Matt Goerz  
Geomatrix  
2101 Webster Street, 12th Floor  
Oakland, CA 94612

NORCAL Project No. 05-325.19

Subject: Geophysical Survey  
SCCRTC Site  
Santa Cruz, California

Dear Mr. Goerz,

This letter report presents the findings of a geophysical investigation performed by NORCAL Geophysical Consultants, Inc. at the SCCRTC site located in Santa Cruz County, California. The investigation was conducted by NORCAL Geophysicist David Bissiri on 26 April, 2005. We investigated an approximately 100- by 100-foot survey area as designated by Geomatrix (see Plate 1). According to background information provided to NORCAL, this portion of the site was the location of one or more railroad maintenance shops and out-buildings. The buildings have been demolished and the site is currently comprised of an open field used for farming. A railroad spur is located approximately 30 feet southwest of the investigation area. The background information also alleges that an underground storage tank (UST) associated with the buildings may be present near the center of the investigation area. The purpose of the survey, therefore, is to determine if subsurface objects such as USTs or their associated piping are present.

We conducted the investigation using a combination of vertical magnetic gradient (VMG), hand-held metal-detection (MD), and electromagnetic line locating (EMLL) methods. Descriptions of these methods, the equipment used, and their limitations are provided in Appendix A. A summary of our field activities and findings is presented below.

The first task undertaken by NORCAL was to establish a survey grid to provide horizontal control for the acquisition of VMG data. The survey grid consisted of a series of parallel lines oriented roughly north-south (perpendicular to the railroad tracks) and spaced 5 feet apart. VMG data were then collected at approximately 5-foot intervals along the lines. Following the VMG data acquisition, the data were uploaded to a field computer and processed to produce a VMG contour map. This map was evaluated for VMG contours indicative of subsurface ferrous material. Areas identified on the contour map as having anomalous VMG contours were then investigated further with the MD method. The MD investigations consisted of systematically operating the MD instrument along multiple bi-directional traverses centered over the VMG anomalies. The MD traverses ranged in length from 10 to 30 feet and were spaced approximately 3 feet apart. Finally, the EMLL method was used to determine if there were underground utilities that may cross the survey area.
RESULTS

The findings of our investigation are shown on the geophysical survey map presented on Plate 1. This map displays the VMG data contours, the approximate survey limits, the location of the nearby railroad track, and the locations of interpreted subsurface objects.

The VMG contour data displays several areas with closely spaced and convoluted contour closures, or anomalies. These VMG anomalies indicate the presence of ferrous material. The five largest anomalies are depicted on the map as the shaded red patterns labeled A through E. None of the anomalies have the magnetic range or magnitude usually associated with steel USTs. The VMG anomalies are more typical of those associated with minor amounts of demolition debris. Furthermore, only two of the anomalies, B and D, indicated the presence of any detectable near-surface metal in their vicinity. Anomaly B appears to be associated with a 25-foot long section of an undifferentiated utility line (probably abandoned) and a rectangular 8-foot by 5-foot MD anomaly (depicted in blue) that is suggestive of a reinforced concrete pad. VMG anomaly D appears to be associated with two smaller MD anomalies. These MD anomalies are more suggestive of such things as reinforced concrete footings or cut-off fence posts.

STANDARD CARE and WARRANTY

The scope of NORCAL’s services for this project consisted of using geophysical methods to assess the area of investigation for buried metal objects. The accuracy of our findings is subject to specific site conditions and limitations inherent to the techniques used. The services were performed in a manner consistent with the standard of care ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the services or products delivered under this agreement, expressed or implied, is made by NORCAL.

We appreciate having the opportunity to provide you with this information.

Respectfully,

NORCAL Geophysical Consultants, Inc.

[Signature]

David Bissiri
Geophysicist GP - 1009

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Enclosures: Plate 1- Geophysical Survey Map
Appendix A - Geophysical Instrumentation, Methods, and Data Interpretation
Appendix A

Geophysical Methodology, Instrumentation, Data Analysis, and Limitations
Vertical Magnetic Gradient (VMG)

**VMG Methodology**

VMG is a method commonly used to detect ferrous objects. This is accomplished by measuring the lateral variations of the earth’s magnetic field. Since the magnetic field at any given point on the earth’s surface is the vector sum of the earth’s field combined with the magnetic fields of nearby metal objects, by removing or suppressing the earth’s field the local magnetic variations due to ferrous objects may be detected. The basis for vertical magnetic gradient surveying starts with measuring the total intensity of the magnetic field. These are referred to as total field measurements (TF) and are recorded in units of nanoTesla (nT). In environmental and engineering investigations it is often more useful to measure the vertical rate of change of the total field magnetic intensity. This is referred to as the vertical magnetic gradient (VMG) and is measured in units of nanoTesla/meter (nT/m).

While both TF and VMG measurements are related to the same phenomena (i.e. the magnetic field), each has certain advantages over the other. However, the VMG method is often chosen for environmental/engineering investigations because of the following:

1) VMG measurements are generally less affected by nearby above ground objects, especially objects to the side of the instrument. This reduces magnetic interference caused by such objects.

2) VMG measurements are not affected by temporal (diurnal) variations in the earth’s magnetic field, unlike TF measurements. This eliminates one more variable from the data.

3) VMG effects attenuate more rapidly with increasing distance from magnetic sources, thus allowing more precise determination of a buried object’s location.

It should be noted, however, that because the VMG method is very sensitive, the effects of small near surface objects can be amplified and be more of a source of noise in VMG data than in TF data.

**Instrumentation**

A vertical magnetic gradiometer is the device that is used to obtain the VMG data. The instrument typically used by NORCAL is a Geometrics 858 Cesium-vapor magnetometer. This instrument operates on the “optical pumping” principle and consists of a console and two total field magnetic sensors that are mounted on a vertical staff. One sensor is mounted at about shoulder-height and the other sensor is mounted at about knee-height. The magnetometer console features a built-in computer that stores the raw TF data, calculates the VMG values, and records survey grid information. The instrument obtains the VMG values by simultaneously measuring the total magnetic field intensity at the two sensors, taking their difference in magnetic intensity, and then dividing by their separation distance. The resulting survey information is later uploaded to a field computer for further processing.
Computer Processing

The uploaded data are converted into a format suitable for contouring using the program SURFER from Golden Software. This program calculates an evenly spaced array of values (data grid) based on the measured field data. These gridded values are then contoured to produce VMG contour maps for interpretation. In most cases the VMG data are processed in the field on a portable computer and used to produce a preliminary data contour map.

Contour Map Interpretation

Generally speaking, in a region with fairly uniform magnetic conditions the VMG values will vary smoothly from one area to another and display contour lines that are usually spaced far apart. In contrast, in those areas where VMG variations are stronger, the contours are more closely spaced. In some cases the variations are so strong that the contours become highly contorted and convoluted, forming roughly concentric circles, tightly wound loops and whorls, or elongated parallel lines. Actual magnitude and shape of the contour lines is dependent on several factors, the most important being the relative position and size of the magnetic object with respect to the location of the magnetic sensors, the orientation of the object within the earth's field, and the magnetic susceptibility of the material comprising the object.

Roughly concentric circles that look like bull's-eyes are generally referred to as monopoles. Monopoles that are roughly limited in extent to the data point spacing of the sampling grid are often caused by relatively small, near surface objects with limited cross-section. These typically consist of well caps, pull boxes, balls of wire, etc. On the other hand, larger monopoles that extend across an area of several data points are typically associated with larger, deeper objects such as well casings, reinforced concrete footers, ends of pipelines, etc. In other cases, two monopoles, one positive and one negative, may be in close proximity and form a pair of high-low closures known as a dipole. Dipoles are often, but not always, attributed to larger objects such as UST's, vaults, buried ordnance, etc. that have a substantial diameter or width. A series of parallel contours typically indicates that an elongate object such as a building wall, fence, or underground pipeline is the magnetic source. Irregular patterns of loops and whorls are often indicative of several magnetic objects being present with variable shape, mass, and distribution. These VMG patterns are the most difficult to interpret. Past experience has shown that such patterns are usually associated with debris fields, landfills, and demolition sites.

Regardless of whether the contours form monopoles, dipoles, or irregular whorls, if there are no obvious nearby above ground sources that could cause such magnetic variations, then subsurface objects are suspected. Contours are typically considered anomalous when large differences in data readings (on the order of several hundred to several thousands of nT/m) from one data station to the next are displayed. The anomalous variations are called VMG anomalies.
Limitations

Buried ferrous metal objects produce localized variations in the earth's magnetic field. The magnetic intensity associated with these objects depends on the mass of the metal and the distance the metal object is from the magnetometer sensor. As a general rule, anomaly magnitude typically decreases and anomaly width increases as distance (depth) to the source increases, thereby making detection more difficult. In addition, the ability to detect a buried metal object is based on the intensity of these variations in contrast to the intensity of background variations. The intensity of background variations is based on the amount of above and below ground metal that is present within the survey area. Cultural features such as chain-link fences, buildings, debris, railroad spurs, utilities, above ground electric lines, etc. typically produce magnetic variations with high intensities. These variations may mask the magnetic effects from buried metal objects and thus make it very difficult to determine whether the magnetic variations are associated with below ground metal or above/below ground cultural features.

Metal Detection (MD)

MD Methodology

This method uses the principle of electromagnetic induction to detect shallowly buried metal objects such as USTs, metal utility conduits, rebar in concrete, manhole covers, and various metallic debris. This is done by carrying a hand-held radio transmitter-receiver unit above the ground and continuously scanning the surface. A primary coil broadcasts a radio signal from a transmitter which induces secondary electrical currents in metal objects. These secondary currents in turn produce a magnetic field which is detected by the receiver.

Instrumentation

The MD instrument that we typically use for shallow subsurface investigations is a Fisher TW-6 pipe and cable locator. This instrument is expressly designed to detect metallic pipes, cables, USTs, manhole covers, and other large, shallowly buried metallic objects. The instrument operates by generating both a meter reading (unitless) and an audible response when near a metal object. The peak instrument response usually occurs when the unit is directly over the object. The TW-6 does not provide a recordable data output that can be used for later computer processing. Results are generally limited to marking the interpreted outlines of detected objects in the field and mapping their locations.

Limitations

In general, the response of the MD instrument is roughly proportional to the horizontal surface area of near surface buried objects (typically in the upper three or four feet). This relationship can be used to advantage in discriminating between metal debris, reinforced concrete pads, and pipelines. However, in the presence of above ground metal objects such as fences, walls, parked cars, and metal debris, this is no longer valid. In some instances, the presence of such objects can make it very difficult to determine whether the instrument responses are associated with below ground targets or above ground cultural features. When multiple sources are present it may not be possible to identify individual targets. Also, relatively large objects that have a limited horizontal cross-section such as well casing and fence posts are sometimes difficult to detect.
Electromagnetic Line Location (EMLL)

EMLL Methodology

This method uses radio signals that are emitted by conductive utility lines to trace out their alignments. Under certain conditions, metallic utility conduits and pipelines can act as radio antennas. Energized utilities like electric, telephone, and grounded water lines often carry electrical currents. Radio signals are radiated from the lines as a result of these currents. These types of signals are referred to as “passive signals” since only a receiver tuned to the appropriate frequency is required to trace them. Other utilities like natural gas lines, drain lines, cathodic protection lines, etc. are not normally energized and thus require a radio signal placed on them in order to be traced. These types of signals are referred to as “active signals” and are placed on the lines by a radio transmitter, either by induction or by directly connecting a lead to them.

Whether the radio signal is passive or active, the surface trace of a line is determined the same way. A specialized radio receiver is carried along a series of traverses and the strength of the emitted signal noted. In most cases, the line is located below the point where the signal is strongest. After a series of traverses have been completed and the position of strongest signal strength has been determined, the alignment of the utility becomes apparent.

EMLL Instrument

The EMLL instrument used for this investigation was a Radio Detection RD 400. This instrument consists of a specialized radio receiver and a separate transmitter. The receiver is a multi-frequency, multiple antenna device that is capable of determining the relative strength and direction of signals broadcast from buried pipes and cables. The receiver generates both a meter reading (unitless) and an audible response when near an energized line. It does not provide any recordable output. The receiver is usually capable of tracing a line buried to a depth of about ten feet. The transmitter is a multi-frequency device with variable power output. In most cases, the highest power setting is sufficient to trace out a line for several hundred feet.

EMLL Limitations

The EMLL works by detecting radio signals. In many cases, the sources of these signals are from isolated known subsurface utility lines. In some cases however, other signals may be present. These other signals may be emitted by overhead electric and telephone lines, grounded water lines, and commercial radio towers. These other signals may distort or completely mask the primary signal of interest. In other cases, the primary signal may actually “jump” from one underground conductor to another, leading to erroneous results. Finally, traceable currents can only be detected as long as there is electrical continuity. Metal conduits having insulating joints and non-metallic utilities cannot be traced with EMLL.