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Using GPS and GIS to Create a Historic Base Map

Petersburg National Battlefield (PNB) was authorized in 1926 "to commemorate the campaign and siege and defense of Petersburg, Virginia in 1864 and 1865 and to preserve for historical purposes the breastworks, earthworks, walls, or other defenses or shelters used by the armies therein." At 2,744 acres in several discrete units, PNB occupies a fraction of the land fought over during the siege. Only four of the 18 significant battles that took place in and around Petersburg fall within the park. To fulfill its mission of protecting resources and interpreting history, the park must continually reach out to the surrounding community.

PNB is working on a new General Management Plan (GMP) that will highlight the interdependence of the park and its surrounding community. The GMP will provide a blueprint for managing the park's resources over the next 15 years and will consider ways to encourage the community to preserve and provide access to significant sites outside park boundaries. As part of the GMP process, cultural parks are required to produce a historic base map detailing the landscape during its period of significance.

A traditional base map is a paper document that shows the historic landscape for the area inside park boundaries. If a park has been diligent, the base map will include scaled transparencies indicating modern roads, structures, or wetlands. Often, comparing past and present landscapes becomes a matter of holding up a topographical quadrangle while estimating the location of certain structures. If nearby landowners call to ask about resources located on their property, it becomes a job for a historian who refers to a different set of maps altogether. It is not an efficient process.

The Cultural Resources GIS Facility (CRGIS) of the National Park Service (NPS) is working with PNB to produce a new type of historic base map. The new map will differ from the park's earlier mapping efforts in several ways. It combines layers of historic and modern information to enable ready comparison between what was and what is at any scale. It can be readily updated to keep pace with changing land use patterns. It allows the park to generate thematic paper maps addressing issues of compliance. And, most importantly for the Petersburg community, it transcends park boundaries to encompass the entire historic landscape.

For Petersburg, we were fortunate to have one of the most accurate and detailed maps produced by topographical engineers during the Civil War. The engineers of the Army of the Potomac, under the direction of Colonel Nathaniel Michler, began mapping Petersburg in 1864, during the siege of the city. By the time they were finished in 1865, they had mapped an area of more than 127 square miles at a scale of 8 inches to the mile (1:792). This map, completed in eight sheets, shows the road network, ground cover, and entrenched Federal and Confederate lines in considerable detail. More than 3,500 structures are depicted, many labeled with residents' names. The Michler Map's scale and resolution made it ideal for our purposes.

We acquired digital images (TIF files) of the eight Michler map sheets through the National Archives and Records Administration and transferred these images into ArcInfo® geographic information systems (GIS) software. At this stage, the map sheets were images without spatial attributes. To be useful in a GIS, images must be assigned real-world coordinates (longitude-latitude). This process is called georeferencing.

To georeference the images, we combined research with modern technologies. Features depicted on each map image were inventoried. The transportation network was compared to modern maps to determine which roads and intersections appeared historic. We consulted with park and local historians to identify which earthworks shown on the Michler Map survived and could be visited. Our list of surviving resources expanded to include ante-bellum structures in the Virginia state register. We identified about 200 possible points of congruence between our map images and the real world.

Two mapping crews set-out to collect coordinates for the identified points using global positioning systems (GPS). GPS units use satellite signals to pinpoint and map locations with an accuracy of +/- 1 meter. Over three days, crews logged about 450 miles and recorded nearly 120 points. These points were loaded into the ArcInfo® pro-

gram. Each surviving feature depicted on an image was assigned the coordinates collected for that location in the field. The map images were then warped, that is, stretched by ArcInfo® to generate "best-fit" coordinates for every location on the map image.

Not every registration point collected proved reliable. For example, a few GPS points were collected in the general vicinity where houses in the state files had since been demolished and built over. Some road intersections were misplaced because roads had been realigned. In other cases, the historic maps proved erroneous. The initial fit, however, was good enough that most of the erroneous points were readily identifiable. The best registration points were kept; others were discarded until features across the map sheets fell within about 20 meters of their corresponding GPS registration point. The georeferenced map sheets were displayed on-screen with modern USGS data. Historic roads and railroads were found to be largely congruent with modern ones. The dense street grid of Petersburg fell into place. Earthworks ran along appropriate contour intervals with batteries holding the high ground. The overall fit of the historic map sheets with modern data was within expected tolerances of +/- 40 meters. Each map sheet was displayed in ArcInfo®; features were traced to create digital data layers for roads, railroads, earthworks, structure sites, and land cover. Digital layers were labeled according to the map's legend.

Downtown Petersburg in digital format. Separating the data into different layers makes the historic map easier to read and allows analysis of land use patterns. Within wartime Petersburg, besieged inhabitants cultivated 327 acres behind and between buildings.

Downtown Petersburg in 1865 from the Civil War-era Michler Map.

Digital images by the authors.

As of this writing, five of the eight map sheets are completed and interesting statistics have begun to emerge. Each sheet displays 12.3 square miles of historic land cover. Before the armies arrived, the proportion of cleared ground to forest was roughly equal. The contending armies altered this balance, clear-cutting 22% of the woodlands (4,400 acres), primarily to create open fields of fire for artillery. This gives some sense of the immense ecological impact of the armies on the landscape during the 292-day siege. The enormity of the trench system becomes more tangible: Confederate defenses extended for 11.7 miles from the Appomattox River while opposing Federal siege lines extended 13.8 miles. Some earthwork lines are quite dense with multiple trenches and excavated approaches. The total length of all earthworks depicted on the five completed map sheets has reached 127.4 miles. Considering that many of these trenches were more than 10 feet wide and deep, this was a mammoth public works project by any measure!

The completed base map will not hang on the wall but function on a desktop. The park will use a low-cost GIS program to view and manipulate data layers and to customize and print thematic maps. Historic map layers or map images can be viewed atop digital USGS topographical quadrangles on CD-ROM. Data layers from a wide range of sources (park boundaries, earthworks mapped with GPS, National Register listings) have been included in the database. The database will continue to grow; historians can add troop movements and resource managers can add vegetation from aerial photographs. Because every point on the historic map corresponds to a real world location, researchers can query the coordinates for a house site or an earthwork, enter the coordinates into their GPS unit, navigate to that location, map what survives, and enter the information back into the database.

PNB will use the computerized historic base map to develop its GMP, but use of the information will not stop there. Information will be shared with city and county planners, particularly as parcels containing historic resources are rezoned. Perhaps it will be demonstrated by printing out a timely map, that preserving history is sometimes as simple as moving a proposed development a few hundred yards down the road. Overall, the park will be in a better position to respond to the many queries originating outside its boundaries and it may become a more responsive partner in the effort to preserve historic resources.

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