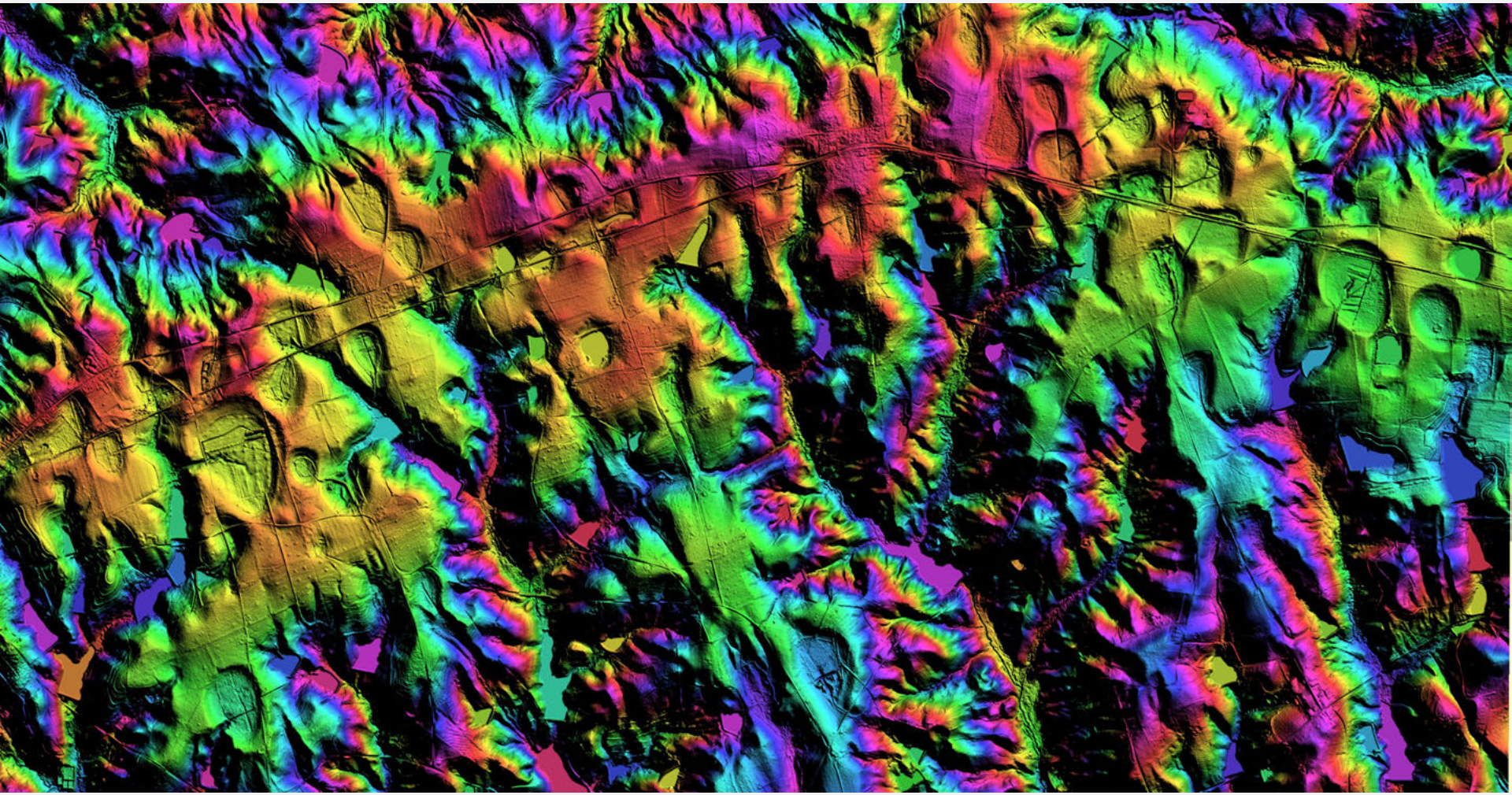
The Carolina Bays of Ridge Spring, SC



Paper No. 19-10
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Richmond, VA 30-31 March, 2017

THE CAROLINA BAYS OF RIDGE SPRING, SC

A narrow, sinuous terrace known locally as The Ridge forms a contiguous drainage divide arcing ~100 km from Augusta, GA, northeastward toward Columbia, SC. A new one-meter-resolution digital elevation map was crafted for the terrace using LiDAR data from the SC Department of Natural Resources, providing a crisp perspective of the surficial features present. From their lofty perch at ~200 m elevation, the low-relief terrain surrounding Ridge Spring, SC represent a surviving island of flat Cretaceous terrace that is being encroached upon by headward fluvial erosion. Edisto River basin headwaters are eating away the southeastern flank, while along the northwestern flank, tributaries of the upper Santee River drainage basin are collaborating with those of the Savanah River to remove the divide. Of the 45,000+ East Coast bays in the Carolina Bay Geospatial Survey, only 171 bays exist at elevations above 185 m. The Ridge Spring terrace is home to 160 of those high-elevation bays, making the assemblage unique in many ways. These bays maintain robust conformance to the archetype "baySouth" teardrop planform common to over 16,000 neighboring bays; their major axis range from 1.22 km down to 140 m, with a mean of 380 m; the orientations of that axis range from 148º to 165º, with a mean of 154º. The bays of Ridge Spring are visualized in LiDAR as basins recessed into a surrounding pediment (here, the terrace), exhibit no raised southeastern rim, and have no aeolian dune formations in their vicinity. The headward erosion has been dissecting the terrace since the time of bay formation, as the LiDAR elucidates a history of systematic bay destruction. Some clearly-defined bays have been penetrated by headward erosion, and are no longer hydraulically closed. Former closed-rim bays - recognizable by surviving rim fragments - have become mere "headwater basins". At some point in the future the last vestiges of the terrace surface and the imbedded Carolina bays will be gone. How long will that take? These observations indicate that Carolina bays are not wispy, ephemeral shorelines, but rather represent the surficial expression of robust structures deeply rooted into the landscape. Ridge Spring represents an ideal locale to investigate the burial chronology of Cretaceous strata by surficial sands using Beryllium-10 cosmogenic exposure techniques.

Goals of Talk

- **Ridge Spring, SC Cretaceous Terrace Remnant**
  - **~200 bays**
- **Valley Head Basins – Juvenile Carolina bays?**
- **Geomorphology hypothesis**
- **Future directions**

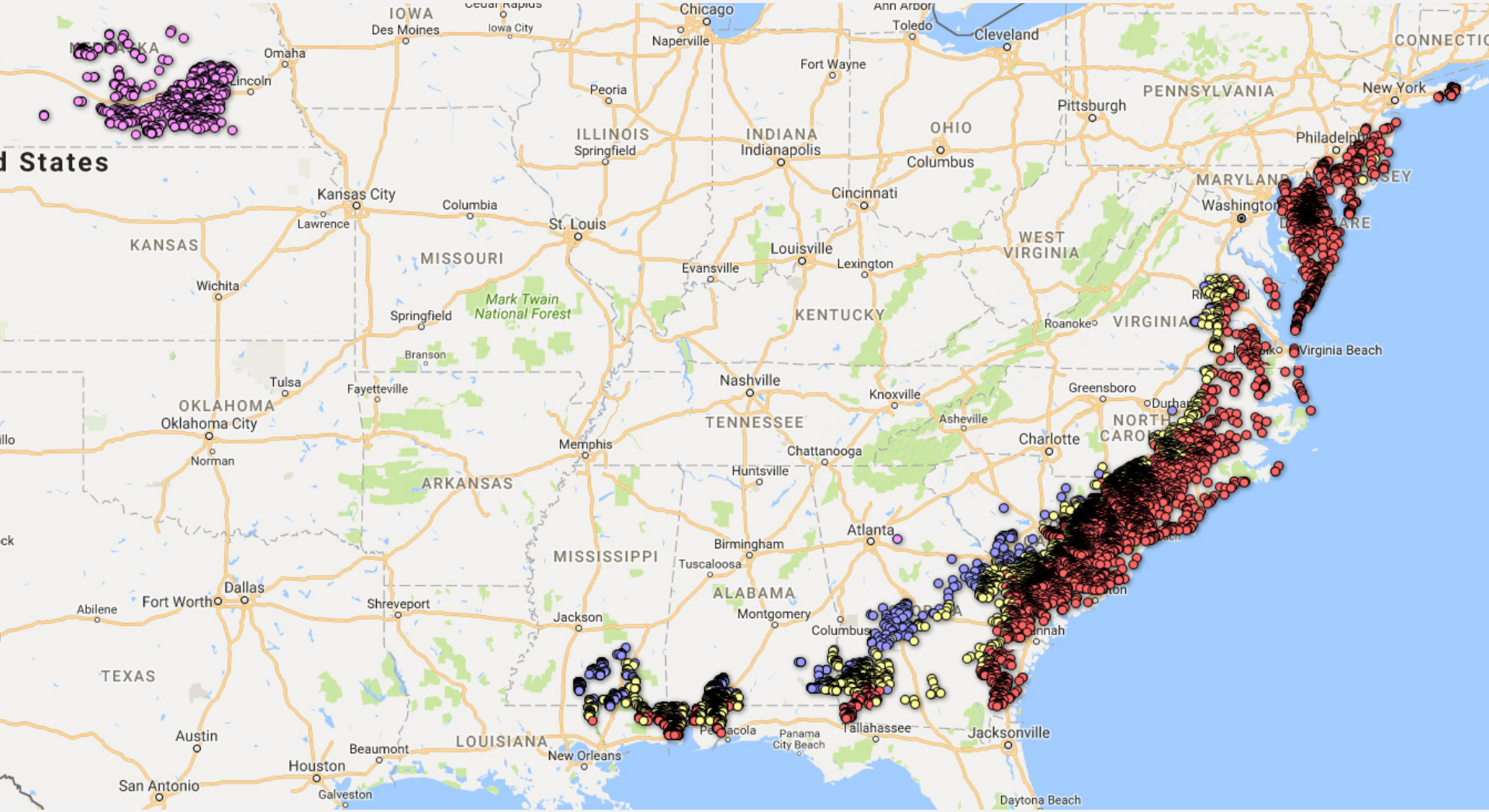
- **All work product freely available @ `cintos.org`**

"No one has yet invented an explanation which will fully account for all the facts observed" Douglas Johnson

"Their very randomness of grouping and scatter demands an explanation. As a statistical phenomenon, they deserve to be studied statistically." W.C. Rasmussen

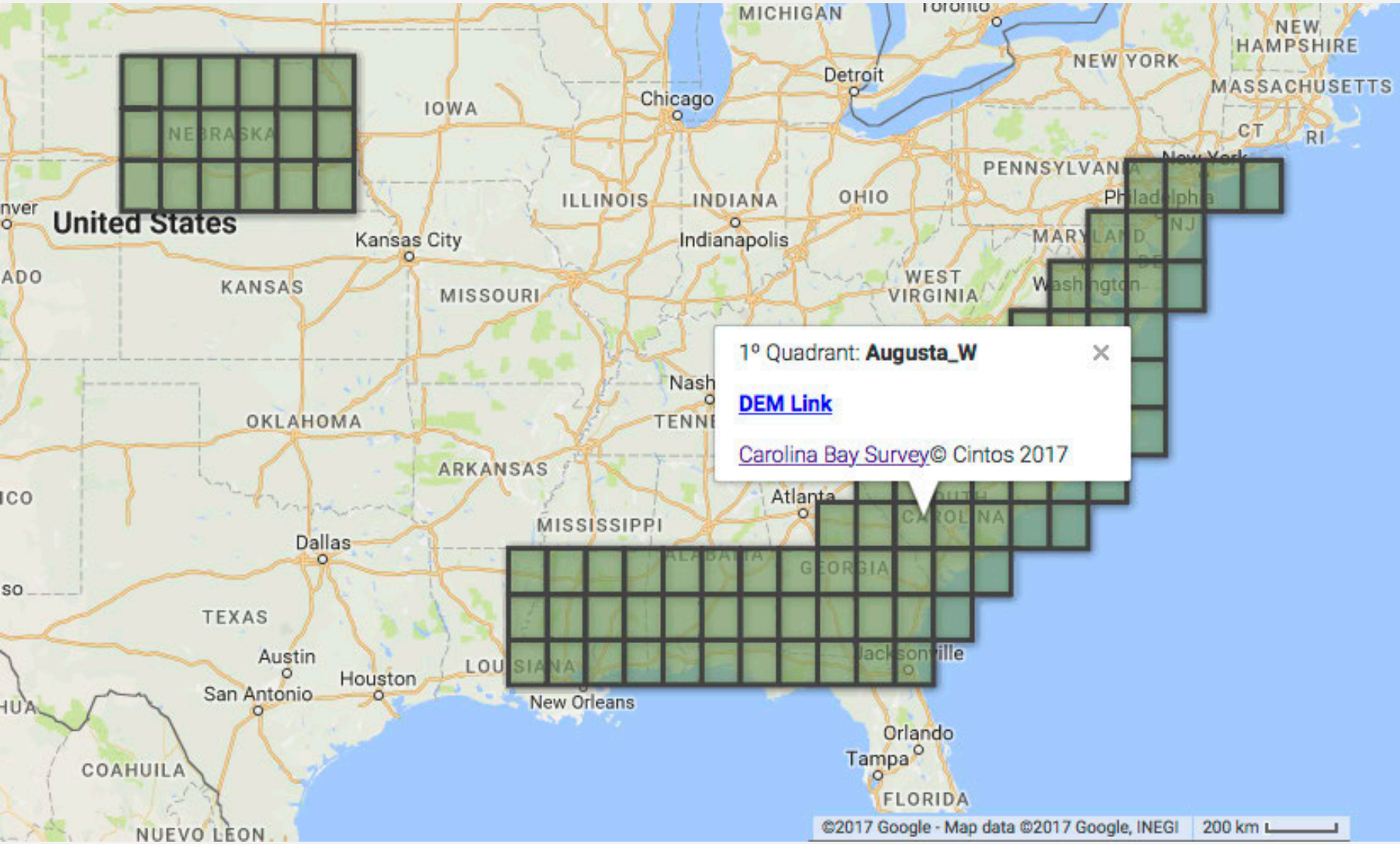
A comprehensive survey might provide the statistics to inspire that "invention".

Carolina Bay Survey



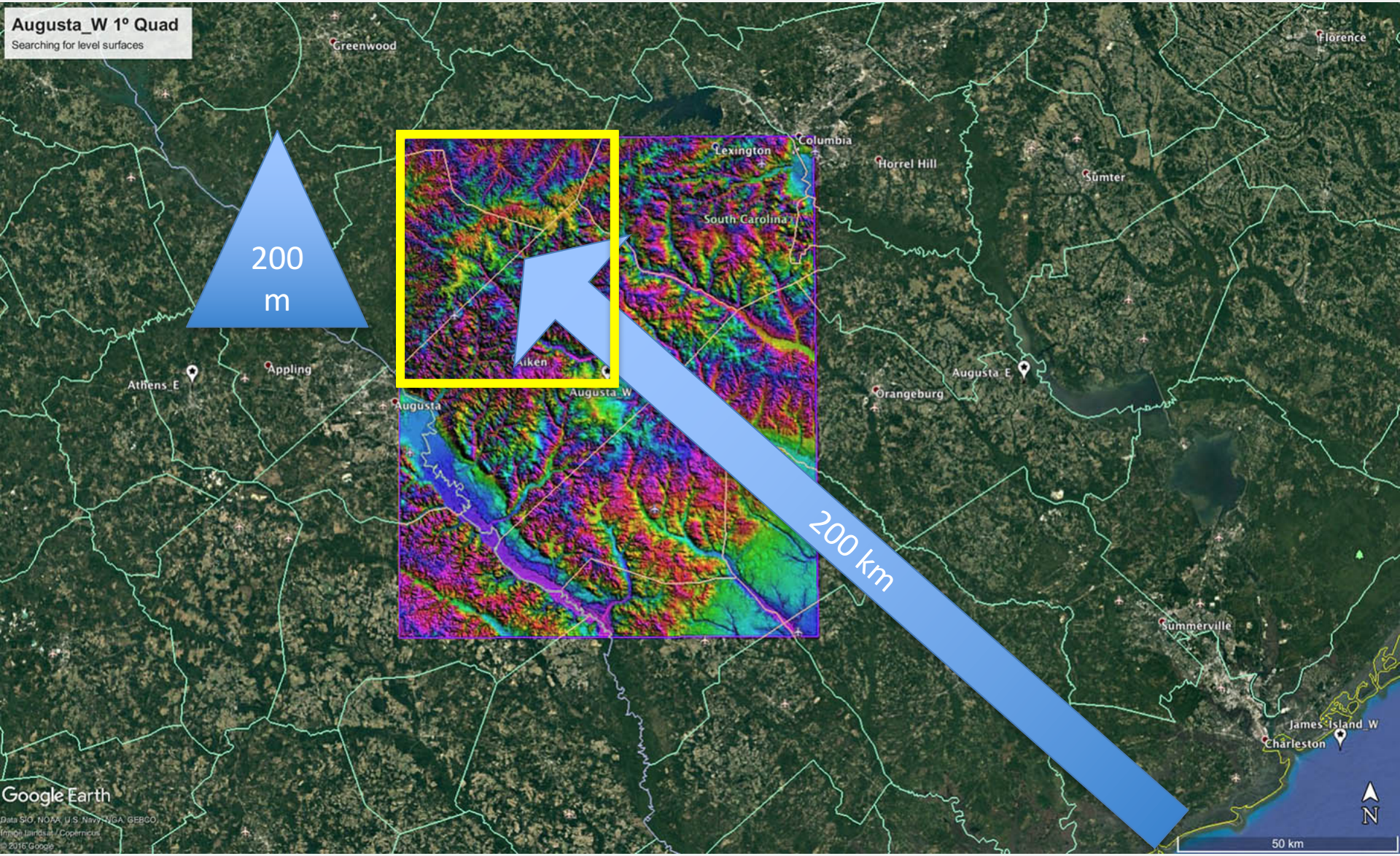
http://cintos.org/SurveyBayMap

Carolina Bay Survey



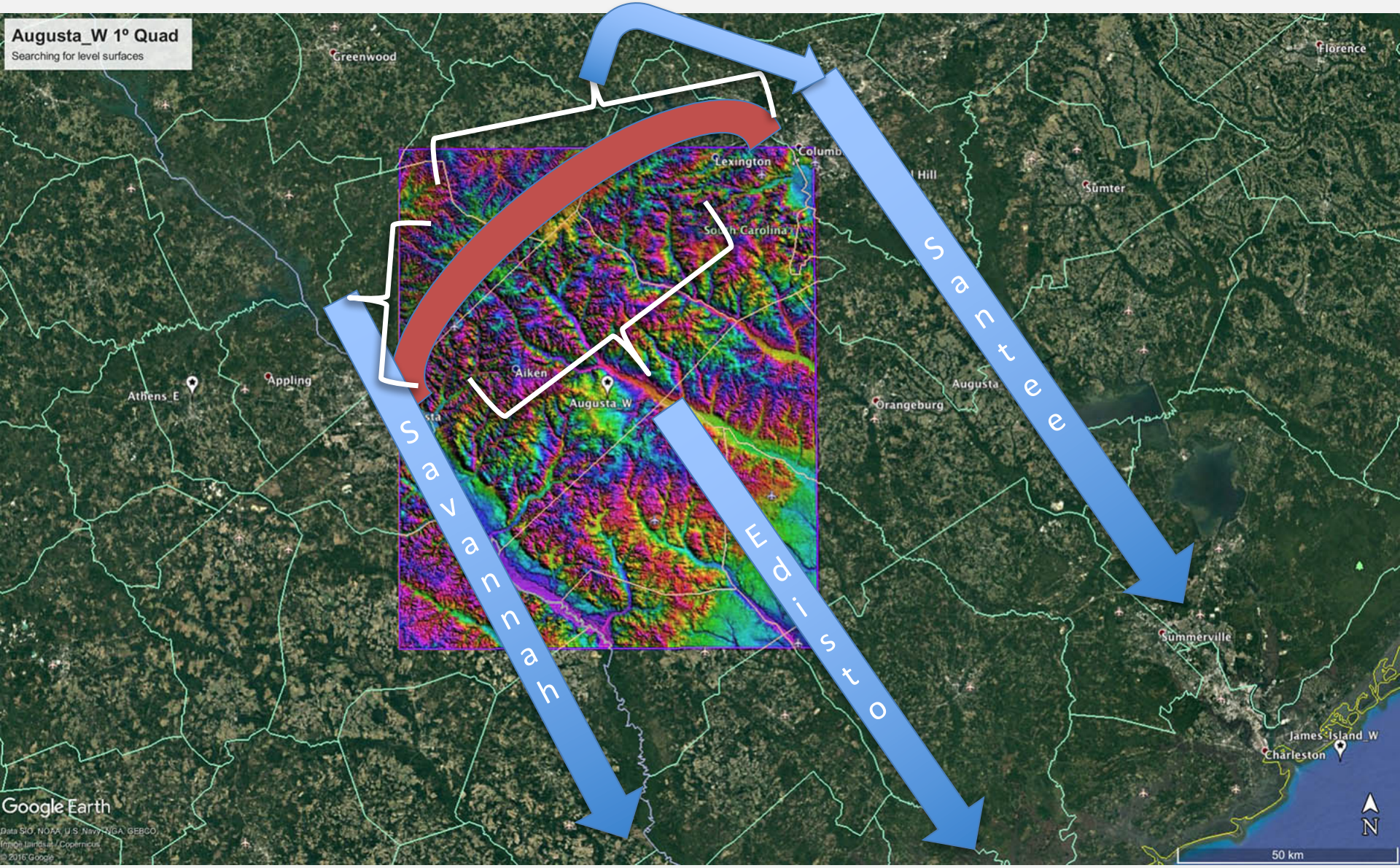
http://cintos.org/SurveyQuadMap

USGS Augusta_W 1º Quad - 10m DEM



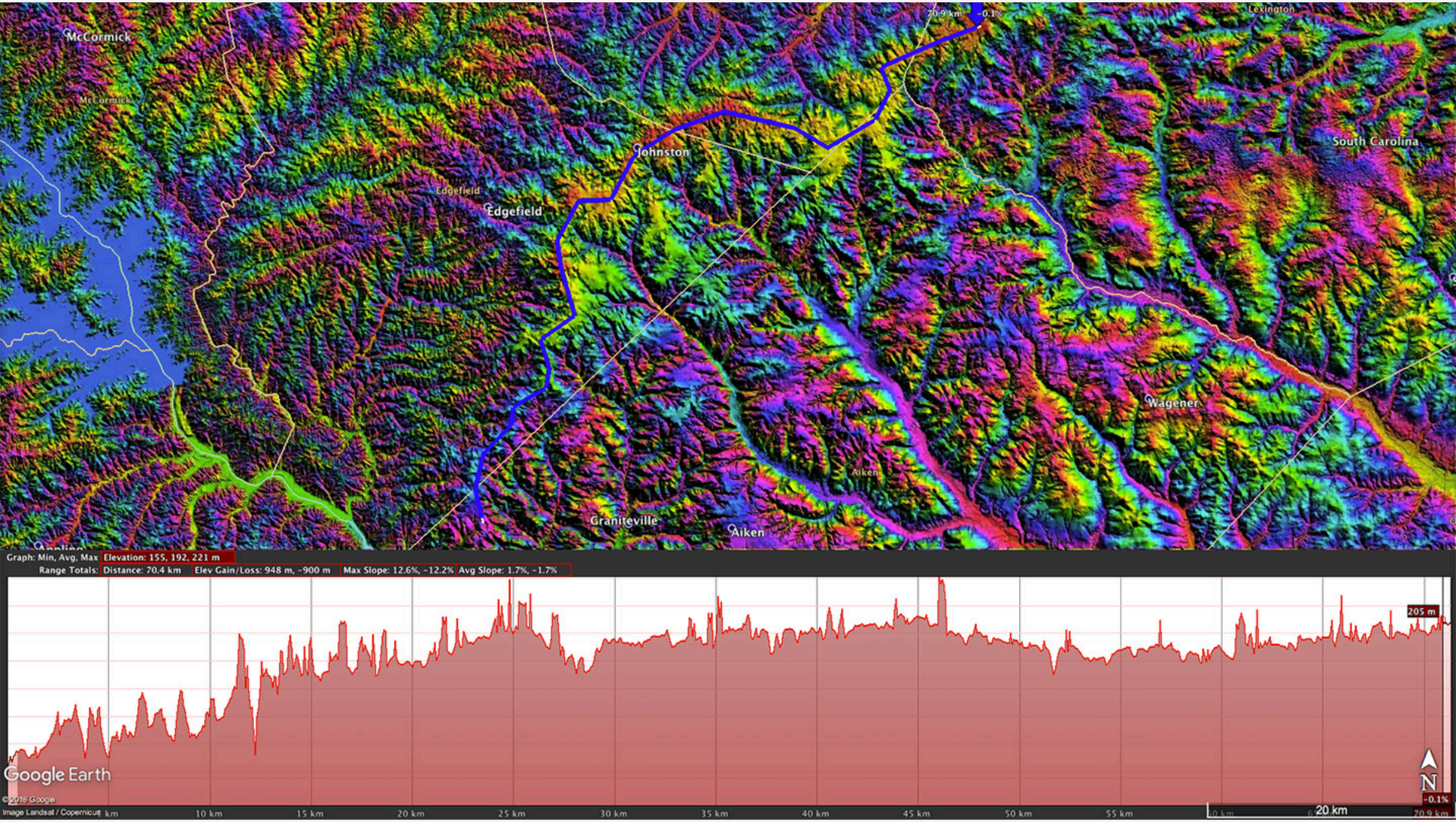
Search for “flat” remnant terrace surfaces which may hold bays

“The Ridge”



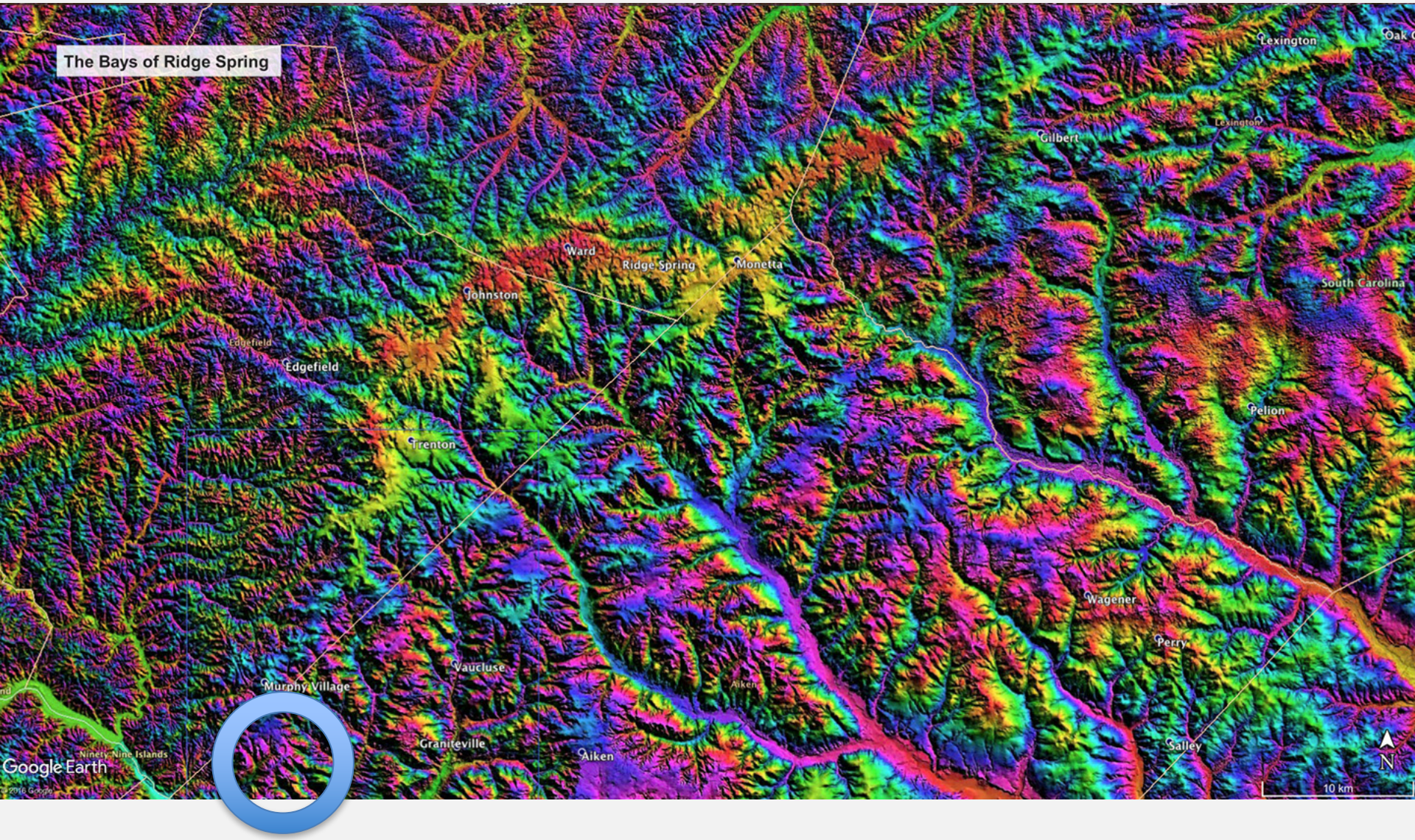
115 km of continuous drainage divide between Augusta and Columbia

Ridge Spring Elevation Profile



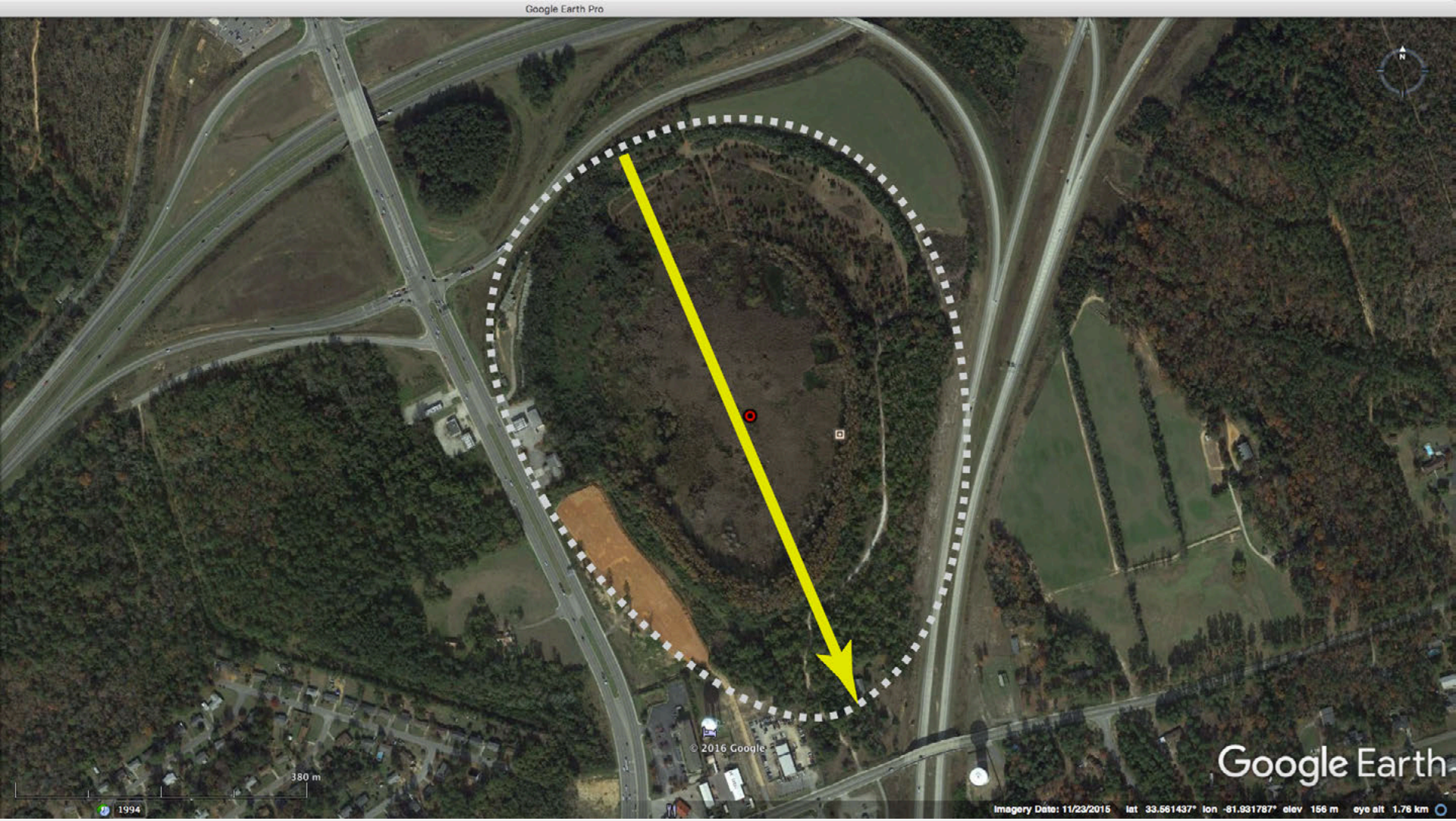
Distance: **70.4** km Elevation: **155** m min, **221** m max, **192** m avg

Ridge Spring Cretaceous Terrace



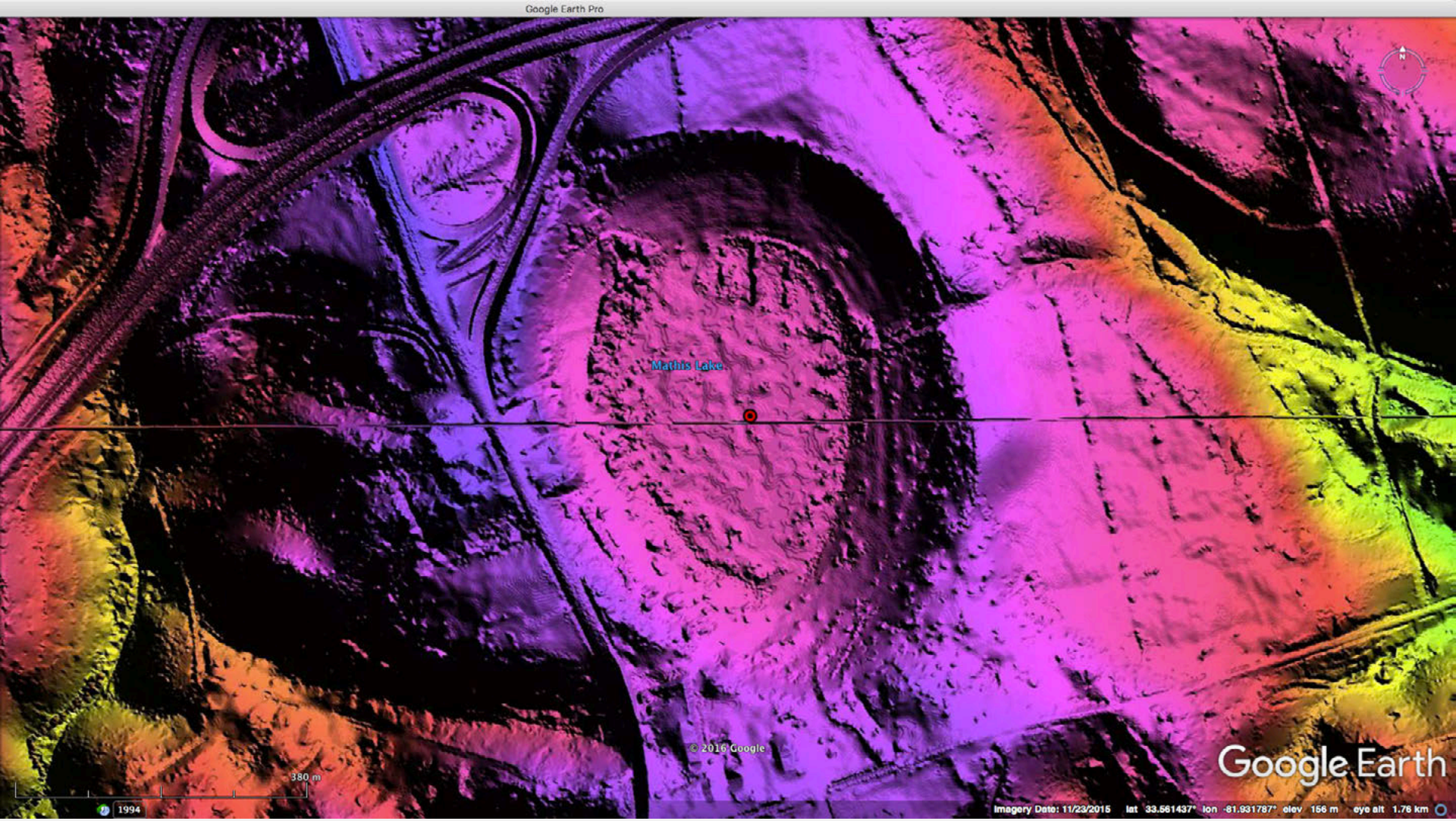
Traversing The Ridge from Augusta to Columbia

Mathis Lake, Northeast Augusta Suburbs



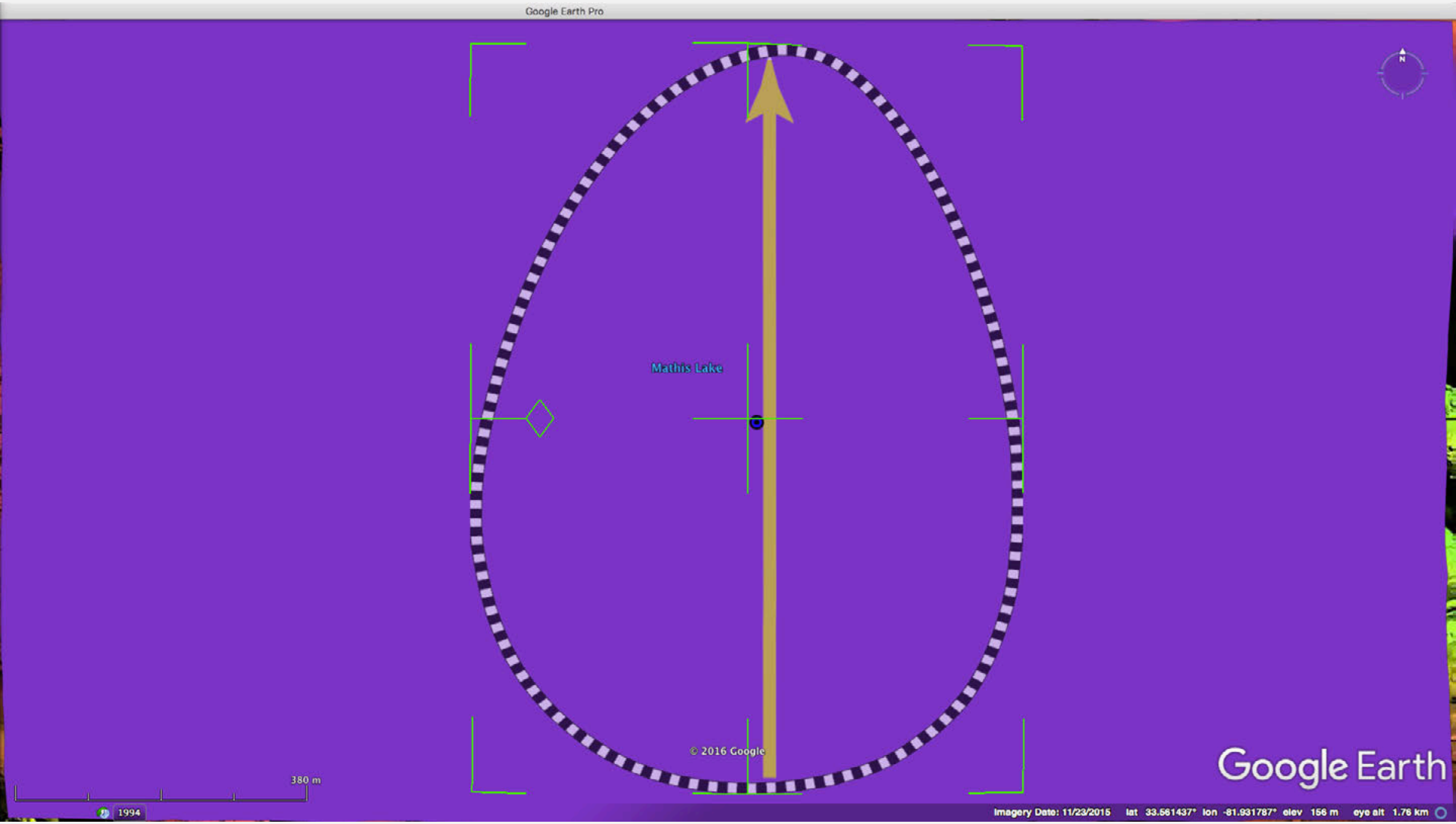
Bay Name	Major Axis	Bearing	Elevation
134327_2472	0.76	158º	146 m

Mathis Lake Bay, Augusta Suburbs



Tiled DEM using Hue-saturation-value (hsv) rendering, 20x elevation exaggeration.
USGS sub-m resolution data rendered at 1.5 or 3 m for network presentation through GE.

baySouth Archetype Template @ 0º



Please reference movie to view GroundOverlay manipulation:
https://gsa.confex.com/gsa/2017SE/webprogram/Handout/Paper291016/MathisBayMeasurment.pdf

Keyhole Markup Language Data in GroundOverlay

```
<GroundOverlay>
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        <Icon>
            <href>http://cintos.org/ge/overlays/baySouth.png</href>
        </Icon>
        <LatLonBox>
            <north>33.56496759262686</north>
            <south>33.55789073070017</south>
            <east>-81.92816781208678</east>
            <west>-81.93459628710748</west>
            <rotation>-157.3564252687467</rotation>
        </LatLonBox>
</GroundOverlay>
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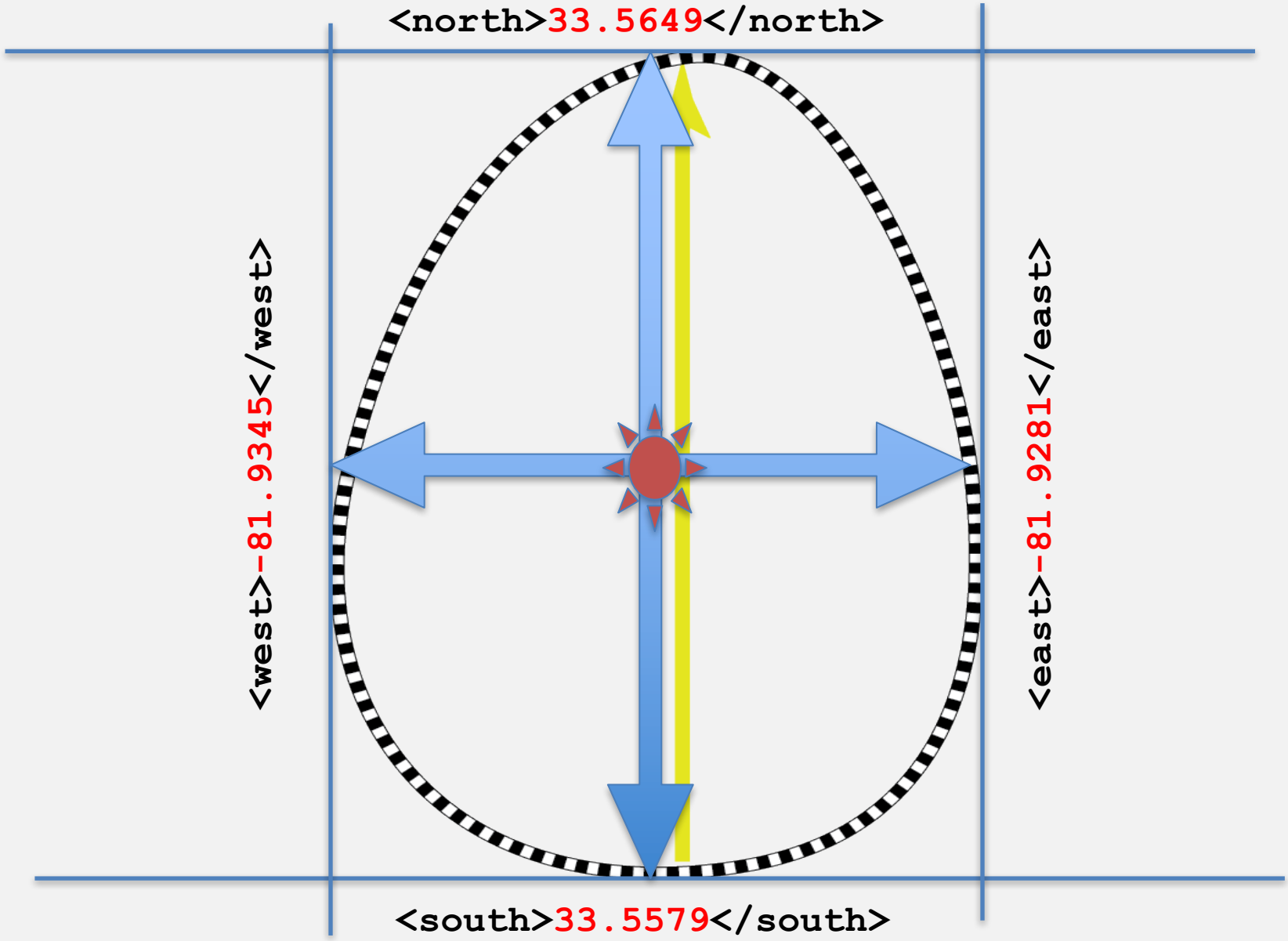
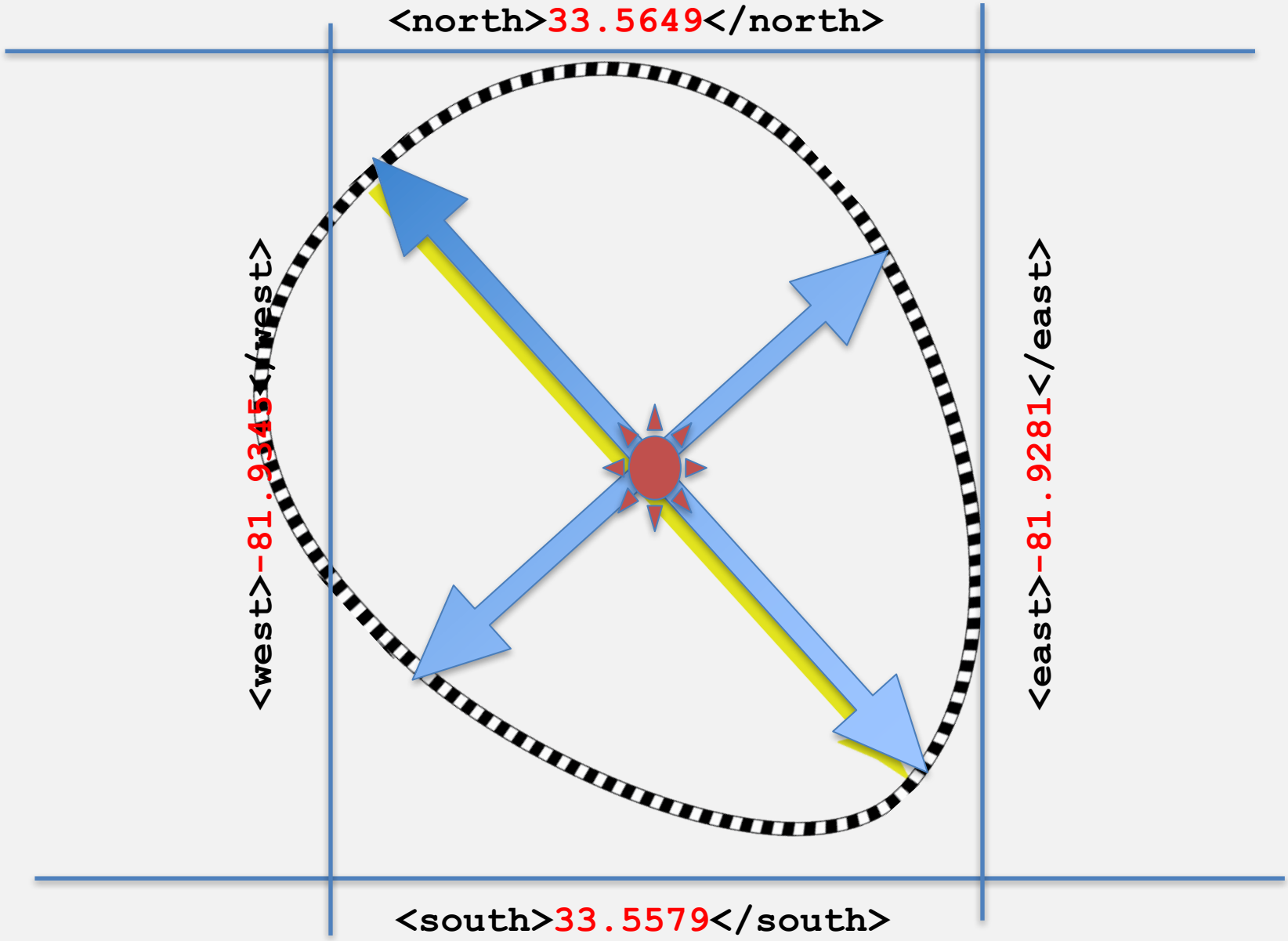
The GroundOverlay meta data's bounding box defines (with a bit of trig) the major and minor axis of the bay, a bay center, and an approximate surface area. Coordinates define the box with zero rotation applied.

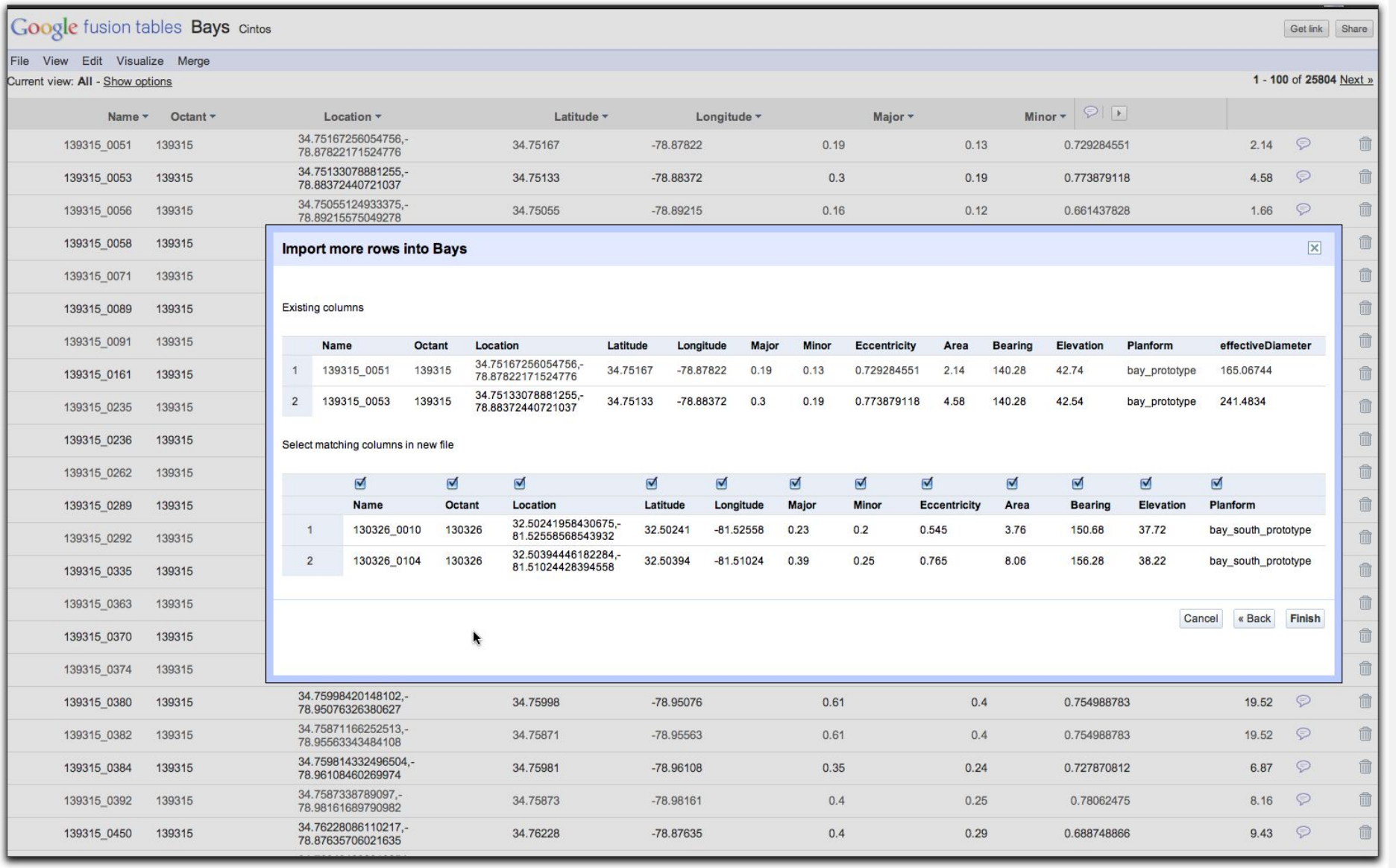
GroundOverlay LatLonBox Computations



GroundOverlay LatLonBox Computations



Loading Fusion Table: Carolina Bay Geospatial Survey

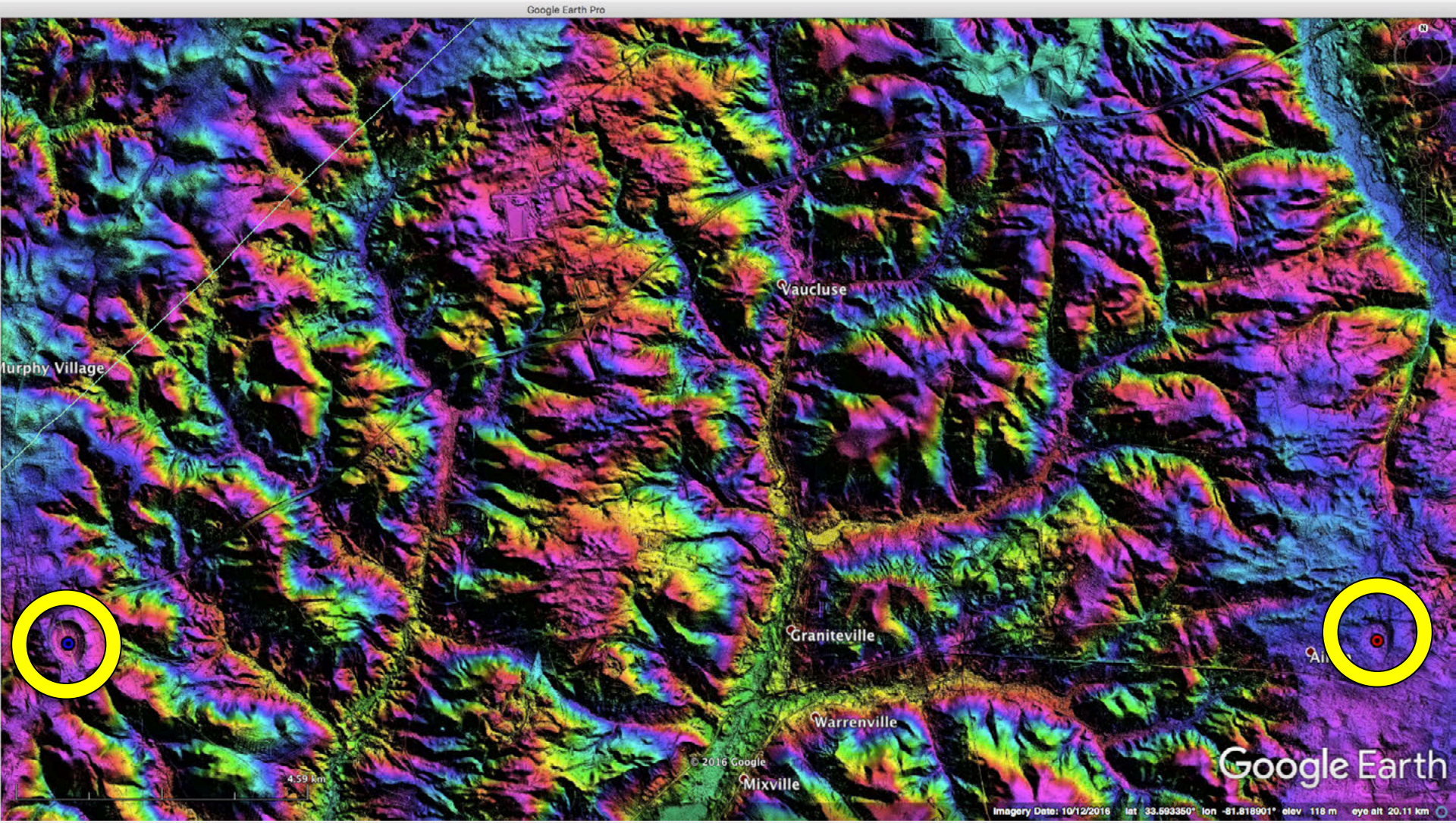


Name	Octant	Location	Latitude	Longitude	Major	Minor	Eccentricity	Area	Bearing	Elevation	Planform	effectiveDiameter
139315_0051	139315	34.75167256054756,-78.87822171524776	34.75167	-78.87822	0.19	0.13	0.729284551	2.14	140.28	42.74	bay_prototype	165.06744
139315_0053	139315	34.75133078881255,-78.88372440721037	34.75133	-78.88372	0.3	0.19	0.773879118	4.58	140.28	42.54	bay_prototype	241.4834
139315_0056	139315	34.75055124933375,-78.89215575049278	34.75055	-78.89215	0.16	0.12	0.661437828	1.66				
139315_0380	139315	34.75998420148102,-78.95076326380627	34.75998	-78.95076	0.61	0.4	0.754988783	19.52				
139315_0382	139315	34.75871166252513,-78.95563434484108	34.75871	-78.95563	0.61	0.4	0.754988783	19.52				
139315_0384	139315	34.759814332496504,-78.96108460269974	34.75981	-78.96108	0.35	0.24	0.727870812	6.87				
139315_0392	139315	34.7587338789097,-78.98161689790982	34.75873	-78.98161	0.4	0.25	0.78062475	8.16				
139315_0450	139315	34.76228086110217,-78.87635706021635	34.76228	-78.87635	0.4	0.29	0.688748866	9.43				

	Name	Octant	Location	Latitude	Longitude	Major	Minor	Eccentricity	Area	Bearing	Elevation	Planform
1	130326_0010	130326	32.50241958430675,-81.52558568543932	32.50241	-81.52558	0.23	0.2	0.545	3.76	150.68	37.72	bay_south_prototype
2	130326_0104	130326	32.50394446182284,-81.51024428394558	32.50394	-81.51024	0.39	0.25	0.765	8.06	156.28	38.22	bay_south_prototype

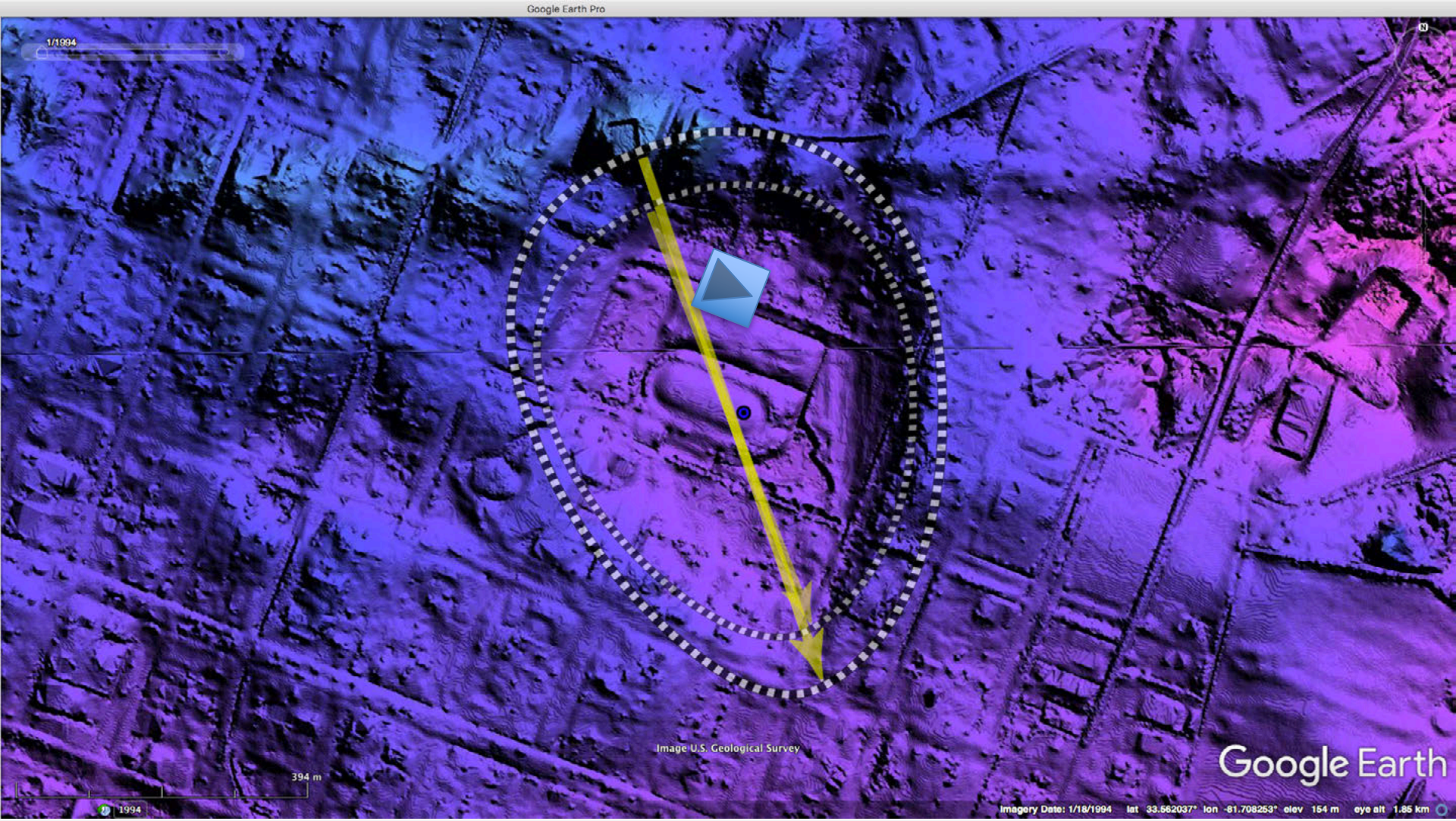
An exclusive index is generated for the bay based on lat & lon, and the summary geospatial data is uploaded into a Google FusionTable. The table today has just under 44,000 entries.

Aiken, SC



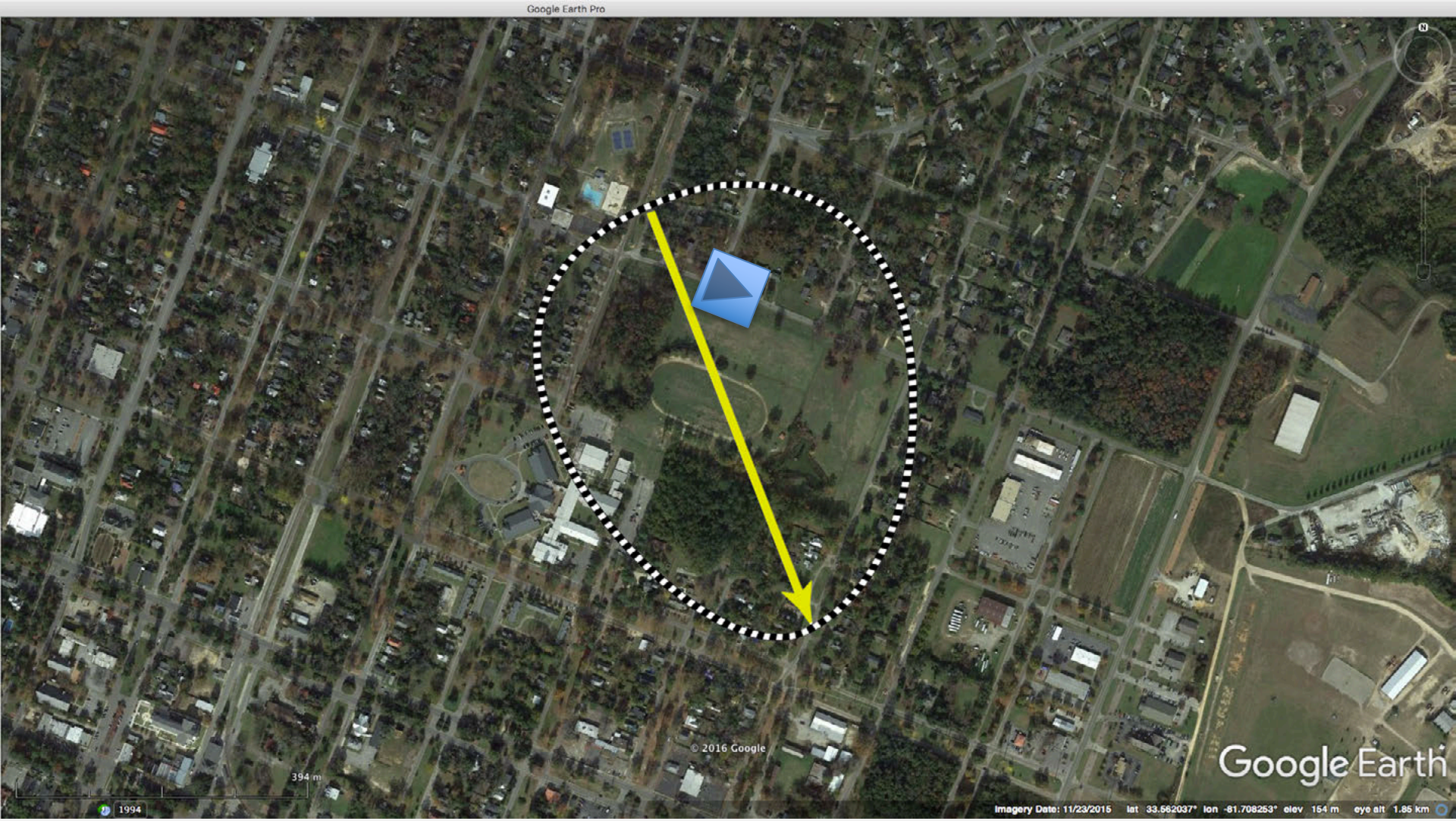
Bay in Aiken, 20 km due east, at same elevation as Mathis Bay

Aiken, SC



Bay Name	Major Axis	Bearing	Elevation
134326_2483	0.61	159º	155 m

Aiken, SC

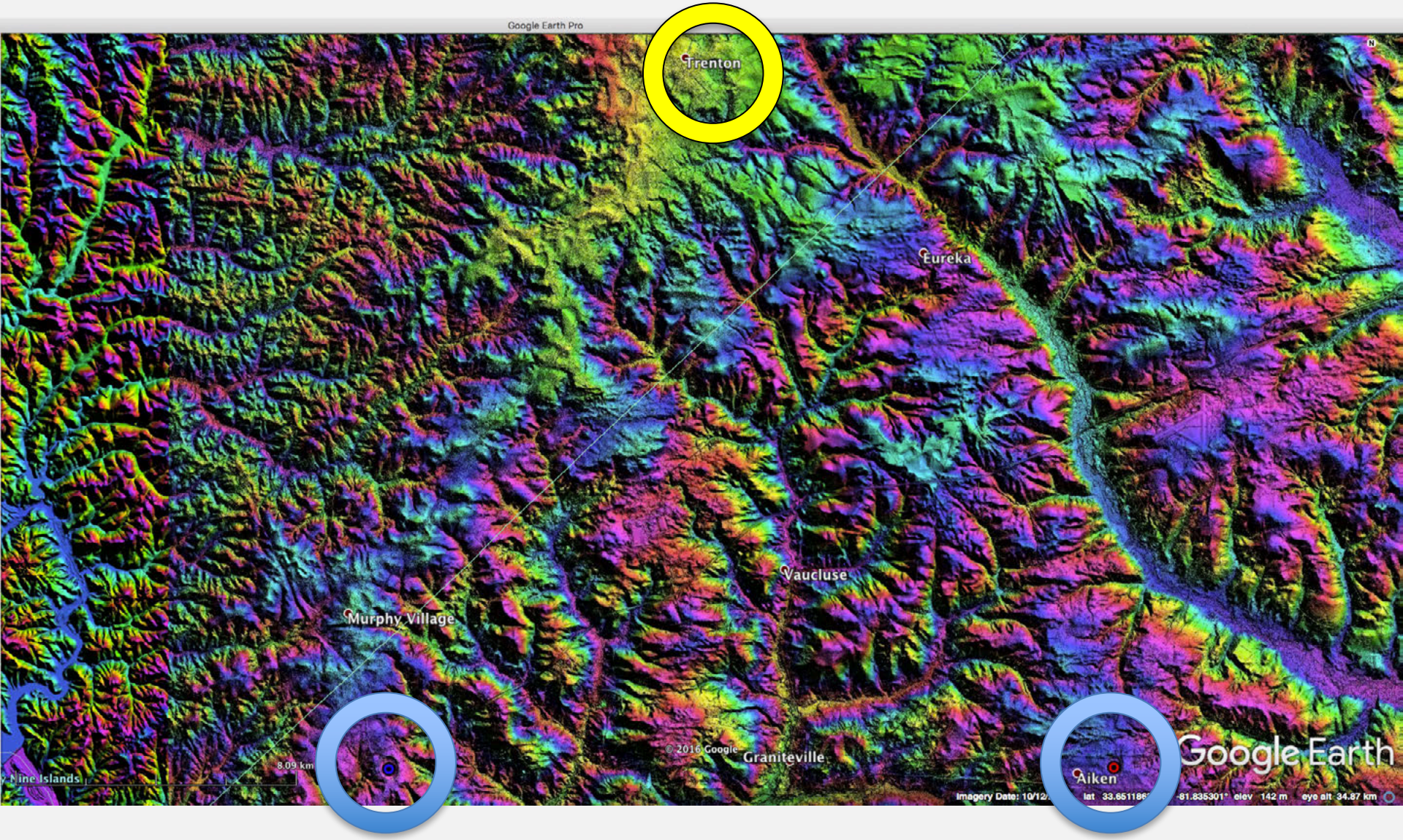


Bay Name	Major Axis	Bearing	Elevation
134326_2483	0.61	159º	155 m

Aiken, SC

Streetview along Abbyville Ave, on bay floor looking at rim 240 meters away

Trenton, SC



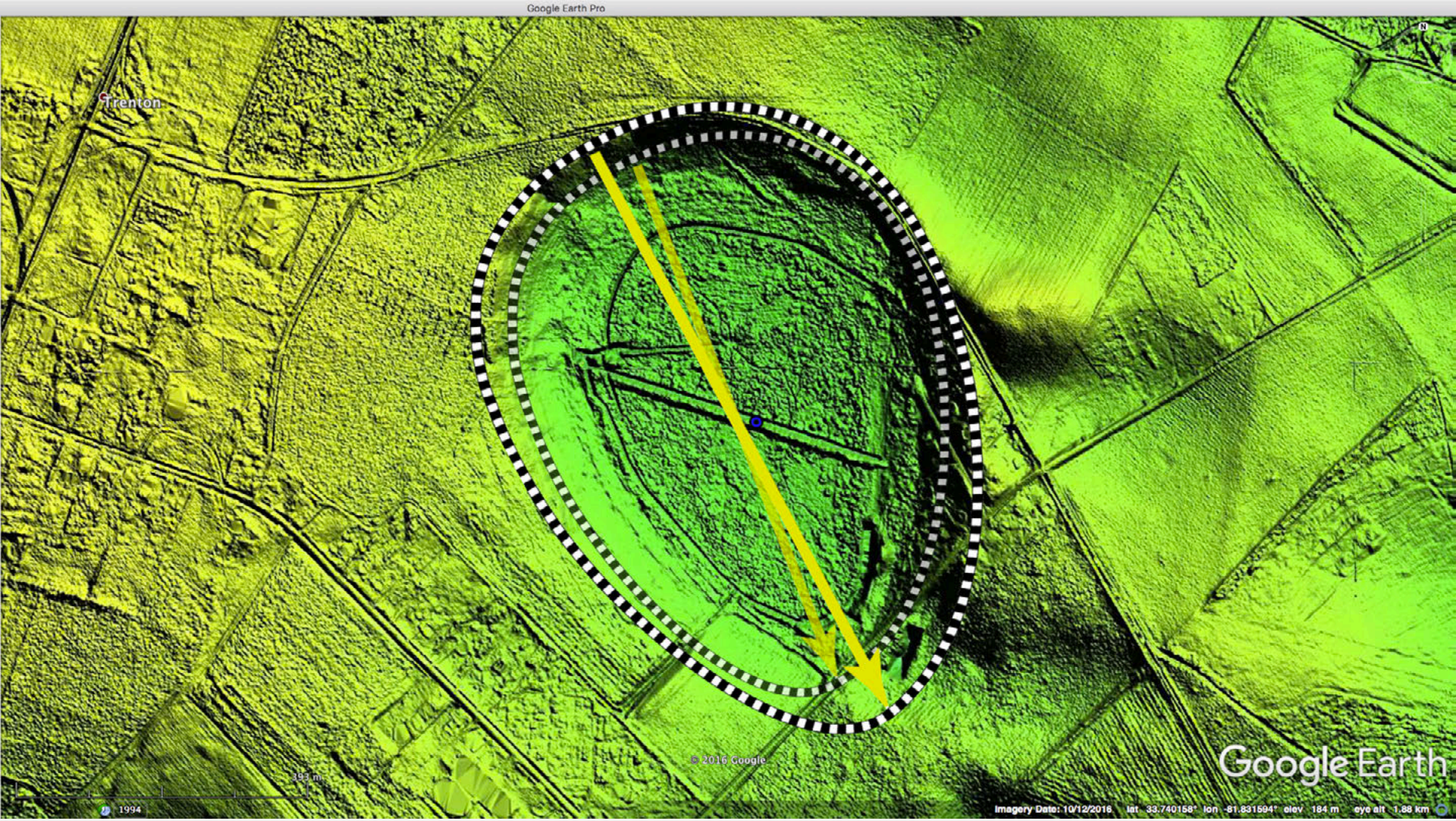
Bay near Trenton, 23 km NNW, with a 20 m rise in elevation

Trenton, SC

Bay near Trenton, 23 km NNW, with a 20 m rise in elevation

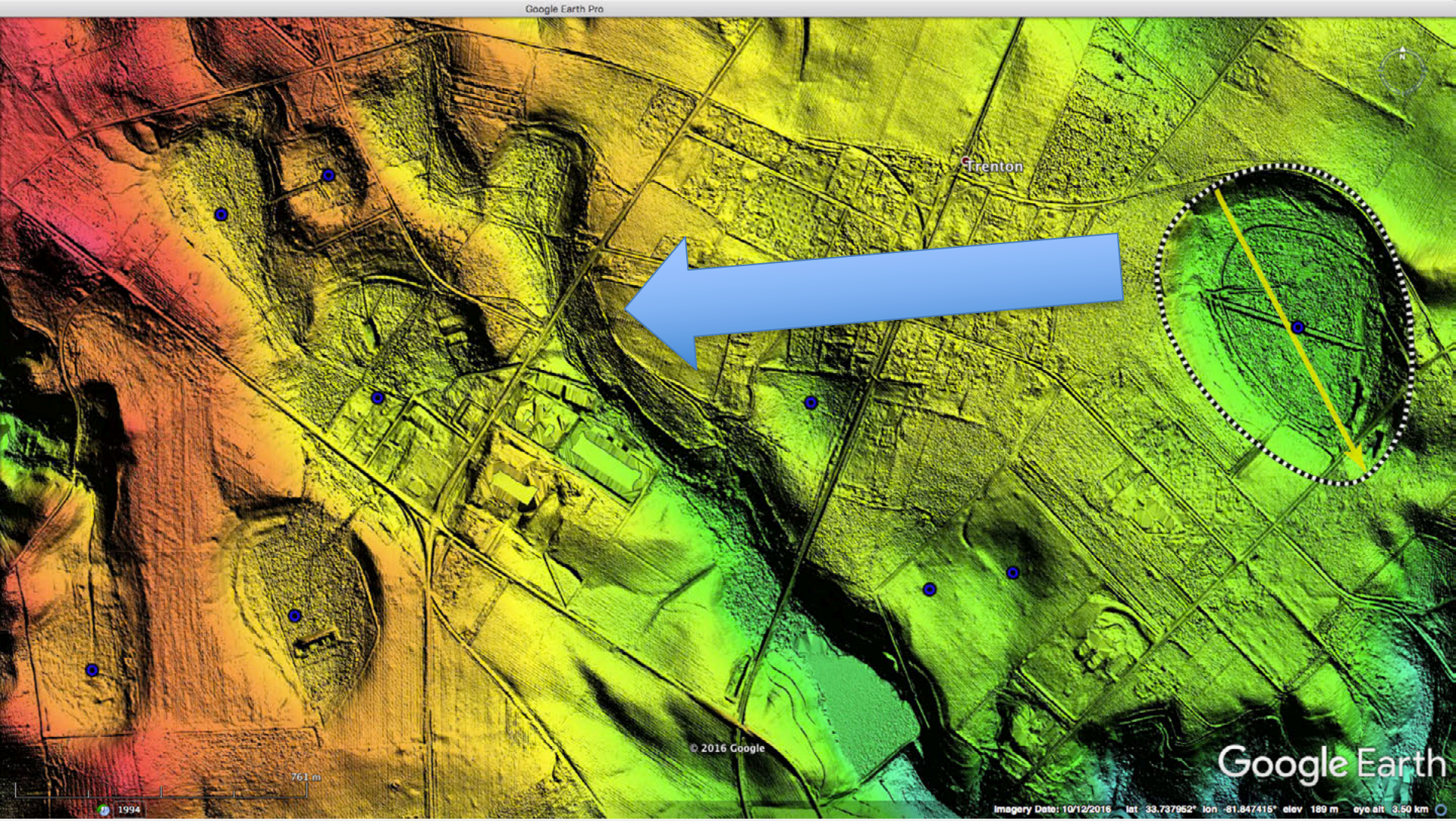
Trenton, SC

Bay near Trenton, 23 km NNW, with a 20 m rise in elevation



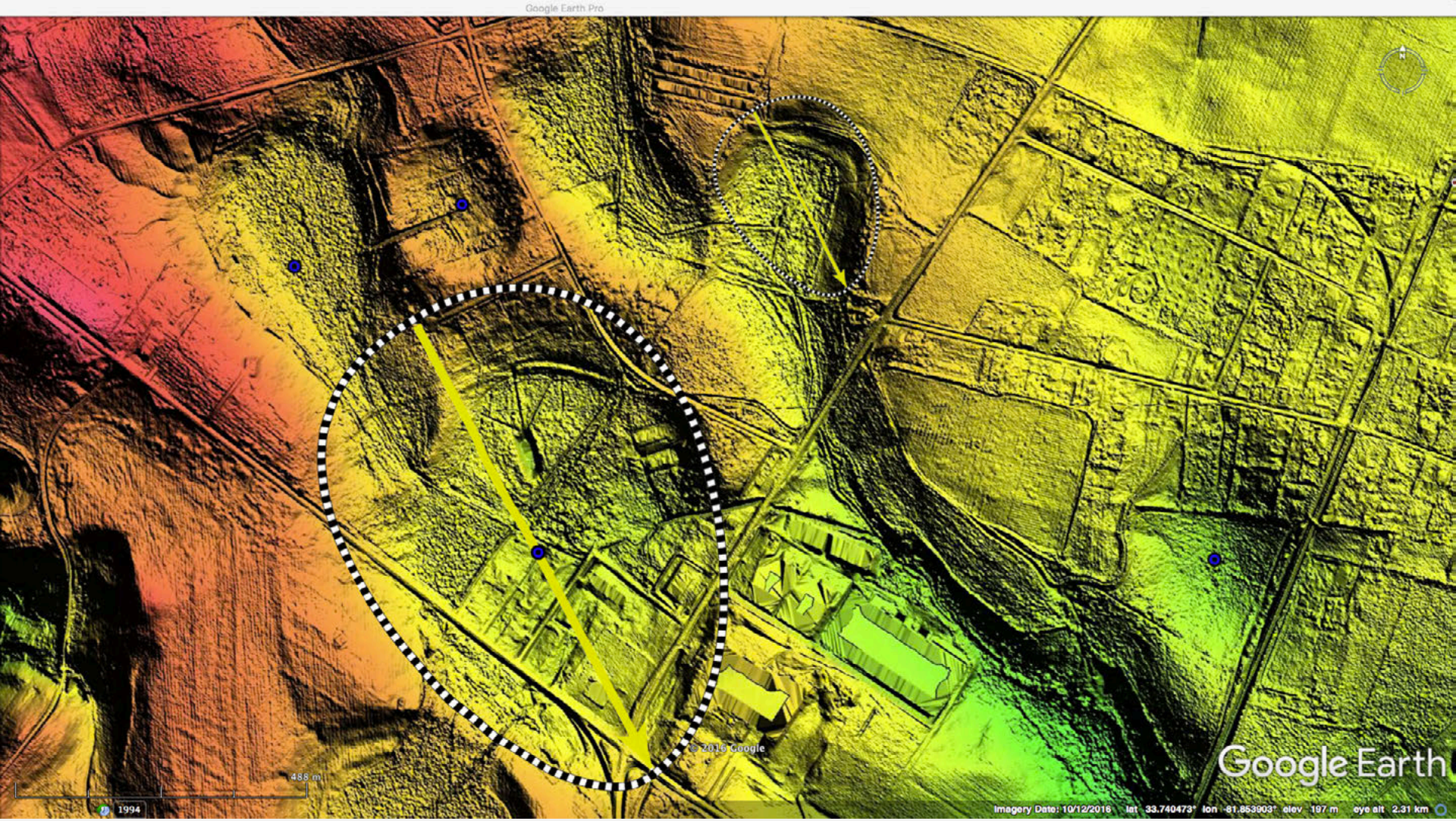
Bay Name	Major Axis	Bearing	Elevation
134327_9632	0.87	152º	181 m

Trenton Area Bays



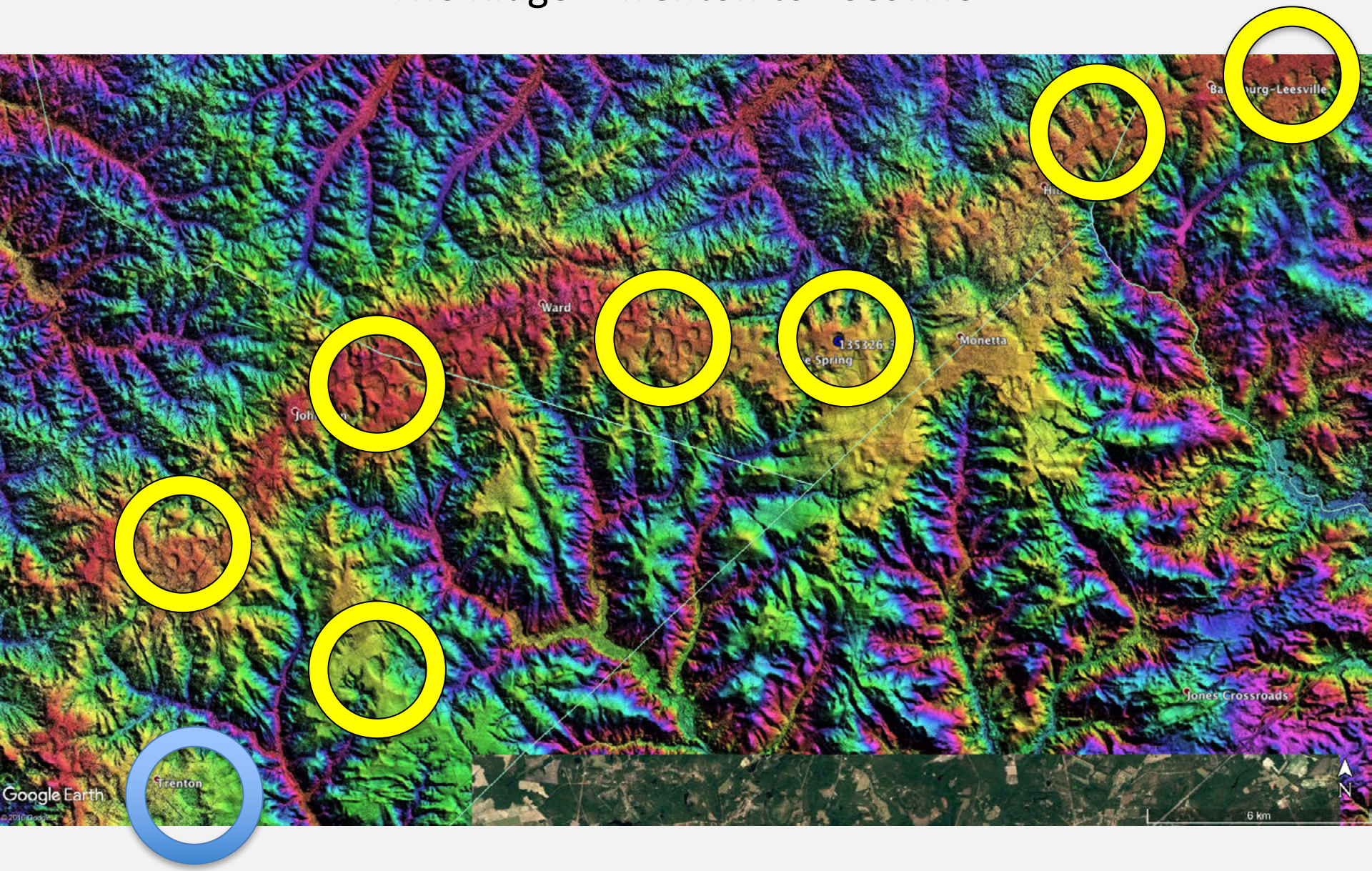
Headward erosion compromising nearby bays

Trenton Area Bays



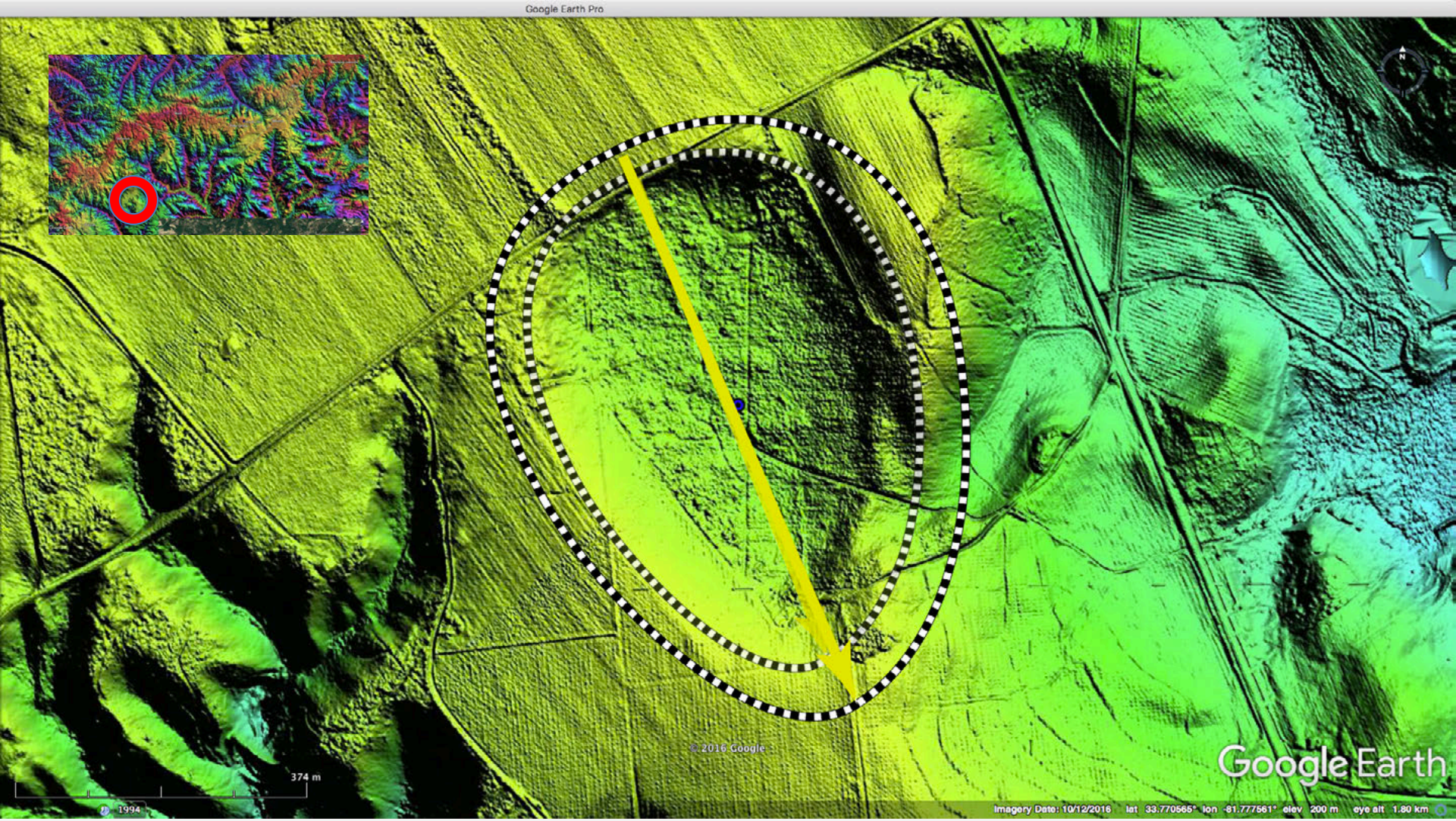
Progression of headward erosion compromising bays – largest here is exactly same size and orientation as previous bay

The Ridge – Trenton to Leesville



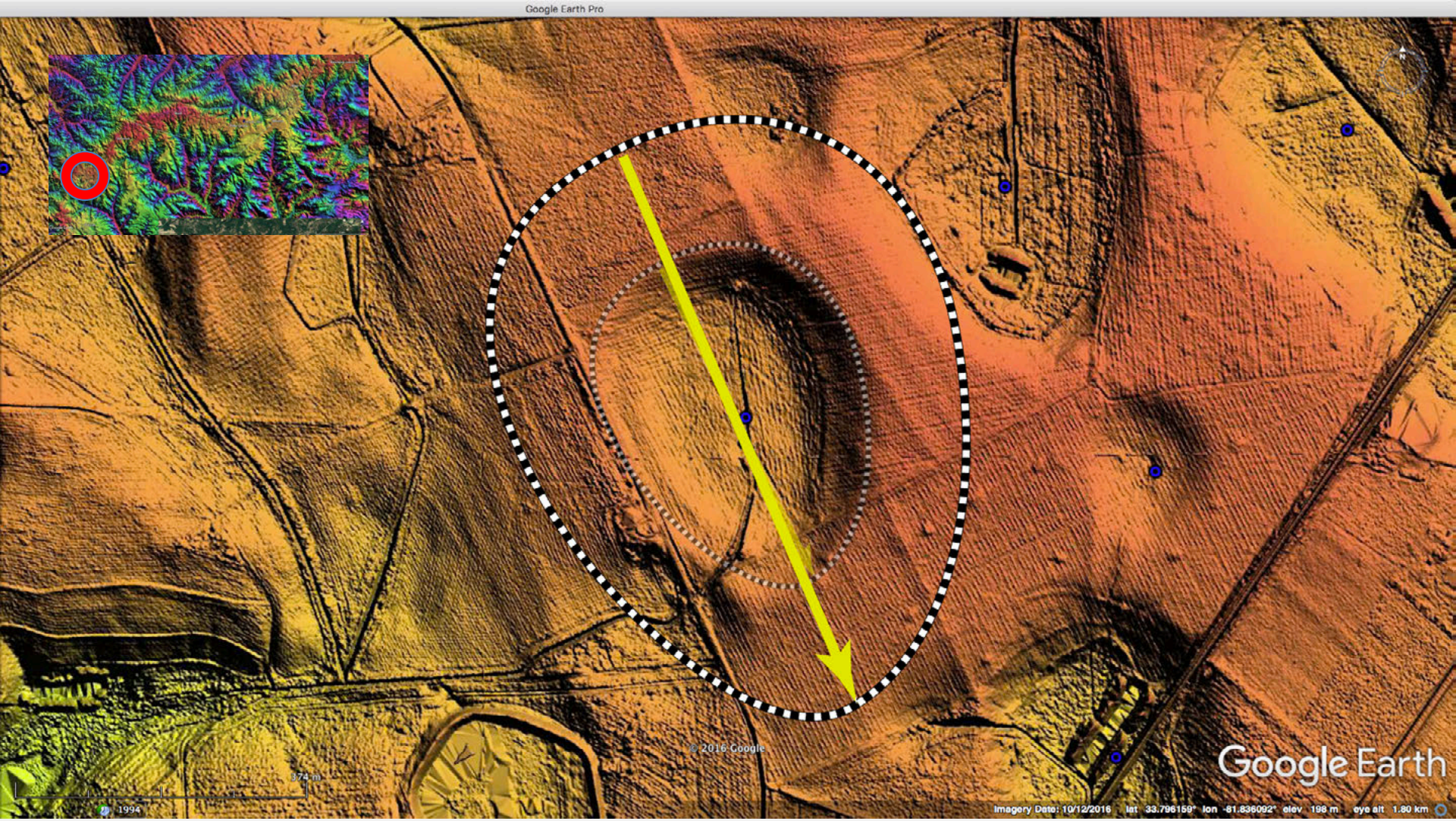
We look at other bays on Ridge, using Trenton as the new Archetype @ .87 km major axis

Bay 135327_0810



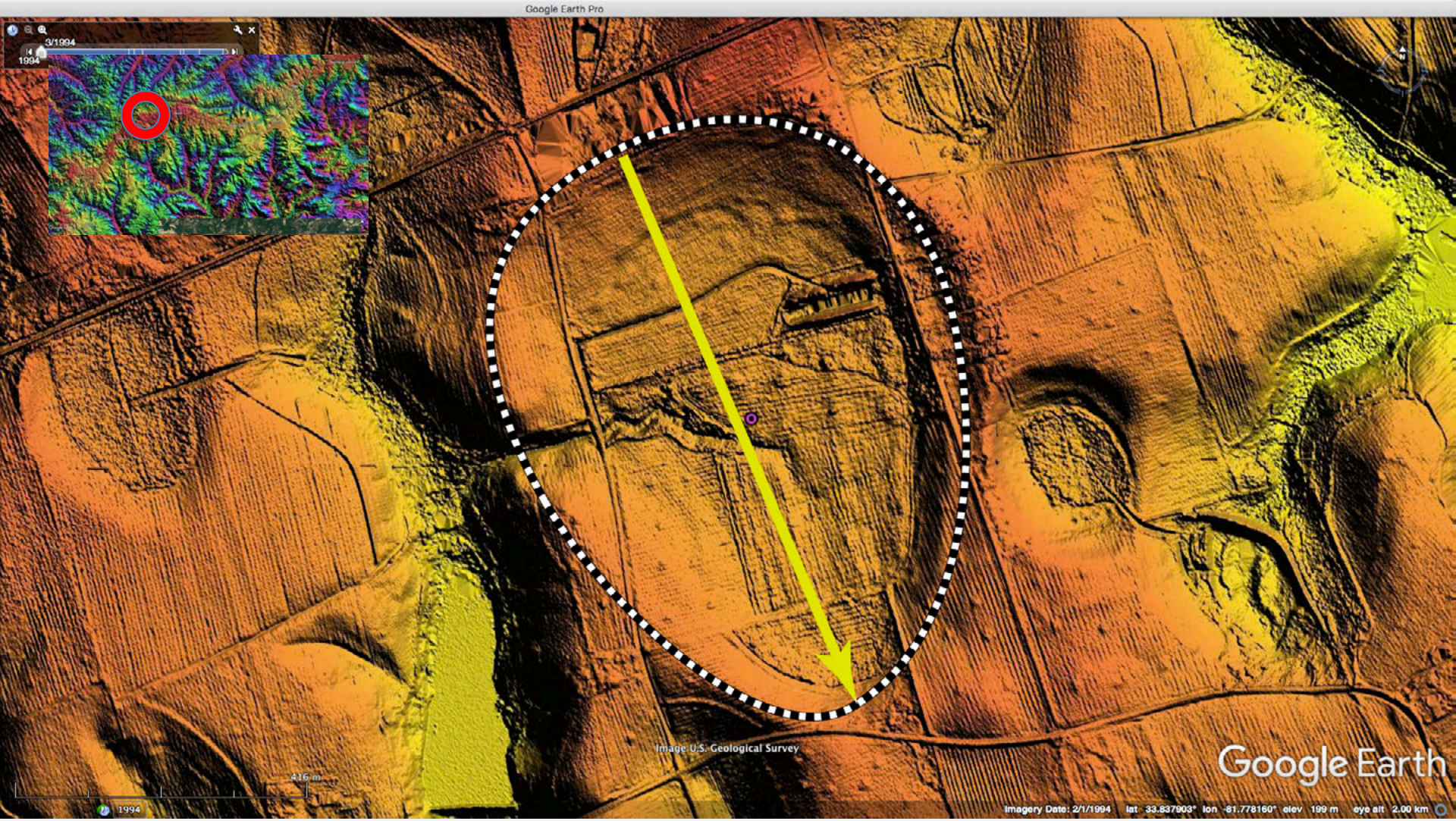
Major axis: 0.7 km Bearing: 158º Elevation: 183 m

Bay 135327_1834



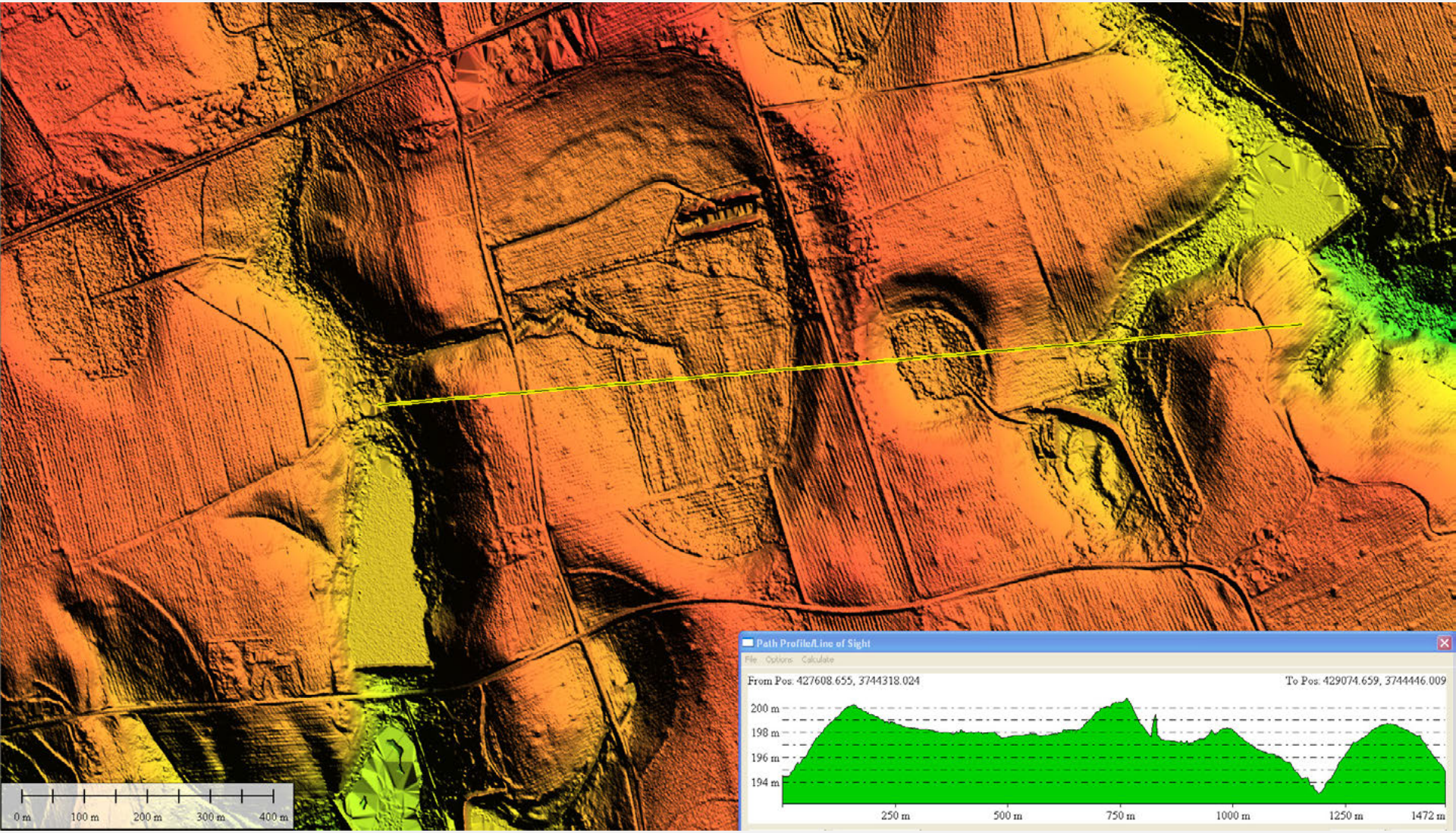
Major axis: 0.45 km Bearing: 154º Elevation: 197 m

Bay 135327_3511



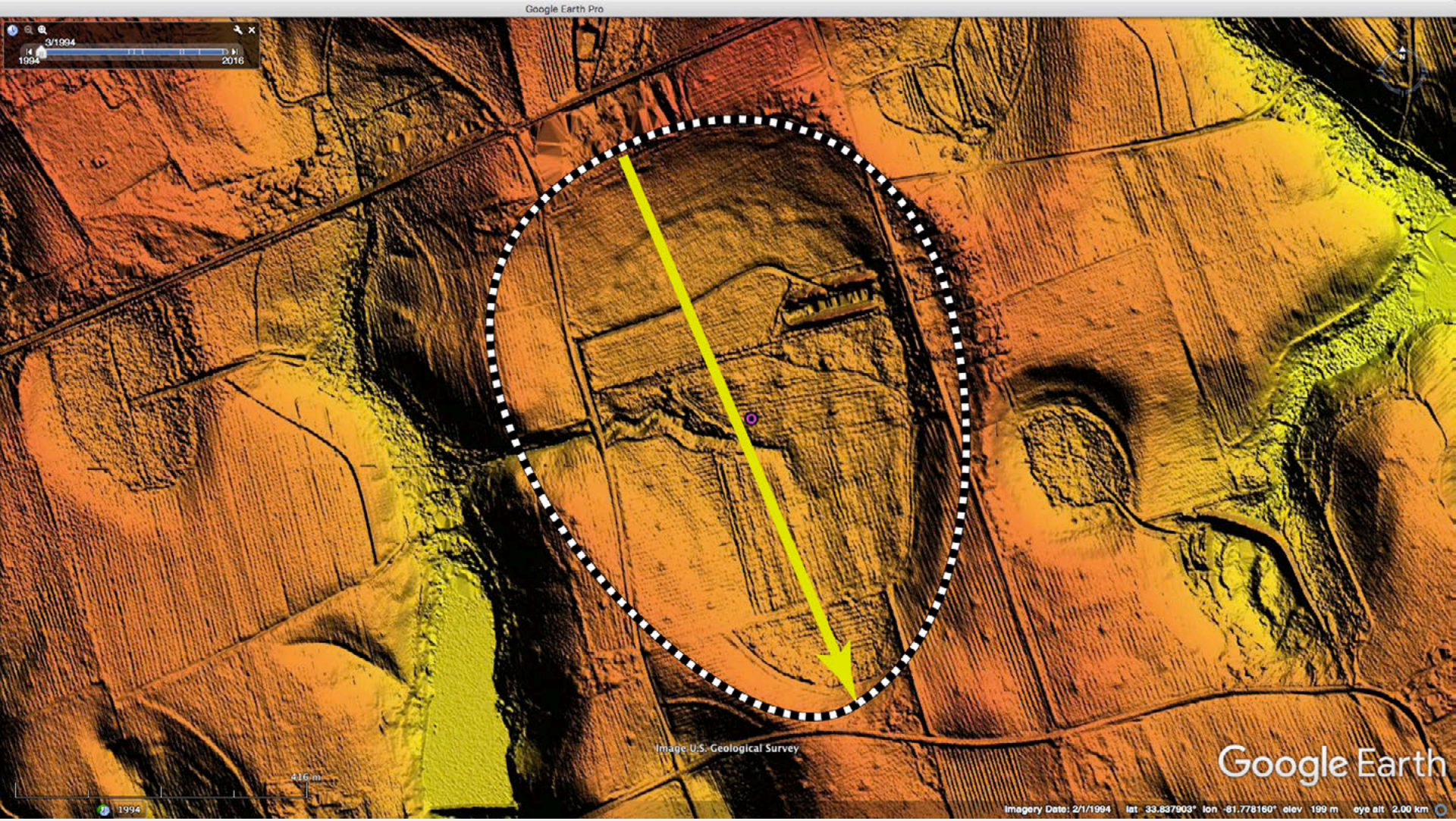
Major axis: 0.89 km Bearing: 159º Elevation: 201 m

Aggrading or Degrading?



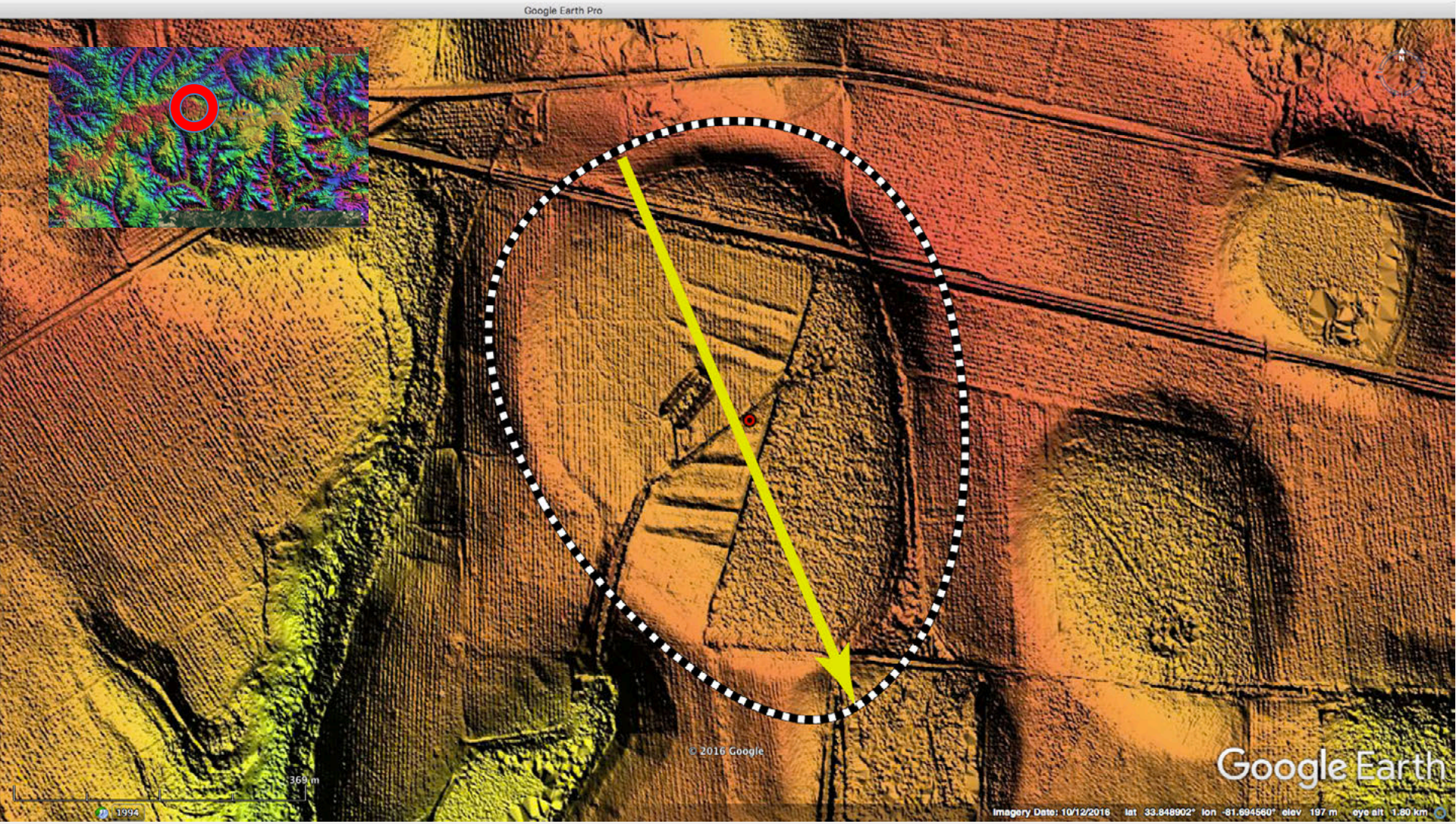
6 meters of relief across 1.5 km

Bays in Johnston, SC Area



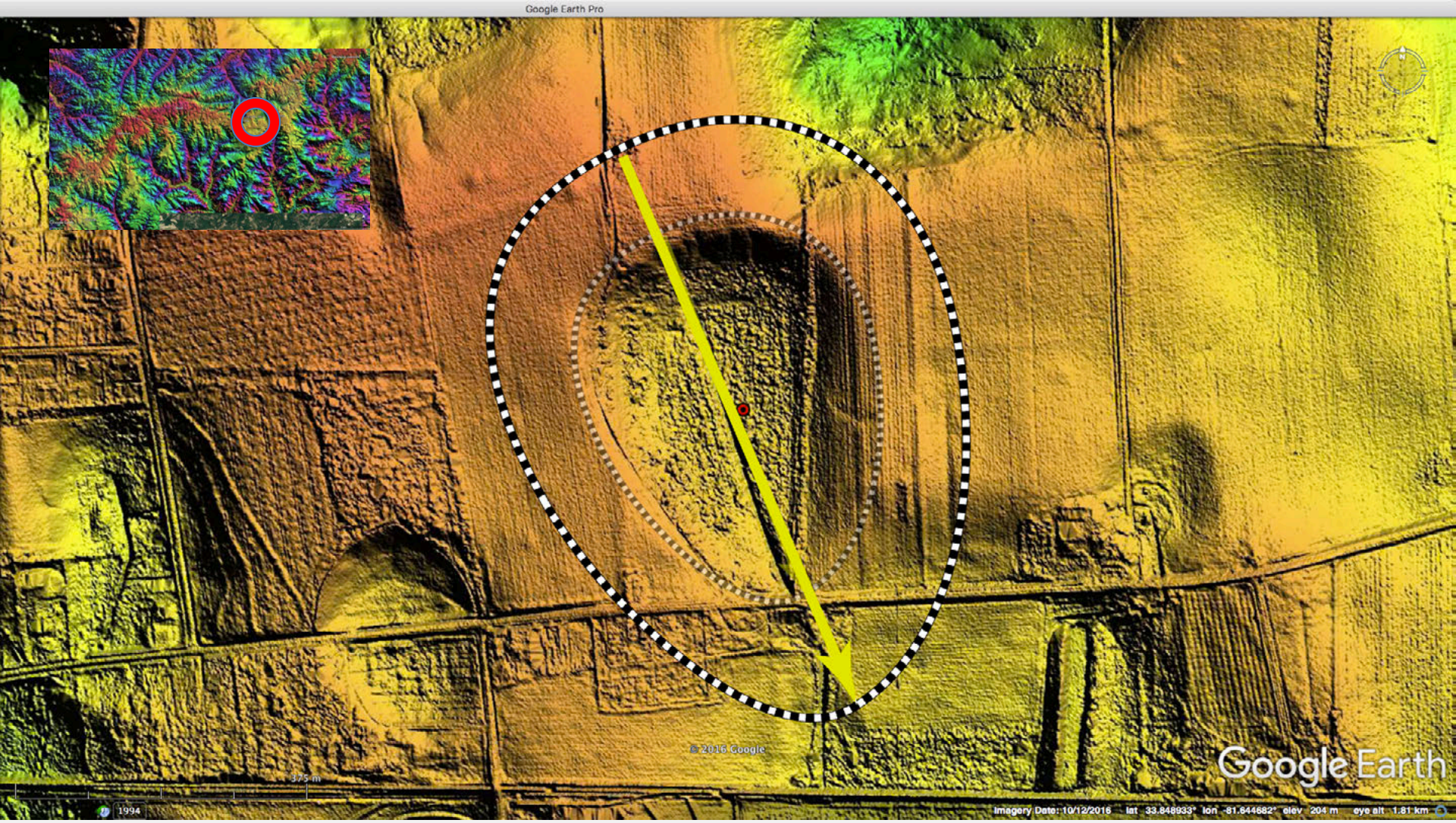
Please reference movie to view cookie-cutter in action:
https://gsa.confex.com/gsa/2017SE/webprogram/Handout/Paper291016/JohnstonBays.pdf

Bay 135326_3977



Major axis: 0.68 km Bearing: 161º Elevation: 194 m

Bay 135326_3957

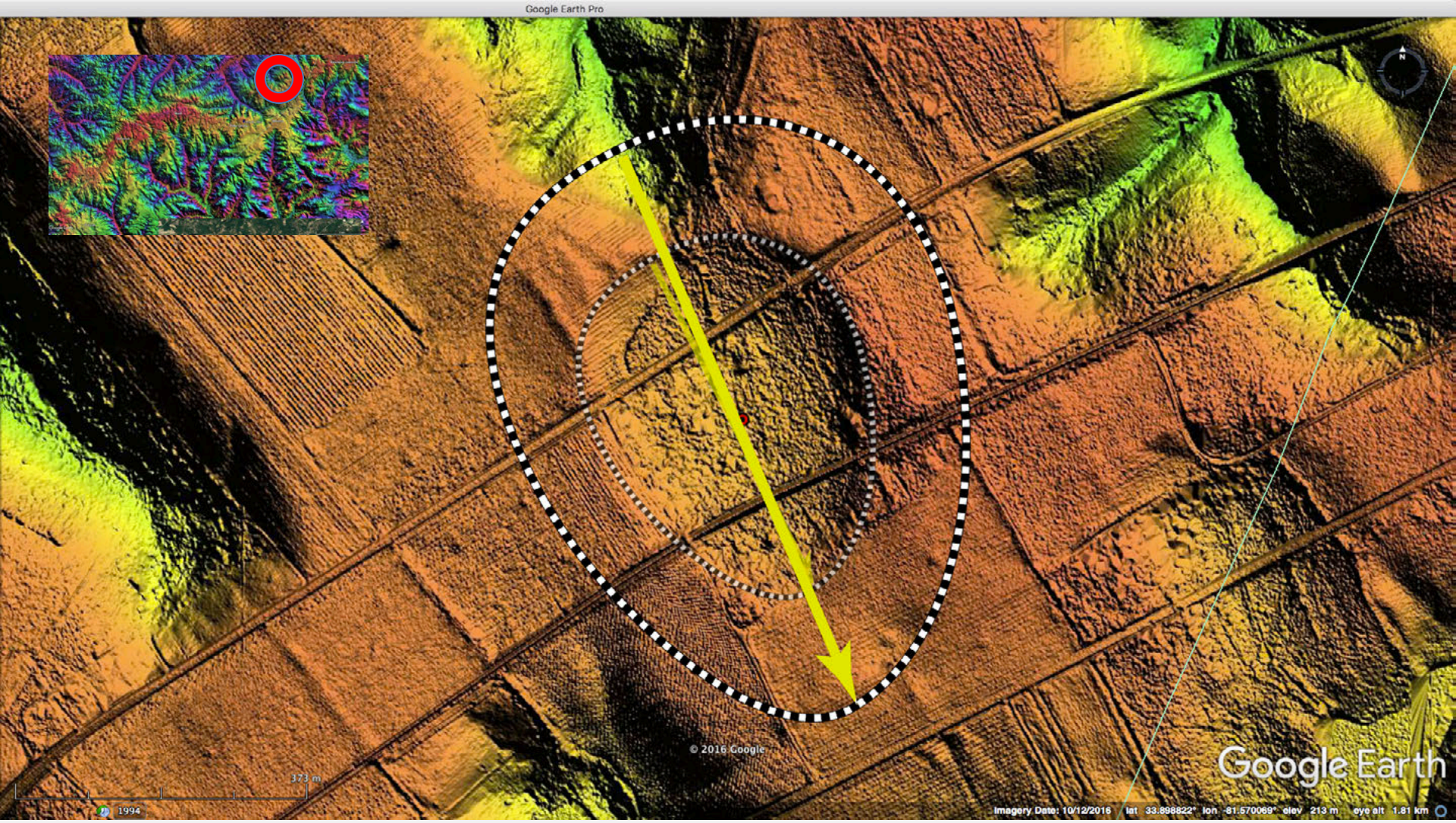


Major axis: 0.5 km Bearing: 158º Elevation: 192 m

Bay 135326_3756 viewed from 2700 m

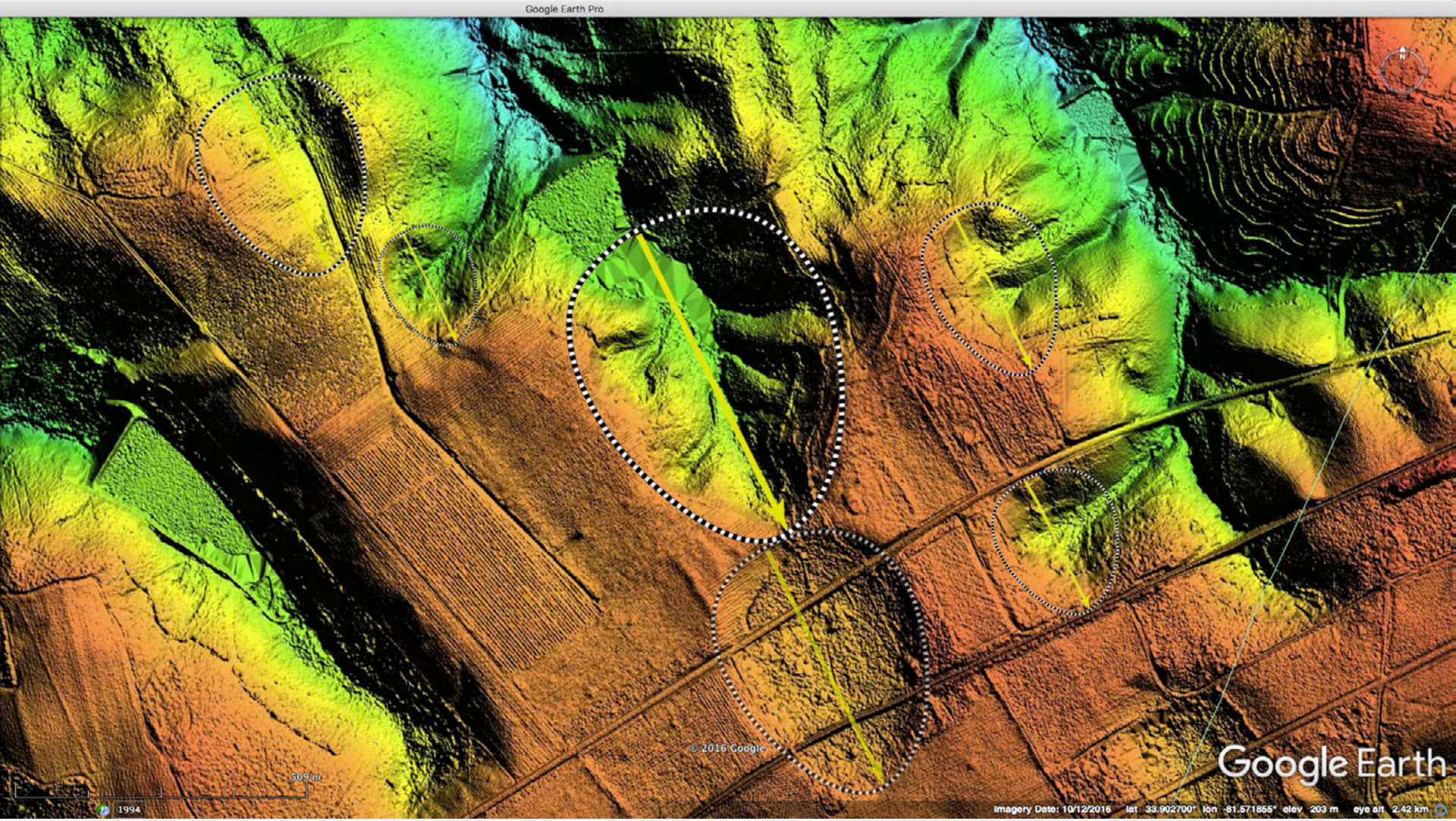
Major axis: 1.22 km Bearing: 153º Elevation: 190 m

Bay 135326_5927



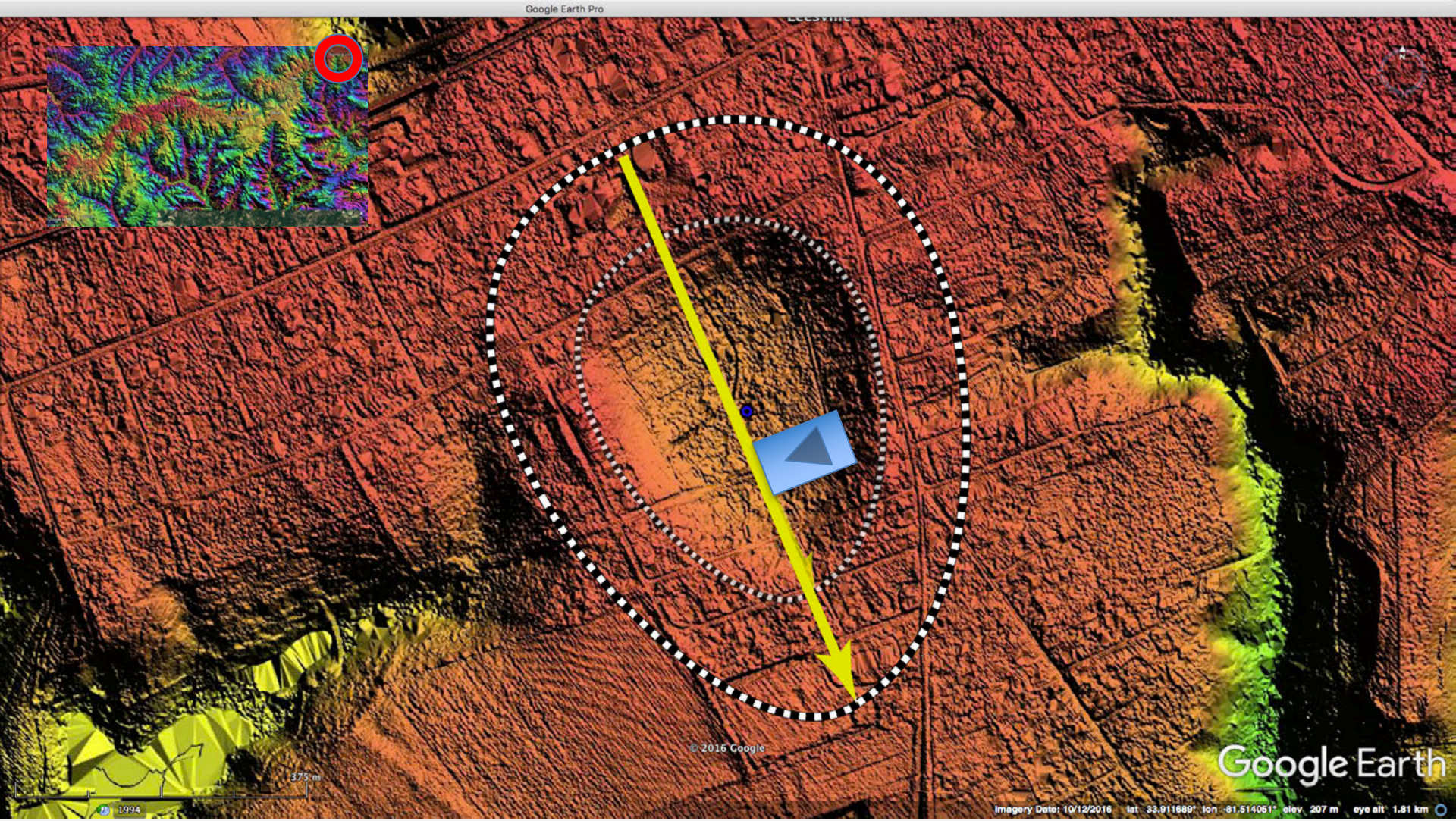
Major axis: 0.47 km Bearing: 152º Elevation: 193 m

Additional bays near 135326_5927



Terrace dissection leaving remnants along edge

Bay 135326_6405



Major axis: 0.49 km Bearing: 156º Elevation: 196 m

Bay 135326_6405

Streetview to West along Hampton Terrace, on bay floor looking at rim 150 meters away

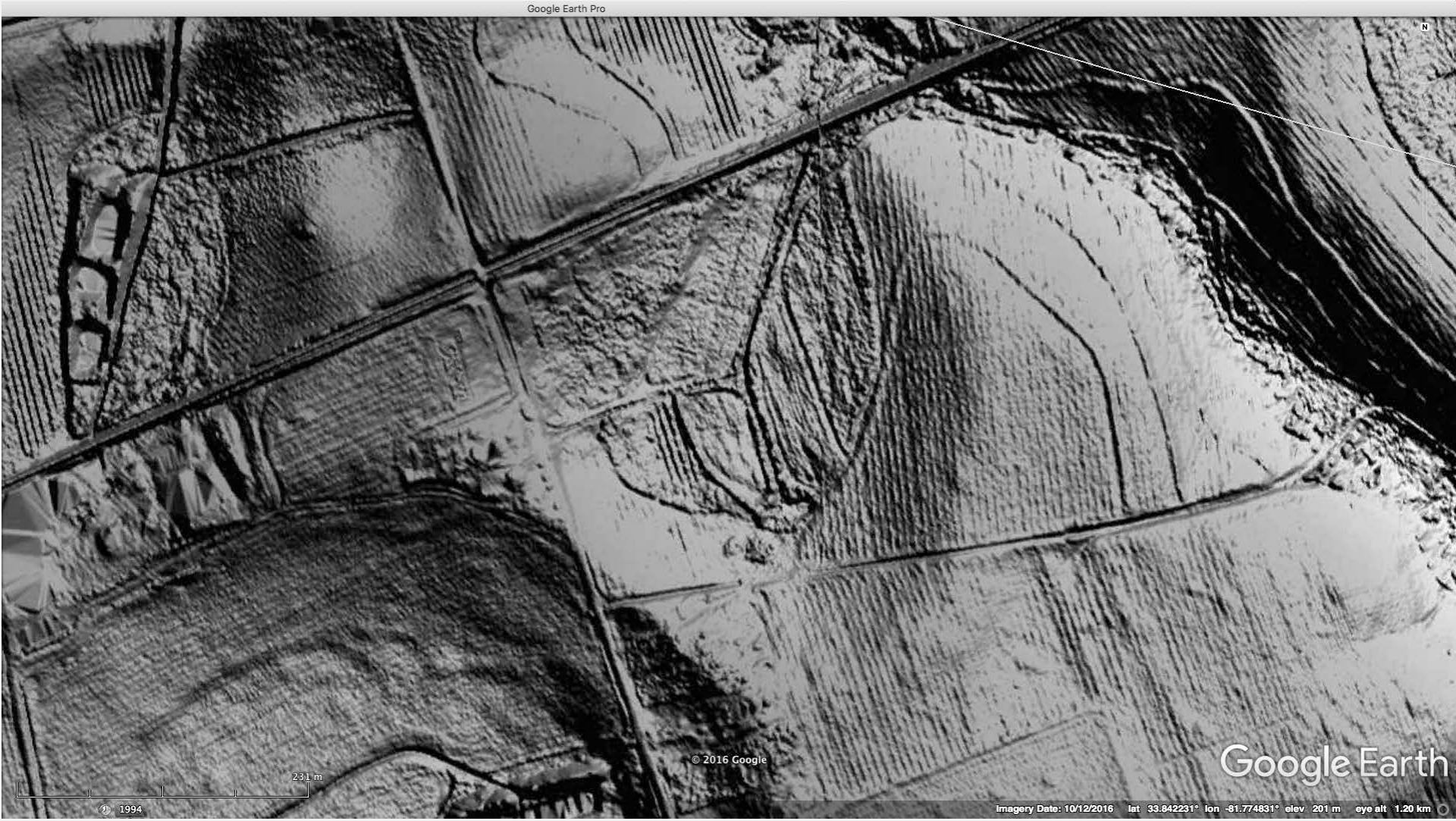
Carolina Bays of Ridge Spring

Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring

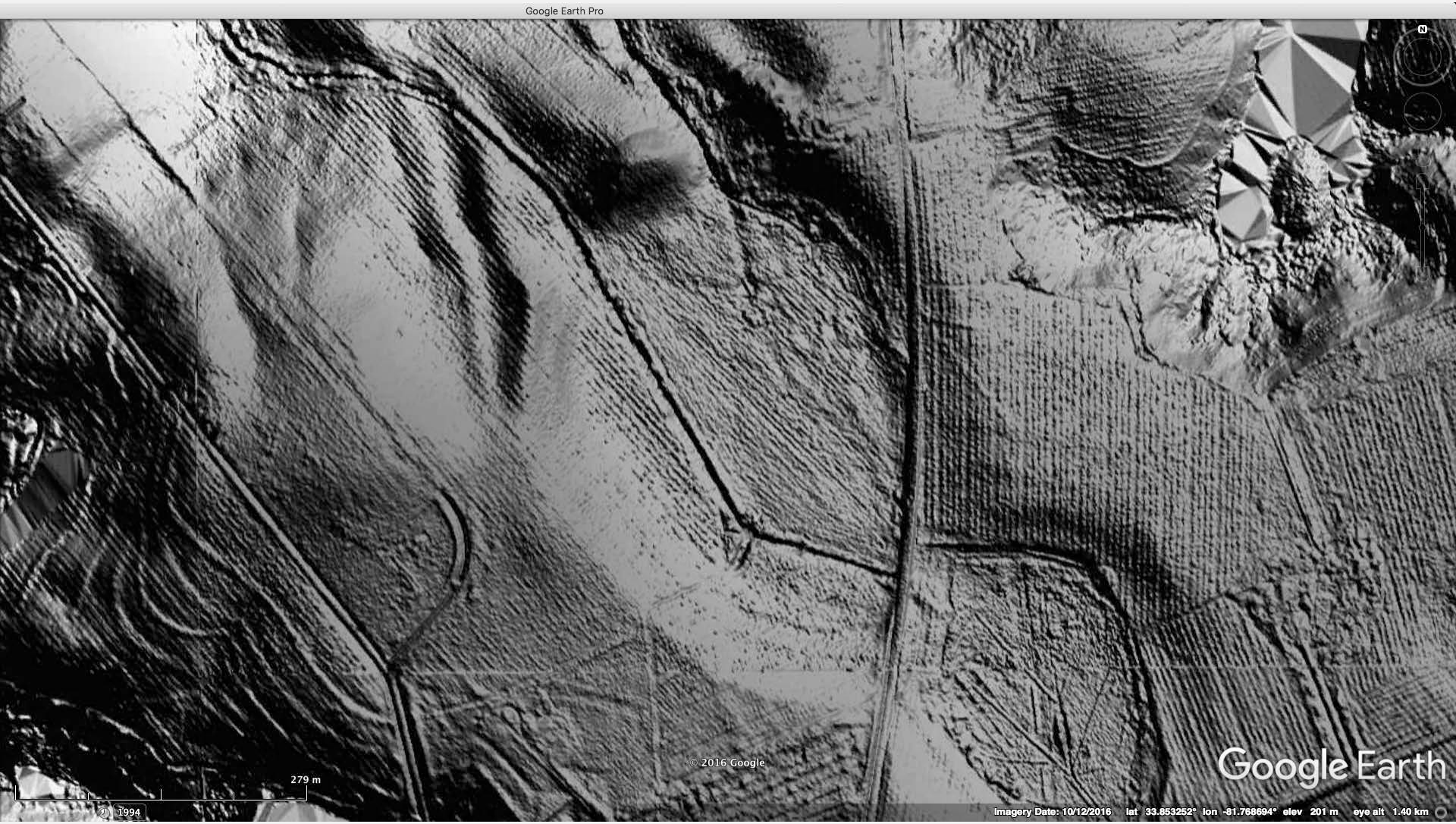
Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring



Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring



Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring

Grey scale comparison, image normalized for size

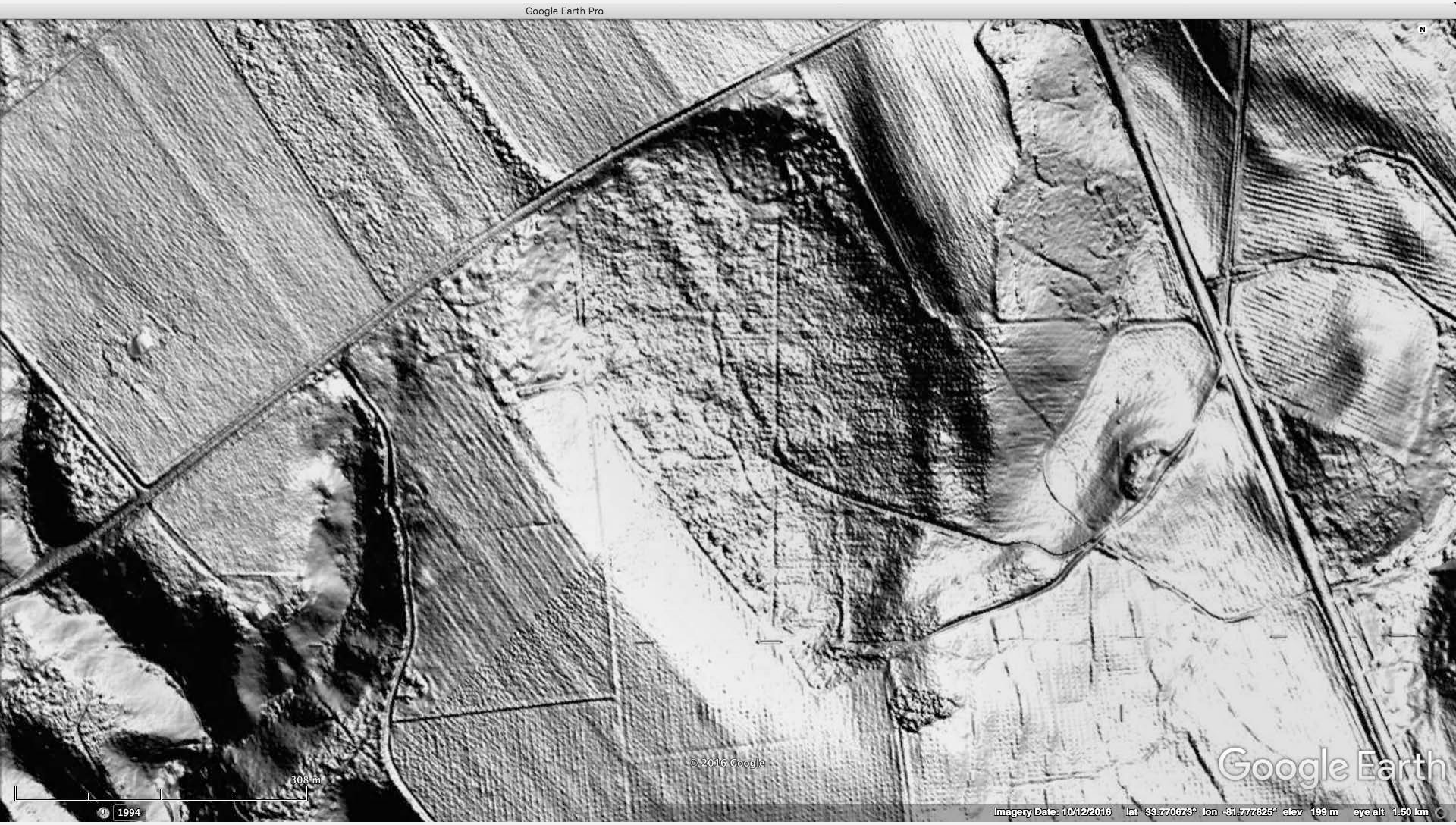
Carolina Bays of Ridge Spring

Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring

Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring

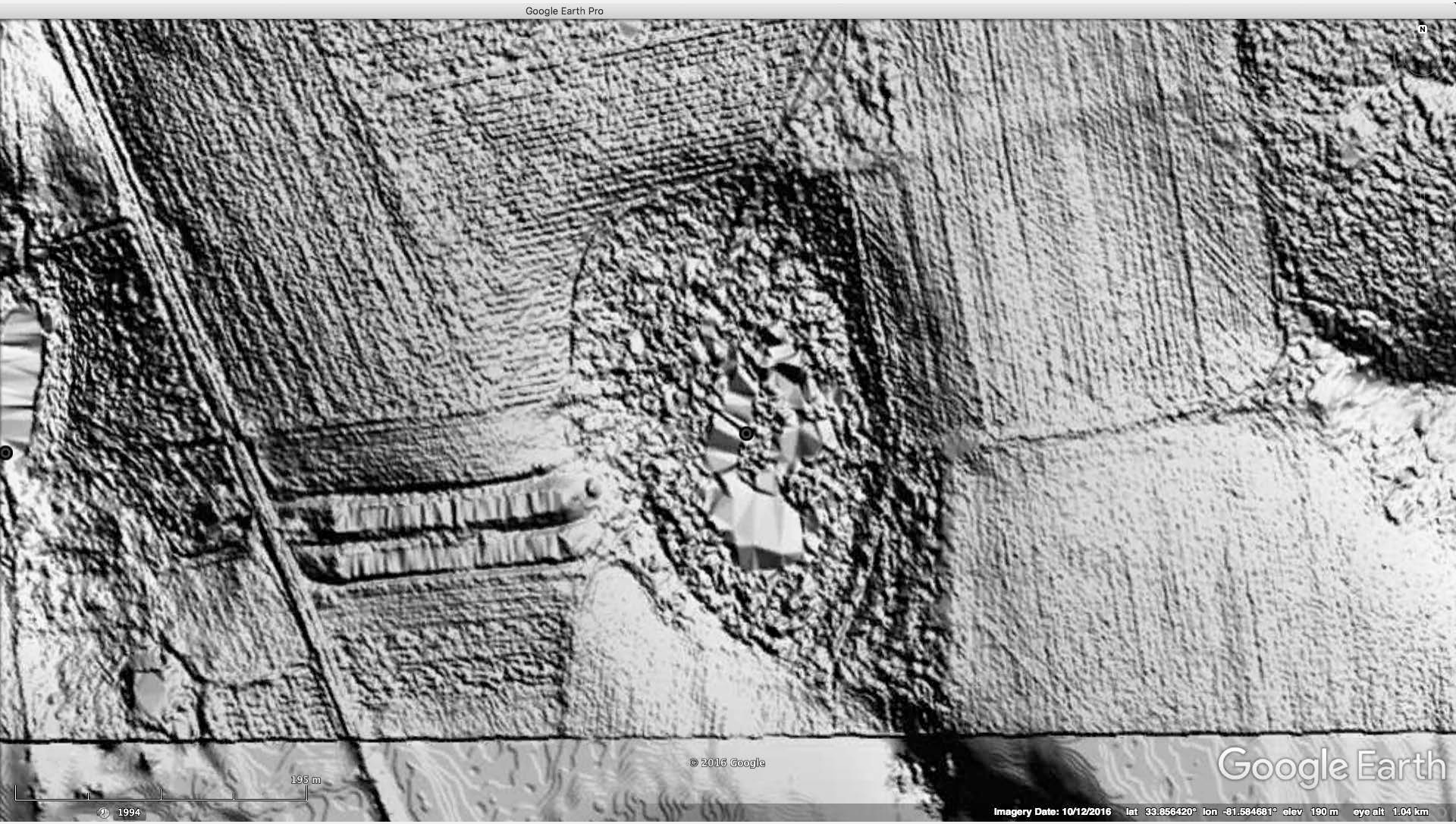


Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring

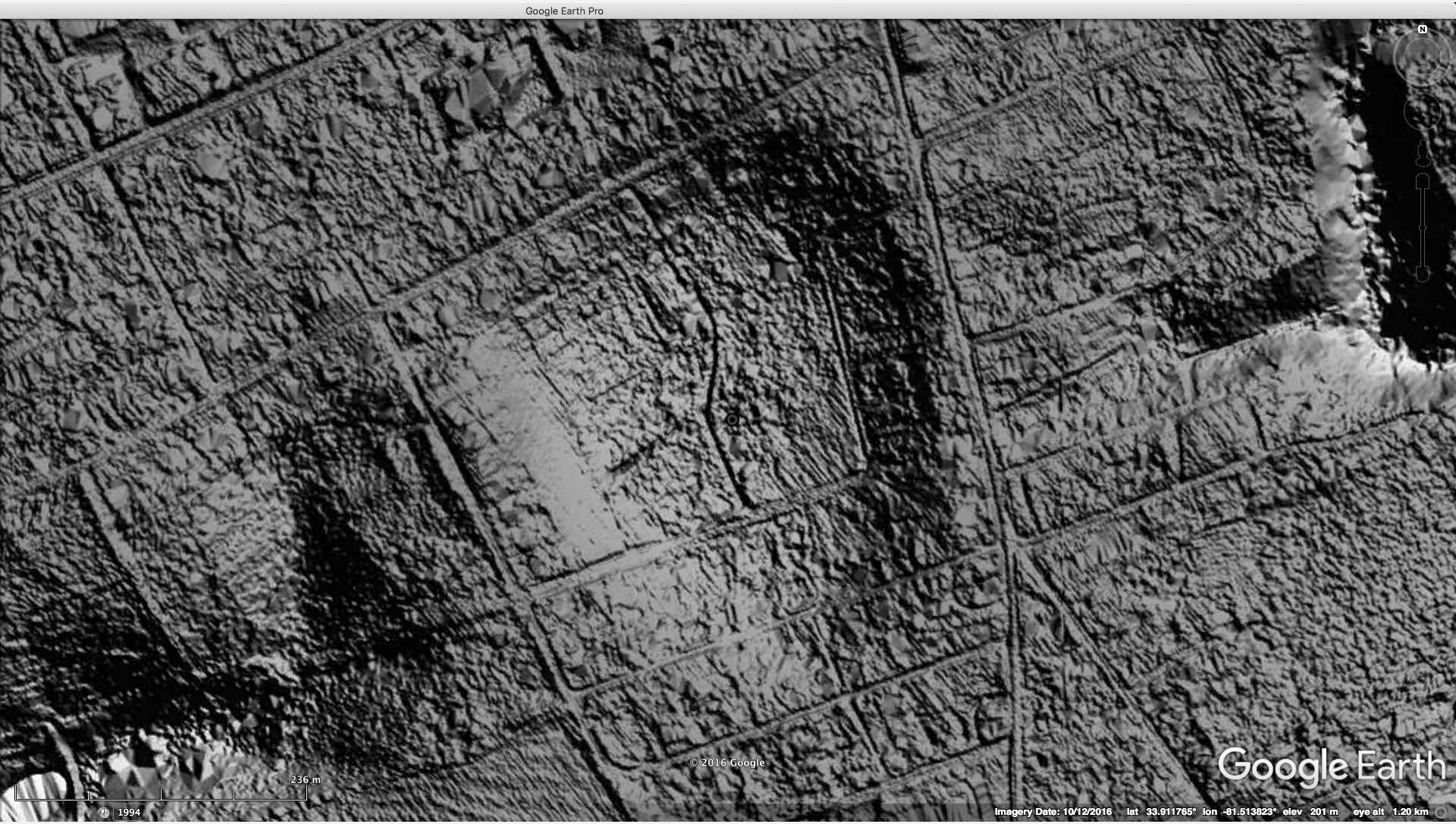
Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring



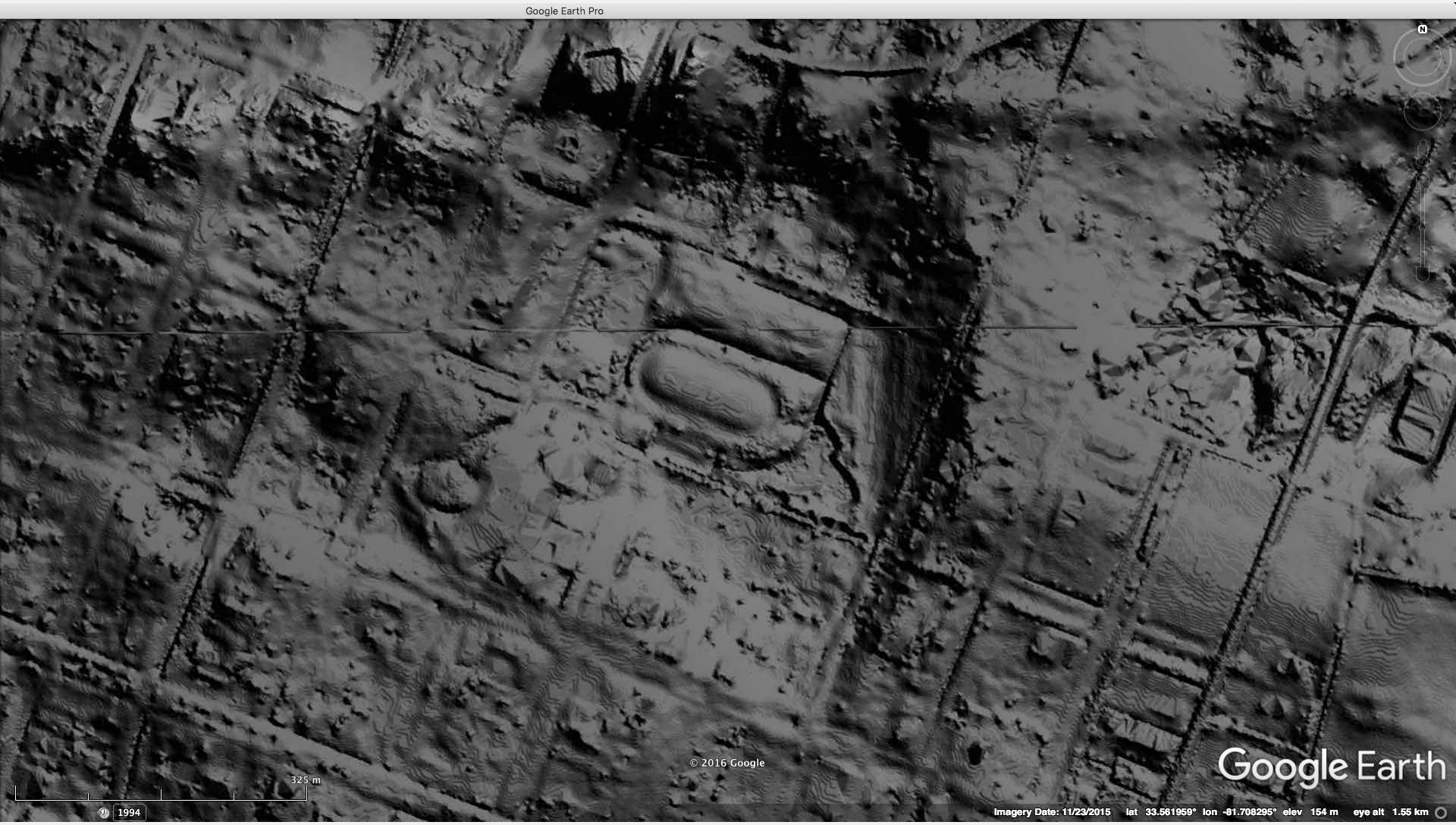
Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring



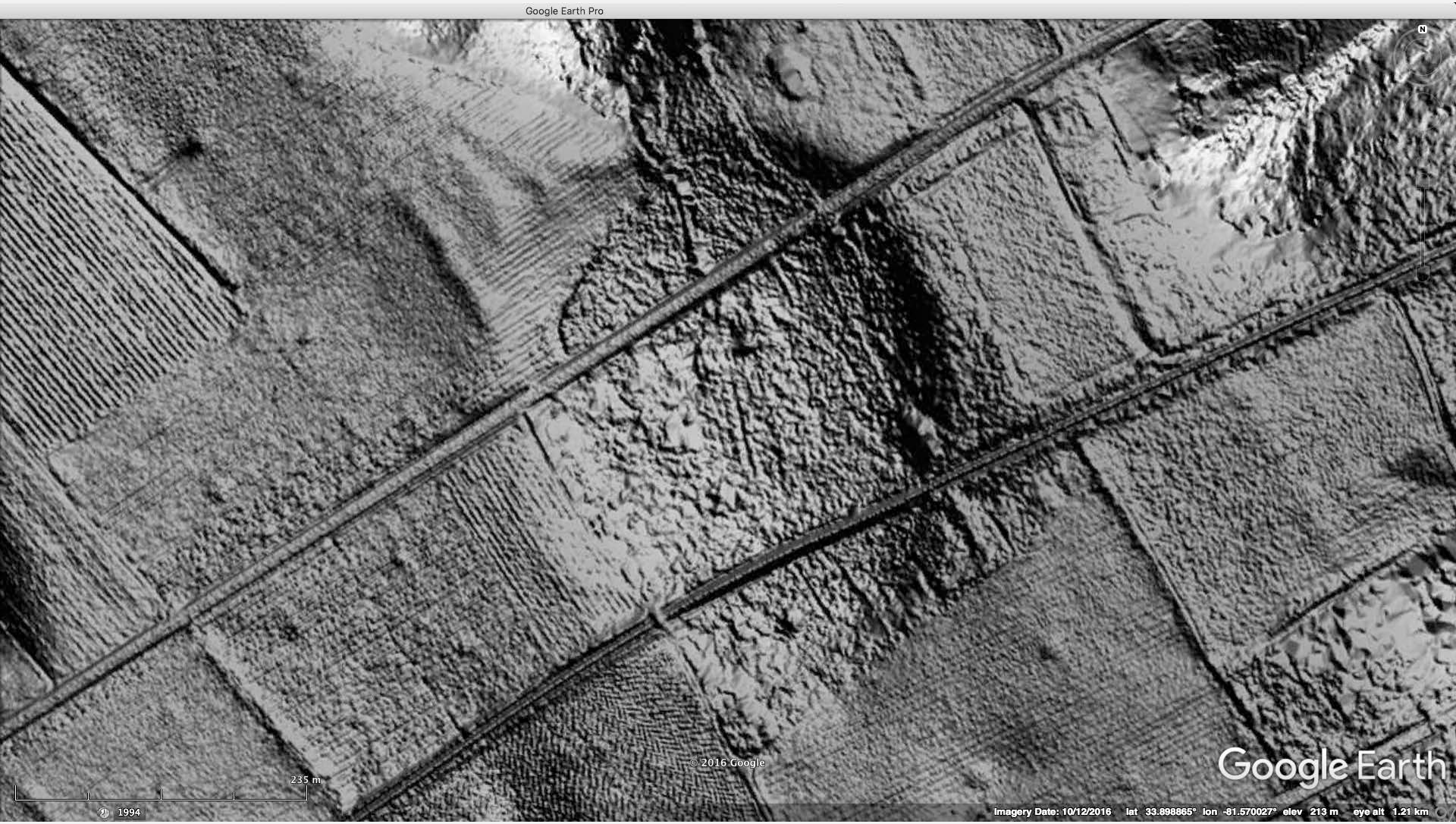
Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring



Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring



Carolina Bays of Ridge Spring

Grey scale comparison, image normalized for size

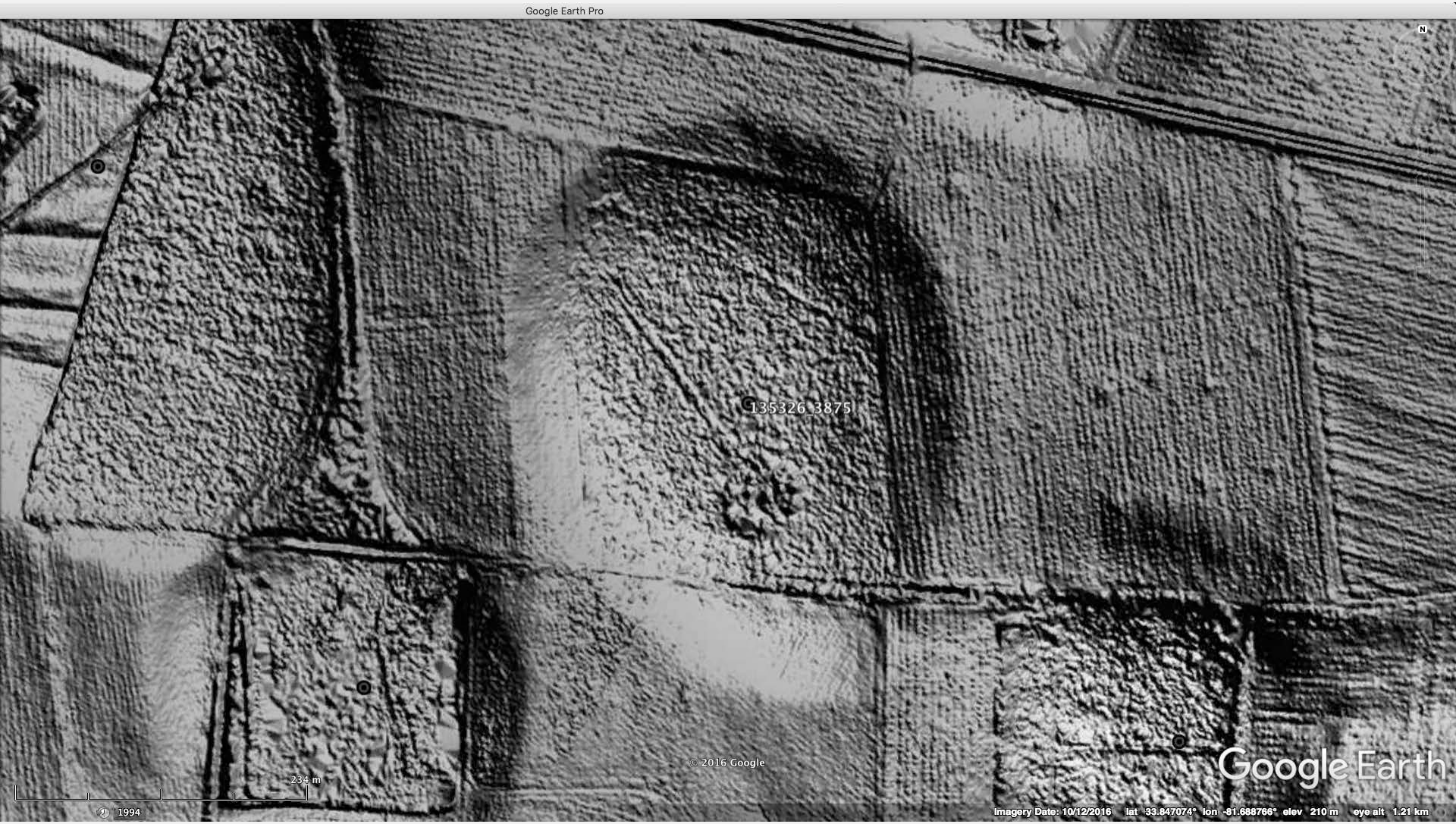
Carolina Bays of Ridge Spring

Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring

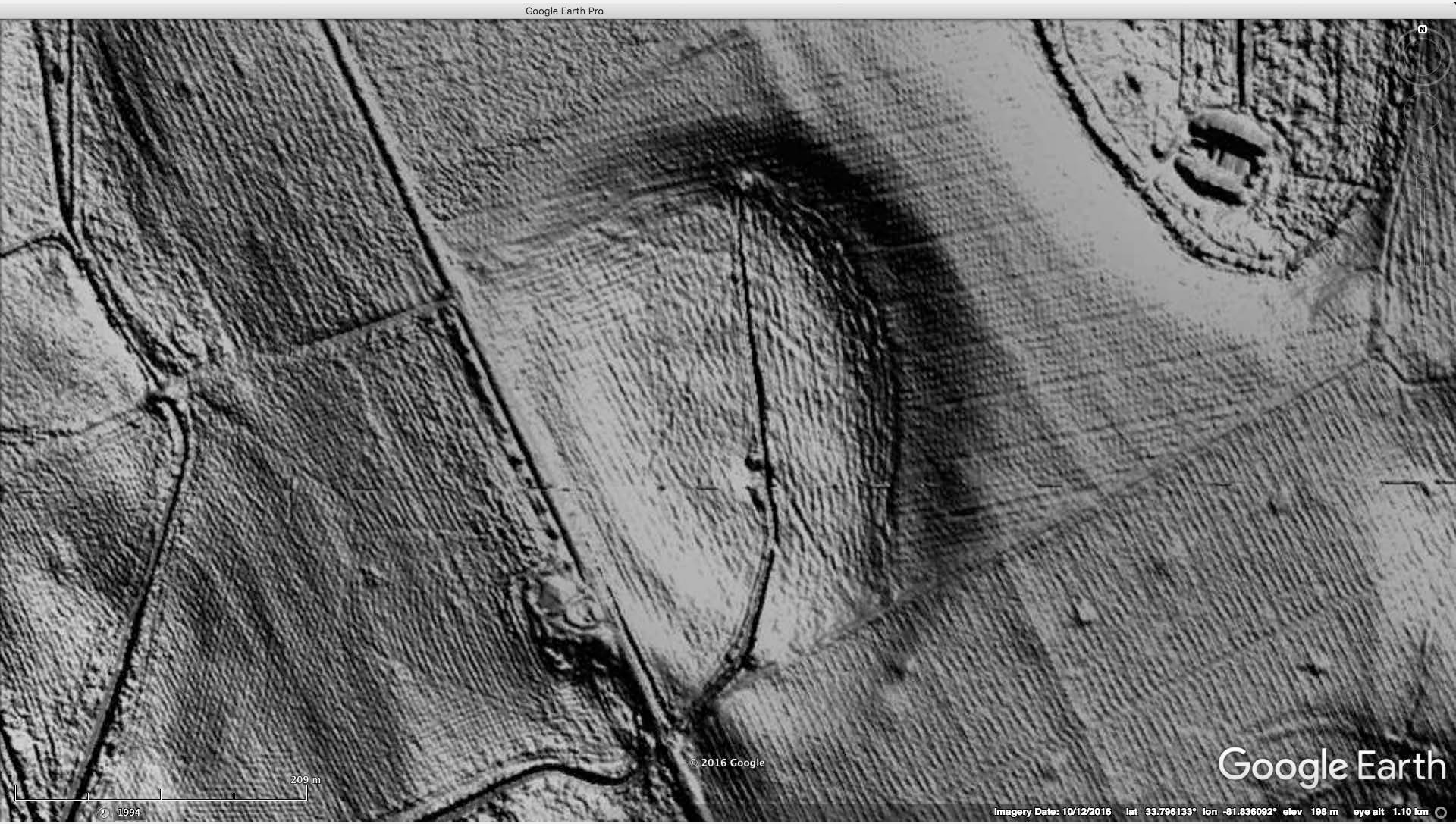
Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring



Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring



Grey scale comparison, image normalized for size

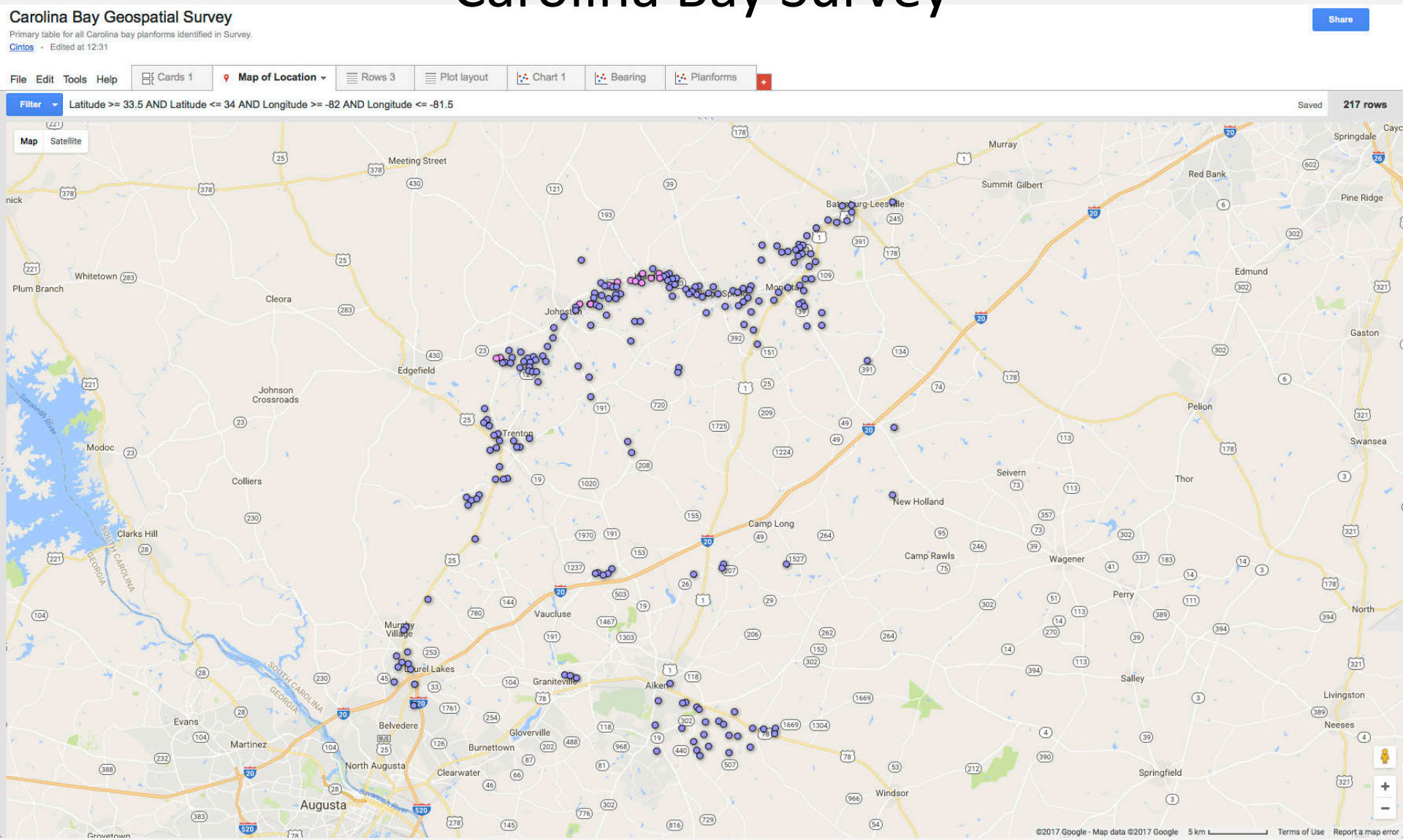
Carolina Bays of Ridge Spring

Grey scale comparison, image normalized for size

Carolina Bays of Ridge Spring

Grey scale comparison, image normalized for size

Carolina Bay Survey



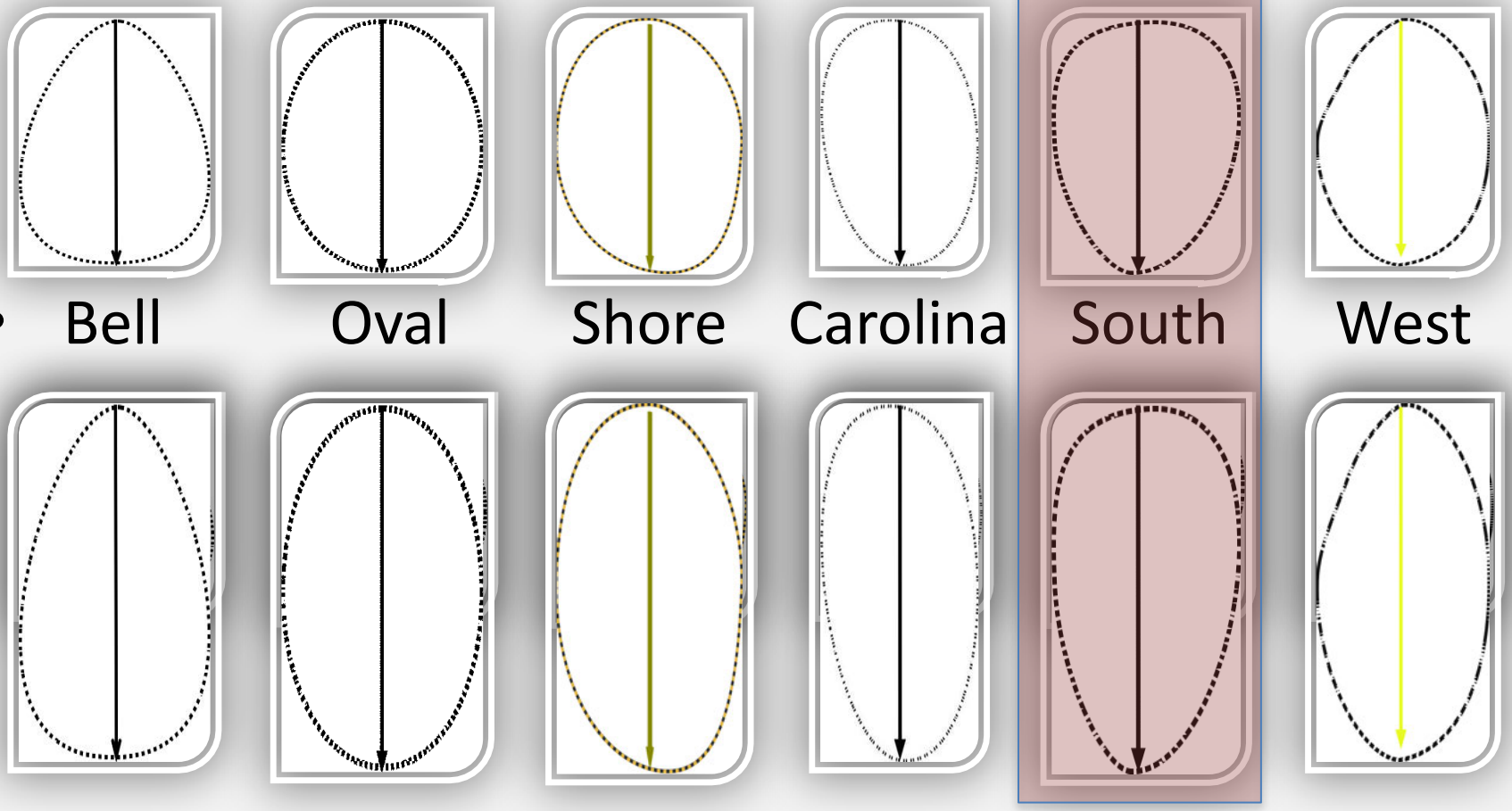
217 bays selected: Lat >= 33.5 AND Lat <= 34 AND Long >= -82 AND Long <= -81.5

Major axis: 140 m to 1.22 km, mean 380 m

Orientations of major axis: 148º to 165º, mean of 154º (clockwise from North)

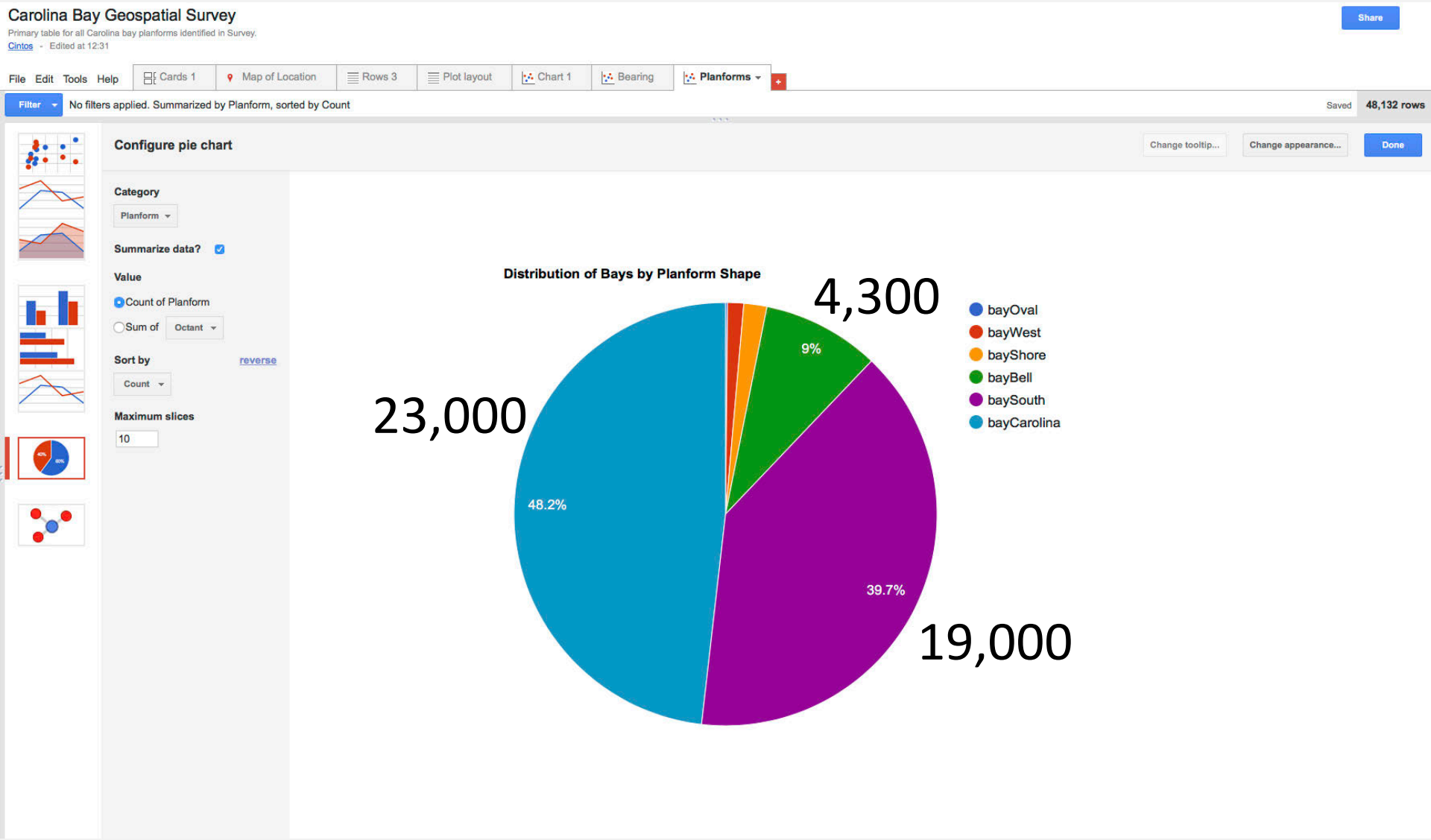
Taxonomy of landform Genus “Carolina Bay”

- Six tightly constrained archetypes as Species

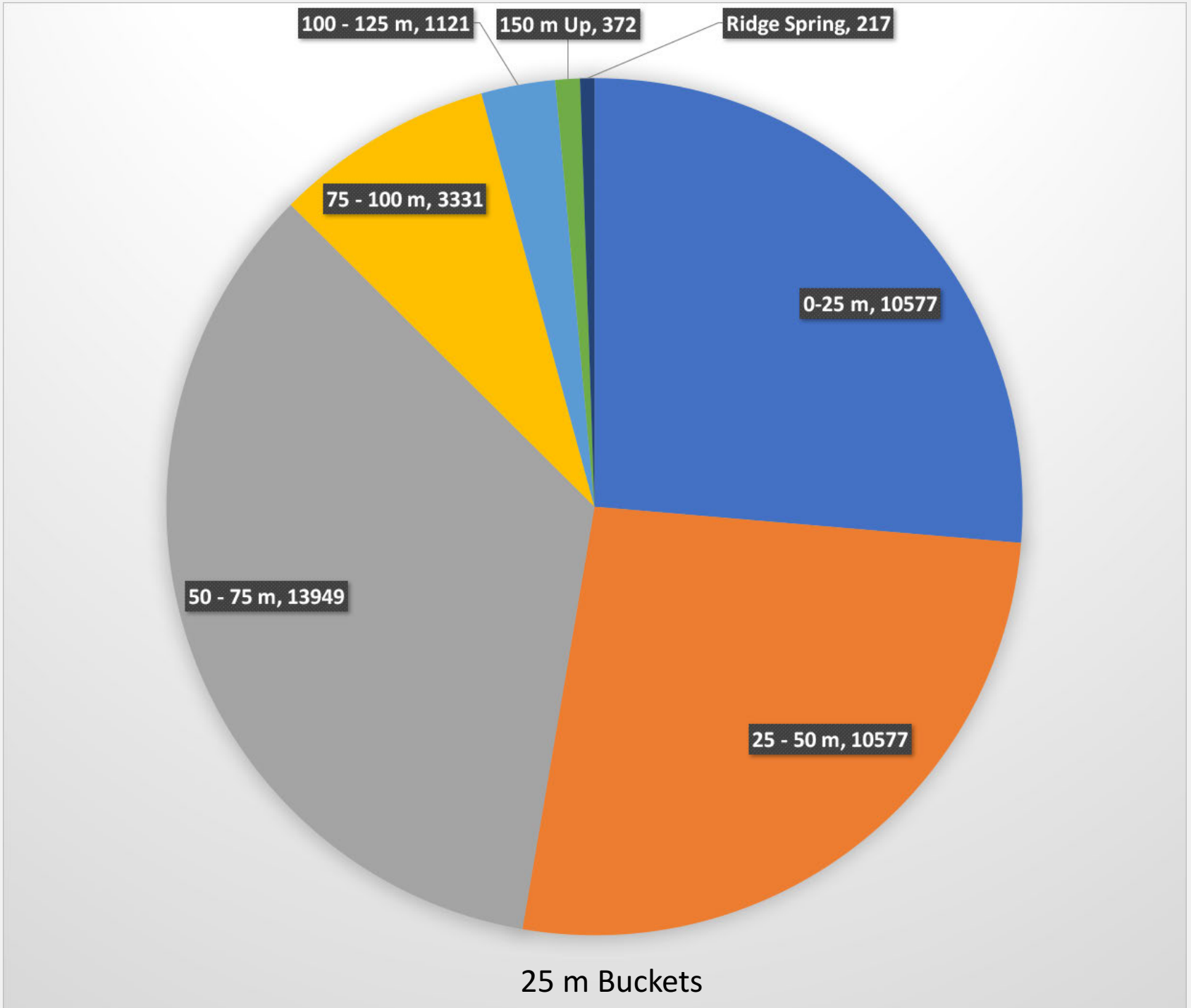


- Bell
- Oval
- Shore
- Carolina
- South
- West

Distribution of Bays by Planform Shape

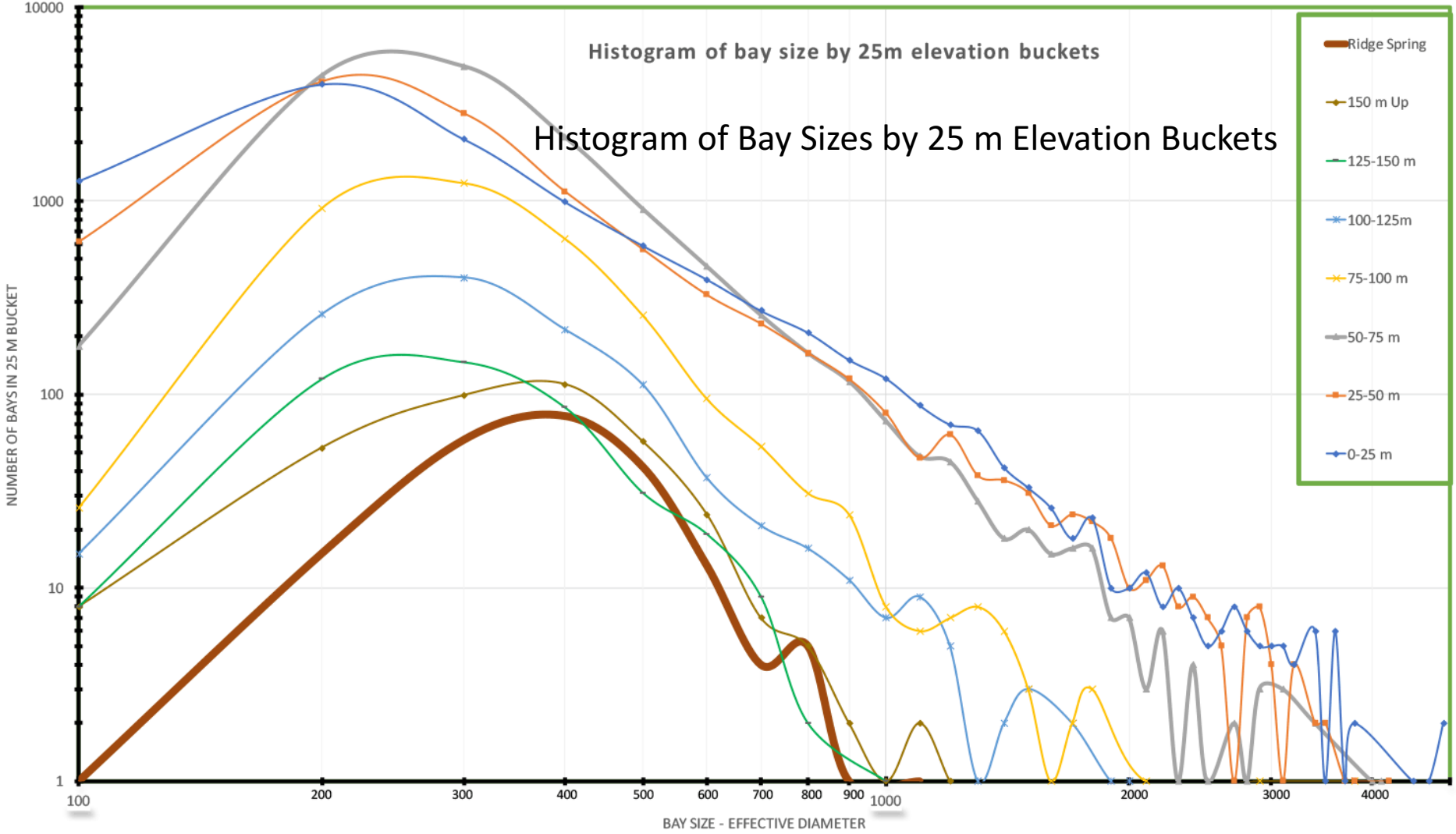


baySouth represents ~40% of all 48,132 bays in Survey


100 - 125 m, 1121
150 m Up, 372
Ridge Spring, 217
75 - 100 m, 3331
0-25 m, 10577
50 - 75 m, 13949
25 - 50 m, 10577

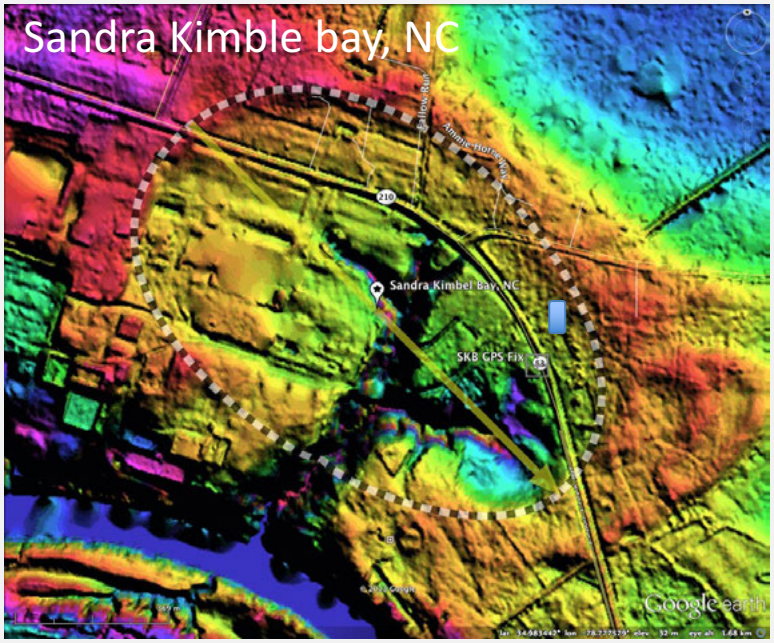
25 m Buckets

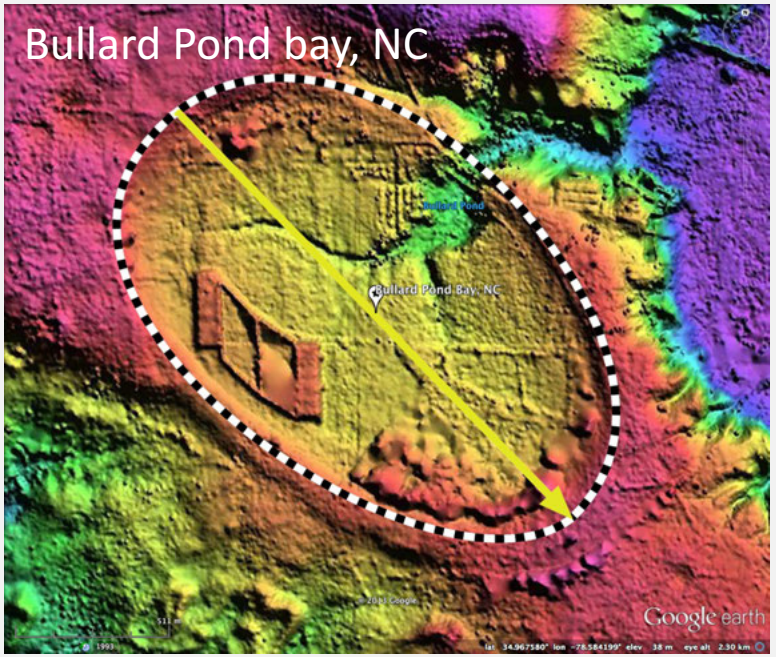
Family Resemblance

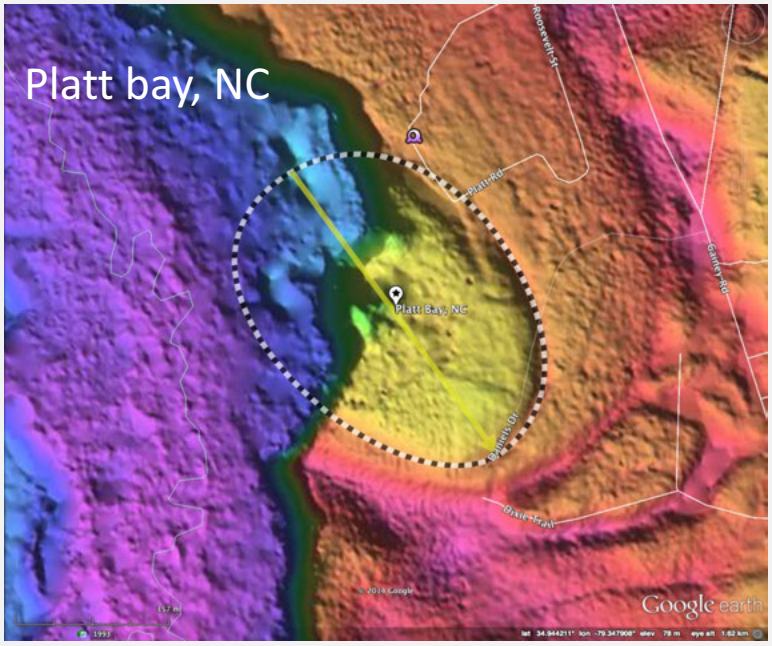


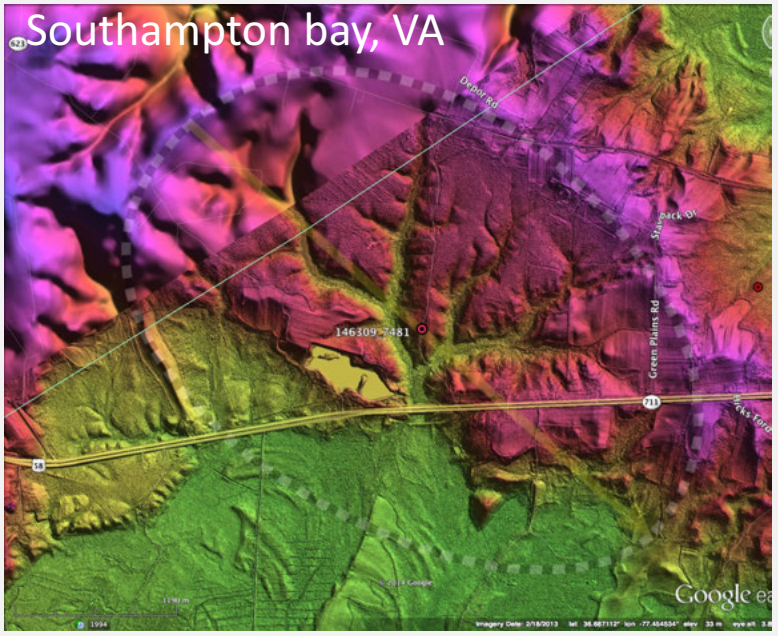
All Eastern bays compared to bays in Ridge Spring area

Heavily Eroded bayCarolina Species

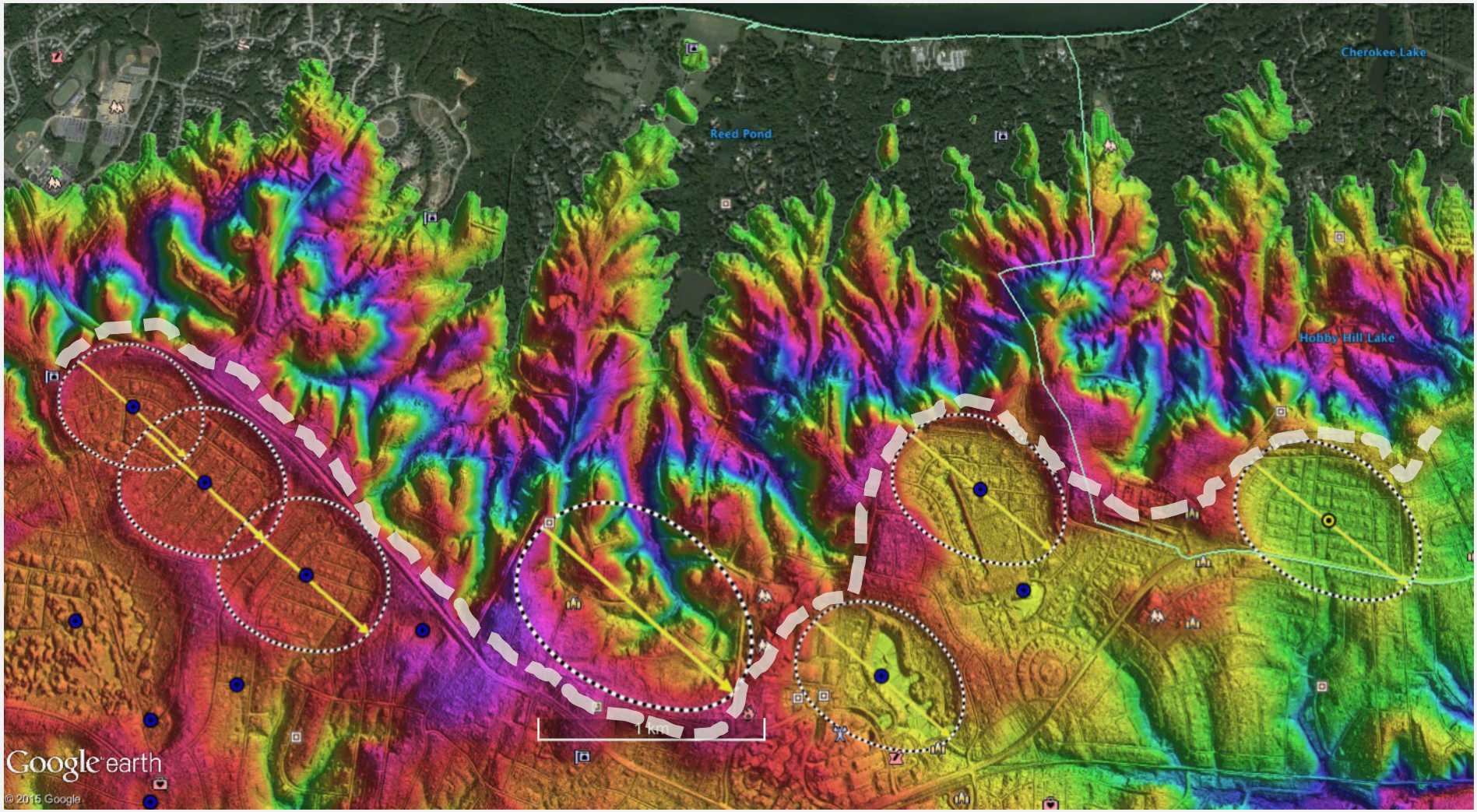






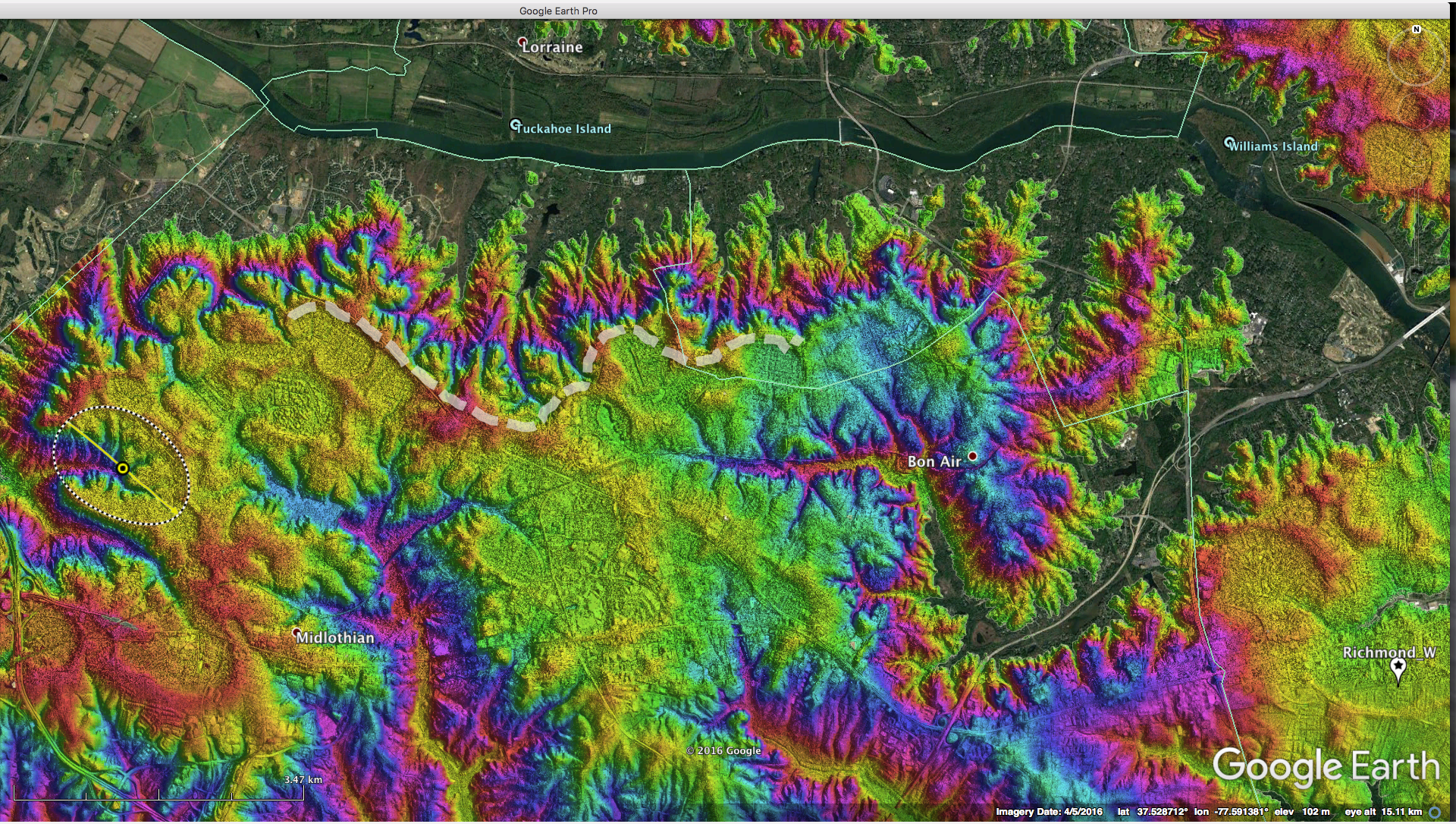


Erosion Control – who's running the show?



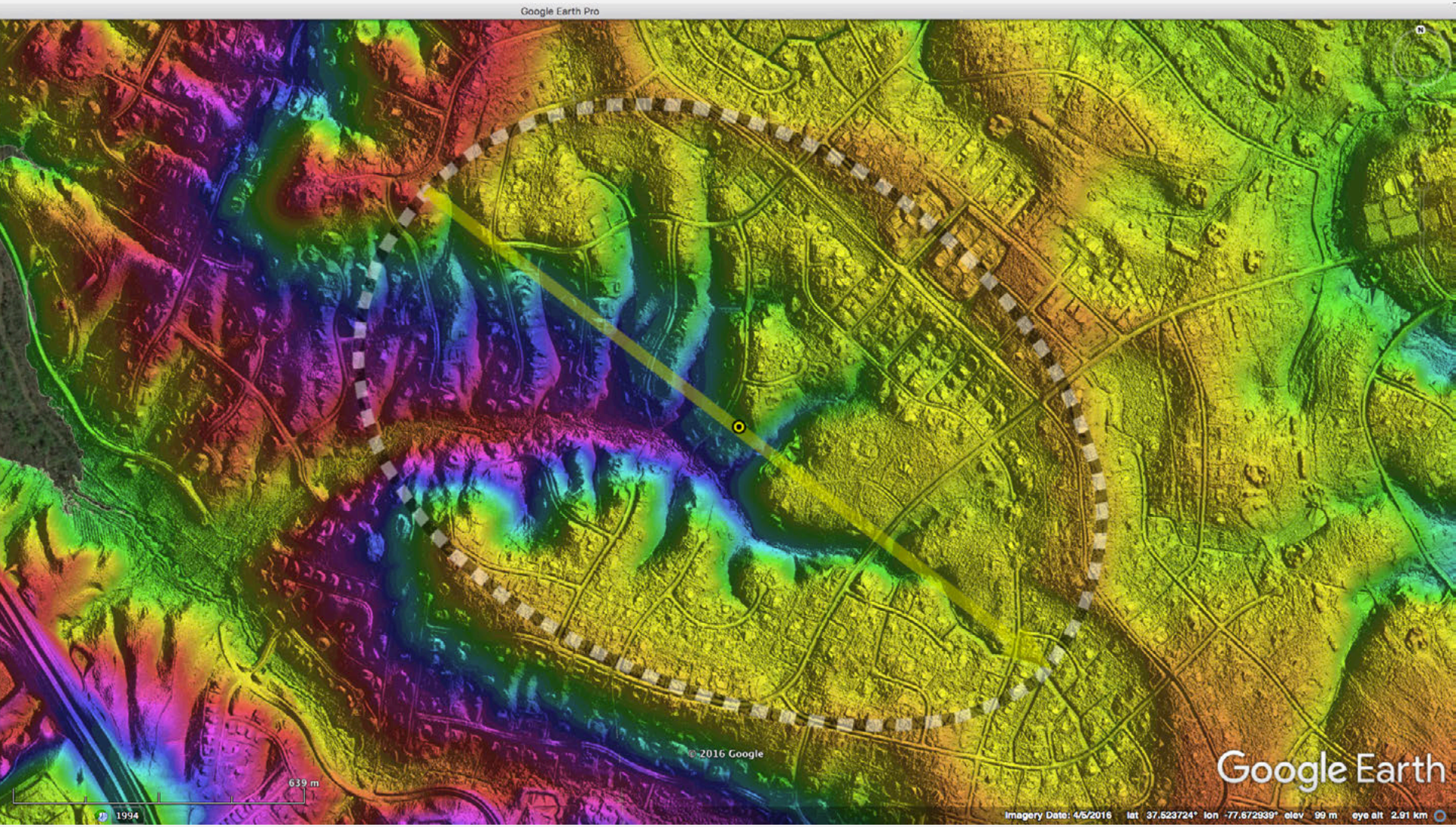
Differential erosion of the Midlothian Plateau

Erosion Control – who's running the show?



Differential erosion of the Midlothian Plateau

Bay 150310_0969, just 20 km West of Here

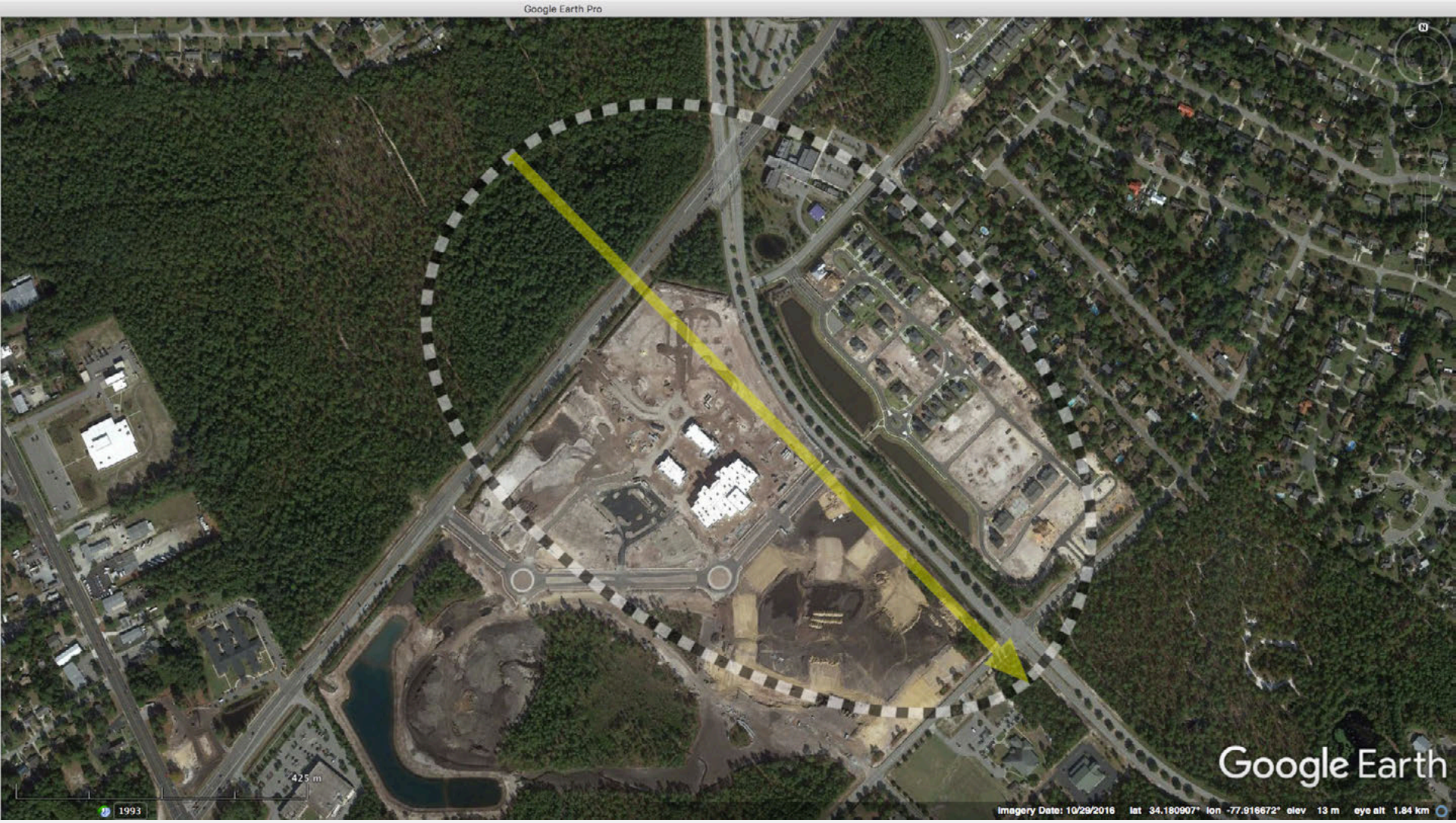


Major axis: 1.76 km Bearing: 130º Elevation: 96 m

Wilmington, NC – a bay “Gentrified” in past 2 years

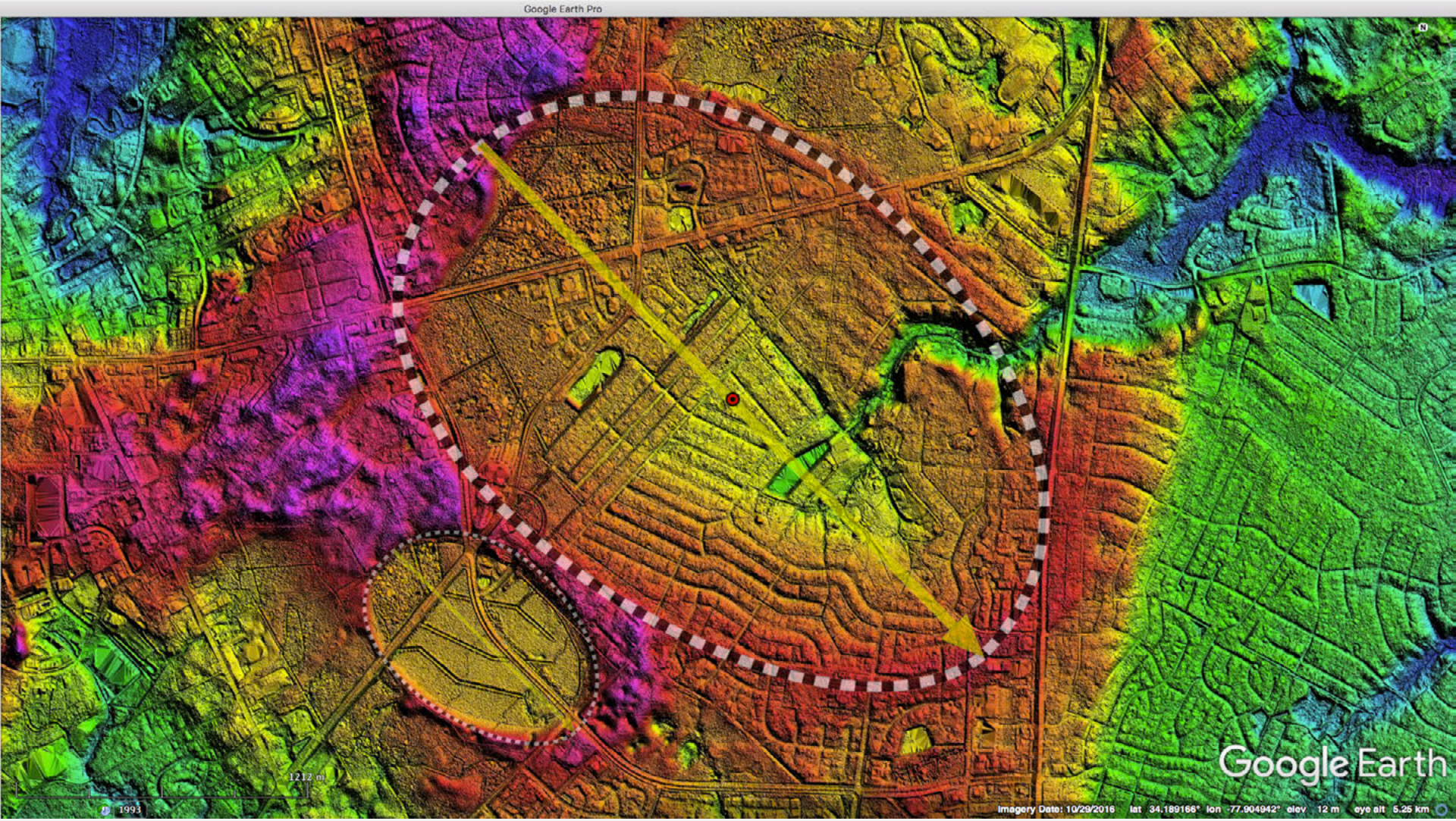
Major axis: 1.0 km Bearing: 136º Elevation: 13 m

Wilmington, NC – a bay “Gentrified” in past 2 years



Major axis: 1.0 km Bearing: 136º Elevation: 13 m

Blythe Bay, Wilmington, NC



Major axis: 3.0 km Bearing: 136º Elevation: 13 m

Saginaw Impact Manifold Hypothesis

Carolina bays are not ephemeral, wispy landforms, but rather represent the surface topology of a sheet of unconsolidated quartzose grains, deposited as ejecta during the Mid Pleistocene Transition impact event ~780 Ka. The planforms and orientations have been robustly imprinted into the landscape, and have resisted ongoing erosional and accretionary processes.

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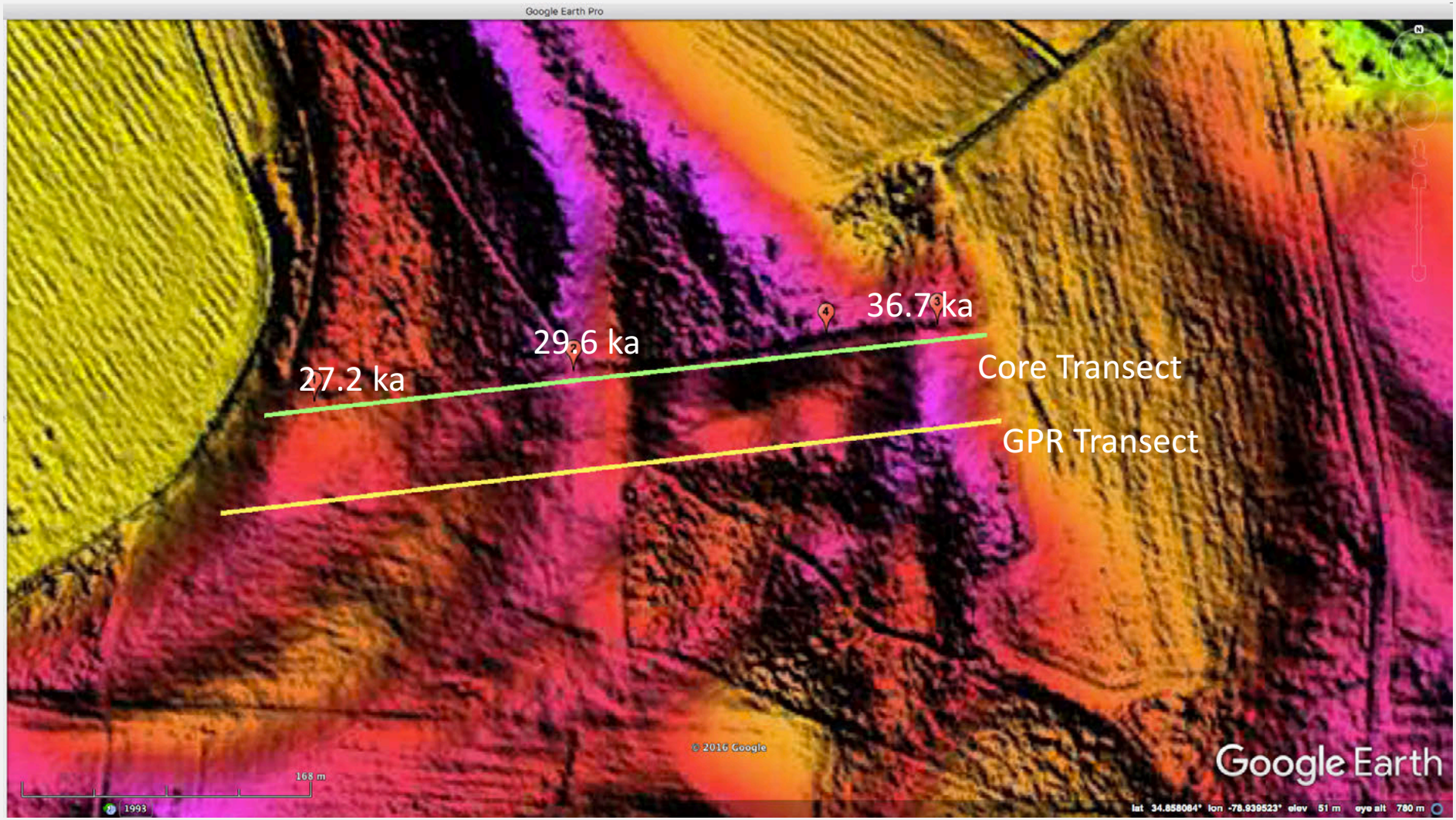
The hypothesis seems easily falsified:

- … **“they don’t look that old!”**
- … **“there is no erosion!”**
- … **“bay sediments dating does not supported a singular event!”**
- … **“they are too far away from the MPT Impact Event!”**

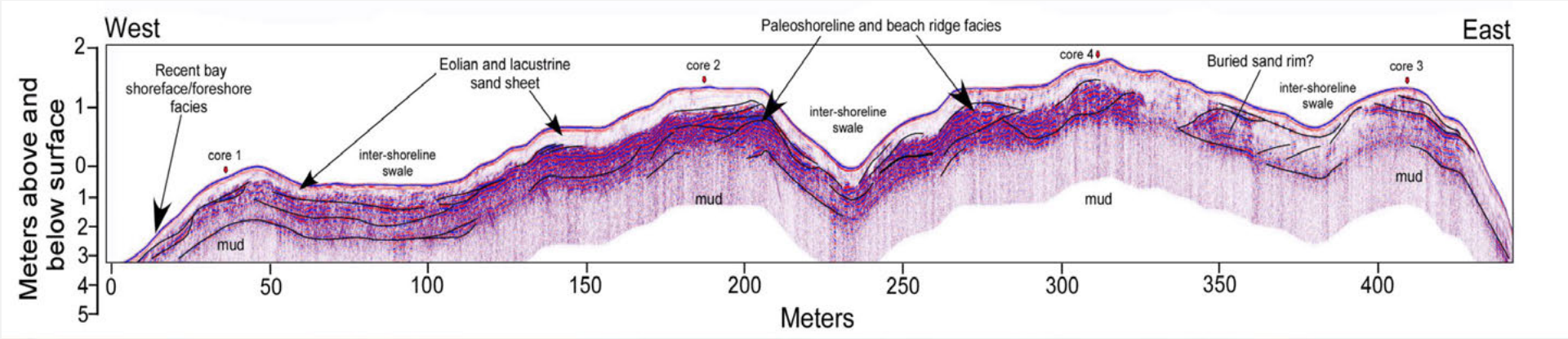
OSL dating fieldwork at Herndon Bay, NC

Moore, et al documented rim construction at 36.7 +/- 4.1, 29.6 +/- 3.1, and 27.2 +/- 2.8 ka



Moore, Brooks, Mallinson, Parham, Ivester And Feathers, *Rapid Scour, Sand Rim Construction, And Basin Migration Of A Carolina Bay In Southeastern North Carolina*, GSA Abstracts With Programs. Vol. 46, No. 3, P.96

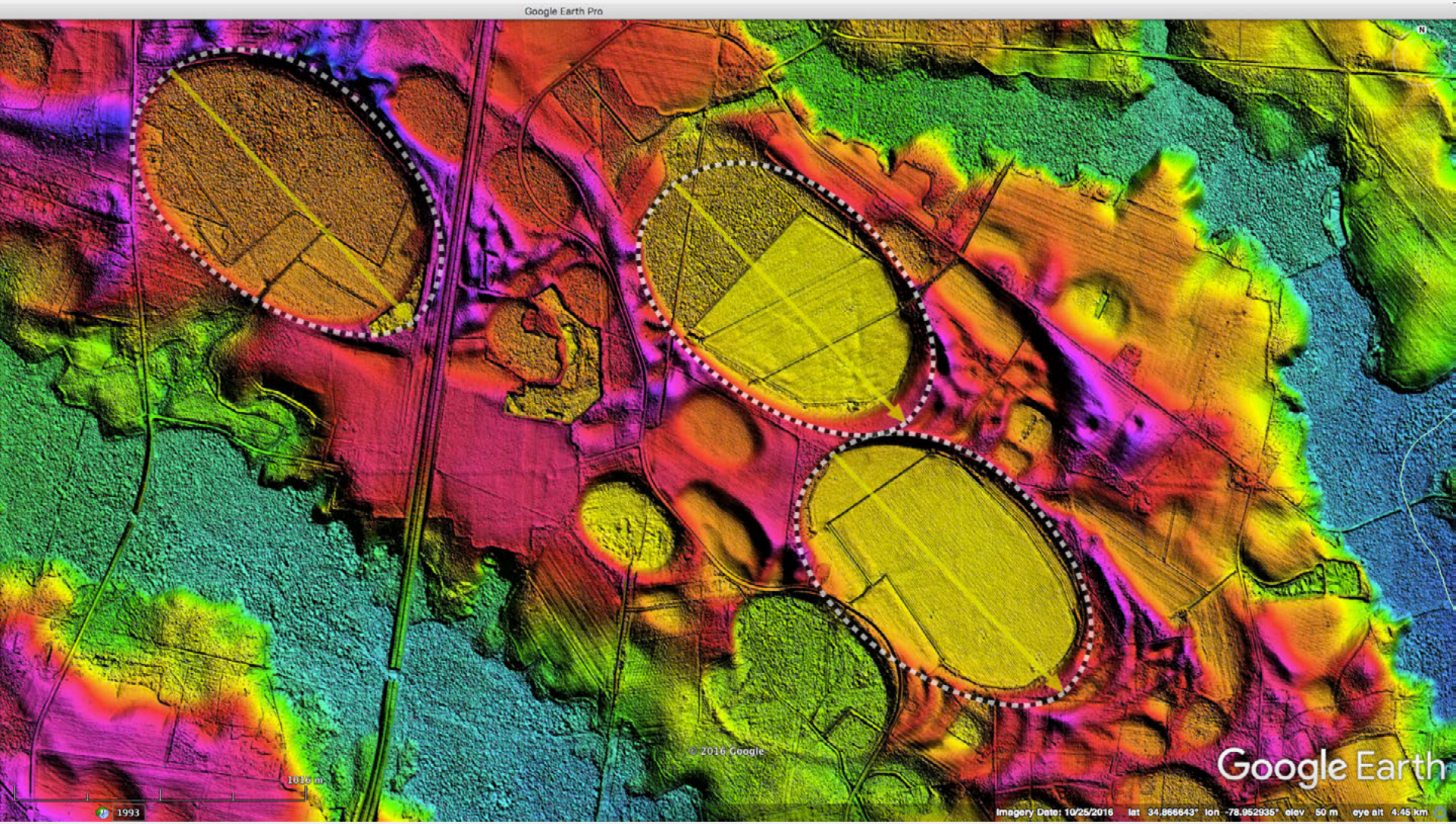
Herndon Bay, NC



Moore's GPR trace clearly illustrates that a structure lying at depths below the sampled strata are actually controlling the relief. What's down there?

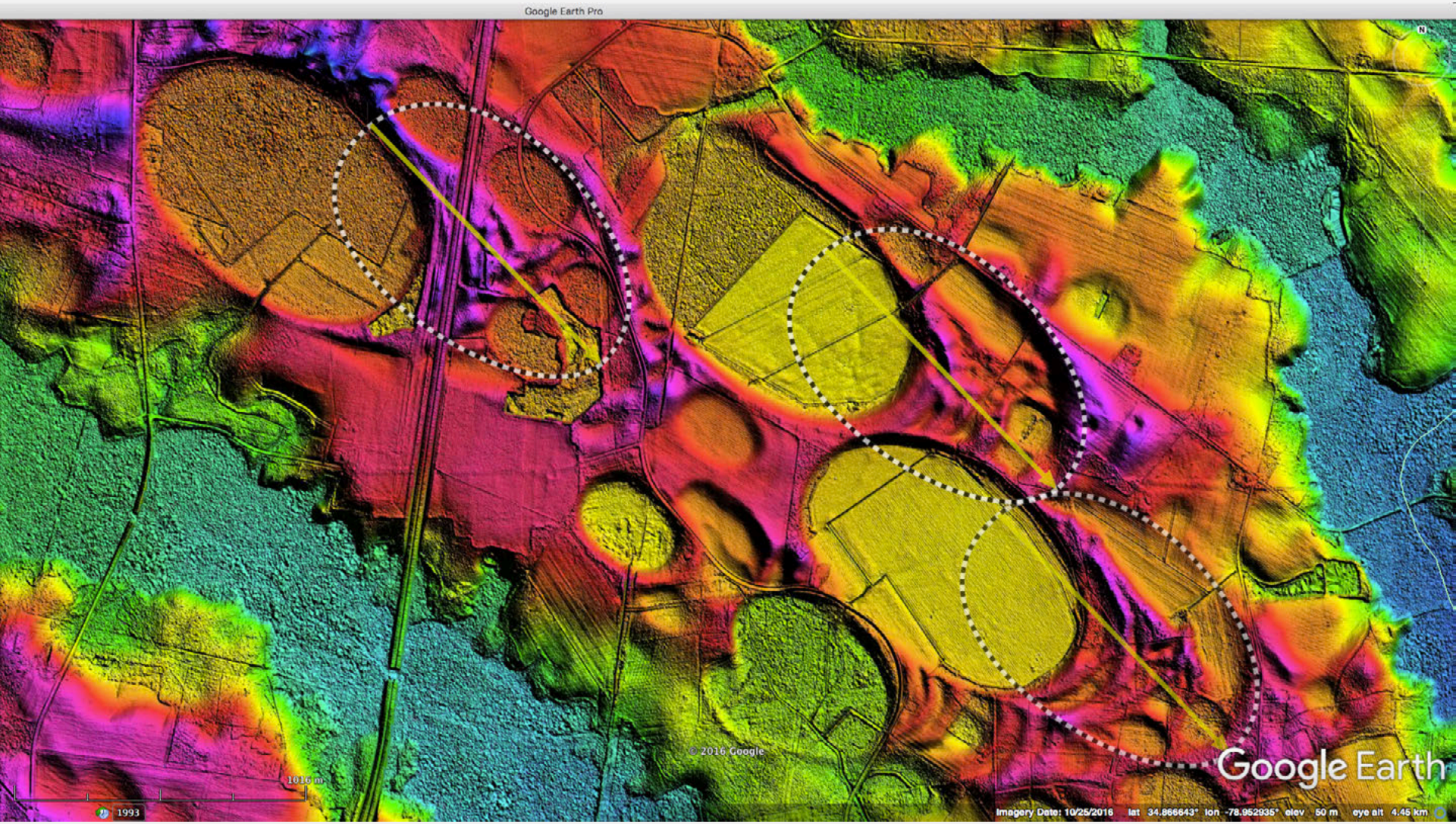
Moore, Brooks, Mallinson, Parham, Ivester And Feathers, *Rapid Scour, Sand Rim Construction, And Basin Migration Of A Carolina Bay In Southeastern North Carolina*, GSA Abstracts With Programs. Vol. 46, No. 3, P.96

Herndon Bay, NC



Herndon bay is on the lower right here in my LiDAR imagery. What is quite enigmatic is that it has two sibling bays which are perfect matches to the same 1.17 km bayCarolina overlay. Exact, just copy and place in Google Earth.

Herndon Bay, NC



And each sibling bay has a correlated shadow bay which are perfect matches to the same 1.17 km bayCarolina overlay. Exact, just copy and place in Google Earth.

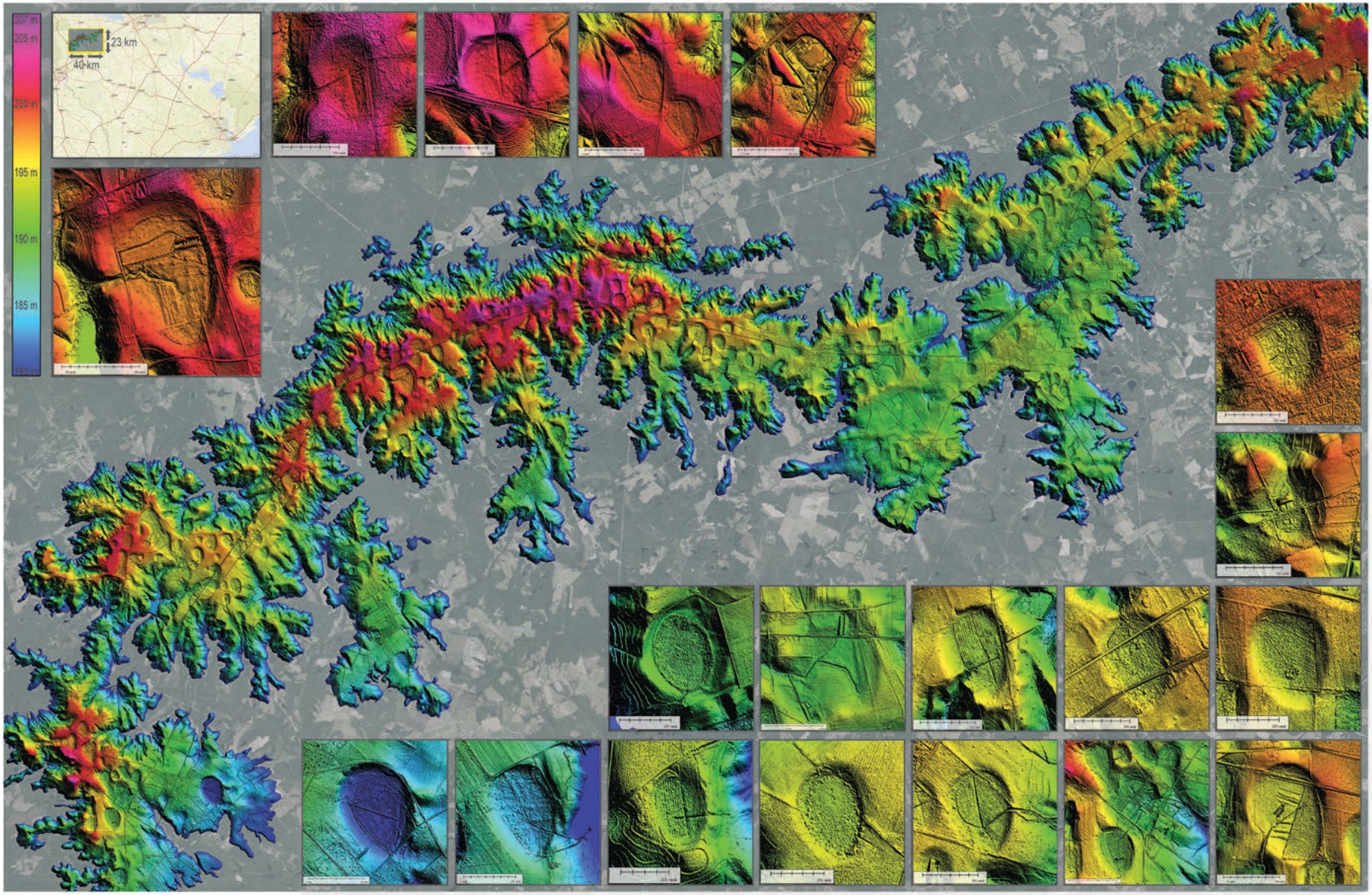
Summary

Eroded Carolina bays exhibit indications of great age

Dissection of Costal terraces generates Valley Head Basins when Carolina bays are penetrated by headward stream erosion

Extensive Deep Coring (10 m) is required to identify deposits controlling surface expression

Cosmogenic ^{26}Al-^{10}Be burial dating needed to reach back beyond 50ka to 200 ka limits of classic dating tools



The Carolina Bays of Ridge Spring

HSV-shaded digital elevation map, 20x vertical exaggeration

LiDAR elevation data courtesy USGS