

State Plane Coordinates: Good Riddance

An introduction to the new
Pima Low Distortion Map projection.

Presented by Patrick McGarrity RLS, CP

Once upon a time some folks decided
to build a GIS

ACRONYMS

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US

TRF00

UTM

GRS 80

NAD 27

WGS 84

NSRS

CORS H

IGRS

NAVD 88

P

HARN

NAD 83

G

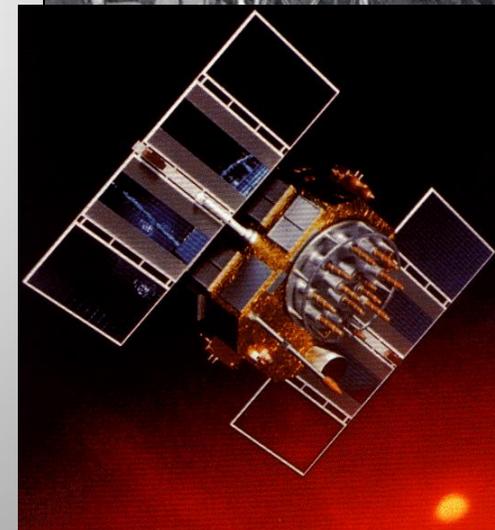
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Where are we?

- Currently on the Arizona Coordinate System
- Defined in Arizona Revised Statutes Title 33
- Datum not fixed to any specific epoch
- Locally fixed on NAD83(92) or HARN
- Required by NGS for inclusion in datasheets
- All map projections have some distortion
 - State Plane \approx 200ppm
 - UTM \approx 600ppm
- Scaling issues from grid to ground

A (very) brief history of NAD 83

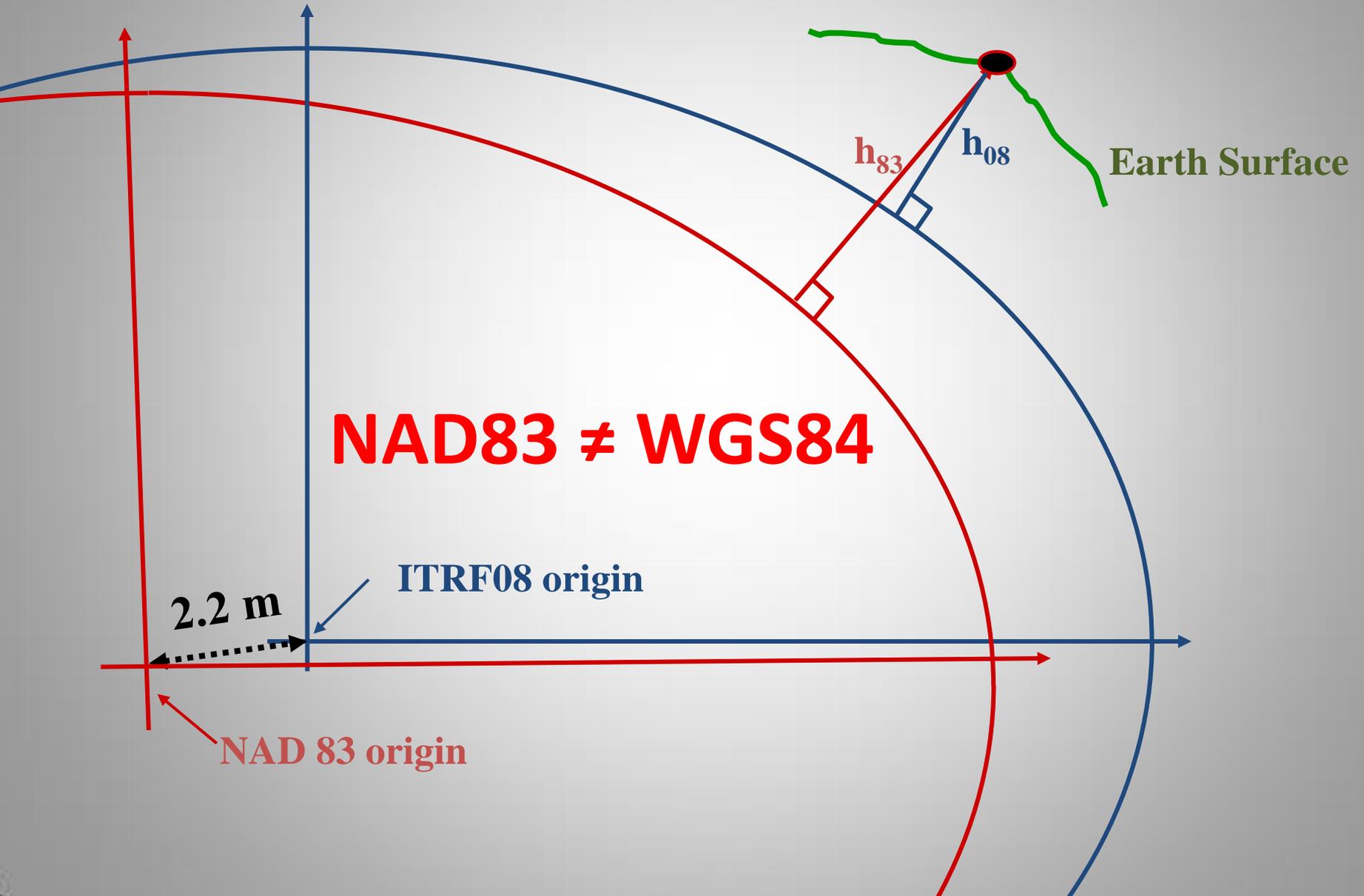
- Original realization completed in 1986
 - Consisted (almost) entirely of classical (optical) observations
- “High Precision Geodetic Network” (HPGN) and “High Accuracy Reference Network” (HARN) realizations
 - Most done in 1990s, essentially state-by-state
 - GNSS based, with classical obs. incl. in adjustments
 - Did NOT use CORS as constraints
- National Re-Adjustment of 2007
 - NAD 83(CORS96) and (NSRS2007)
 - Simultaneous nationwide adjustment (GNSS only)
- ***New realization: NAD 83(2011) epoch 2010.00***
 - CORS included



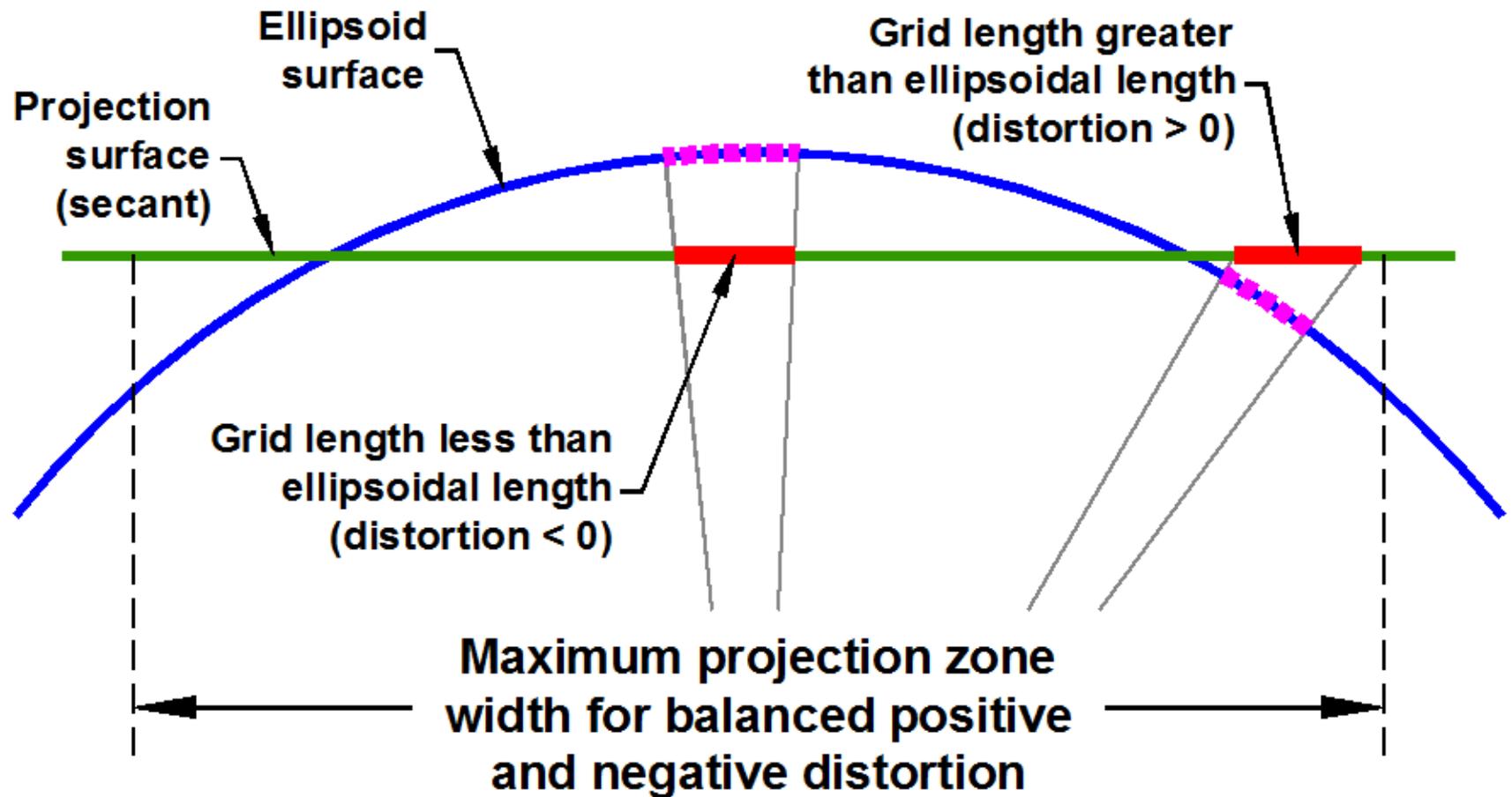
National Spatial Reference System (NSRS) Improvements over time

NETWORK	TIME SPAN	NETWORK ACCURACY	LOCAL ACCURACY	SHIFT
NAD 27	1927-1986	10 meters	(1:100,000)	10-200 m
NAD83(86)	1986-1990	1 meter	(1:100,000)	0.3-1.0 m
NAD83(199x)* “HARN”, “FBN”	1990-2007	0.1 meter	(1:1 million) (1:10 million)	0.05 m
NAD83(NSRS2007)	2007-2011	0.01 meter	0.01 meter	0.03 m
NAD83(NSRS2011)	2011	0.01 meter	0.01 meter	0.01 m

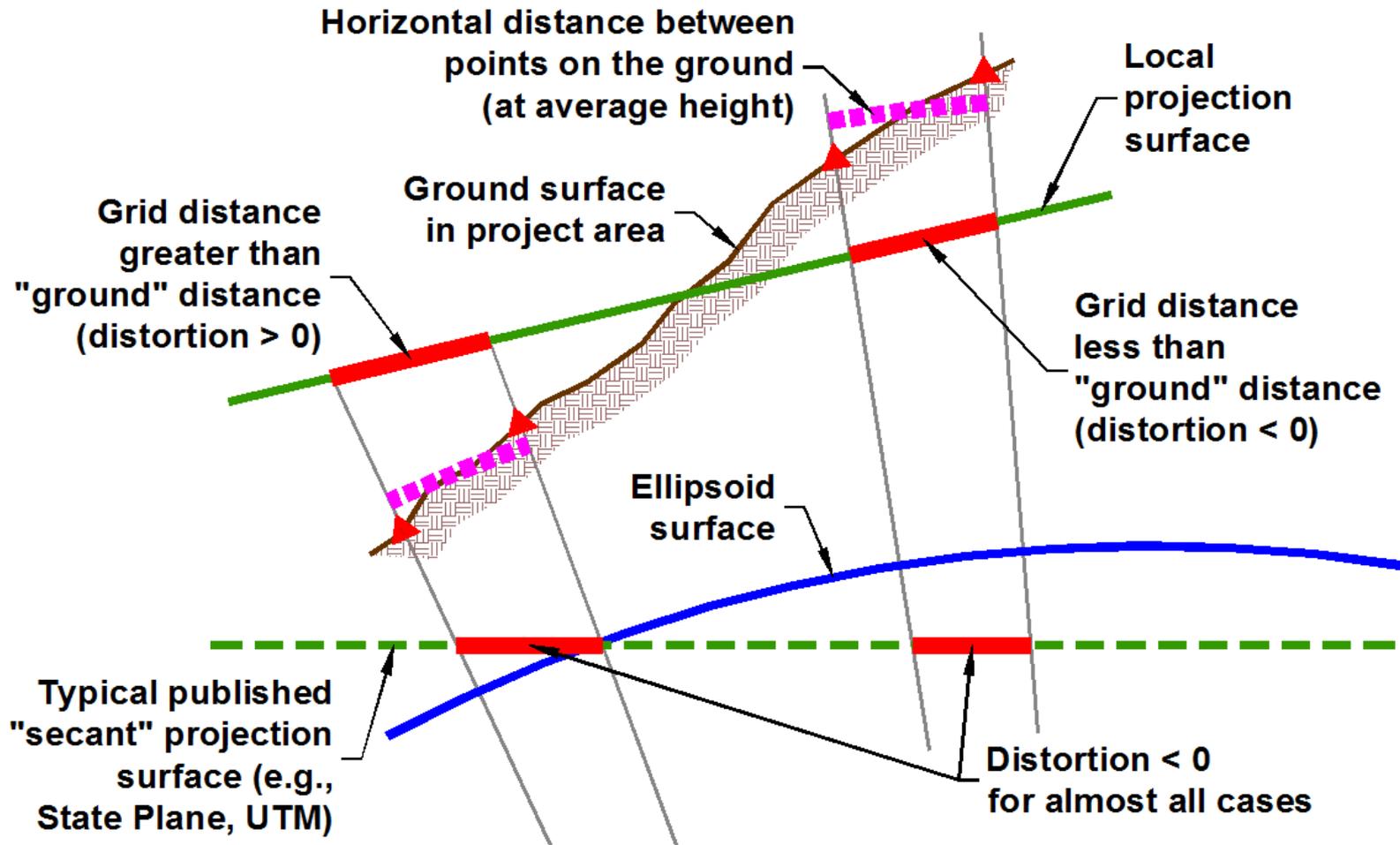
Simplified Concept of **NAD 83** vs. **ITRF08 (& WGS84)**



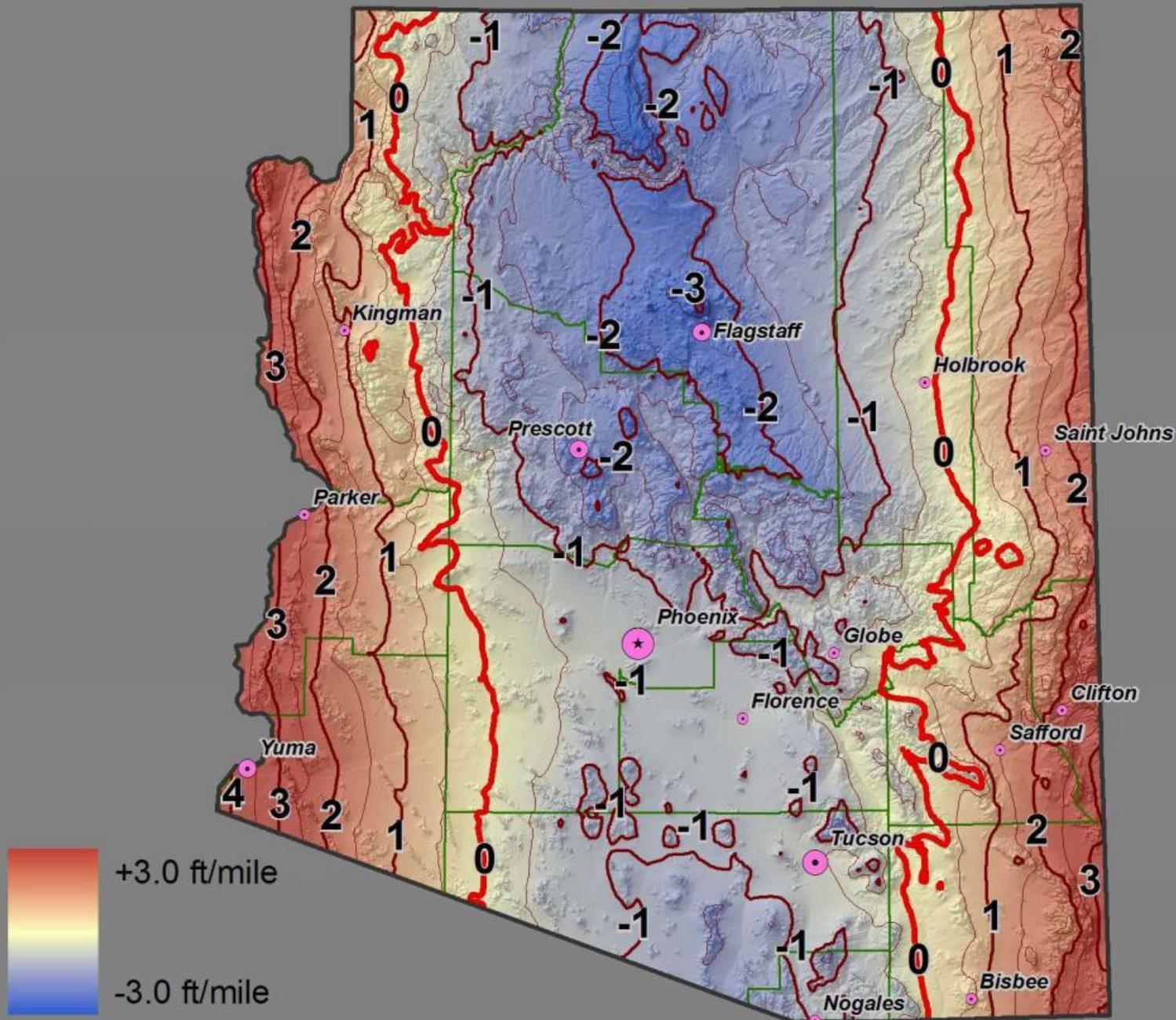
Linear distortion due to Earth curvature



Linear distortion due to ground height above ellipsoid



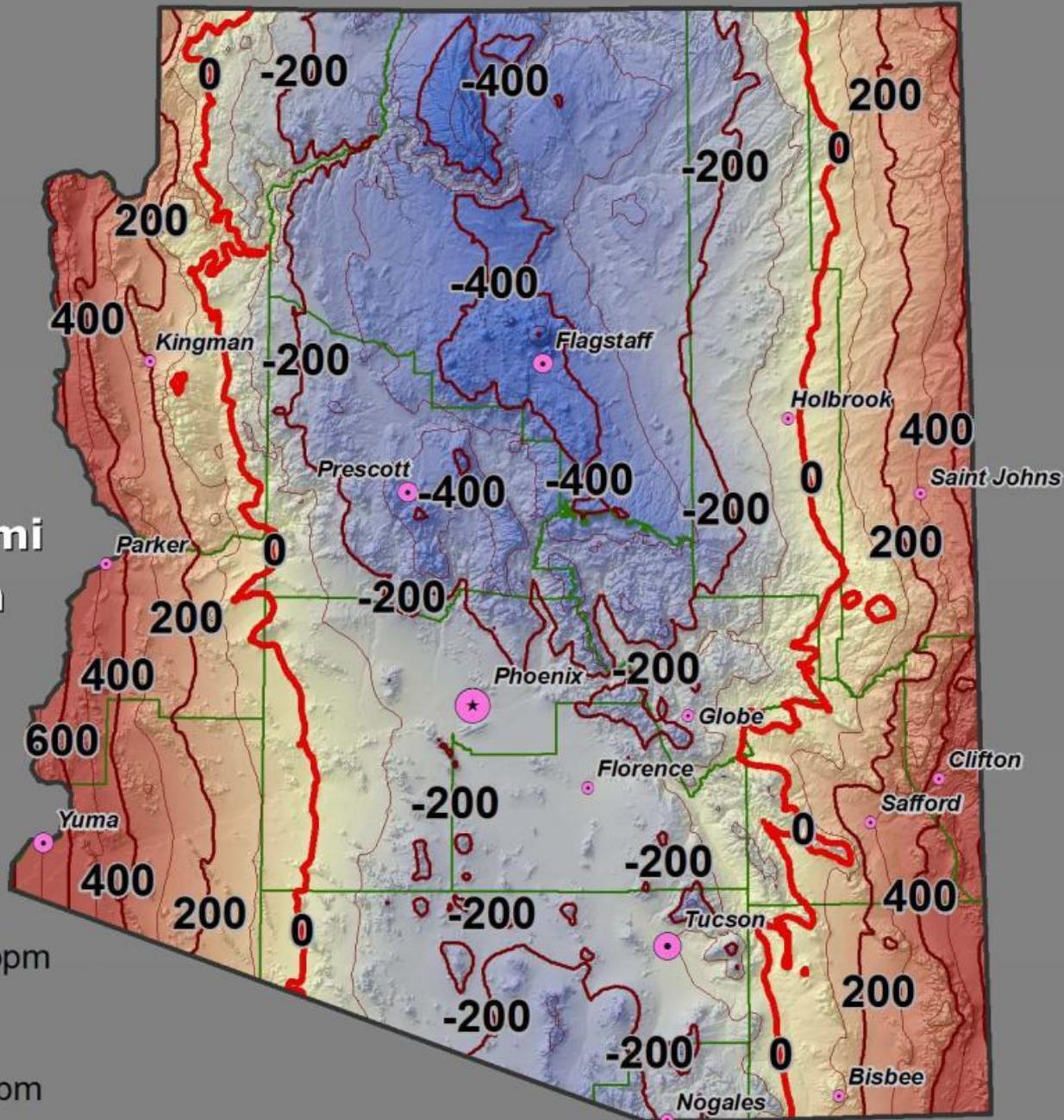
State Plane (AZ Zone C) "linear distortion" (feet/mile)



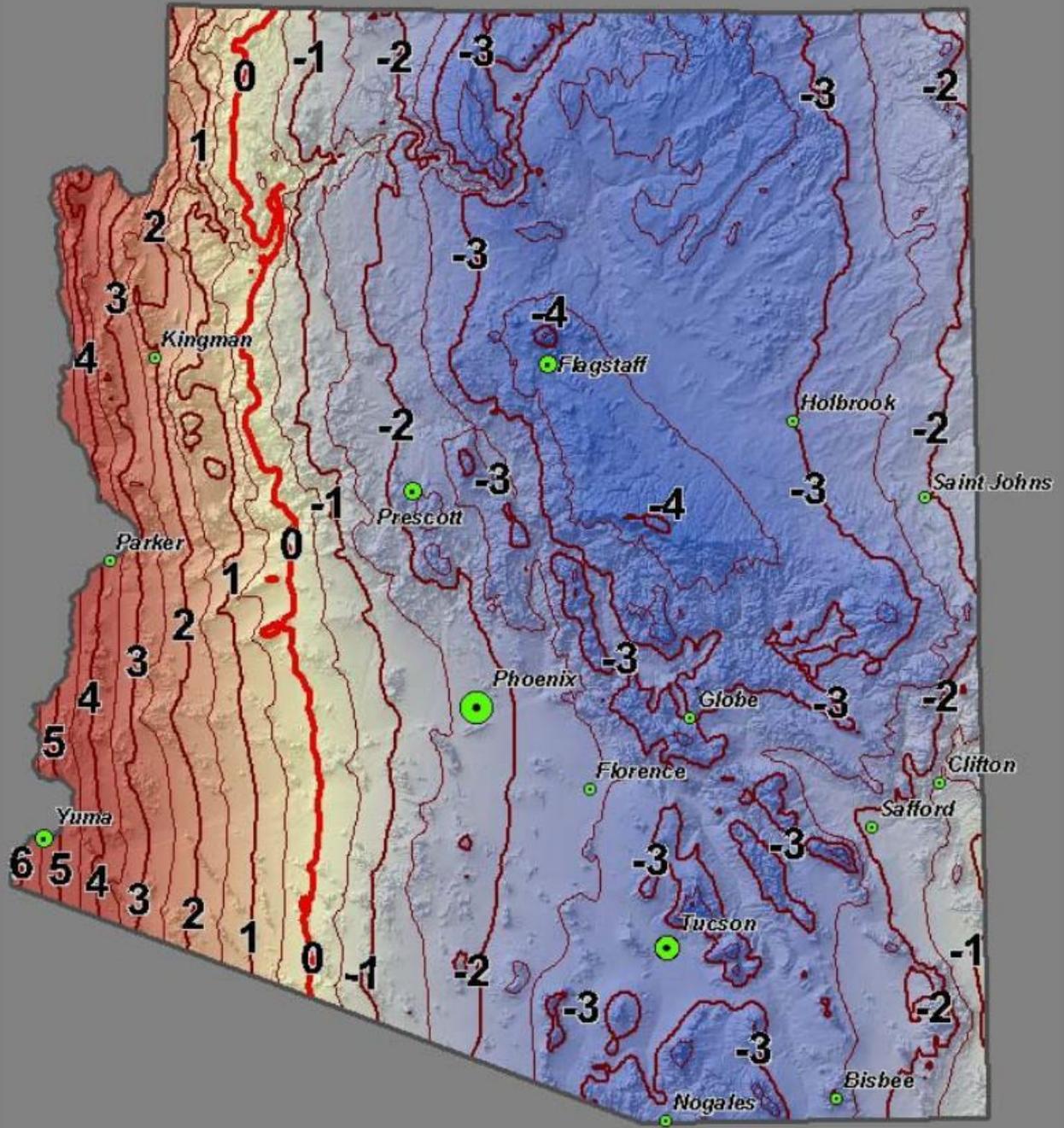
State Plane (AZ Zone C) "linear distortion" (parts per million)

1 ft/mile
= 189 ppm

1 ppm
= 0.005 ft/mi
= 1 mm/km

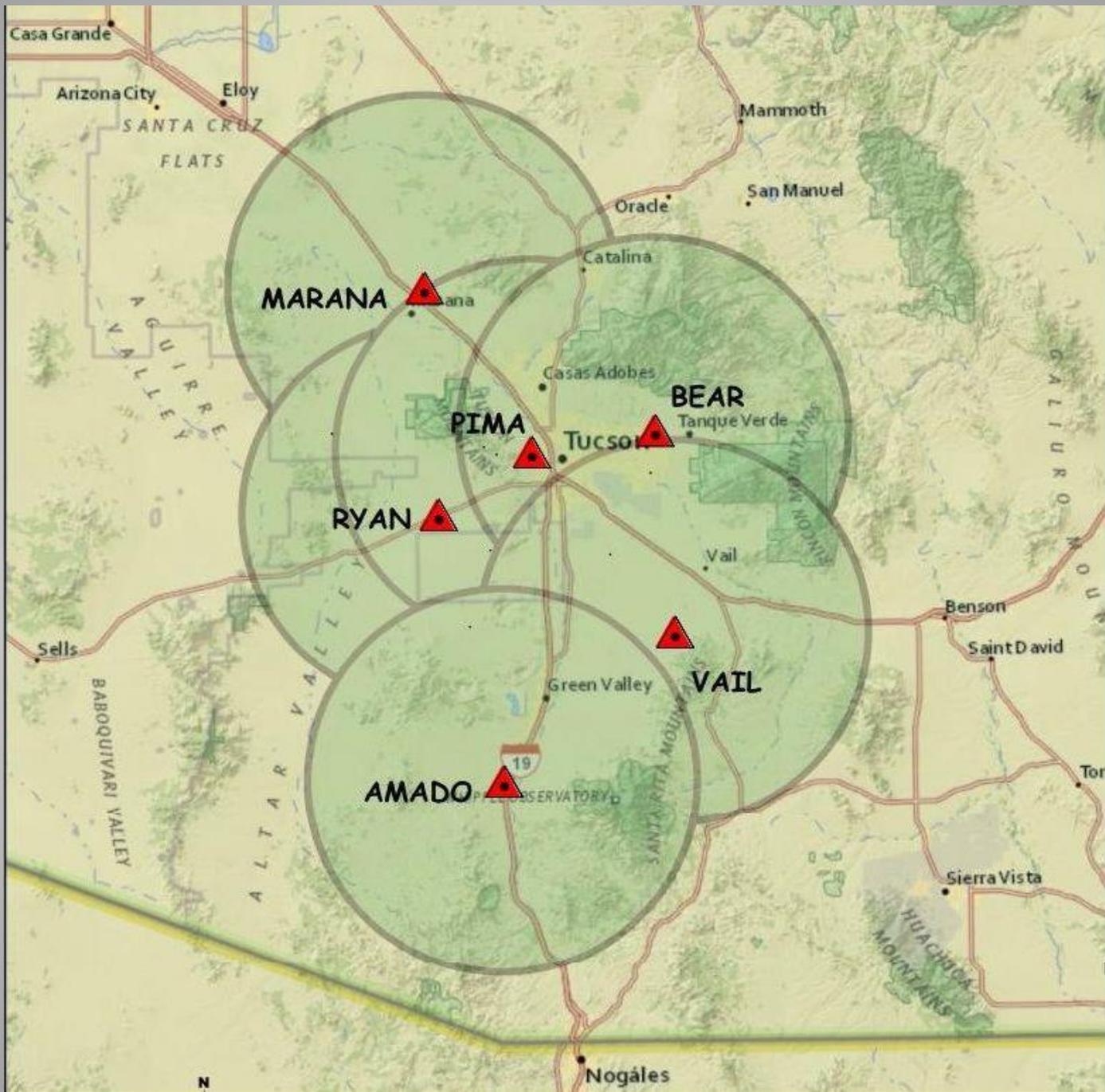


UTM (Zone 12 North) "linear distortion" (feet/mile)



Where are we going?

- Passive control is becoming obsolete
- NGS moving to a GNSS based system
- AZCORS now fully operational in Pima Co.
- New national datum coming:
 - New horizontal datum by 2022
 - New vertical datum by 2018
- Location technology seeing wider adoption and importance



How do we get there?

- Adopt a Low Distortion Map Projection
 - Reduces map distortion
 - No more grid/ground scaling issues
 - Works well with GIS
 - Buffer from future datum realizations
 - Provide consistent framework for cadastre
 - Improved local continuity

LDPs – Who wants them and why?

- Engineers & Surveyors use them daily
- The value of a GIS increases directly as a function of its accurate portrayal of items of interest
 - Local govt. GIS managers are realizing the benefits of incorporating as-builts and COGO
 - Better decision support from the GIS
- There is virtually no “cost” to using them
 - “On-the-fly” re-projection is a reality
- Standard Projections are not good enough for local GIS
 - UTM distortion is 1:2,500 (2.1 ft per mile)
 - SPC distortion is 1:10,000 (0.5 ft per mile)
 - But in both cases distortion at ground usually much greater

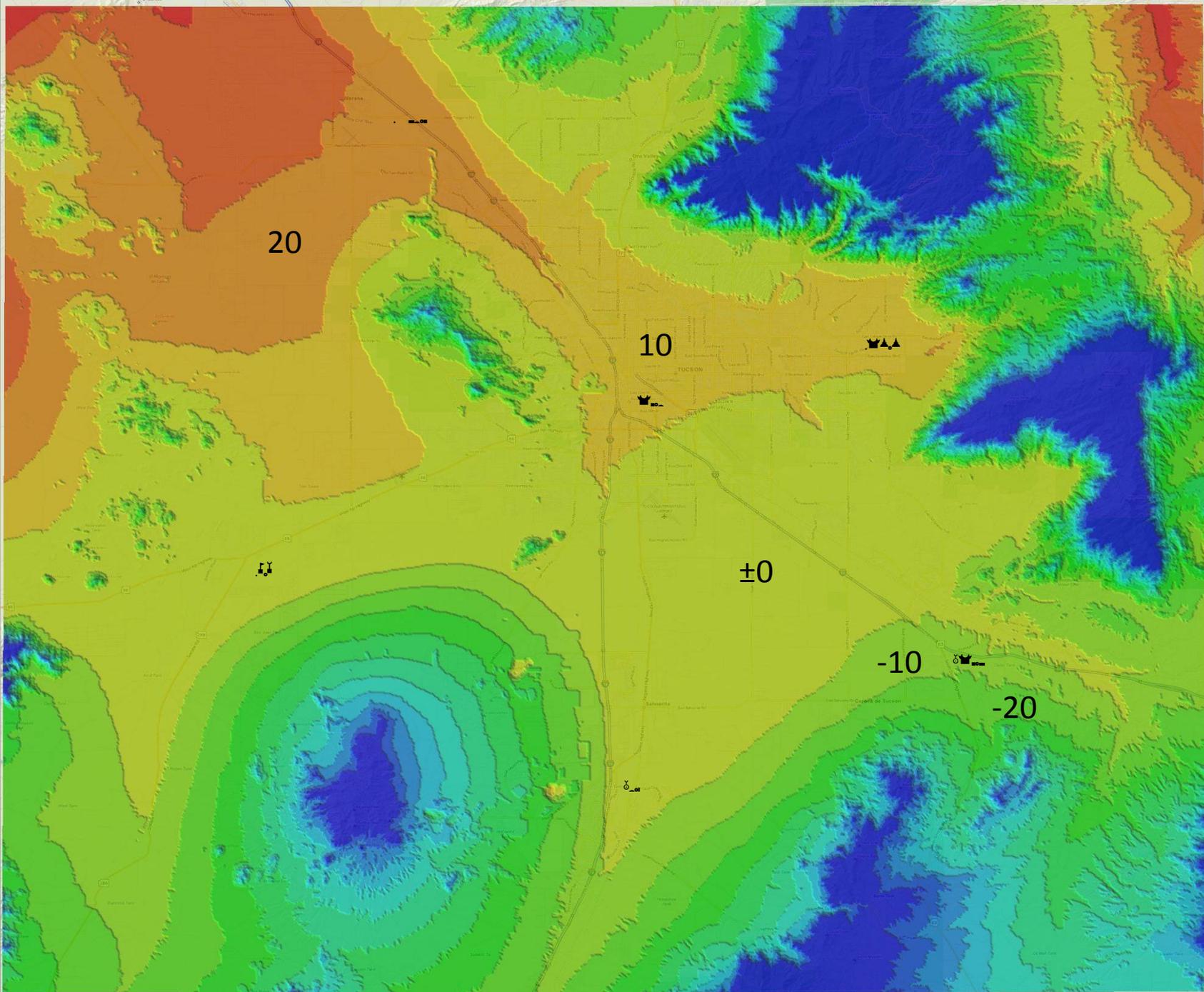
LDPs – Who's Using Them?

- Cochise County
 - ✓ One of the first to require use of LDP for maps & plats
 - ✓ Their GIS parcel layer was built on record documents and real PLSS data, i.e. no rubber sheeting or scaling
- Maricopa County
- Gila County
- Navajo Nation
- State of Oregon
 - ✓ They have 8 different LDP's across the state

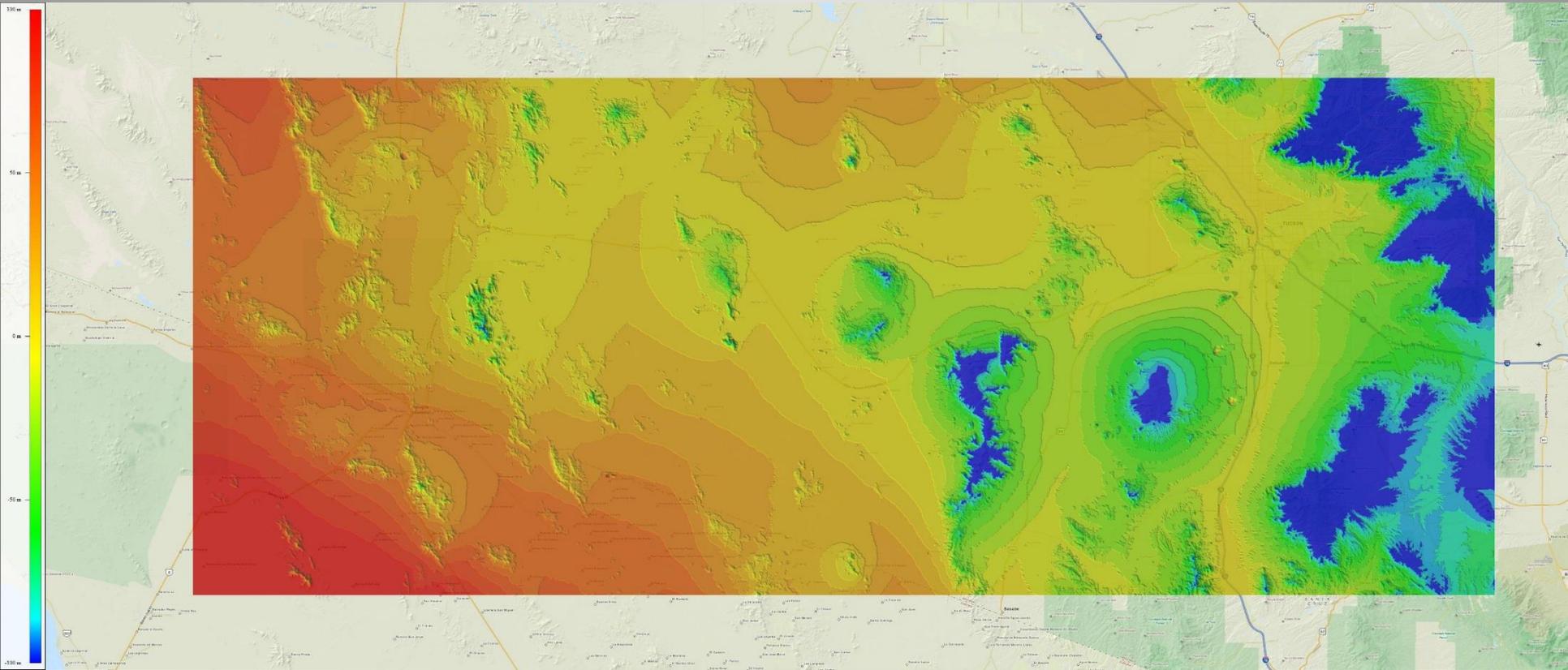
The Metro Pima Low Distortion Map Projection

Projection Definition

Datum:	NAD83(2011)
Projection Type:	Transverse Mercator
Ellipsoid:	GRS80
Latitude of Grid Origin:	32° 00' 00" N
Central Meridian:	111° 10' 00" W
False Northing:	200,000
False Easting:	500,000
Grid Scale Factor:	1.00012
Linear Unit:	International Feet



Entire County in LDP



Projection type: Lambert Conformal Conic 1-parallel
Standard parallel: 32°10'00.0"N (32.166666666667)
Latitude of grid origin: 32°05'00.0"N (32.083333333333)
Central meridian (grid origin): 111°30'00.0"W (-111.5)
Datum: D_NAD_1983_2011

False northing: 500000.0 ft
False easting: 1000000.0 ft
Linear unit: International Feet
Grid scale factor: 1.0001
Ellipsoid: GRS_1980

2010 NAIP Image







State Plane Bearing & Distance along South line SE ¼ Sec. 7



S 89° 41' 06" E 2646.15'

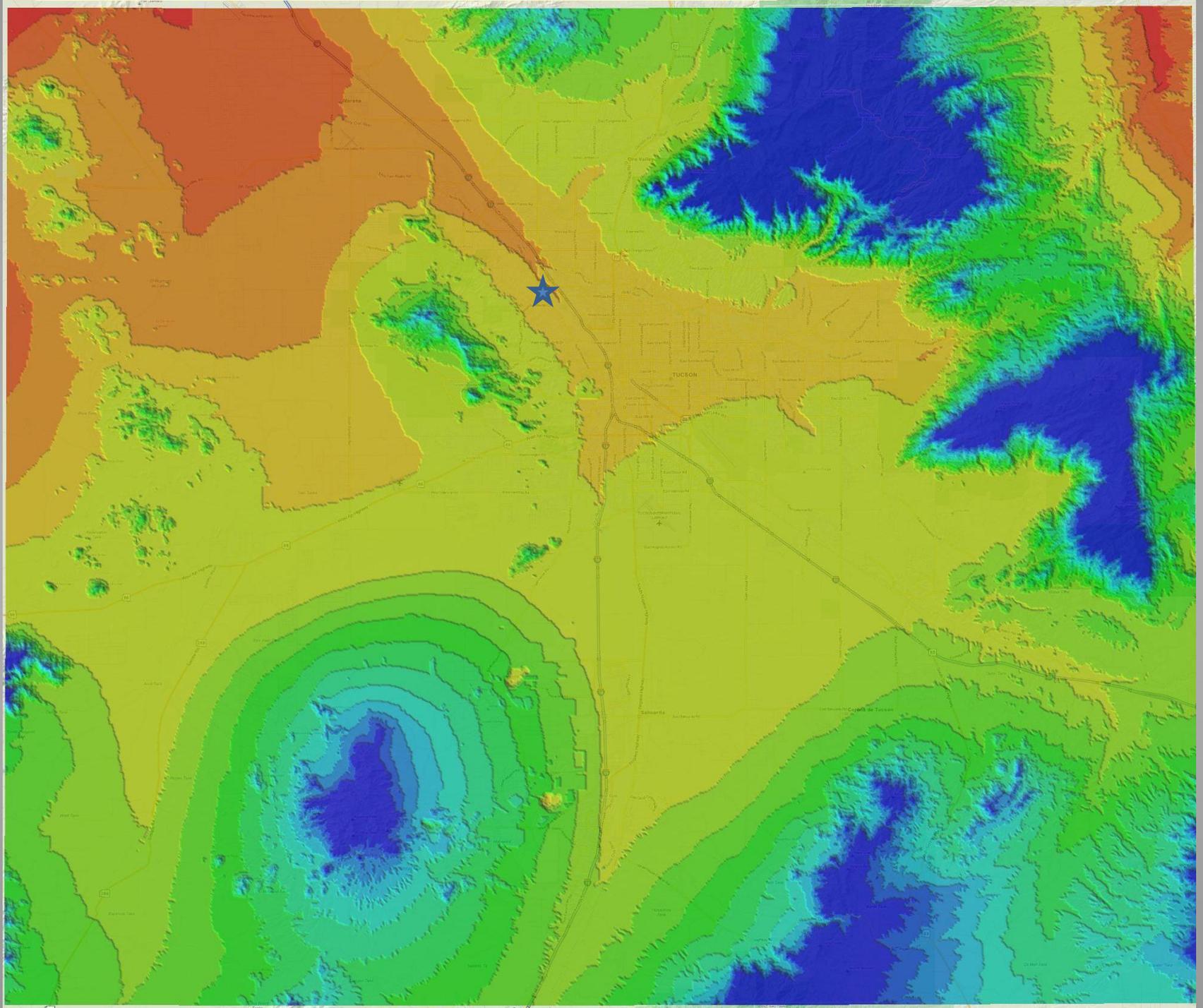
$2646.15' \times 1.00012 = 2646.47'$ scaled by SPC Combined Factor

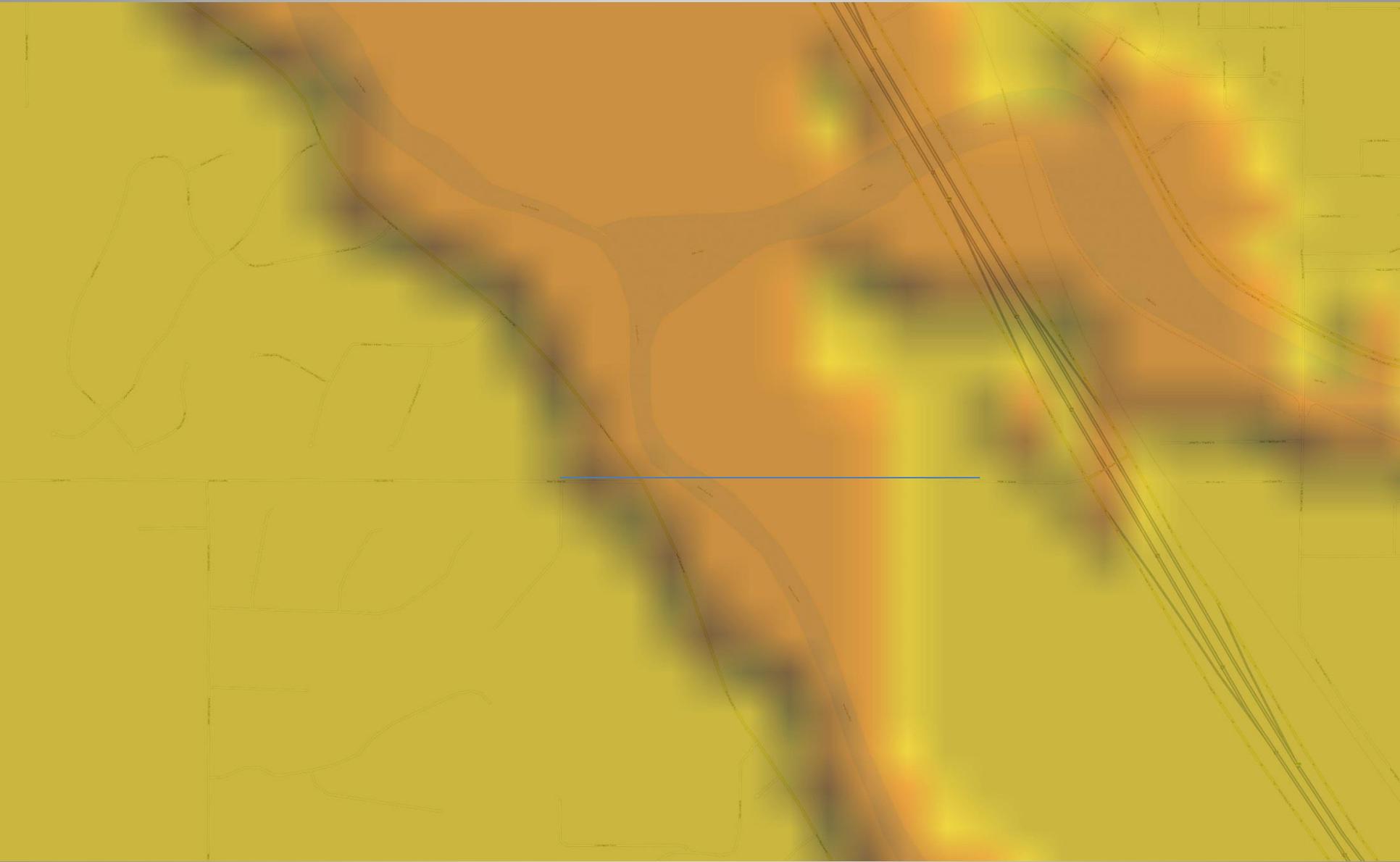
Pima LDP Bearing & Distance along South line of SE ¼ of Sec. 7



S 89° 54' 51" E 2646.52'

$$2646.52' - 2646.47' = 0.05' \text{ or } \approx 19\text{ppm}$$





... and they all measured happily ever after.

The end.

CREDITS

Michael Dennis (our own LDP guru)

All the great folks at National Geodetic Survey

LDP Design <https://geo.ldpdesign.com/>

You can contact me at pmcgarrity@psomas.com if you would like to get the Pima LDP projection (.prj) file for you own use.