Digging for Datums and Aligning Aerial Imagery

Association of State Floodplain Managers Conference - 2019

Christine Gallagher - Communication & Outreach Branch Chief
Outline

1. Introducing NOAA’s National Geodetic Survey (NGS)

2. Remote Sensing at NGS

3. Aligning Data
   - **Terminology Review**

4. Improving Height and Elevation Information

5. Case Studies **NEW!!!**

6. Get Engaged and Learn More!
What does NGS do?

**Geodesy:** measuring and monitoring the size and shape of the Earth…

*from the Sky, from Space, and from the Ground.*
SECTION 6.0 – MAPPING METHODS

6.1 Vertical and Horizontal Control

All FIS Reports and FIRMFs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS Reports and FIRMFs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the completion of the North American Vertical Datum of 1988 (NAVD88), many FIS Reports and FIRMFs are now prepared using NAVD88 as the referenced vertical datum.

Flood elevations shown in this FIS Report and on the FIRMFs are referenced to NAVD88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between NGVD29 and NAVD88 or other datum conversion, visit the National Geodetic Survey website at [www.ngs.noaa.gov](http://www.ngs.noaa.gov).

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the archived project documentation associated with the FIS Report and the FIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks in the area, please visit the NGS website at [www.ngs.noaa.gov](http://www.ngs.noaa.gov).

The datum conversion locations and values that were calculated for Flood County are provided in Table 20.

<table>
<thead>
<tr>
<th>Quadrangle Name</th>
<th>Quadrangle Corner</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Conversion from NGVD29 to NAVD88 (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood Forest</td>
<td>SE</td>
<td>44.500</td>
<td>-80.625</td>
<td>-0.620</td>
</tr>
<tr>
<td>Flood Lake</td>
<td>SE</td>
<td>44.500</td>
<td>-80.625</td>
<td>-0.655</td>
</tr>
<tr>
<td>Flood Point</td>
<td>SE</td>
<td>44.500</td>
<td>-80.625</td>
<td>-0.655</td>
</tr>
<tr>
<td>Flood Pond</td>
<td>SE</td>
<td>44.500</td>
<td>-80.625</td>
<td>-0.655</td>
</tr>
<tr>
<td>Flood SE</td>
<td>SE</td>
<td>44.250</td>
<td>-80.750</td>
<td>-0.647</td>
</tr>
<tr>
<td>Flood SW</td>
<td>SW</td>
<td>44.250</td>
<td>-80.625</td>
<td>-0.692</td>
</tr>
<tr>
<td>Floodland</td>
<td>SW</td>
<td>44.250</td>
<td>-80.625</td>
<td>-0.705</td>
</tr>
<tr>
<td>Metropolis SE</td>
<td>SE</td>
<td>44.375</td>
<td>-80.625</td>
<td>-0.554</td>
</tr>
<tr>
<td>Metropolis SW</td>
<td>SW</td>
<td>44.500</td>
<td>-80.625</td>
<td>-0.722</td>
</tr>
</tbody>
</table>

**Average Conversion from NGVD29 to NAVD88 = -0.630 feet**

A countywide conversion factor could not be generated for Flood County because the maximum variance from average exceeds 0.25 feet. Calculations for the vertical offsets on a stream by stream basis are depicted in Table 21.

<table>
<thead>
<tr>
<th>Flooding Source</th>
<th>Average Vertical Datum Conversion Factor (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flower Creek</td>
<td>-0.654</td>
</tr>
<tr>
<td>Inundation River</td>
<td>-0.651</td>
</tr>
<tr>
<td>Little Creek</td>
<td>-0.545</td>
</tr>
<tr>
<td>North Fork Inundation</td>
<td>-0.627</td>
</tr>
<tr>
<td>Petal Creek</td>
<td>-0.515</td>
</tr>
</tbody>
</table>
NGS in the News

Hurricane Michael October 2018

Images can be viewed at:
https://storms.ngs.noaa.gov
NGS’ Emergency Response

**Mission:** Meet NOAA requirements and Pre-Scripted Mission Assignments with FEMA

**Data:** Typically nadir or oblique imagery in GIS-ready formats
Coastal Mapping Program

National Shoreline defines territorial limits, used in NOAA Nautical Charts, and supports many other coastal applications.

Remote sensing technologies include imagery, lidar, radar, etc. from various sources, like aircraft and satellites.
Remote Sensing Products

Shoreline (CUSP and Charting Scale)

Ortho Mosaic Imagery

RGB Colorized Lidar Point Cloud

Lidar Point Cloud (intensity)

View Related Video: The Importance of Accurate Coastal Elevation and Shoreline Data
Accessing Remotely Sensed Data

- Imagery and Lidar (NOAA Data Access Viewer)
- Shoreline Vector Data (Shoreline Data Explorer)
- Emergency Response Imagery (Event specific web maps)
Aligning Geospatial Products

Requirements

- CONSISTENCY

Expectations

- Semi-CONSTANT Coordinates
  - stamped with position and elevation information

- CONVENIENCE

- COHERENCE with Sea Level
The National Spatial Reference System (NSRS)

NGS defines, maintains and provides access to the NSRS

- Latitude
- Longitude
- Elevation
- Gravity
- Shoreline Position

+ changes over time

- North American Datum of 1983 (NAD 83)
- North American Vertical Datum of 1988 (NAVD 88)
Reliable FIRM\textsuperscript{s} require data from disparate sources and dates be \textit{consistently aligned}.

\begin{itemize}
  \item Airborne or mobile lidar data.
  \item Stream hydrograph
  \item Elevation certificate
\end{itemize}

\begin{align*}
\text{Airborne or mobile lidar data.} & \quad \text{Stream hydrograph} \\
\text{Elevation certificate} & = \text{Flood Insurance Rate Map}
\end{align*}
Recap

1. **NGS measures the Earth** from the sky, space and ground

2. **NGS collects imagery** for Emergency Response and Coastal Mapping NGS

3. **NGS defines the NSRS**, helping align geospatial data
   - *Terminology Review*

4. **Improving** Height and Elevation Information

5. **Practical advice:** Case Studies and Learning More!
What is a Datum?

Datums are a starting point for surveys

Horizontal datums let us measure distances

Vertical datums let us measure heights

An example...

Mixing datums can give you the wrong answer.
More About Vertical Datums

**Ellipsoidal**
- Native GPS measurements
- Raw Lidar

**Orthometric**
- USGS Topography
- FEMA Flood Insurance Rate Maps

**Tidal**
- Daily and Extreme Water Levels
- Shoreline Mapping (MHW) and Boundaries

**Geoid**
- Earth’s gravity field and the geoid
- Experimental Geoid 2018 (XGEOID18)

**NOT A DATUM, but useful surface...**
Do you know your datum?

NAD83(2011) epoch 2010.00

H. Datum  Realization/Adjustment  Reference Epoch

NAVD88 (GRS80, Geoid12B)

V. Datum  Reference Ellipsoid  Geoid Model

Coming Soon: HYBRID GEOID18
North American Vertical Datum of 1988 (NAVD88) Heights

1) Passive Control
2) GPS Derived Heights

Accurate Heights Today

GEOID12B

The NGS Data Sheet

Official path
North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

1) GPS Derived Heights
2) Passive Control GPS/GNSS Derived Heights in 2022

Accurate Heights in 2022

GRAVIMETRIC
NSRS Modernization: Vertical Change

Vertical offset of more than 1 meter

GEOID12B (NAVD88) xGEOID17

Approximate predicted change from NAVD 88 to new vertical datum
Predicted change estimated as NAVD 88 “zero” (datum) surface minus NGS gravimetric geoid

Updates available online from the New Datums website and Modernization News

https://geodesy.noaa.gov/datums/newdatums/index.shtml
**Transformation Tools**

**NGS Coordinate Conversion and Transformation Tool (NCAT)**

- Single Point Conversion
- Multipoint Conversion
- Web services
- Downloads
- About Converter Tool

- Enter latitude and longitude in decimal degrees
- Convert to SPC
- Convert to UTM

**Vertical Datum Transformation (VDatum)**

- Welcome to VDatum
- VDatum includes:
  - tidal datums
  - Horizontal time dependent positioning (HTDP)
  - Geoids: BOTH NSRS (hybrid) and experimental models

**Notes**

- Identical Transformations
- Web Services
- Be aware of versioning
Recap

1. **NGS measures the Earth** from the sky, space and ground

2. **NGS collects imagery** for Emergency Response and Coastal Mapping NGS

3. **NGS defines the NSRS**, helping align geospatial data

4. **NGS will modernize the NSRS in 2022**, replacing **NAVD 88 with NAPGD2022** and a **new geoid model**

5. **Practical advice**: Case Studies and Learning More!
Lidar Case Study

Fairbanks 2017 Lidar

- 2017 3DEP Project
- USGS/Borough/GVEA Partnership
- QL1 and QL2 lidar
- Acquired to support range of applications
Improvements to Hydrologic Flow Models

Location Map

GIS Flow Accumulation Analysis

Example performed with ESRI ArcGIS hydrology toolset

GEOID12B Flow Accumulation
Improvements to Hydrologic Flow Models

Notes
• Same lidar data
• Fully gravimetric geoid model

Impacted products/activities
• DEM blunder control
• Automated stream mapping
• Watershed determination
• Contaminant flow models
• Runoff management plans
• Floodplain mapping

xGEOID17B Flow Accumulation
Remember Your Vertical Datums

**Ellipsoidal**

*Today*
NAD 83 (2011)

*Future*
NATRF 2022

**Orthometric**

*Today*
NAVD 88

*Future*
NAPGD 2022

**Geoid**

NOT A DATUM, but useful surface...

**HYBRID**

GEOID 12B
Soon geoid18

**GRAVIMETRIC**

GEOID 2022
Test with xGEOID18 etc
Simplified Transformation of Elevation Models

**Input**
- NAVD 88 Heights
- GEOID12B
- NAD 83 Ellipsoid

**Output**
- NAPGD2022 Heights
- GEOID2022
- NATRF2022 Ellipsoid

NCAT transformation grids are shared by VDatum
GPS on Bench Marks

Objectives

• Improve the 2022 Transformation Tool
• Update Passive Control Status
• Automatic Reprocessing in 2022

How to participate?

• Recover
• Observe
• Report

Download Prioritized Marks
GPS on BM Priority List for Transformation Tools

**Priority map shows where:**

1) data is needed for minimum coverage

2) densification can take place to “buy up” the quality of the transformation.
Preparing Geospatial Data for NSRS Modernization

• Ensure metadata contain all information needed for best possible transformation:
  – reference frame and epoch (e.g. NAD 83 (2011) epoch 2010.0
  – geoid model (e.g. GEOID12B or GEOID18)
  – basis of project control (method and survey dates)

• Retain original GPS data whenever possible

• Keep apprised of, and help support, NGS transformation tool development
  – BETA testing and feature recommendation
  – GPS on Bench Marks
Thank You! Learn More:

- Educational Videos (12)
- Online Lessons (4)
- Monthly Webinar Series
- NGS Testing and Training Center

Christine.Gallagher@noaa.gov
Contact Information

• Christine.Gallagher@noaa.gov

Case Study

• Nicole.Kinsman@noaa.gov
• Stephen.A.White@noaa.gov
• Jamie.Kum@noaa.gov
Extra Slides
## NSRS Modernization

**Improving Height and Elevation Info.**

<table>
<thead>
<tr>
<th>Primary Elements Today</th>
<th>2022 Replacements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Horizontal/ Ellipsoid</strong></td>
<td></td>
</tr>
<tr>
<td>NAD 83 (2011) coordinates</td>
<td>NATRF2022</td>
</tr>
<tr>
<td></td>
<td>plus the Caribbean, Pacific, and Mariana plates</td>
</tr>
<tr>
<td><strong>Vertical</strong></td>
<td></td>
</tr>
<tr>
<td>NAVD88 orthometric heights</td>
<td>NAPGD2022</td>
</tr>
<tr>
<td><strong>Geoid</strong></td>
<td></td>
</tr>
<tr>
<td>HYBRID GEOID12B</td>
<td>GRAVIMETRIC GEOID2022</td>
</tr>
</tbody>
</table>