



# Vertical Geodetic Control in Southern Louisiana: Providing the National Spatial Reference System in Dynamic Regions



Renee Shields  
Height Modernization Manager

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Height Modernization Manager  
National Geodetic Survey

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# Overview

- NGS mission
- Approaches to provide up-to-date data:  
Louisiana model
- National Height Modernization Program
- Future

## Mission of NGS

To define, maintain and provide access to the **National Spatial Reference System** to meet our nation's economic, social, and environmental needs.

[http://geodesy.noaa.gov/INFO/ngs\\_tenyearplan.pdf](http://geodesy.noaa.gov/INFO/ngs_tenyearplan.pdf)

# From the NGS 10-Year Plan

- **Define the NSRS**
  - “The NSRS must be more accurate than all activities which build upon it, while still being practicably achievable.”
- **Maintain the NSRS**
  - “NGS must track all of the temporal changes to the defining points of the NSRS in such a way as to always maintain the accuracy in the NSRS definition.”
- **Provide Access to the NSRS**
  - “NGS must develop and maintain guidelines for users to access the NSRS at a variety of accuracies.”
  - “NGS will publish all coordinates of defining points of the NSRS with an epoch tag and will furthermore publish velocities relative to that epoch-tagged set of coordinates”

# Mission – The NSRS is...

- **The official national coordinate system of the U.S. federal government which includes:**
  - Geodetic latitude, longitude and height
  - Scale, gravity, and orientation
  - **How these values change with time**
- **Components include:**
  - National and Cooperative CORS
  - Network of passive monuments
  - Official national shoreline
  - Precise orbits of GNSS satellites used to define NSRS
  - **Models and tools to describe how all of these quantities change over time.**



# Why worry about updating heights?



## Height Modernization is ...

...the establishment of accurate, reliable heights using GNSS technology in conjunction with traditional leveling, gravity, and modern remote sensing information....

## To improve GPS-derived orthometric heights we need:

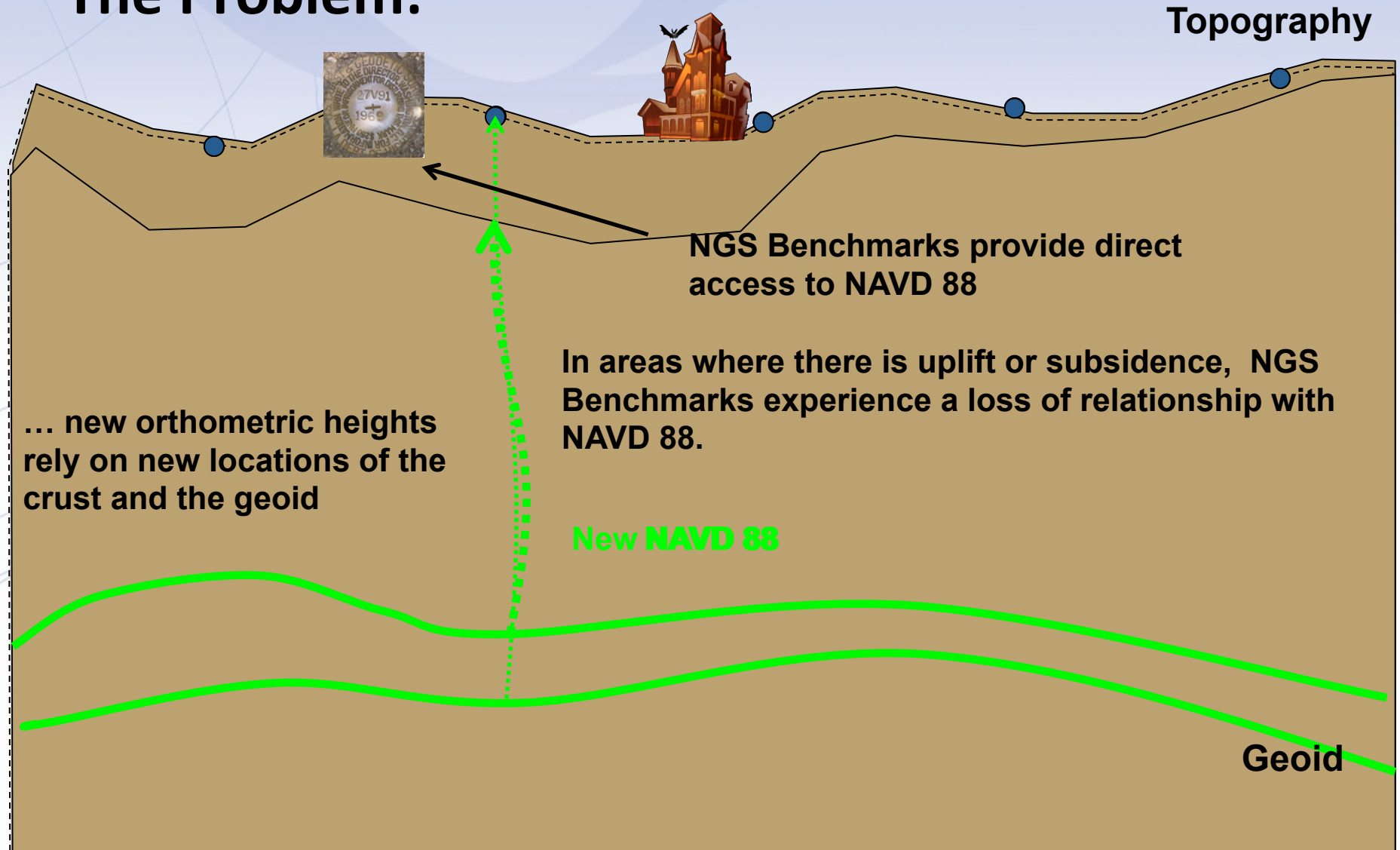
- Good ellipsoid heights
  - Better field procedures
  - Accurate ellipsoid heights at control stations
- An improved geoid model
  - Accurate ellipsoid heights
  - More bench marks observed by GPS
- Accurate orthometric heights at bench marks



## Goals of NHMP

- Access to accurate, reliable heights nationally  
– NGS 58/59
- Standards that are consistent across the nation
- Data, technology, and tools that yield consistent results regardless of terrain and circumstances
- A system/process that will stand the test of time – “Maintain-able”

# The Problem:



**Effect of Subsidence on Orthometric Heights**

# Options for Updating Geodetic Control

1. Re-observe/Readjust – special case projects, gravity
2. Model motion, develop tools – monitor with CORS, satellite gravity
3. Metadata: Epochs, reliability scale, i.e. “Expiration date” on coordinates

# NOAA Technical Report 50: Rates of Vertical Displacement

- 2004 Study by Kurt Shinkle , NGS and Dr. Roy Dokka, LSU
- Louisiana vertical control was out of date
- Study of historic leveling data provided a crude model for updating heights: Vertical Time Dependent Positioning (VTDP)
  - Historical 1<sup>st</sup> Order leveling from 1920-1995
  - Pensacola, FL – Texas border (short of Beaumont)
  - Include relative sea level change from tide gauges
  - Include CORS velocities
- Highest rates of subsidence, over 25mm/yr in Mississippi River Delta



**RATES OF VERTICAL DISPLACEMENT AT BENCHMARKS IN THE LOWER MISSISSIPPI VALLEY AND THE NORTHERN GULF COAST**

Kurt D. Shinkle  
National Geodetic Survey

Dr. Roy K. Dokka  
Louisiana State University

July, 2004

U.S. DEPARTMENT OF COMMERCE  
Donald L. Evans Secretary

National Oceanic and Atmospheric Administration  
VADM Conrad C. Lautenbacher Jr., USN (Ret.)  
Under Secretary of Commerce for Oceans and Atmosphere

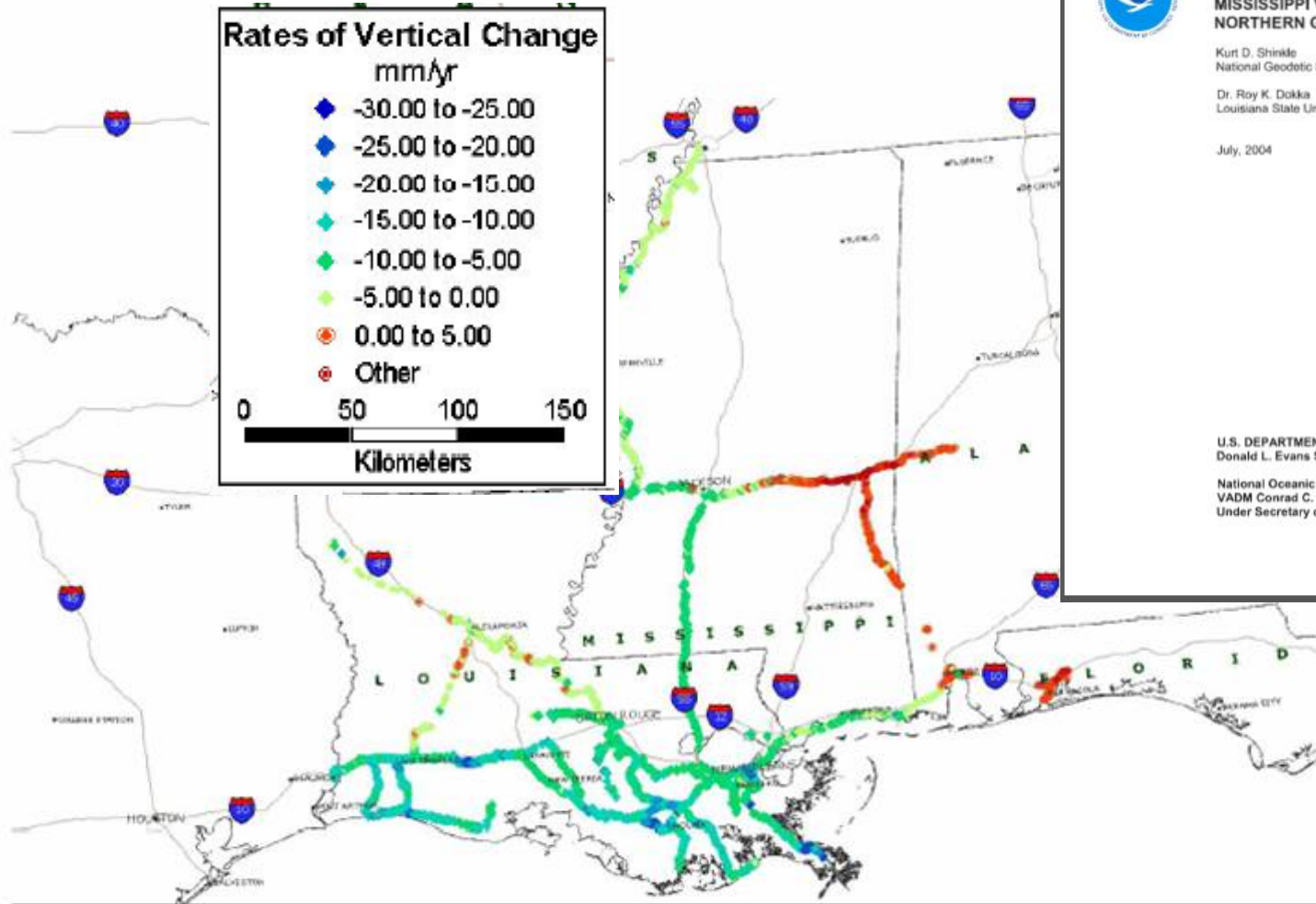


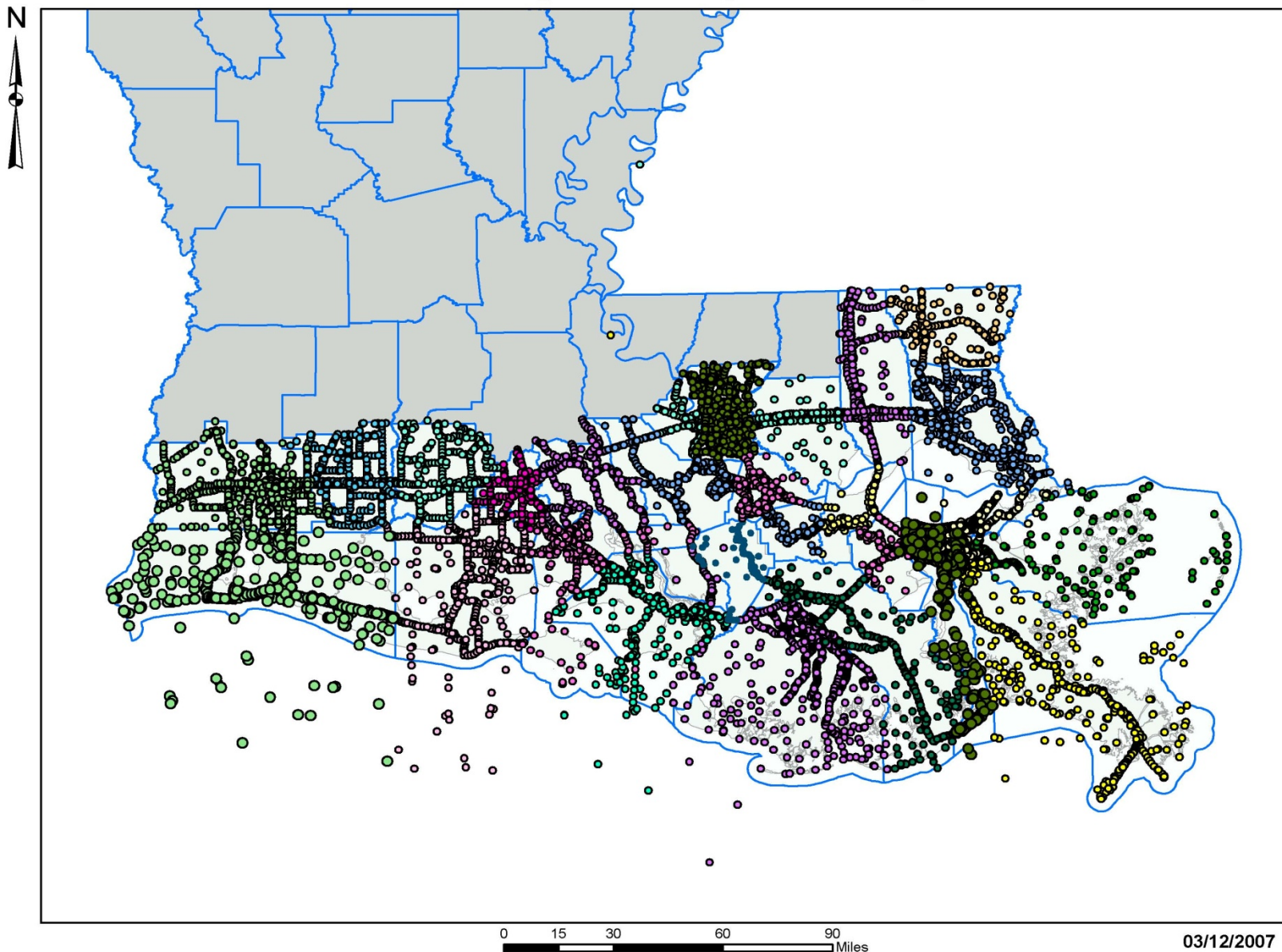
Figure 5. Rates of vertical change derived from the latest rates computed for the benchmarks in this study.



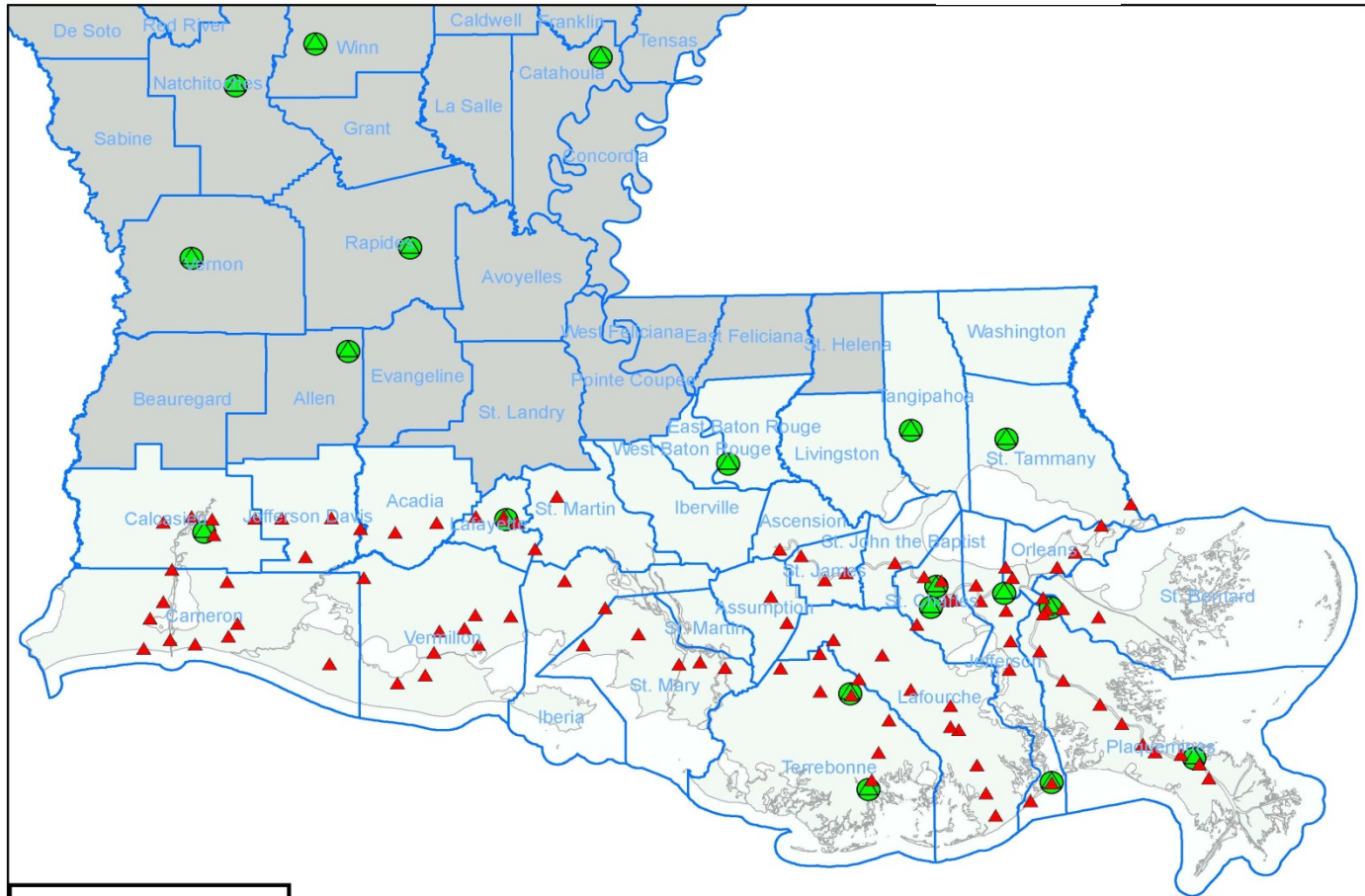
## 2004 Survey to Update Vertical Control Network

- New leveling, GPS surveys to 99 bench marks
- Area of Survey – south of I-10
- Used VTDP to validate control and consistency of observations in adjustment
- New NAVD 88 heights used to refine geoid model (GEOID03)
- Control published for new heights only; other heights 'suppressed'

### S. Louisiana Height Mod. Project - Existing NGS Marks

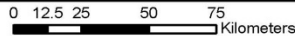


### NGS Louisiana Height. Modernization - 2004



**Legend**

-  LA CORS
-  99 - 2004.65 Marks



## 2006 Southern Louisiana Project – Post-Katrina Recovery Project

- FEMA provided Funding through NGS
- Joint Survey Project between NGS and CO-OPS of NOAA, & the Louisiana Spatial Reference Center at LSU
- Included 27 Parishes across Southern Louisiana

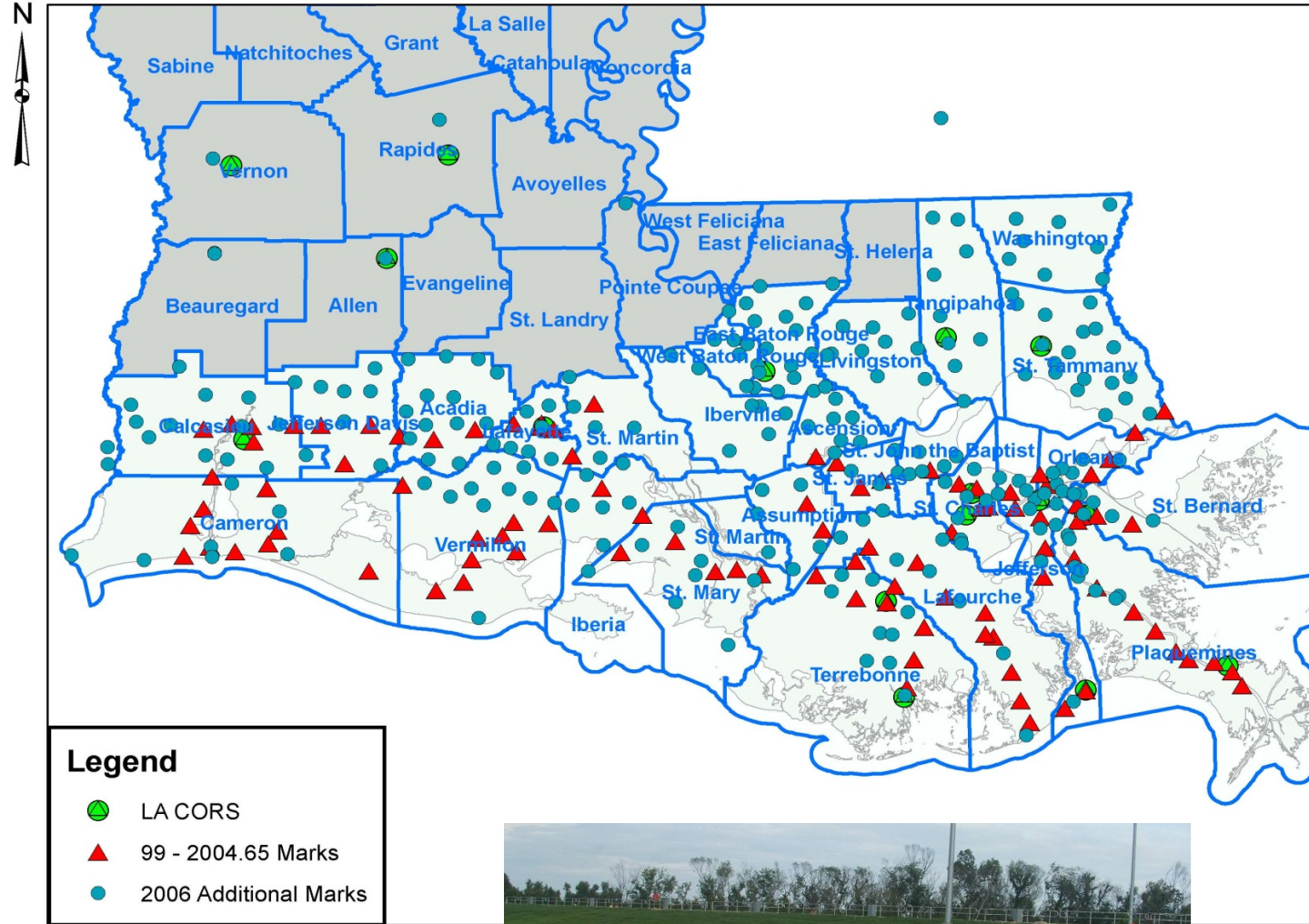


## Project Components

- Re-observe the 2004.65 Marks (99 marks)
- Observe & update an additional 240 marks
- Install a minimum of 16 additional Continuously Operating Reference Stations (CORS)
- Set up a pilot GPS Real Time Network (RTN) in SE LA
- Take gravity observations at 16 sites (relative & absolute)
- Install two new tide stations (Shell Beach & Amerada Pass)

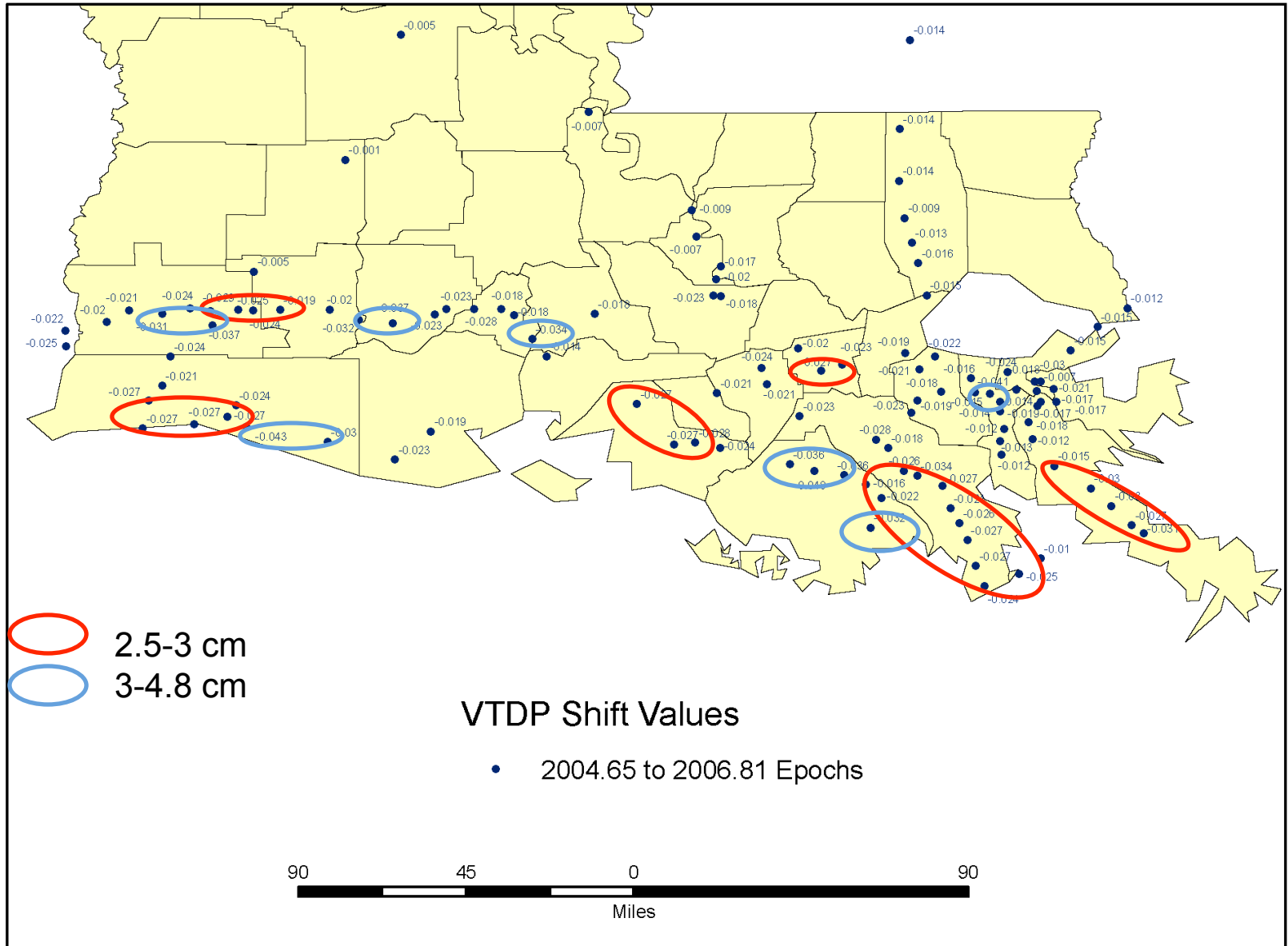


# 2006 Southern Louisiana Height Modernization Project



02/09/2007

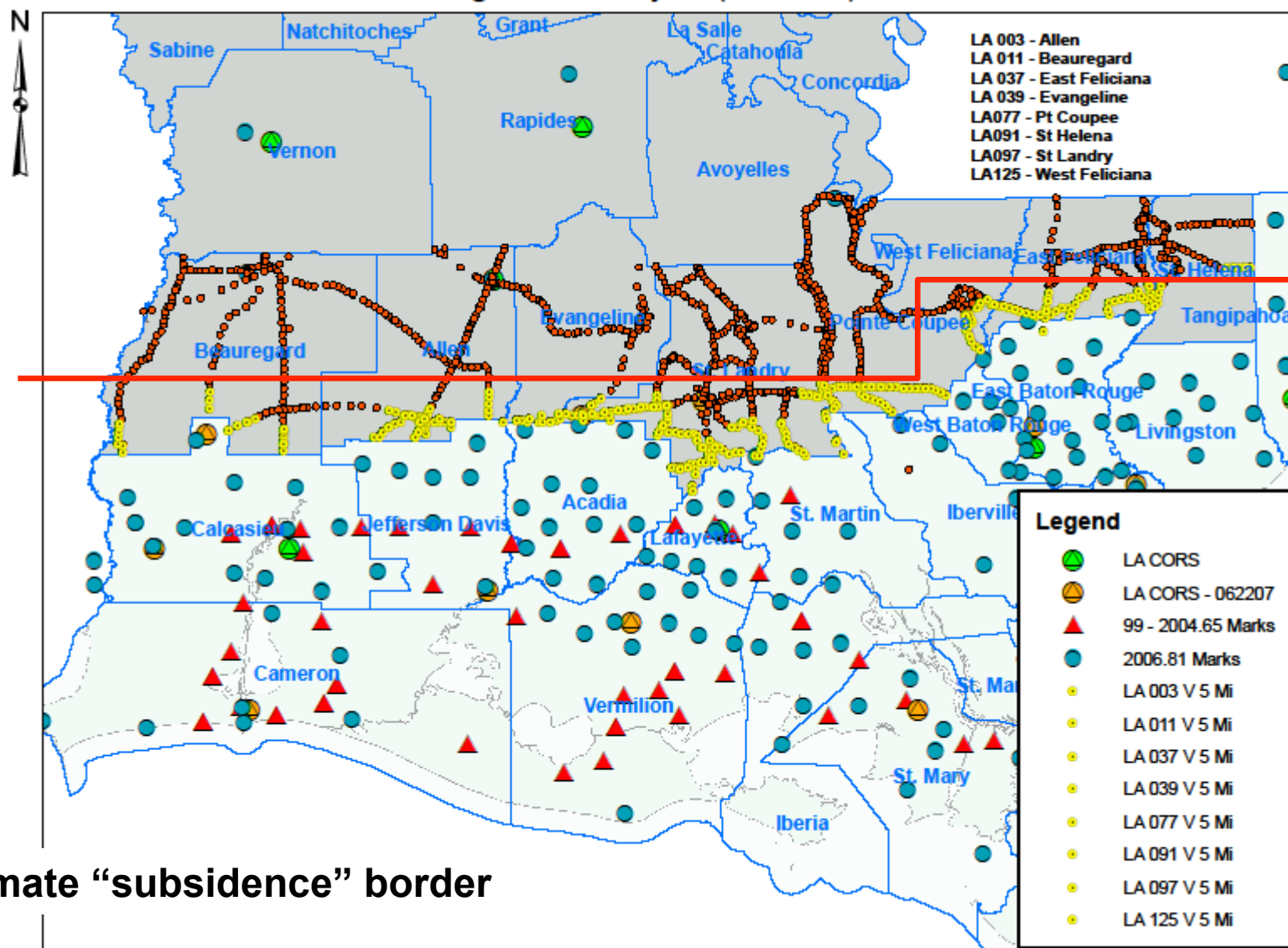
# South Louisiana Height Modernization Project 2006



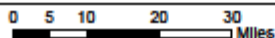
# Results of 2006 Survey

- Updated Heights on 340 bench marks
- Observation data to contribute to subsidence rate research
- Additional gravity and height data to improve the geoid model used to convert GPS heights to NAVD88 heights
- Suppression of inconsistent out-dated heights

### 2006 S. LA Hgt. Mod. Project (2006.81) - DS Limiter



Estimate "subsidence" border





# NGS Datasheet – Leveling

```

1      National Geodetic Survey,  Retrieval Date = JUNE 19, 2011
AA2906 *****
AA2906 DESIGNATION - 18 V 32
AA2906 PID - AA2906
AA2906 STATE/COUNTY- LA/EAST CARROLL
AA2906 USGS QUAD - MILLIKIN (1994)
AA2906
AA2906 *CURRENT SURVEY CONTROL
AA2906
AA2906* NAD 83(2007)- 32 54 27.65574(N) 091 13 35.40957(W) ADJUSTED
AA2906* NAVD 88 - 32.001 (meters) 104.99 (feet) ADJUSTED
AA2906
AA2906 EPOCH DATE - 2002.00
. . .
AA2906 LAPLACE CORR- -1.92 (seconds) DEFLEC09
AA2906 ELLIP HEIGHT- 5.765 (meters) (02/10/07) ADJUSTED
AA2906 GEOID HEIGHT- -26.24 (meters) GEOID09
AA2906 DYNAMIC HT - 31.966 (meters) 104.88 (feet) COMP
AA2906
AA2906 ----- Accuracy Estimates (at 95% Confidence Level in cm) -----
AA2906 Type PID Designation North East Ellip
AA2906 -----
AA2906 NETWORK AA2906 18 V 32
AA2906 -----
. . .
AA2906 VERT ORDER - SECOND CLASS
AA2906 .The orthometric height was determined by differential leveling and
AA2906 .adjusted in May 1997.
    
```

$$\begin{aligned}
 & \text{NAVD88} - \text{Ellipsoid Ht} + \text{Geoid Ht} = \\
 & 32.001 - 5.765 - 26.241 = -0.005 \quad \text{GEOID03} \\
 & 32.001 - 5.765 - 26.244 = -0.008 \quad \text{GEOID09}
 \end{aligned}$$



# NGS Datasheet – GPS Height Mod

```

• 1 National Geodetic Survey, Retrieval Date = MARCH 18, 2009
• BJ0196 *****
• BJ0196 HT_MOD - This is a Height Modernization Survey Station.
• BJ0196 FBN - This is a Federal Base Network Control Station.
• BJ0196 DESIGNATION - E 284 X
• BJ0196 PID - BJ0196
• BJ0196 STATE/COUNTY- LA/ST LANDRY
• BJ0196 USGS QUAD - BAYOU CURRENT (1994)
• BJ0196
• BJ0196 *CURRENT SURVEY CONTROL
• BJ0196
• BJ0196* NAD 83(2007)- 30 46 55.32566(N) 091 46 23.63541(W) ADJUSTED
• BJ0196* NAVD 88 - 11.54 (meters) 37.9 (feet) GPS OBS
• BJ0196
• BJ0196 EPOCH DATE - 2002.00
• BJ0196 X - -169,707.673 (meters) COMP
• BJ0196 Y - -5,481,757.847 (meters) COMP
• BJ0196 Z - 3,245,148.124 (meters) COMP
• BJ0196 LAPLACE CORR- 0.08 (seconds) DEFLEC99
• BJ0196 ELLIP HEIGHT- -15.814 (meters) (02/10/07) ADJUSTED
• BJ0196 GEOID HEIGHT- -27.25 (meters) GEOID03
• BJ0196
• BJ0196 ----- Accuracy Estimates (at 95% Confidence Level in cm) -----
• BJ0196 Type PID Designation North East Ellip
• BJ0196 -----
• BJ0196 NETWORK BJ0196 E 284 X 0.25 0.25 0.76
• BJ0196 -----
  
```

# NGS Datasheet – GPS Height Mod

- BJ0196; North East Units Scale Factor Converg.
- BJ0196;SPC LA S - 253,039.136 957,891.868 MT 1.00001848 -0 13 11.8
- BJ0196;SPC LA S - 830,179.23 3,142,683.57 sFT 1.00001848 -0 13 11.8
- BJ0196;UTM 15 - 3,406,089.525 617,384.539 MT 0.99976997 +0 37 40.4
- BJ0196
- BJ0196! - Elev Factor x Scale Factor = Combined Factor
- BJ0196!SPC LA S - 1.00000248 x 1.00001848 = 1.00002096
- BJ0196!UTM 15 - 1.00000248 x 0.99976997 = 0.99977245
- BJ0196
- BJ0196
- BJ0196
- BJ0196 NAD 83(1992)- 30 46 55.32569(N) 091 46 23.63496(W) AD( ) B
- BJ0196 ELLIP H (12/29/04) -15.825 (m) GP( ) 4 1
- BJ0196 ELLIP H (06/20/00) -15.817 (m) GP( ) 3 1
- BJ0196 NAD 83(1992)- 30 46 55.34409(N) 091 46 23.62954(W) AD( ) 1
- BJ0196 NAD 83(1992)- 30 46 55.32544(N) 091 46 23.63514(W) AD( ) A
- BJ0196 ELLIP H (09/04/92) -15.720 (m) GP( ) 3 1
- BJ0196 NAVD 88 (02/14/94) 11.408 (m) 37.43 (f) ADJUSTED 1 1
- BJ0196 NAVD 88 (06/15/91) 11.444 (m) 37.55 (f) UNKNOWN 1 1
- BJ0196 NGVD 29 (??/??/??) 11.404 (m) 37.41 (f) ADJUSTED 1 1
- BJ0196
- BJ0196.Superseded values are not recommended for survey control.
- BJ0196.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
- BJ0196.See file [dsdata.txt](#) to determine how the superseded data were derived.
- BJ0196

# NGS Datasheet – New Datasheets

```

1      National Geodetic Survey,   Retrieval Date = MARCH 17, 2009
AV0426 *****
AV0426 HT_MOD      -   This is a Louisiana Height Modernization Survey Station.
AV0426 DESIGNATION D 215
AV0426 PID        -   AV0426
AV0426 STATE/COUNTY- LA/CAMERON
AV0426 USGS QUAD   -   CREOLE (1982)
AV0426
AV0426                               *CURRENT SURVEY CONTROL
AV0426
AV0426* NAD 83(2007)- 29 51 37.54827(N)    093 05 15.70510(W)    ADJUSTED
AV0426* NAVD 88      -           0.65 (meters)      2.1 (feet)  GPS OBS(2006.81)
AV0426 **This station is located in a suspected subsidence area (see below)
AV0426 **This station is included in the VTDP model (see below).
AV0426
AV0426 EPOCH DATE   -           2002.00
AV0426 X           -   -298,190.692 (meters)           COMP
AV0426 Y           -   -5,527,916.711 (meters)        COMP
AV0426 Z           -     3,156,952.642 (meters)        COMP
AV0426 LAPLACE CORR-           0.40 (seconds)         DEFLEC99
AV0426 ELLIP HEIGHT-           -26.050 (meters)       (03/12/08) ADJUSTED
AV0426 GEOID HEIGHT-           -26.76 (meters)         GEOID03
AV0426
AV0426 ----- Accuracy Estimates (at 95% Confidence Level in cm) -----
AV0426 Type      PID      Designation                North   East   Ellip
AV0426 -----
AV0426 NETWORK AV0426 D 215                0.96   0.82   2.00
AV0426 -----
    
```

# NGS Datasheet

- AV0426 ----- Accuracy Estimates (at 95% Confidence Level in cm) -----
- AV0426 Type PID Designation North East Ellip
- AV0426 -----
- AV0426 NETWORK AV0426 D 215 0.96 0.82 2.00
- AV0426 -----
- AV0426 ELLP ORDER - THIRD CLASS I
- AV0426
- AV0426.The horizontal coordinates were established by GPS observations
- AV0426.and adjusted by the National Geodetic Survey in February 2007.
- AV0426
- AV0426.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
- AV0426.See National Readjustment for more information.
- AV0426.The horizontal coordinates are valid at the epoch date displayed above.
- AV0426.The epoch date for horizontal control is a decimal equivalence
- AV0426.of Year/Month/Day.
- AV0426
- AV0426.The orthometric height was determined by GPS observations and a
- AV0426.high-resolution geoid model.
- AV0426 \*\* Due to the variability of land subsidence, the orthometric, ellipsoid,
- AV0426 \*\* and geoid heights are valid at the date of observation. These heights
- AV0426 \*\* must always be validated when used as control.
- AV0426 \*\* The orthometric height was determined with a Vertical Time-dependent
- AV0426 \*\* Positioning (VTDP) model and has been validated through GPS observations
- AV0426 \*\* for the epoch indicated (see [www.ngs.noaa.gov/heightmod/VTDP.shtml](http://www.ngs.noaa.gov/heightmod/VTDP.shtml)).
- AV0426 \*\* The geoid height was determined by a new realization of GEOID03 for the
- AV0426 \*\* epoch indicated which incorporates improved geoid heights for the
- AV0426 \*\* Southern Louisiana Subsidence area
- AV0426 \*\* (see [www.ngs.noaa.gov/PC\\_PROD/GEOID03](http://www.ngs.noaa.gov/PC_PROD/GEOID03)).

# NGS Datasheet – Mask Heights

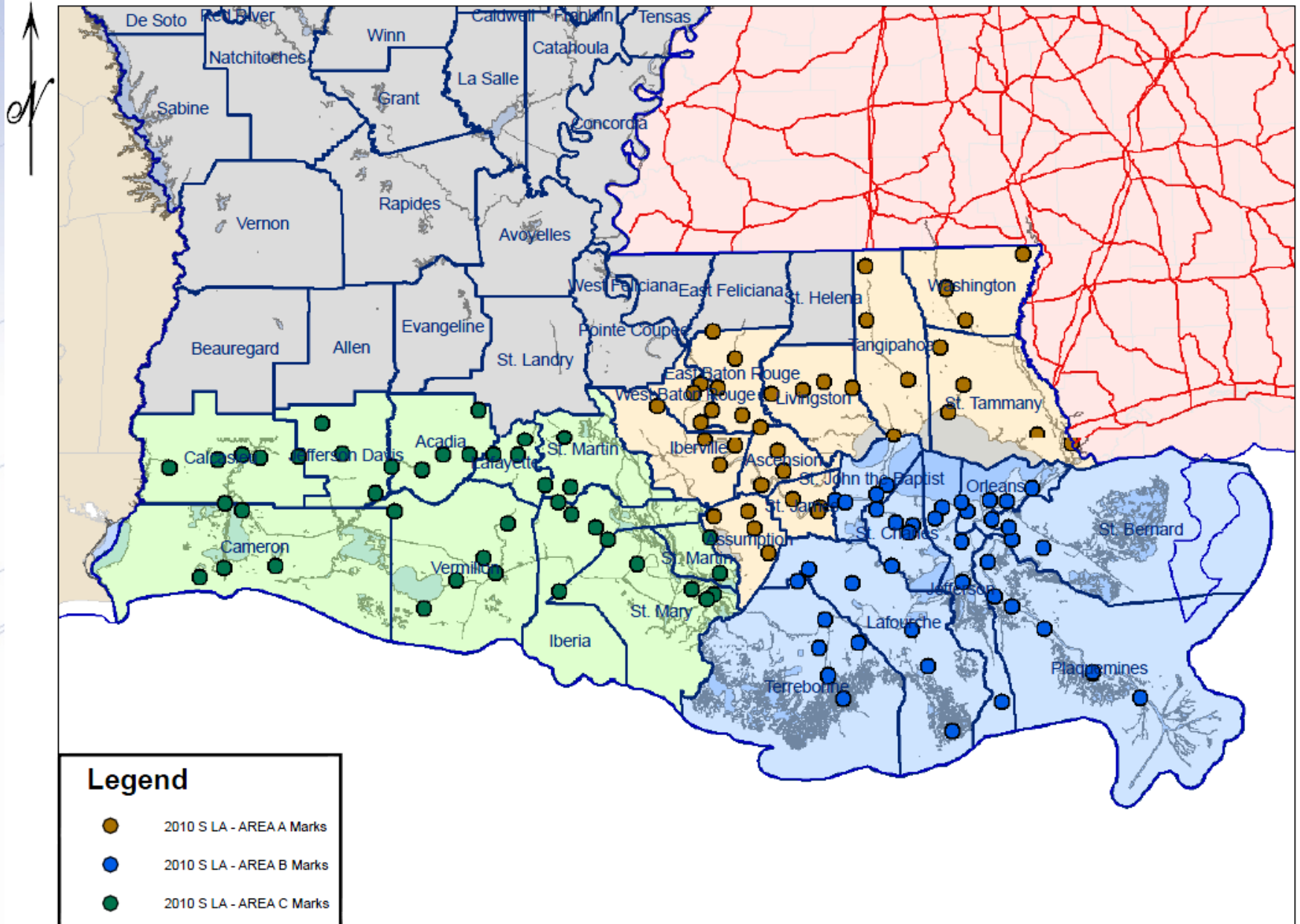
- BK2416 \*\*\*\*\*
- BK2416 DESIGNATION - 28 A 032
- BK2416 PID - BK2416
- BK2416 STATE/COUNTY- LA/ST LANDRY
- BK2416 USGS QUAD - SUNSET (1983)
- BK2416
- BK2416 \*CURRENT SURVEY CONTROL
- BK2416
- BK2416\* NAD 83(1992)- 30 23 01.12137(N) 092 03 15.21777(W) ADJUSTED
- BK2416\* NAVD 88 - \*\* (meters) \*\* (feet) NOT PUB
- BK2416 \*\*This station is located in a suspected subsidence area (see below).
- BK2416
- BK2416 LAPLACE CORR- 0.40 (seconds) DEFLEC99
- BK2416 GEOID HEIGHT- -27.45 (meters) GEOID03
- BK2416 DYNAMIC HT - 14.510 (meters) 47.60 (feet) COMP
- BK2416 MODELED GRAV- 979,322.9 (mgal) NAVD 88
- BK2416
- BK2416 HORZ ORDER - SECOND
- BK2416 VERT ORDER - FIRST CLASS II
- BK2416
- BK2416.The horizontal coordinates were established by classical geodetic methods
- BK2416.and adjusted by the National Geodetic Survey in January 1993.
- BK2416
- BK2416.The orthometric height was determined by differential leveling
- BK2416.and adjusted in February 1994.
- BK2416 \*\* Due to the variability of land subsidence, the orthometric, ellipsoid, ...



# Underway: 2010 Survey

- GPS Observations on 120 Marks
- GPS Processing complete; Adjustment in progress
- Suppression of inconsistent out-dated heights – including those observed in 2006 not re-observed in 2010

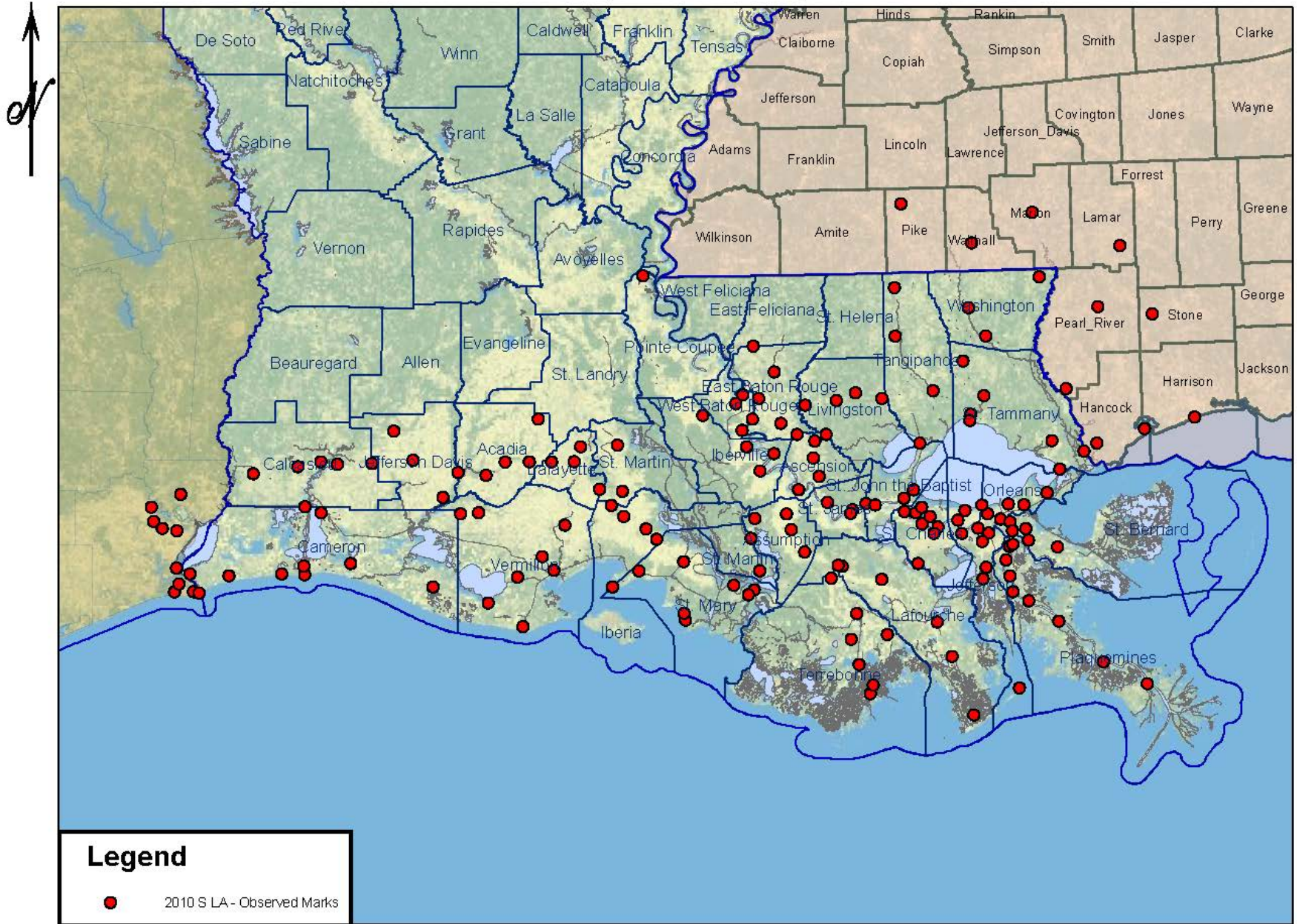
# 2010 South Louisiana Survey Control Project



0 5 10 20 30 40 50  
Miles

08/31/2010

# 2010 South Louisiana Survey Control Project - Observed Marks



0 10 20 40 60 80 100 Miles



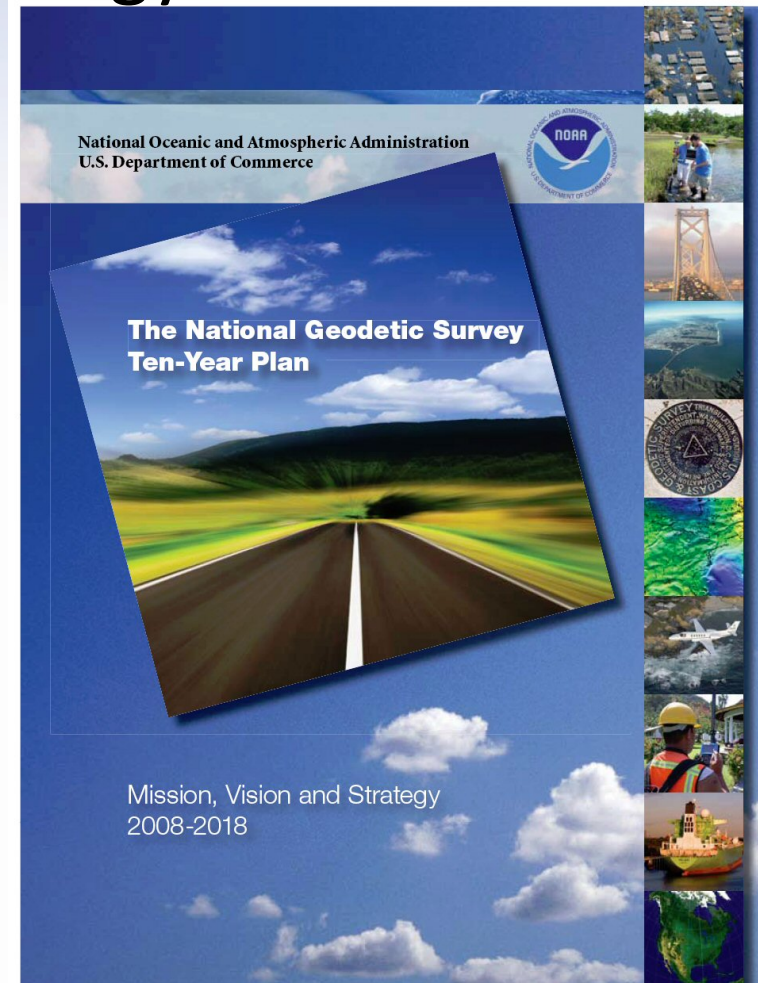
# What's Next?

## National Height Modernization Program

- Improve access to NAVD 88 today
  - Survey methods? Static vs. Real Time?
  - Ensure control is current?
  - Enable easy input of user data for NGS models
- Enhance infrastructure where there are gaps
- Support development of better geoid models
- Develop plan for maintaining datum
- Encourage partnerships, collaboration
- Support NGS ten-year plan

# The National Geodetic Survey 10-year plan -- Mission, Vision and Strategy 2008-2018

- Official NGS policy as of Jan 9, 2008
  - Attention to accuracy
  - Attention to time-changes
  - Improved products and services
  - Integration with other fed missions
  - [www.ngs.noaa.gov/10yearplan](http://www.ngs.noaa.gov/10yearplan)
- 2022 Targets:
  - NAD 83 and NAVD 88 replaced
  - Cm-accuracy access to all coordinates
  - Customer-focused agency
  - Global scientific leadership
- New Datum Managers
  - Mark Eckl, Geometric (Horizontal)
  - Joe Evjen, Geopotential (Vertical)

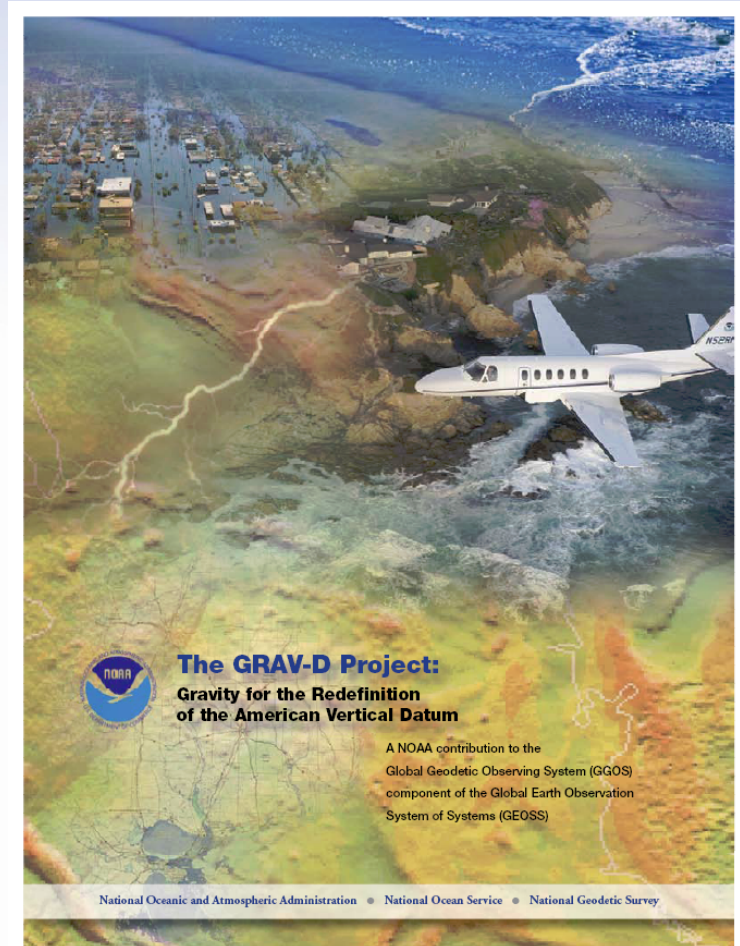




# Transition to the Future – GRAV-D

## Gravity for the Redefinition of the American Vertical Datum

- Airborne Gravity Snapshot of all US and Territories
- Tracking of Absolute Gravity Changes at specific locations
- Re-define the Vertical Datum of the USA by 2022
- New subsidence monitoring paradigm



# Height Modernization and the NGS Business Plan: Three Areas of Focus

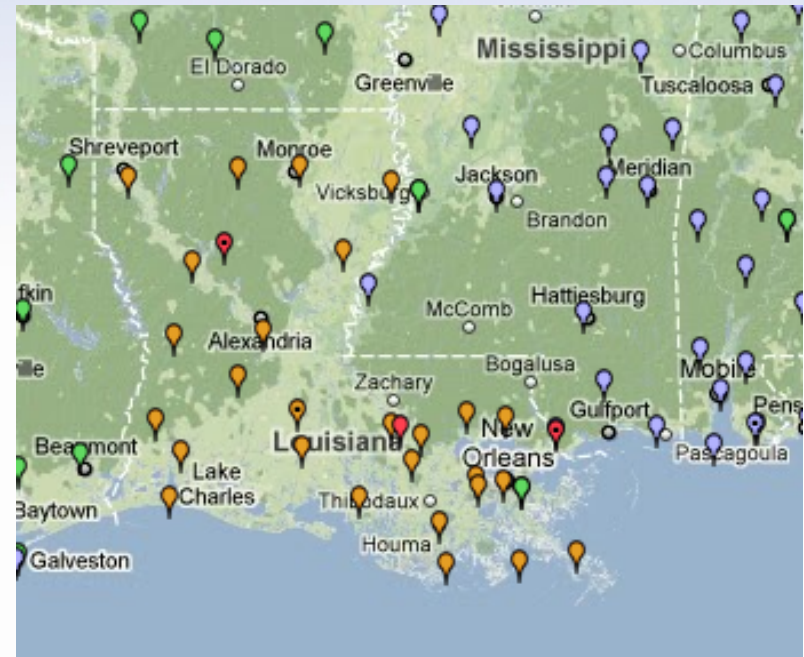
Infrastructure

Models and Tools

Outside Capacity Building

# Infrastructure

- CORS - Active control network helps us monitor movement 24/7
- Passive control network as needed
  - Use repeat surveys to monitor movement
  - Update coordinates: resurveys? Velocity models? Adjust accuracies or expire values?



# Infrastructure

- Inclusion of data in NGS database improves models
- Metadata provided on datasheets: epoch dates, accuracy/reliability measures
- Multi-Year CORS Solution (MYCS) and NA2011
- Infrastructure gap analysis

# Guidelines, Models, and Tools

- Guidelines: NGS58/59, RT, RTN
- Modeling
  - 1-cm geoid
  - HTDP, VTDP = TDP?
- Development of software, tools
  - Transformation models, VDatum
  - OPUS Variety Pack including -DB, -Projects



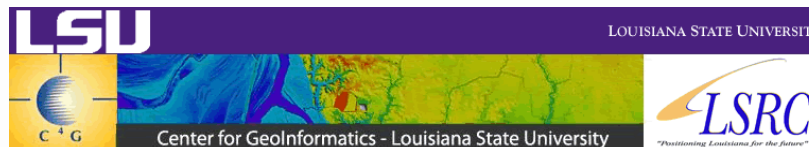
# Outreach, Capacity Building

- Stage Geodetic Advisor Program
- Conferences, Workshops, Forums
- Corbin Training Center, Webinars
- Hands On Training: Leveling, OPUS-Projects
- Federal Geospatial Summits (2010, 2012)
- Regional partner meetings

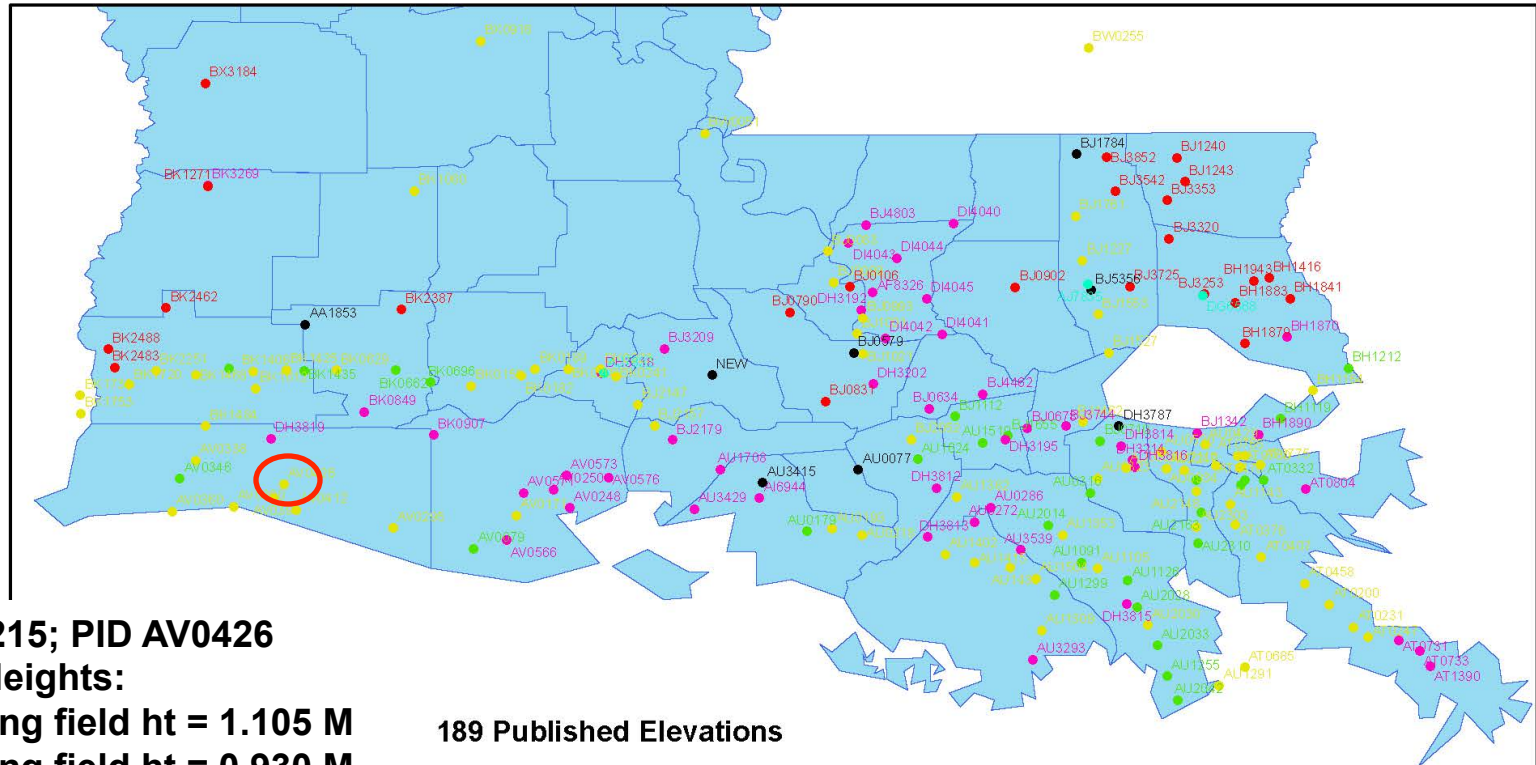


# National Height Modernization Building Partnerships

- Funded Partners
  - Academic Institutions
  - State and Local Governments
  - Spatial Reference Centers
- Offices within NOAA
  - National Weather Service
  - National Hurricane Center
  - Ocean and Atmosphere Research
  - National Ocean Service
- Other federal agencies
  - Department of Homeland Security/FEMA
  - US Army Corps of Engineers – e.g. levees, dams
  - US Geological Survey – e.g. stream gages



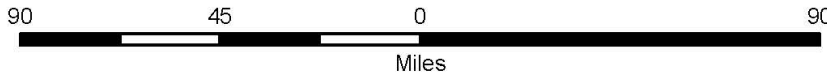
# South Louisiana Height Modernization Project 2006



**Station D 215; PID AV0426**  
**NAVD 88 Heights:**  
 1965 leveling field ht = 1.105 M  
 1986 leveling field ht = 0.930 M  
**NAVD 88 adj. = 0.9684 M**  
**2004 GPS = 0.677 M**  
**2006 GPS = 0.653 M**

**189 Published Elevations**

- From 2004 Project, VTDP Station
- From 2004 Project VTDP Station Constrained in 2004 Project
- From 2004 Project GPS Height
- Leveled HT, No Epoch, Original NAVD88
- Leveled fr VTDP ht
- CORS



*Fast is fine, but accuracy is everything. – Wyatt Earp*

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*A witty saying proves nothing. - Voltaire*



## Questions

**Renee Shields**  
**Height Modernization Manager**  
301-713-3231, x116  
[Renee.Shields@noaa.gov](mailto:Renee.Shields@noaa.gov)

<http://www.ngs.noaa.gov/heightmod/EventsArchive.shtml>