Geoscience Day
Surveying and Positioning

Presenter: Michael Barnes, Cain & Barnes LP
Barnes, Conner, Stigant & Young

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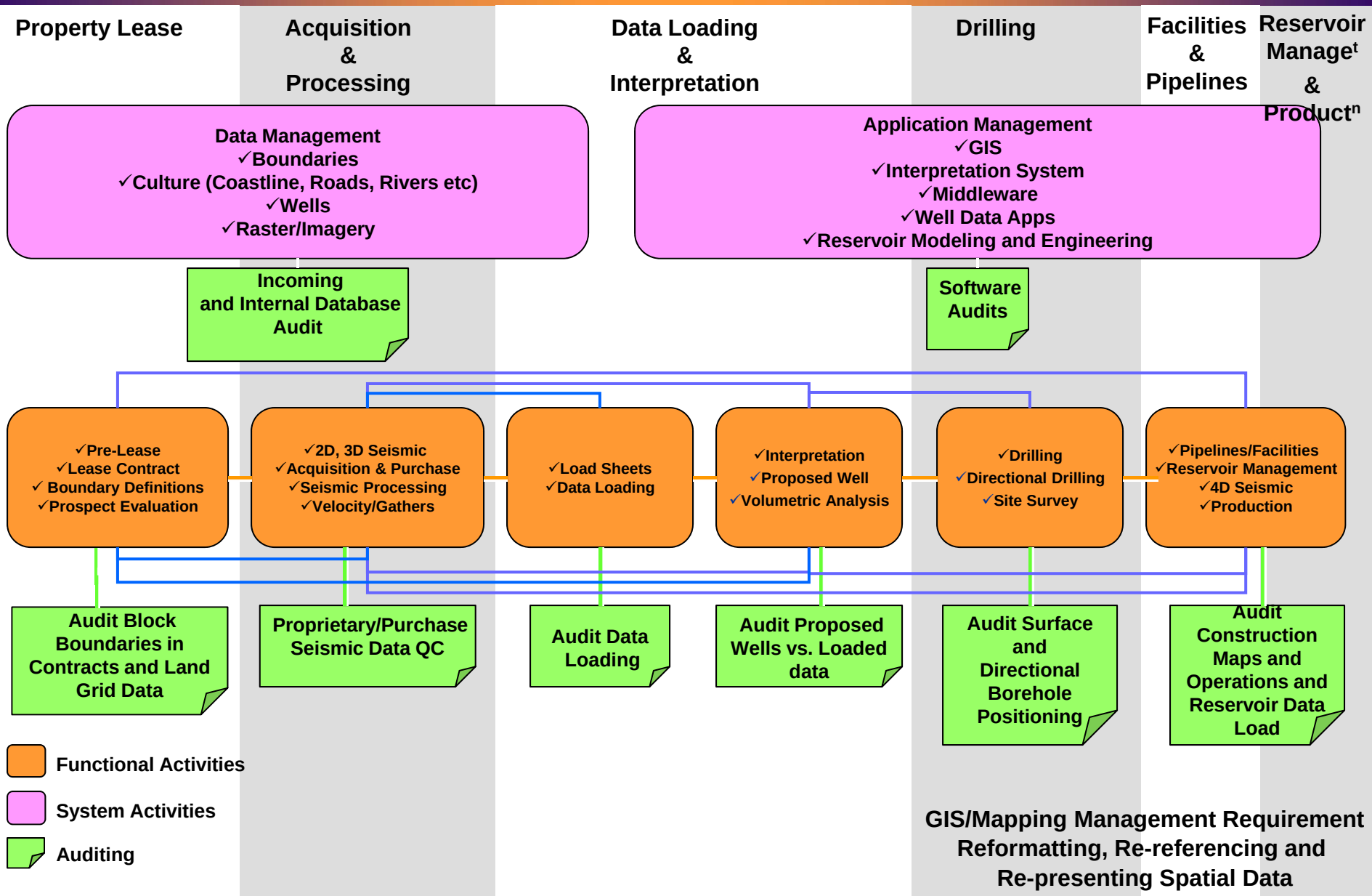
ESRI PUG February 2007

- Finding and producing hydrocarbons
  - Mapping Sciences
  - Making and Communicating with Maps
  - Data Sources and Software Applications
  - Education
  - Audit/Review of mapped data
  - Holistic Approach

= Enterprise Wide Spatial Data Management

Summary '30,000 Ft' Spatial Workflow



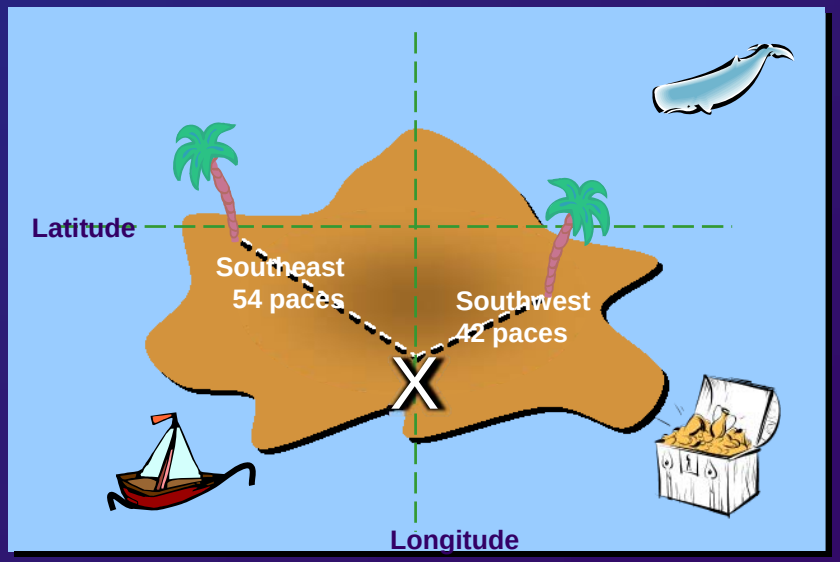
Audit/Review of mapped data

- 50% of all surface well locations from industry sources are wrongly mapped by over 100ft and often as much as 500ft and many of them contain no vertical data
- 25% of all directional survey data are wrongly mapped by over 500ft in 3 dimensions
- 16% of all seismic data loaded in workstations for interpretation have significant disagreement in spatial data between components
- All versions of the Texas Land grid have problems that are manifested, so far in the mapped boundary placement of the units, mineral tracts and any feature placed in relation to them, such as well spots

Mapping – Some Concepts

Location, Location, Location

Treasure Island



My Motto

Find it!

Know You Own It!

Fact

Petroleum Industry is Location Dependent!

Principle vs. Technique – A Revolution!

Mapping Principles/No Change

- Understanding **Geodesy** is the **foundation** of all good surveying and maps
- **Cartography** describes the mapping science

Technique/Revolutionary Changes

- **GPS** is the **survey utility** of the 21st century
- **GIS** is the **mapping utility** of the 21st century
- Over 75% of our data is spatially referenced, whether we know it or not!

Bottom Line - Doing it right the first time can save our Industry millions of dollars

Principle vs. Technique – A Revolution!

Mapping Principles/No Change

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Technique/Revolutionary Changes

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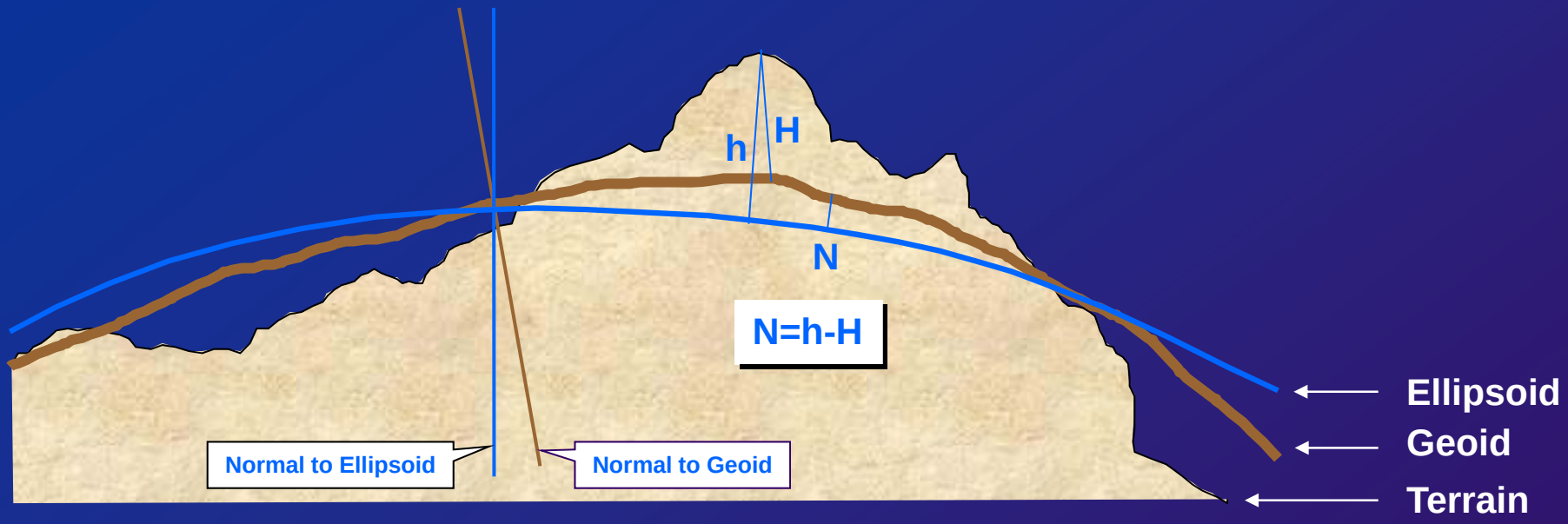
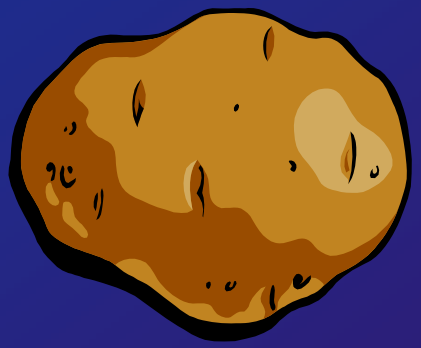
The corollary is also true!

Overview – Tale of Two Models!

Geodetic/Cartographic Model
Organizational Model
Some Ideas

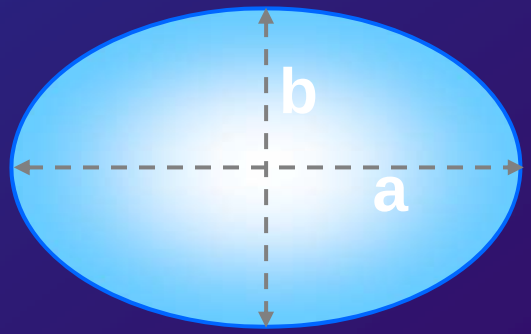
Geodesy Reference Surfaces





Geoid

Equipotential surface which approximates to MSL



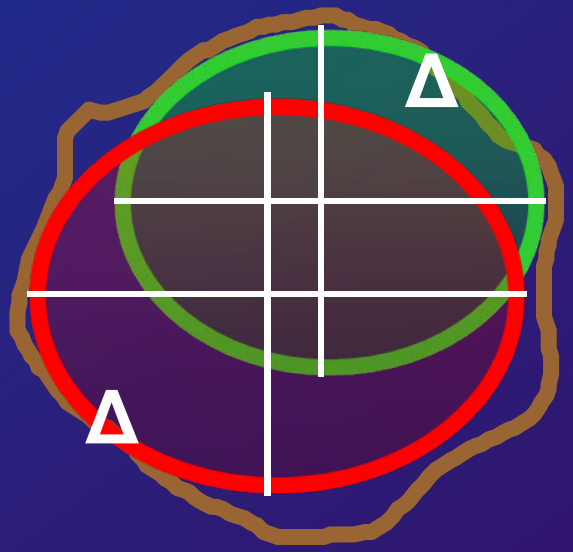
Ellipsoid

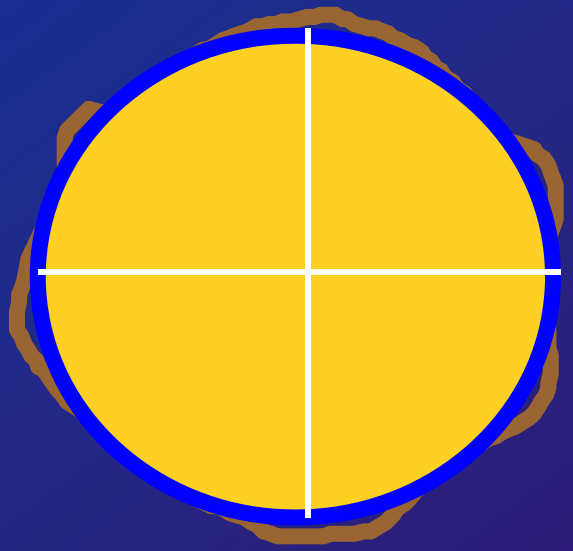
Surface where Computations are made
$1/f = a/(a-b)$

Datum Relationships

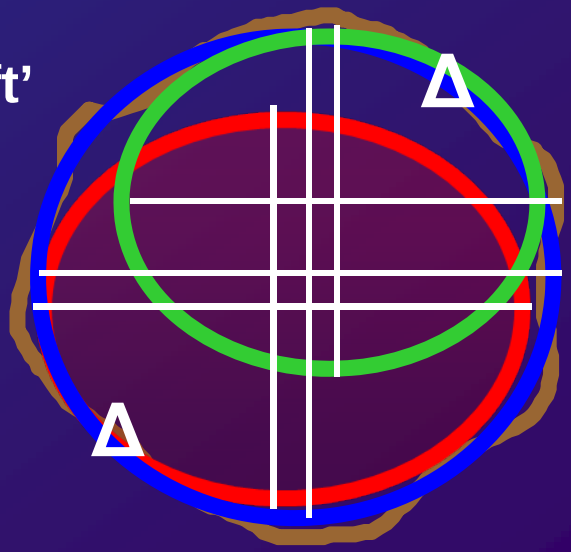
Geoid

Green and Red
Ellipsoid
Regional Datums



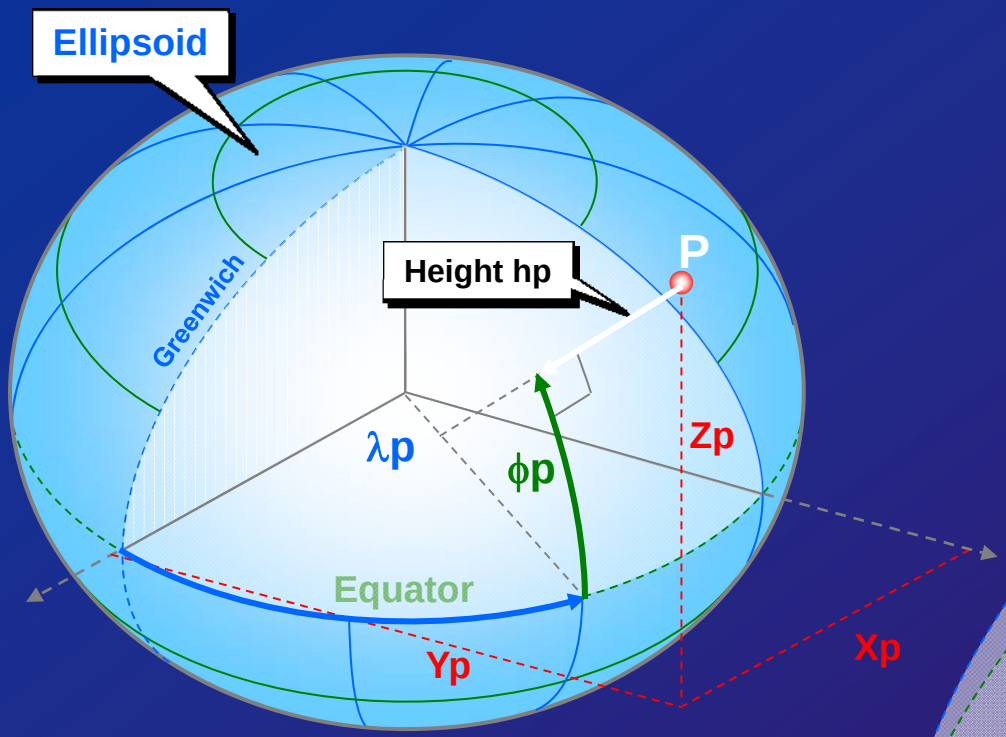


Need ‘Datum Shift’
to transform
between datums



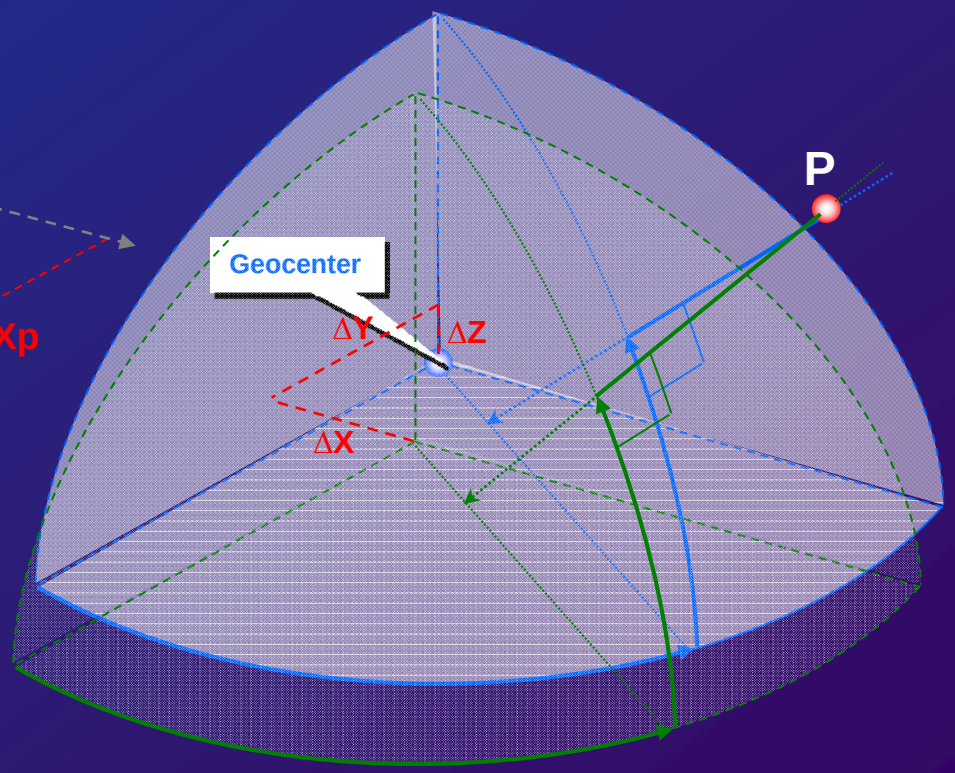
Blue Ellipsoid
Global Datum
(Satellite)

Geodesy Datum Shifts



Ellipsoid A (Global Datum)

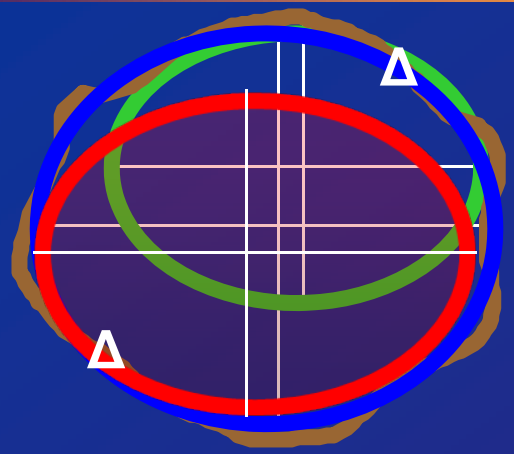
Ellipsoid B (Regional Datum)

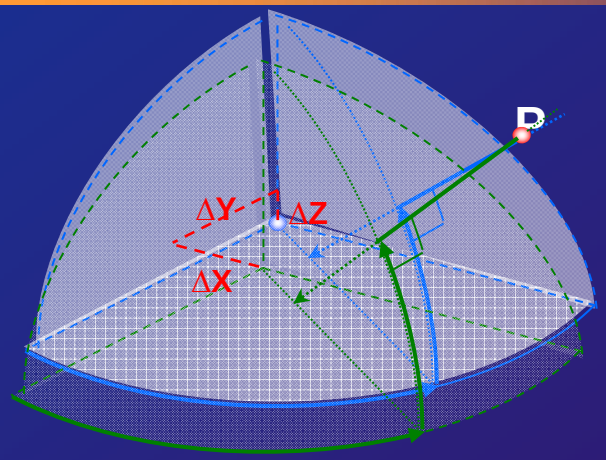


If the geographical area is small, then

$$\begin{bmatrix} X_g \\ Y_g \\ Z_g \end{bmatrix} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + \begin{bmatrix} X_b \\ Y_b \\ Z_b \end{bmatrix}$$

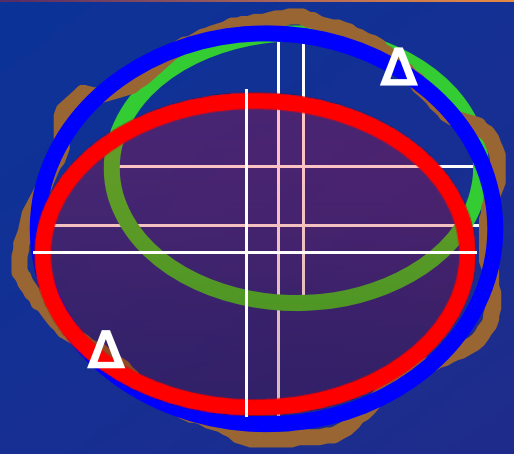
Mixing Projections - Brazil Example

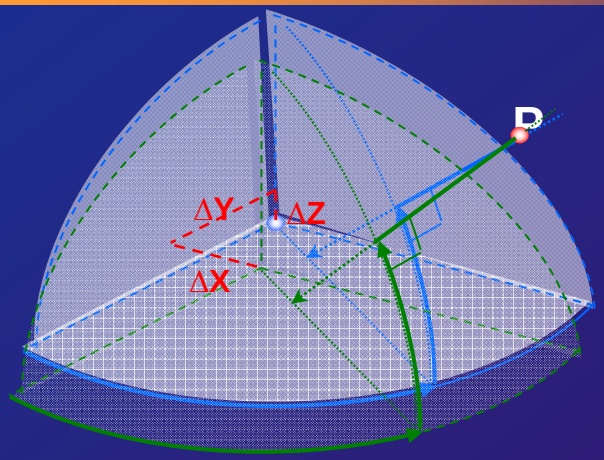




Datum	Latitude	Longitude	Local to WGS84	Local to Local
Aratu	20º 36’ 13.2757”N	38º 56’ 56.3341”W	236.7 meters	220.56 meters
SAD69	20º 36’ 17.4283”N	38º 56’ 50.1240”W	65.12 meters	
WGS84	20º 36’ 19.2794”N	38º 56’ 51.2166”W		
Datum	**Easting UTM 24S**	**Northing UTM 24S**	**Local to WGS84**	**Local to Local**
Aratu	505,316.4	2,278,317.4	214.7 meters	208.8 meters
SAD69	505,495.9	2,278,424.1	58.4 meters	
WGS84	505,464.2	2,278,473.1		

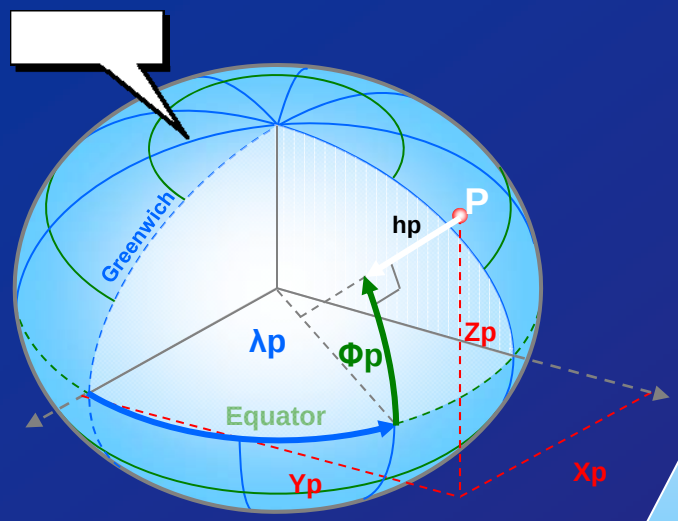
Mixing Projections - Brazil Example





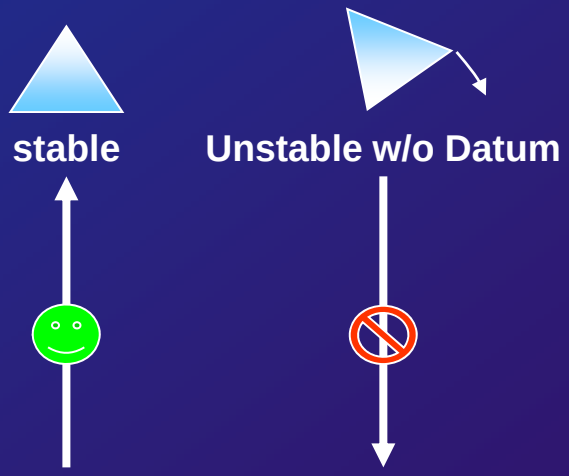
- This example showed coordinates of the SAME physical point
- Corollary: The same coordinates can represent different points depending on the reference origin (datum).
- 50% of purchased well data are not associated with a reference datum.

Hierarchy of Mapping

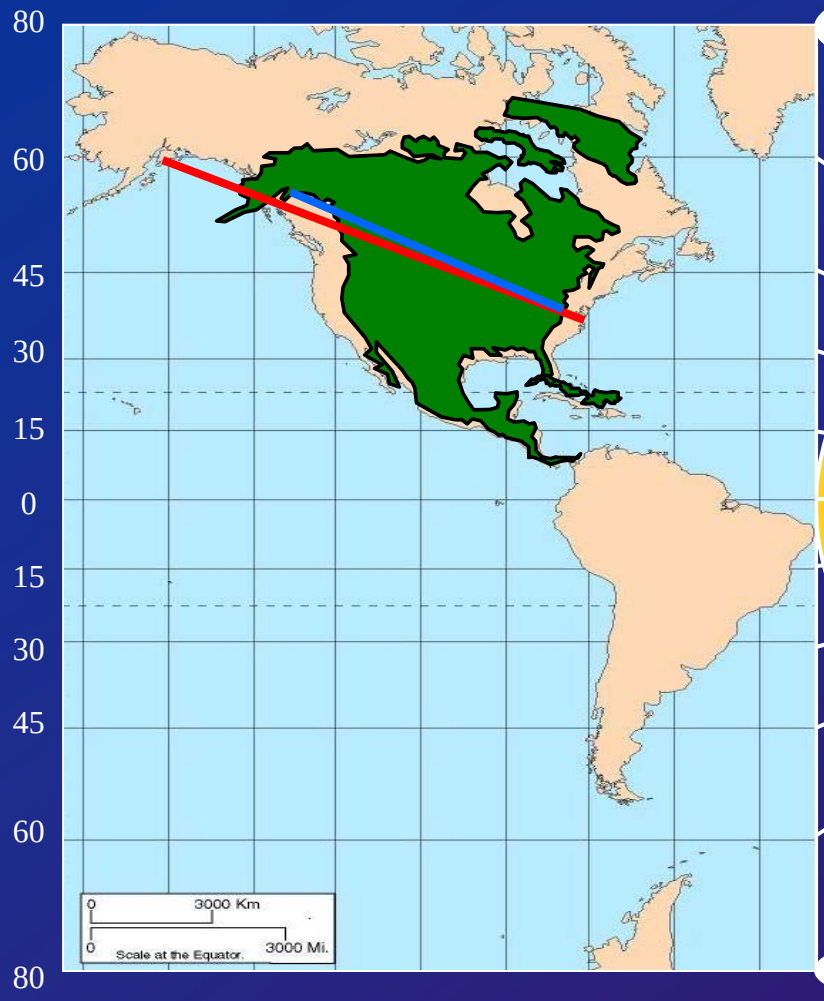


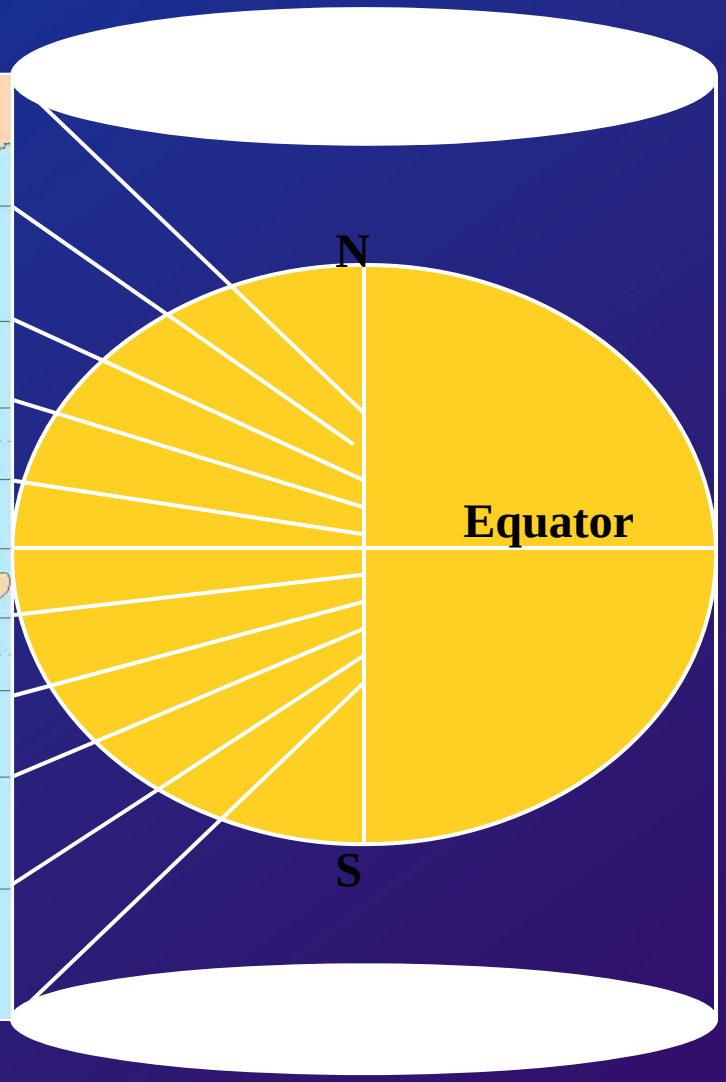
Projected CRS
is a derivative
of the Datum
(Geog CRS)
Easting, Northing,
Elevation (above MSL)

Datum (includes ellipsoid)
is the Foundation
X,Y,Z Cartesian and Lat Long, Ht



Mercator Projection - Distortion





Scale Distortion (N:1)

[1/cos(lat)]

0 °	1
48 °	1.5
60 °	2
71 °	3
76 °	4
80°	6

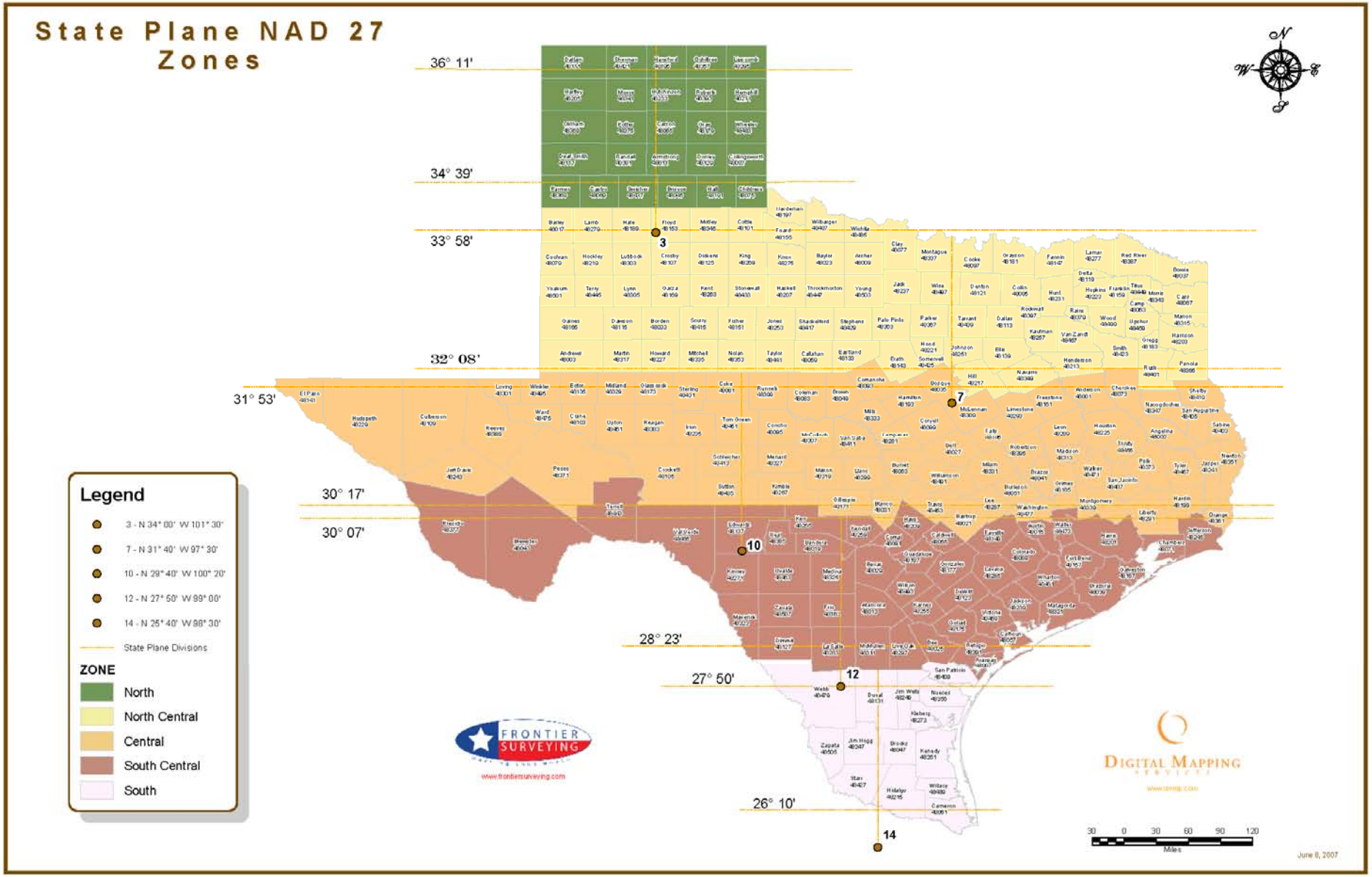
Lines on the ground and Lines on the map have different values to represent the same thing

If you remember nothing else…..

- **Latitudes and Longitudes are not unique unless qualified with datum name!**
- **Projection Coordinates are not unique unless qualified with Projection name, Zone and Datum!**
- **Heights are not unique unless qualified with Surface Reference (Vertical Datum)!**
- **Orientations are not unique unless qualified with Heading Reference!**
- **Units are not unique unless qualified with Unit Reference!**

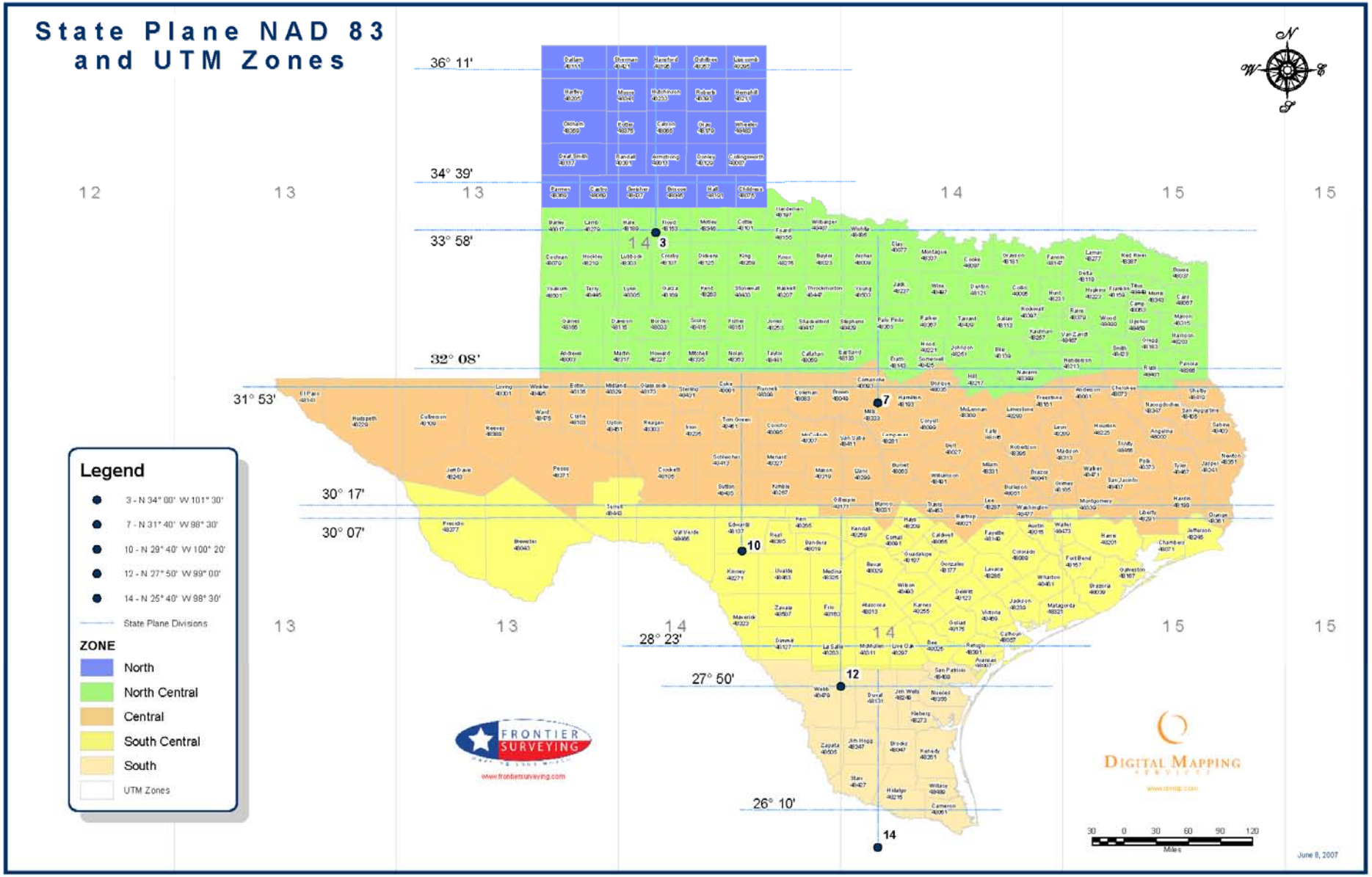
State Plane Zones

North American Datum 1927



State Plane and UTM Zones

North American Datum 1983



6 22 '93

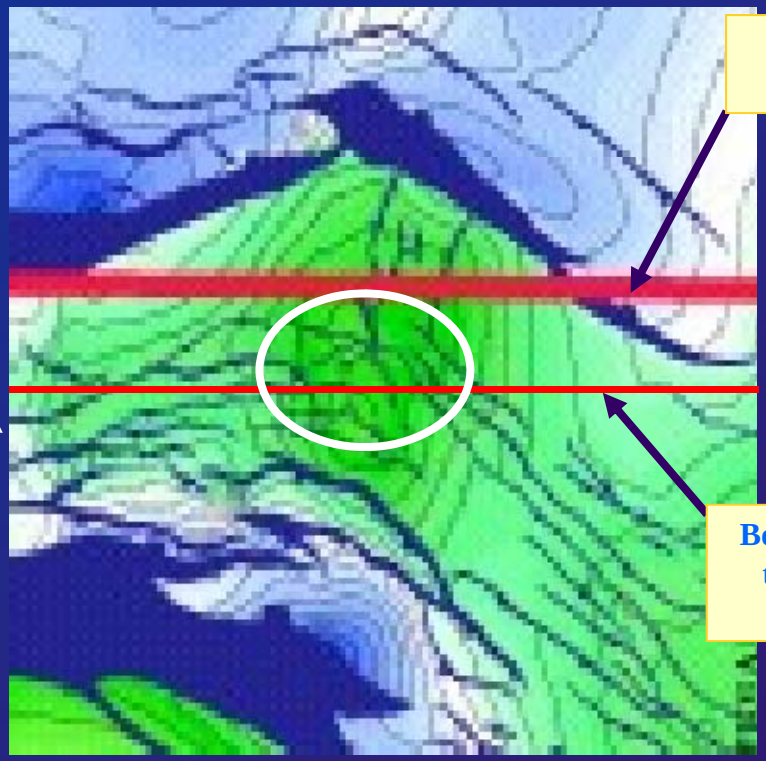
U.S. GENERAL LAND OFFICE SURVEY
PENALTY $250 FOR REMOVAL
19

2 6:12PM

Steriline
FREEDOM
2 4:11PM

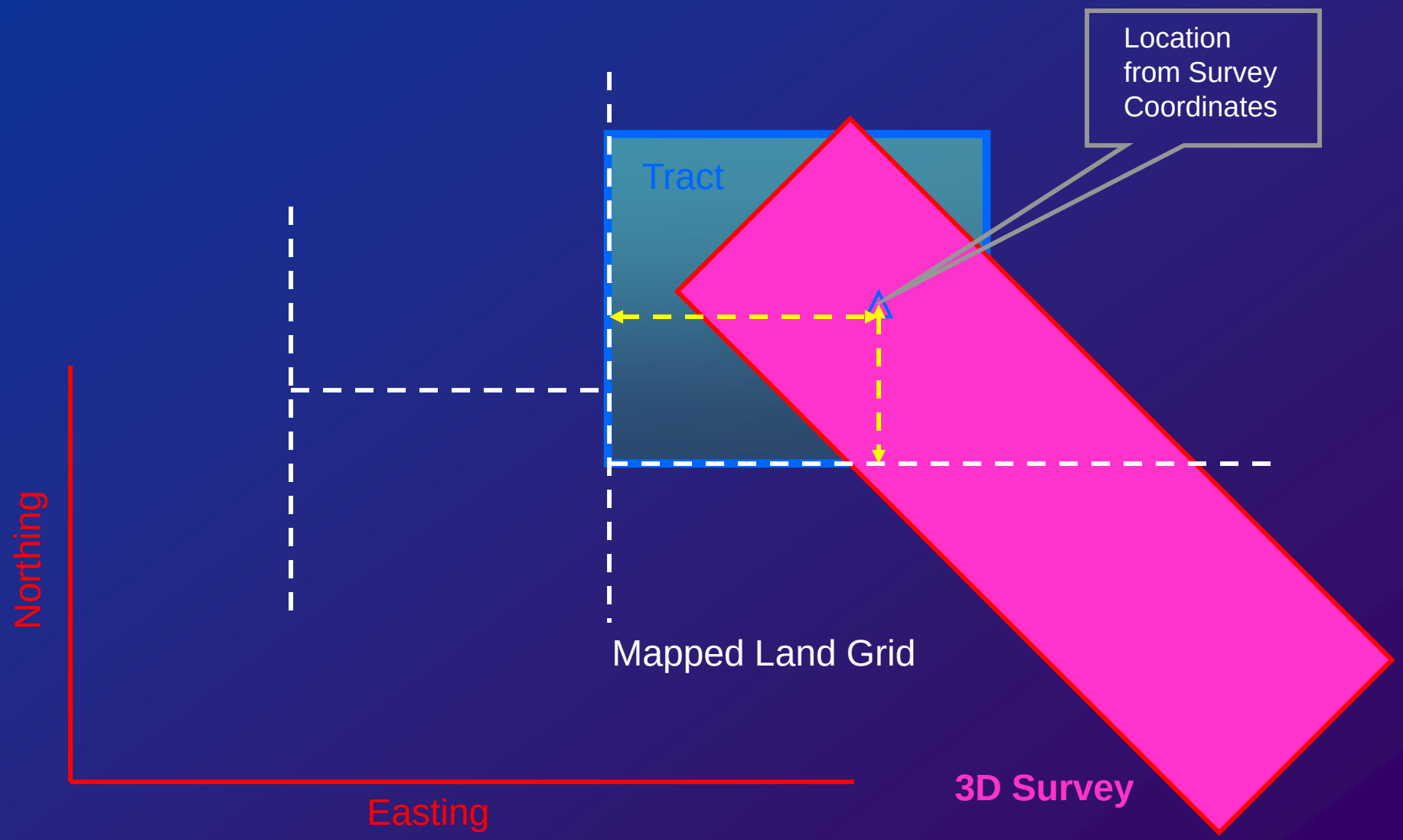
5:28PM

Block Boundary Bust!

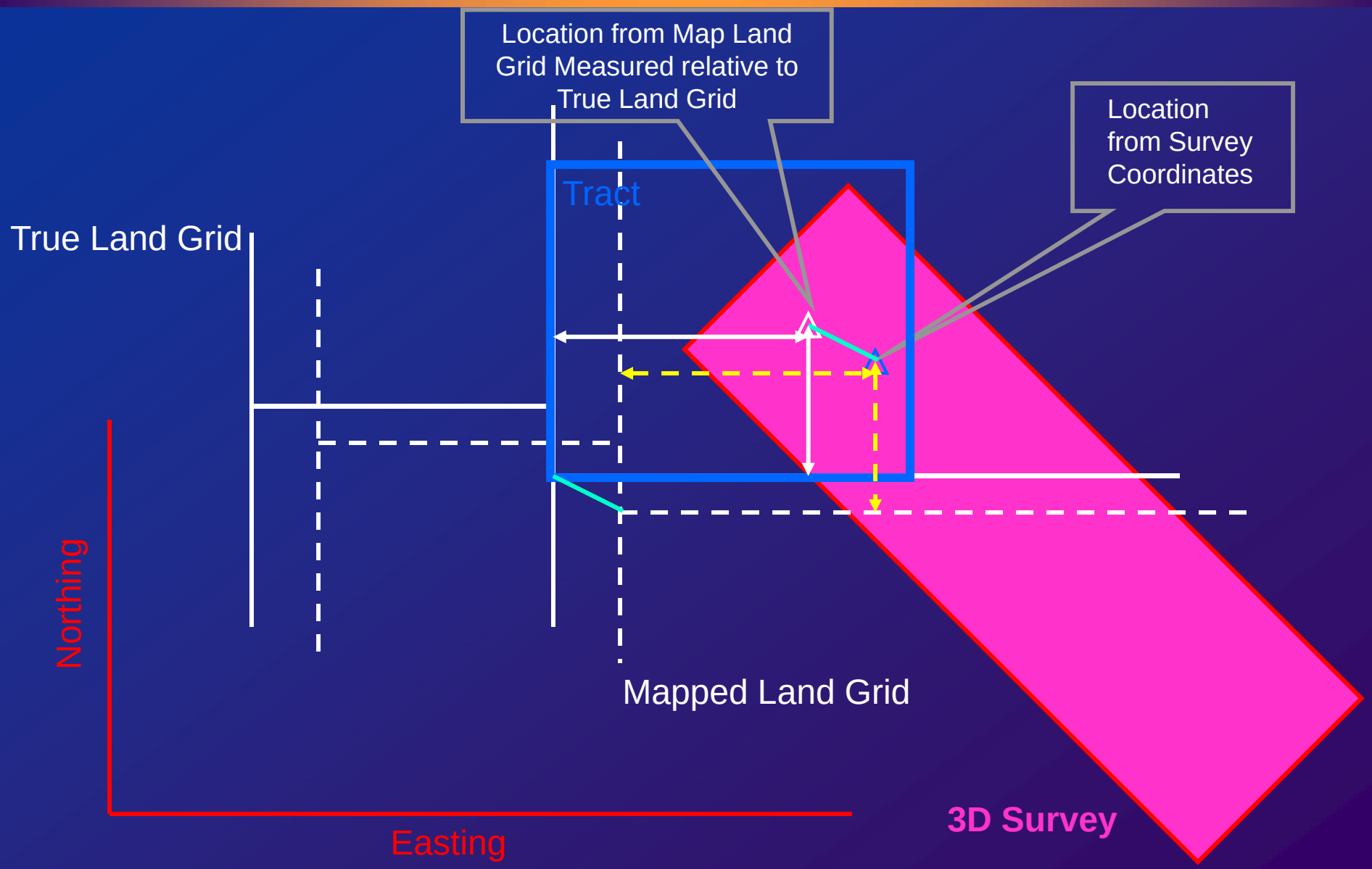


At ~300 barrels per acre foot, this represents about 49 MM barrels per 100 ft of pay in the next door block!

Land Lease Liability

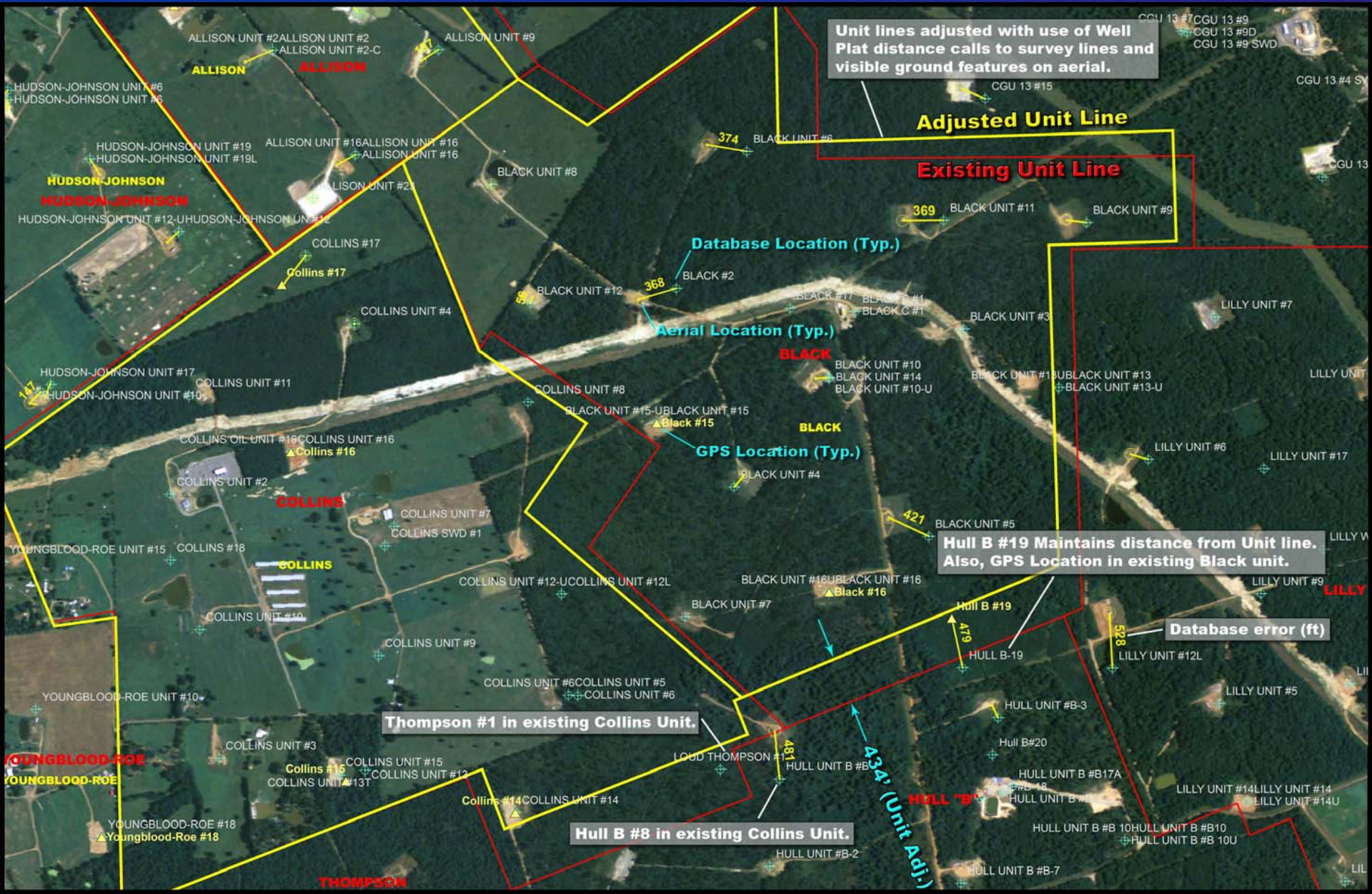


Land Lease Liability



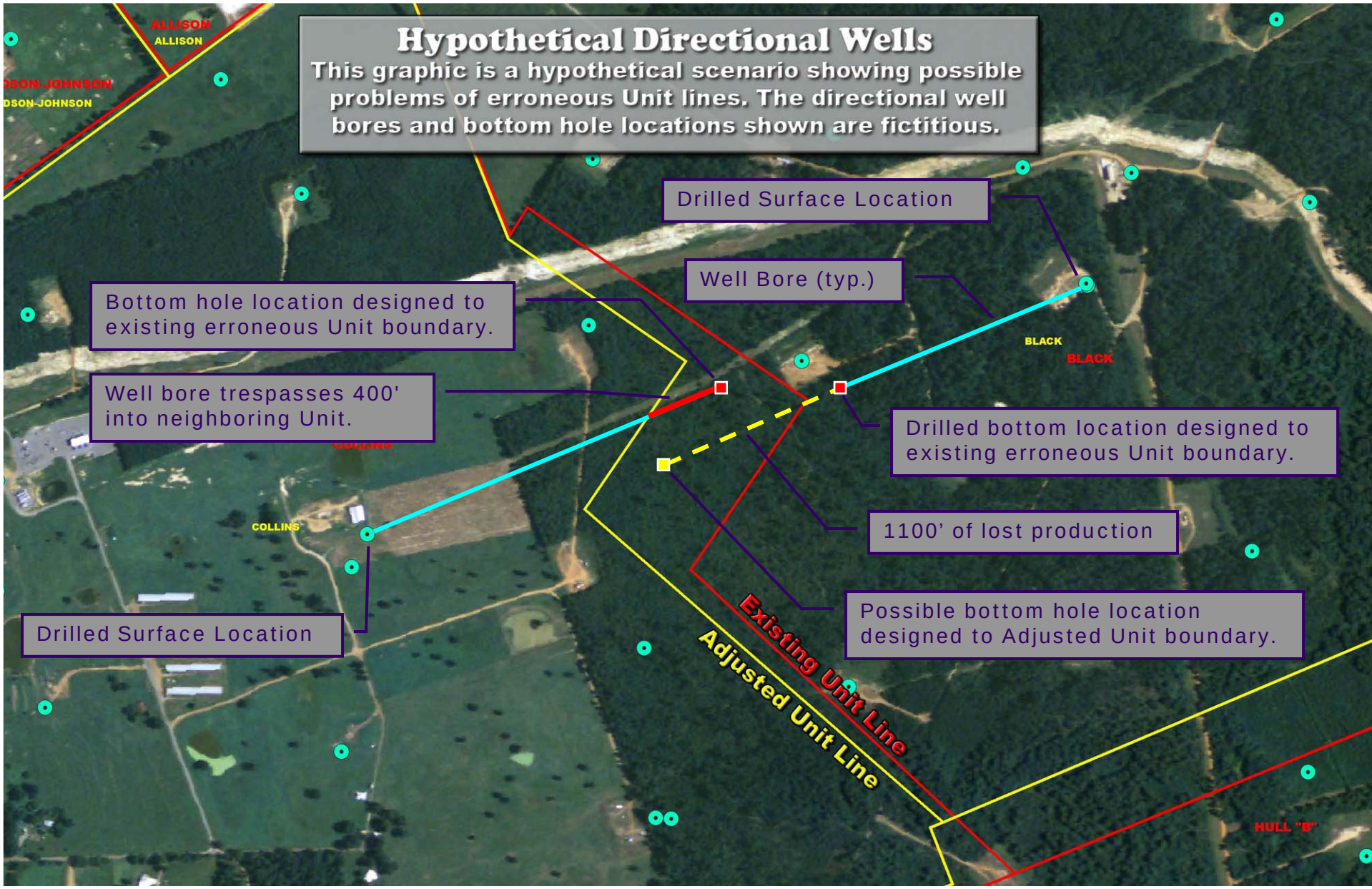
Unit Boundary & Wells

Unit boundary & Well database errors



Hypothetical Directional Wells

Fictional directional wells trespass and loss of production



Double Trouble!

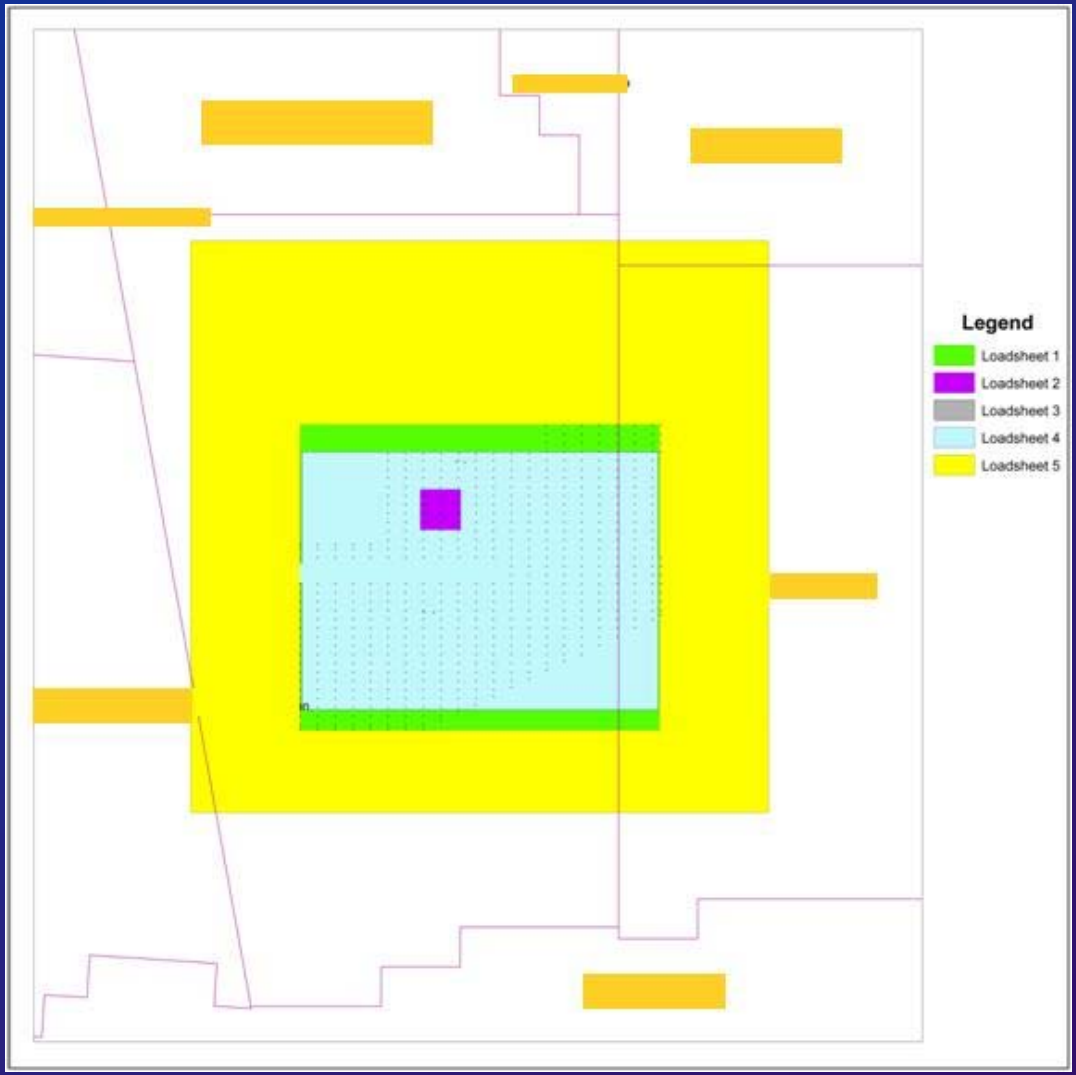
Survey acquired Satellite Datum

Acquisition Contractor transformed Navigation Data to Local Datum

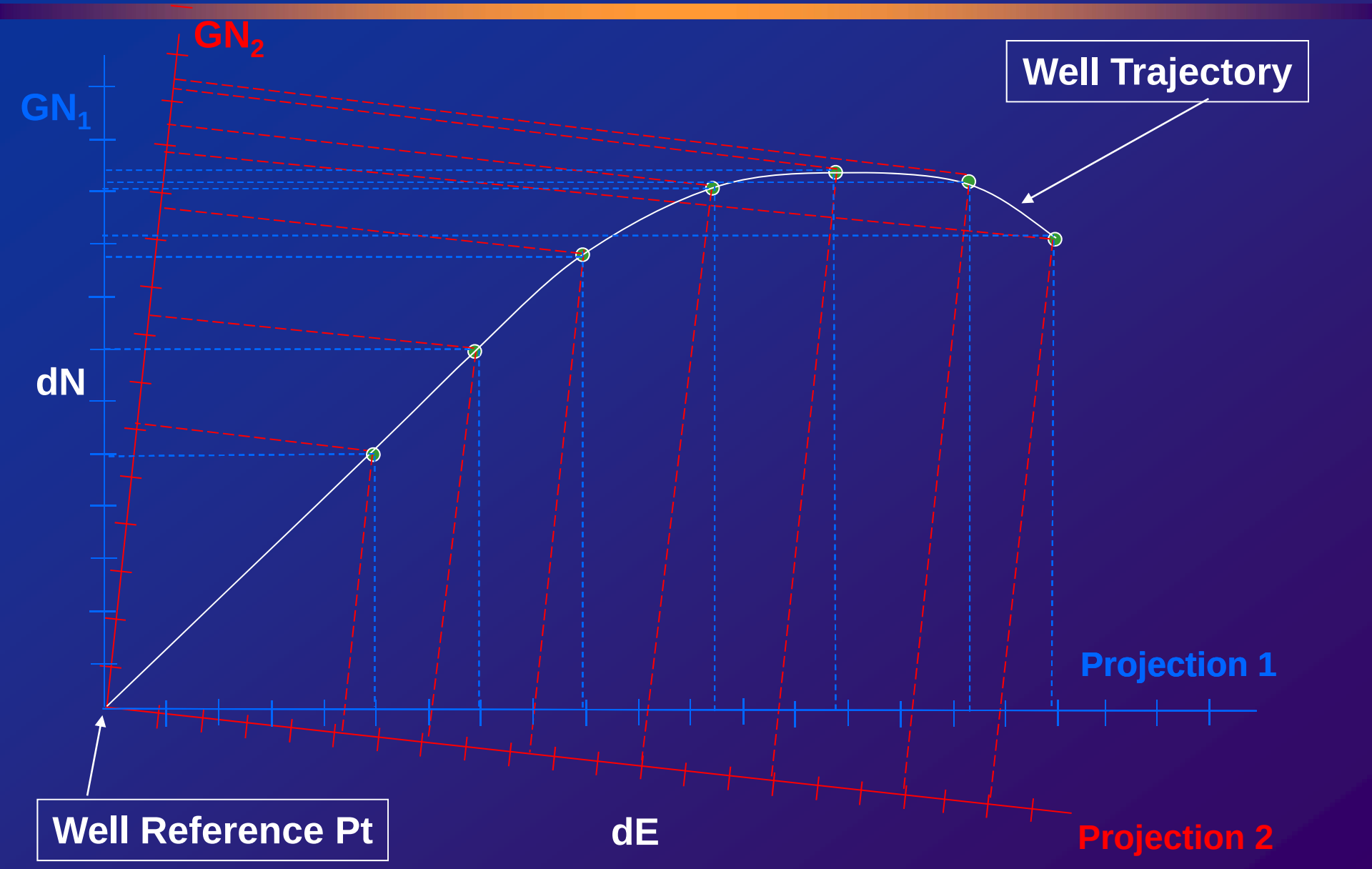
Processing requested acquisition Datum

Retransformed data

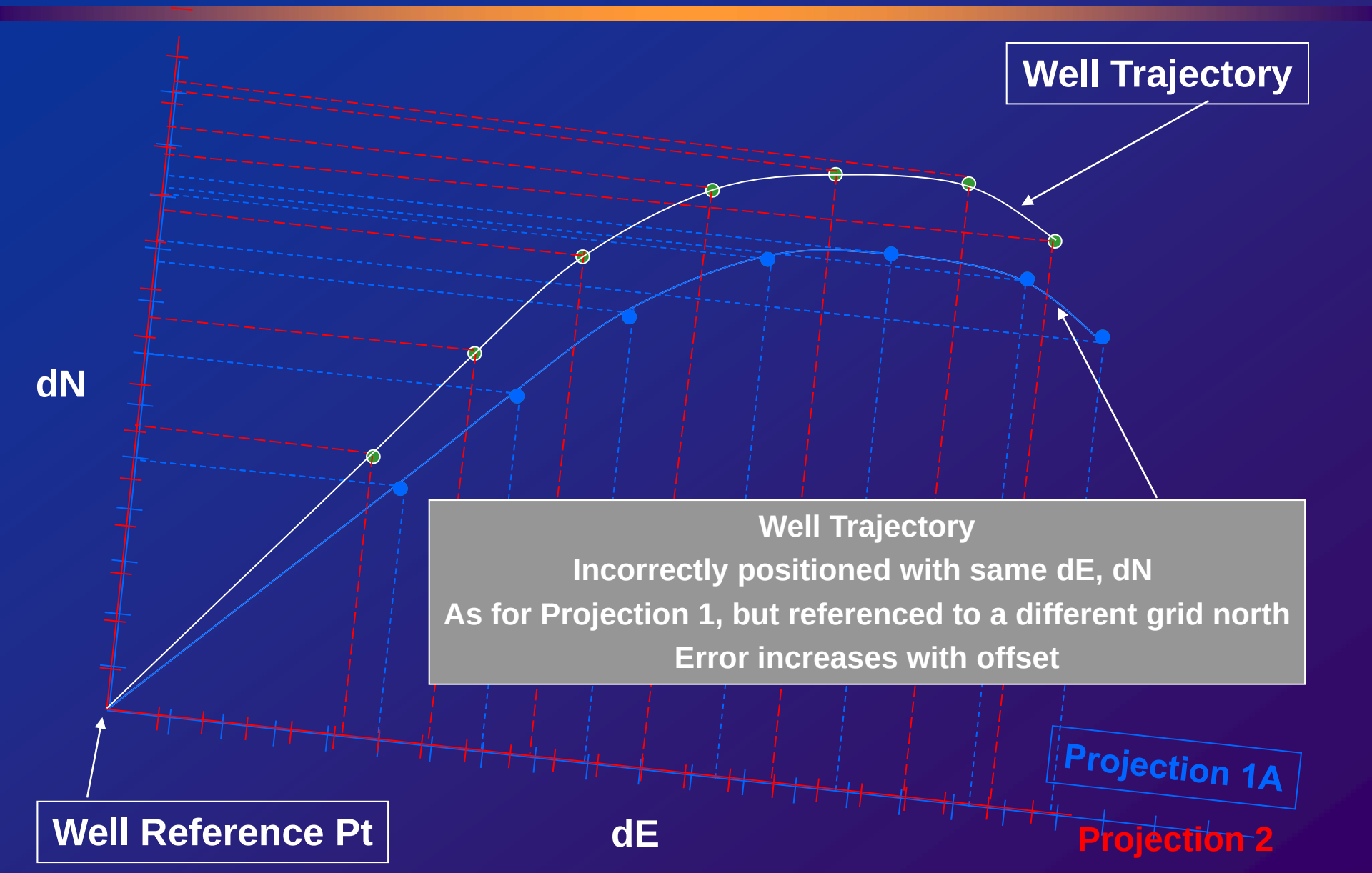
Loading Sheet Lament!



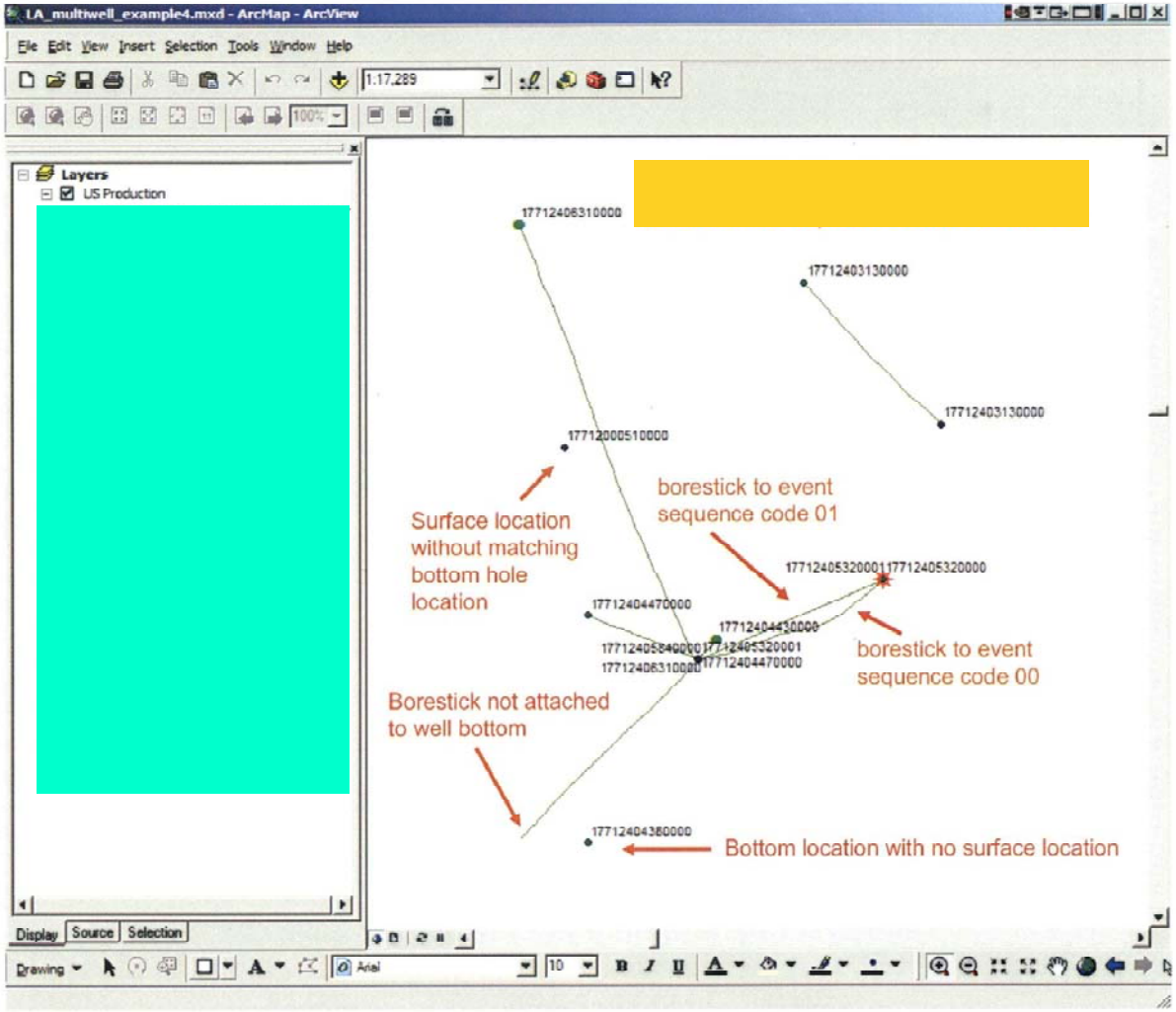
Grid to Grid Transform



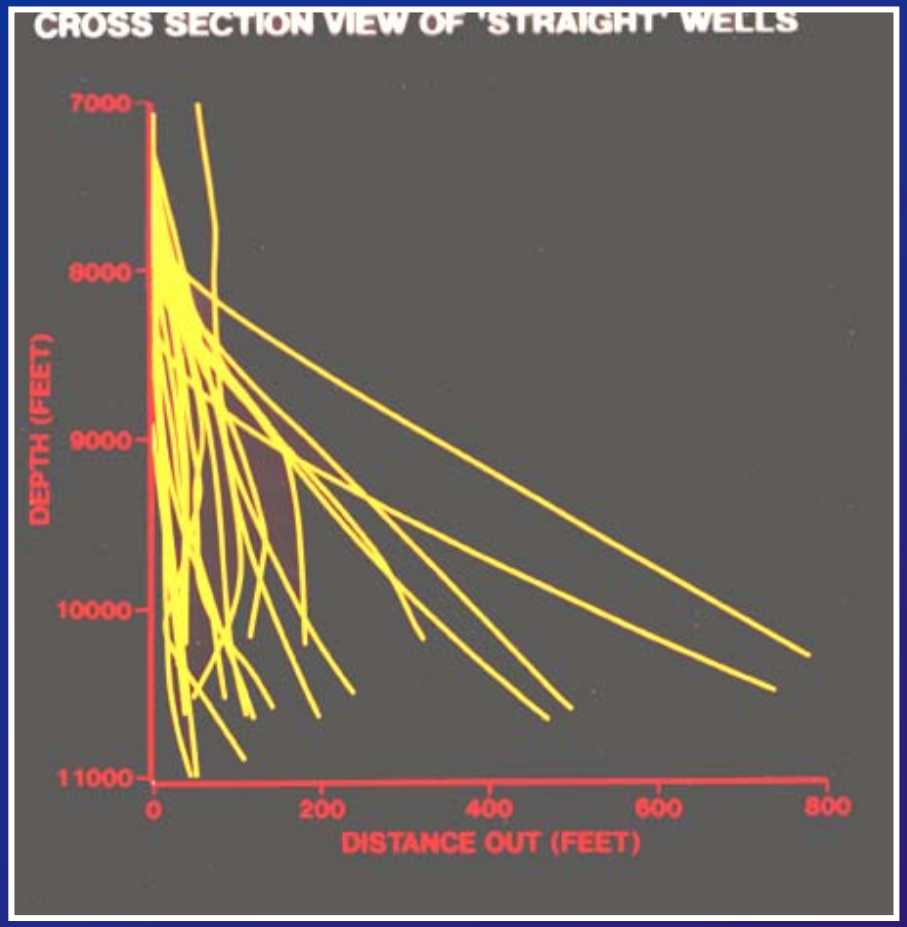
What happens if dE and dN are not adjusted



Commercial Well Location Data



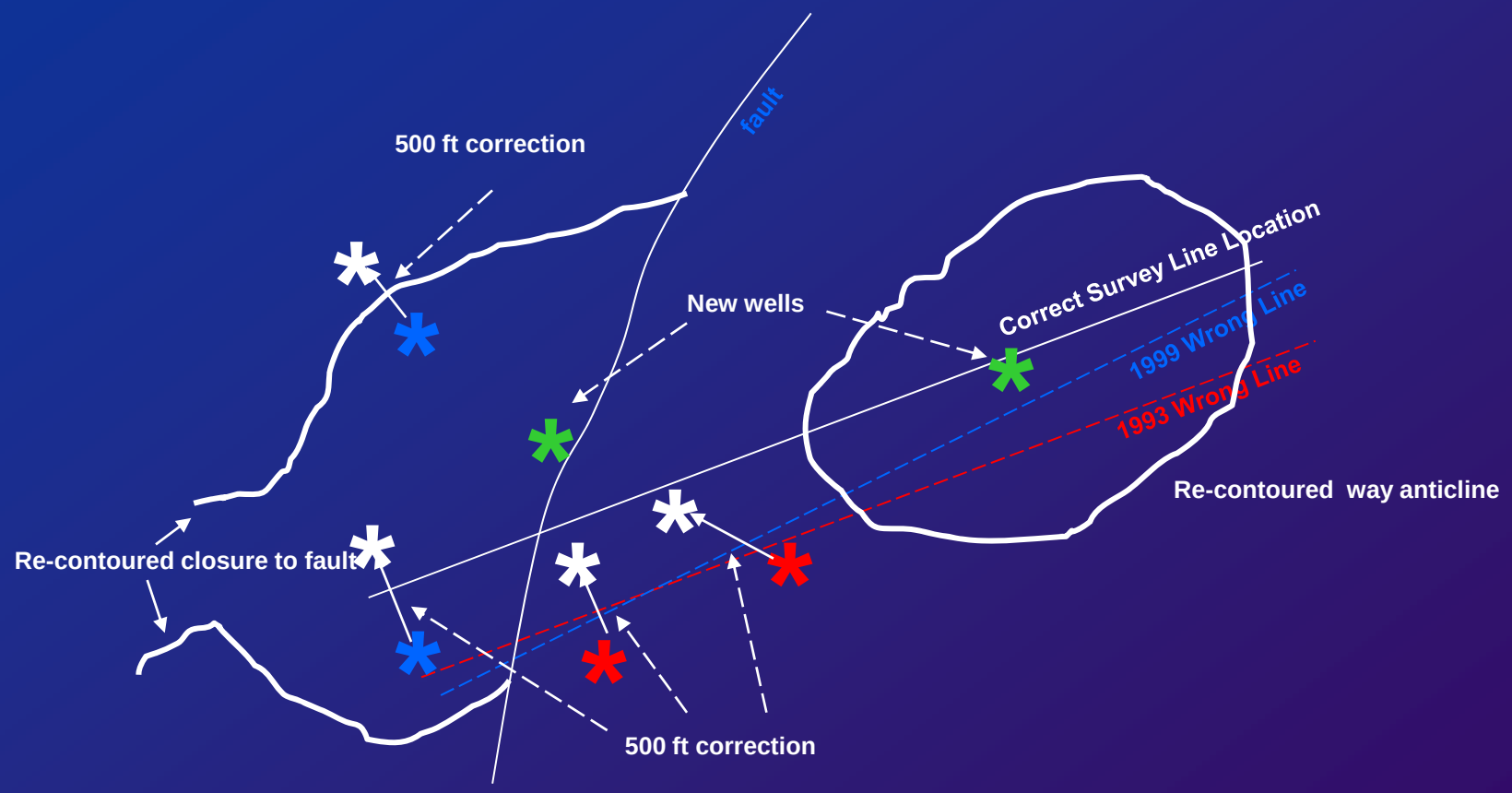
Angle of Dangle!!



One manager estimated that his staff of 5 geologists spent 80% of their time figuring out where wells were and 20% interpreting the geological horizons!!

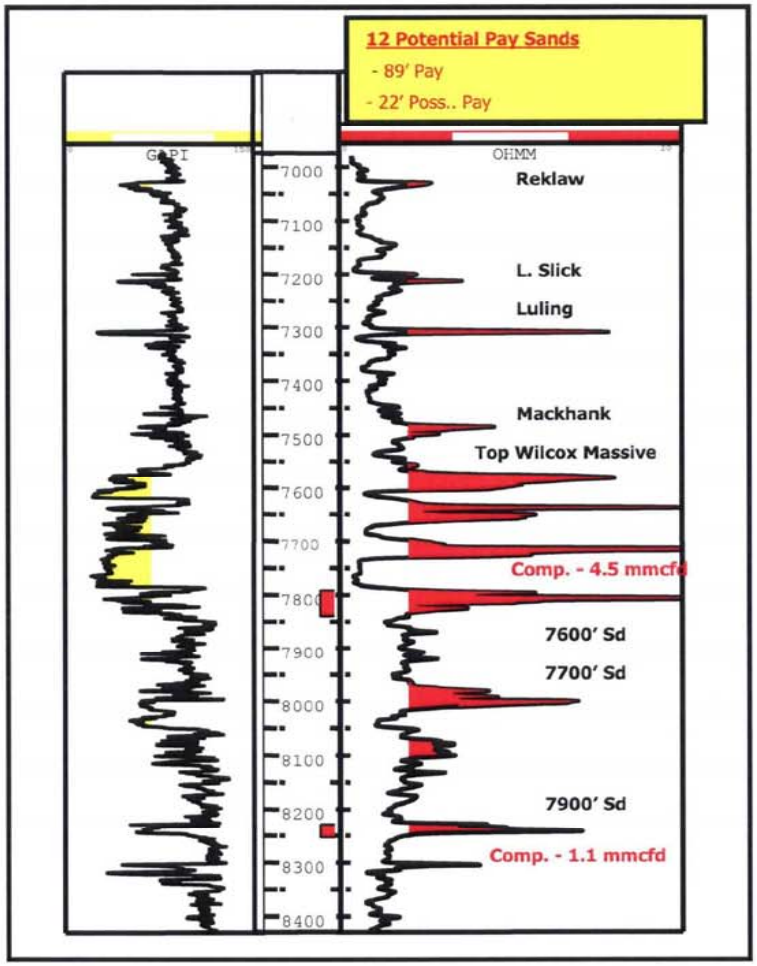
All posted as 'straight wells'!!!

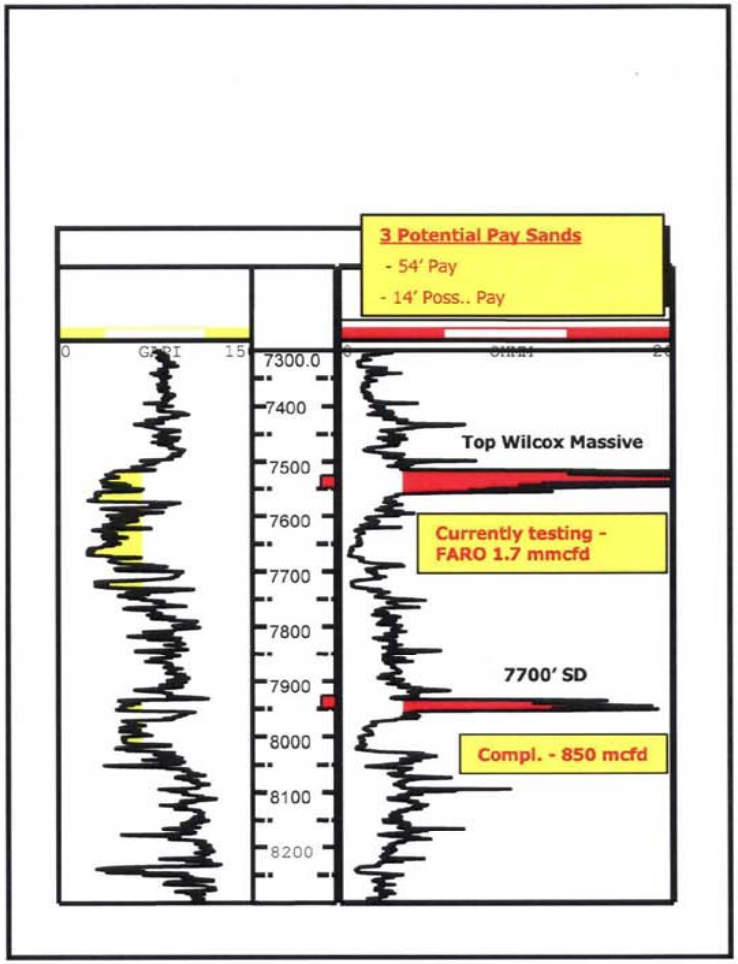
Contour Catastrophe!



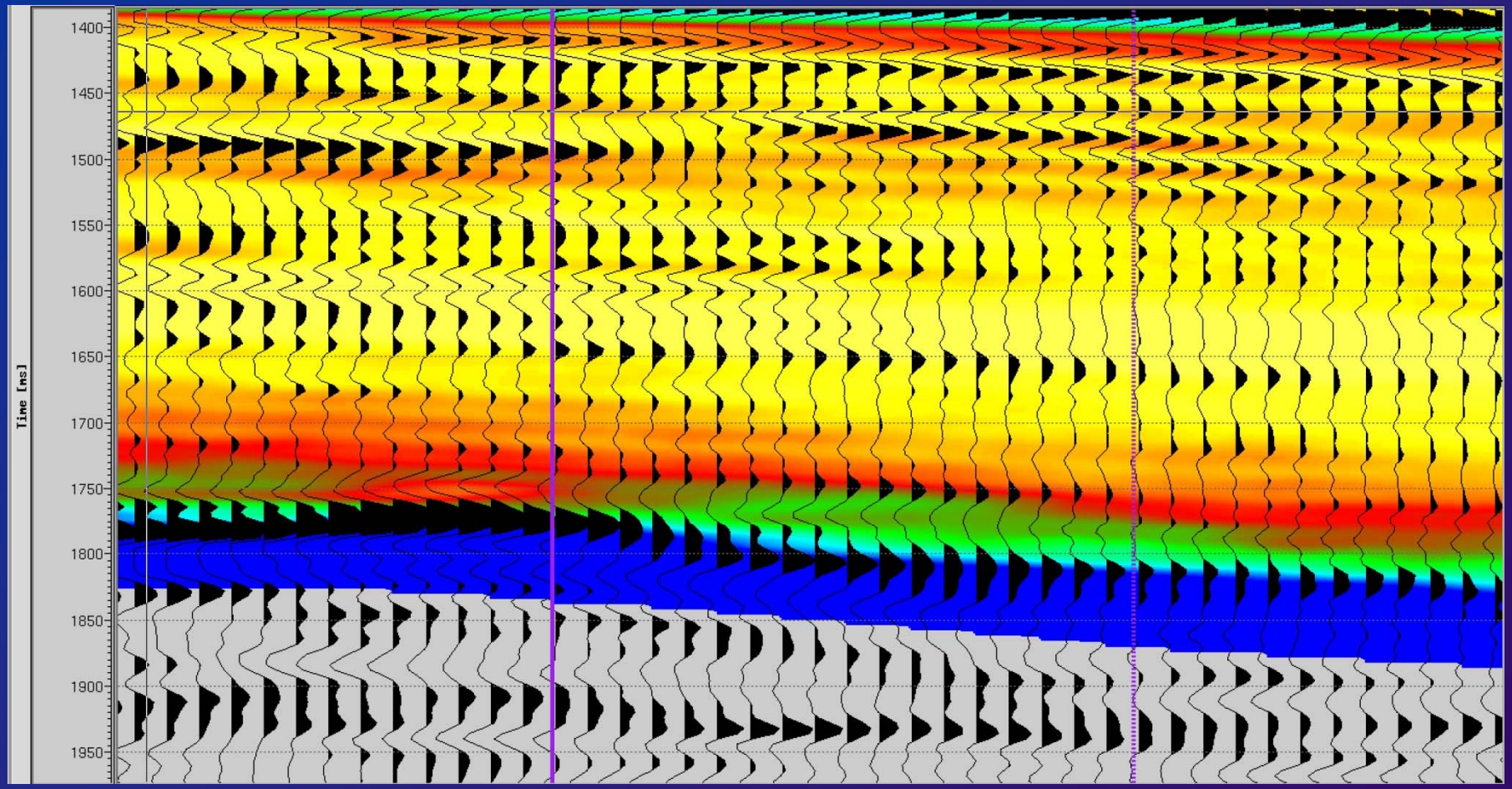
New wells would not have been drilled without the correction to the grid

.....Production Triumph!





Inversion Insanity!



Applying the right knowledge to complete a complex task!

Position data loading is an exercise in this!

Remember 2/3rds of seismic is X & Y*

Note: Geodetically this s/b Easting & Northing

What are the issues?

- **Positioning Issues:**
  - **Geodetic and projection identity**
  - **Project and point identity**
  - **Media & formats of positioning data**
  - **Precision and presentation**

If the geodesy doesn't fit, you must a quit!

Latitude	Longitude	X	Y
29 25 00.00 N	89 56 30.00 W	2,443,081.1	275,426.9
29 25 00.79 N	89 56 30.25 W	3,723,882.6	336,132.4
29 25 00.65 N	89 56 30.80 W	214,552.1	3,257,770.7
29 24 59.77 N	89 56 29.99 W	744,653.0	83,943.2

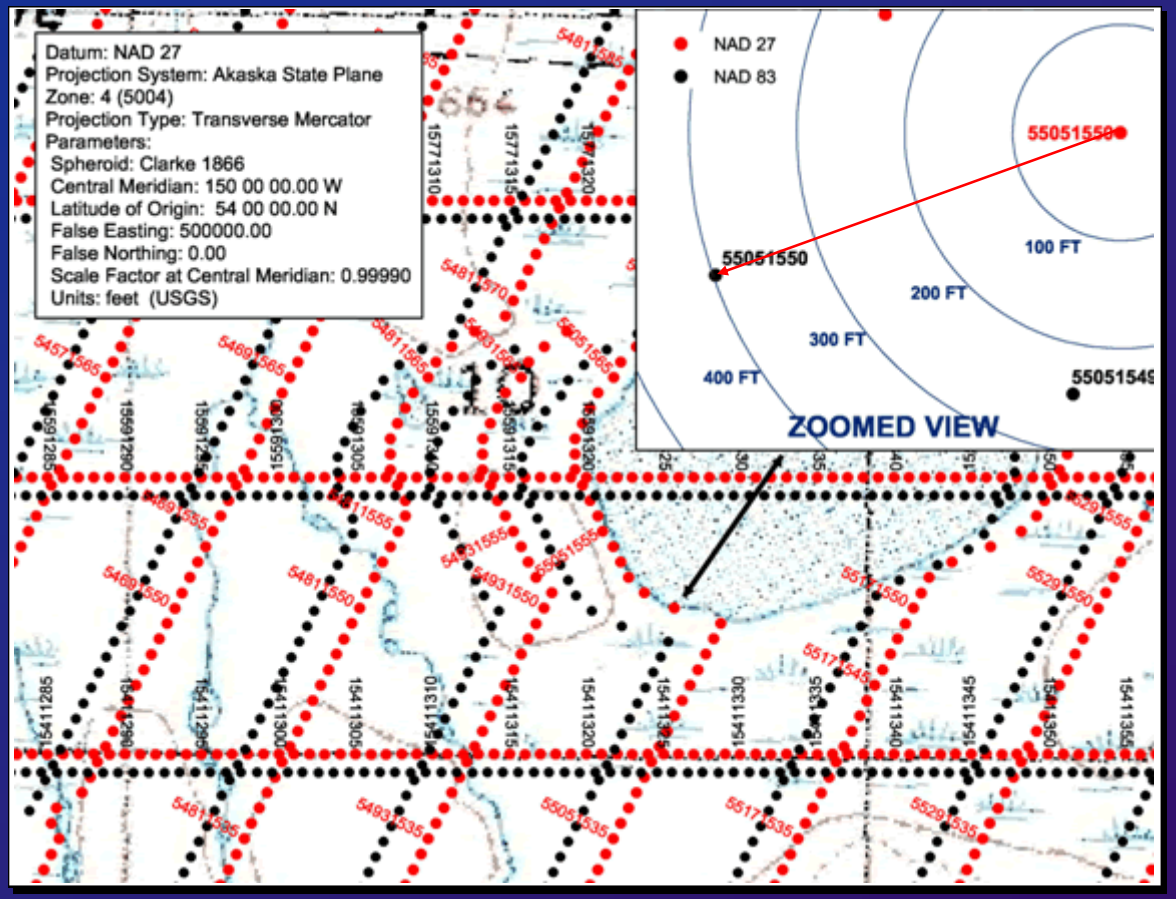
- All these coordinates represent the exact same physical point on the Earth.
- They are all correct coordinates.
- Individually, they could also represent another point somewhere else on the Earth and still be correct.

Intermixing misidentified coordinates can create positional errors ranging from a few feet or meters to miles or kilometers.

This is the number 1 reason for positioning differences!

Misidentified datums is a common problem

Mismatched datums NAD-27 Vs. NAD-83 (400' misties for this area in Alaska). Mapped NAD-83 incorrectly as NAD-27.



You will NOT see a block shift in seismic data!

X,Y's without proper identity can be a problem

```
POWDER RIVER BASIN, WYOMING SEGP1 FORMAT XY'S

182          101                    578770.05347346.
182          109                    578539.65347195.
182          117                    578303.75347061.
182          125                    578064.65346927.
182          133                    577842.95346821.
182          141                    577616.85346677.
182          149                    577376.45346549.
182          157                    577137.15346427.
182          165                    576913.65346313.
182          173                    576676.05346163.
182          181                    576422.05346099.
182          189                    576160.05345991.
182          197                    575919.75345908.
182          205                    575665.75345849.
182          213                    575403.25345733.
182          221                    575146.05345637.
182          229                    574921.25345522.
```

- What do we really know about this information?
- I know the coordinates are not in Wyoming.
- The format is not SEG-P1.
- There is absolutely no identity telling you what the points are.
- And how much time would you spend figuring it out?
- Is this time well spent for a Geophysicist, Geologist or even a data loader?
- If it was UKOOA or SPS, you'd have a chance!

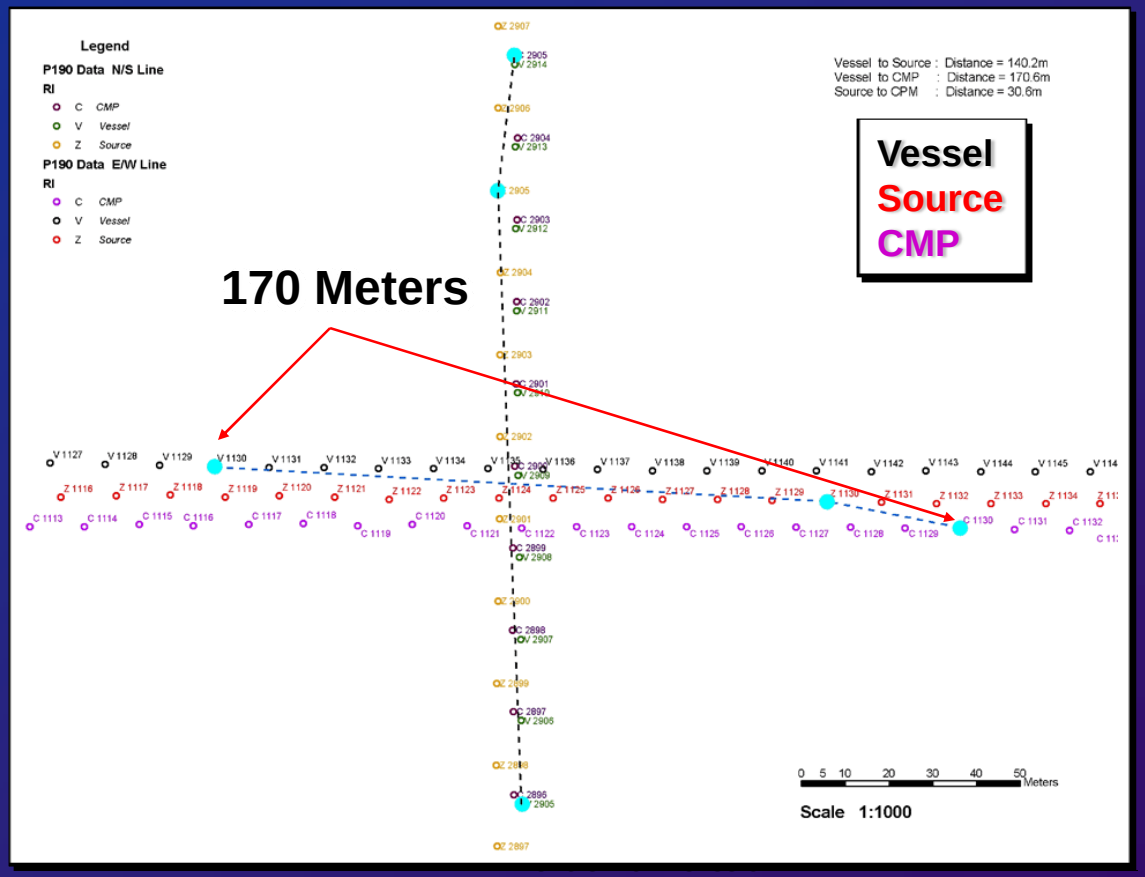
Issues relating to identity.

- **Project and point Identification**
  - **Line and shot numbering**
    - **Overlap / re-shoot schemes**
  - **Position location**
    - **Vessel, common reference point, antenna**
    - **Source and receivers**
    - **Common Mid Point, common depth point**
    - **Echo sounder**
    - **Skids, relays, re-shoots, offset**

Errors approaching hundreds of meters due to miss-matched position types.

A mistie due to incorrect point identity.

- **Point identity**
  - **What happens If your project is Source and you add some Common Mid Point (CMP) data?**



"I need a UKOOA tape"

Formats and what they mean

- **These are Seismic Standards**
  - **UKOOA - Generally marine**
  - **SEG – Generally land**
  - **SPS – Generally land and TZ/OBC**
- **ASCII text formats (100's)**
- **Workstation exchange formats. (Many)**
- **E-mail me a list.**
- **Soon to be XML, GML etc.**

What is UKOOA?

UKOOA: United Kingdom Offshore Operator's Association

- De-facto standard for many positioning formats
- These relate to seismic
  - UKOOA P1 is for the exchange of positioning data
    - P1/78 (many), P1/84, P1/90 (current)
    - May have many position types
  - UKOOA P2 is used to record raw data during acquisition.
    - P2/86, P2/91(current), P2/94 (current)
    - Must be processed to obtain positions!!
- Extensive headers / metadata – Don't throw them out!

  - http://www.oilandgas.org.uk/ukooa/newpublications/srchResults.cfm

SEG P1 – The format that wouldn't die!

- SEG - Society of Exploration Geophysicists
  - SEG "P1" – Position exchange format.
    - Considered by our "industry" as the standard for exchange of "Final" land positions.
    - Used for almost anything else as well.
  - Last updated by SEG in 1983.
  - Supported by most if not all workstations.
  - 80 character "card image" records, blocked 20 is the standard. Rarely blocked, Rarely 80 characters.
  - Often encoded as EBCDIC rather than ASCII.
  - Many non-standard versions.
  - Avoid if possible!

  - http://seg.org/publications/tech-stand/

SEG P1 – Pretty normal – incorrect headers

```
POWDER RIVER BASIN, WYOMING SEGP1 FORMAT XY'S

182                 101                 578770.05347346.
182                 109                 578539.65347195.
182                 117                 578303.75347061.
182                 125                 578064.65346927.
182                 133                 577842.95346821.
182                 141                 577616.85346677.
182                 149                 577376.45346549.
182                 157                 577137.15346427.
182                 165                 576913.65346313.
182                 173                 576676.05346163.
182                 181                 576422.05346099.
182                 189                 576160.05345991.
182                 197                 575919.75345908.
182                 205                 575665.75345849.
182                 213                 575403.25345733.
182                 221                 575146.05345637.
182                 229                 574921.25345522.
182                 237                 574684.85345413.
182                 245                 574475.55345275.
182                 253                 574235.35345172.
182                 261                 573981.65345035.
182                 269                 573763.75344896.
182                 277                 573516.05344757.
182                 285                 573293.45344613.
182                 293                 573079.05344496.
182                 301                 572840.55344343.
182                 309                 572600.05344210.
182                 317                 572358.15344090.
182                 325                 572138.05343941.
182                 333                 571901.15343807.
182                 341                 571695.55343661.
182                 349                 571457.75343548.
182                 357                 571229.15343437.
182                 365                 571002.85343282.
182                 373                 570780.65343147.
```

SEG P1 – Unusual – very good headers

```
H                                SEISMIC SURVEY DATA
--------------------------------------------------------------------------------
PROSPECT     :Wyoming
LINE         :182
FILE NUMBER  :Line182.SEG
LINE ID      :
LINE LENGTH  :1.118
LENGTH UOM   :MI
RESHOOT CODE:
HORIZONTAL DATUM:NAD27, USGS FEET, Degrees/Minutes/Seconds
PROJECTION   :NAD27, Wyoming SPCS, Zone: East, USGS FEET
      _1     :There are instances where it appears that during digitization
      _2     :some SP's were assigned the wrong ID. Corrections were made for
      _3     :errors with one only solution. OB logs or some other doumantation
      _4     :are needed to determine the correct method to resolve SP ID's.
      _5     :Questionable SP's and corrections are flagged in the
      _6     :QC spreadsheet.

--------------------------------------------------------------------------------
<LINE          ><POINT >R< LAT    >< LONG    >< EAST ><NORTH ><ELE><PLOT FLAG>< >
182                  101 04493500N108590260W  189885 1754375    0
182                  109 04493451N108590335W  189809 1754326    0
182                  117 04493407N108590411W  189732 1754282    0
182                  125 04493363N108590488W  189653 1754238    0
182                  133 04493328N108590559W  189581 1754203    0
182                  141 04493281N108590633W  189506 1754156    0
182                  149 04493239N108590710W  189428 1754114    0
182                  157 04493199N108590788W  189349 1754074    0
182                  165 04493161N108590859W  189276 1754036    0
182                  173 04493112N108590936W  189198 1753987    0
182                  181 04493090N108591018W  189115 1753966    0
182                  189 04493055N108591103W  189029 1753931    0
182                  197 04493027N108591181W  188950 1753903    0
182                  205 04493008N108591263W  188866 1753884    0
182                  213 04492970N108591348W  188780 1753846    0
182                  221 04492937N108591431W  188696 1753814    0
182                  229 04492900N108591504W  188622 1753777    0
182                  237 04492864N108591579W  188545 1753741    0
182                  245 04492819N108591647W  188476 1753696    0
```

All these are freeform. No standard format.

The marriage of positioning and seismic - SPS

- **SPS - The Shell Processing Support Format for land 3D data.**
  - **Principal format for TZ/OBC.**
  - **Endorsed by both SEG & UKOOA.**
  - **Built in to many newer acquisition systems.**
  - **Has extensive header structure similar to UKOOA.**
  - **Easting, Northing coordinates only.**
  - **Principal sub files are the “S”, “R” and “X”.**
    - **“S” = source, “R”= receivers, “X”= relationship to seismic.**
  - **The “X” file requires seismic information to construct. Channel mapping.**

  - **http://seg.org/publications/tech-stand/**

How come the coordinates changed?

- Precision of coordinates for seismic.
  - "Generally"
    - Latitude, longitude to 6 decimal places if decimal degrees
    - Latitude, longitude & seconds to 2 decimal places if degrees minutes and seconds
    - X,Y coordinates to 1 or 2 decimal places
  - Most expect meters or feet.
  - The recorded resolution between X,Y and latitude, longitude are not generally equivalent.
    - What came first the Lat,Lon or the X,Y?

How come only the Y coordinates changed!

- **Precision of coordinates for seismic.**
  - **Some formats were not specified to allow for full precision of all projections and units.**
  - **You should know about "implied decimals".**
  - **The standard format specifications are defined in FORTRAN nomenclature (FW.D or IW).**
    - **I8, I10, F8.0, F8.1, F10.2 etc.**
      - **12345678 = I8**
      - **1234567. = F8.0**
      - **12345678 = 1234567.8 if F8.1**

DMSH,DMSSS,IMPLIED,SIGNED, UNSIGNED!

```
G965                 1435302716.67N 88 1 4.46W1319785.111054512.  11.5190 40318
S1157                1336302341.76N 8758 2.26W 407074.23362764.0   3.9221 45502
R1349                1016 30120536N  87545847W  1351066210962203 54194103170817
R3 D              83715183030170 10N 880305980W  1309321 11072824     0152
S1029                1278 30.359719 -88.000678 1324907.211019956. 13.10200 01250
```

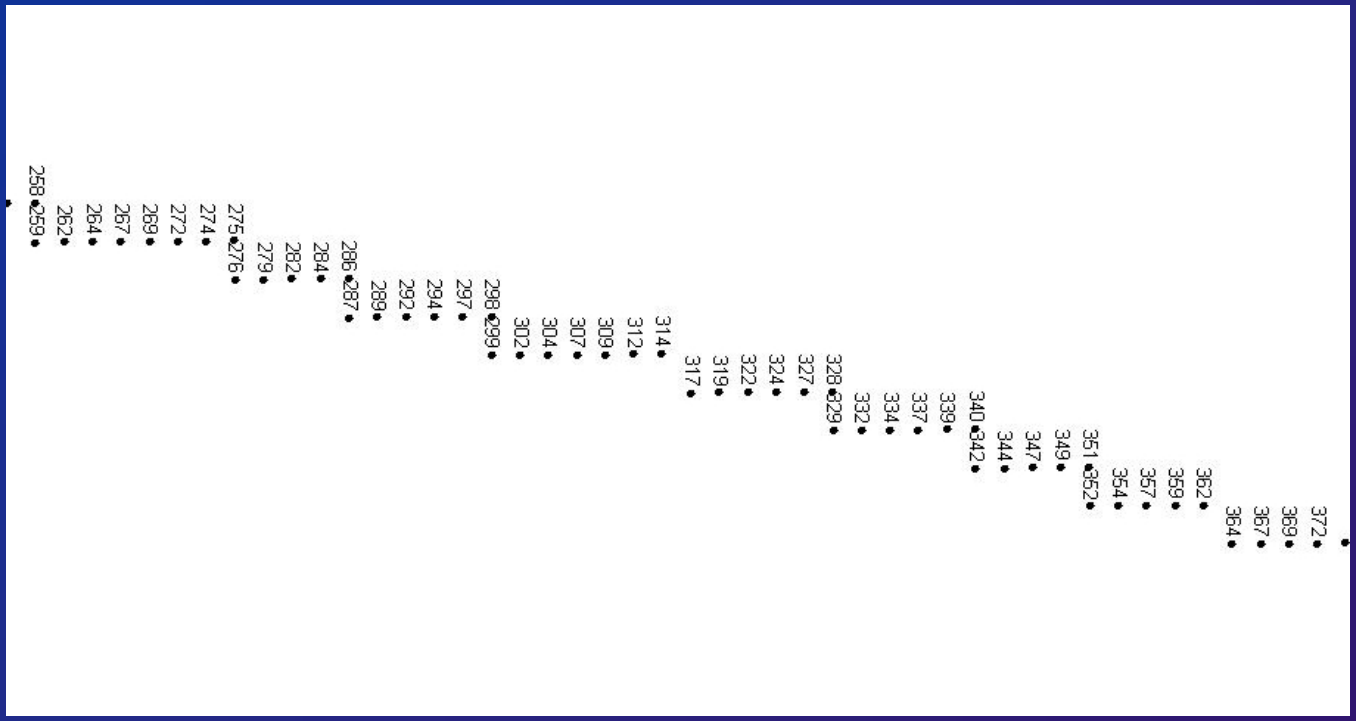
All of these records come from the same project.

There are 4 different formats for Latitude & Longitude.
There are 5 different formats for E,N + 1 change of units.
There are 4 different formats for depth / elevation.
Two of the records are UKOOA P1/84.
Two of the records are UKOOA P1/90.
One was made up in the field.
Some of them were in the same files.

How good are you with a text editor?

If not, what do your DBF and SHP files look like?

Wonder why they shot it like that, looks like stairs!



- **If you misidentify or do not understand the precision of coordinates**

Understand Precision and Presentation

Be sure and visit the APSG website and download

Guidance Note for Geodetic and Cartographic Applications (Precision and Presentation)

http://apsg.home.texas.net/

How to solve / understand the issues

- **Learn basic Geodesy.**
- **Realize that Metadata must be retained along with coordinates.**
- **Exchange data according to accepted standards.**
- **Understand precision and presentation of coordinates.**
- **Join or support the APSG and get involved in change.**
- **Support the EPSG/OGP geodetic database (www.epsg.org).**

Cost Summary

Lease	$ 20,000,000
Seismic A&P	$ 10,000,000
Interpretation	$1,000,000
Management	$1,000,000
Drilling the Well	$ 12,000,000
Facilities	$100,000,000

Putting the well in the right place…….. “priceless”

There are Some Things Money Can’t Buy….

There are Some Things Money Can't Buy.....!

For Everything Else, there's

Poor POSITIONING is a HIGH RISK activity!!!