

## Why is height modernization needed?

Applications that need and rely on more accurate vertical measurements:

- ✓ The design, construction, and safety of roads and buildings:
  - Design, construction, and maintenance of highways, including complex interchanges (the objective of the Wisconsin HMP is to provide measurements of monument location that are within 2 cm (0.8 of an inch) accuracy for both the vertical and horizontal dimensions).
  - Design and construction of high-speed rail networks.
  - Planning and construction of buildings in or near flood prone areas.
- ✓ The transportation of goods and people by auto, ship, or plane:
  - Runway endpoints to facilitate low-visibility landings.
  - Provide safe storm evacuation routes under flooding and storm surge conditions.
  - Provide safe under-keel and overhead clearance for ships.
- ✓ The monitoring and protecting of our environment, including:
  - Tectonic plate movement.
  - Groundwater and surface water movement.
  - Point and non-point pollution.
  - Floodplain mapping.
  - Efficient fertilizer and pesticide use (precision farming) while minimizing pollution and related clean-up costs.

## Who does height modernization?

HMP is led by the National Geodetic Survey (NGS), of the National Oceanic and Atmospheric Administration (NOAA).

- ✓ NGS, the nation's positioning agency, has been directed by Congress to implement a HMP throughout the country.
- ✓ NGS has developed working partnerships with four "cornerstone" states (North Carolina, California, Wisconsin, and Louisiana) for the development of statewide height modernization networks. Additional networks are currently planned for states in the New England area, the Great Plains, and for the Alaska/Pacific region.
- ✓ Limitations on funding are restricting HMP expansion, requiring the use of the following criteria to determine state eligibility to participate in HMP:
  - The extent of state program interest and involvement.
  - The extent of state and regional program needs for improved vertical data.
  - The presence of NGS state advisors and university support within the state and region.
  - The presence of NOAA offices and services within the state and region.



Drilling Hole for a Concrete Post

## How is a State HMP carried out?

- ✓ Example of HMP partnership in Wisconsin:
  - The Wisconsin Department of Transportation (WisDOT), with an active HMP since 1998, was a logical candidate to assume leadership of a statewide HMP in the Great Lakes region.
  - An agreement was reached between WisDOT and NGS whereby NGS would provide:
    - The development of standards to guide HMP.
    - Technical assistance to the state in support of HMP.
    - Inclusion of improved data in the National Spatial Reference System (NSRS) database.
    - Support and coordination of research and development activities funded by Congress.
    - Support of outreach efforts to increase exposure of HMP within the state and to share results with other states and regions.
  - Funding:
    - WisDOT funded initial pilot project HMP efforts, beginning in 1998.
    - Federal Highway Administration SPR funds added beginning in 2001.
    - Congressional earmark funds through NOAA beginning in 2002.
- ✓ Process used by WisDOT for HMP in Wisconsin:
  - Divide state into geographic regions (phases), based on area that can be completed each year.
  - General process calls for planning and reconnaissance one year, monumentation the next, with leveling and GPS surveys the third, followed by processing and adjustment of data for submission to NGS for insertion into the NSRS.
  - Specific steps in the HMP process used by WisDOT include:
    - Review NSRS database for existing geodetic monuments.
    - Field check to verify existence of monuments selected in planning in the office (reconnaissance so

far has found about 50 percent of NGS bench marks have been destroyed by construction and other development activities).

- Install new monuments (preliminary plans called for as many as 9,000 monuments statewide). A monument is a 16-inch diameter, 8-foot deep, poured in place, concrete post with a 3½-inch diameter bronze survey disk placed in the top.
- After sitting over one winter, to ensure stability of the monument, differential leveling and GPS observations are performed to determine both vertical and horizontal position of each geodetic monument:
  - GPS observations involve positioning the GPS antenna over the monument while collecting data from four or more satellites.
  - Differential leveling via a series of steps—each sight not exceeding a horizontal distance of 60 meters (200 feet)—is used to measure the vertical difference between adjacent bench marks, averaging 3 kilometers (1.9 miles) apart. WisDOT has developed a **motorized leveling procedure** involving the use of All Terrain Vehicles (ATV) that has **increased the productivity of leveling field crews by 40 percent**.
  - The data collected by leveling and GPS are processed and adjusted by WisDOT staff, then submitted to NGS for verification and insertion into the NSRS database.
- WisDOT is currently using contractors and consultants for much of the work involved in the HMP, including building monuments and acquiring GPS and leveling data.
- ✓ WisDOT is beginning to install permanent base stations in select locations to promote more efficient use of the HMP data. These permanent base stations—also called Wisconsin Continuously Operating Reference Stations (CORS)—will eventually facilitate real-time, 3-dimensional, near centimeter-level positioning over wide areas.



Finished Monument

## What are specific benefits resulting from HMP activities?

- √ An 83-percent reduction in costs to counties in conducting quality control analysis of photogrammetry products they receive:
  - Many counties acquire photogrammetric images under contract on a regular basis.
  - Before HMP in Wisconsin, it took Dodge County 24 hours per PLSS township to verify the vertical and horizontal positions of checks for the photogrammetry.
  - With the HMP completed, Dodge County was able to use Real Time Kinematic (RTK) GPS procedures and complete the field checks of location in 4 hours. Countywide this translates into savings of thousands of dollars. **Once the HMP is completed statewide, the savings are projected to be about \$1.5 million for statewide coverage** (or \$300,000 annual savings assuming photogrammetry is repeated for each township on at least a 5-year cycle).
- √ An 89-percent reduction in costs to WisDOT in determining the location of photogrammetric targets placed in the field for control of planning and design of highway construction and reconstruction projects.
  - Most WisDOT projects require the placement of photogrammetric targets in the field and the determination of their location.
  - Before the HMP was in place, static GPS and leveling procedures required about 280 hours per project to determine the vertical and horizontal position of targets for each project.
  - With the HMP completed, RTK methods have reduced the time needed for this process to 30 hours per project.
  - The per project savings amount to about \$12,500. When completed statewide, **the annual savings for the 100 projects completed each year will amount to \$1.25 million.**
- √ Savings of hundreds of thousands of dollars per county when improved floodplain maps are completed, based on more accurate elevation data. Winnebago County, Wisconsin, is already receiving the following benefits, made possible by the increase in accuracy of Flood Insurance Rate Maps (FIRMs), since the new maps are based on 2-foot contour maps (the old FIRMs were based on 10-foot contour maps):
  - Of the 5,700 structures that the old maps indicated were in the floodplain, 2,400 were actually outside and therefore didn't need to be paying for flood insurance.
  - Conversely, 1,300 structures were actually in the floodplain, contrary to the old maps.
  - Net result: 1,100 owners don't have to pay \$12,000 in flood insurance premiums over the 30-year life of their mortgage, **a savings of over \$13 million to these homeowners.**
  - Other benefits:
    - The assessed **value of these 1,100 properties has increased by over \$1 million**, a benefit when property is sold.

- The 1,300 owners who are now correctly identified as being in the floodplain **can now buy needed insurance.**
- Governments benefit directly as they can **better regulate development in flood-prone areas.**
- Everyone benefits from having **more accurate 2-foot contour maps** (compared to the old 10-foot contour maps).
- Elimination of cost of Flood Hazard Certification fee (\$18 for every transfer). For Wisconsin, the savings for the 230,000 average transfers per year will produce an **annual savings of over \$4 million** for property purchasers.



Motorized Leveling

# Wisconsin Height Modernization Program



GPS Survey, Winter or Summer, Few Limitations

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To report endangered survey stations  
call WisDOT at 1-866-568-2852

U.S. Department of Commerce  
National Oceanic and Atmospheric Administration  
National Geodetic Survey  
[www.ngs.noaa.gov](http://www.ngs.noaa.gov)

Wisconsin Department of Transportation  
Division of Transportation Infrastructure Development  
Bureau of Highway Development  
Surveying & Mapping Section

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## What is it?

- √ The Height Modernization Program (HMP) has the goal of enhancing the vertical component of the National Spatial Reference System (NSRS) through the use of Global Positioning System (GPS) technology. The NSRS is the consistent national geodetic reference framework that includes a number of parameters for each geodetic control monument in the United States, including:
  - Latitude and longitude (horizontal)
  - Height (elevation)
  - Scale
  - Gravity, and
  - Orientation
- √ The NSRS thus provides accurate knowledge about the size, shape, and position of our environment.
- √ The horizontal component of the NSRS is in place and functioning.
- √ The vertical component of the NSRS is currently lacking in density and accuracy, thereby restricting the benefits of real-time GPS measurements of heights.