United States Department of Agriculture
Soil Conservation Service
Northeast NTC
160 E. 7th Street
Chester, PA 19013

Subject: SOI - Report of GPR Technical Assistance; Chesapeake and Ohio Canal National Historical Park

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To: Pearlie S. Reed
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PURPOSE

To assist the National Park Service assess the condition of earthen materials within the towpath prism of the Chesapeake and Ohio Canal.

PARTICIPANTS

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EQUIPMENT

The equipment used during this field trip was the SIR System-8, the ADTEK SR-8004H graphic recorder, and the ADTEK DT-6000 tape recorder. The 120 MH_z antenna with the model 705DA and 705DA2 transceivers were used. The 705DA2 transceiver did not substantially increase the probing depth of the GPR along the towpath, and the 705DA transceiver was preferred as a result of its greater resolution of subsurface features.

The scanning time on the control unit was established at either 116 or 232 nanoseconds. Assuming that the dielectric constant of the earthen materials within the towpath is 19 (for wet, loamy soils), the radar scanned to depths of either 4 or 8 meters.

The equipment operated well with no observed malfunctions.

DISCUSSION

The earthen materials of the towpath prisms restricted the probing depth of the GPR. Generally, the maximum depth of consistent penetration ranged from 1 to 1.6 meters. Greater depths were infrequently recorded in areas of lower conductivity along the prisms. Areas of higher conductivity rapidy dissipates the radar signal and restricts the probing depth. Generally, conductivity increases with the amount and type of clays, the degree of saturation, and the amount and type of salts in solution. The wet, compacted clays of the towpath prisms afforded an especially poor environment for the application of ground-penetrating radar techniques.

Without the benefit of ground-truthing the radar's images with soil borings and samples, only general statements can be made at this time concerning the interpretations of the radar imagery. Numerous point objects are evident in the upper part of each profile. These objects are most likely large rocks or artifacts; some are metallic and can be identified by their hyperbolic pattern and multiple reverberations.

No large or air filled cavity can be identified in the upper part of the profiles. Smaller cavities or piping is suggested in some areas by the occurrence of white-out areas. These areas are caused by the superpositioning and mutual cancellation of two closely spaced or overlapping signals. Piping is suggested by the more steeply inclined and transverse images which appear to segment the natural continuum.

The towpath can be segmented with the aid of the radar's profiles into two distinct areas: 1) areas of relatively undisturbed, uniform, and continuous subsurface images; and 2) anomalous areas of segmented and superimposed subsurface images. The former is believed to correspond with the more stable areas of the prism; the latter with possible seepage or flood prone areas having a history of fill operations. The anomalous areas can be further subdivided into areas with disturbances near or at the surface, and areas with subsurface disturbances. Perhaps the former areas coincide with sites of open cavities or flood damage which have been filled; the latter with areas of subsurface lateral flow or major flood ravaged areas which have been deeply buried by reclamation.

RESULTS

GPR techniques were severely limited by the high conductivities of the towpath prism. The value of using GPR techniques over conventional methods (such as daily observations of towpath conditions) is questionable in view of the limited probing depth and resolution of subsurface features. It is probable that the GPR has confirmed that no major subsurface cavity exists within the upper 1.5 meter. If a cavity was large (1 to 2 meters in diameter) and air or water-filled, the GPR would have detected such a highly contrasting feature occurring within the upper 3 meters of the surface. Although the GPR discern areas of disturbance and suspected piping, the individual seepage pipes are two small to be adequately resolved by the 120 MH_z antenna. Resolution could be improved by shifting to a higher frequency antenna (200, 300, or 500 MH_z). However, the effective probing depth would be evenly more severely restricted by using these less powerful antennas.

The GPR has provided evidence of disturbance along the towpath. With the GPR it is possible to quickly assess those areas of the towpath which have been affected by seepage or flooding, and to qualitatively assess the degree of damage or the amount of fill that has occurred within the upper 1 to 1.6 meters of the towpath. For the intended use of detecting areas of progressive piping and seepage, the GPR failed to provide adequate depth of penetration or resolution of subsurface features to be of value other than as a general reconnaissance tool. Conventional methods of visual observations are, in this instance, more suitable than GPR techniques.

This investigation, while not successful for the intended use, provided valuable information concerning the application of GPR techniques to earthen structures. I wish to thank you for this opportunity to explore potential applications for GPR. A complete record of the graphic profiles have been returned to James Patterson, Research Agronomist, CUE-NPS, under a separate cover letter.

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cc:
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