:

- Elevation Models (DEMs, DTMs or TINs)
  - Relief (Hillshades)
  - Contours
  - Slope
  - Aspect
  - Cross-sections
  - Cut/fill
- Vegetation Height, Biomass
- Building Footprints

LiDAR Products - Hillshades

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1:12,968
Editor
Layer: be39092b7nwb
Task: Create New Feature
Target:
Tools
Layers
area2_fullqqquads_delivery
area1_fullqqquads_delivery
Hillshade of be39092b7nwb
Value
High : 254
Low : 0
be39092b7nwb
Value
High : 255.098
Low : 181.65
ortho_1-1_1n_s_mo195_2010_1.s
RGB
Red: Band_1
Green: Band_2
Blue: Band_3
Layer Properties
General Source Extent Display Symbology Fields Joins & Relates
Show:
Unique Values
Classified
Stretched
Draw raster stretching values along a color ramp
Import...
Color
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254
High : 254
Edit High/Low Values
0
Low : 0
Color Ramp:
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as
Use hillshade effect
Z:
Display NoData as
Stretch
Type:
Minimum-Maximum
Histograms...
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Minimum-Maximum
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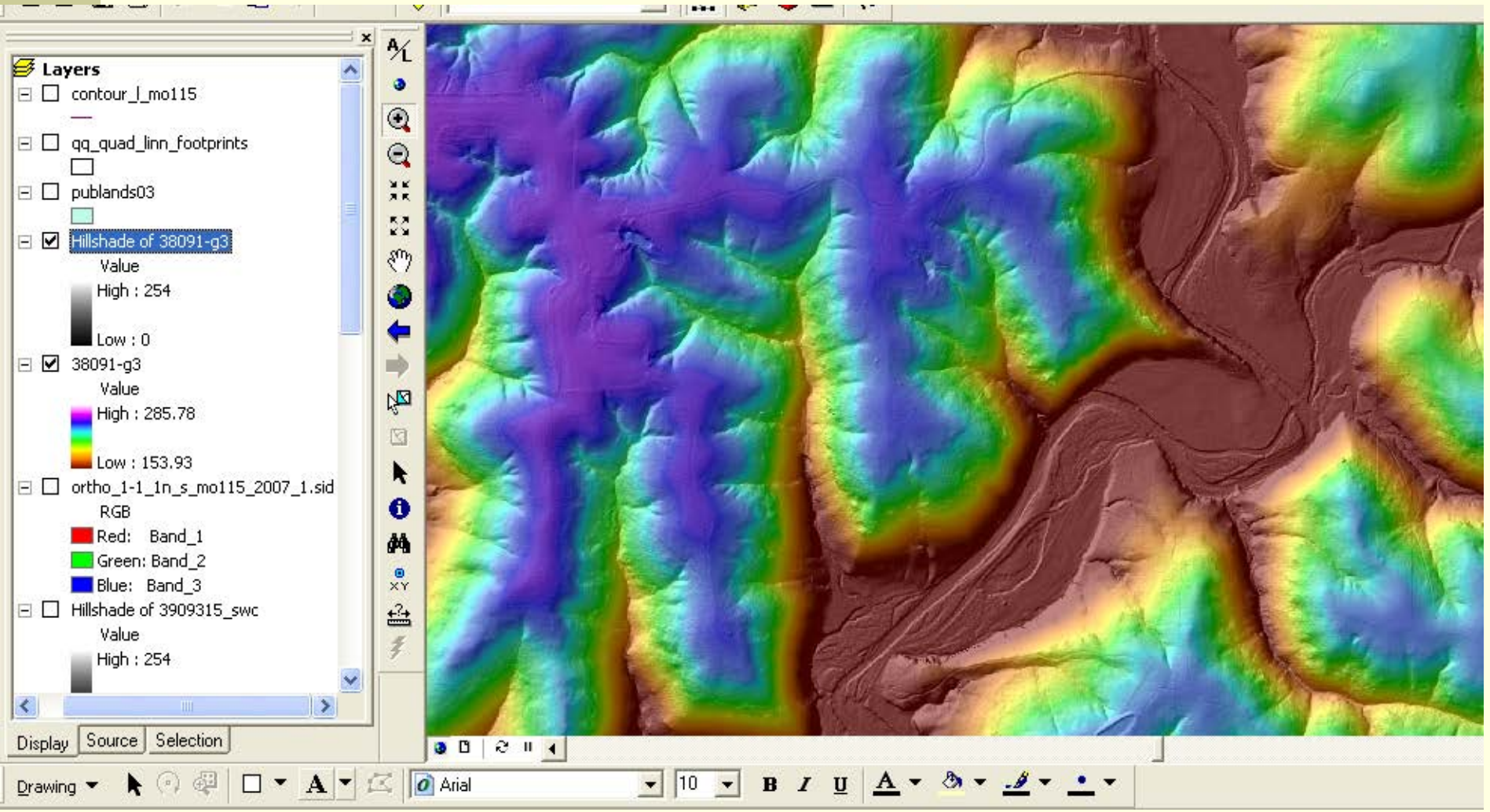
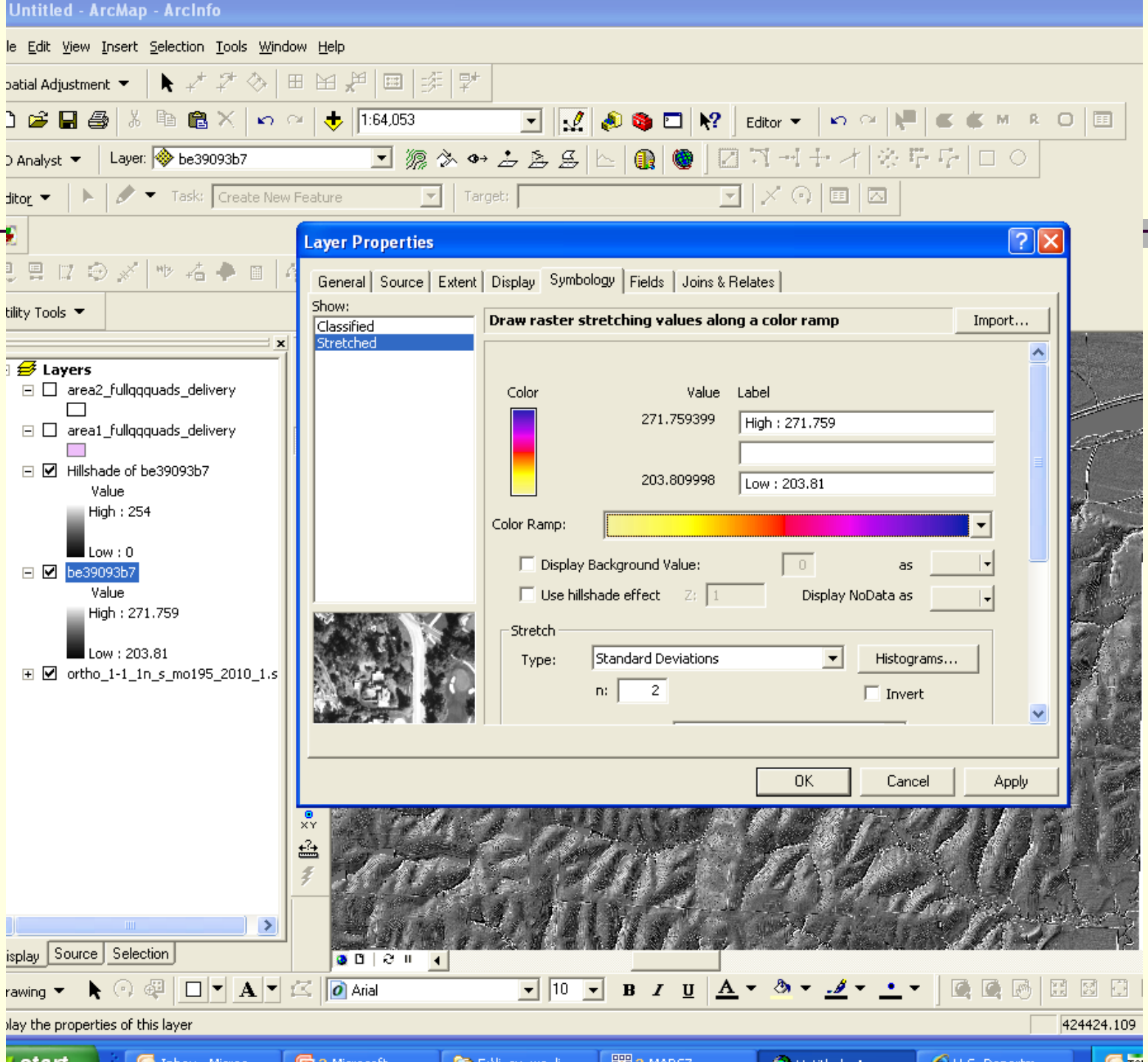
Invert
OK
Cancel
Apply

LiDAR Products – Elevation-colorized hillshades

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271.759399
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Low : 203.81
Color Ramp:
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Stretch
Type:
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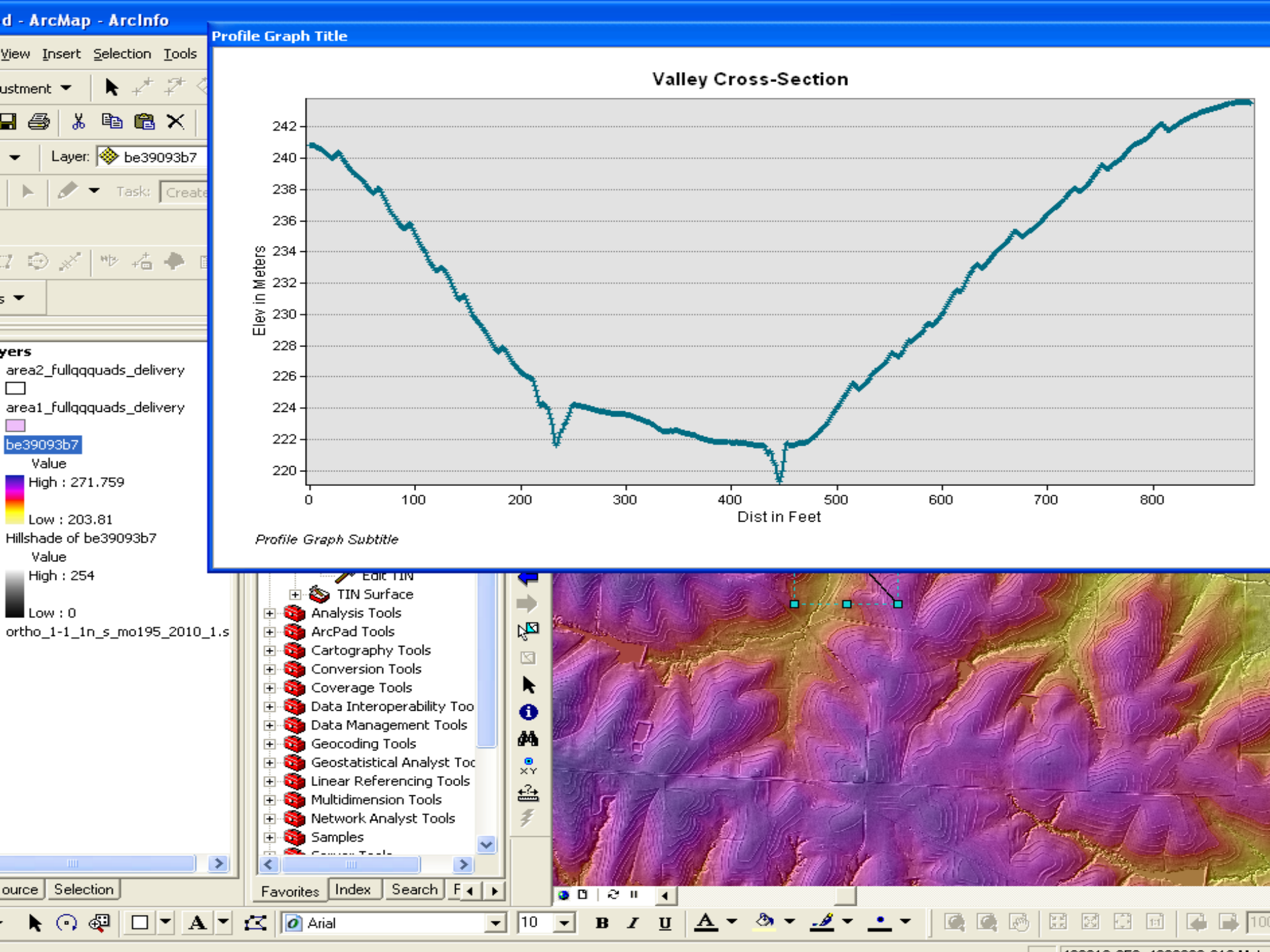
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TIN Surface
Analysis Tools
ArcPad Tools
Cartography Tools
Conversion Tools
Coverage Tools
Data Interoperability Too
Data Management Tools
Geocoding Tools
Geostatistical Analyst Toc
Linear Referencing Tools
Multidimension Tools
Network Analyst Tools
Samples
Favorites
Index
Search
Arial
10
Profile Graph Title
Valley Cross-Section
Elev in Meters
242
240
238
236
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230
228
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224
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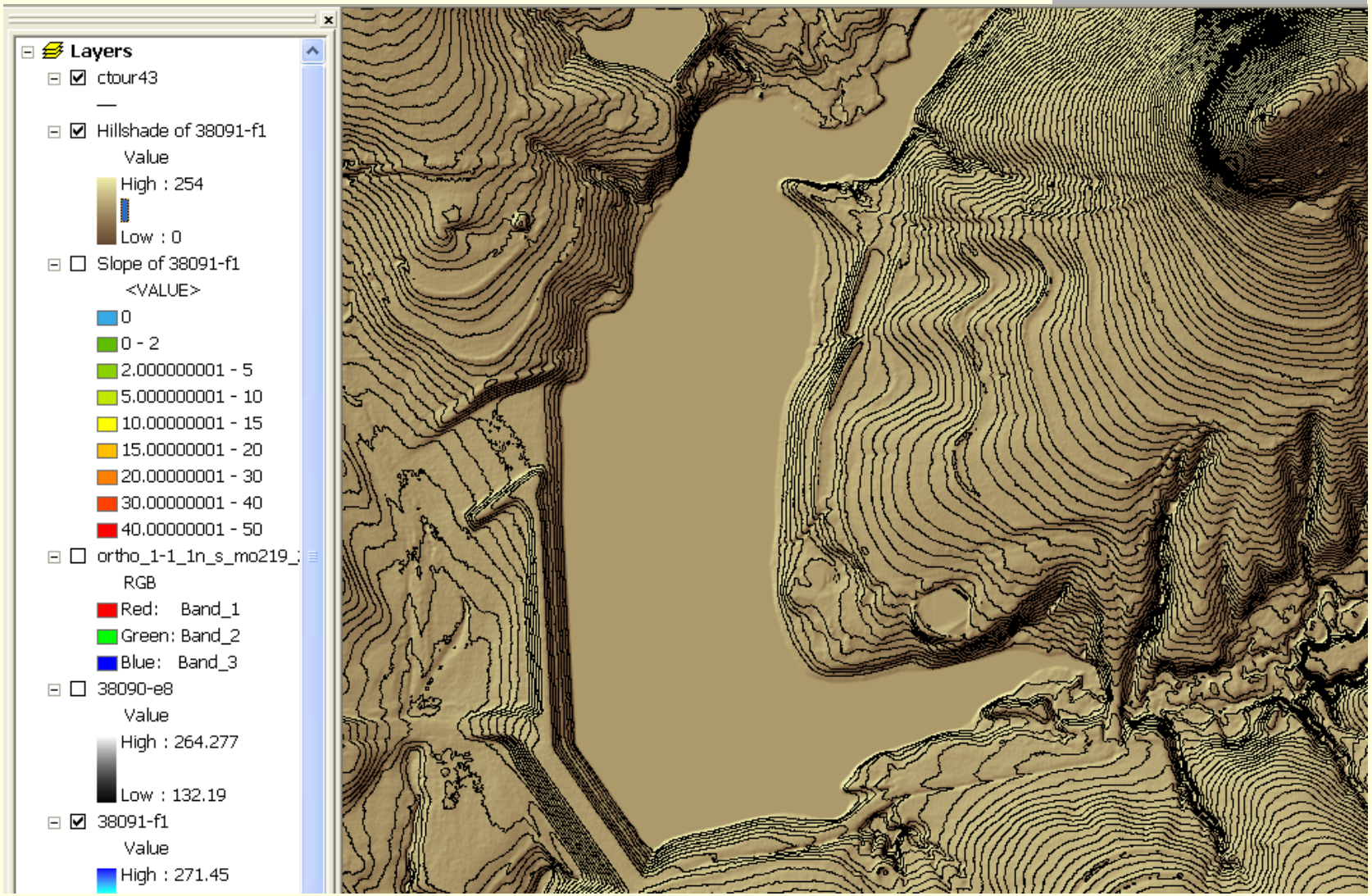
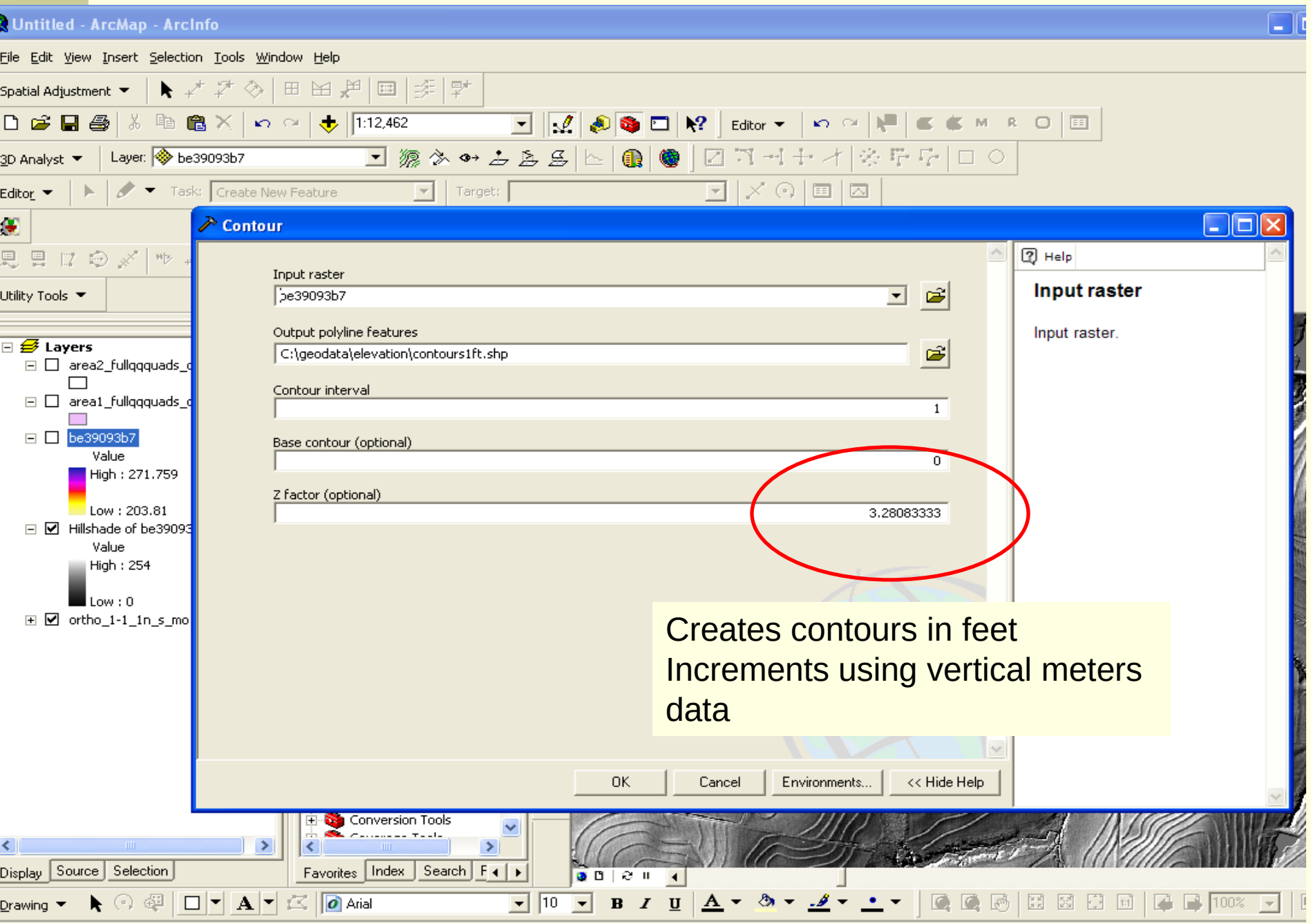
800
Dist in Feet
Profile Graph Subtitle

LiDAR Products - Contours

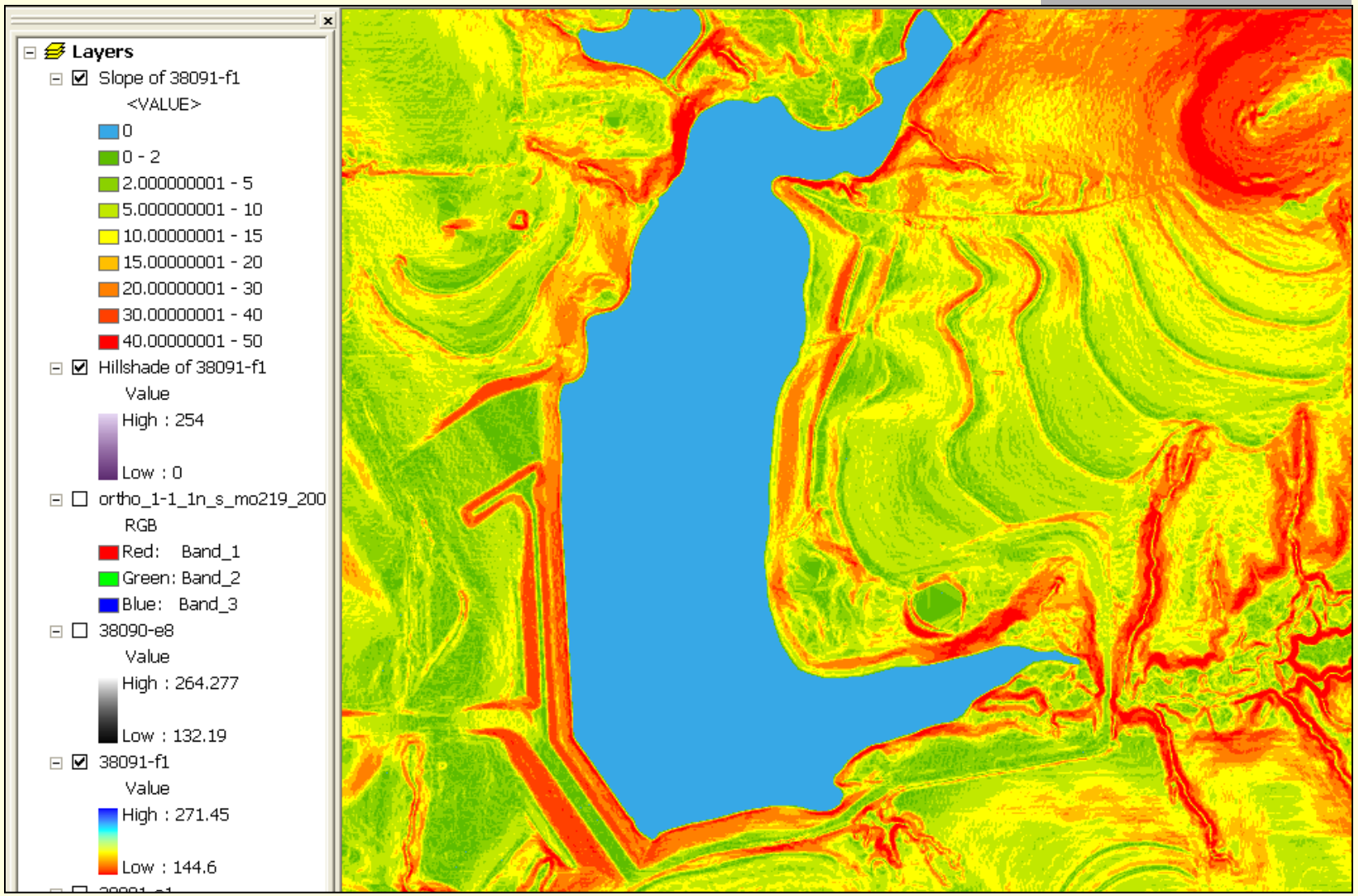


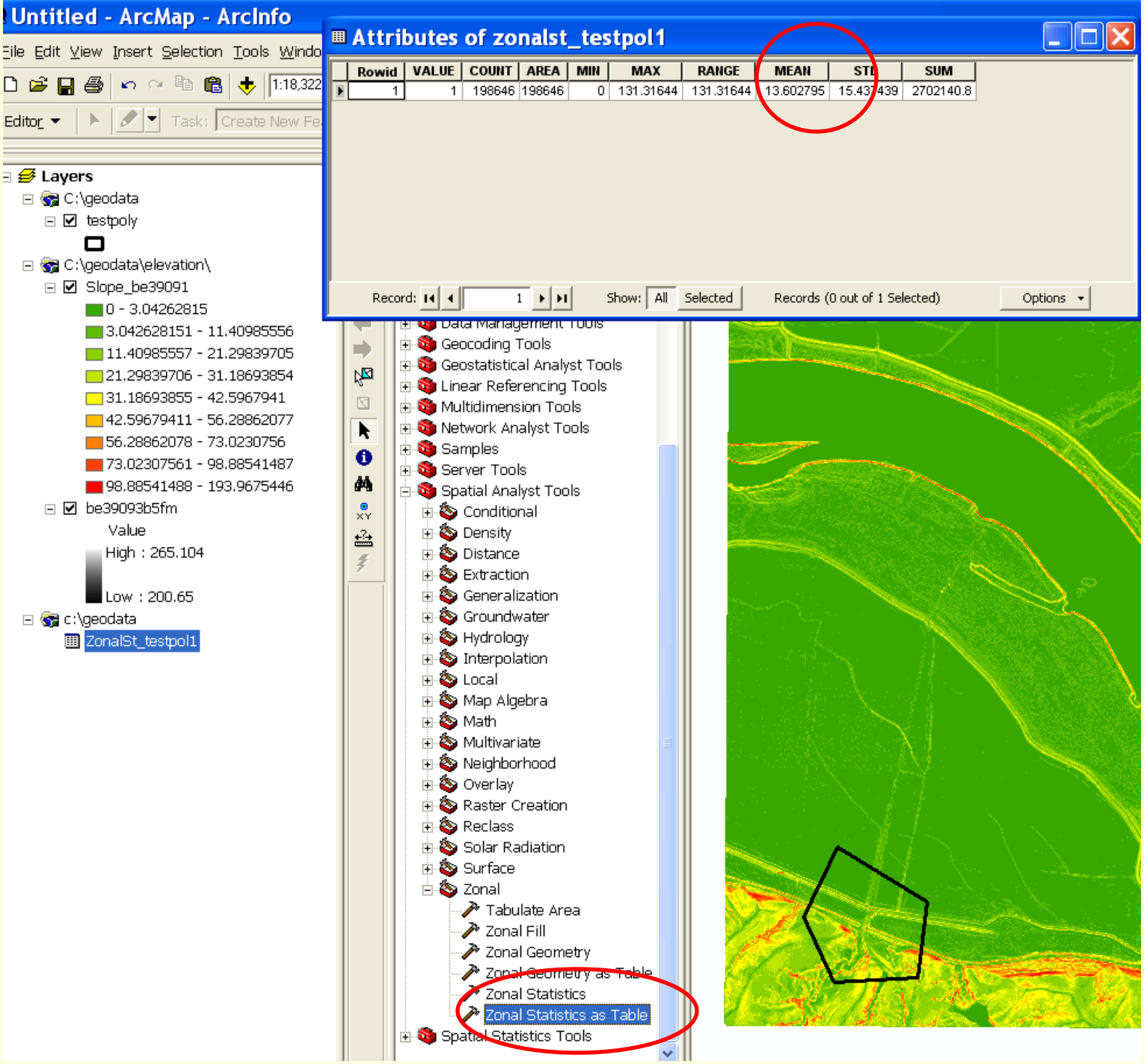
Considerations for Making Contours

- Smooth DEM using Focal Statistics – Mean
- Produce contours for relatively small areas; algorithm prone to crashing or locking up on large areas
- Encourage use of raster elevation tools


Untitled - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
Spatial Adjustment
1:12,462
Editor
3D Analyst
Layer: be39093b7
Editor
Task: Create New Feature
Target:
Utility Tools
Layers
area2_fullqqquads_c
area1_fullqqquads_c
be39093b7
Value
High : 271.759
Low : 203.81
Hillshade of be39093
Value
High : 254
Low : 0
ortho_1-1_1n_s_mo
Contour
Input raster
be39093b7
Output polyline features
C:\geodata\elevation\contours1ft.shp
Contour interval
1
Base contour (optional)
0
Z factor (optional)
3.28083333
Help
Input raster
Input raster.
OK
Cancel
Environments...
<< Hide Help
Creates contours in feet
Increments using vertical meters data
Conversion Tools
Favorites
Index
Search
Display
Source
Selection
Drawing
Arial
10
100%

LiDAR Products – Land Slopes

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testpoly
C:\geodata\elevation\
Slope_be39091
0 - 3.04262815
3.042628151 - 11.40985556
11.40985557 - 21.29839705
21.29839706 - 31.18693854
31.18693855 - 42.5967941
42.59679411 - 56.28862077
56.28862078 - 73.0230756
73.02307561 - 98.88541487
98.88541488 - 193.9675446
be39093b5fm
Value
High : 265.104
Low : 200.65
c:\geodata
ZonalSt_testpol1
Attributes of zonalst_testpol1
Rowid
VALUE
COUNT
AREA
MIN
MAX
RANGE
MEAN
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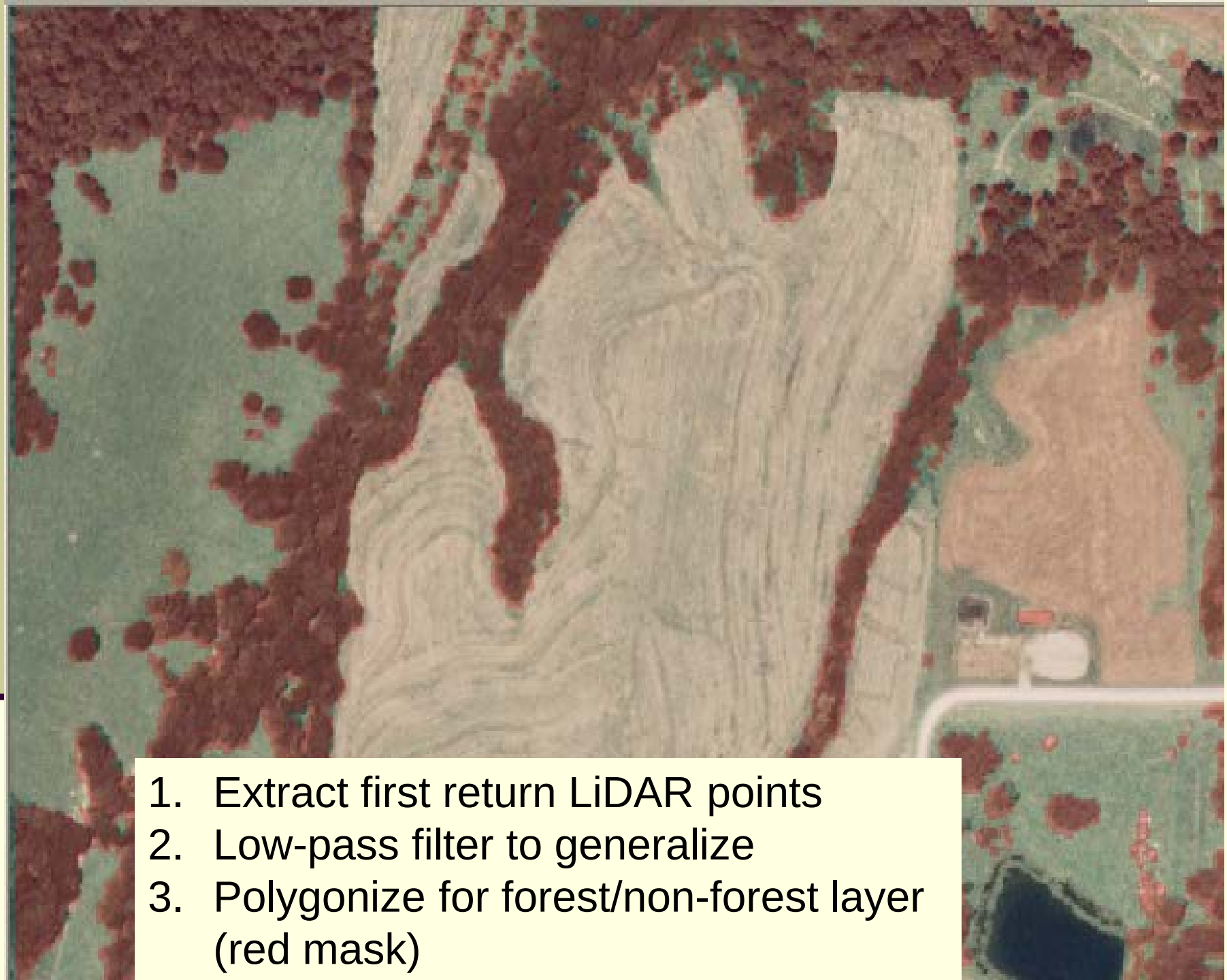
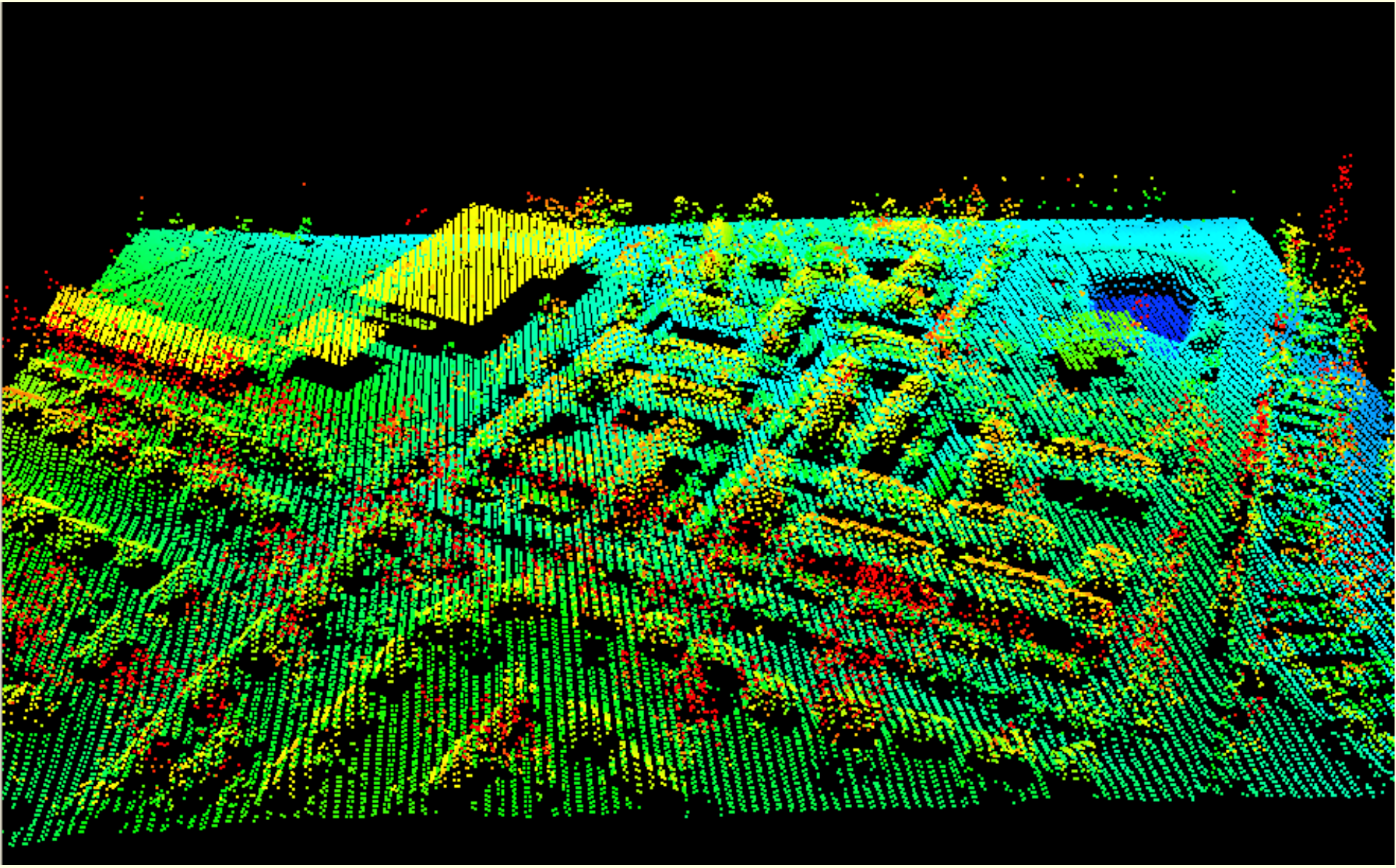
SUM
1
1
198646
198646
0
131.31644
131.31644
13.602795
15.437439
2702140.8
Record:
1
Show:
All
Selected
Records (0 out of 1 Selected)
Options
Data Management Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Multidimension Tools
Network Analyst Tools
Samples
Server Tools
Spatial Analyst Tools
Conditional
Density
Distance
Extraction
Generalization
Groundwater
Hydrology
Interpolation
Local
Map Algebra
Math
Multivariate
Neighborhood
Overlay
Raster Creation
Reclass
Solar Radiation
Surface
Zonal
Tabulate Area
Zonal Fill
Zonal Geometry
Zonal Geometry as Table
Zonal Statistics
Zonal Statistics as Table
Spatial Statistics Tools



1. Extract first return LiDAR points
2. Low-pass filter to generalize
3. Polygonize for forest/non-forest layer (red mask)



Delivering/Serving data

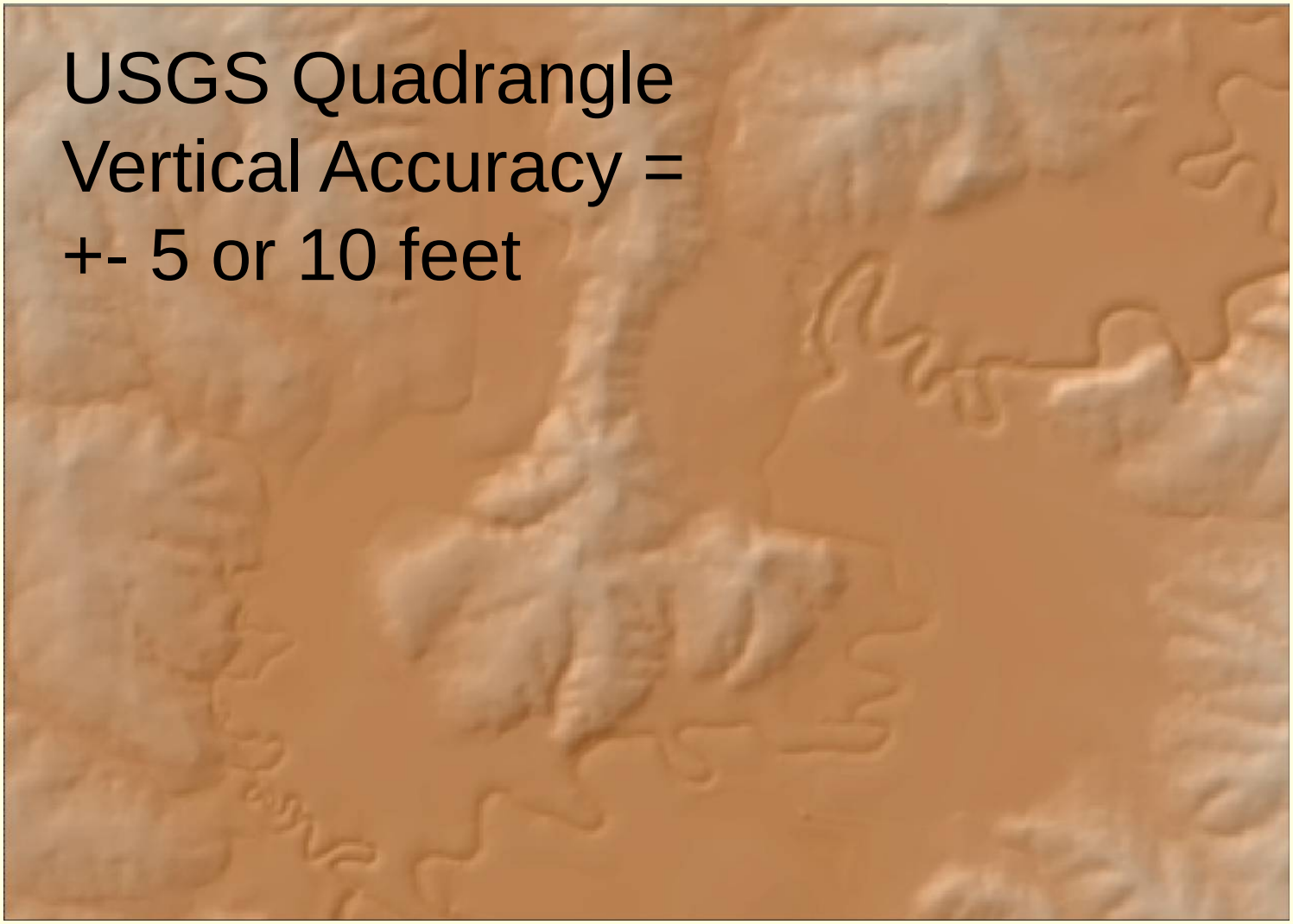
- Consider what derivatives are most important to your users and whether they should be pre-processed or instruct users to create their own.
  - If create and deliver several derivatives per tile, storage space can be an issue
  - If you train, can be complicated for users and/or a waste of their time
  - Web service – issues include clip/ship limitations, transfer speed, server processing demands, etc.

LiDAR Accuracy

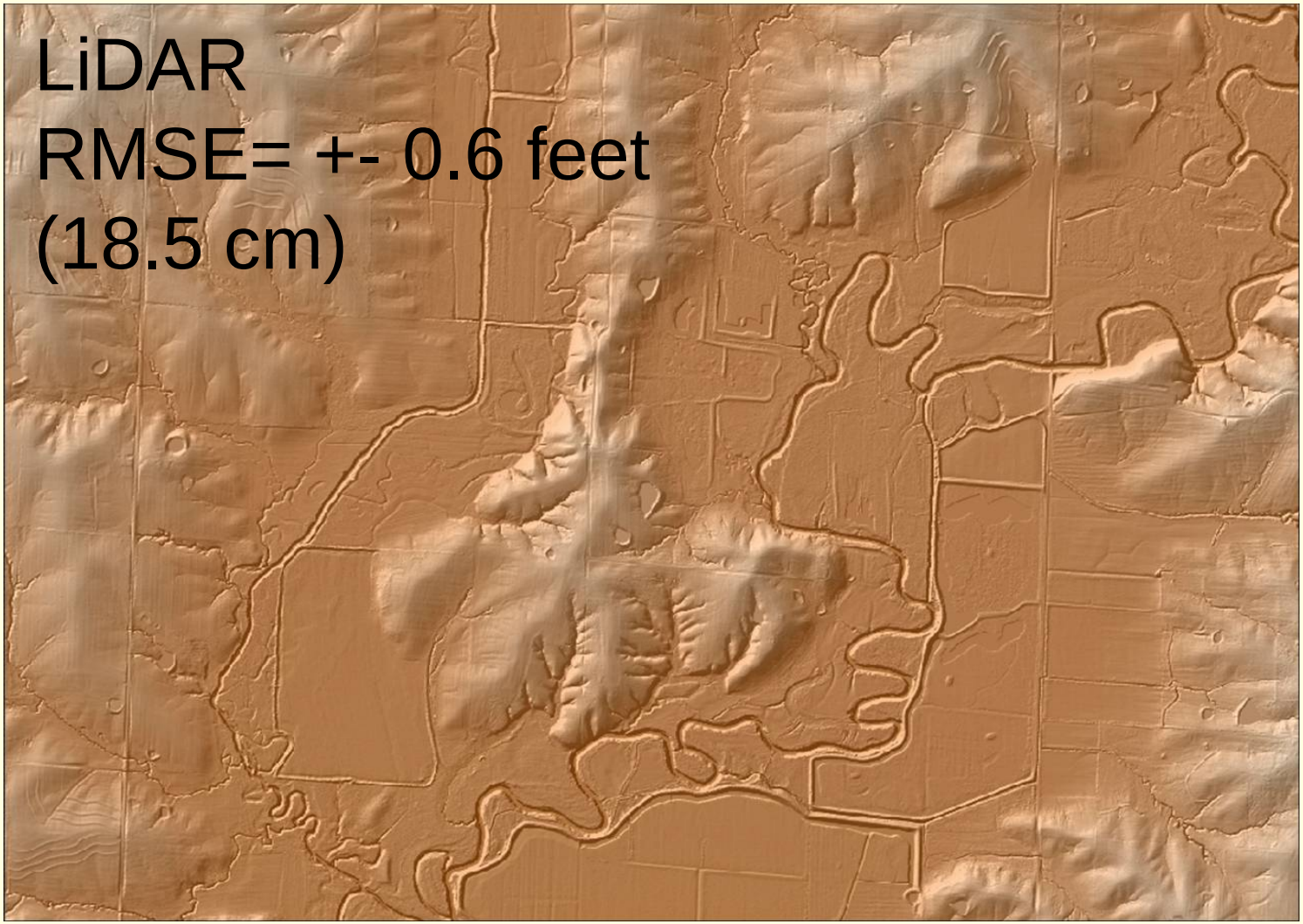
Determined by:

- LiDAR sensor quality and calibration
- GPS and IMU accuracy
- Flying height, density of points
- Removal of above-ground features, noise
- Control points
- Hydro-flattening breaklines

Accuracy



Accuracy



LiDAR Accuracy, Check Points

Asphalt

Gravel

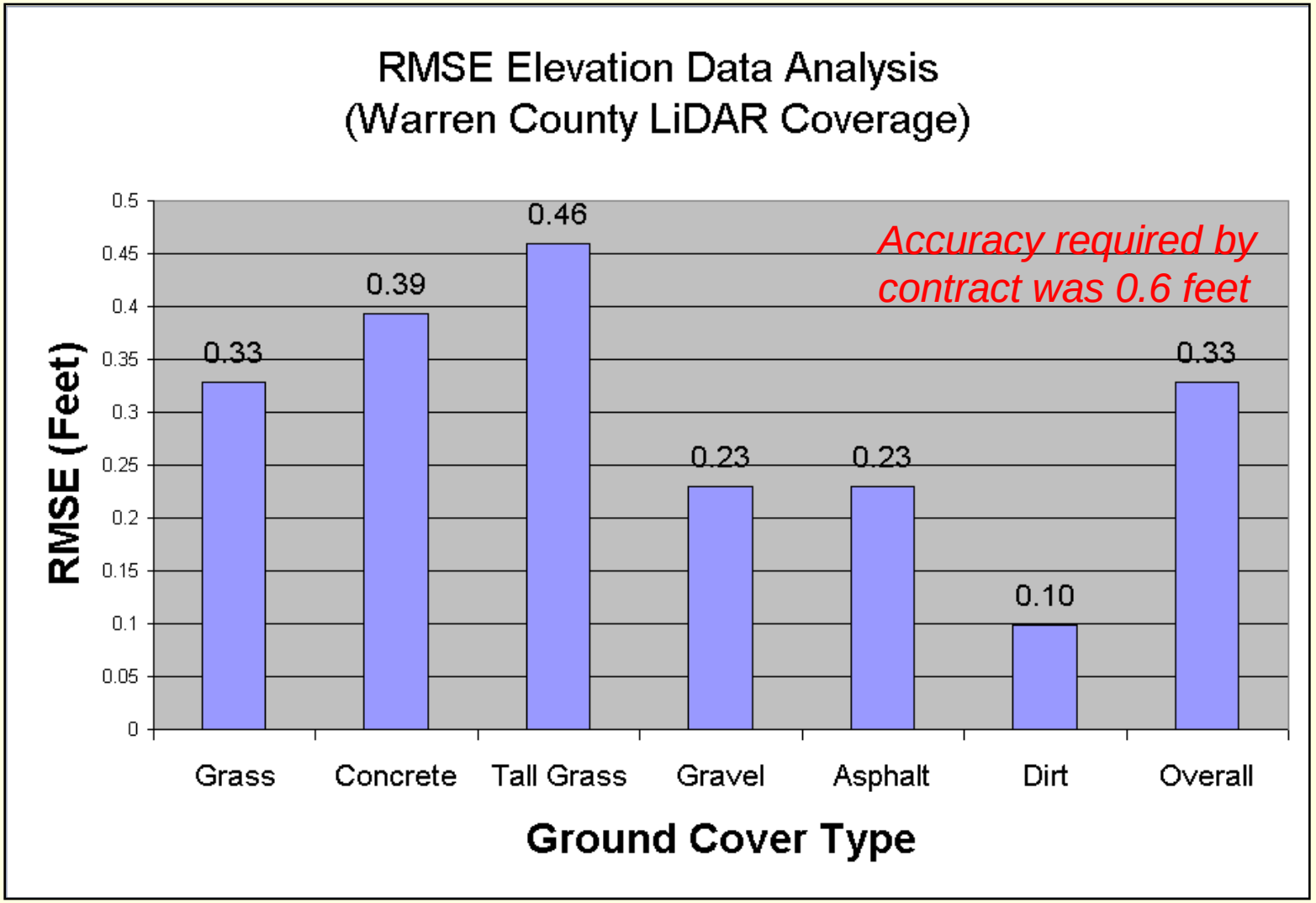
Concrete

Grass

Tall Grass

Trees

LiDAR Accuracy, an example



Applications

Regardless of how the data is collected, the accuracy dictates how it can be used.

Ground Surveys

- Level
- Transit
- GPS

Remote Sensing

- Stereo Photogrammetry
- SONAR
- **LIDAR**

LiDAR Applications

Point Spacing (Meter)	Vertical Accuracy (RMSE) (Meter)	Contour Interval (Feet)	Application Supported				
			Base Mapping	Floodplain Mapping	Natural Resources	Civil Planning	Civil Design
1	0.09	1’					 w/ Limits
2	0.20	2’					
3	0.30	3’					
4	0.40	4’					
5	0.51	5’					

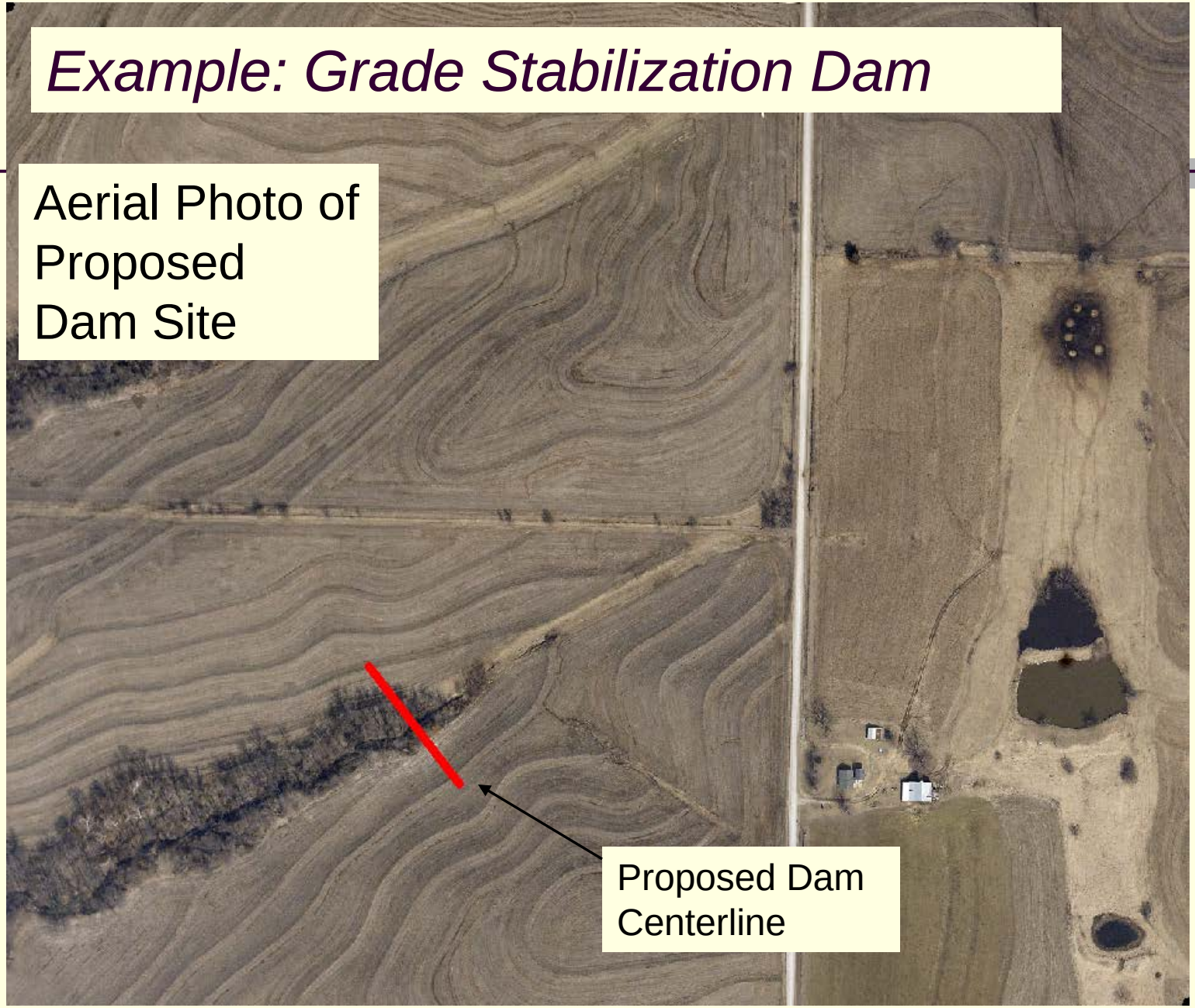
Note: This table is for example only. Required accuracy for a specific project must be defined on a case-by-case basis.

LiDAR Applications - NRCS

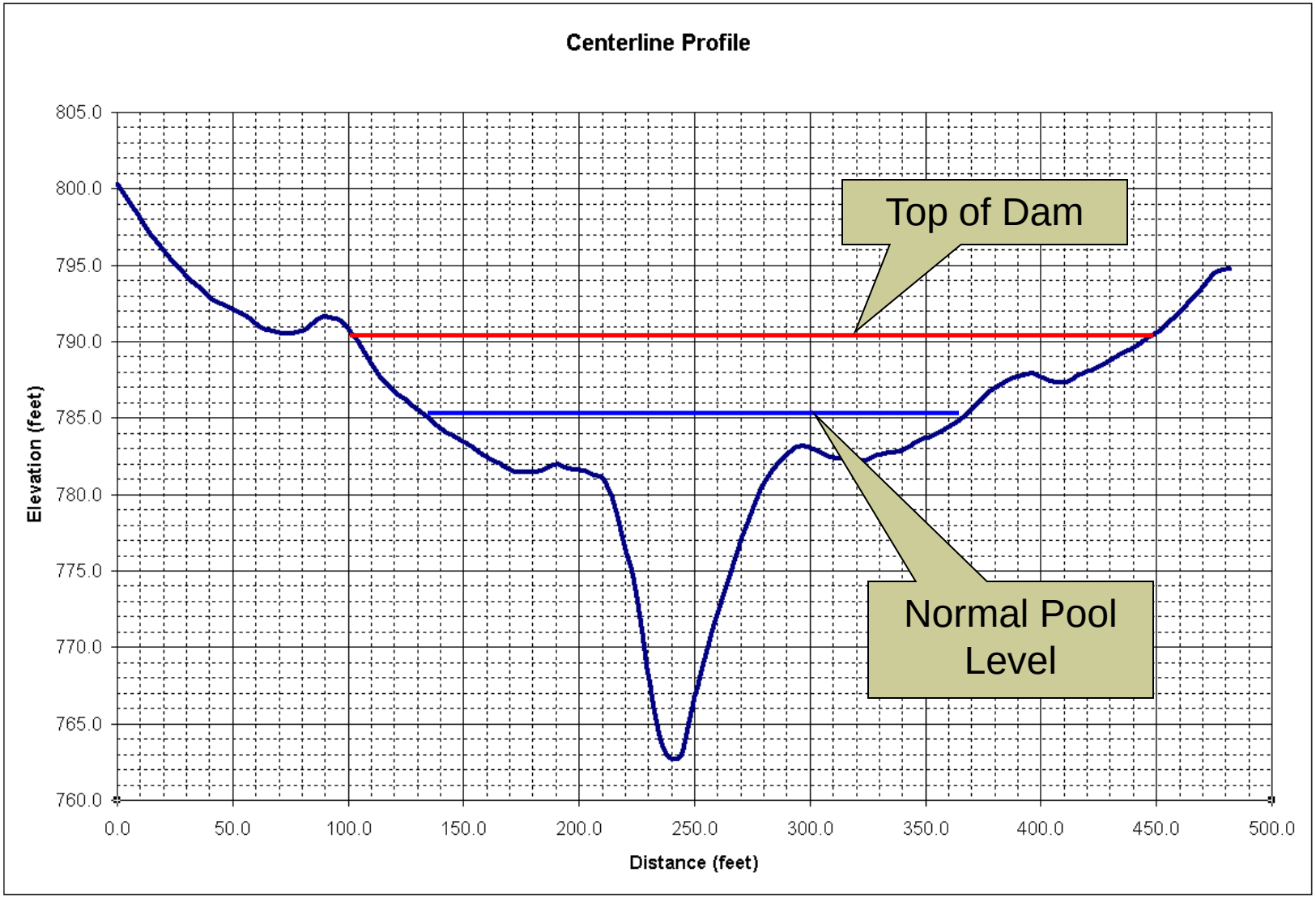
- Watershed Delineation
- Average Watershed Slope
- RUSLE2 Slopes
- Pipeline Profiles
- Terrace Layout Planning
- Pond and Structure Stage Storage
- Wetland Restoration Planning
- Quantity Estimating
- Floodplain Management Studies
- Improving Soils Mapping

Example: Grade Stabilization Dam

Aerial Photo of Proposed Dam Site

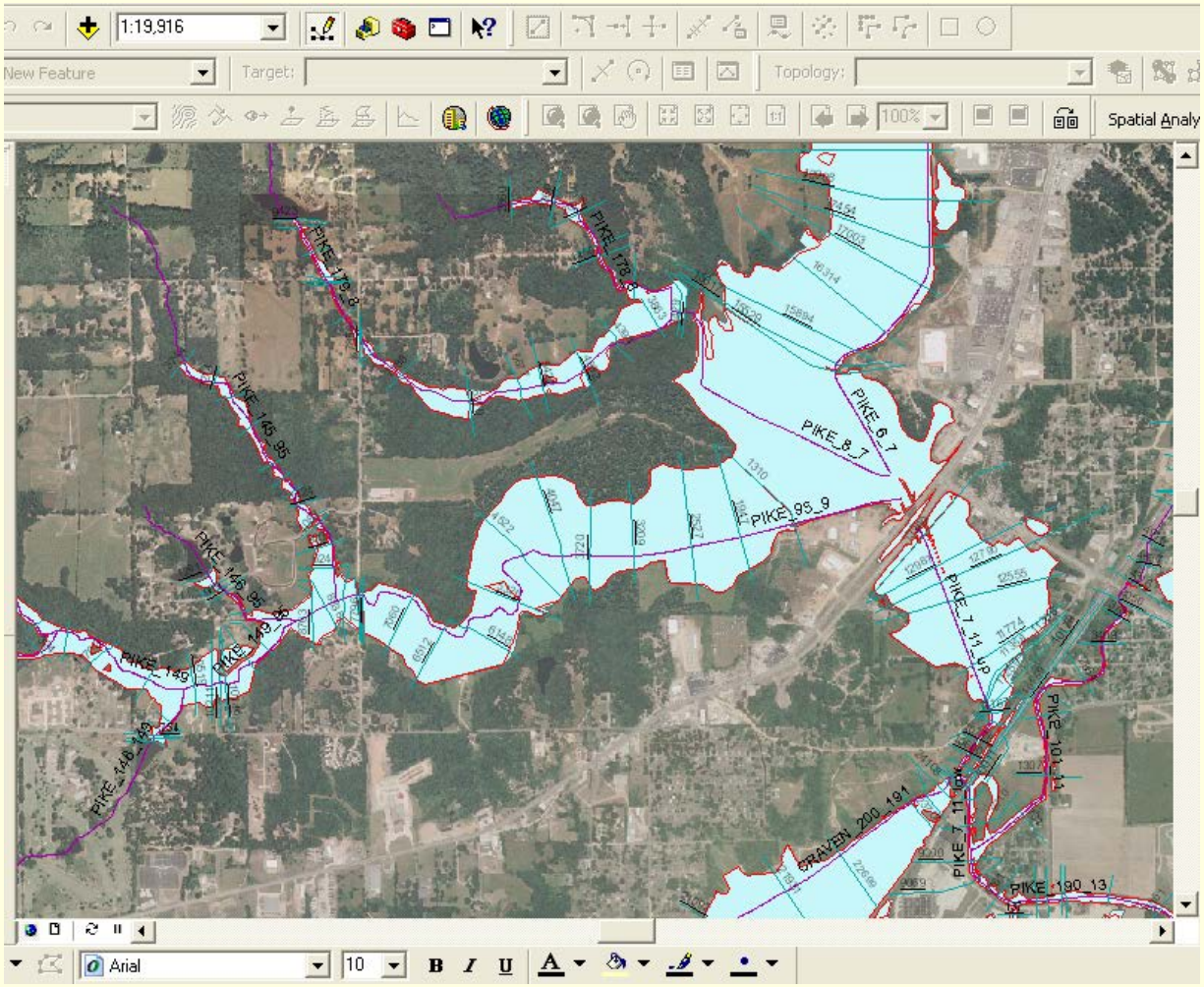


Example: Grade Stabilization Dam

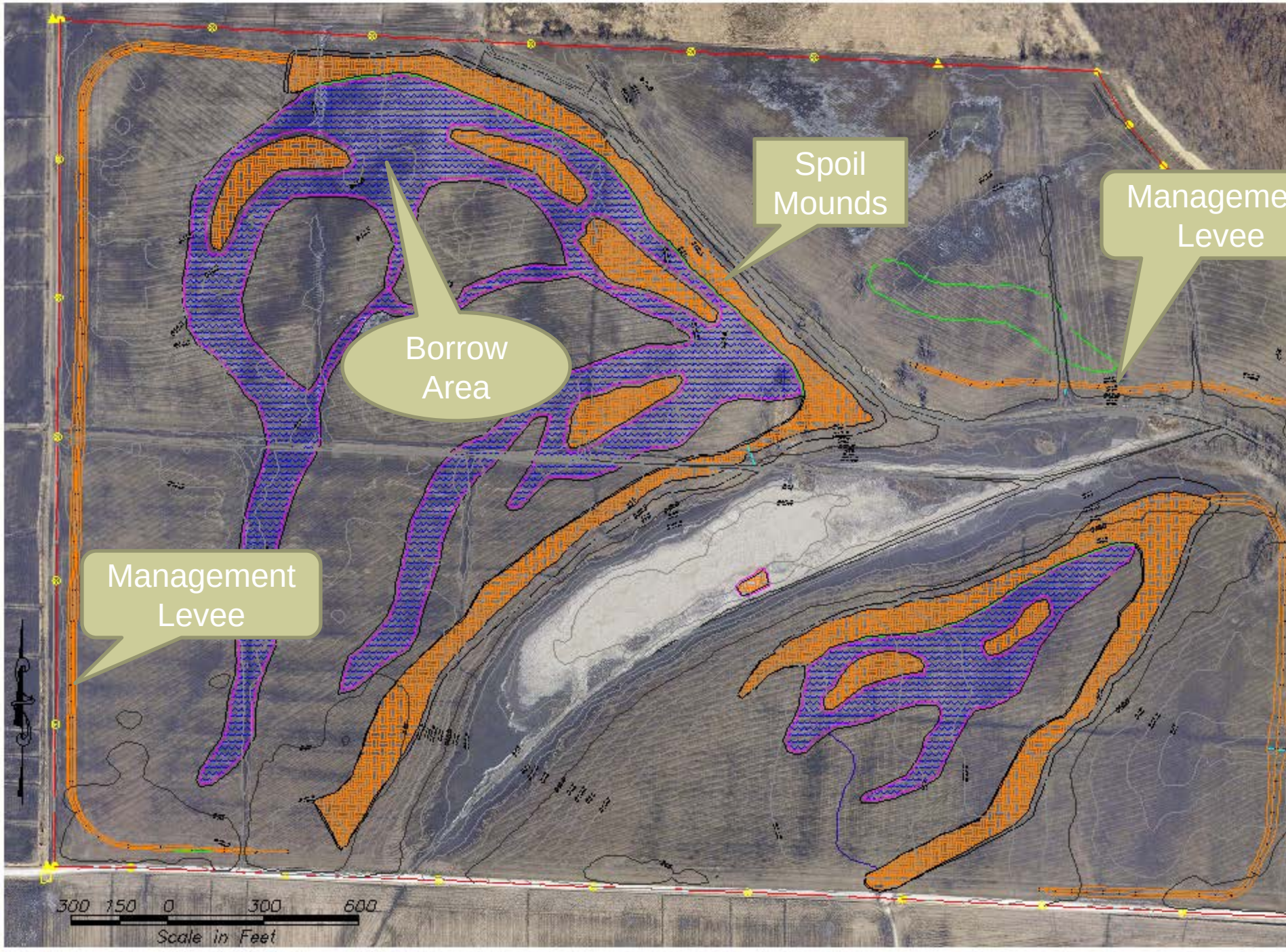


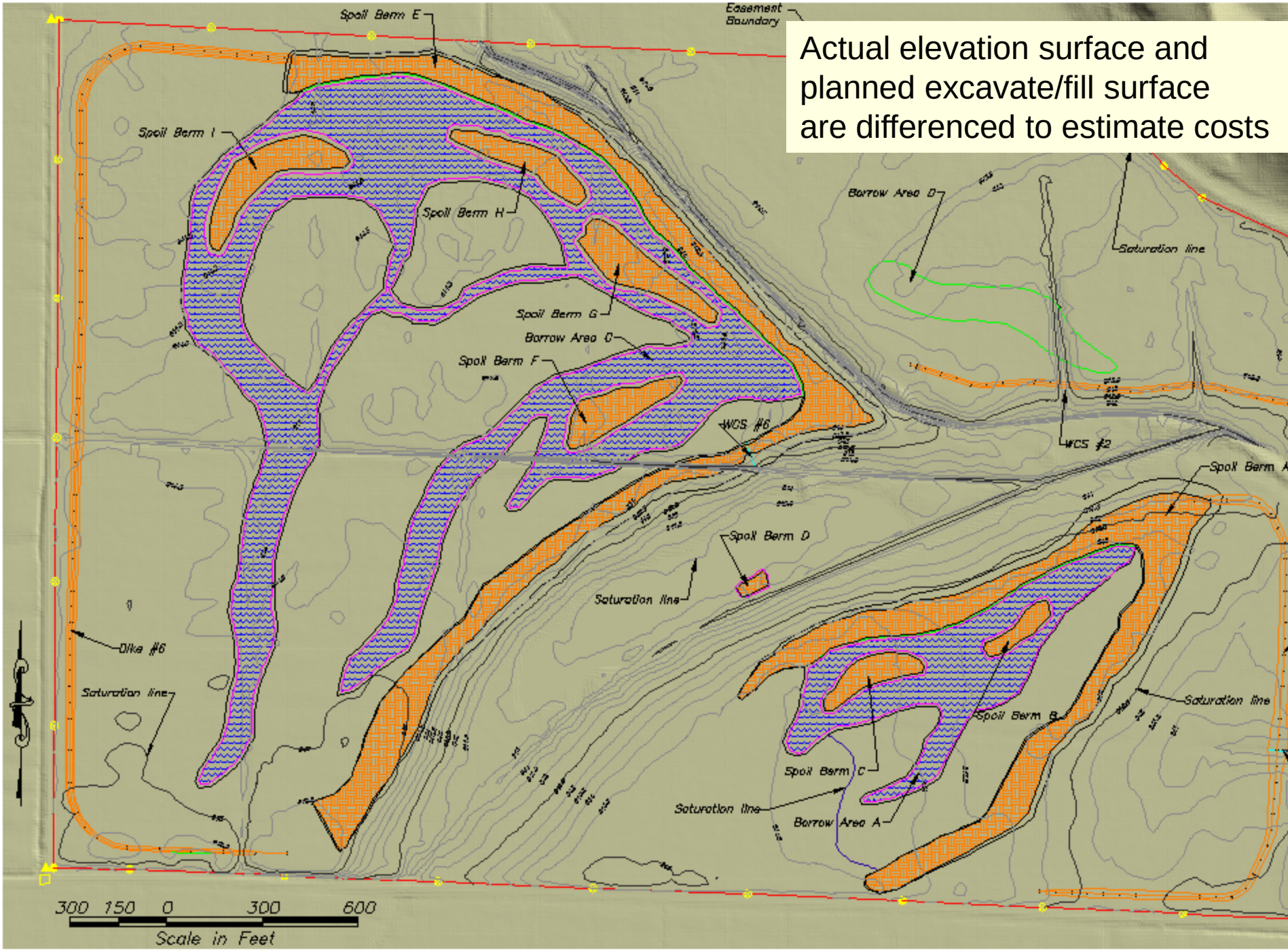
Dam Breach Modeling

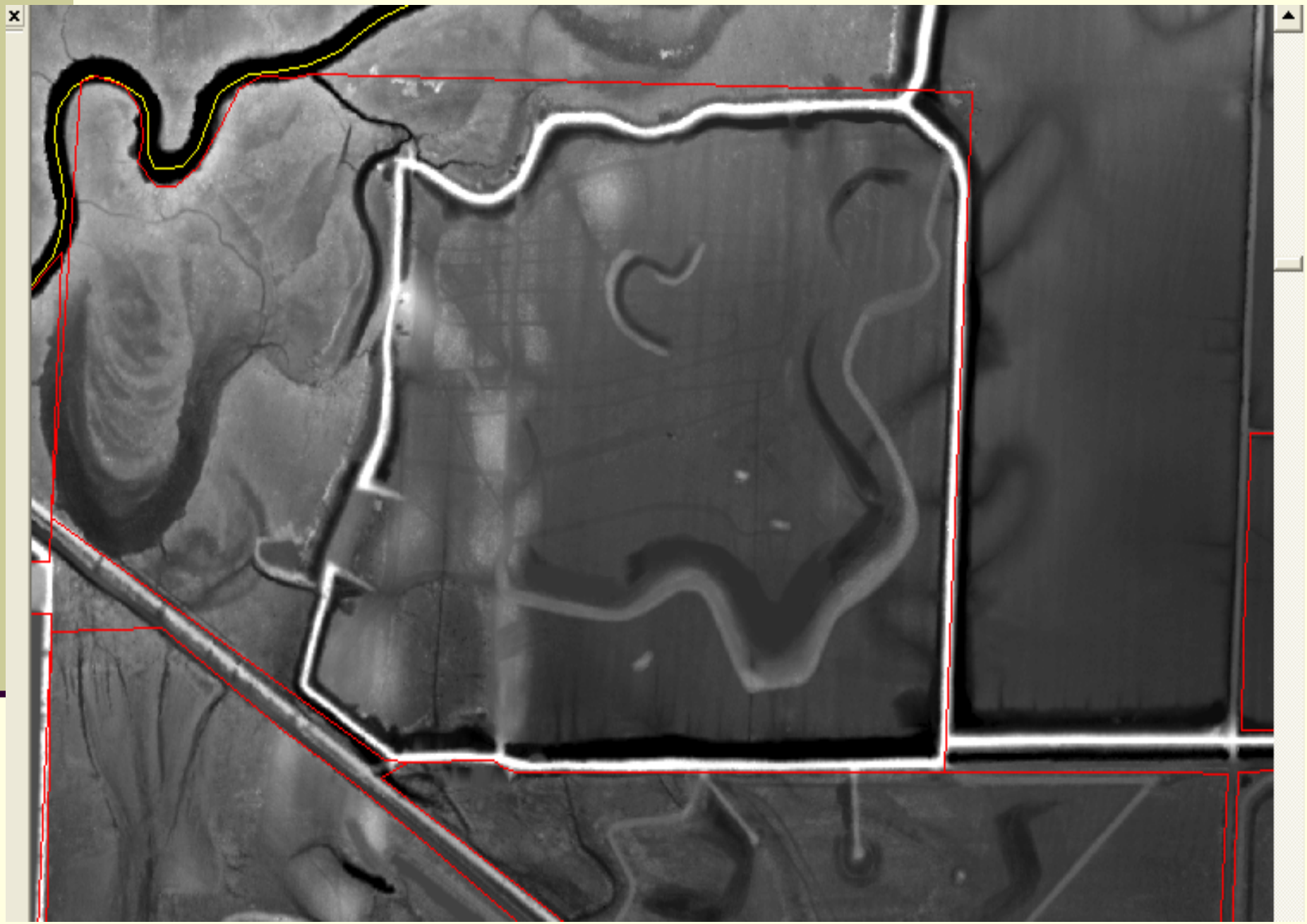
- Identify and map flood frequencies
- Identify and map hazard areas downstream of structures



Wetland Restoration


Spoil Mounds
Manageme Levee
Borrow Area
Management Levee
300 150 0 300 600
Scale in Feet


Actual elevation surface and planned excavate/fill surface are differenced to estimate costs
Spoil Berm E
Easement Boundary
Spoil Berm I
Spoil Berm H
Spoil Berm G
Borrow Area C
Spoil Berm F
Borrow Area D
Saturation line
WCS #6
WCS #2
Spoil Berm A
Spoil Berm D
Saturation line
Dike #6
Saturation line
Saturation line
Spoil Berm B
Spoil Berm C
Saturation line
Borrow Area A
300 150 0 300 600
Scale in Feet

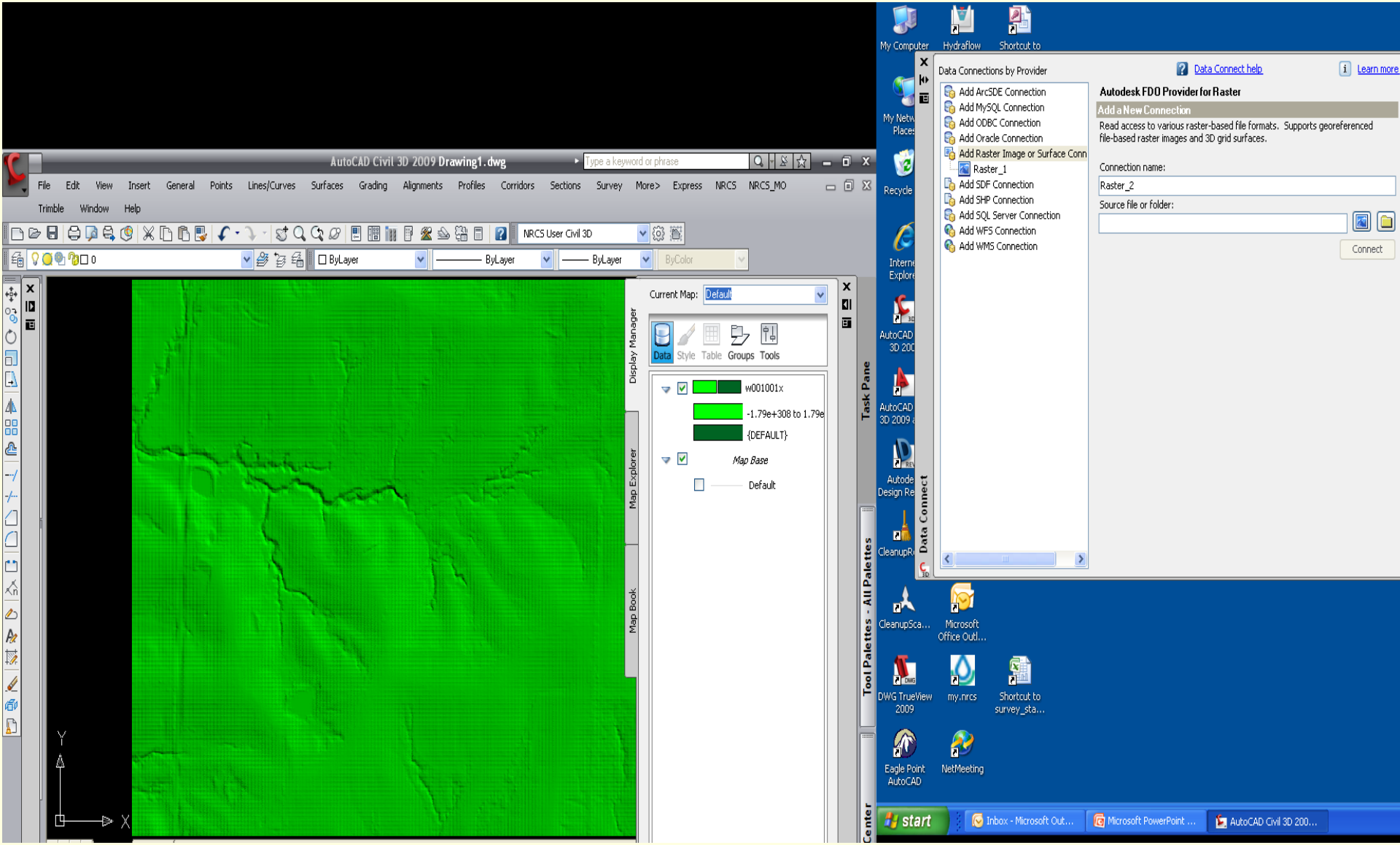


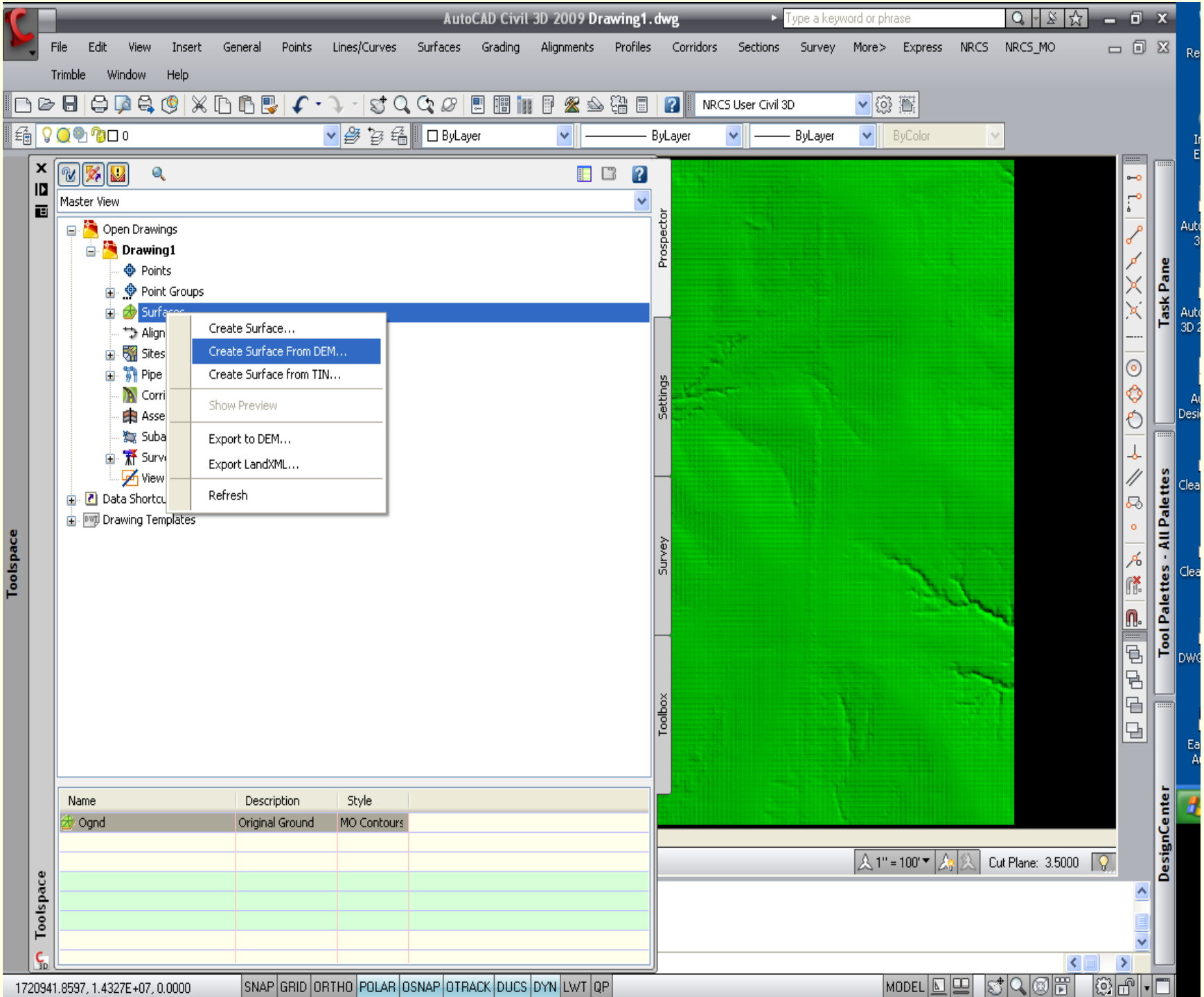
LiDAR Applications

Benefits of a Wide Area Coverage Elevation Model:

- Available on demand.
- Coverage of entire site.
- Coverage of land adjacent to site.
- Can complete planning activities without field surveys.

Data Connect to ESRI Grid in AutoCad




AutoCAD Civil 3D 2009 Drawing1.dwg
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Create Surface From DEM...
Create Surface from TIN...
Show Preview
Export to DEM...
Export LandXML...
Refresh
Data Shortcuts
Drawing Templates
Prospector
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Survey
Toolbox
Toolspace
Name
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Original Ground
MO Contours
1" = 100'
Cut Plane: 3.5000
Task Pane
Tool Palettes - All Palettes
DesignCenter
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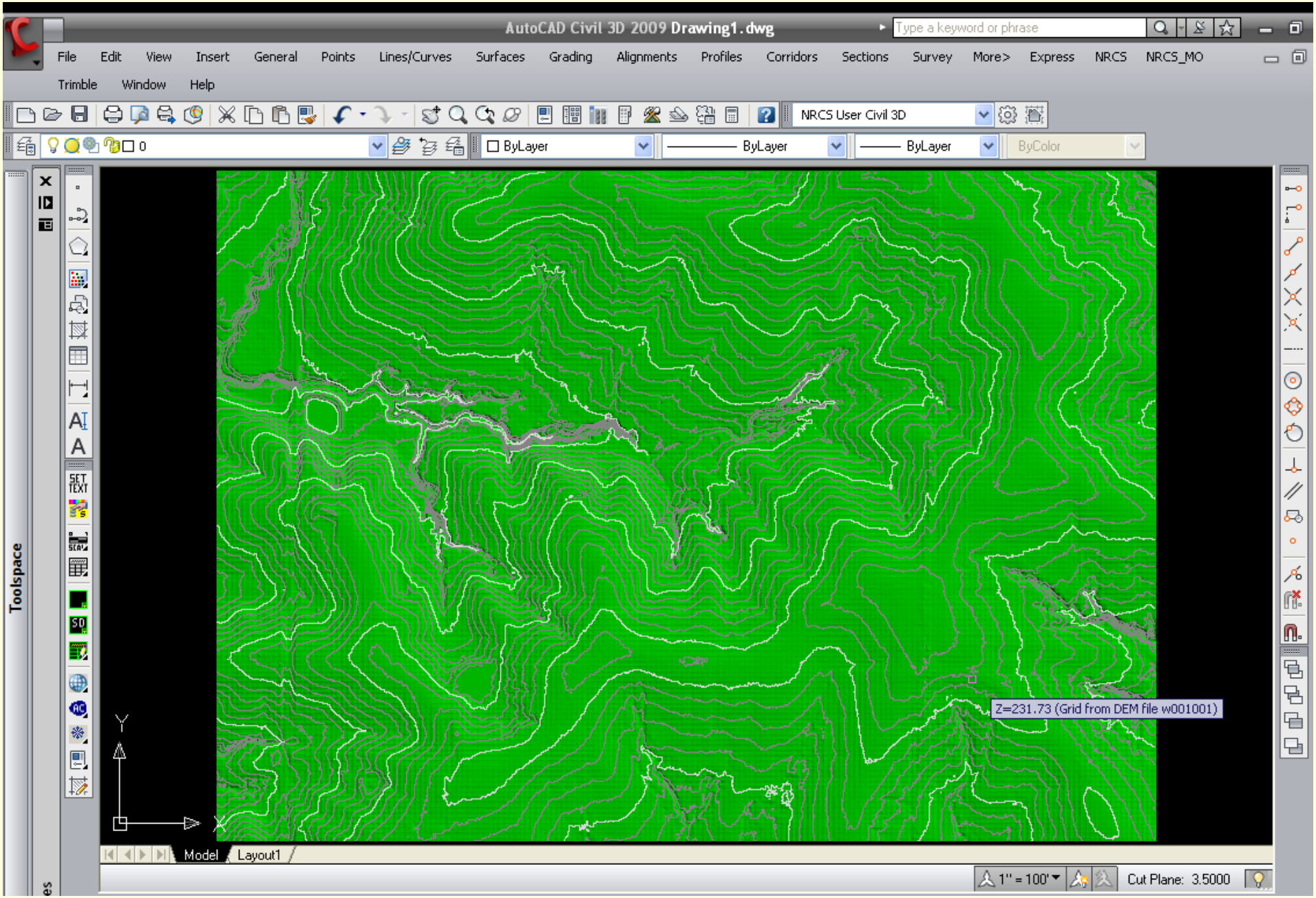
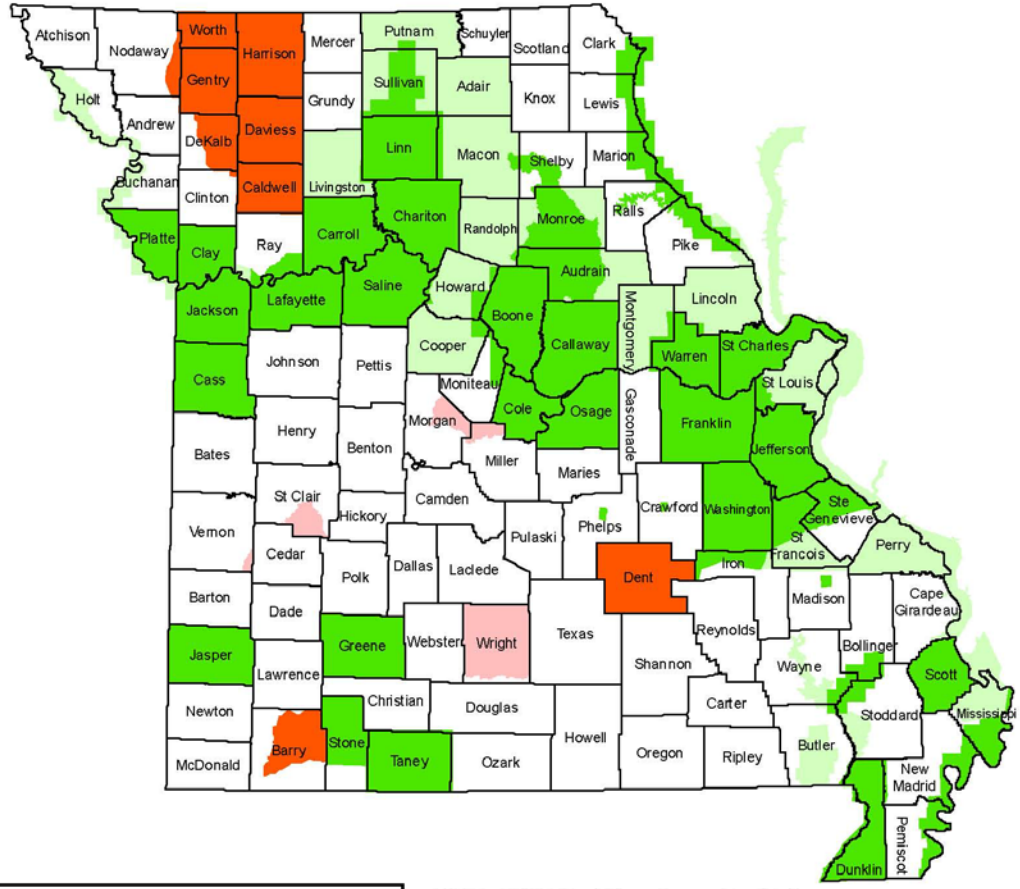
SNAP GRID ORTHO POLAR OSNAP OTRACK DUCS DYN LWT QP
MODEL


AutoCAD Civil 3D 2009 Drawing1.dwg
Type a keyword or phrase
File Edit View Insert General Points Lines/Curves Surfaces Grading Alignments Profiles Corridors Sections Survey More> Express NRCS NRCS_MO
Trimble Window Help
NRCS User Civil 3D
ByLayer
ByLayer
ByLayer
ByColor
Toolspace
Z=231.73 (Grid from DEM file w001001)
Model
Layout1
1" = 100'
Cut Plane: 3.5000

Status of Elevation mapping from Airborne LiDAR in Missouri



Legend

Status

- Complete: RMSE <=18.5cm
- In Progress: RMSE <=18.5cm
- Complete: RISKMap specs
- In Progress, RISKMap specs

NOTE: RMSE (Root Mean Square Error) is the square root of the average of the set of squared differences between the modeled (DEM) elevation values and known elevations from an independent surveyed source. The overall vertical accuracy of a DEM is 1.96 times RMSE at the 95% confidence level.

RISKMap specs vary some, but generally have an RMSE of 72.6cm and only the floodplain areas are processed into DEMs. For more details on RISKMap see www.fema.gov/library/viewRecord.do?id=4345

Updated June 2012

Working Together

- The Missouri Geographic Information Systems Advisory Council

www.mgisac.org

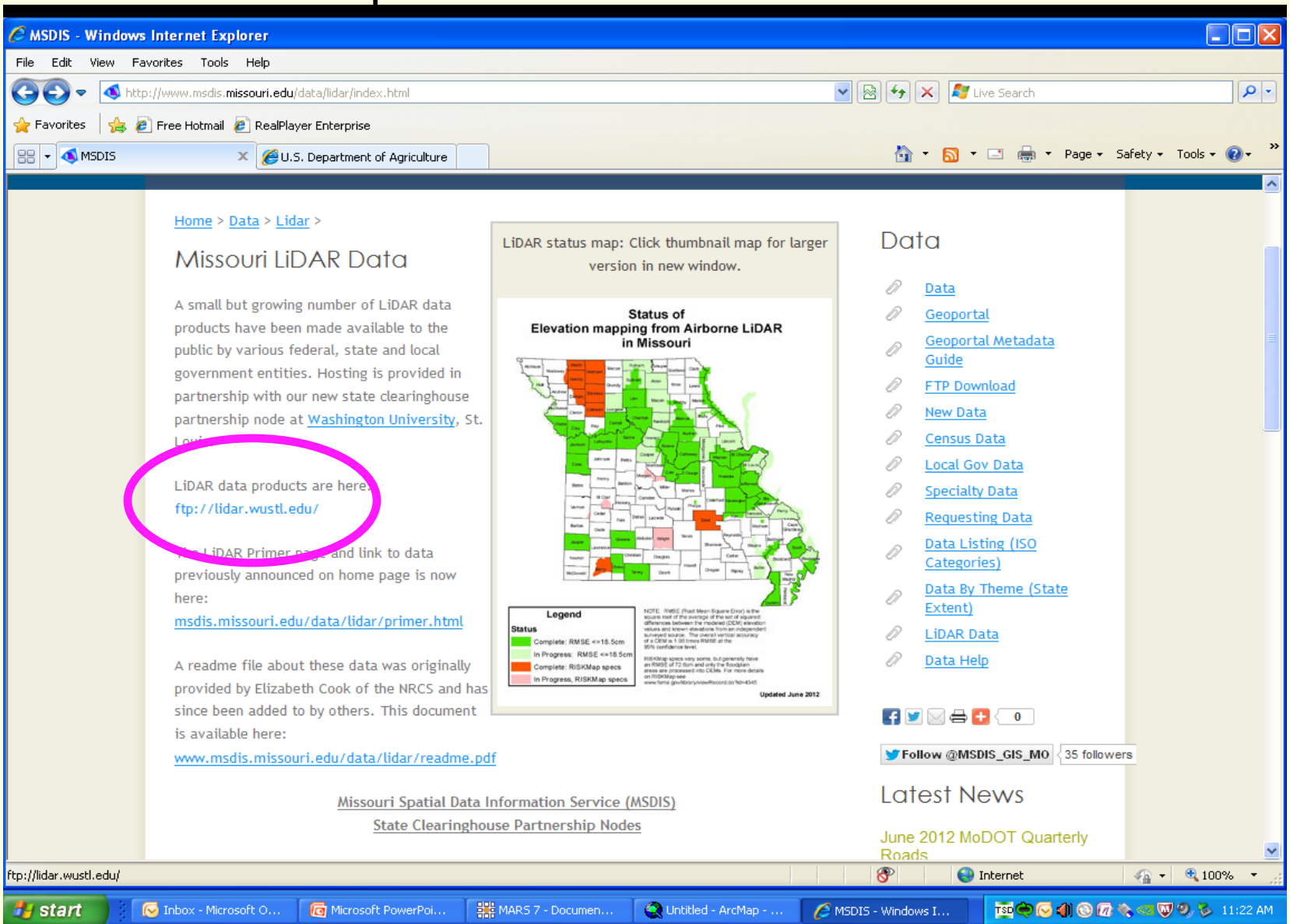
MGISAC

MISSOURI GEOGRAPHIC INFORMATION SYSTEMS ADVISORY COUNCIL

Members include representatives from Federal & State Agencies, County & City Governments and Universities

http://www.msdis.missouri.edu/data/lidar/index.html

ftp://lidar.wustl.edu



Downloading Tip

- Copy/Paste the ftp address in Windows Explorer to download folders of data instead of a file at a time.
- Grids are folders of data, and if you use IE as the ftp client you can only download a file at a time which is very cumbersome on Grids!!

Helping People Help the Land