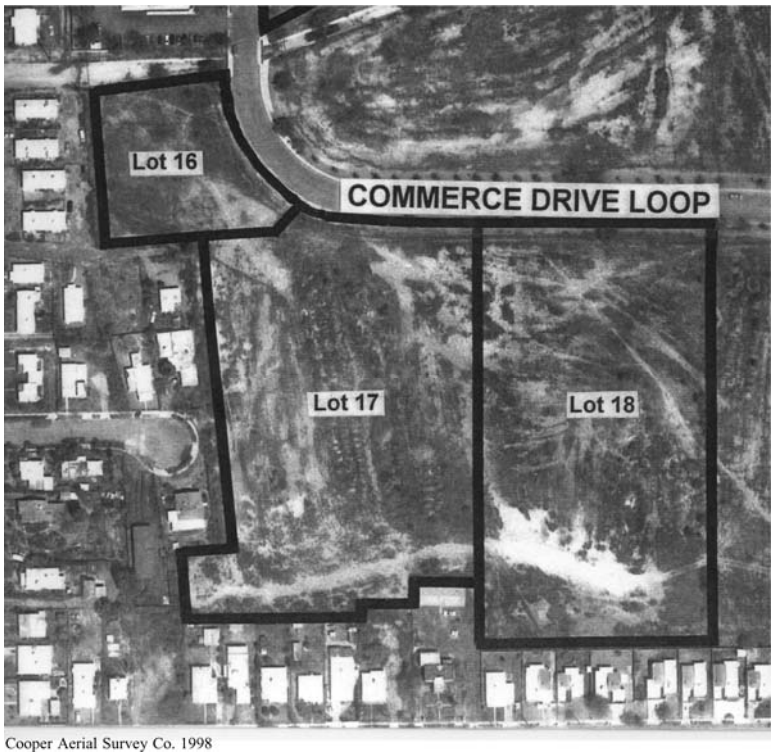
Rio Nuevo North

Buried Landfill Delineation with IP



Cooper Aerial Survey Co. 1998

Induced polarization (IP) and resistivity can be very useful tools in mapping environmental features such as buried landfills, but the survey speeds and pseudosection interpretations have been drawbacks. New multichannel receivers with computer-controlled multiplexers now allow extremely fast data acquisition, and two-dimensional smooth-model inversion (with topography) provides realistic geo-electric cross-sections that allow for the interpretation of the edges of buried landfills, thickness of soil cover, and thickness of waste material.

Historical records indicate that the Rio Nuevo North Landfill was probably comprised of multiple, irregularly shaped pits resulting from clay, sand, and gravel mining. Several deep and numerous shallow pits, evident from aerial photographs, have been filled with construction debris, landscaping waste, and municipal solid waste. Haphazard cleaning of the area in the early 1980's left pockets of garbage in the subsurface below 17 feet. The result of the excavation and fill activity is an area that may or may not contain small pockets of waste material.

Area photograph from 1953

Cooper Aerial Survey Co. 1953

Area photograph from 1973

Cooper Aerial Survey Co. 1973

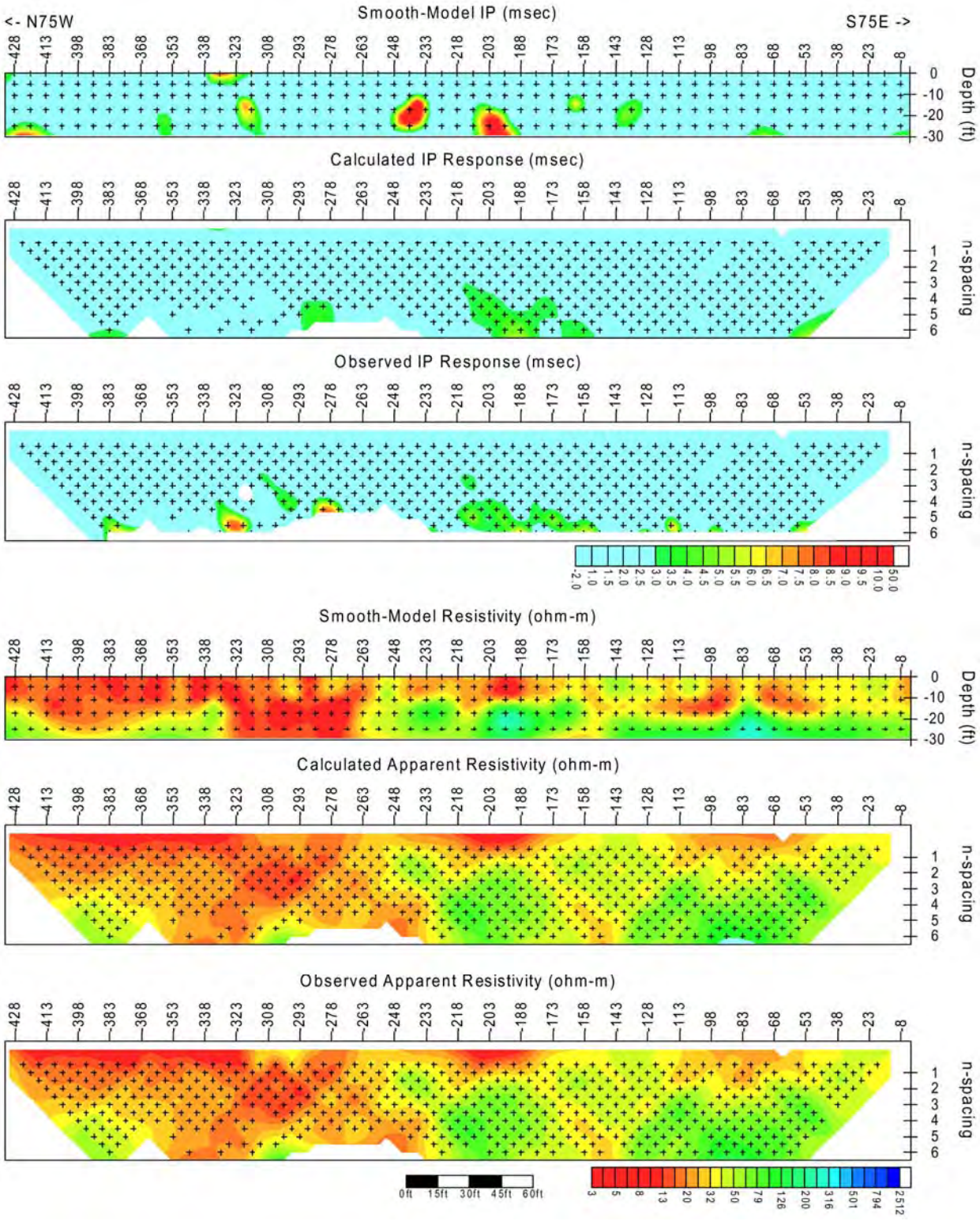
The aerial photographs above and on the front cover show the same portion of the project area over time. In the 1953 photograph one of the deep pits is evident along with two scarp-like features. Stock piles can be seen covering the surface in the 1973 picture. The cover picture shows the current state of the area; leveled with a couple of berms. The berm on the western edge of the property contains little metallic debris while the berm on the eastern is comprised of concrete with rebar. A few smaller piles of metallic debris and concrete are in the lower mid-western portion of the area.

The location of the test line was chosen primarily on the basis of aerial photographs taken in 1953 and 1967 which showed the presence of a large depression near the center of the line. Though it is not possible to determine from the photographs whether or not waste material was being disposed of in the depression, it was assumed that this was one of the most likely locations for remaining subsurface waste material. Results from the test line and plan views can be seen in the following figures.

Zonge minimized expenses by utilizing the MX-30 which is a computer-controlled switching interface between a resistivity transmitter, a multi-channel receiver such as the GDP-32, and an array of up to 30 electrodes. All data were acquired in the dipole-dipole configuration with a station-spacing of 7.5 feet and a dipole size of 15 feet. Twelve points were collected along each diagonal (n=0.5, n=1.0, …n=6). The electric-field signal was sensed at the receiver site using tin-coated copper braid elect-rodes. A time domain, 0.5 Hz signal was used, stacking and averaging eight cycles to minimize random noise. All data points were measured at least twice to establish repeatability. A crew of three can acquire 3300 data points plus repeats in one day (2500 linear feet).

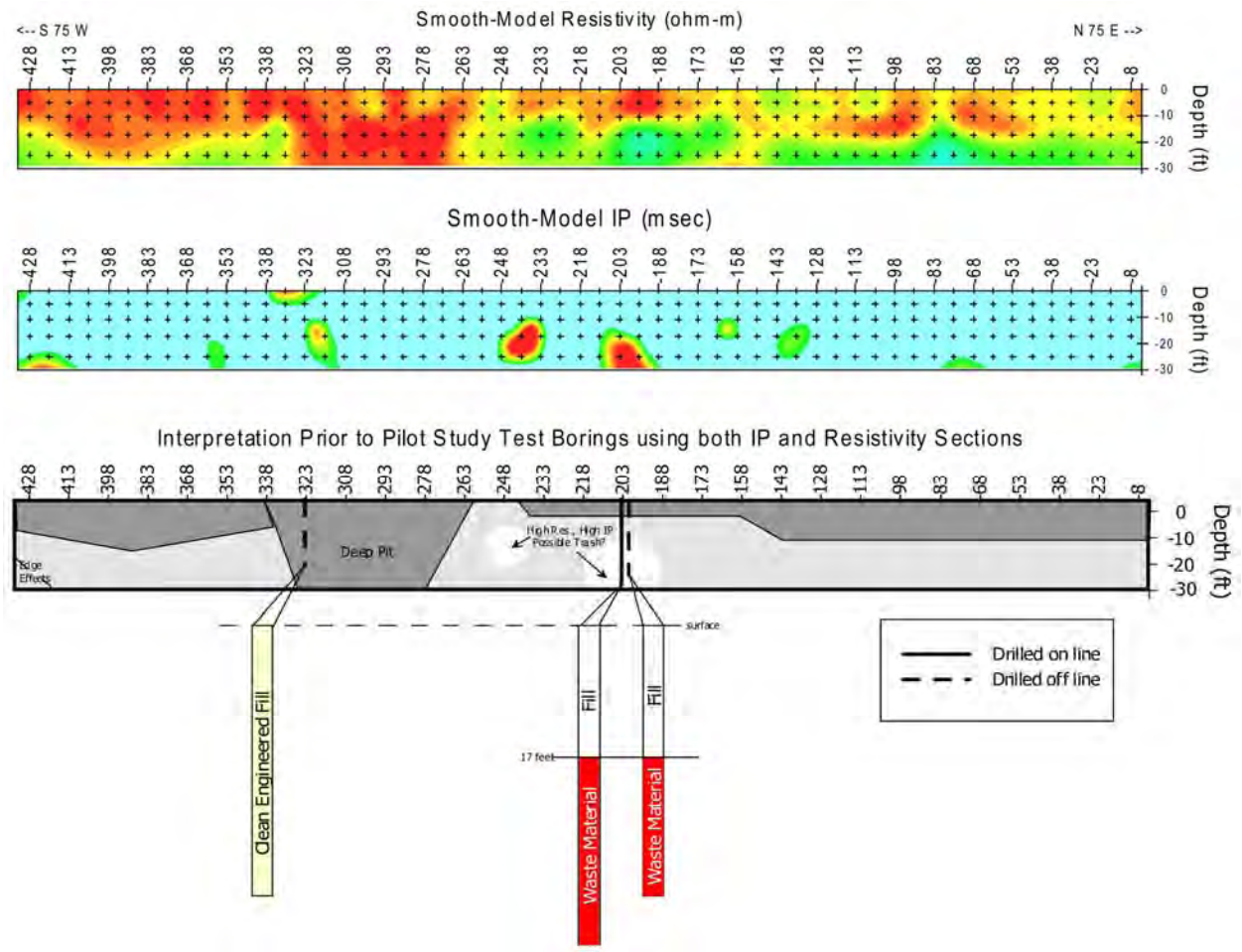
ZETA System: GDP-32, MX-30 and ZT-30

Modeling the survey data consisted of a two dimensional smooth-model technique with topographic compensation. The resistivity and IP phase responses, as a function of n-spacing, are converted to a two-dimensional model of the electrical structure, as a function of depth. The results of modeling create a realistic geo-electric cross section that allows for the interpretation of the edges of buried landfills, thickness of soil cover, and thickness of waste material.



An IP anomaly interpreted as the result of possible waste, centered approximately below station –203, was drilled. Green waste, textiles, and miscellaneous municipal waste were encountered beginning at a depth of approximately 17 feet. A second borehole was placed approximately 20 feet south of the line to further test the extent of the waste material. This borehole encountered similar waste materials.

A third borehole was positioned on an area that showed no IP anomaly, but that appeared to be within the historical limits of the depression. This position is characterized by low resistivities, and was interpreted to be a deep pit containing fill material with no waste. The boring recovered clean, engineered fill, primarily of sand and clay.

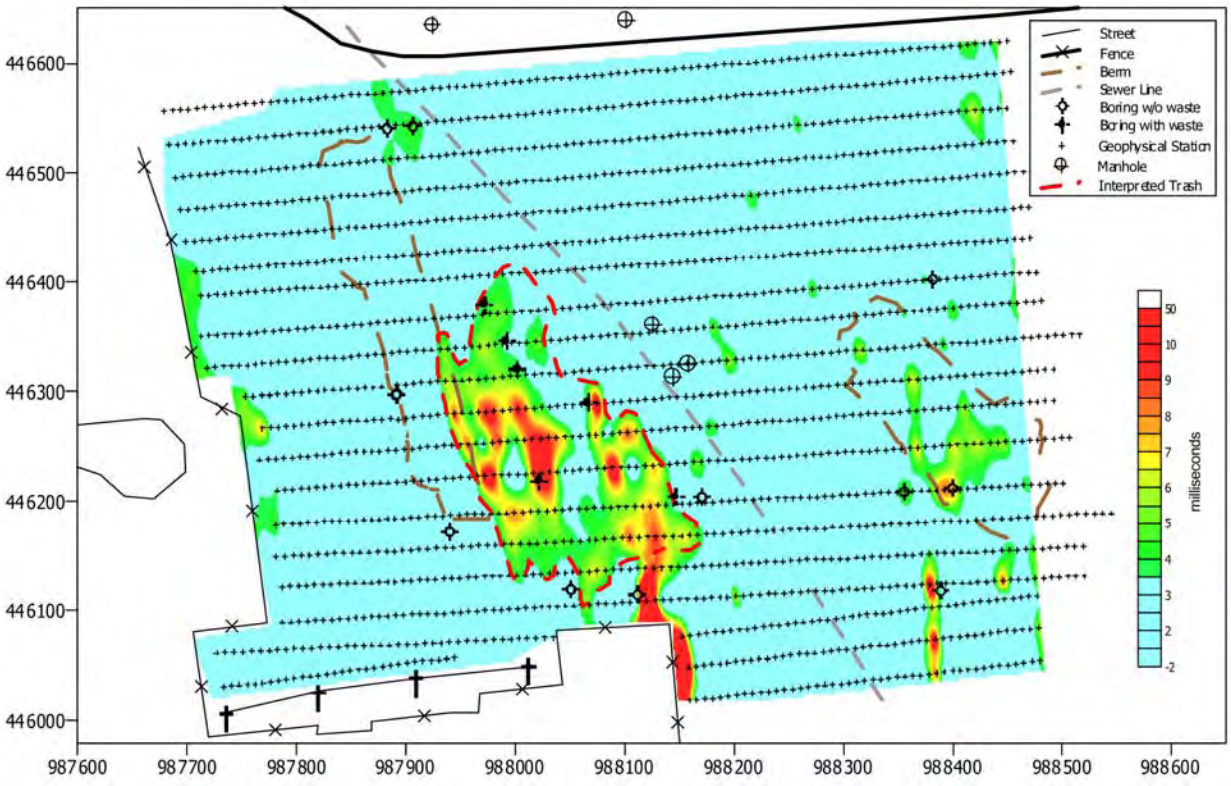


The excellent correlation between the geophysical survey results from the IP data and the three boreholes provided sufficient reason to expand the survey to include 22 acres within the Rio Nuevo North Resubdivision. Upon completion of the geophysical survey, additional borings were made to aid in interpreting the geophysical data.

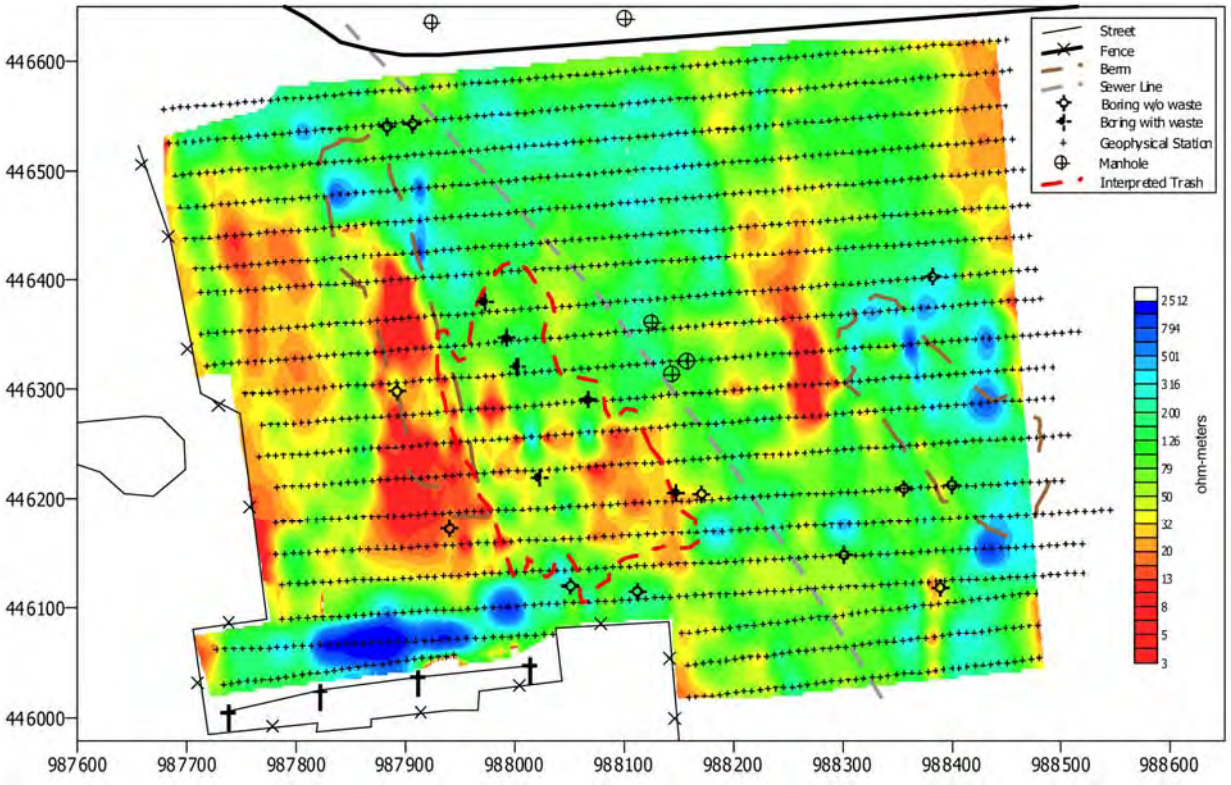
Only Lots 17 and 18 contain anomalous IP readings that could not be associated with cultural features. Seventeen borings were advanced on the two lots to confirm the IP results. Borings were drilled to test the limits of the garbage, confirm positive IP highs correlating with garbage, and to confirm the absence of garbage in areas without IP highs.

The red dashed line outlines the location of the buried solid waste interpreted from the IP results and boring confirmations. The linear IP anomaly in the lower right corner is thought to be caused by an old utility line (this feature correlates with a dirt road in earlier aerial photographs. The IP anomalies on the western edge of the property are caused by the fence.

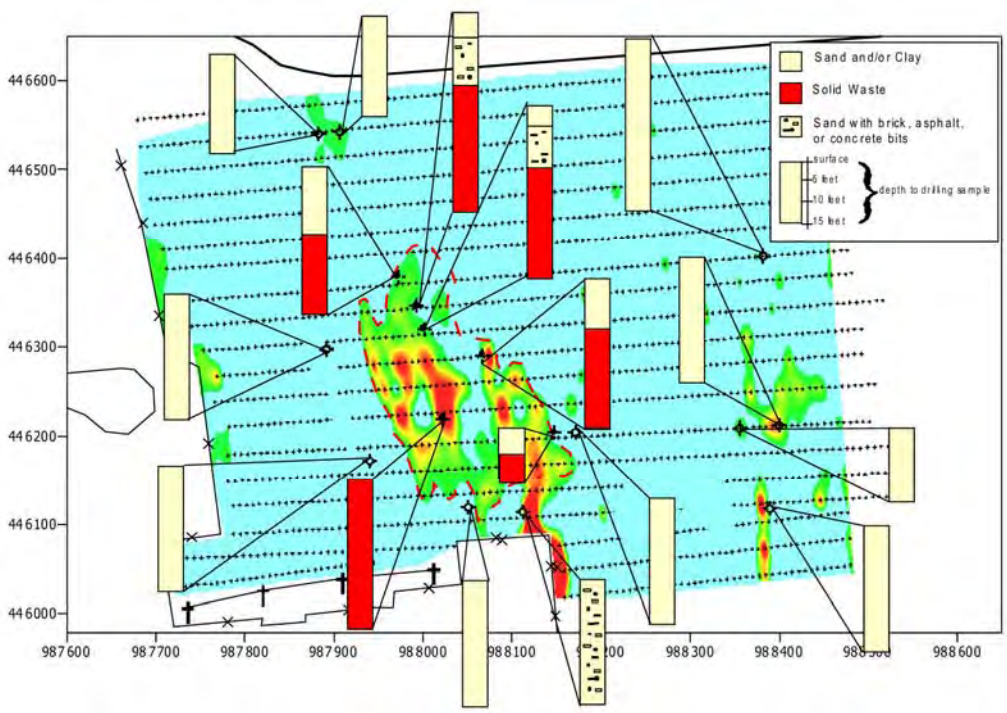
Smooth-Model Inversion of IP data at 20 ft. Depth



Smooth-Model Inversion of Resistivity data at 20 ft. Depth



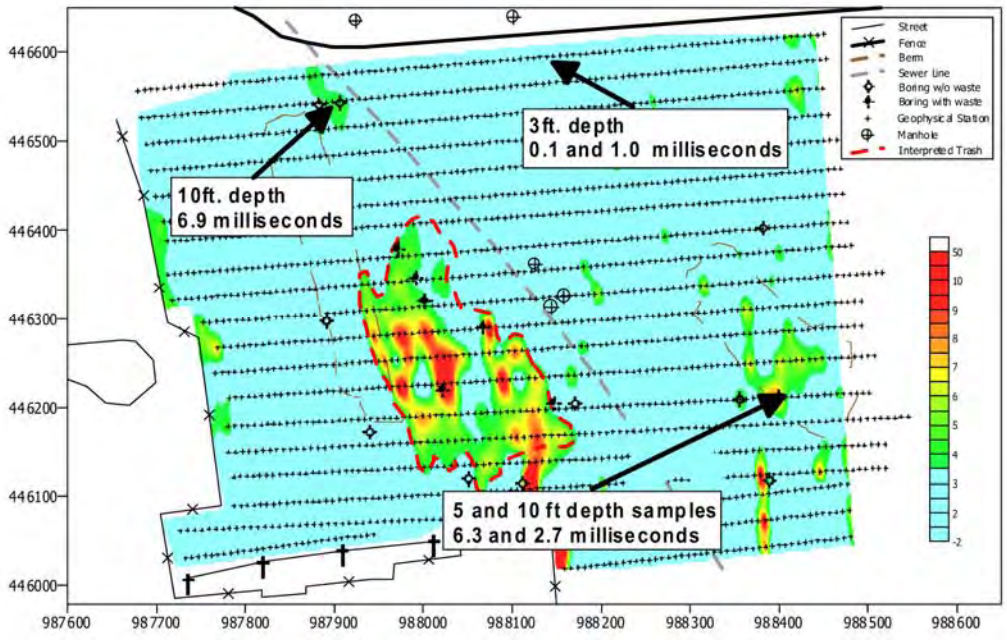
Drilling Results



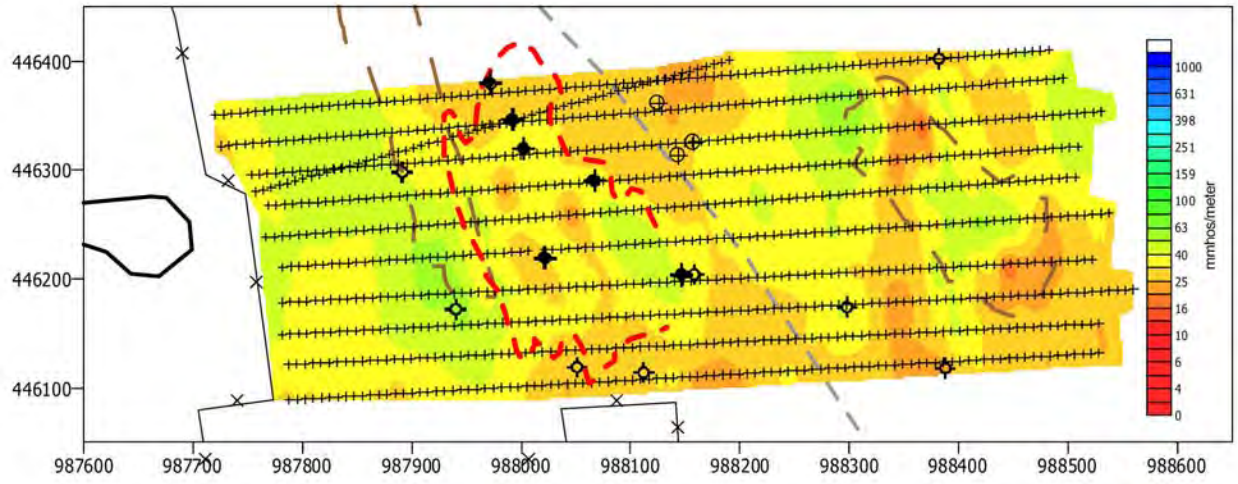
The drilling results confirm the interpretation of the IP anomalies as waste material. Five borings were placed within the main IP anomaly and all encountered waste material. Three holes were drilled into IP anomalies that did not recover waste material. These areas are thought to contain small amounts of clay, causing IP effects. All borings advanced into background or IP values less than 3 milliseconds did not encounter waste.

Lab measurements were performed on samples recovered from the areas with IP anomalies but where drilling did not encounter waste material and on several samples taken from an area with background IP responses. The lab measurements confirmed the responses recorded in the field.

Lab Results



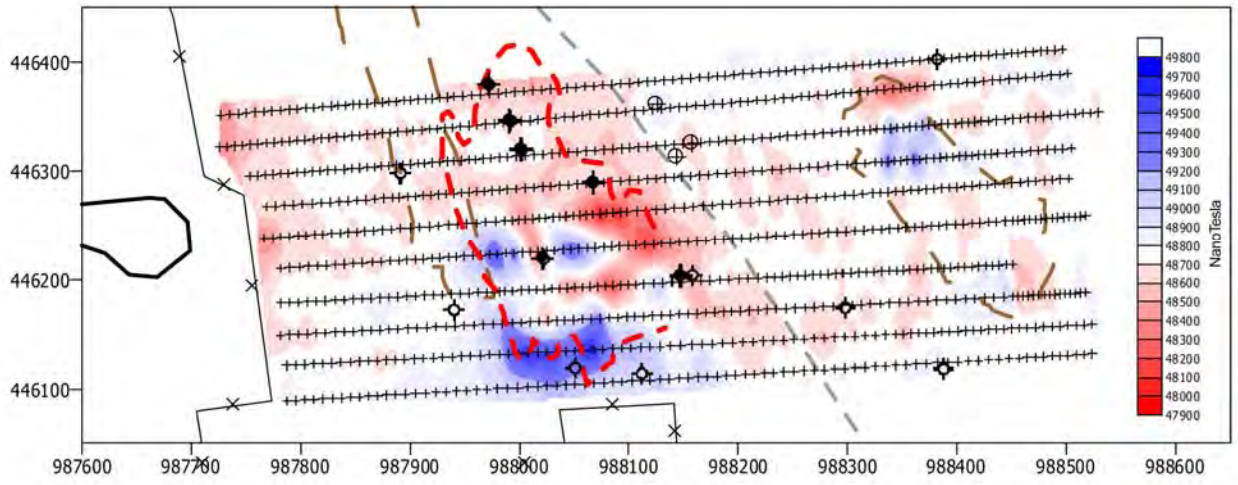
EM-31 Conductivity Data



To test the effectiveness of other traditional techniques in delineating the edge of the buried landfill, an EM-31 and a magnetometer were also run over the portion of the property that contains garbage. The conductivity data from the EM-31 is plotted above. Again, the berms and other features are shown with the data. Note that the data does not show any correlation between the location of the trash and anomalies in the data. The anomalous reading in the magnetics data are mostly caused by surface metallic debris.

It also should be noted that the results from both the EM-31 and magnetics surveys do not offer any vertical information such as depth to garbage and thickness of the landfill.

Magnetics Data



To date, large grids of IP data have been acquired over two landfills in Tucson. The method has been tested at three other landfills. At all five sites, there is an excellent correlation between the IP results and the location of subsurface waste.

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