

Understanding and Implementing Mapping and the US National Grid for Emergency Services

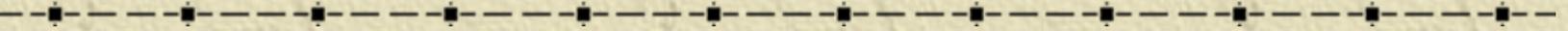
OH GIS Conference

Talbot Brooks and Dick Kotapish

This work supported by USGS Cooperative Agreement
07ERAG0083



A Disaster In Three Parts



- ✦ The problem.
- ✦ Finding our way.
- ✦ Making the “right” maps.



Part I: The Problem

WARNING: Some may find these images disturbing – massive destruction and smoking ruins will be shown

Photos courtesy OH Task Force 1







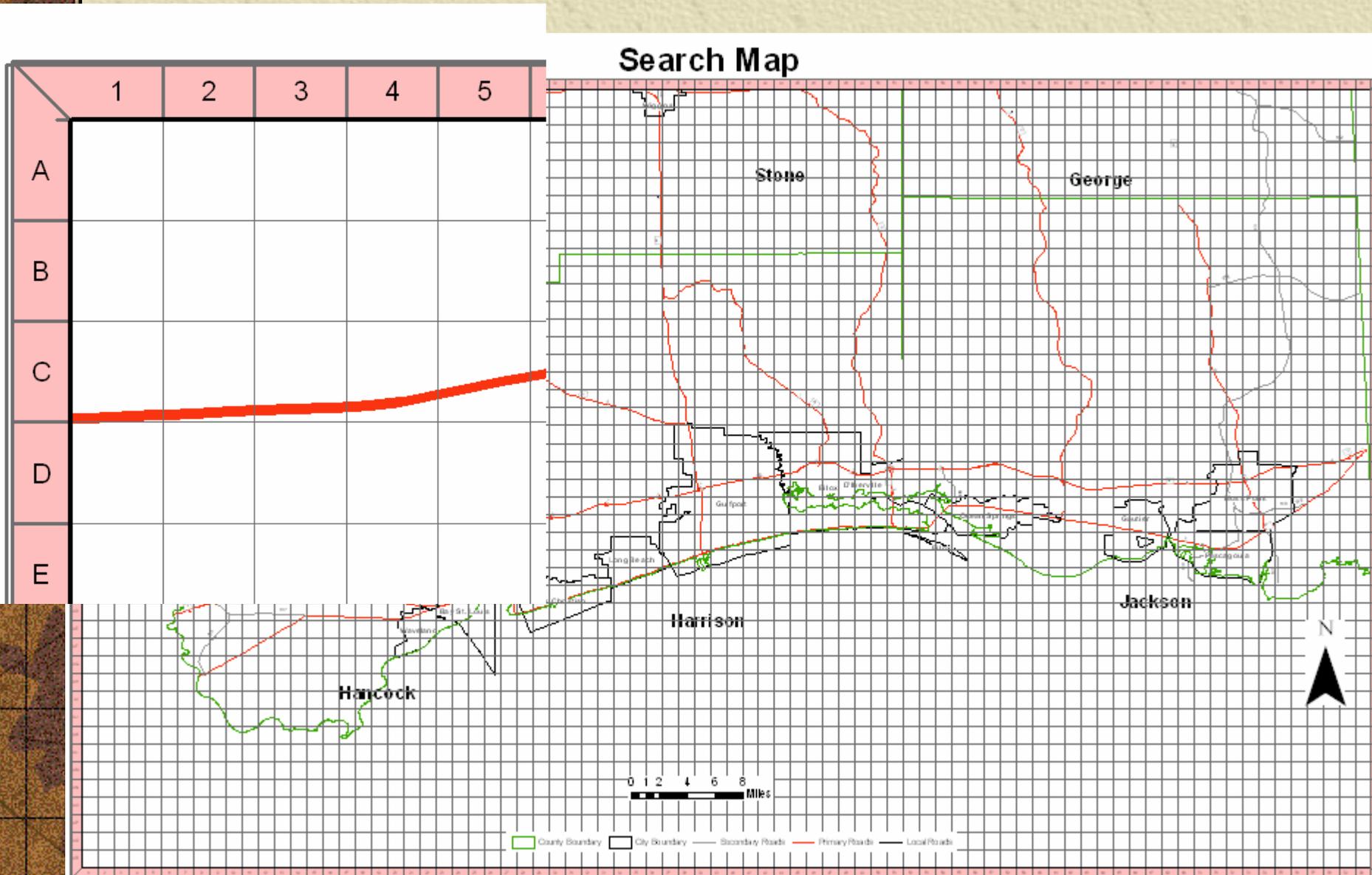




“Who are we and why are we here?”

- ✦ On 27 August 2005 I was tasked by the Bolivar County, MS Office of Emergency Management to find 2-4 people with solid computer skills to respond to the Mississippi Emergency Management Agency’s Emergency Operations Center in Jackson to help prepare written documents in support of the Hurricane Katrina operation.
- ✦ We were soon tasked by MEMA to help provide map support using “that GSI stuff” for emergency responders and decision makers.
- ✦ One of the very first products we were tasked with making was a map for search and rescue. The specifications were that it should contain streets with a 1-mile x 1-mile grid squares that could be uniquely addressed. The extent of the map should cover the three coastal counties (Jackson, Harrison, and Hancock).

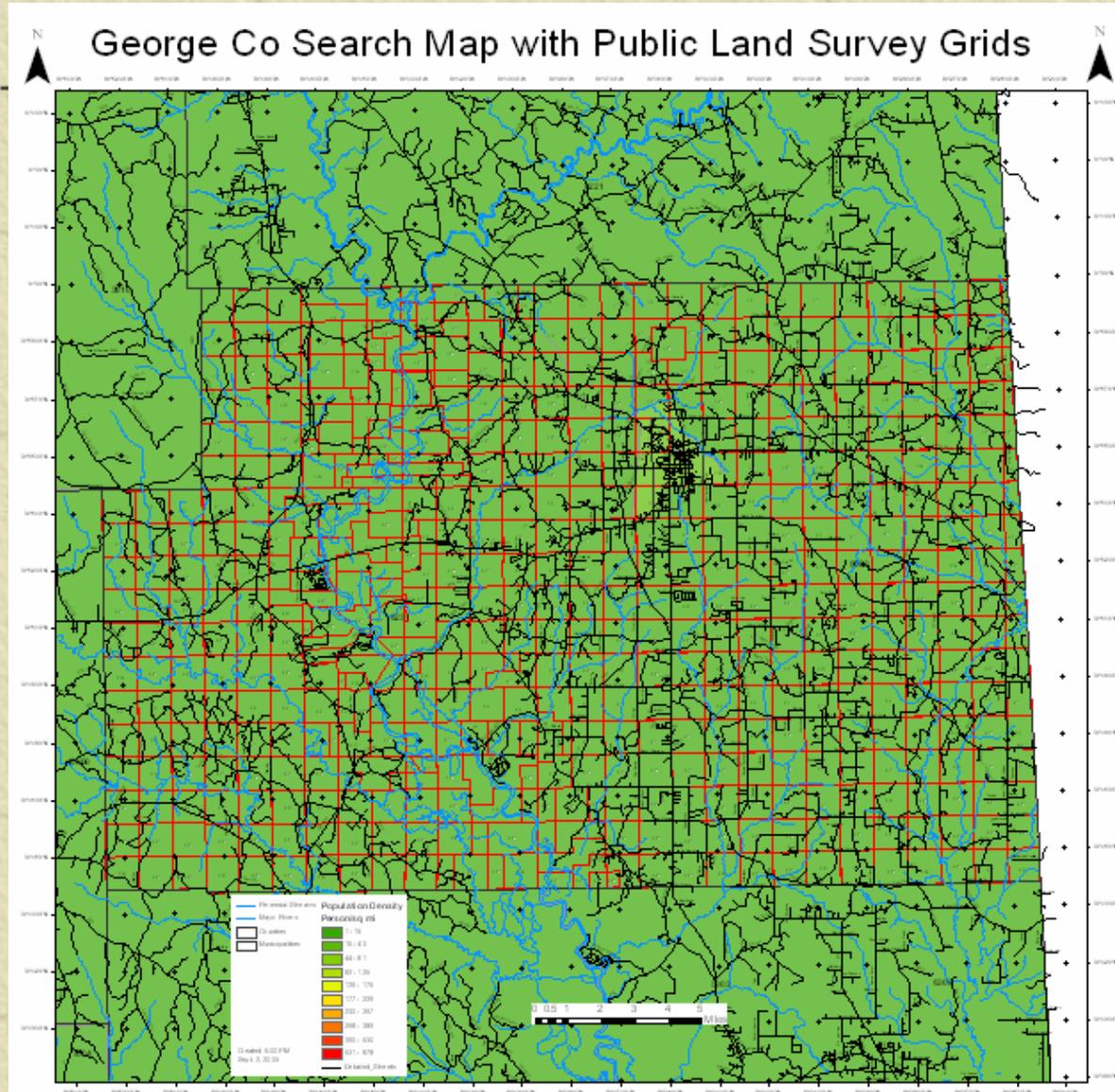
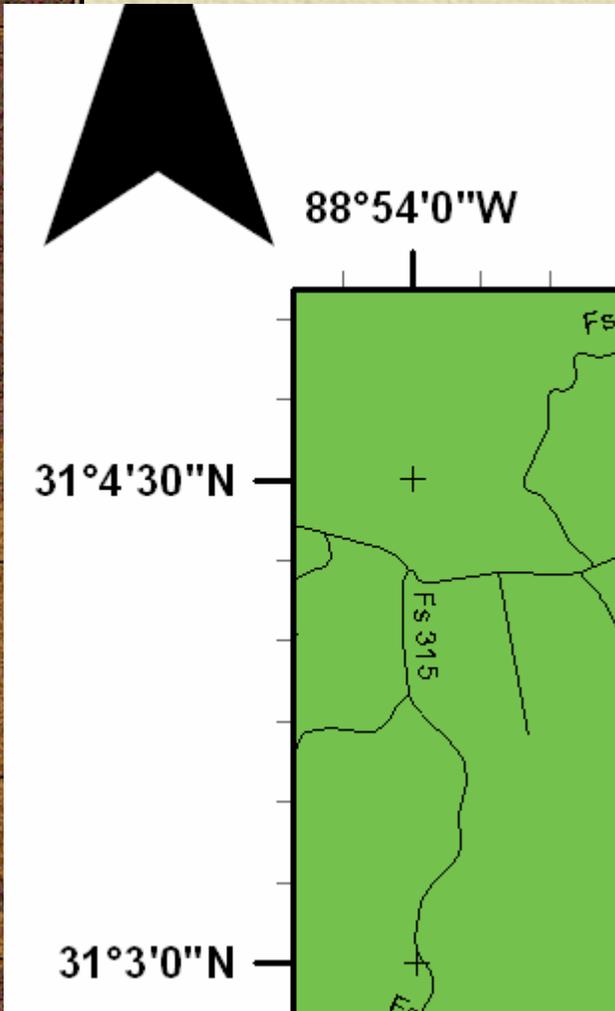
So we made 250 of these and had them laminated and sent to the field...



Two days later...

- ✦ Katrina had made landfall and the devastation exceeded most expectations
- ✦ The search area was expanded to include Stone, Lincoln, George, and Pearl River counties.
- ✦ I realized very quickly that I had screwed up. How was I to expand the map to encompass the new search area without altering the grid ID's being used already?

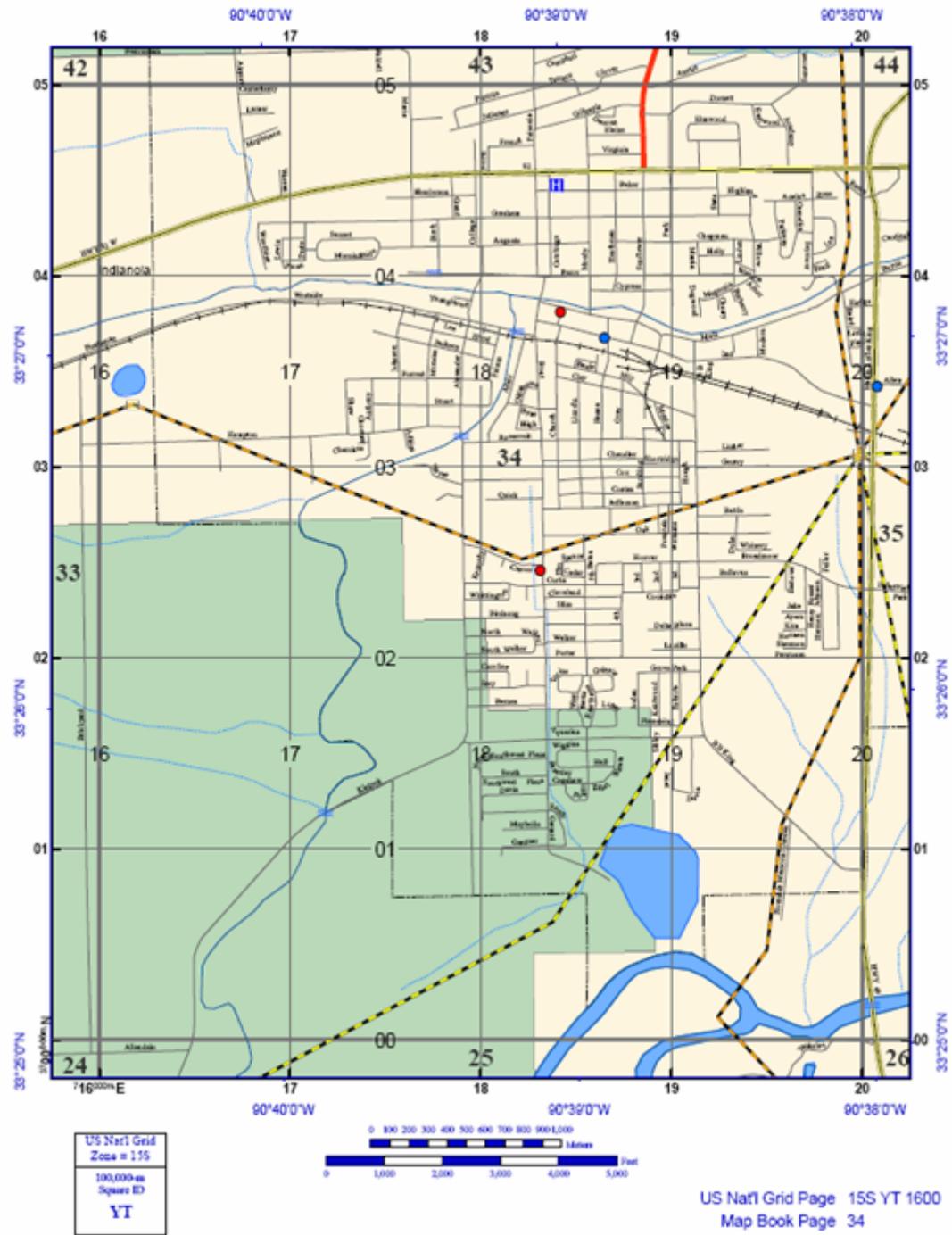
We'll use PLSS – what genius! (NOT!)



There is a better way...

- ✠ It's called the US National Grid and it would have greatly facilitated the solution to a lot of other problems:
 - Reporting of locations for evac, SAR activities, recoveries, etc...
 - It was already being used by 70,000 emergency responders – we call them the MILITARY (USNG is equivalent for most purposes to the Military Grid Reference System)
 - Comes complete with ready made grid boxes
 - Solves many other problems for emergency managers by allowing them to manage an event using maps to provide a **common, spatially-based, operational framework.**

Sample USNG-based map Book page created using 4km x 5km assemblies of 1km x 1km USNG grids with layers for critical infrastructure. Background polygon layer is Electric utility Service Areas. Note that both a local page number and USNG page number are provided.



Recommended solution using US National Grid to create 1km x 1km grid squares (contact DSU for procedure as it is involved and not straight forward – especially when working at zone junctions, but still preferable to any other lat/long or other grid system.

The 1km x 1km grids may be used as the basis for 4km x 5km map pages (ideal for 8.5" x 11" printing). Because each page is based on USNG, each page may be assigned both a local page number and a universally unique and standardized USNG page number.

Map Book Page Index

As created for
Sunflower County 911 Office, Mississippi



Indianola - Moorhead

This map book and all contents are the intellectual property of Delta State University and the Center for Interdisciplinary Geospatial Information Technologies. Critical infrastructure data courtesy US Dept. of Homeland Security HSP data set.

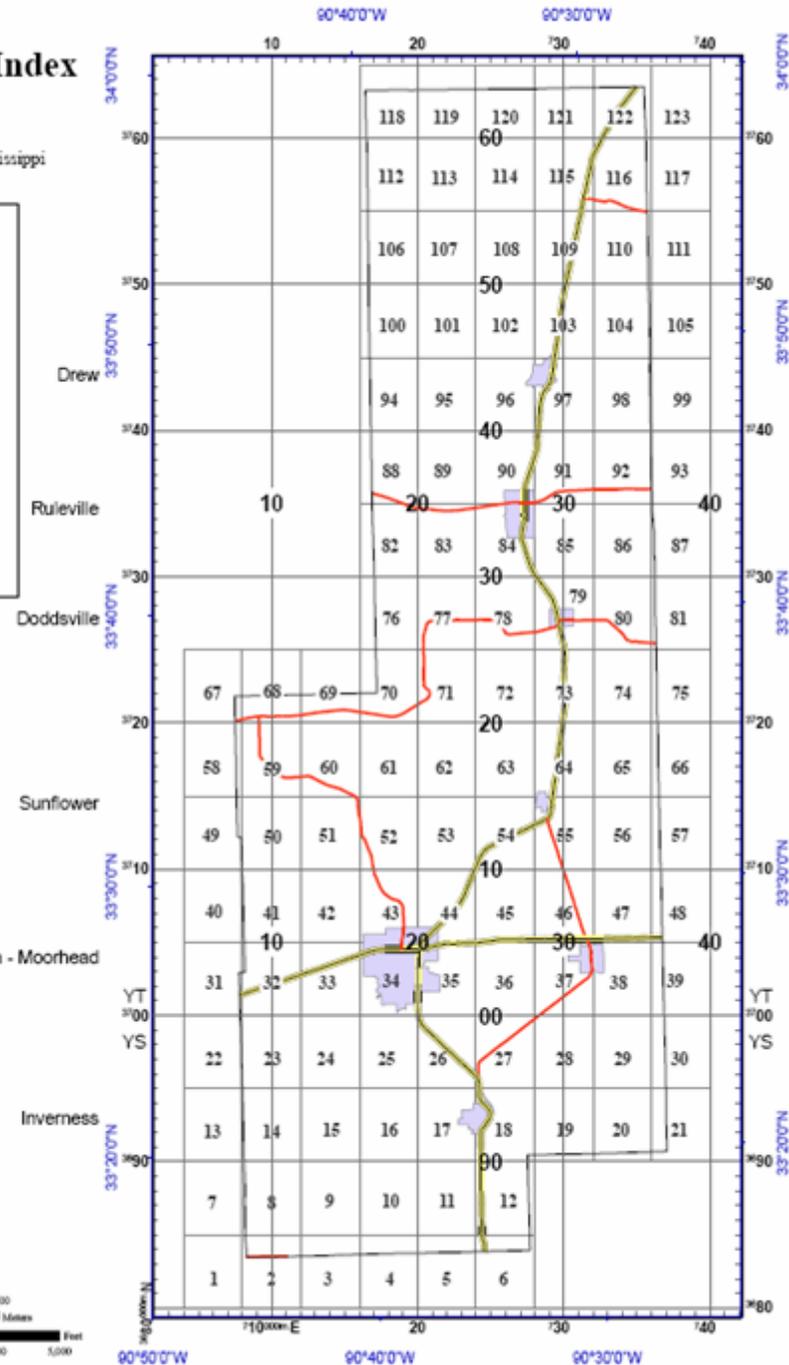
Version 1, September 2006

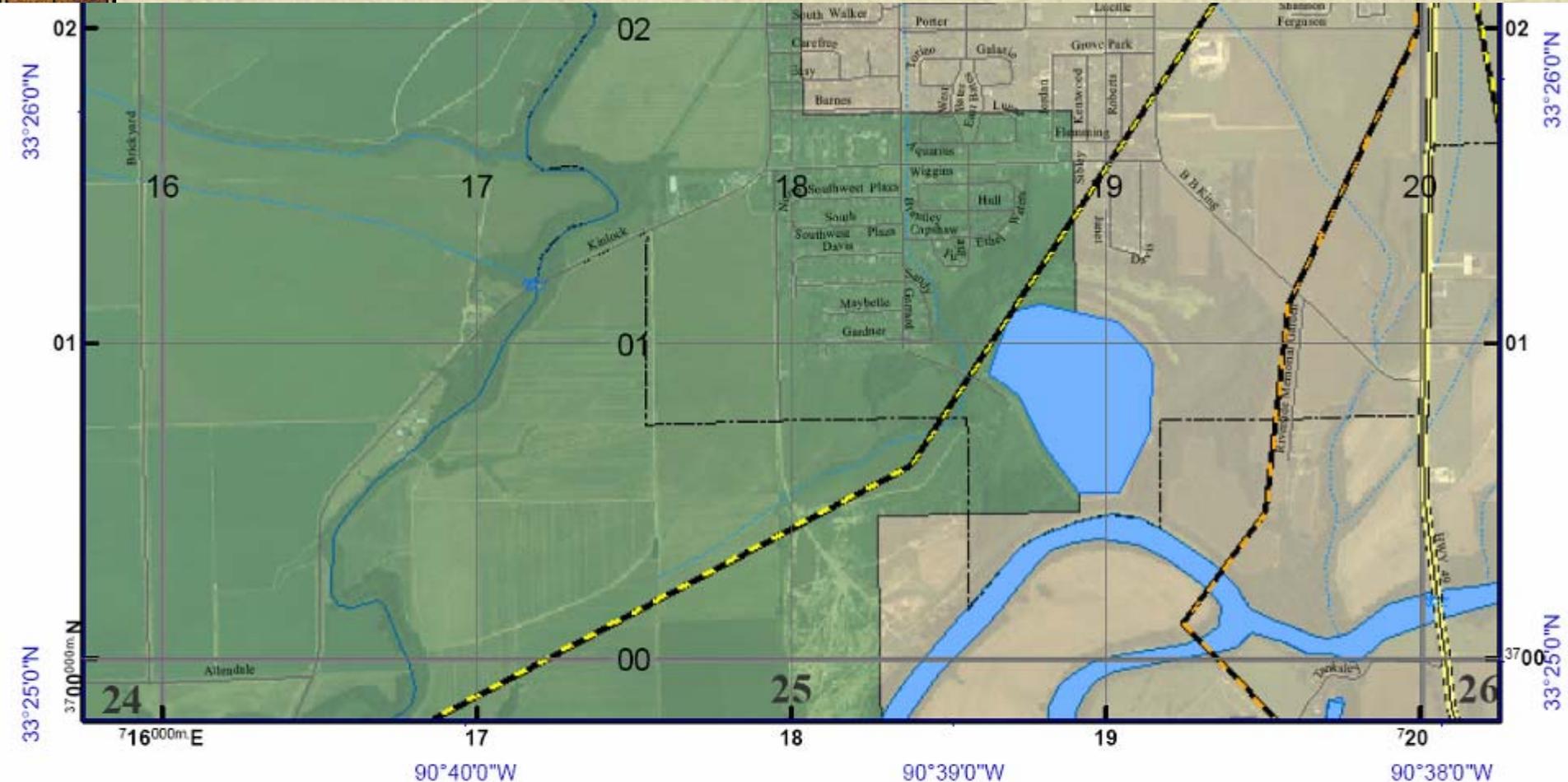
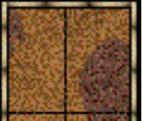
US Nat'l Grid
Zone = 15S
100,000m Square ID
YT
YS

0 100 200 300 400 500 600 700 800 900 1,000

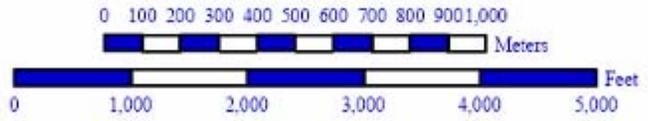
Meters Feet

1:350,000





US Nat'l Grid
 Zone = 15S
 100,000-m
 Square ID
YT



Why not use Lat/long, state plane, 5' grids, 2.5' grids, UTM, etc...?

✦ Latitude/longitude

- Many different position reporting formats
- Just how far is 1 minute of longitude anyway?
- Ever tried to fix a position to within 10-m using a paper map and DMS?

✦ But we have GPS!!!

- Which works great when you're not
 - In heavy weather
 - An urban environment
 - In a time of National crisis when the system gets shut off
- And is fantastic if
 - Can remember the “-” sign when plotting longitudes
 - You like to lug around batteries
 - Enjoy watching football on 13” black and white TV’s
 - Can manage not to lose it while slogging through the mud but still can afford to give one to every person involved in a rescue.

✦ **But the #1 REASON IS THAT THE US NATIONAL GRID IS A NATIONAL STANDARD!**



Federal Emergency Management Agency

Washington, D.C. 20472

APR 26 2001

Julie Binder Maitra
Standards Coordinator
US Geological Survey
590 National Center
Reston, Virginia 20192

Subject: FEMA's Recommendation on the Proposed US National Grid Standard

Dear Ms. Binder Maitra:

The Federal Emergency Management Agency (FEMA) supports the adoption of the US National Grid (USNG) as a standard for horizontal reference mapping in the United States. The FEMA program offices anticipate that use of this system for identifying locations among emergency management personnel and agencies will help save lives, reduce the costs of disaster, and enhance preparedness, response, recovery, and mitigation efforts. Particularly valuable is its compatibility with the system used by the National Guard and others, the Military Grid Reference System (MGRS). The USNG standard also appears reasonably compatible with current capabilities of the Global Positioning System (GPS), and has the potential to be quite effective as a locational tool if future GPS devices adopt the standard. FEMA recommends that the FGDC adopt the USNG system as the horizontal reference system for all general-purpose mapping.

Sincerely,

A handwritten signature in black ink, appearing to read "Michael K. Buckley". The signature is fluid and cursive, with a long, sweeping tail that loops back under the name.

Michael K. Buckley, P.E., Director
Technical Services Division
Mitigation Directorate

**Appendix I: National SAR Committee (NSARC)
Georeferencing Policy -
Catastrophic Incident Search and Rescue.**

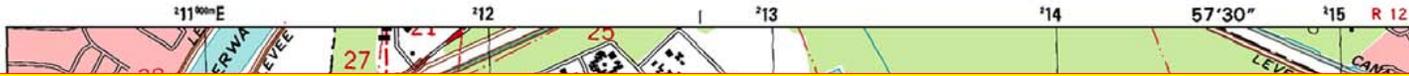
Georeference System User	USNG	Latitude/Longitude (DD-MM.mmm) (Note 1)	GARS-compatible
Land SAR Responder (Note 2)	Primary	Secondary	N/A
Aeronautical SAR Responders (Note 3)	Secondary	Primary	Tertiary
Airspace Deconfliction (Note 4)	N/A	Primary	N/A
Land SAR Responder/ Aeronautical SAR Responder Interface (Note 5)	Primary	Secondary	N/A
Incident Command: Air SAR Coordination	Secondary	Primary	N/A
Land SAR Coordination	Primary	Secondary	N/A
Geospatial information aggregation/dissemination (Note 6)	Tertiary	Secondary	Primary



Part II: Finding Our Way

While we tweaked it, the following section represents significant work by Tom Terry (The Public X/Y Project and USMC, Geospatial Plans and Policy Branch) and the encouragement of the Federal Geographic Data Committee

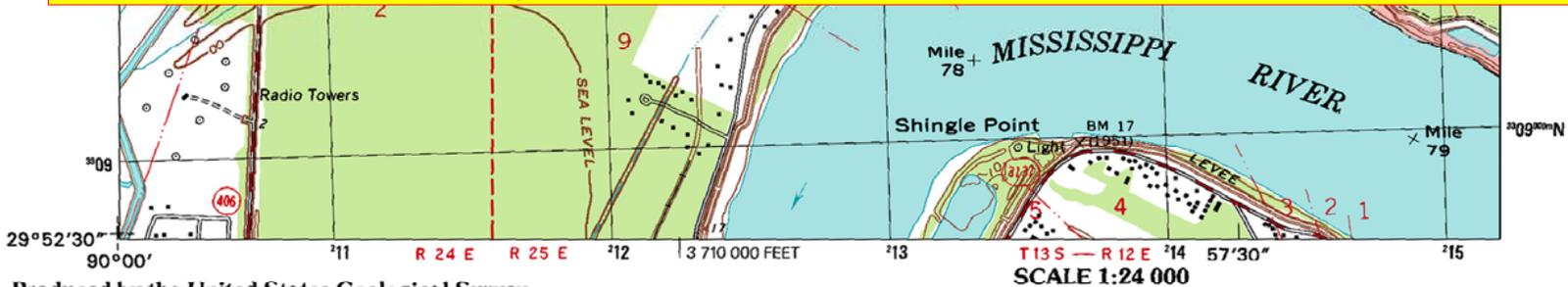
US National Grid Training Map



How to Read and Use Grid Coordinates Federal Geographic Data Committee US National Grid (FGDC-STD-011-2001)

- Tom Terry

neri.terry@usmc.mil , (703) 695-3118



Produced by the United States Geological Survey

Topography compiled 1964. Planimetry derived from imagery taken 1998 and other sources. Public Land Survey System and survey control current as of 1967

North American Datum of 1983 (NAD 83). Projection and 1 000-meter grid: Universal Transverse Mercator, zone 16 10 000-foot ticks: Louisiana Coordinate System of 1983 (south zone)

North American Datum of 1927 (NAD 27) is shown by dashed corner ticks. The values of the shift between NAD 83 and NAD 27 for 7.5-minute intersections are obtainable from National Geodetic Survey NADCON software

There may be private inholdings within the boundaries of the National or State reservations shown on this map

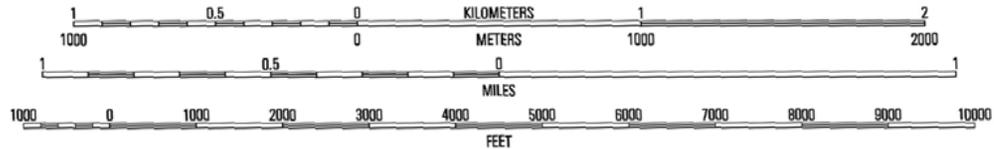
City of New Orleans and Orleans Parish are coextensive

This quadrangle covers a subsidence area

Landmark buildings verified 1967



QUADRANGLE LOCATION

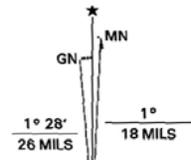


CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
TO CONVERT FROM FEET TO METERS, MULTIPLY BY 0.3048

1	2	3	1 Spanish Fort 2 Little Woods 3 Chef Menteur
4	5	6	4 New Orleans East 5 Martello Castle 6 Bertrandville
6	7	8	7 Belle Chasse 8 Delacroix

ADJOINING 7.5' QUADRANGLE NAMES
LA 200A

U.S. National Grid
100,000-m Square ID
BU
Grid Zone Designation
16R



UTM GRID AND 2000 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Review and relevance: Map Accuracy (National Map Accuracy Standards)

- ✦ NMAS => 1:20,000 = 90% of well defined features will be within 1/50 inch on map of true position.
- ✦ USGS 1:24,000 series topo maps = NMAS
 - ◆ @ 1:24,000, 90% of well defined mapped features will be within 12.19-m of true position on the ground.
 - ◆ @ 1:24,000, 12-m = 0.5-mm...
...or dot from 0.5-mm pencil lead

Review and relevance: GPS Accuracy

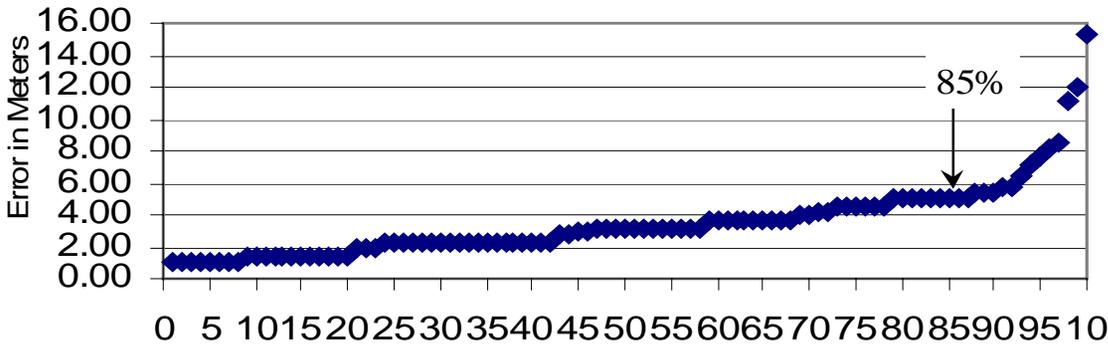


Figure 37. Samples listed by distance errors.

This chart depicts the 100 sample locations over a period of 100 minutes from a consumer GPS receiver, listed by miss distance. Y values represent the error (miss distance) between what the GPS receiver displayed and the true position of the receiver at horizontal control station GPS 112 on the GMU campus.

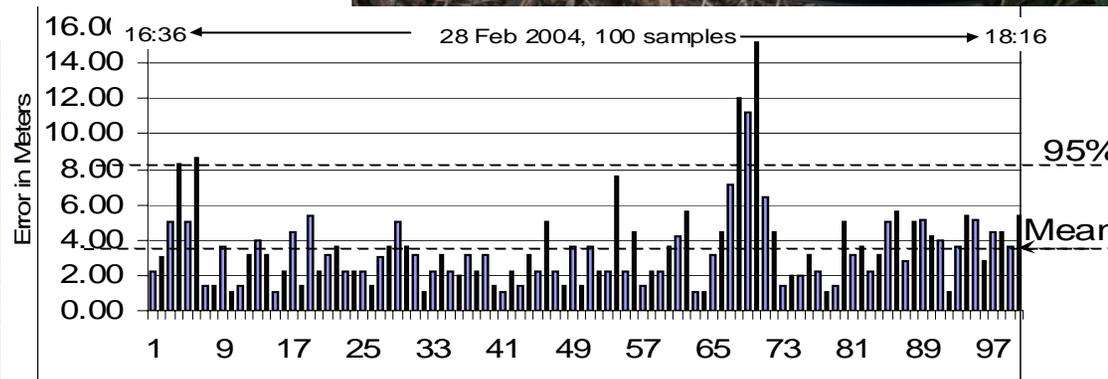
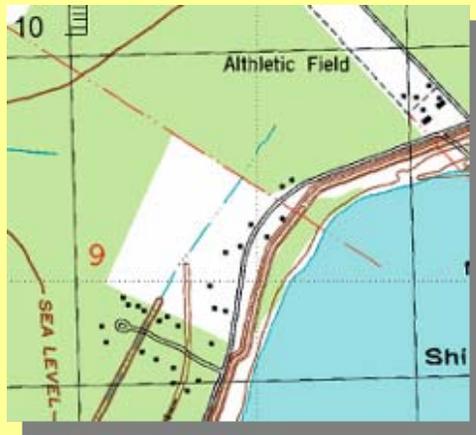


Figure 38. Location samples in temporal sequence.

This chart depicts a temporal sequence of the 100 position samples taken at 1min intervals from a consumer GPS receiver. Y values represent the error (miss distance) between what the GPS receiver displayed and the true position of the receiver at horizontal control station GPS112 on the GMU campus. The average error was only 3.5-m, and 95% were within 8.2-m, an amazing capability given the cost and reliability of these consumer devices. Note the outlier excursion out to 15-m beginning at ~67 minutes.

In other words...



matches GPS...



...in accuracy.

It is worth noting, this accuracy was achieved at no trivial cost to the US Treasury over the last century.

The lessons: 1) Do not point at position with your finger.
2) Attention to detail when working.

Attention to detail when working.

Orientation to the US National Grid format:

Water Tank at grid: 16R BU 1028 0976

100,000-m Square ID

USNG format: 16R BU 1028 0976

Grid Zone Designation (GZD)
(6° lat x 8° longitude quad)

Easting Northing
Grid Coordinates

Read right and up. ↑

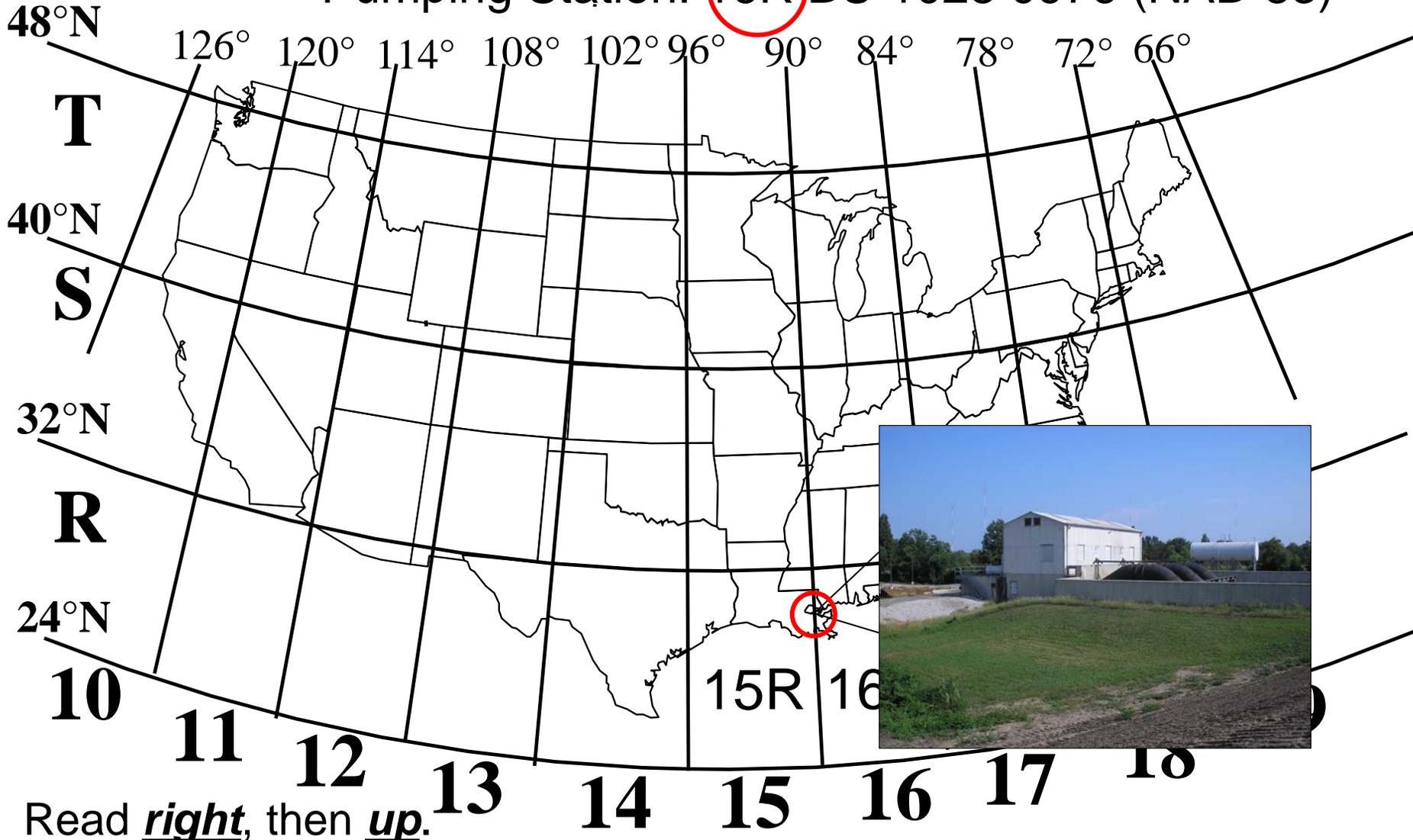
UTM format: 16R, 210280mE, 2309760mN

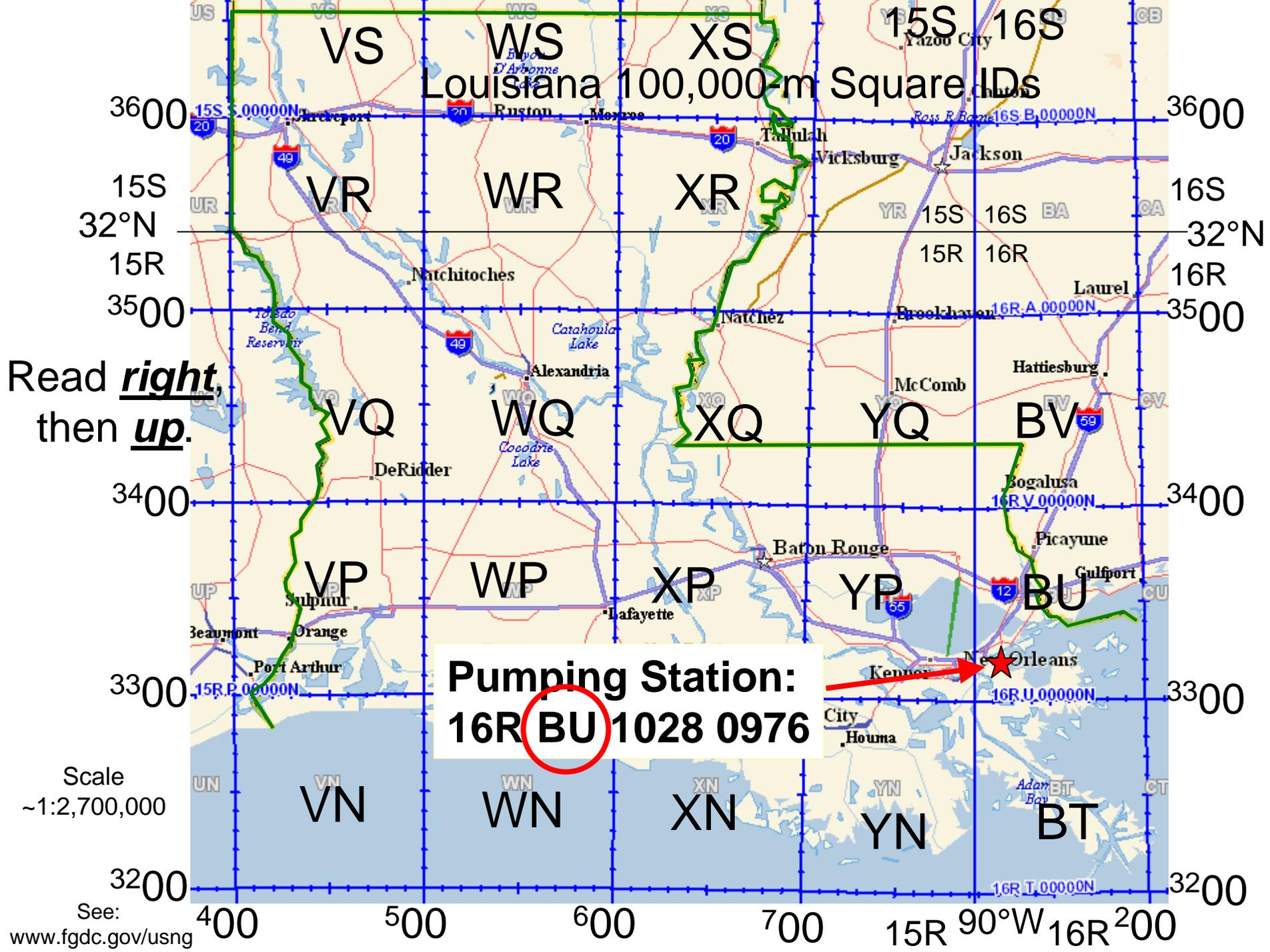
(Well suited for surveying / distance and direction calculations
and a component of the US National Grid.)

How to read the USNG...

UTM/USNG Grid Zone Designations

Pumping Station: **16R** BU 1028 0976 (NAD 83)

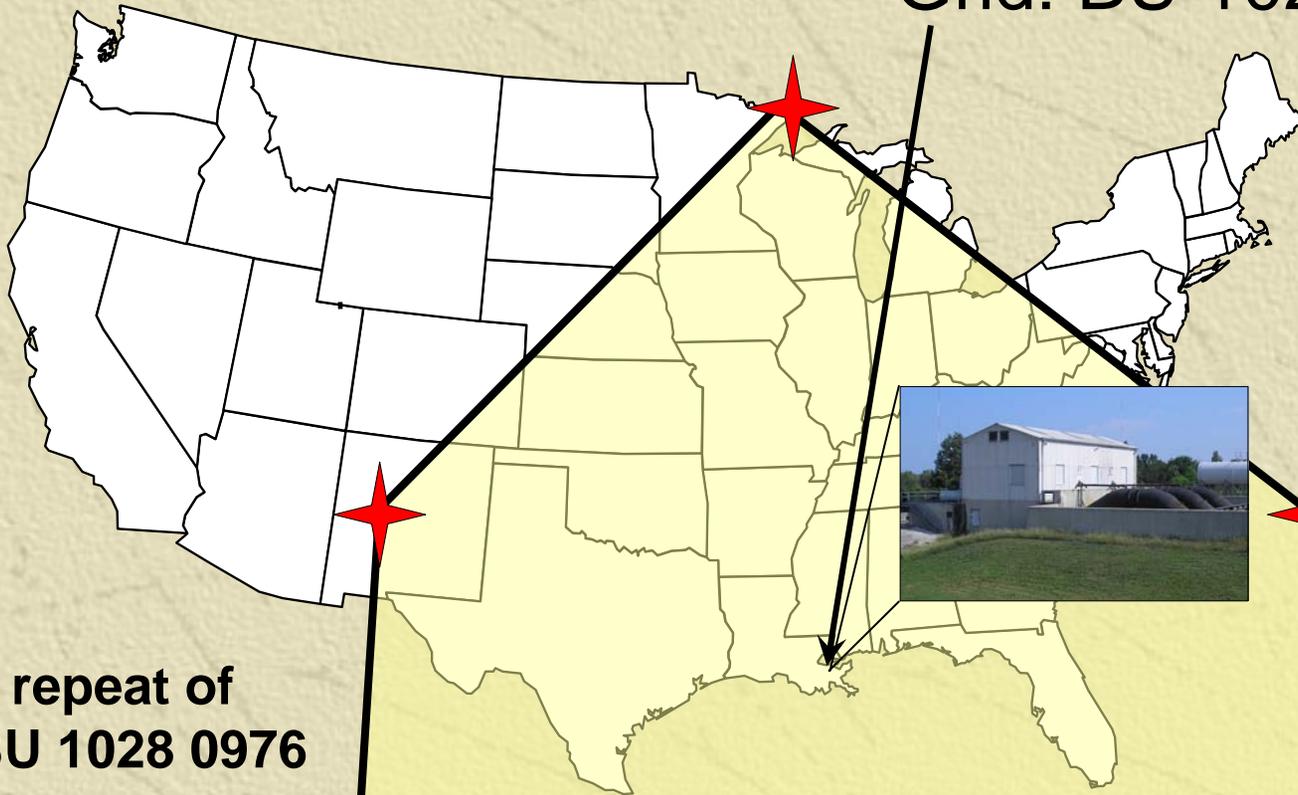




The Power of Truncated USNG Values

Pumping Station: 16R BU 1028 0976

Grid: BU 1028 0976



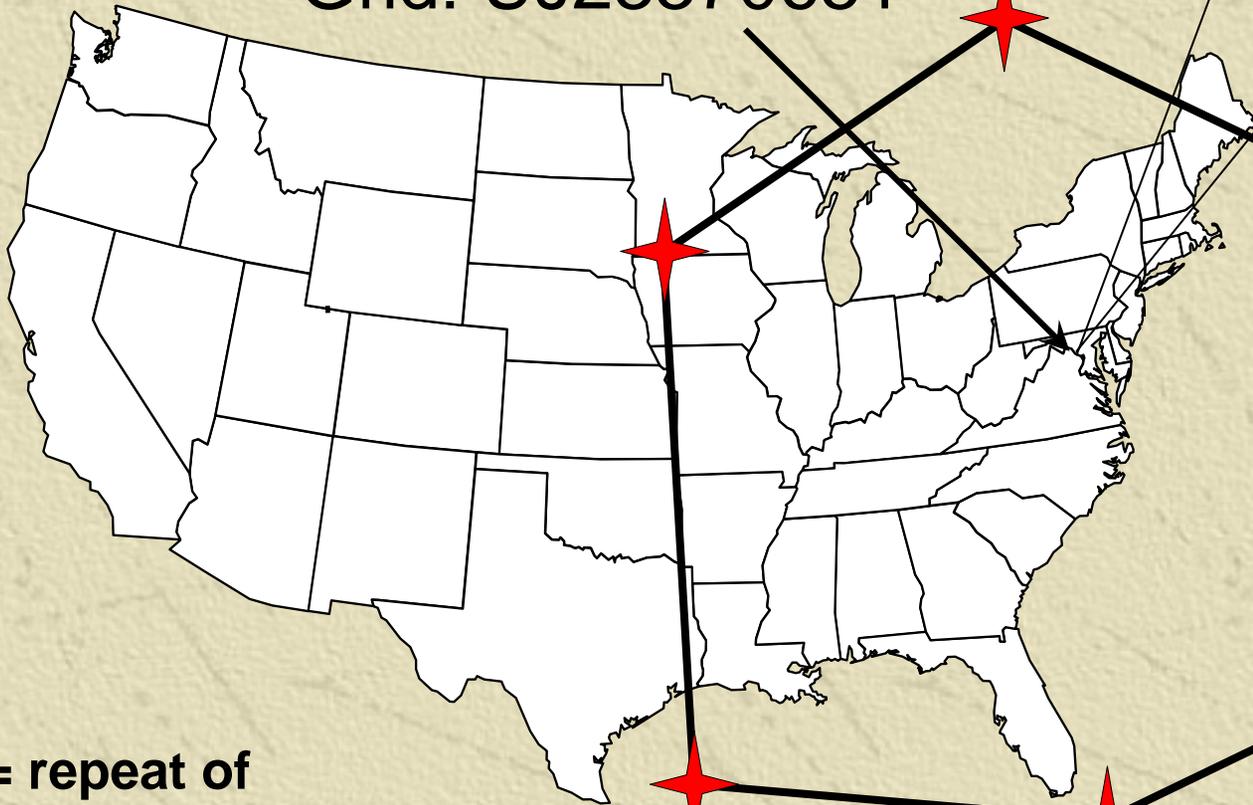
 = repeat of
BU 1028 0976

Each 2 letter/8 digit USNG value
(10-m posting) in the outlined area is unique.

The Power of Truncated USNG Values

Jefferson Pier, Washington, DC

Grid: UJ23370651



 = repeat of
UJ23370651

Each 2 letter/8 digit USNG value
(10-m posting) in the outlined area is unique.

Reading USNG Grid Coordinates

Water tank located at grid: 16R BU **1249 1084**

Read **RIGHT** to grid line **12**

Then measure right another 480-meters.

Water Tank at grid: 12491084

(think 1249 / 1084)

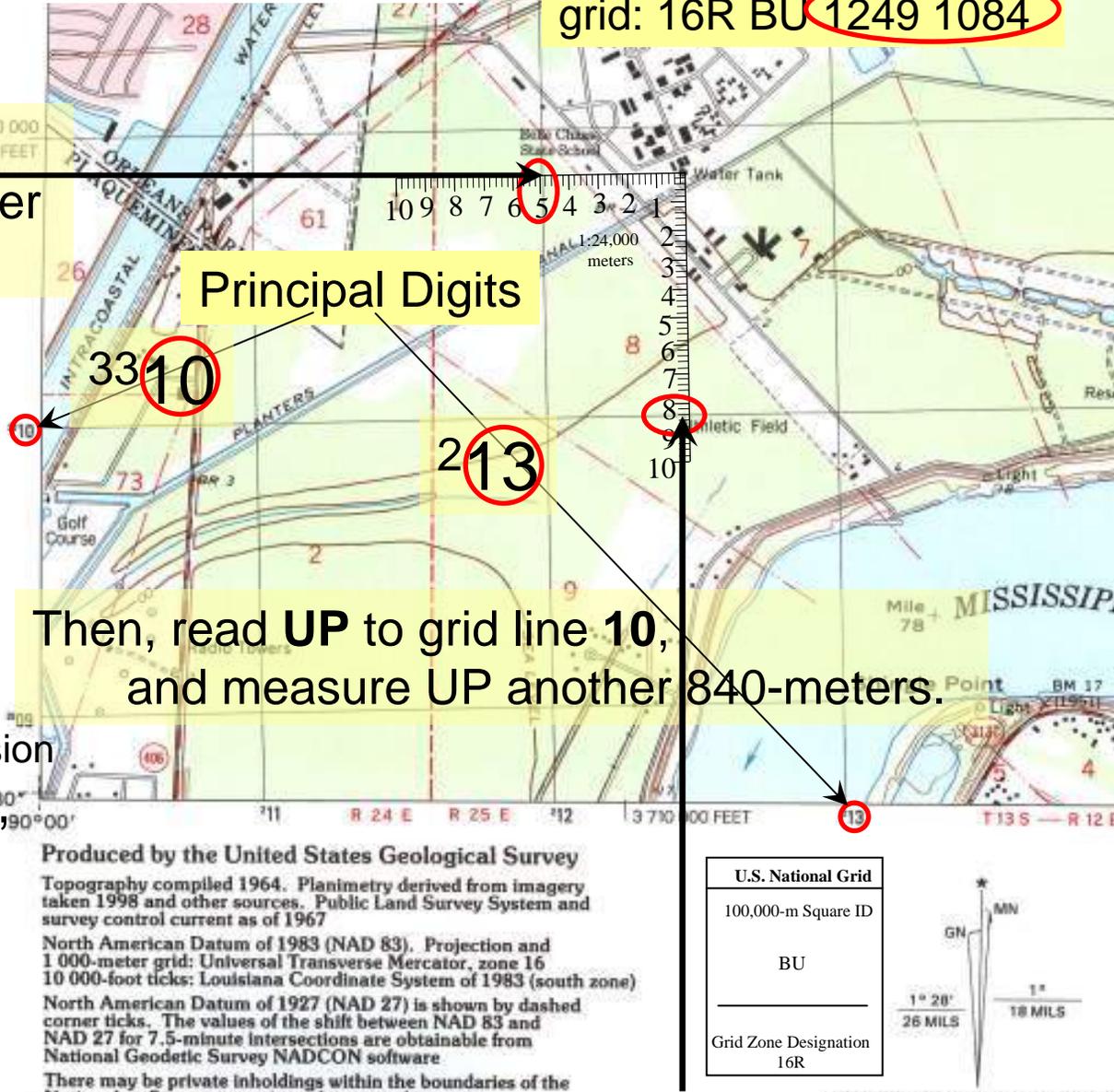
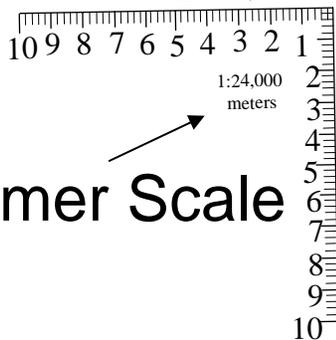
4-digit: 12 10 = 1,000m

6-digit: 124 108 = 100m

8-digit: 1249 1084 = 10m

10-digit: 12490 10840 = 1m precision

Read **Right**, Then **Up**



Then, read **UP** to grid line **10**, and measure UP another 840-meters.

Produced by the United States Geological Survey

Topography compiled 1964. Planimetry derived from imagery taken 1998 and other sources. Public Land Survey System and survey control current as of 1967

North American Datum of 1983 (NAD 83). Projection and 1 000-meter grid: Universal Transverse Mercator, zone 16 10 000-foot ticks; Louisiana Coordinate System of 1983 (south zone)

North American Datum of 1927 (NAD 27) is shown by dashed corner ticks. The values of the shift between NAD 83 and NAD 27 for 7.5-minute intersections are obtainable from National Geodetic Survey NADCON software

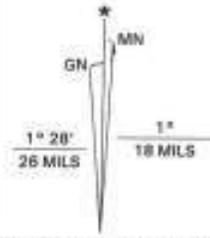
There may be private inholdings within the boundaries of the National or State reservations shown on this map

City of New Orleans and Orleans Parish are coextensive

This quadrangle covers a subsidence area

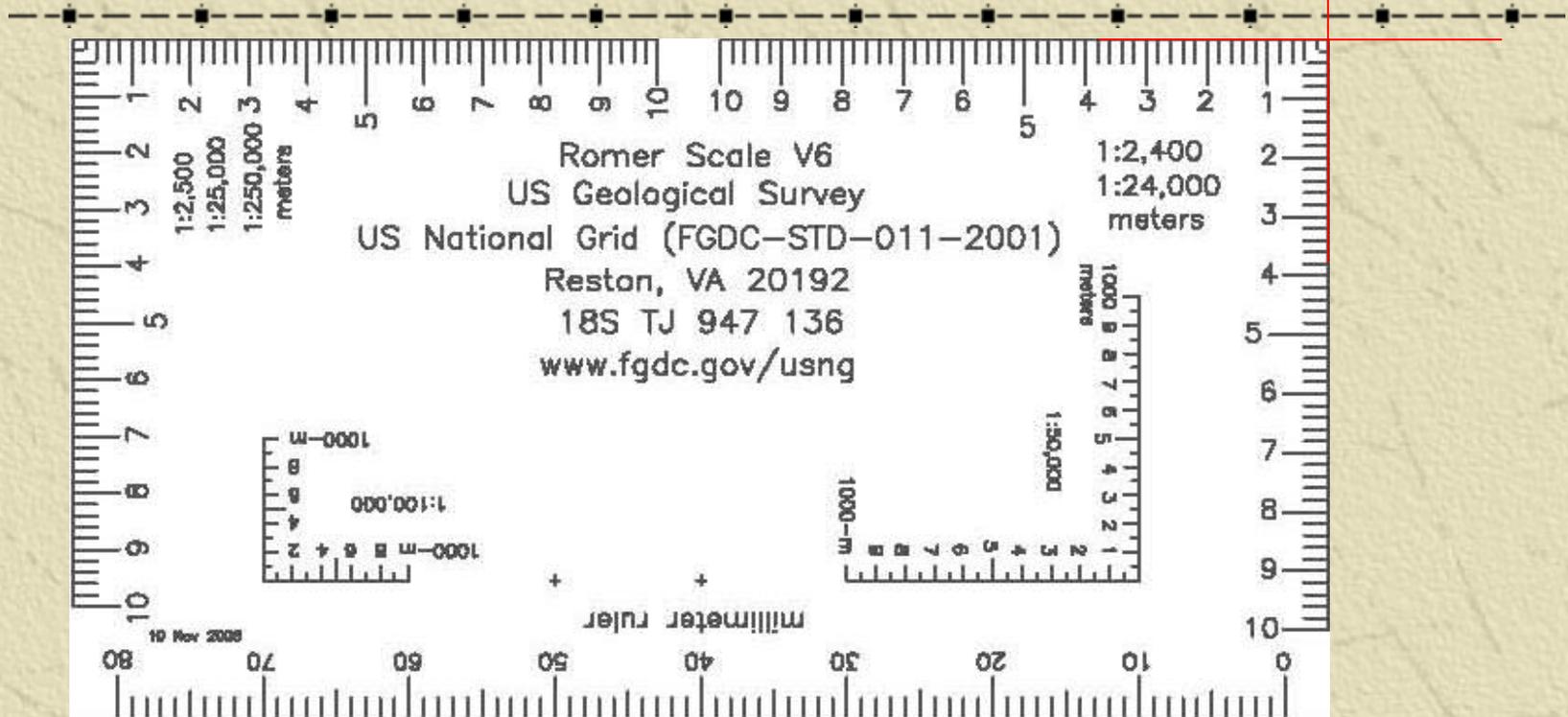
Landmark buildings verified 1967

U.S. National Grid
100,000-m Square ID
BU
Grid Zone Designation
16R



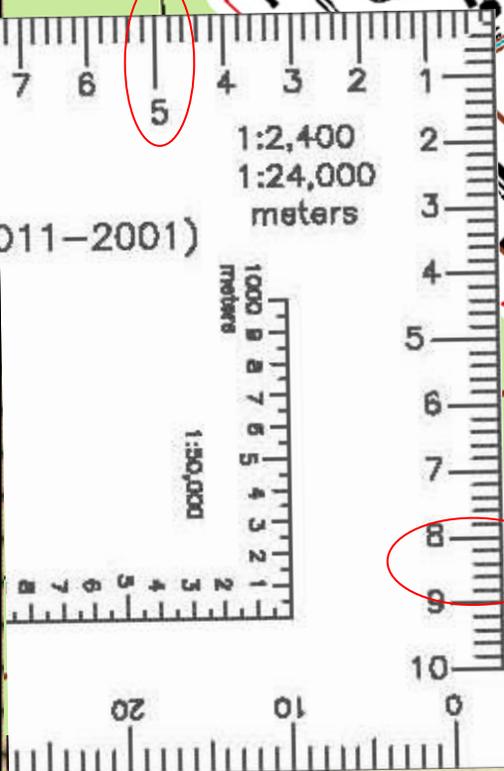
UTM GRID AND 2009 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
CHALMETTE, LA

Orientation on the Romer Scale



Reading and Using the Romer Scale

Water Tank at grid:
1249 1084



Athletic Field

3311

3310

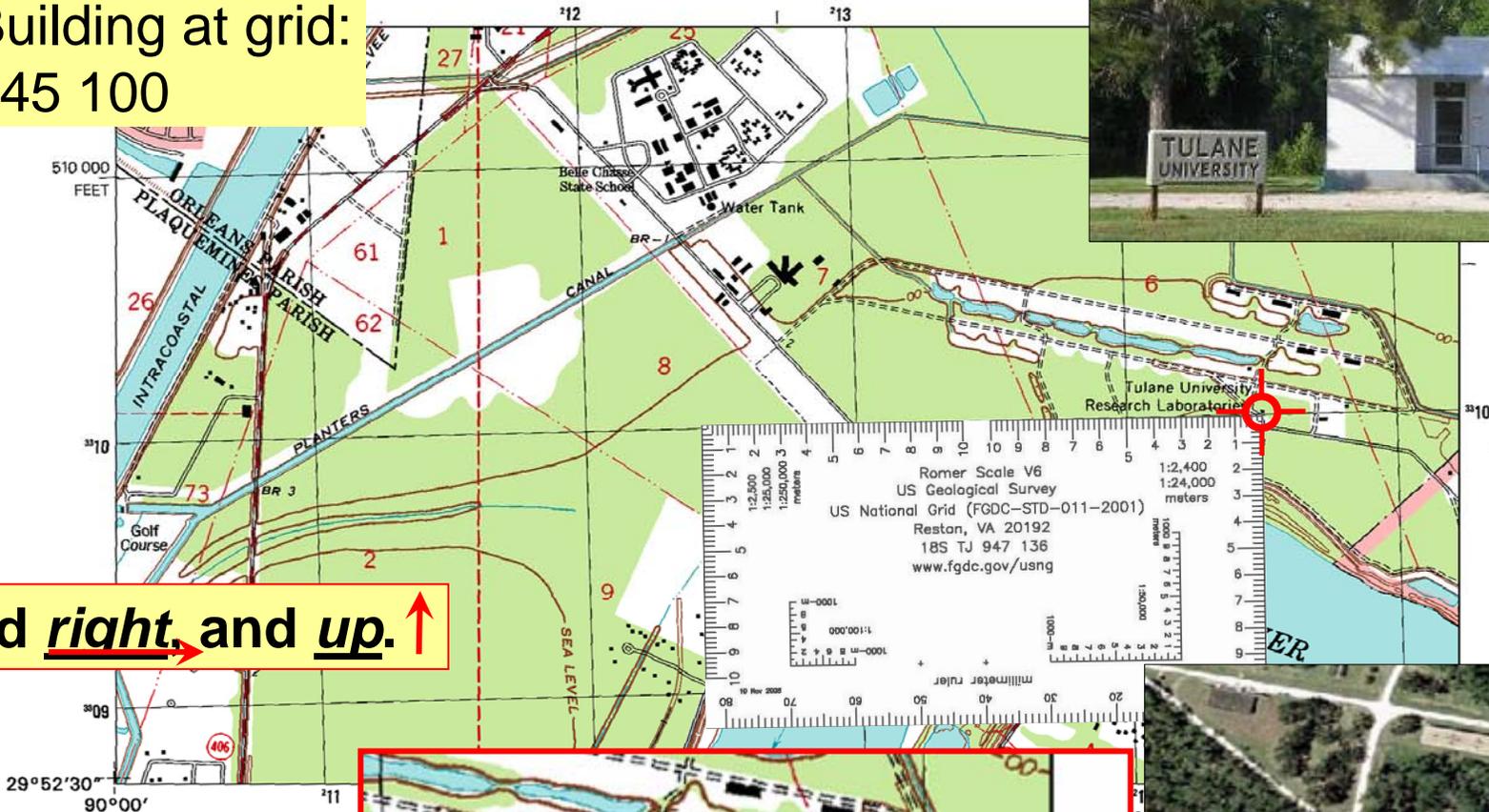
Tulane University
Research Laboratories

LEVEE

Read right and up. ↑

US National Grid Training Map

Building at grid:
145 100



Read right, and up. ↑

Produced by the United States Geological Survey
 Topography compiled 1964. Planimetry data taken 1998 and other sources. Public Land Survey control current as of 1967
 North American Datum of 1983 (NAD 83). 1 000-meter grid: Universal Transverse Mercator 10 000-foot ticks: Louisiana Coordinate System
 North American Datum of 1927 (NAD 27) corner ticks. The values of the shift between NAD 27 for 7.5-minute intersections are of National Geodetic Survey NADCON software
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 City of New Orleans and Orleans Parish are shown
 This quadrangle covers a subsidence area
 Landmark buildings verified 1967



4	5	5 Martello Castle 6 Bertrاندville 7 Belle Chasse 8 Delacroix
6	7	8

ADJOINING 7.5' QUADRANGLE NAMES
LA 200A

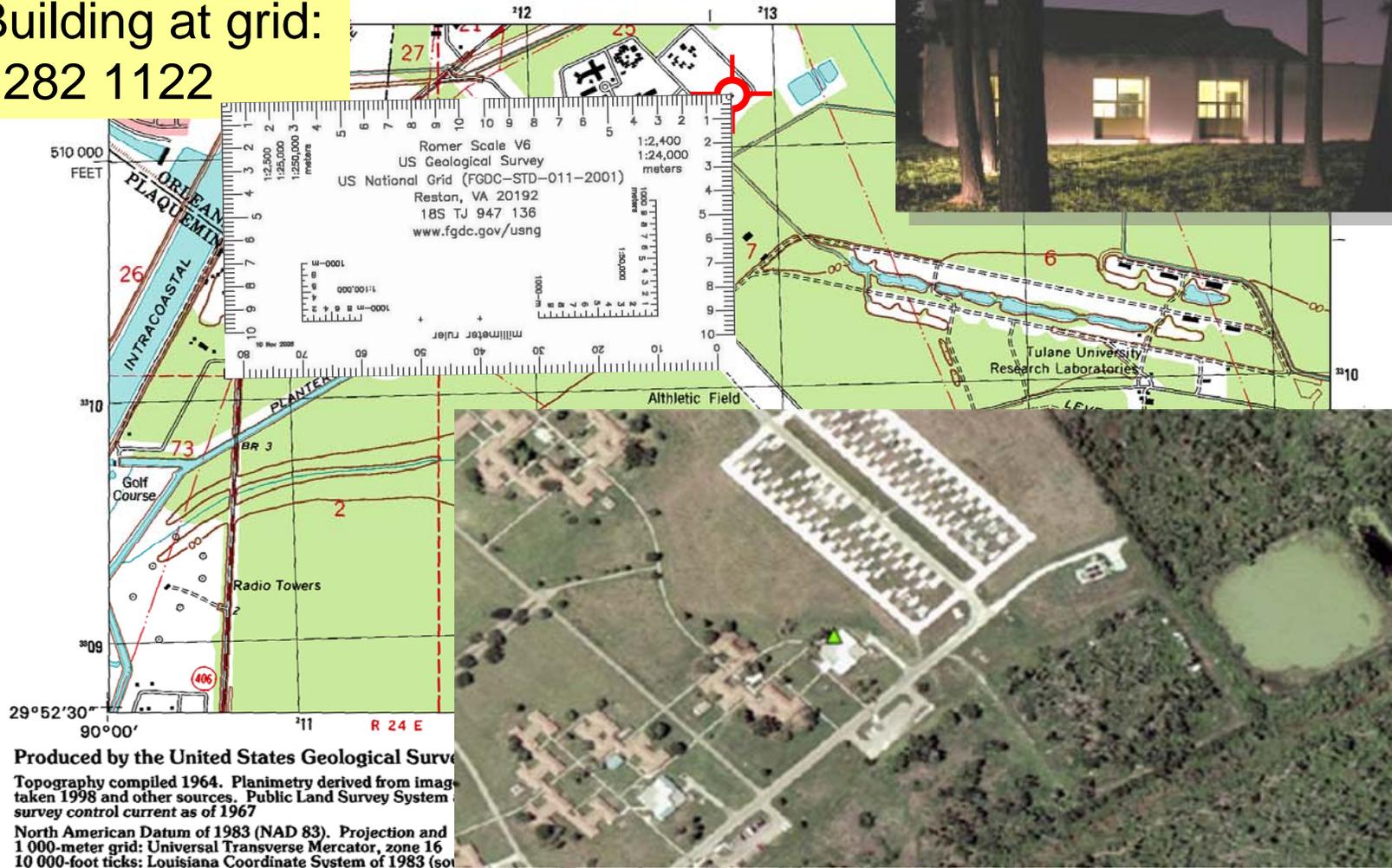
BU
 Grid Zone Designation
 16R

UTM GRID AND 2000 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Ex 1

US National Grid Training

Building at grid:
1282 1122



Produced by the United States Geological Survey
 Topography compiled 1964. Planimetry derived from imagery taken 1998 and other sources. Public Land Survey System survey control current as of 1967
 North American Datum of 1983 (NAD 83). Projection and 1 000-meter grid: Universal Transverse Mercator, zone 16 10 000-foot ticks: Louisiana Coordinate System of 1983 (so
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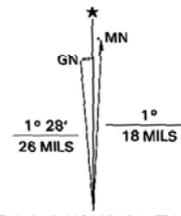
QUADRANGLE LOCATION

1	2	3	1 Spanish Fort 2 Little Woods 3 Chef Menteur
4		5	4 New Orleans East 5 Martello Castle
6	7	8	6 Bertrandville 7 Belle Chasse 8 Delacroix

ADJOINING 7.5' QUADRANGLE NAMES
LA 200A

CONTOUR INTERVAL 5 FEET
 NATIONAL GEODETIC VERTICAL DATUM OF 1929
 TO CONVERT FROM FEET TO METERS, MULTIPLY BY 0.3048

U.S. National Grid
 100,000-m Square ID
BU
 Grid Zone Designation
16R

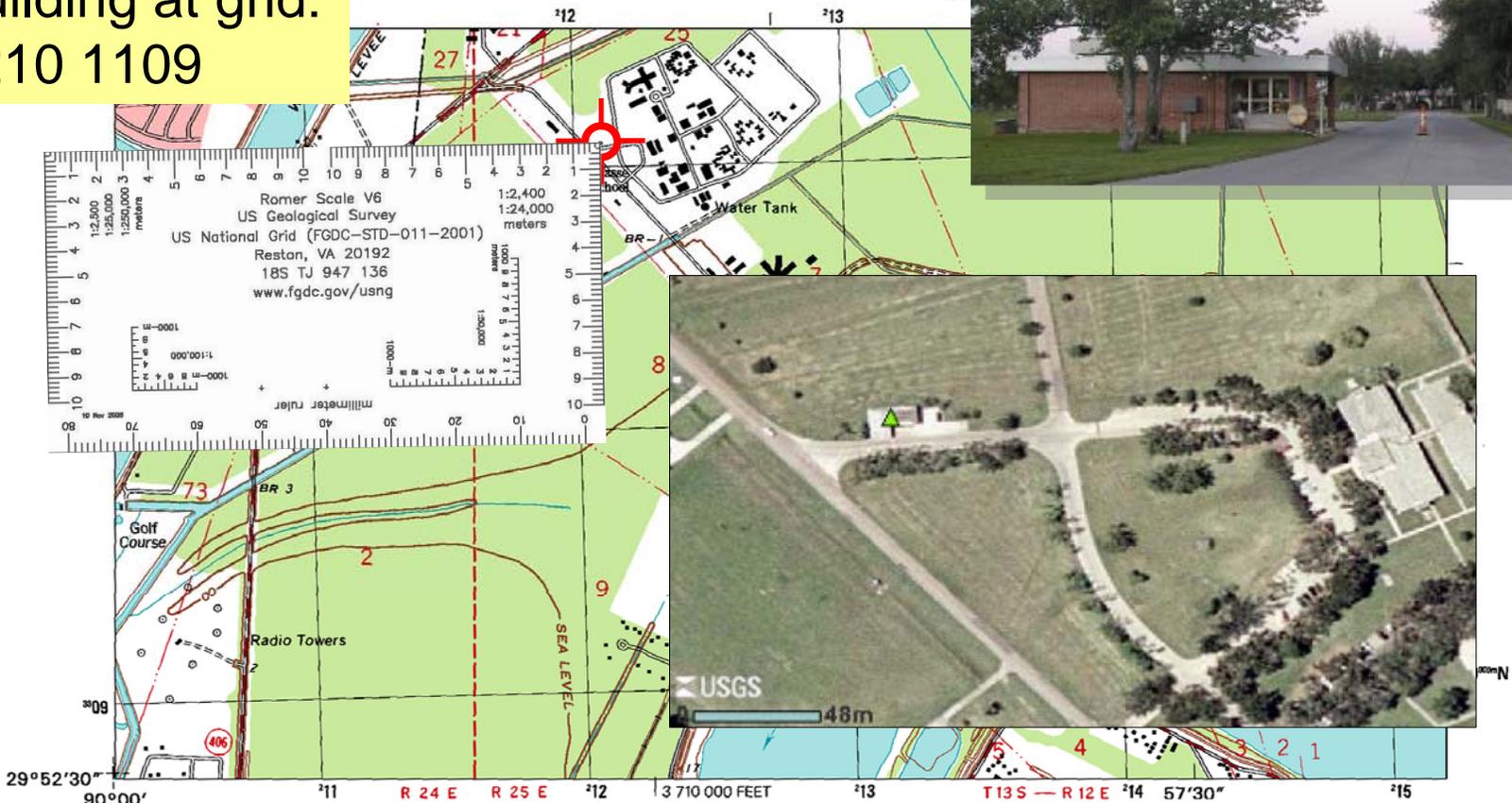


UTM GRID AND 2000 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

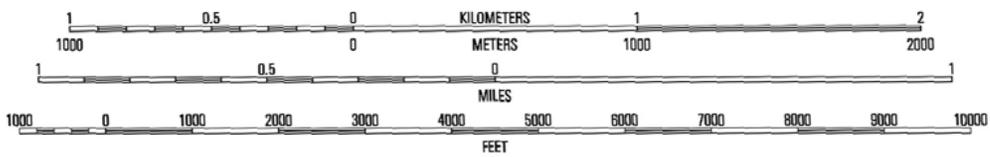
Ex 1

US National Grid Training

Building at grid:
1210 1109



Produced by the United States Geological Survey
 Topography compiled 1964. Planimetry derived from imagery taken 1998 and other sources. Public Land Survey System and survey control current as of 1967
 North American Datum of 1983 (NAD 83). Projection and 1:24,000 meters scale. *U.S. National Grid Training Manual, page 16*



Read right, and up.

National Geodetic Survey NADCON software
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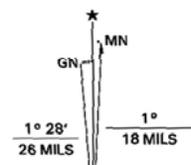
QUADRANGLE LOCATION

1	2	3	1 Spanish Fort
			2 Little Woods
			3 Chef Menteur
4	5		4 New Orleans East
			5 Martello Castle
			6 Bertrاندville
6	7	8	7 Belle Chasse
			8 Delacroix

ADJOINING 7.5' QUADRANGLE NAMES
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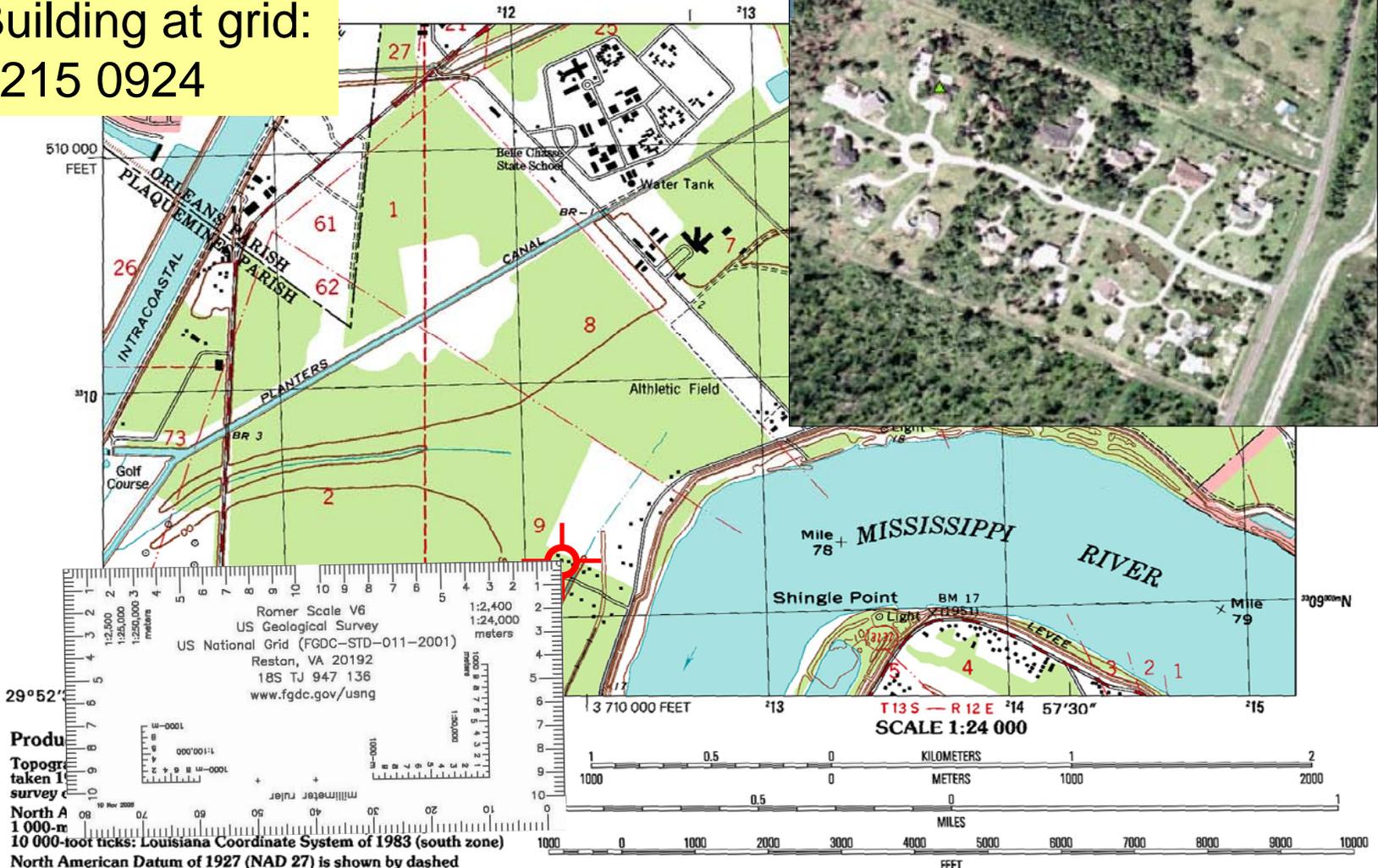
U.S. National Grid
 100,000-m Square ID
BU
 Grid Zone Designation
16R



UTM GRID AND 2000 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

US National Grid Training Map

Building at grid:
1215 0924



Produced from topographic survey data
North American Datum of 1927 (NAD 27)
1 000-m
10 000-foot ticks: Louisiana Coordinate System of 1983 (south zone)

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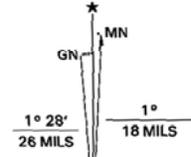


1	2	3	1 Spanish Fort 2 Little Woods 3 Chef Menteur
4	5		4 New Orleans East 5 Martello Castle
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ADJOINING 7.5' QUADRANGLE NAMES
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U.S. National Grid
100,000-m Square ID
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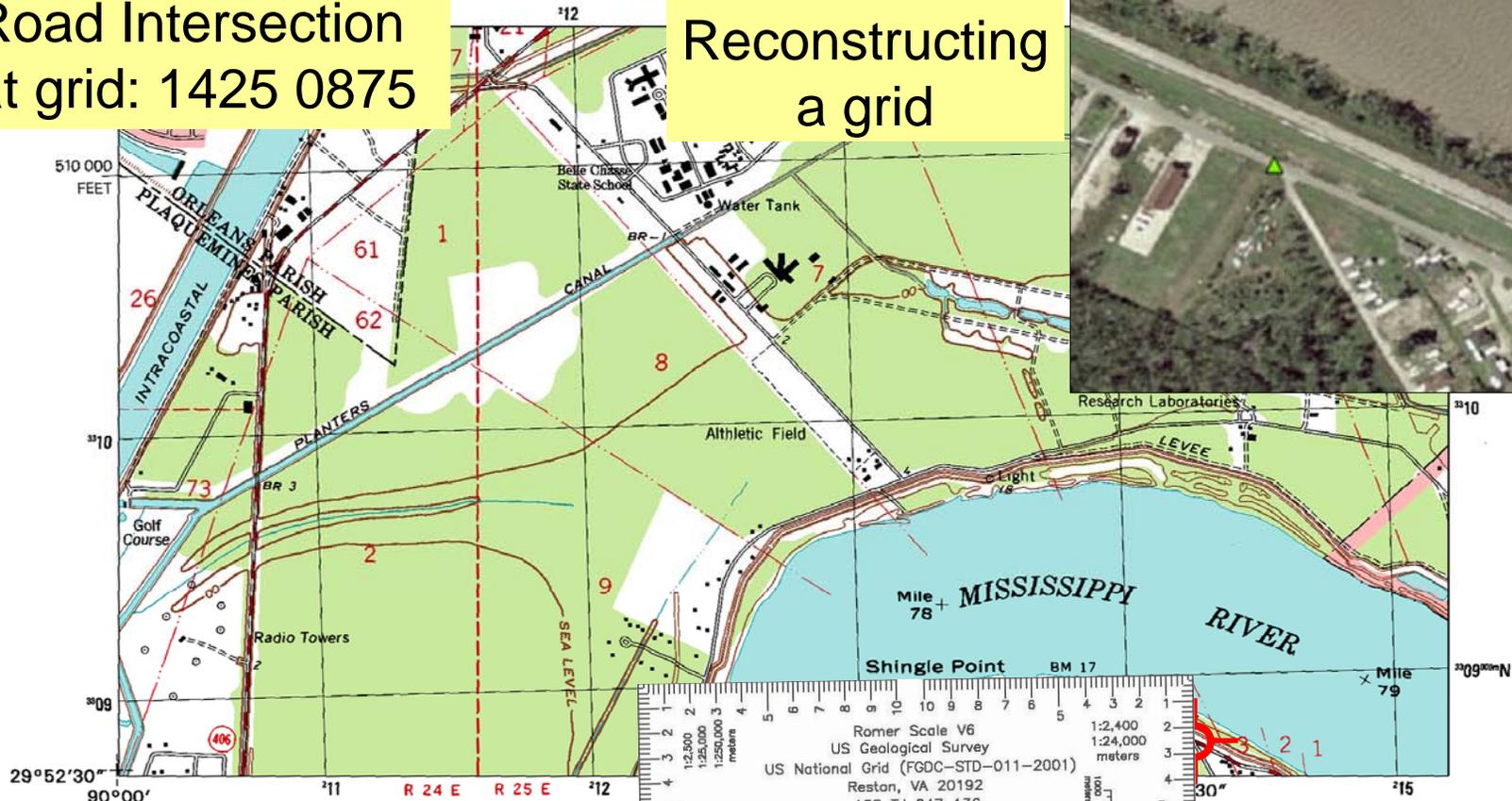
UTM GRID AND 2000 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Ex 5

US National Grid Training Map

Road Intersection
at grid: 1425 0875

Reconstructing
a grid



Produced by the United States Geological Survey

Topography compiled 1964. Planimetry derived from imagery taken 1998 and other sources. Public Land Survey System and survey control current as of 1967

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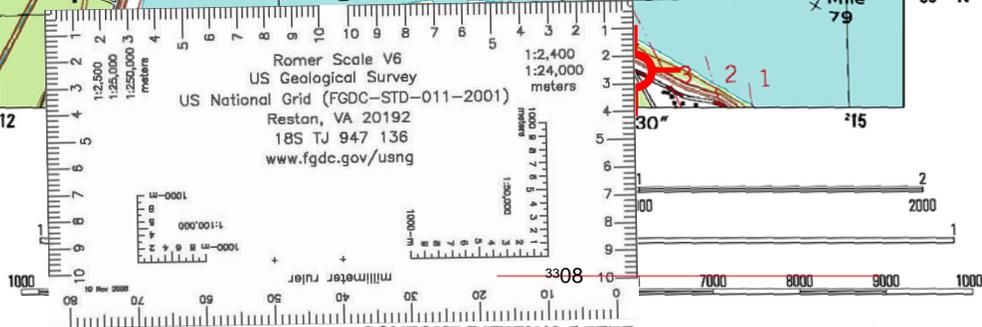


QUADRANGLE LOCATION

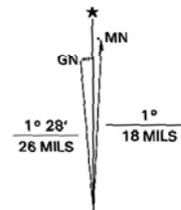
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ADJOINING 7.5' QUADRANGLE NAMES
LA 200A

Romer Scale V6
US Geological Survey
US National Grid (FGDC-STD-011-2001)
Reston, VA 20192
185 TJ 947 136
www.fgdc.gov/usng



U.S. National Grid
100,000-m Square ID
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Grid Zone Designation
16R

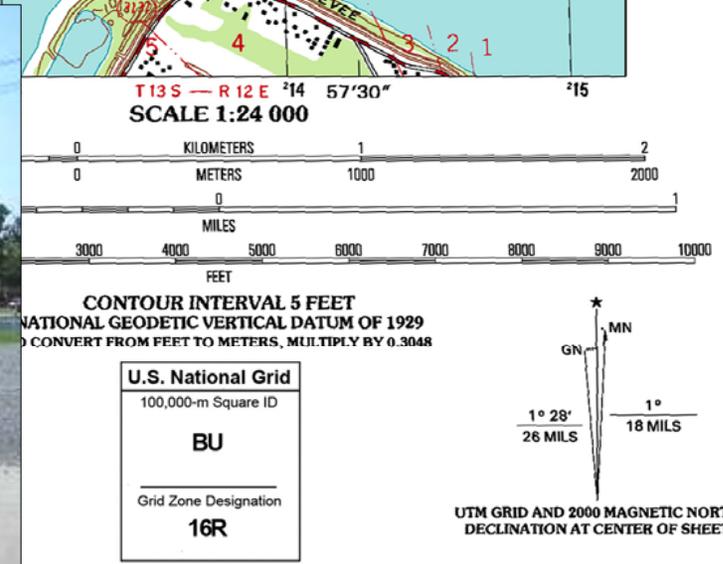
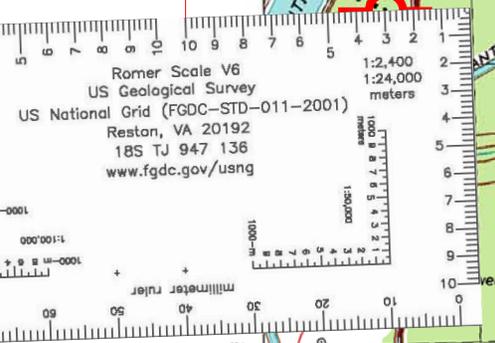
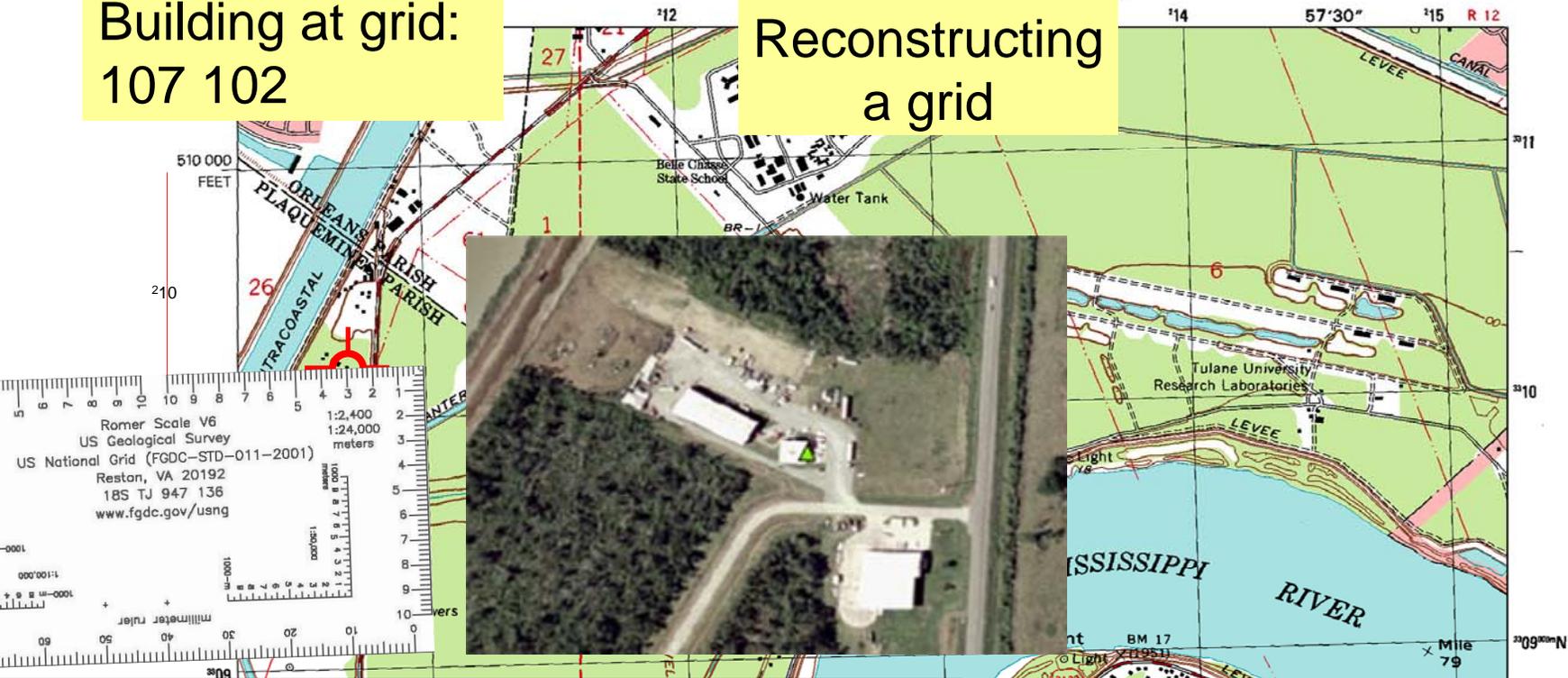


UTM GRID AND 2000 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

US National Grid Training Map

Building at grid:
107 102

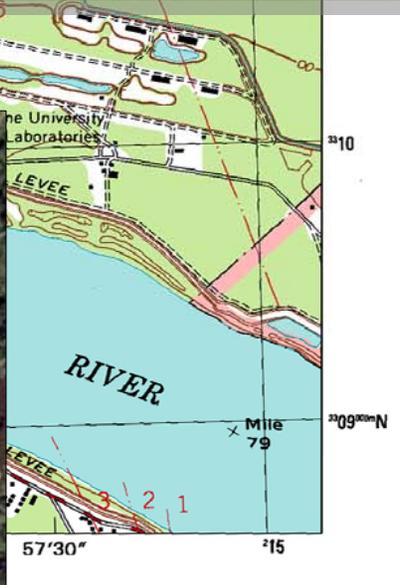
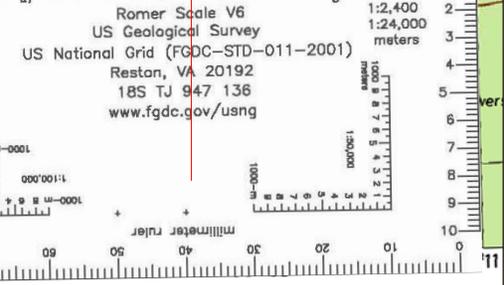
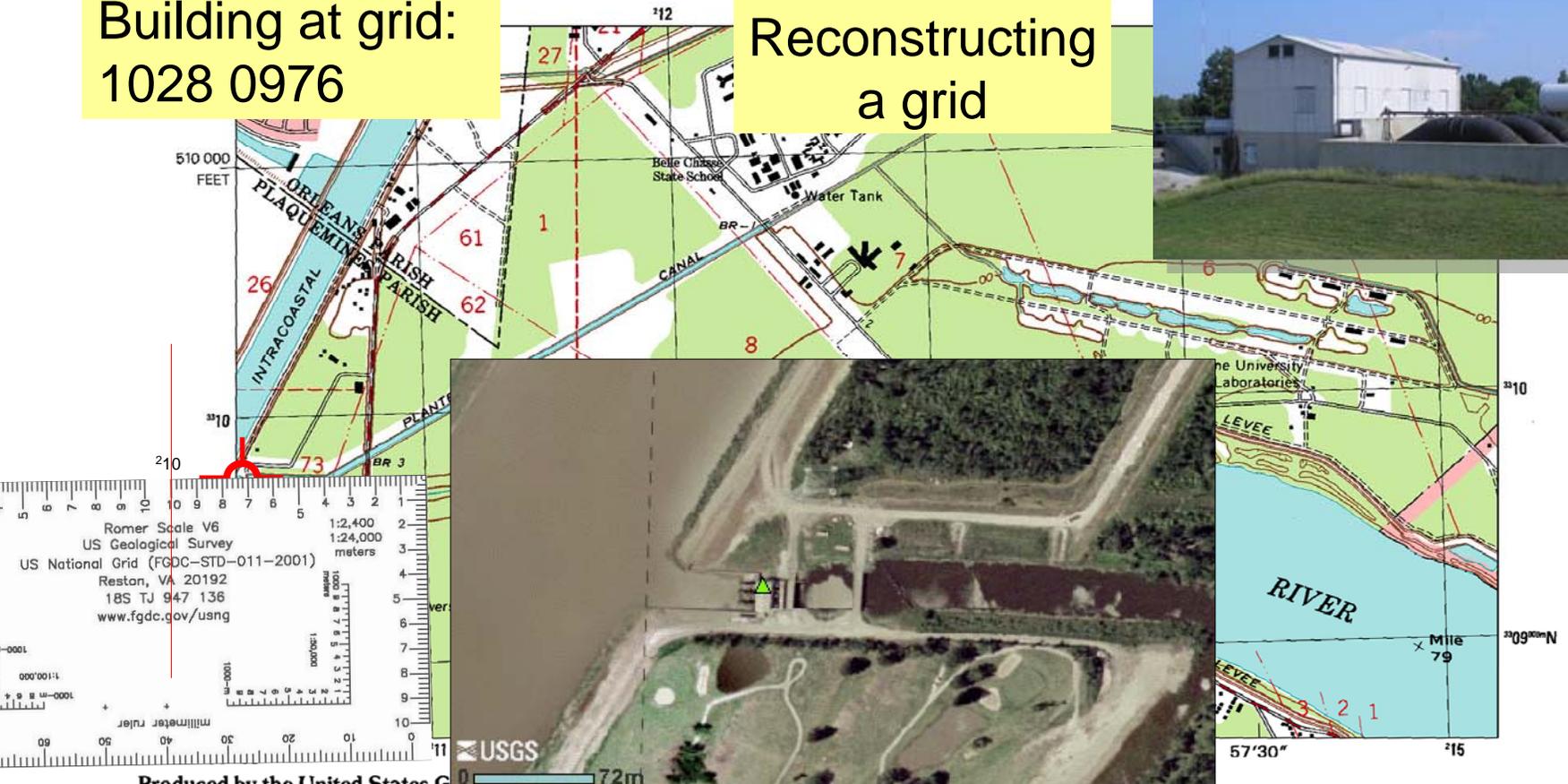
Reconstructing
a grid



US National Grid Training Map

Building at grid:
1028 0976

Reconstructing
a grid



Produced by the United States Geological Survey

Topography compiled 1964. Planimetry derived from imagery taken 1998 and other sources. Public Land Survey System and survey control current as of 1967

North American Datum of 1983 (NAD 83). Projection and 1 000-meter grid: Universal Transverse Mercator, zone 16 10 000-foot ticks: Louisiana Coordinate System of 1983 (south zone)

North American Datum of 1927 (NAD 27) is shown by dashed corner ticks. The values of the shift between NAD 83 and NAD 27 for 7.5-minute intersections are obtainable from National Geodetic Survey NADCON software

There may be private inholdings within the boundaries of the National or State reservations shown on this map

City of New Orleans and Orleans Parish are coextensive

This quadrangle covers a subsidence area

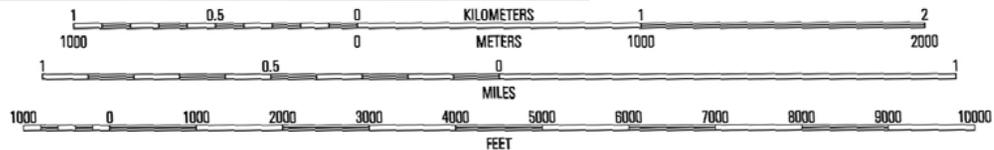
Landmark buildings verified 1967



QUADRANGLE LOCATION

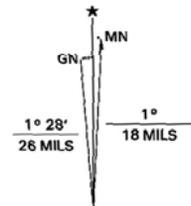
1	2	3	1 Spanish Fort 2 Little Woods 3 Chef Menteur
4	5	6	4 New Orleans East 5 Martello Castle 6 Bertrandville
6	7	8	7 Belle Chasse 8 Delacroix

ADJOINING 7.5' QUADRANGLE NAMES
LA 200A



CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
TO CONVERT FROM FEET TO METERS, MULTIPLY BY 0.3048

U.S. National Grid
100,000-m Square ID
BU
Grid Zone Designation
16R



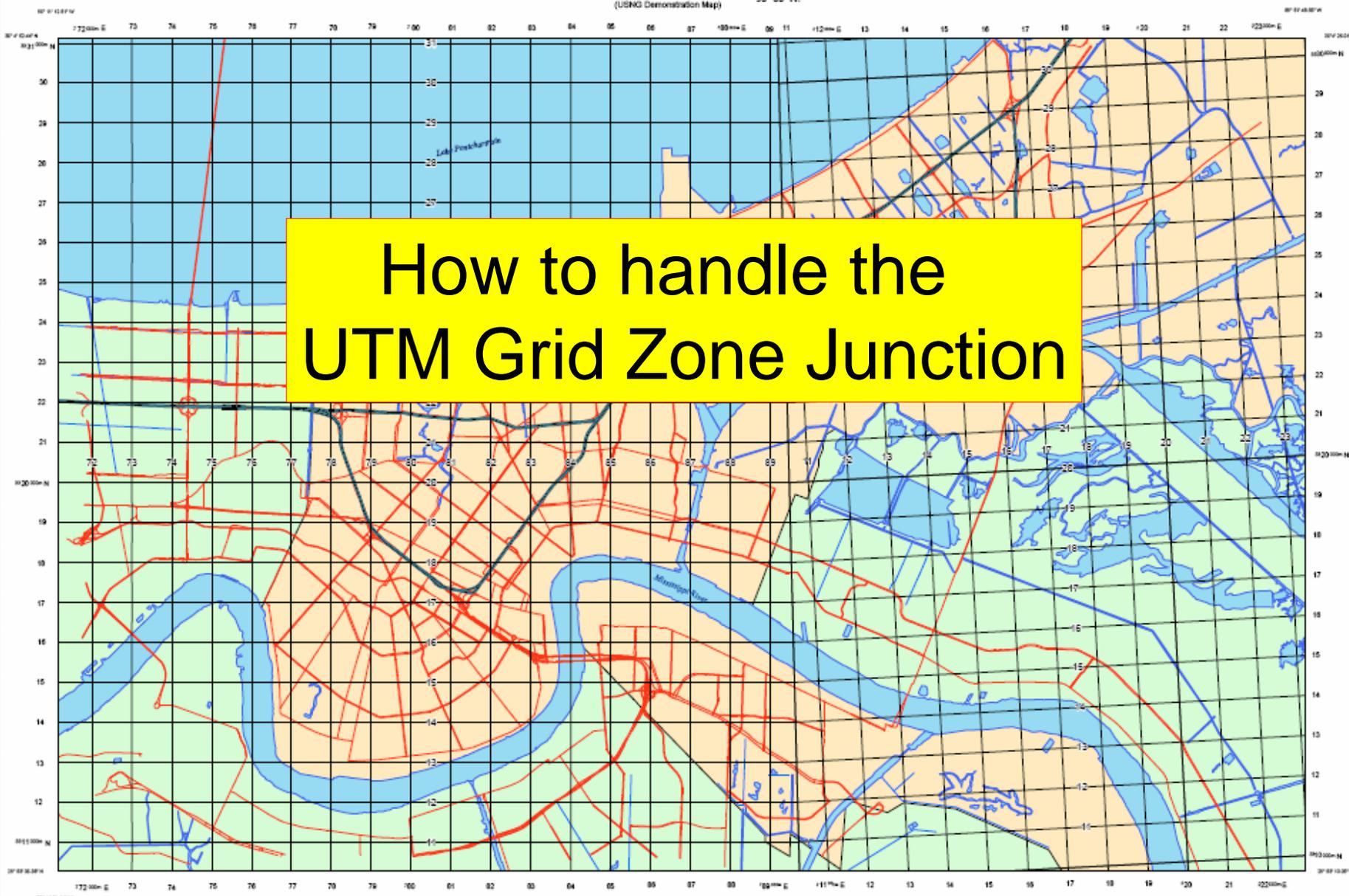
UTM GRID AND 2000 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

NEW ORLEANS, LA

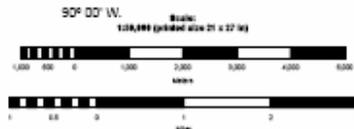
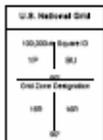
(USNG Demonstration Map)

90° 00' W.

How to handle the UTM Grid Zone Junction



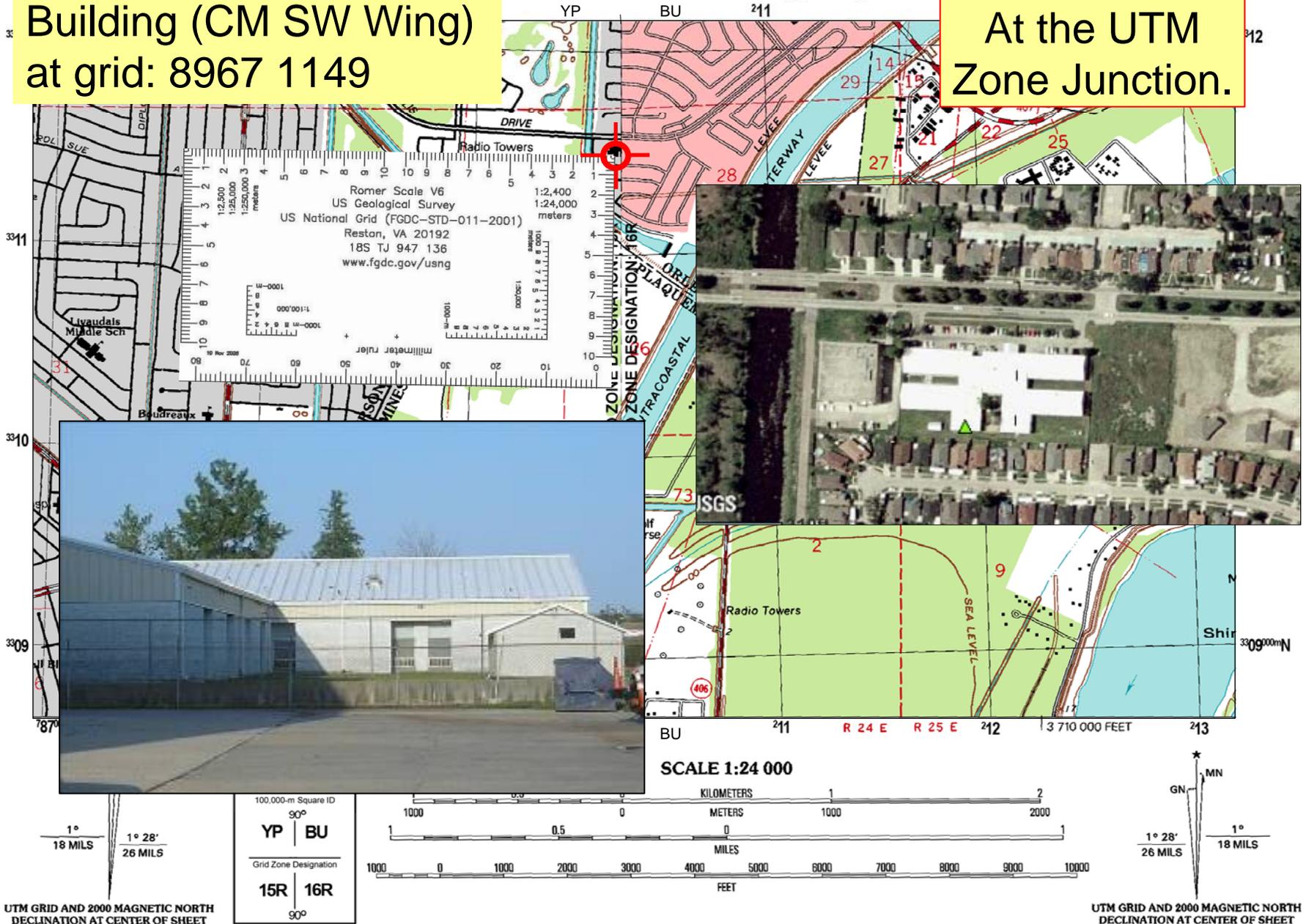
UTM GRID ZONE JUNCTION



US National Grid Training Map

Building (CM SW Wing)
at grid: 8967 1149

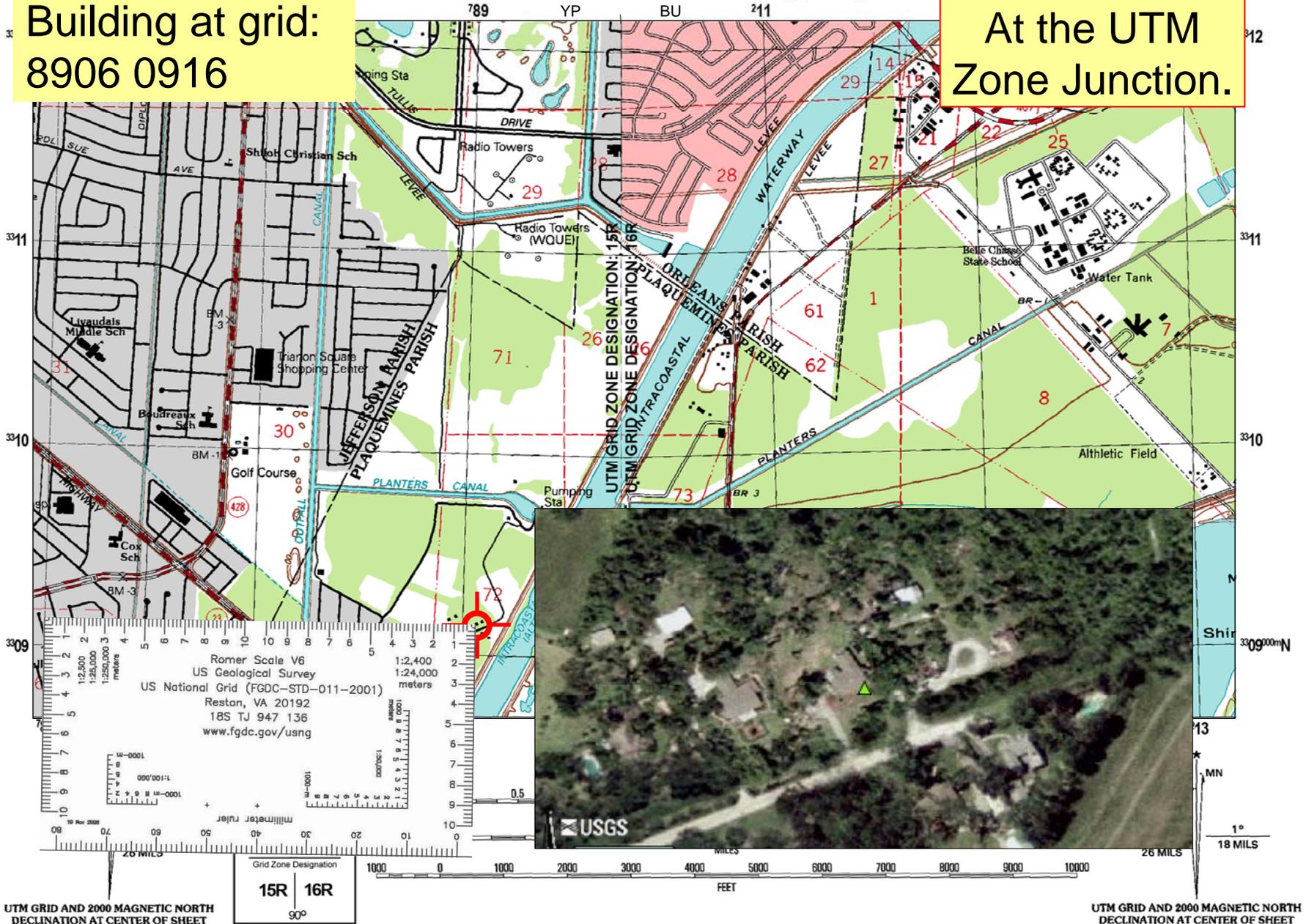
At the UTM
Zone Junction.



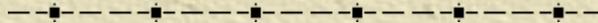
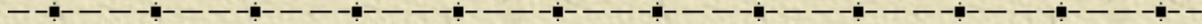
US National Grid Training Map

Building at grid:
8906 0916

At the UTM
Zone Junction.



Part III: Making the “Right” Map



Fundamentals of Mapping Support

✦ Two audiences:

◆ Decision Makers

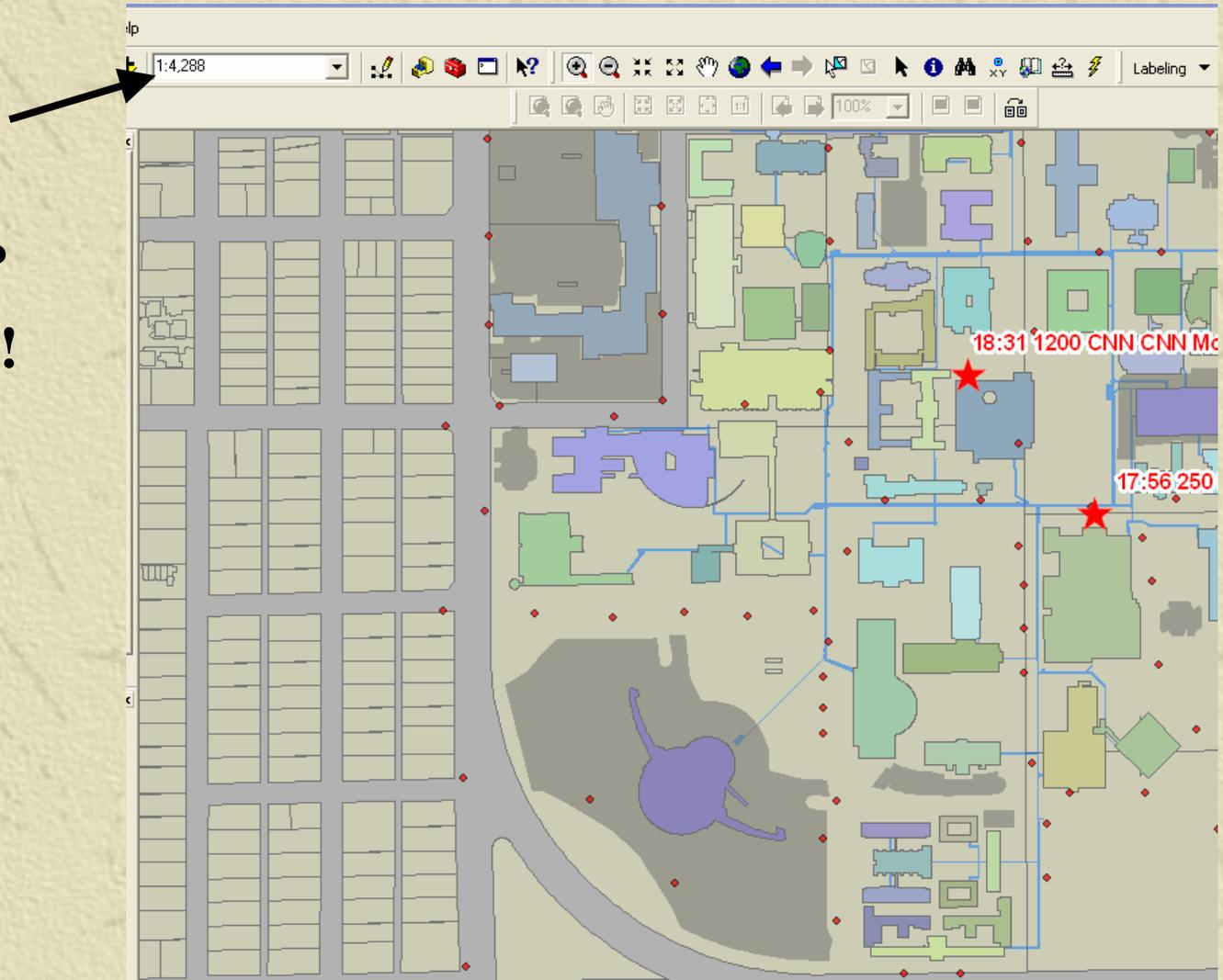
- Provide a “picture” (aka: a map) that describes the situation in a way that supports informed decision making
- The picture should be framed in a **common, spatially-based operational framework**

◆ Responders

- **Navigation tools**
- Local decisions (where is...)

GIS Professionals Gone Bad (aka: Oh, how we forget!)

**ARGH!!!
BAD MAP
MAKER!!!**



The Need For Standardized and Paper Map Products

✦ Responders and Decision Makers Need Maps With

- ◆ Standard Scale
- ◆ Standard Symbology
- ◆ USNG Overlay
- ◆ (Kinda sounds like a topo map, huh?)

Size Does Matter

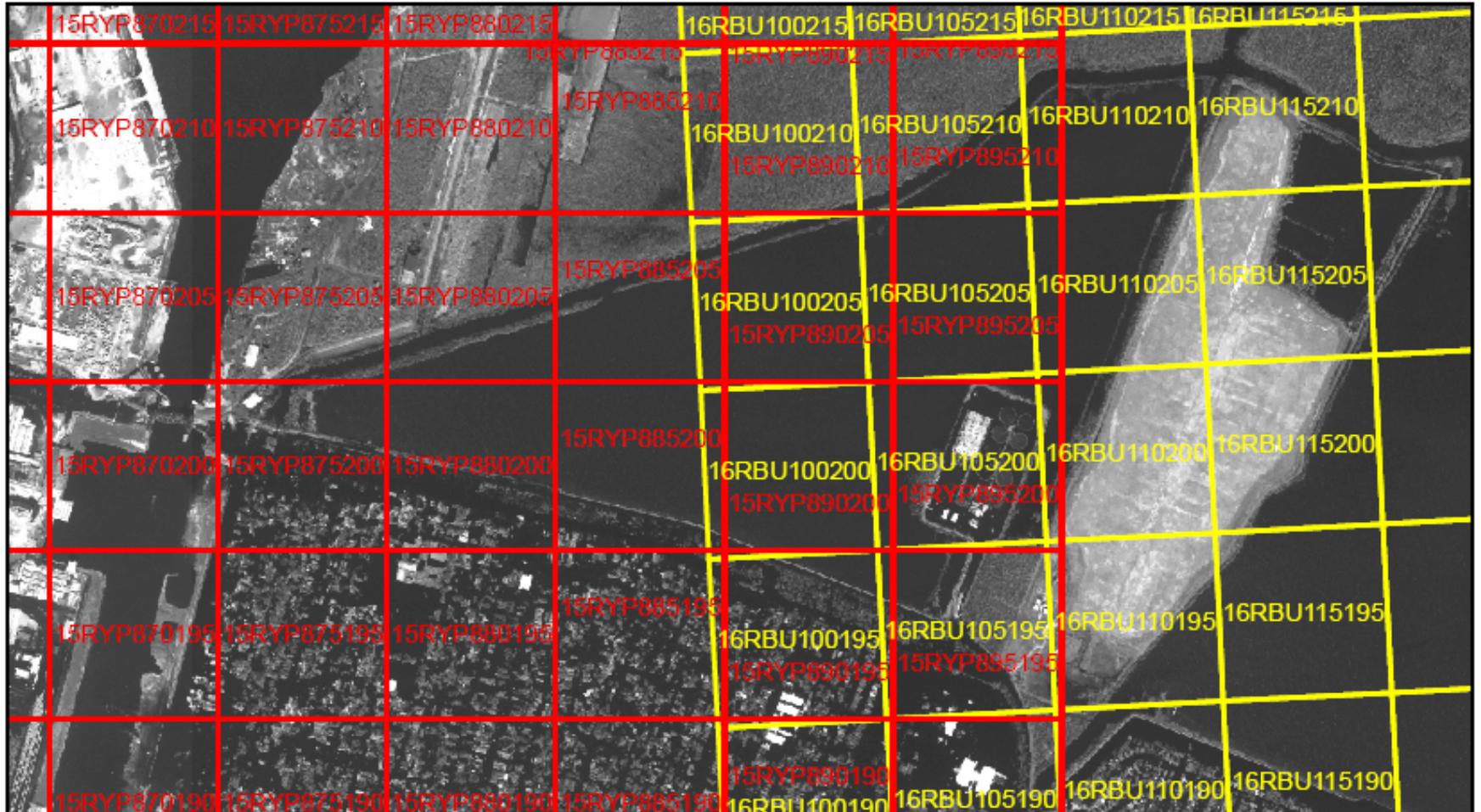
- ✦ While we, as geospatial professionals, often have plotters available, most responders do not. They get stuck with
 - ◆ Printing to fit
 - ◆ Printing cut-out areas
 - ◆ A map that's not to scale (also a problem with Internet mapping services)
- ✦ Simple strategies that consider the responder will help far more than elaborate spatial data clearinghouses, large format plots, etc..
 - ◆ Consider exporting 8.5" x 11" maps into pdf or GeoPDF format and pre-position on the Web and promote a "Know Before You Go" attitude.

Common USNG Mistakes With ESRI Products

- ✦ Grid zone junctions will not display correctly if creating the grid as a graphic in layout view.
- ✦ Graticule coordinates will be incorrect if the correct UTM zone is not set as the base coordinate system.
- ✦ Tick marks are at odd intervals
- ✦ Scale bar done in feet and/or in odd intervals

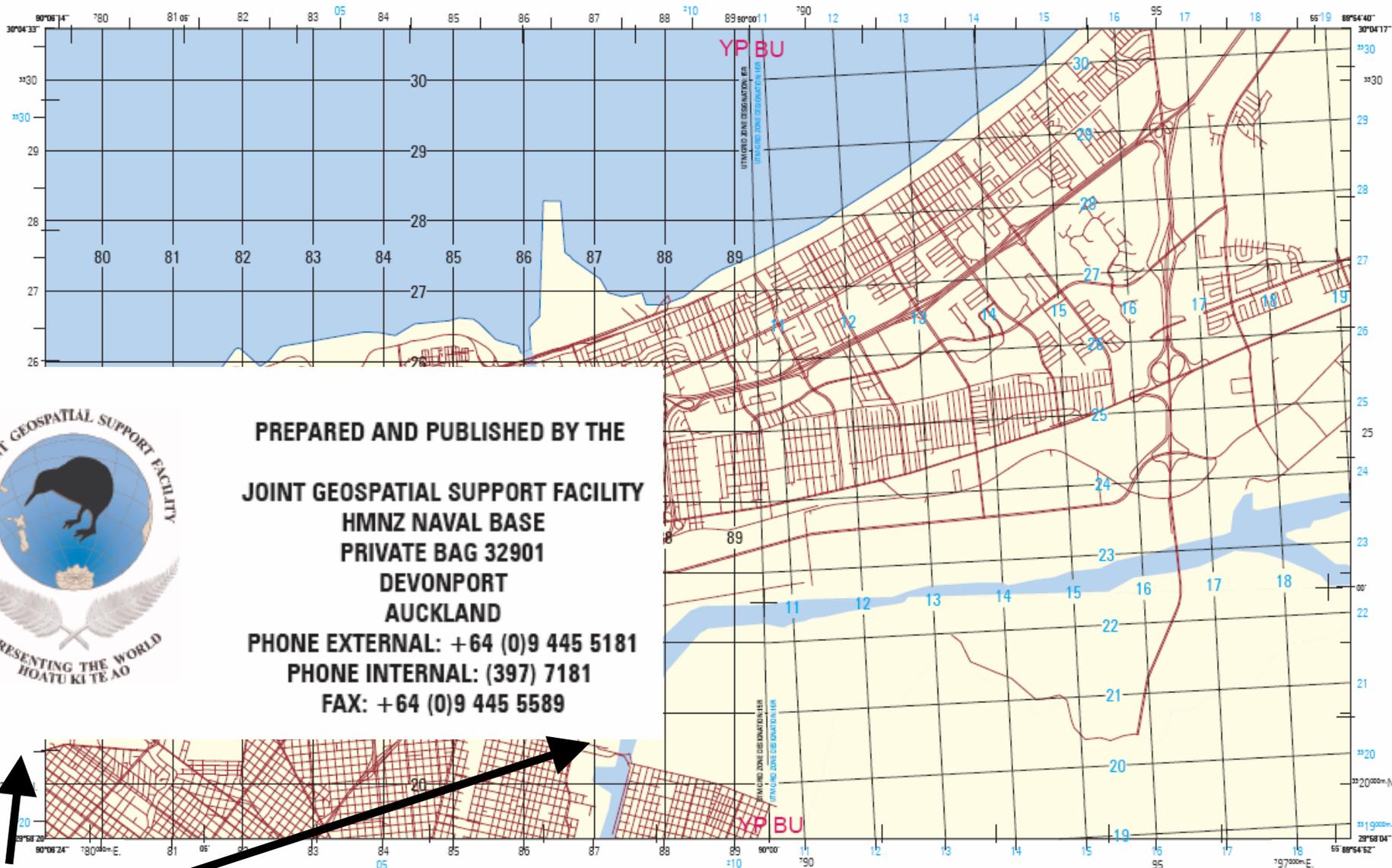
New Orleans - Lower 9th Ward

National Grid (500M) - **Zone 15** & **Zone 16**

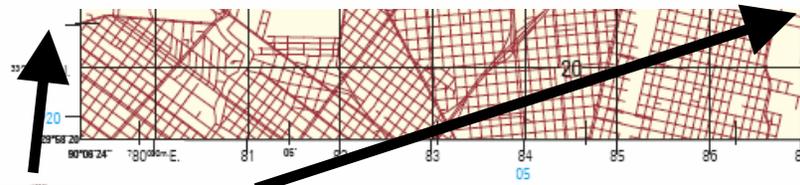


NEW ORLEANS, LA

(MGRS Demonstration Map)

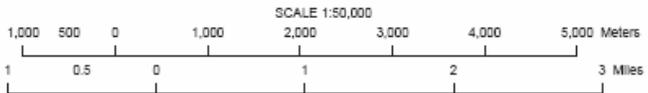


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Disclaimer Notice
 The Roads information on this map is derived from the City of New Orleans Enterprise GIS Database. All other data is derived from VMAP level 1



ELLIPSOID WORLD GEODETIC SYSTEM 1984
GRID 1,000 METRE UTM ZONE 18R (BLACK NUMBERED LINES)
 1,000 METRE UTM ZONE 18R (BLUE NUMBERED LINES)
PROJECTION TRANSVERSE MERCATOR
HORIZONTAL DATUM MEAN SEA LEVEL
HORIZONTAL DATUM WORLD GEODETIC SYSTEM 1984
PRINTED BY JOINT GEOSPATIAL SUPPORT FACILITY



Parking Lot
Zone

- 1
- 2
- 3
- 4
- 5
- 6

Bolivar.sid
RGR

Display Source Selection Map Book

Coordinates

Lat: 33.747296 Lon: -90.750098

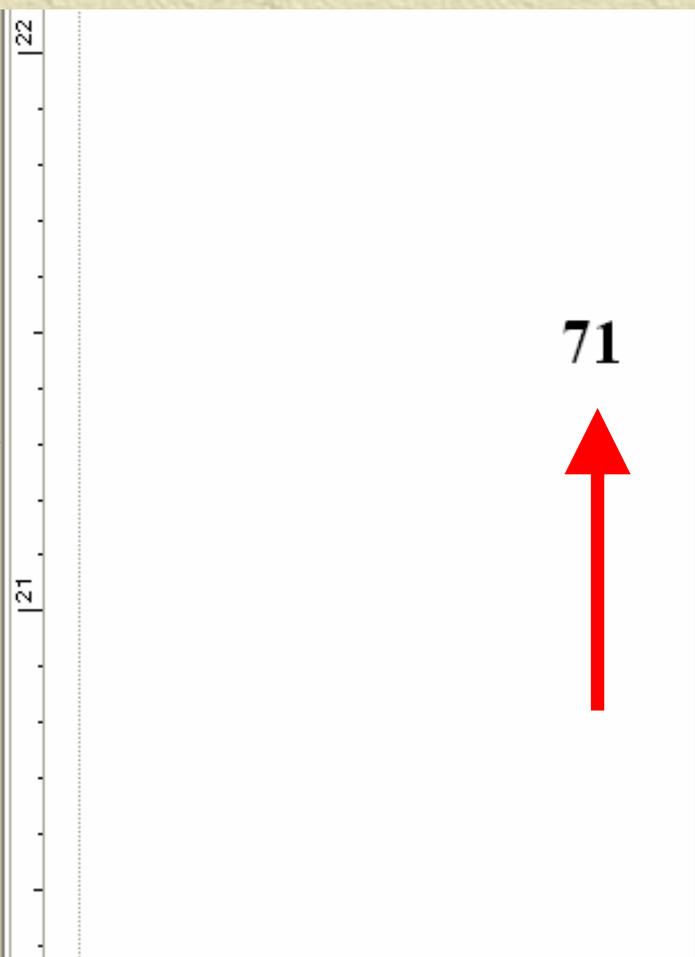
DMS: 334450.26N 0904500.35W

UTM: 15N 708407 3736411

MGRS: 15S YT 0840736411

Datum: North American Datum 1983 (NAD83)

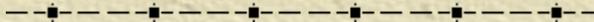
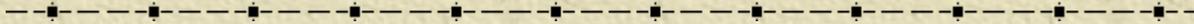
Ellipsoid: GRS 1980 (GRS)



71



**REMEMBER: MAPS
DURING A TIME OF
CRISIS ARE NOT FOR
YOU!**





Take Home Messages

- ✦ Geospatial information technologies create the common, operational framework for managing an event
- ✦ The US National Grid provides the common reference system for such a framework
- ✦ This approach answers many of the criticisms, findings, and recommendations presented in Congress' report on Katrina ("A National Still Unprepared", multiple references, but most significantly Recommendation 51, pg 624)

Goals: Strategic

- ✦ Better understand the mapping needs of emergency responders and decision makers
- ✦ Provide supporting map education programs and services to emergency responders
 - ◆ Create an awareness of what is possible with mapping
 - ◆ Teach fundamental skills such as US National Grid
 - ◆ Create mapping products needed by communities for planning, prevention, response, and recovery phases of response in coordination with all potential participants

Goals: Tactical

- ✦ Understand the US National Grid as demonstrated by an ability to:
 - ✦ Navigate using a map, compass, and map protractor with a USNG overlay
 - ✦ Be able to construct a map with a USNG overlay using ArcGIS
 - ✦ Be able to plot data using USNG
 - ✦ Communicate and interpret spatial information using the USNG

Mechanisms to explore

✦ Local

- 911 Commissions
- County Government
- Regional Response Teams
- Fire, Police, EMS...

✦ State

- State-level offices of HS, Fire Marshall, etc..

✦ National

- FEMA mitigation planning (may incorporated into your local plan or established as a project)
- DHS critical infrastructure protection

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