10 October 2019

To: Richard Shaw, USDA-NRCS, NJ-NY State Soil Scientist

Subject: Soil Health - Bedrock Study, Geophysical Survey for Green Infrastructure

Field Date: 11th and 13thth September 2019

Purpose:

To develop interpretation maps of bedrock composition in soils utilizing geophysical tools. A geophysical study will aide in determining the presence and depth to bedrock in areas mapped by the Soil Survey Geographic Database (SSURGO) as UGCRB: Urban land – Greenbelt-Chatfield- Rock outcrop complex, 0 to 8 percent slopes. Urban land is a miscellaneous land unit of pavement and buildings. Greenbelt is a Human Altered Human Transferred (HAHT) soil consisting of a mantel of loamy fill material more than 100cm (40") thick. The Chatfield series consists of well-drained soils formed in loamy melt-out till. Chatfield soils are moderately deep to crystalline bedrock at depths of 50 to 100 cm (20" to 40") on bedrock-controlled hills and ridges.

An Electromagnetic Induction (EMI) survey was conducted to determine areas of decreased apparent soil electrical conductivity (σ, mS/m). Areas of decrease conductivity can be due to a decline in clay content often associated with rise bedrock to the surface. The agronomical abbreviation for electrical conductivity is "EC." The EMI measures apparent conductivity which is symbolized by σ. The ground penetrating radar (GPR) will provide depth to contrasting strata (bedrock) in areas of low conductivity that are identified during EMI survey.

Activities:

A geophysical survey was conducted of a park with a known bedrock component to determine the extent and depth of the bedrock.

An Electromagnetic Induction Meter (EMI), Profiler EMP-400 meter (VDI- Vertical Dipole Moment – Inline) was used as a survey tool to determine the overall extent of bedrock-controlled areas of the park area (of ~ 1.5 acre). The EMI readings of σ are also affected by moisture and temperature; therefore, the results from two different days cannot be compared. This EMI Survey was completed during a two-hour period including transect (~22) lines from NE to SE with a variable distance between transects. This was not a grid mapping, as time did not allow for that level detail, but a reconnaissance survey (freeway mapping) of the area.

Ground Penetrating Radar Unit (GPR) with a 400 MHz antenna was utilized to determine the depth to bedrock. GPR was calibrated by excavation a small pit and placing a known metal target at a depth of 10 inches. Four transects where completed in the southern half of the park area.

The results of the two mapping methods were compared to determine the extent and depth of the bedrock in the area. Maps showing interpolations from the data collected are included with this report.

Participants:

Karen Argenti
Paul S. Mankiewicz, Ph.D., The Gia Institute /SWCD
Richard Shaw, USDA-NRCS, NJ-NY State Soil Scientist
Olga Vargas, USDA-NRCS, NY Soil Scientist

Summary:

The EMI and GPR both verified the soil map unit: Urban land – Greenbelt-Chatfield- Rock outcrop complex, 0 to 8 percent slopes. The soils in the park are consistent with the Chatfield series that is moderately deep (50-100 cm) to bedrock. **The bedrock in the park is variable but predominantly at a depth of 2.8-3.5 feet (86-107cm).**

Please review attached maps and interpretations and let me know if you have further questions.
Sincerely,

Olga Vargas, USDA-NRCS-Soil Scientist

Geophysical Survey Tuscarora Farm, Madison County NY
Technical Report - Olga Vargas, NRCS- Soil Scientist

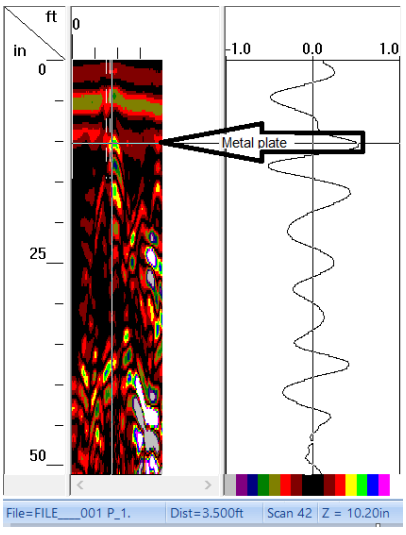
Equipment: The data was collected with the ground penetrating radar unit TerraSIRch Subsurface Interface Radar (SIR) System-3000 and the 400 MHz antenna manufactured by Geophysical Survey Systems[1]. The data was processed in RADAN (version 7.5) software program by utilizing easy processing. Apparent conductivity (σ) data was also collected using a Profiler EMP-400 meter manufactured by Geophysical Survey Systems, Inc[1]. The Profiler unit was georeferenced utilizing a Trimble Global Positioning System GeoExplorer 6000 series (XT). The Data is processed using MagMap V5[1] and exported to Surfer 16[1]. In Surfer contour maps were created by Kriging interpolation methods.

Calibration of GPR: Ground-penetrating radar (GPR) is a time scaled system. The system measures the time it takes electromagnetic energy to travel from an antenna to an interface (e.g., bedrock, soil horizon, stratigraphic layer) and back. To convert the travel time into a depth scale, the velocity of pulse propagation or the depth to a reflector must be known to convert the travel time into a depth scale.

The relationships among depth (D), two-way pulse travel time (T), and velocity of propagation (*v*) are described in the following equation (after Daniels, 2004): $v = 2D/T$. The velocity of propagation is principally affected by the relative dielectric permittivity (Er) of the profiled material(s) according to the following equation (Daniels, 2004): $Er = (C/v)\ 2$, where C is the velocity of propagation in a vacuum (0.299 m/ns).

The velocity of pulse propagation is commonly expressed in centimeters per nanosecond (cm ns^{-1}). In soils, the amount and physical state of water (temperature dependent) have the greatest impact on the Er and *v*.

The velocity of propagation and the relative dielectric permittivity through the upper part of the soil profiles were estimated using the equations above based on the measured depth and the two-way pulse travel time to known subsurface reflector: cast iron lid placed above a presumed bedrock surface at 25 cm / 10 inches. At the time of the study, in September the estimated Er was about 5.21. The estimated *v* is 5.17 in./ns.



1 Trade names are used for specific references and do not constitute endorsement.

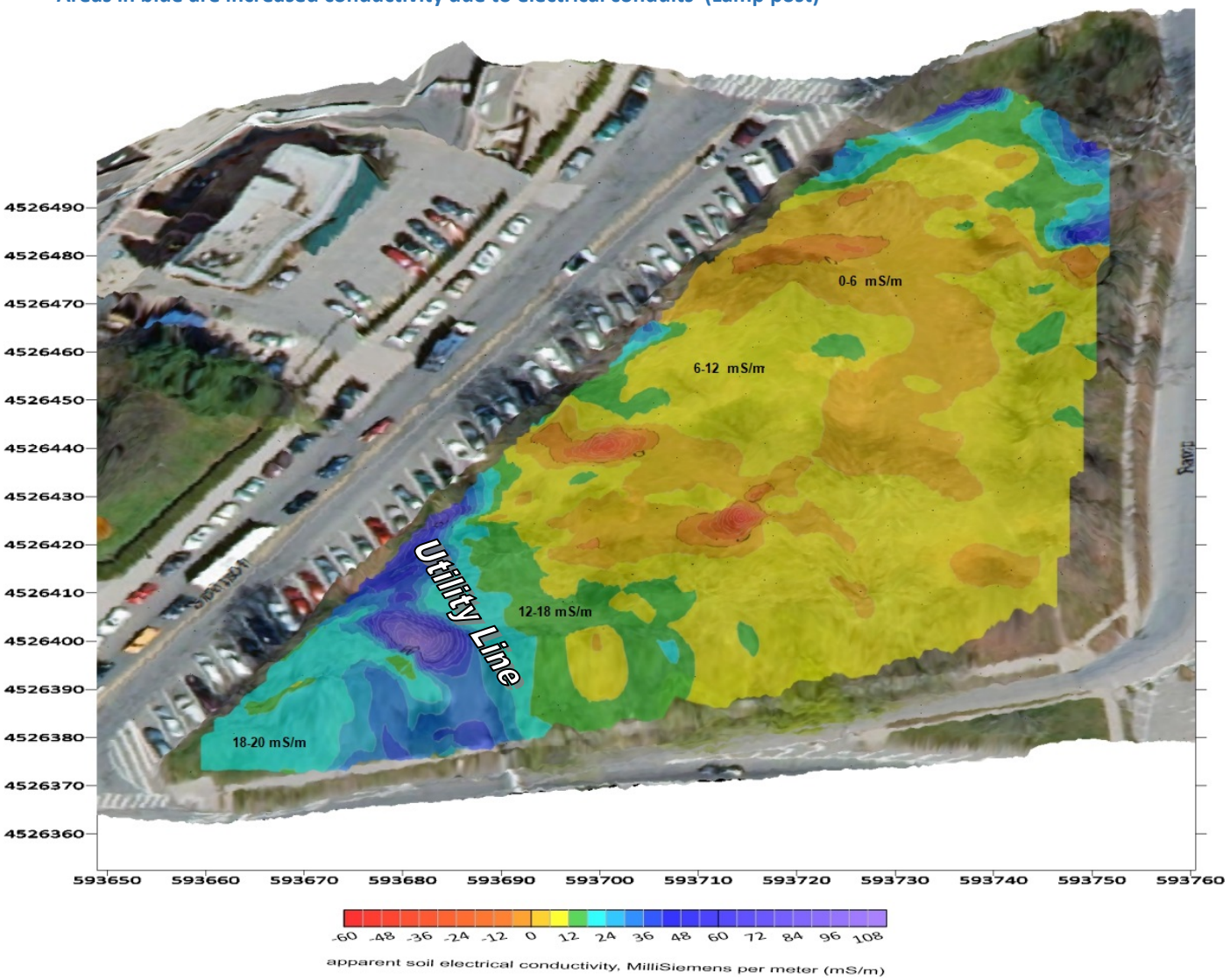
Profiler EMP-400 meter in VDI- Vertical Dipole Moment – Inline, with effective depth of 1.8 meters: Electromagnetic induction (EMI) compares spatial conductivity patterns and associates them with changes in soil characteristics. σ is measured in milli- Seimens per area (meters) or mS m^{-1}. Characteristics that influence apparent conductivity are:

- Salt content (>salts, >EC)
- Cation Exchange Capacity (CEC) (> 2:1 clays)
- Water content (>soil moisture, >EC)
- Porosity or compaction (>Db, >EC)
- Temperature (>temp, <EC)
- Size, shape, and orientation of conducting objects

Geophysical interpretations are considered preliminary estimates of site conditions. The results of geophysical site investigations are interpretive and do not substitute for direct ground-truth observations (soil sampling). The use of geophysical methods can reduce the number of coring observations, direct their placement, and supplement their interpretations. Interpretations contained in this report should be verified by ground-truth observations.

Results and interpretations:

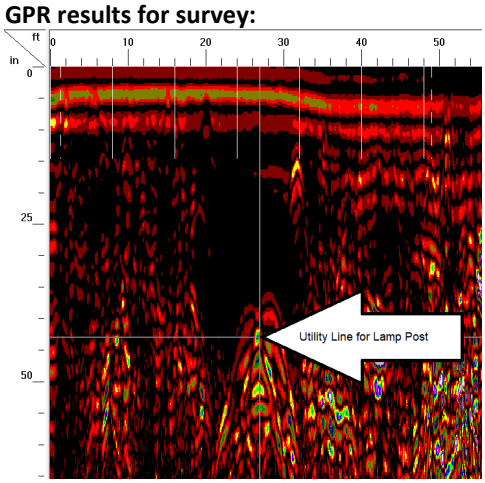
Areas in blue are increased conductivity due to electrical conduits (Lamp post)

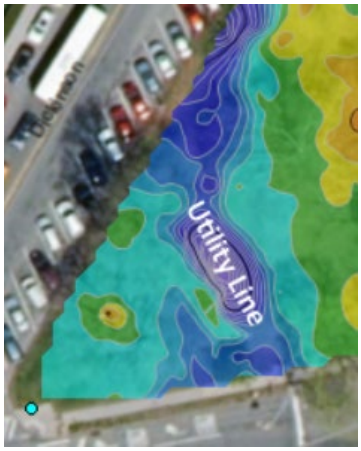


EMI results for survey:

Areas with lowest conductivity value in orange (<6 mS/m) included areas with fragments near the surface above bedrock areas. The bedrock was still predominantly below 2.5 feet but also may consist of bedrock near the surface in areas that were not part of the GPR transects.
Areas with moderately low conductivity value in yellow (6-12mS/m) have bedrock at moderate depths of ~2.5-3.3 feet (75-100cm) and correlate with Chatfield soils. Moderately deep Chatfield soils are the predominant soil component of the park.
Areas with moderately high conductivity values green have bedrock slightly deeper from the surface (~3.3-4 ft).
Area with the highest conductivity values in blue where impacted by the electrical conduits along the road and between lamp posts.

GPR results for survey:

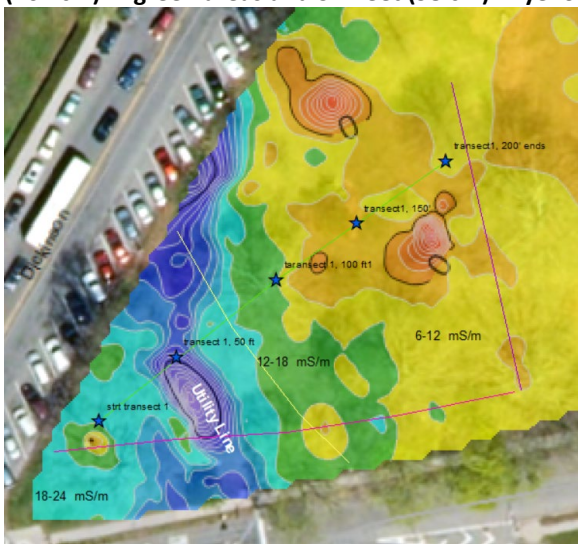




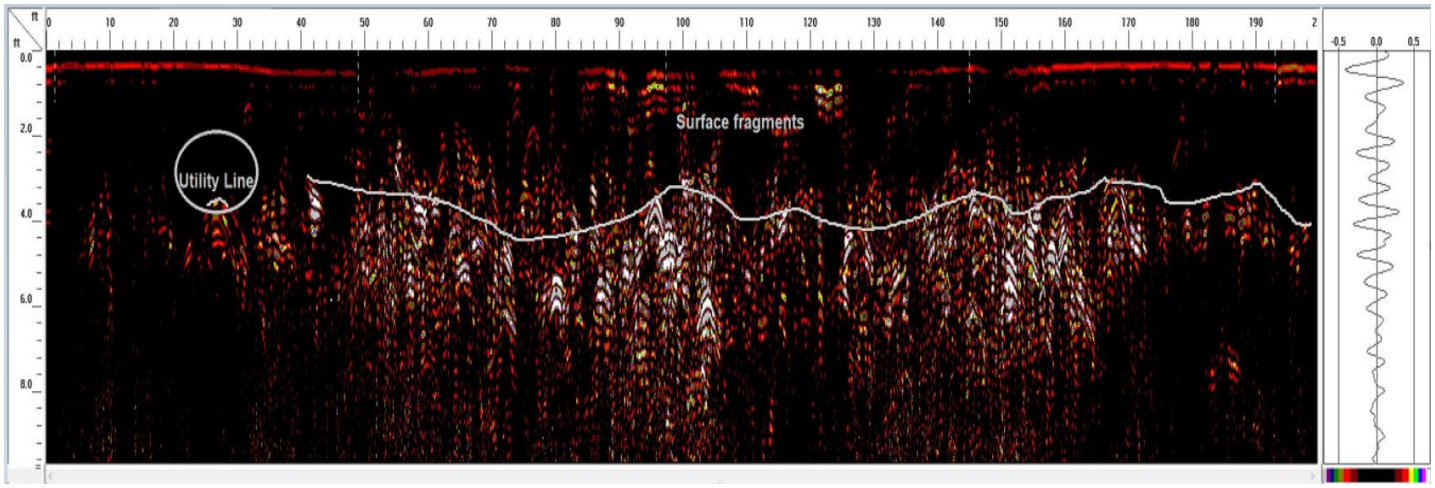
Transect 1: The values of high conductivity from EMI, correlate with lamp post on Sedgwick and Dickinson. It appears a utility line goes through the park at about 42" in depth.

Green (12-18 mS/m) areas of moderate conductivity on EMI map

The average depth to contrasting strata (bedrock) is ~ 2.9 - 4.1 feet in depth, with an **average depth of 3.5 feet (107 cm) in green areas and 3.2 feet (98 cm) in yellow areas**

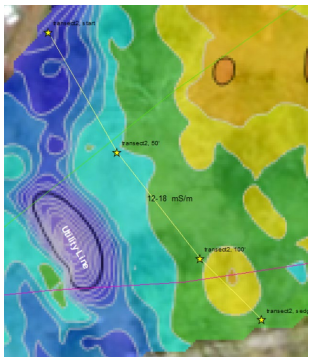


The first 25 feet before the utility line are difficult to make out the contrasting strata
From 50 to 100 ft along the trasect were areas of moderate conductivity (green areas) 12-18 mS/m and the depth to contrasting strata, bedrock, average was about 3.5 feet in depth (107 cm) which is slighlt deeper than the Chatfield series of (50-100cm). From 100 to 200 feet along the transect were area of moderately low conductivity (yellow) 6-12 mS/m) and the depth to contrasting strata, bedrock, average was about 3.3 feet in depth (98 cm).



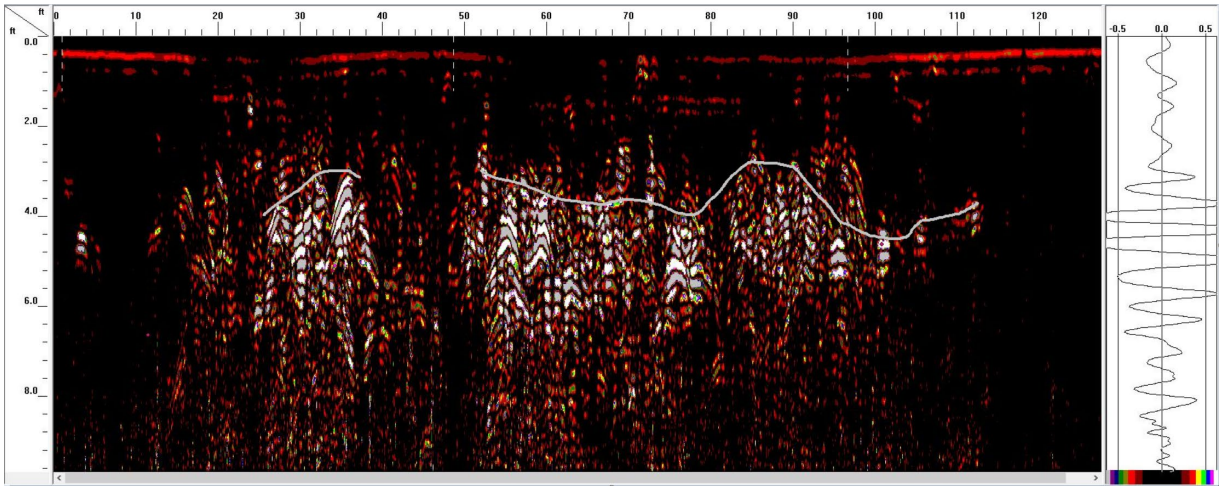
Color xform 4.

Transect 2: NW to SE from Dickinson to Sedgwick.



Green areas of moderate conductivity (12-18 mS/S) on EMI map

The average depth to contrasting strata (bedrock) is 3.5 feet (107cm).

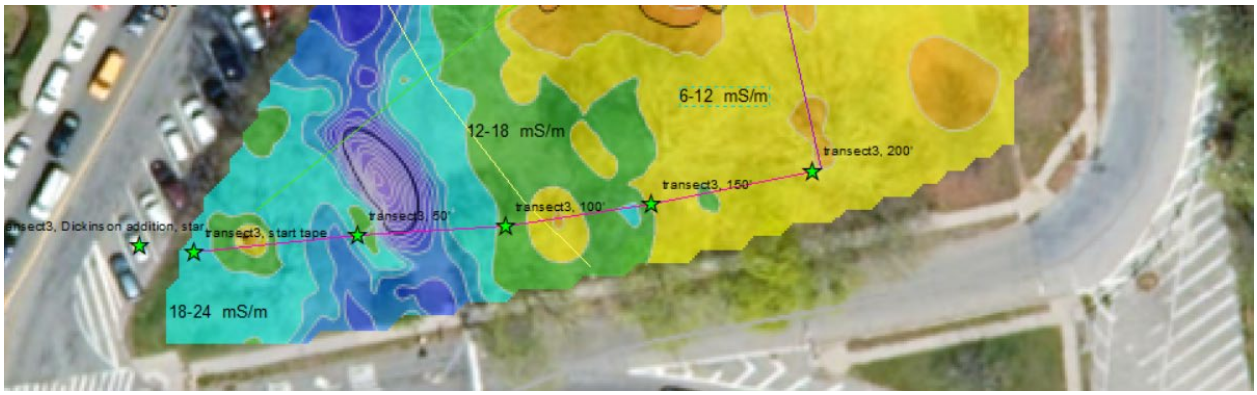


Transect 3: Along West to East along Sedgwick.

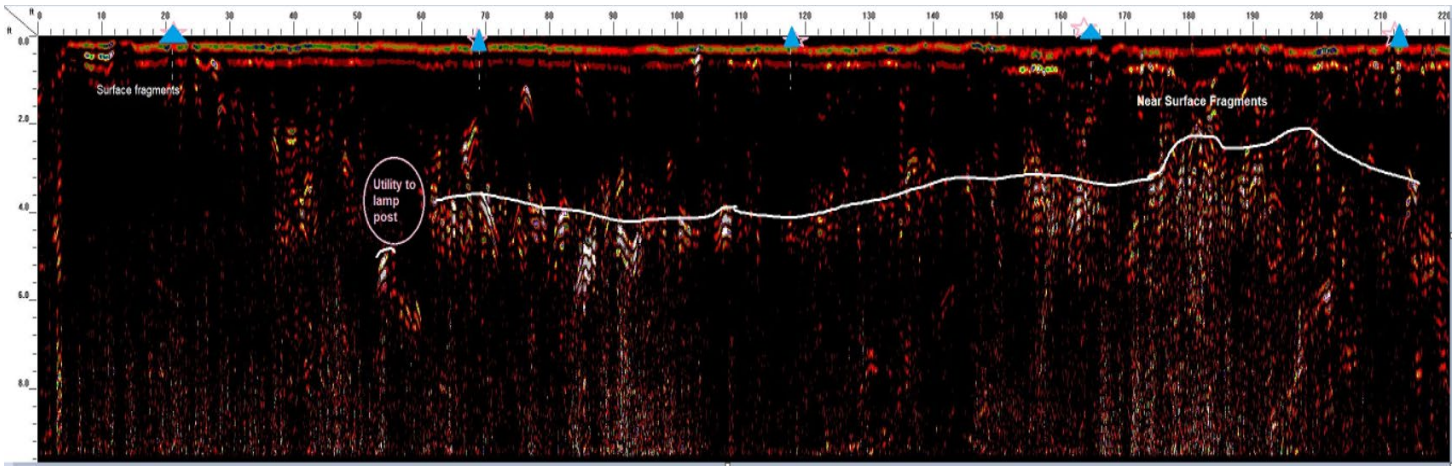
Green to yellow areas

West to east

Moderately high to moderately low conductivity on EMI map



Transect 3 - continued:



The average depth to contrasting strata (bedrock) is 2.8 feet (68 cm)

0-50' near surface fragment sloping down , conductivity may be impacted by drift from lamp post.

50-150' The average depth to contrasting strata (bedrock) is ~ 2.7 - 4.0 feet in depth, with an average depth of 3.4 feet (104 cm) in green areas .

150-210 The average depth to contrasting strata (bedrock) is ~ 2.0 – 3.2 feet in depth, with an average depth of 2.5 feet (76 cm) in yellow areas . some areas also consisted of near surface fragments.

Transect 4, south to North from Sedgwick

yellow areas of moderately low conductivity (EMI)

The average depth to contrasting strata (bedrock) is of 2.8 feet (86 cm) – Correlates to a Chatfield Soil

Surface fragments above bedrock lowers conductivity in areas (orange <6 mS/m)
The area along transect 4 is predominantly yellow (6-12 mS/m) with an average depth of 2.8 feet (86 cm)