WRP Technical Note WG-SW-2.2
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# Differential Global Positioning System Techniques For Surveying/ Mapping within Forested Wetlands

**PURPOSE:** This technical note describes the use of Differential Global Positioning System (DGPS) techniques to locate sampling sites and to delineate sampling transects within bottomland hardwood (BLH) forested wetlands. DGPS positioning techniques provide biologists and field scientists with coordinate positions of sample sites throughout the world. A common misconception is that GPS will not provide positions inside a forested area (i.e. BLH). This technical note describes techniques used by scientists at the U.S. Army Engineer Waterways Experiment Station (WES) to provide reliable XY coordinate positions within a BLH forested wetland.

**SURVEY TECHNIQUES:** The Global Positioning System data collection techniques used for locating XY coordinate positions and mapping transect lines and boundaries within a BLH forested environment were primarily the same as those used outside the forested environment, with the exception of a few tailored operational and data processing steps. Some GPS radio signals do penetrate the forest canopy, and therefore reliable positions can be obtained using proper procedures and equipment. GPS positioning is dependent on the GPS receiver collecting and processing a usable signal from a minimum of three two-dimensional (2-D) or four three-dimensional (3-D) GPS satellites. At this time there are 26 operational satellites in orbit for use with GPS surveys. A reference receiver is required to collect positioning data simultaneously at a known location within 100-150 miles of the field position. Data collected from the fixed GPS receiver and positions collected by a roving GPS receiver allow post-processing to obtain differential GPS/DPGS positions which are more precise than those obtained using a single receiver.

Mapping grade GPS receivers are commonly only single frequency (L1) GPS receivers. These units receive only the course acquisition (C/A) code and are capable of computing the post-processed DGPS position to an accuracy within 2 to 5 m X-Y, and 4 to 10 m Z, or elevation. GPS receivers require a relatively unobstructed view of the sky (i.e. GPS satellites).

Many locations within a BLH forest are suitable for GPS reception using mapping grade receivers; however, the time spent at these locations is dependent upon good planning and proper field techniques which allow a suitable number of position observations to be recorded with the satellites. Most receivers can provide coordinate display for monitoring position and system performance as well as the total number of observations collected for a group point.

**GPS PROCEDURES:** A GPS demonstration project was conducted within the Cache River Basin, AR, to determine the position of sediment stations adjacent to a flagged transect line, to determine the azimuth of that line, and to record the relationship of established sampling sites for mammal, soils, vegetation, and sediment stations along each transect line. The transect was originally laid out with a compass and tape (Fig. 1), and trees were tagged every 60 m along the line.

In order to conduct a proper DGPS survey, several U.S. Geological Survey (USGS) control points were located within a 35-km radius of the area. These marks had published latitude, longitude, and elevation available. The WES field team deployed the 12 channel GPS reference receiver on a control point at the local airport for use during GPS data collection periods.

An L1, C/A code, 6 channel roving receiver was used for surveying the XY positions. The receiver was equipped with an external antenna, 10-m antenna cable, extendable range pole, and a data recorder capable of recording positions both as points, or as point features, allowing names and notes to be entered about each.

The receiver was set to the manufacturers recommendations concerning satellite elevation, Positional Dilution of Precision (PDOP), and 2-D/3-D mode switching. The L1 roving receiver was deployed and immediately began receiving information from six satellites, using the best four satellites for determining the current coordinate position. As field personnel entered the forest, where the tree foliage and branching interrupted some signals (Fig. 2), the unit began receiving signals from as few as three satellites while continuing to compute positions. As the team walked along the flagged path, points were recorded by computing positions every three seconds. An audible beep would sound as each ground position was logged. The receiver was allowed to automatically switch to the best combination of satellites to assure the tracking and recording of the best positions. The antenna was carried atop a 2-m extendable pole, and the pole held such that the antenna's orientation would allow signals to be received on the flat antenna plate inside the top cover. When satellite signal reception was interrupted due to dense foliage and heavy branching, the field party would pause or move slowly along the line until signal reception and recording was reobtained. The team collected both 2-D and 3-D satellite position data.

**Figure 1.** Location of transect line

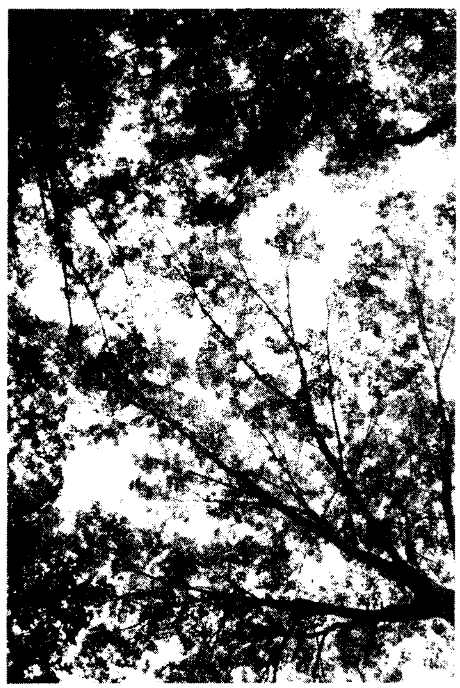

**Figure 2.** Foliage and branching structure

Four different transect lines were previously established within the Cache River forested wetland, each about 2 km in length. The DGPS survey results of one line, transect "C", are shown graphically in Figure 3. Figure 3a shows the 2079 corrected 2-D positions (3 satellites), plotted to determine the azimuth/orientation of the transect line. Figure 3b shows the line using 2094 corrected 3-D points (4 satellites). Figure 3c is a plot of 2-D and 3-D data used together (4173 points). If the best line is defined by calculating the mean, the deviation of the points from the calculated line was only 2-6 m, except for a few "extreme" 2-D points. After manual editing of the 2-D and 3-D data points, the resulting line was defined and is shown in Figure 4a. There was little accuracy advantage to using 3-D data alone, as the majority of the 2-D points were equally as reliable.

The positions of sediment sampling sites located adjacent to the transect line in the BLH forest were determined by acquiring GPS positions at stationary locations for three minutes, collecting data once per second. Again both 2-D and 3-D data were collected. The observations recorded at these seven sampling sites were later processed as group points, to determine the mean, and standard deviation for each site surveyed. These data are displayed in Figure 4b. The overall accuracy of an individual sampling site location (XY coordinate) was considered to be improved using this technique. The computed transect line with the mean position of the seven sediment sites is displayed in Figure 4c.

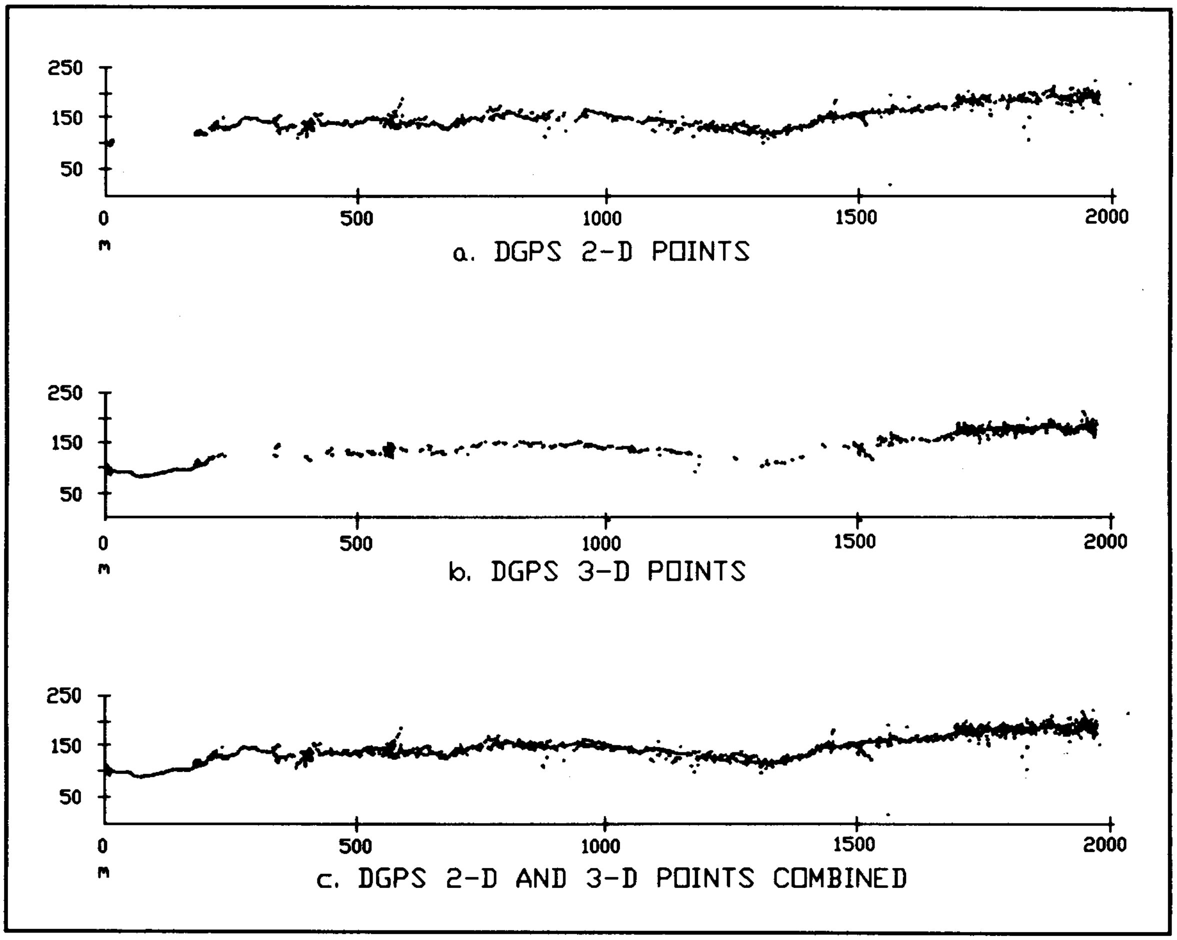


**Figure 3.** Raw DGPS data within the Cache River BLH forest

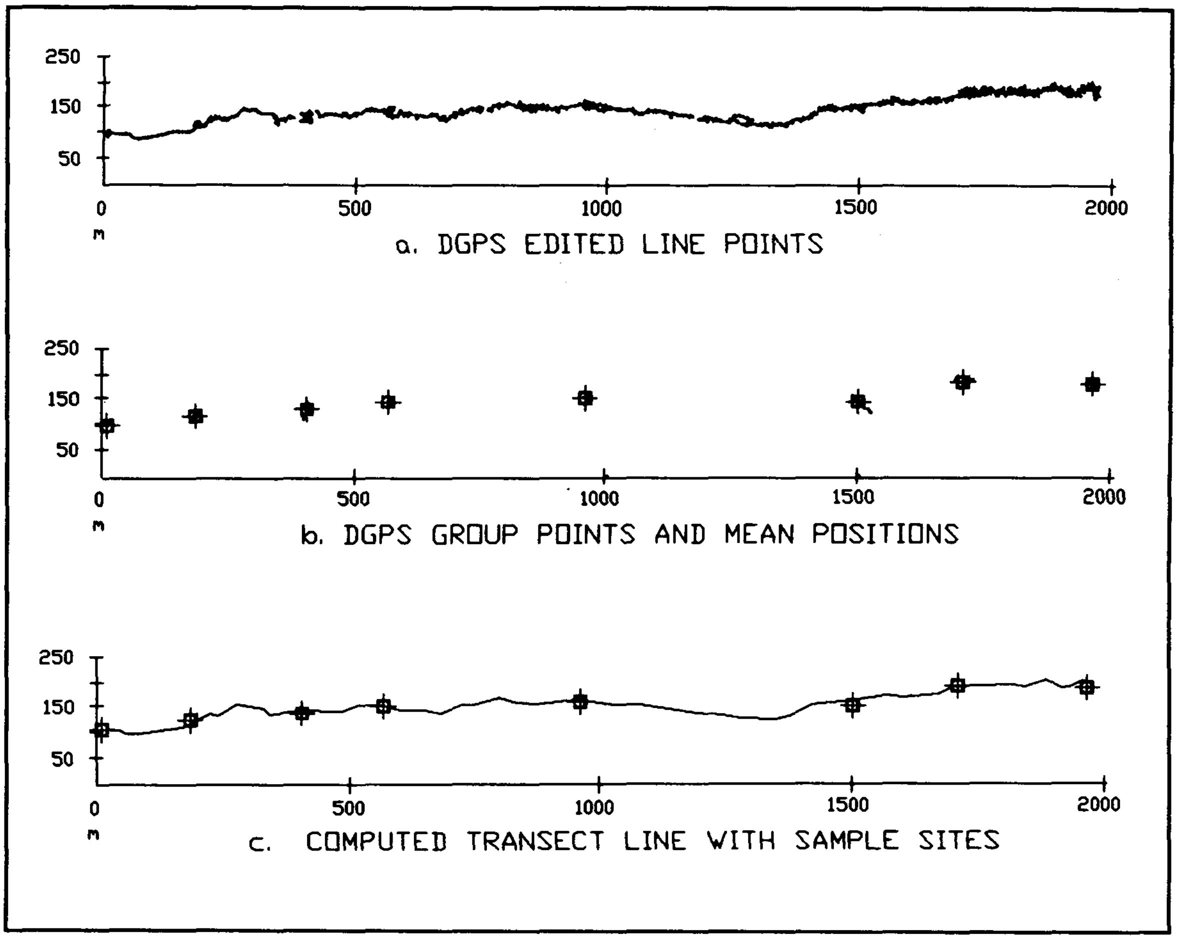


**Figure 4.** Edited DGPS data within the Cache River BLH forest

The sediment sites were located accurately with respect to the transect line as shown in Figure 4c. These reduced and edited transect line data are now suitable for transfer to a Geographic Information System (GIS) database system such as the one available for the Cache River Basin.

Elevation data (Z coordinates) could not be reliably obtained using DGPS techniques and as a result standard survey procedures were used to determine the elevation of the sediment sites.

**CONCLUSIONS:** GPS XY coordinate positions were obtained within a BLH forested wetland to an accuracy of approximately 2-6 m. However, GPS position data are best obtained by using the stationary site (group point) method, such as used for the sediment sites. A transect line is best defined by locating GPS positions or points every 50-75 m along the line.

If elevations within a BLH forest are required, monumented control points should be established by static DGPS methods outside the forest, at the beginning of each transect, and then the elevations transferred along the transect using traditional leveling techniques.

**ADDITIONAL INFORMATION SOURCES:**

USACE. 1991. NAVSTAR Global Positioning System Surveying. Engineer Manual EM 1110-1-1003. Washington, DC.

Trimble Navigation. 1991. TRIMVEC-PLUS® GPS Survey Software, User's Manual and Technical Reference Guide. Part Number 12351. Sunnyvale, CA: Trimble Navigation Ltd.

Trimble Navigation. 1992. General Reference, GPS Pathfinder® System. Part Number 18470-00. Sunnyvale, CA: Trimble Navigation Ltd.

Trimble Navigation. 1991. PFINDER® Software User's Guide. Part Number 18473-00. Sunnyvale, CA: Trimble Navigation Ltd.

**ADDITIONAL INFORMATION ON GPS:**

The U.S. Army Topographic Engineering Center (TEC), Fort Belvoir, Va. is conducting research on GPS methods/procedures, and additional information and list of publications may be obtained by contacting: Mr. Steven R. DeLoach, ATTN: CETEC-TL-SP, Fort Belvoir, VA 22060-5546. Phone (703) 355-3026.

Also, Office, Chief of Engineers, Directorate of Civil Works provides information of use of GPS Technologies to support broad mission areas. Point of contact is Moody K. Miles, III, ATTN: CECW-EP-S, Washington, DC. Phone (202) 272-8885.

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