United States Department of Agriculture

Natural Resources Conservation Service

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Subject: ARCH-Geophysical Field Assistance **Date:** 11 October 2007

To: Richard Sims
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Purpose:
At the request of the Idaho State Parks and Recreation archaeologist, geophysical field assistance was provided to park rangers at Farragut State Park. The objectives of this investigation were to locate seven buried pools associated with a former Naval Training Base and determine whether rumored military hardware had been buried in two of these pools.

Principal Participants:
Mark Alley, District Conservationist, USDA-NRCS, Coeur d'Alene, ID
Ray Bible, Volunteer, USDA-NRCS, Coeur d'Alene, ID
Eric Blair, Park Ranger, Idaho State Parks and Recreation, Farragut State Park, Athol, ID
Jim Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
Kim Golden, RC&D Coordinator, USDA-NRCS, Coeur d'Alene, ID
Jason Oliver, Park Ranger, Idaho State Parks and Recreation, Farragut State Park, Athol, ID
Darin Vrem, Archaeologist, USDA-NRCS, Boise, ID
Dennis Woolford, Park Ranger, Idaho State Parks and Recreation, Farragut State Park, Athol, ID

Activities:
All field activities were completed on 4 and 5 October 2007.

Summary:

1. Electromagnetic induction (EMI) techniques were successfully used to locate and characterize the six pools of the former Farragut Naval Training Station. Plots of both conductivity and inphase data are enclosed in this report and may help park rangers direct future archaeological investigations

2. Ground-penetrating radar (GPR) was used to provide high resolution images of two pools. It had been rumored that Scott Pool contained a large amount of buried military hardware and artifacts from the former base. Base on two orthogonal GPR traverses, the fill materials within the Scott Pool appears relatively homogenous with comparatively few anomalies. In contrast, base on two orthogonal GPR traverses over the Pederson Pool, the fill materials within this pool appears relatively heterogeneous with a comparatively large number of point anomalies. These anomalies obscured the reflection from the base of the pool.

It was my pleasure to work in Idaho and to be of assistance to you and your staff.

With kind regards,

James A. Doolittle
Research Soil Scientist
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cc:
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Site Background:
Shortly after the outbreak of World War II, the Navy decided to establish a new training station on the shores of Lake Pen Oreille, Idaho. Construction of the training station, which was designed to accommodate 30,000 recruits, began in April 1942. The training station was named Farragut after a Civil War admiral and naval hero. Farragut Naval Training Station covered more than 4,000 acres. The facilities on the base were designed to support over 45,000 people. During World War II, Farragut was second only to Great Lakes (IL) in size and trained more than 293,000 recruits. The base was divided into six, 5000-personnel training units or camps. The first recruits arrived at the first camp in September 1942, and by March 1943, all six camps were completed and operational. The six camps were named after naval Congressional Medal of Honor or Distinguished Service Cross recipients who had died in action. The camps were named after Mervyn Bennion, James Ward, John Waldron, Edwin Hill, Norman Scott, and Oscar Peterson. Each of the six camps had a similar oval configuration. Each camp contained a large drill hall. At one end of each drill hall was a large 50 by 75 foot swimming pool.

Farragut Training Station was deactivated in June 1946. In 1950, the base was declared surplus and the Idaho Fish and Game Department assumed control over the site. In 1956, the Idaho Department of Parks and Recreation assumed control of the former naval station. Today, there are few vestiges of the former Naval Station. Most structures have been removed and/or covered with fill materials.

While detailed plans and information are available on the former Farragut Naval Training Station, the exact location of its buildings and facilities is unclear. The objectives of this investigation was to locate the exact position of six former swimming pools and to ascertain whether rumors concerning the possible dumping of military hardware into Scott's pool are founded.

Equipment:
The radar unit is the TerraSIRch Subsurface Interface Radar (SIR) System-3000, manufactured by Geophysical Survey Systems, Inc. (North Salem, New Hampshire).[1] The SIR System-3000 weighs about 9 lbs and is backpack portable. With an antenna, this system requires two people to operate. A 200 MHz antenna used to characterize the composition of fill within Scott and Peterson pools.

Radar records contained in this report were processed with the RADAN for Windows (version 5.0) software program (Geophysical Survey Systems, Inc).[1] Each radar record was submitted to the following processing procedures: setting the initial pulse to time zero, color transformation, marker editing, distance normalization, and horizontal signal stacking.

An EM31 meter (manufactured by Geonics Limited, Mississauga, Ontario) was used in this study.[1] This meter is portable and needs only one person to operate. No ground contact is required with this meter. The EM31 meter weighs about 12.4 kg (27.3 lbs), has a 3.7-m intercoil spacing, and operates at a frequency of 9,810 Hz. When placed on the soil surface, the EM31 meter provides a theoretical penetration depth of about 6 meters in the vertical dipole orientation (McNeill, 1980). Both inphase and quadrature phase data were recorded with the EM31 meter.

The Geonics DAS70 Data Acquisition System was used with the EM31 meter to record and store both EMI and position data.[1] The acquisition system consisted of the EM31 meter; an Allegro CX field computer (Juniper Systems, North Logan, UT) with Geomar's Trackmaker 31 software (Geomar Software, Inc., Mississauga, Ontario); and a Garmin Global Positioning System (GPS) Map 76 receiver (with a CSI Radio Beacon receiver, antenna, and accessories that are fitted into a backpack) (Garmin International, Inc., Olathe, KS).[1] When attached to the acquisition system, the EM31 meter is keypad operated and measurements can be automatically triggered.

To help summarize the results of the EMI survey, SURFER for Windows, (version 8.0), developed by Golden Software, Inc. (Golden, CO), was used to construct the simulation shown in this report.[1] Grids of EMI data (both apparent conductivity (EC_a) and inphase component data) were created using kriging methods with an octant search.

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[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

Operations:
Both electromagnetic induction (EMI) and ground-penetrating radar (GPR) were used in this investigation. EMI was used to rapidly reconnoiter and gain a broad picture of spatial patterns of apparent conductivity (EC_a) and inphase response in the areas of the six pools and a heating plant. Once, the locations of the pools were defined and characterized with EMI, GPR was used to provide high resolution records of the fill materials within Peterson and Scott Pools.

EMI:
Electromagnetic induction operates by inducing circular eddy current loops into the soil and measuring the magnitude of the electromagnetic energy in these loops. Under certain conditions (known as operating at low induction numbers), the magnitude of energy in these current loops is proportional to the apparent conductivity (EC_a) of the earthen materials near the loops. Apparent conductivity is a weighted, average conductivity measurement for a column of earthen materials to a specific depth (Greenhouse and Slaine, 1983).

Electromagnetic induction responds to the electrical conductivity of earthen materials. The electrical conductivity of earthen materials is influenced by the amount and type of salts in solution, amount and type of clays, porosity, and degree of water saturation. Variations in EC_a are produced by changes in the electrical conductivity of the earthen materials. Absolute EC_a values are seldom diagnostic in themselves. Interpretations are based on the identification of spatial patterns within data sets. Lateral and vertical variations in EC_a have been used to infer changes in soils and soil properties and the presence of buried artifacts.

EMI interacts well with highly conducting and permeable targets (McNeill, 1983). The EM31 meter has been used for mapping electrically conductive buried metal containers and hazardous wastes (McNeill, 1983). Metallic objects can be detected with the EM31 meter, provided they are not too deeply buried and have a favorable size-to-depth ratio. McNeill (1983) noted that the detectability of large, buried metallic features is greatly enhanced by measuring the inphase component of the induced magnetic field. For the surveys conducted at Farragut State Park, both the inphase and quadrature phase (EC_a) components were simultaneously recorded with the EM31 meter.

GPR:
Ground-penetrating radar is an impulse radar system designed for relatively shallow investigations. Pulses of electromagnetic energy are radiate into the ground from a transmitting antenna. Whenever a pulse contacts an interface separating layers of contrasting dielectric properties, a portion of the energy is reflected back to the receiving antenna. By moving an antenna along the soil surface, GPR provides a continuous profile of the subsurface.

Compared with other geophysical techniques, GPR provides the highest resolution of subsurface features. However, GPR does not work well in all soil environments. Soils having high electrical conductivity rapidly dissipate the radar's energy, restrict observation depths, and create low signal to noise ratios, which impair image quality and interpretability. In highly conductive soils, the use of GPR is inappropriate. GPR has been most successfully used in areas of sandy or coarse loamy soils. Generally, observation depths range from 5 to 30 m in sandy soils, 1 to 5 m in loamy soils, and less than 0.6 m in clayey soils.

A problem with all geophysical techniques is target identification. Sensors detect, but do not identify buried features. As a consequence, all interpretations should be confirmed with ground-truth observations.

Survey Procedures:
A *random walk* or *wild-cat* EMI survey was conducted with the EM31 meter at each site. The EM31 meter was operated in the deeper-sensing (0 to 6 m) vertical dipole orientation and in the continuous mode (measurements recorded at 1-sec intervals). Using the NAV31W software program, both GPS and EMI data were simultaneously recorded in a field computer. The meter was held at hip height and orientated with its long axis parallel to the direction of traverse. Surveys were completed by walking at a uniform pace, in a random or back and forth manner across each suspected site.

Two short GPR transect lines were established at the sites of both Peterson and Scott Pools. At each site the two lines were laid out orthogonal to each other. Along each line, survey flags were inserted in the ground at an interval of 1 m and serve as reference points. Radar data were collected with the 200 MHz antenna. The radar records were displayed and reviewed on the video screen, and interpretations were discussed in the field.

Results:
Basic statistics for the EMI surveys are summarized in Tables 1 and 2. Table 1 provides a summary of the basic statistics for data collected in the quadrature phase (conductivity). With the exception of the number of observations (column 2), all data in Table 1 are expressed in milliSiemens per meter (mS/m). Table 2 provides a summary of the basic statistics for data collected in the inphase phase (often referred to as the *metal detection phase*). With the exception of the number of observations (column 2), all data in Table 2 are expressed in parts per thousand (PPT).

Within the survey areas, more than half of the observations had apparent conductivity between 1.9 and 16.4 mS/m and inphase responses between 0.48 and 9.8 ppt (see Tables 1 and 2, respectively). These values are presumed to characterize mostly undisturbed soil and geologic materials. Strong positive or negative inphase or quadrature phase response (< ±10 ppt or 20 mS/m) are presumed to indicate the presence of artifacts with the more extreme values indicating near-surface metallic objects. The summarized statistical data shown in Tables 1 and 2 may be used by park rangers to characterize the expected composition of the fill materials within each of the six pools.

Table 1.
Basic statistics for the conductivity data collected over the six pool sites with the EM31 meter.

Site	*Obs.*	*Minimum*	*25%-tile*	*75%-tile*	*Maximum.*	*Mean*	*Std. Deviation*
Bennion	1140	82.75	6.00	7.50	361.25	18.61	36.48
Hill	611	76.20	3.10	16.43	204.78	15.01	32.62
Peterson	983	161.10	2.80	6.20	204.78	15.45	40.02
Scott	941	148.48	2.50	6.50	204.78	14.04	34.53
Waldron	983	65.60	1.90	3.30	29.20	26.00	5.35
Ward	1718	204.70	2.40	3.90	204.78	9.48	31.31

Table 2.
Basic statistics for the inphase data collected over the six pool sites with the EM31 meter.

Site	*Obs.*	*Minimum*	*25%-tile*	*75%-tile*	*Maximum*	*Mean*	*Std. Deviation*
Bennion	1140	20.47	0.58	0.94	17.77	0.73	2.75
Hill	611	20.47	0.48	0.81	20.48	1.44	6.20
Peterson	983	20.47	0.54	1.77	20.48	3.15	6.44
Scott	941	20.47	1.07	9.83	20.48	4.56	9.94
Waldron	983	20.47	0.64	2.11	20.48	3.79	8.14
Ward	1718	20.47	0.94	1.71	20.48	3.40	7.33

Figures 1 thru 6 shows the spatial distribution of conductivity (upper plots) and inphase (lower plots) data at the six pool sites. Figure 7 shows the spatial distribution of conductivity (upper plots) and inphase (lower plots) data at the North Road Heating Station. These data were collected with the EM31 meter in the deeper-sensing, vertical dipole orientation. In each figure, the same isoline intervals were used to plot the apparent conductivity (isoline interval of 10 mS/m) and inphase (isoline interval of 2 PPT) data. The same color scale was used in each plot. In each plot, areas that were not surveyed with the EM31 meter have been *blank*. This was necessary as spatial patterns within these areas of no data are interpolated by the software program.

With the exception of the Waldron Pool Site (see Figure 5), the locations of the pools were identified. As would be expected from their common design, similar spatial patterns are evident at each pool site. The geometry of these patterns suggests the presence of the pool and boiler rooms. Differences in the magnitudes of the measured responses suggest the presence of dissimilar types and quantities of materials used to fill these structural cavities. The Waldron Pool Site has been highly impacted by park development and construction. The absence of a noticeable response from this former pool suggests that the pool may have been missed during surveying, largely destroyed and removed, and/or filled with materials similar to the surrounding soils.

It was rumored that the Scott Pool contained a large number discarded artifacts from the former base. In an attempt to confirm this report, GPR was used to profile the subsurface at both the sites of Scott and Peterson Pools. Two orthogonal traverse lines were laid out at each site. The locations of these lines are shown on Figures 3 and 4. Radar records collected at the Scott Pool clearly showed the sides and bottom of the pool. Along each traverse line, the fill materials appear relatively homogenous with few anomalies. Anomalies may represent larger rock fragments or buried artifacts.

Figure 8 is a portion of the radar record that was collected along the east-west orientated GPR traverse line (see Figure 4). On this record, all scales are in meters. Anomalies are evident within the pool area between the 15 and 19 m, and 38 and 41 m distance marks (see top of record). An isolated anomaly occurs at the base of the pool near the 32 m distance mark. Along this traverse line, the remainder of the pool area appears to be relatively uniform with no contrasting subsurface features present.

Figure 9 is a portion of the radar record that was collected along the east-west orientated line (see Figure 3) over the site of the former Peterson Pool. On this record, all scales are in meters. The large number of point reflectors in this pool masks the reflections from the base of the pool. Compared with radar records collected over the Scott Pool, records from the Peterson Pool suggest the possibility of a greater number of buried artifacts.

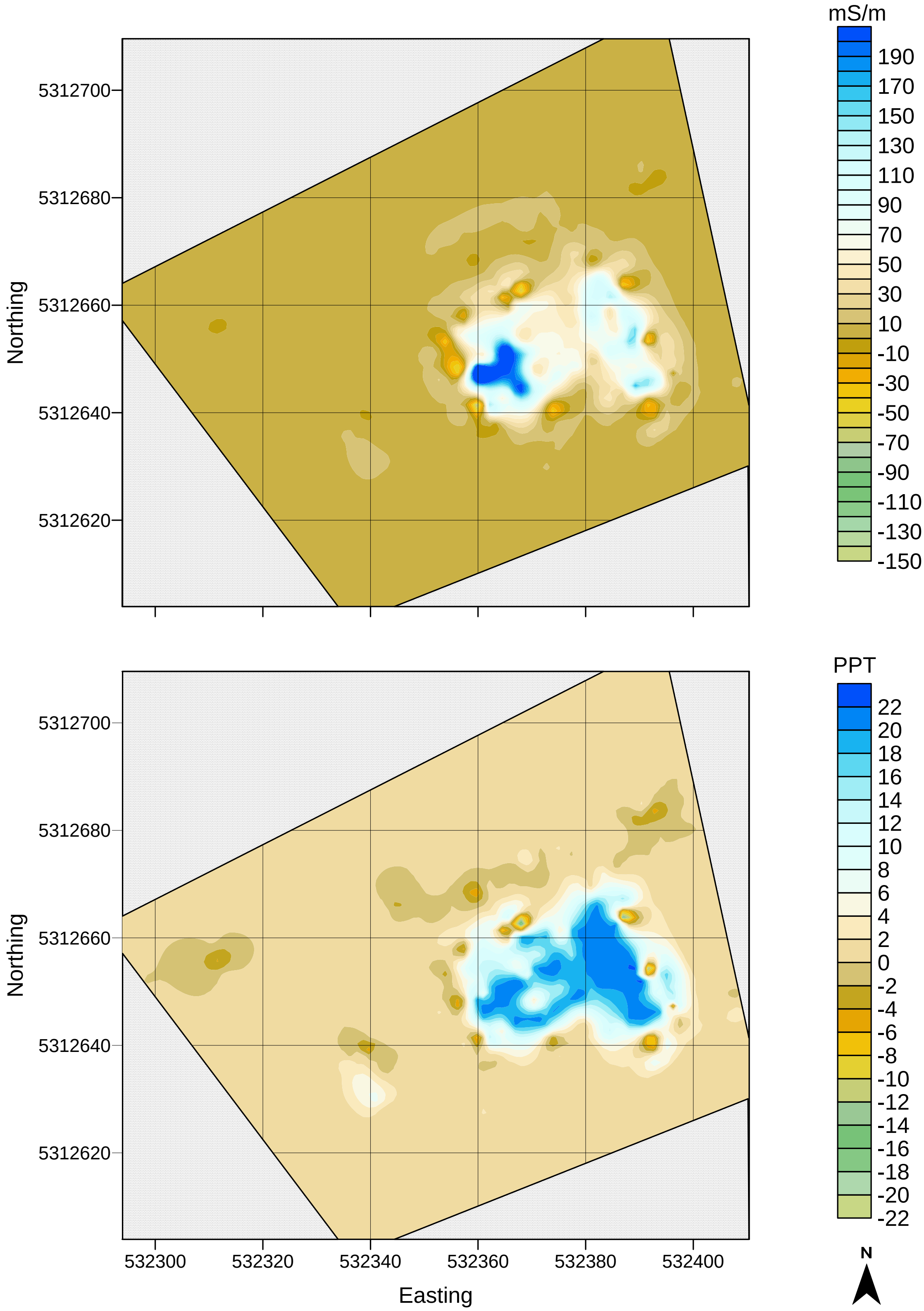

Figure 1. Plots of conductivity (upper) and inphase (lower) data collected at the Bennion Pool Site.

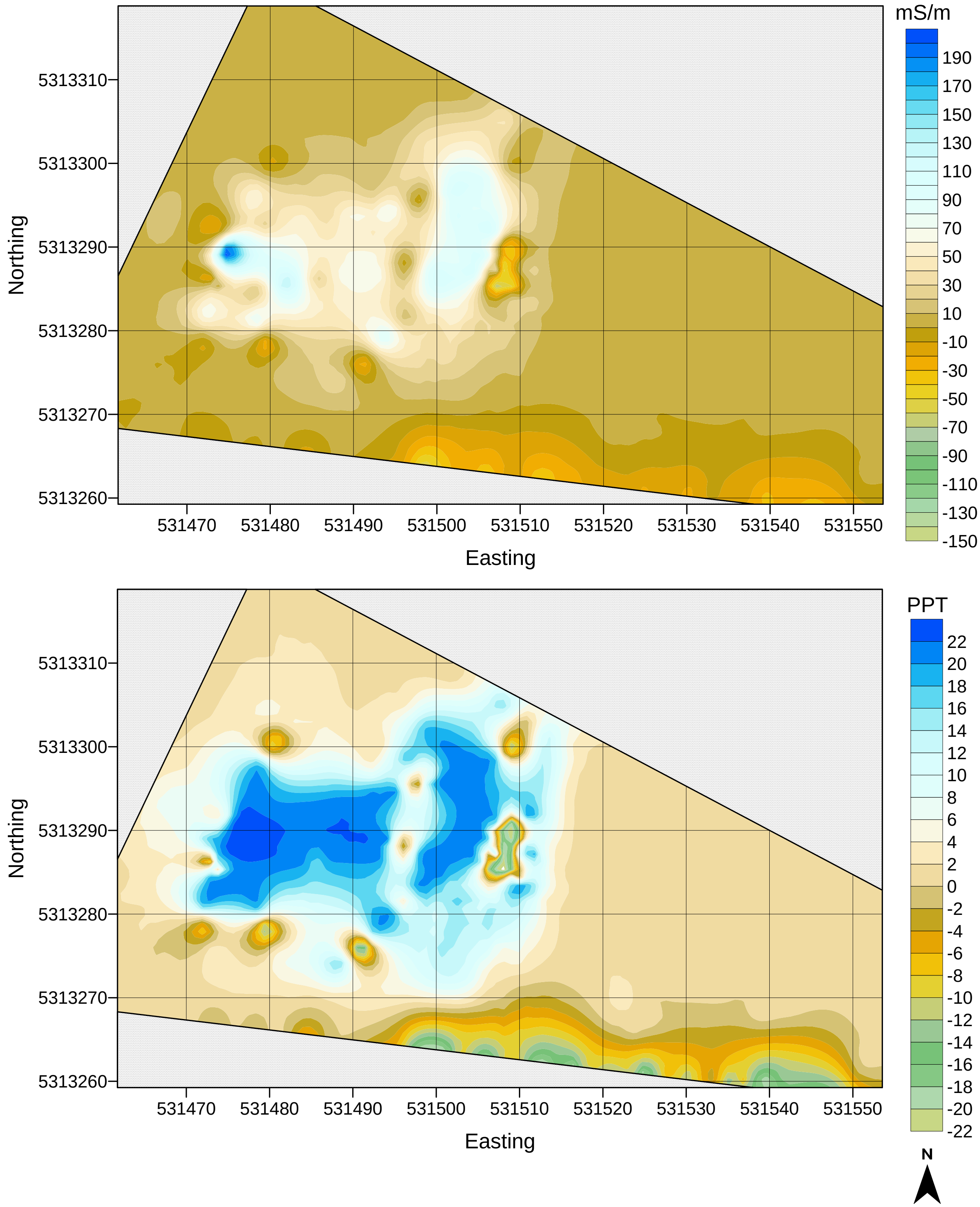

Figure 2. Plots of conductivity (upper) and inphase (lower) data collected at the Hill Pool Site.

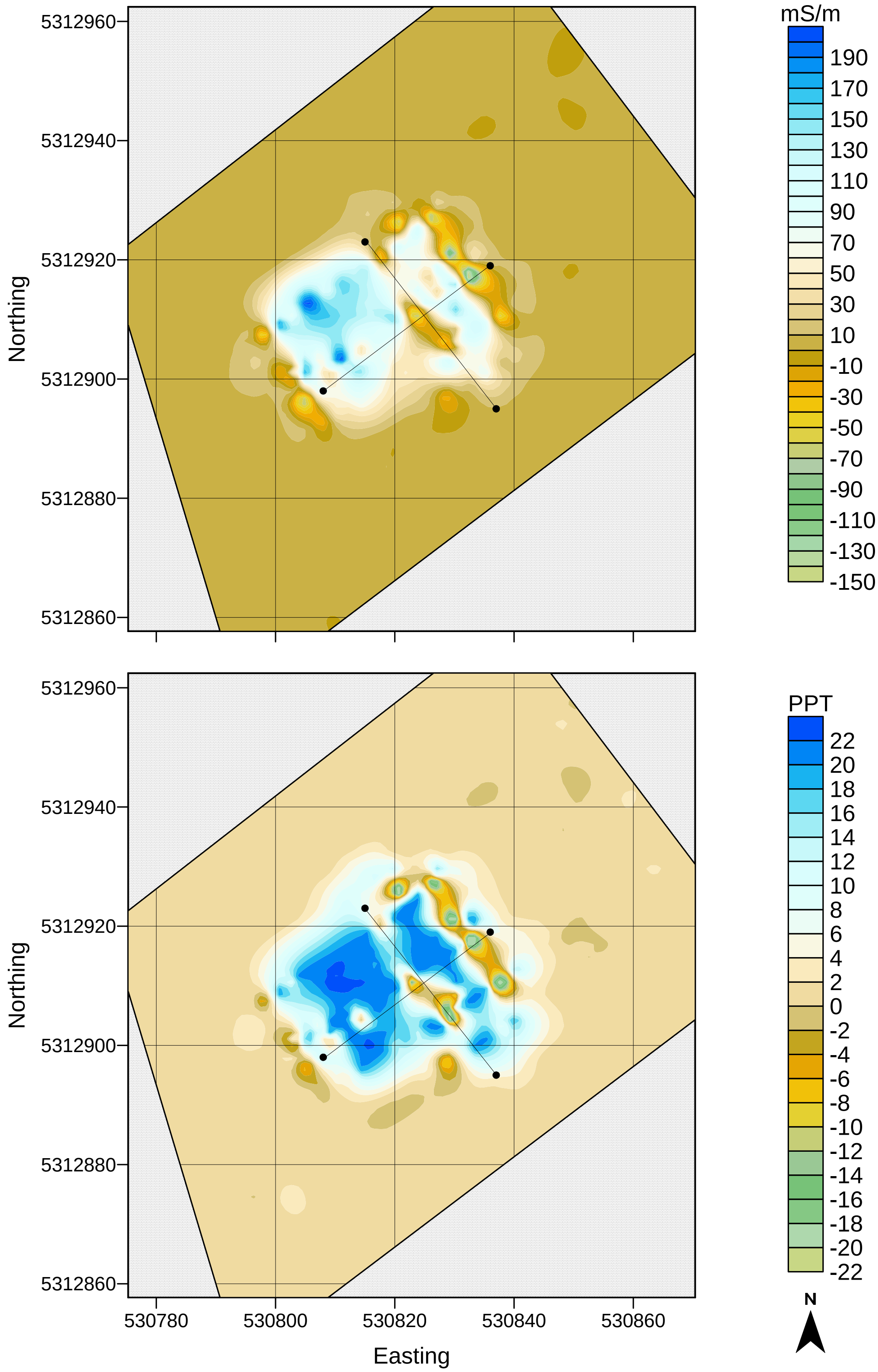

Figure 3. Plots of conductivity (upper) and inphase (lower) data collected at the Peterson Pool Site.

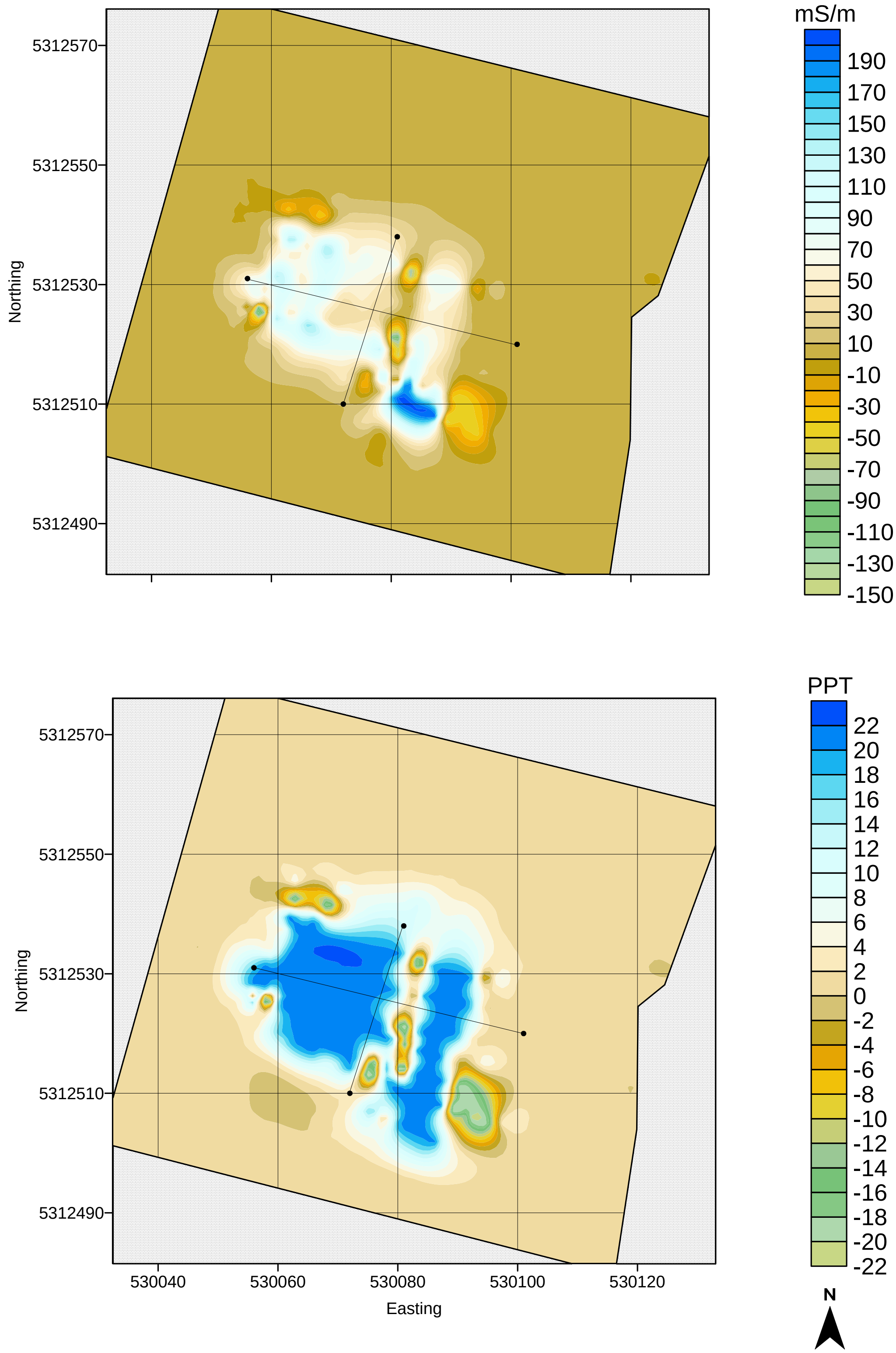

Figure 4. Plots of conductivity (upper) and inphase (lower) data collected at the Scott Pool Site.

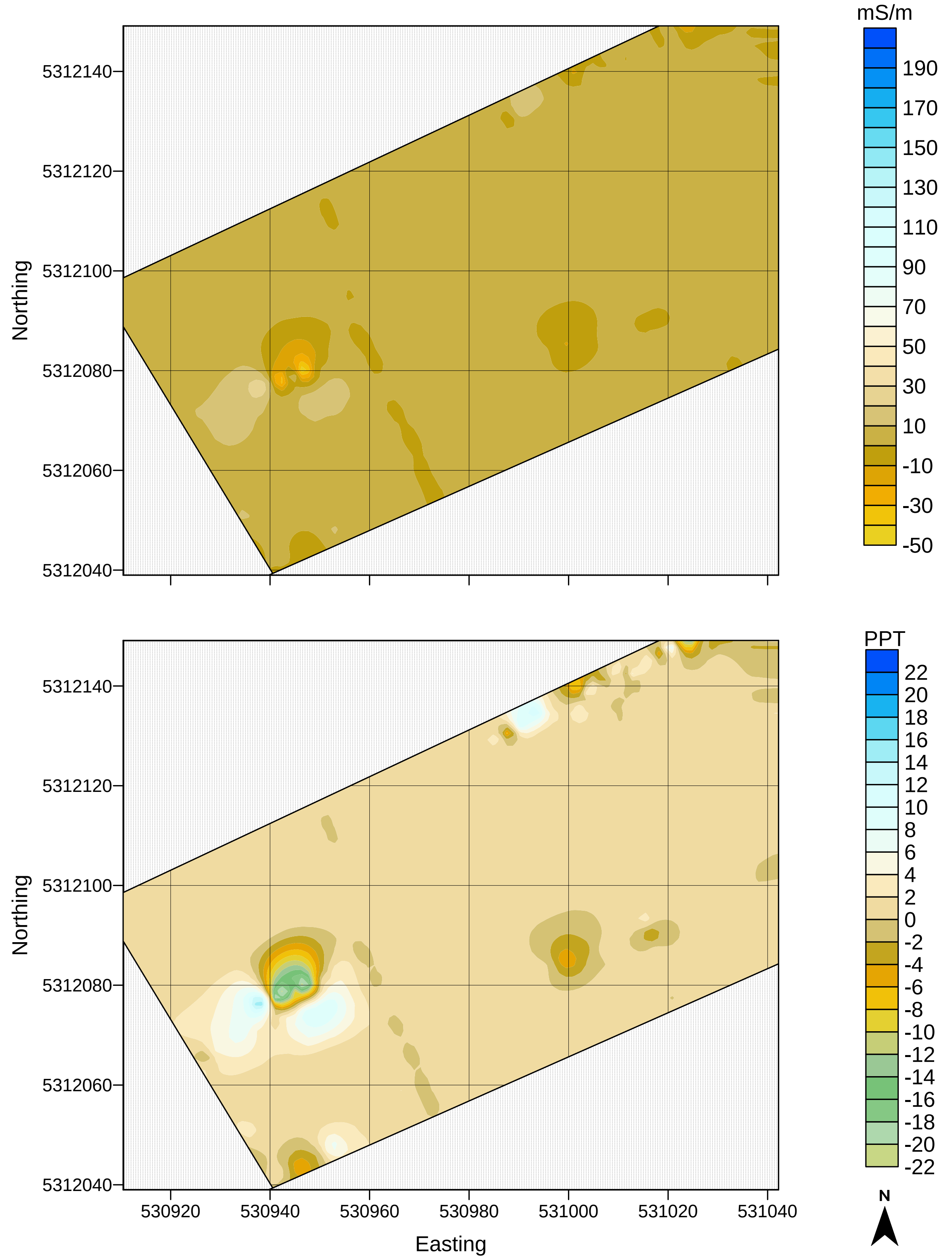

Figure 5. Plots of conductivity (upper) and inphase (lower) data collected at the Waldron Pool Site.

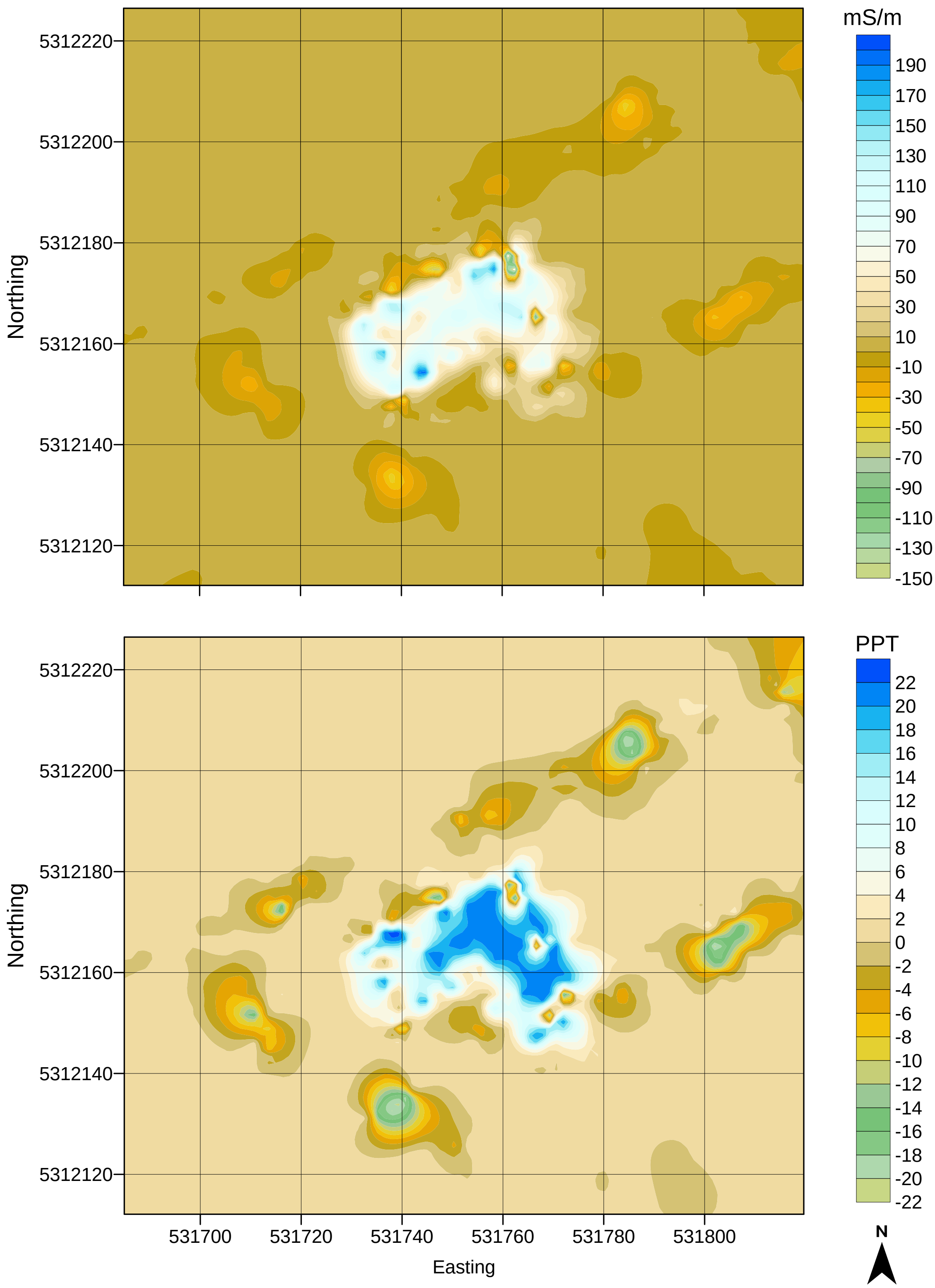

Figure 6. Plots of conductivity (upper) and inphase (lower) data collected at the Ward Pool Site.

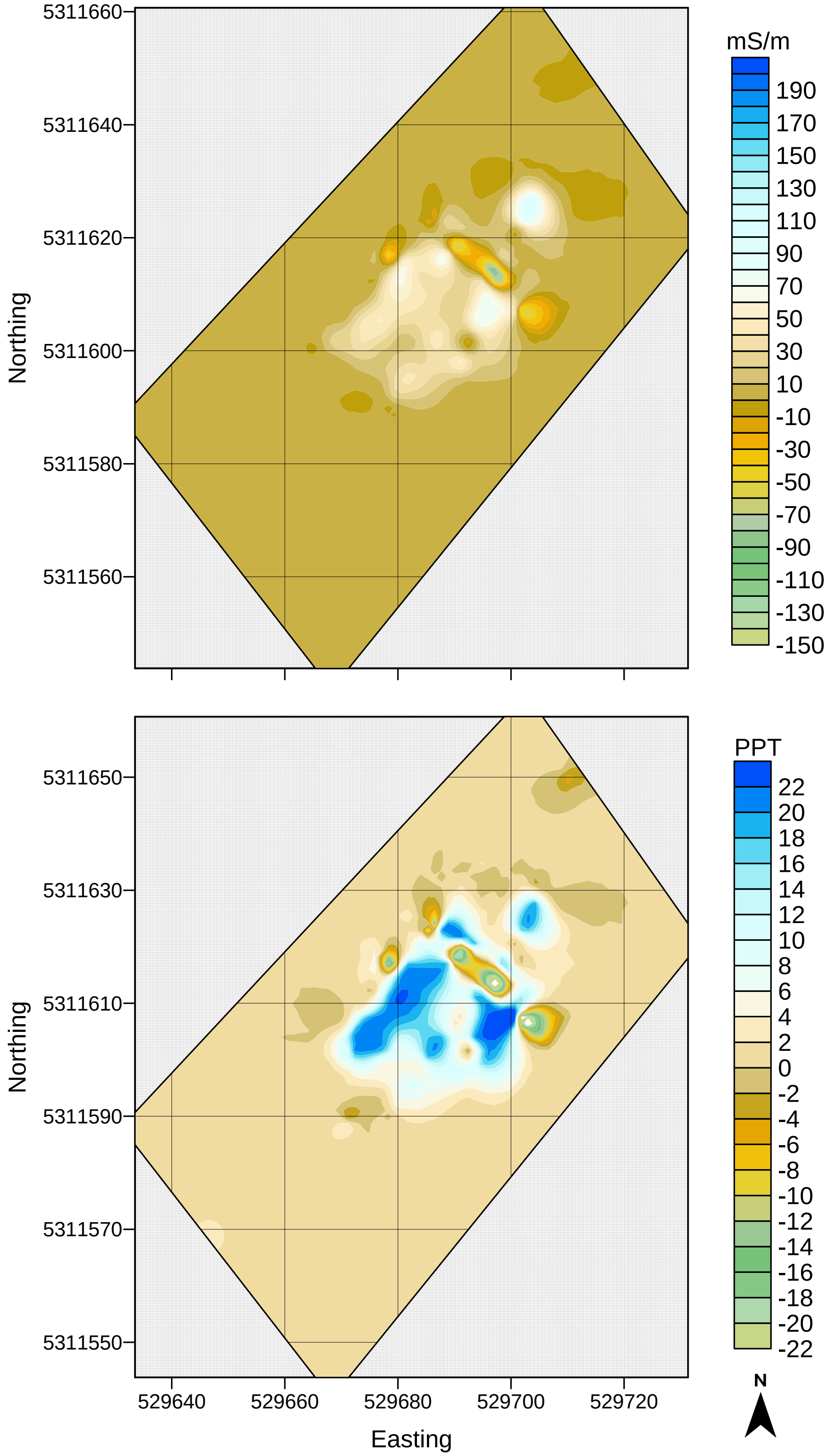

Figure 7. Plots of conductivity (upper) and inphase (lower) data collected at the North Road Heating Station.

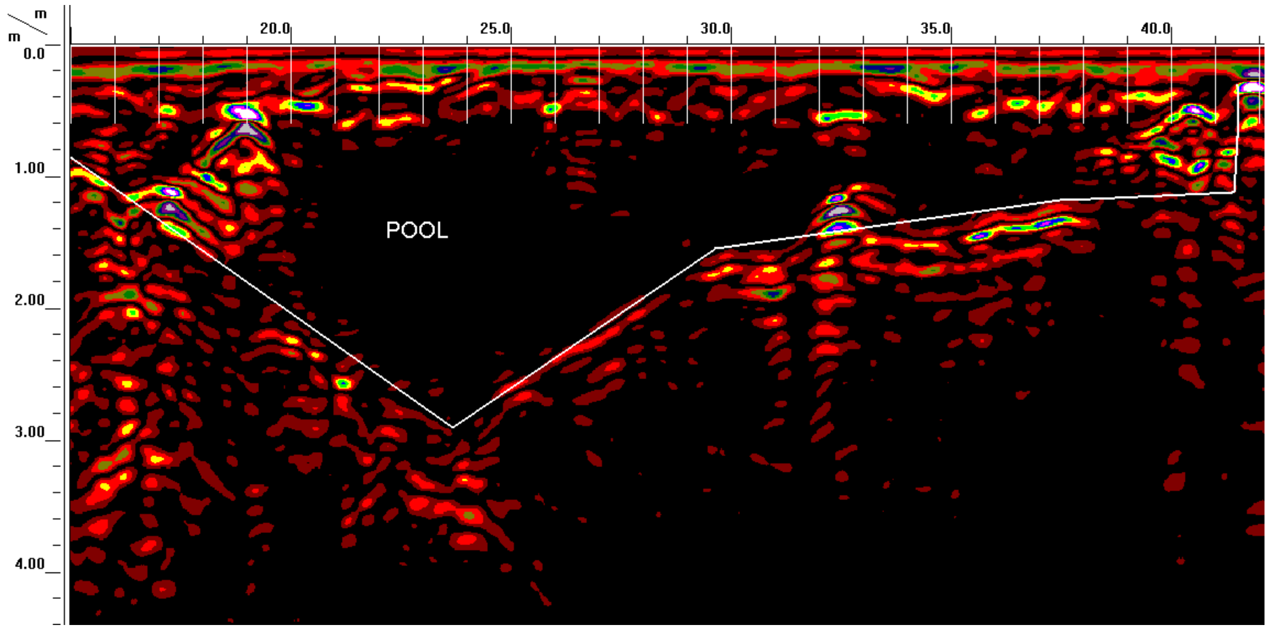

Figure 8. This GPR record from the Scott Pool Site shows mostly uniform and homogenous fill materials.

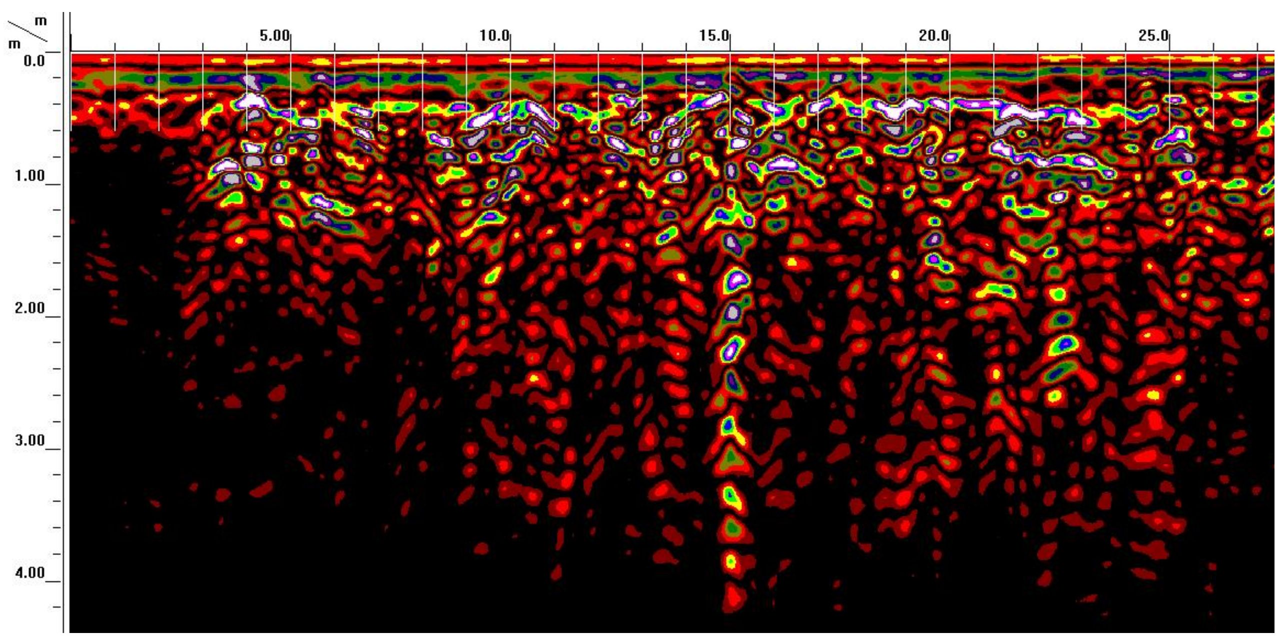

Figure 9. This GPR record from the Peterson Pool Site shows a greater number of heterogeneities in the fill materials.

References:

Greenhouse, J. P., and D. D. Slaine. 1983. The use of reconnaissance electromagnetic methods to map contaminant migration. Ground Water Monitoring Review 3(2): 47-59.

McNeill, J. D. 1980. Electromagnetic terrain conductivity measurement at low induction numbers. Technical Note TN-6. Geonics Limited, Mississauga, Ontario.

McNeill, J. D. 1983. Use of EM31 inphase information. Technical Note TN-11. Geonics Limited, Mississauga, Ontario.