GEOPHYSICAL INVESTIGATION REPORT

POPLAR POINT SITE
WASHINGTON, D.C.

FOR

RIDOLFI ENGINEERS, INC.
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1.0 INTRODUCTION

This report summarizes the results of the geophysical investigation that I performed at the Poplar Point Site between July 15 and August 5, 2002. Geophysical investigations were performed at eight areas of concern. Objectives at some areas included delineating buried debris which may include pesticides, fertilizers and miscellaneous metal debris. Underground storage tanks (USTs) and pipes are of concern in other areas. Some areas had a combination of possible subsurface features.

The manner and detail of data collection depended on the objectives of each investigation. At most of the sites I used both electromagnetic (EM-31) and ground penetrating radar (GPR) methods. Both of these methods respond to changes in the electrical properties of the subsurface and are useful in locating possible burial sites, USTs and pipes. The combined use of these methods helps provide a more complete interpretation of subsurface conditions. A brief description of the methods is provided in Attachment A.

1.1 Summary of Areas of Concern

The locations of the areas of concern for the geophysical investigations are shown on Figure 1a, and are summarized below. The original Work Plan site numbers and the objectives of the investigation are provided for each area of concern. Figure 1b is an airphoto of the site.

North Burn Pit Area (Work Plan Sites 2 & 3) to delineate pit and extent of refuse. Area includes headwall of drain pipe.

South Central Tree Nursery Area (Work Plan Site 4) for general investigation.

South Pad, Tree Nursery Area (Work Plan Site 1) for USTs & pipes.

South Road, Tree Nursery Area (Work Plan Site 1) for USTs & pipes.

Former UST, Greenhouse Area (Work Plan Site 6) for pipes.

West Perimeter Road, Greenhouse Area (Work Plan Site 5) for pipes.

South Perimeter Fence, Greenhouse Area (Work Plan Site 7) for general investigation and pipes.

Stickfoot Sewer Pipe (Work Plan Site 8) to trace small-diameter metal pipe.

1.2 General Description of Interpretation Results

The primary tool of investigation at all of the sites was the EM-31, and utilized both the conductivity data and the in-phase data. The conductivity data (mS/m) is a measure of the electrical conductivity of the subsurface to a depth of about 18 feet. The conductivity data can be affected by metal objects as well as soil and ground water contamination and changes in soil properties. The in-phase data (ppt) can be affected by extremely high conductivities, but is typically affected by buried metal (both ferrous and non-ferrous).

The GPR data provided a shallow cross section of the subsurface (usually no greater than five feet deep) which helped confirm the EM-31 results and better delineate many of the anomalous zones.

Anomalous zones near visible surface metal or debris are interpreted to indicate additional buried material, although some of the anomaly is caused by the visible material. Anomalous

zones are dashed in areas where their extent is not known due to interference from fences or buildings, or in areas with limited data.

High Anomalous Zone: Indicates large concentrations of buried metal (possible drums, debris, etc). Based on very large in-phase and conductivity anomalies and usually associated with a higher density of strong GPR targets.

Moderate Anomalous Zone: Indicates moderate concentrations of buried metal. Based on moderate in-phase and conductivity anomalies and usually associated with numerous GPR targets.

Low Anomalous Zone: Indicates low concentrations of buried metal. Based on low in-phase and conductivity anomalies and less concentrated GPR targets.

Very Low Anomalous Zone: Indicates scattered buried metal. May indicate mixture of scattered metal, construction debris, etc. Indicates interpreted edge of landfill materials. Based on very minor in-phase and conductivity anomalies.

High Conductivity Zone: Indicates a zone with elevated conductivity but relatively free of buried metal. May indicate finer-grained soils such as dredged materials from the river, silts, or soil contamination.

Linear Features: Indicates possible buried conduit, pipes, or foundations.

2.0 NORTH BURN PIT AREA

2.1 Description of Area and Objectives

The North Burn Pit Area is located in the northern portion of the Tree Nursery parcel. The site is primarily wooded with some clearings of grass and brush in the central and northern portions of the area (see Figure 2a, Site Sketch Map). The site is bordered by a chain link fence to the north, east, and south, and by a wetland to the west indicated by the heavy growth of purple loosestrife. The drainage pipe head wall is located in the northwest corner of the survey area near Piezometer PZ-8. Moderate amounts of surface debris, including old rusty drums with their tops and bottoms cut out, are visible along the ditch adjacent to the fence along the south and east sides of the area.

An electromagnetic (EM-31) survey was performed over the entire area of interest to delineate zones with buried metal debris or elevated conductivities which may indicate possible soil and/or ground water contamination. A ground penetrating radar (GPR) survey was made over areas with EM-31 anomalous zones in areas with reasonable access conditions (light brush and trees) to help confirm the EM-31 results and provide additional definition of the zones.

2.2 Interpretation Results, North Burn Pit Area

The Interpretation Results Map (Figure 2b) shows the results of the geophysical investigation as well as observed features at the site. The field reference grid system is shown by the numerous reference baselines (e.g. 100S, 80E), which is overlain on the US State Plane 1983, Maryland 1900, NAD 1983 (Conus), GEOIDD99 (Conus). Directions mentioned in the text refer to the field reference grid coordinate system. The EM-31 data contour maps are provided in the Appendix on Figures A-1 (conductivity data) and A-2 (in-phase data).

Numerous relatively small High Anomalous Zones indicate that there was probably sporadic dumping over much of the site. The greatest concentration of anomalous zones is along the

fence to the south, the eastern flank of the wooded area, and the northeast and northwest corners of the site. The northern edge of the anomalous zones along the fence cannot be determined because of the interference from the fence on the EM-31 data. The trees to the south of this fence limited the usefulness of the GPR data in delineating the northern boundary.

The west-central portion of the site is interpreted as a Very Low Anomalous Zone, with a few small High and Moderate Zones. Numerous large trees, and burnt trees were observed in this area, and this area contains a broad topographic low. This general area may have been the actual large “burn pit”, with perhaps the non-burnable material discarded and subsequently buried off to the side of the actual pit.

A High Conductivity Anomalous Zone is located in the northeast corner of the Very Low Zone, and may indicate a zone with possible soil contamination or an area with finer-grained soils. This High Conductivity Zone also seems to be associated with the grassy clearing (with sparse trees), and is situated at the highest elevation of the North Burn Pit Area.

A few EM-31 transects extended to the west into the thick purple loosestrife and provided clean, background data away from the fill material. The north-central and northeastern portions of the site seem to be relatively free from buried material. However, the interference from the nearby fences and anomalous zones may mask the presence of smaller amounts of buried metal. In the north-central area the GPR data indicated some minor shallow targets (less than 2 feet deep), which may have been non-metallic debris, but more likely are tree roots.

2.3 Field Methodology, North Burn Pit Area

2.3.1 Survey Control, North Burn Pit Area

Reference baselines were established at the North Burn Pit Area using 300-foot tape measures, a Brunton Compass, and orange and yellow pin flags. Reference baseline 0N was oriented east-west (grid orientation) along the southern edge of the clearing in the northern portion of the site. This baseline was marked with alternating yellow and orange pin flags at 20-foot intervals (e.g.: 0E = yellow, 20E = orange, 40E = yellow, etc.).

A north-south baseline was then established along Line 120E and marked with yellow pin flags at 50-foot intervals. Additional baselines were then oriented east-west (using a compass) and were located along 85N, 50N, 100S, 200S, 250S and 310S. These east-west baselines used the same sequence of yellow and orange flags as Line 0N. Please note that Line 200S was run at an improper orientation. Additional blue flags were spaced at 25-foot intervals along several north-south transects to provide additional reference for the GPR survey over selected areas. Numerous reference flag locations were located using the GPS sensor mounted on a 8-foot tall pole and averaging over 8 to 12 measurements, which provided accuracies within about 1 to 3 feet.

2.3.2 EM-31 Survey, North Burn Pit Area

Both conductivity data (milliseimens/meter) and In-phase data (parts/thousand) were digitally recorded at 4-foot intervals (paced) while walking along transects oriented north-south and spaced 20 feet apart. Several transects were oriented east-west to better delineate the western and eastern extent of the disturbed area. Additional transects were run in areas with numerous anomalous zones to help delineate them.

The EM-31 data and GPS location data were recorded simultaneously during the survey. However, because of the wooded terrain at this site, the GPS measurements were often in error of more than 10 feet or so. The EM-31 station locations were corrected based on the

locations of the reference flags placed in the field. The plotted station locations are estimated to generally be within 3 to 5 feet of the actual field locations.

For all of the geophysical survey areas, base station EM-31 data were recorded at the start and end of each field day to check for any irregularities in the instrument. Only small variations in values (1 mS/m and 1 ppt) were generally observed during the course of a field day, and did not affect the interpretation of the data at any of the areas of concern. These variations may be caused by changes in soil moisture over time or jarring of the instrument in the field.

2.3.3 GPR Survey, North Burn Pit Area

The GPR survey used the 400 MHz antenna at this area. The GPR lines were spaced 20 feet apart and oriented north-south in areas with numerous anomalous zones and as access conditions allowed. The soils in this area limited the depth of signal penetration to about 4 feet. A 200 MHz was evaluated at this area, but did not greatly increase the depth penetration. The larger 200 MHz antenna was also not effective in the wooded areas. An example GPR profile is provided in the Appendix (Figure A-3), and is along Line 120E. Distance is noted along the top of the profile, and the EM-31 anomalous zones are noted along the bottom. The estimated depth is shown along the side, and is based on a one-way radar travel time of 3 ns/foot, which is in the range of silty to sandy coastal soils.

3.0 SOUTH CENTRAL TREE NURSERY AREA

3.1 Description of Area and Objectives

The South Central Tree Nursery Area is primarily a grassy and brushy field (see Figure 3a, Site Sketch Map). The eastern portion of the area is wooded and contains large amounts of heavy surface debris, including rusty drums that have their tops and bottoms cut out.

The northern portion of the area is heavily wooded and contains two large piles of dirt, and one large pile of dirt and debris further to the north. Just to the south of the two dirt piles is a row of metal poles that are presumably from a former fence that ran east-west near Line 320N. The two visible drums along the former fence near coordinate 180E, 320N are newer. One drum is labeled “Johnson Wax”, while the other drum is rusty (but whole).

The South Central Tree Nursery Area is bordered by wetlands to the north and east, by a wooded area to the west, and the South Pad Area and the drainage ditch to the south. Please note that in some areas the treeline marked on Figure 3a is dashed, indicating a questionable location.

An electromagnetic (EM-31) survey was performed over the entire area of interest to delineate zones with buried metal debris or elevated conductivities which may indicate possible soil and/or ground water contamination. The GPR survey was concentrated over the large anomalous region in the eastern portion of the site in areas with reasonable access. Several GPR lines were located across the site and oriented east-west.

3.2 Interpretation Results, South Central Tree Nursery Area

The Interpretation Results Map (Figure 3b) shows the results of the geophysical investigation as well as observed features at the site. The EM-31 data contour maps are provided in the Appendix on Figures B-1and B-2.

A large region with High, Moderate and Low Anomalous Zones is located in the eastern portion of the site. The eastern edge of this region has large amounts of exposed metal debris. The

southeast portion of this region was not investigated in detail because of the large amounts of debris in this area.

A relatively large Moderate Anomalous Zone and two High Zones is located in proximity to the visible surface metal and debris in the northern portion of the site. These anomalous zones indicate buried metal in addition to the visible debris. The dirt and metal pile was surveyed to a limited extent due to the large amounts of interference. However, this pile also contains more metal than is observed on the surface. The eastern extent of this zone was not determined because of the heavy brush (purple loosestrife in the wetlands, and heavy blackberries covering the former road/ trail).

Three Low Anomalous Zones and four Moderate Anomalous Zones were observed in the west-central portion of the site and probably indicate pockets of debris. The low anomalous zone to the west of the existing monitoring well is associated with a patch of very thick fragmities which allowed only limited access.

A shallow linear feature was observed in the EM-31 data near the southwest corner of the site. This feature is of limited extent and is only about one foot deep based on the GPR data over this area. It is probably a pipe or perhaps a metal bar or girder.

Portions of the South Central Tree Nursery Area not interpreted as anomalous zones are probably relatively free of buried metal debris, although some very small amounts may be present in isolated locations. The EM-31 did not detect any zones with elevated conductivities indicating possible zones of soil contamination. The dirt pile near coordinate 180E, 350N shows relatively low conductivity values, which may indicate it contains coarser-grained materials. Also, the increase in elevation (further away from the water-saturated finer-grained materials) will also lower the conductivity values. This dirt pile, as well as the dirt pile to the west are interpreted to be relatively free of buried metal.

Numerous very shallow and small GPR targets (less than 2 feet deep) were observed in areas with no EM-31 anomalous zones, and may be due to the reworking of the soils caused by the planting and removal of trees, or may be related to the former roadway throughout the site. Two moderately-sized GPR targets were observed near coordinate 60E, 30N at a depth of about 2 feet (see Figure 3b). These may indicate non-metal debris, buried tree stumps, changes in soil conditions.

3.3 Field Methodology, South Central Tree Nursery Area

3.3.1 Survey Control, South Central Tree Nursery Area

Reference baselines were established at the South Central Tree Nursery Area using 300-foot tape measures, a Brunton Compass, and orange and yellow pin flags. Reference baseline 0N was oriented east-west (grid orientation) along the northern edge of a wooded area in the southern portion of the site. This baseline was marked with alternating yellow and orange flags at 20-foot intervals (e.g.: 0E = yellow, 20E = orange, 40E = yellow, etc.).

A north-south baseline was then established along Line 0E and marked with yellow pin flags at 50-foot intervals. North-south baselines were also run along Line 260E in the southern portion of the site, and along Line 230E in the northern, wooded portion of the site. Numerous baselines were then oriented east-west (using a compass) and were located along 540N, 440N, 350N, 235N, 100N and 75S. Additional blue flags were spaced at 25-foot intervals along several north-south transects to provide additional reference for the GPR survey in the eastern portion of the site. Numerous reference flag locations were located using the GPS to within about 1 to 3 feet.

3.3.2 EM-31 Survey, South Central Tree Nursery Area

Both conductivity and in-phase data were digitally recorded at 4-foot intervals (paced) while walking along transects oriented north-south and spaced 20 feet apart (see Appendix, Figures B-1 and B-2). Several transects were oriented east-west to better delineate the western and eastern extent of the anomalous zones. Additional transects were run in areas with numerous anomalous zones to help delineate them.

The EM-31 data and GPS data were recorded simultaneously during the survey. However, in the wooded portions of this site the GPS measurements were often in error by more than 10 feet or so. The EM-31 station locations in the wooded areas were corrected based on the locations of the reference flags placed in the field. EM-31 stations located in the open areas of the site used the GPS coordinates. The plotted station locations are estimated to generally be within 3 to 5 feet of the actual field locations.

3.3.3 GPR Survey, South Central Tree Nursery Area

The GPR survey used both the 200 MHz and 400 MHz antennas at this area. The GPR survey was concentrated over the large anomalous region in the eastern portion of the site in areas with reasonable access. The GPR lines were spaced 20 feet apart and oriented north-south. Several GPR lines were oriented east-west across the site. The soils at the site limited the depth of signal penetration to about 5 feet.

4.0 SOUTH PAD, TREE NURSERY AREA

4.1 Description of Area and Objectives

The South Pad Area is composed of a large concrete pad along the northern edge of the area and several smaller pads along the southern edge, with a broken asphalt/gravel road running east-west through the middle of the site (see Figure 4a, Site Sketch Map). The western portion of the site is brushy with scattered trees. The southern pads and road are overgrown with brush and small trees. The field reference grid is oriented with respect to the large pad, and coordinates south and west of the origin are indicated by a "-" sign. (e.g.: 20S is –20). The state plane coordinate system is overlain on the field reference grid.

The South Pad Area is bordered by the South Central Tree Nursery Area to the north, the southern property fenceline to the south, and the main access road and a wooded area to the west. The South Road Area is to the east and adjacent to the South Pad Area.

A detailed electromagnetic (EM-31) survey was performed over the entire area of interest to delineate zones with buried metal debris, possible USTs, and underground pipes. A detailed GPR survey was also performed over most of the site, to provide additional delineation of EM-31 anomalies, as well as to locate possible non-metal pipes.

4.2 Interpretation Results, South Pad Area

The Interpretation Results Map (Figure 4b) shows the results of the geophysical investigation as well as observed features at the site. The EM-31 data contour maps are provided in the Appendix on Figures C-1 through C-4.

The most prominent anomaly is the High Anomalous Zone (near coordinate 30W, 10S) located to the west of the large concrete pad in a small stand of trees just south of the two old monitoring wells. This anomaly encompasses an area with several types of visible surface metal.

A metal bar imbedded in the ground is oriented east-west, which seems to form the northern edge of a flat gravel pad to the south. A small-diameter vertical pipe is visible going into the gravel pad. A short section of pipe was observed lying on the ground surface just south of the vertical pipe. These visible features are not interpreted to be the primary cause of the anomalous zone, and buried metal pipes or debris, a septic tank, or possibly a small UST may be present. The dense trees over this anomaly prevented further characterization with the GPR. A linear feature extends to the south from this anomalous zone, and may be the underground extension of the visible vertical pipe.

Please note that the location for this High Anomalous Zone (and the associated gravel pad) is about 70 feet west and 40 feet south of the Former Fuel Pad location shown on Figure 1a (Geophysical Survey Area Locations).

A second High Anomalous Zone was interpreted near coordinate 70W, 50S. This anomalous zone is relatively minor in the conductivity data, which may indicate that the source is one or more round, vertical objects (such as a vertical pipe or drum). If it is a single vertically oriented object, its location is probably located near coordinate 70W, 45S. However, the larger area is considered to be anomalous to take into account the many variables of the EM-31 method.

GPR transects along Lines 40S and 50S near this second High Anomalous Zone did not detect any targets, although the GPR depth penetration was limited to about 4 feet. Also, if it is a relatively small object (such as a single vertical drum) and is fairly shallow, the GPR transects may have missed the object if it is indeed five feet off to the side of either transect. No north-south GPR transects were run over this anomaly.

Three Low Anomalous Zones were observed near the south edge of the large concrete pad and may indicate small amounts of buried metal debris or piping.

A long linear feature (possible pipe, foundation etc.) is oriented east-west below the large concrete pad. This feature is interpreted to end below the pad near coordinate 25E, 7S. No visible change was observed in the concrete pad at this location. This linear feature continues to the east into the South Road Area (see Figure 5b, South Road Area Interpretation Results Map). This is the only EM-31 linear feature that was observed by the GPR in the South Pad area. The GPR indicates the linear feature is at a depth of about 4 feet.

A short linear feature is observed near the southeast corner of the South Pad Area, and also extends into the South Road Area. This feature may extend to (and possibly connect to) the long linear feature described previously.

A short east-west linear feature was observed to the west of the row of smaller concrete pads near coordinate 140E, 100S. This feature does not continue to the west past about Line 165W, and may continue to the south to the nearby linear feature along Line 165W. These linear features may be related to the fire hydrant near 165W, 70S. However, the data in this area is limited as it was beyond the area of concern.

A gas valve was observed near coordinate 128W, 184S near the utility pole and fence. Please note that any utilities running north-south and near the chain link fence would not be observed in the EM-31 data because of interference from the fence. No GPR data were recorded in the area west of Line 120W.

Numerous visible vertical pipes and drains were visible in the two western-most smaller pads along the fence. Broken porcelain near the visible pipes and drains indicates these were probably utilities associated with restroom facilities. Two of the previously discussed linear

features may be associated with some of these observed pipes and drains. Additionally, a series of questionable low amplitude GPR targets seems to form a linear feature along the north edge of the concrete pad to the east of the restrooms. This linear feature is fairly shallow (2 feet deep) and does not seem to continue past the drums located near coordinate 20E, 86S. This linear feature may turn to the south to the light pole just south of the drums. However, no GPR data were recorded south of the drums because of a thick growth of vines covering the slab in this area. Please note that any utilities running east-west and near the chain link fence would not be observed in the EM-31 data because of interference from the fence.

The short linear feature to the north of the South Pad Area (north of the two old monitoring wells) is the shallow linear feature observed in the South Central Tree Nursery Area (see Figure 2b for a more precise location). It is shown on the South Pad Map only as a general reference.

Numerous low amplitude and moderate GPR targets were observed in the South Pad Area, and are not associated with any EM-31 linear features. The lack of consistent GPR targets between several adjacent transects (spaced 10 feet apart) seems to indicate that these targets do not represent linear features such as non-metal pipes or foundations. They probably indicate discrete non-metal objects such as construction debris or rocks. However, variable soil conditions could mask the low amplitude targets, so a yellow line is shown connecting GPR targets to indicate questionable linear features in the GPR data.

Please note that depths to GPR targets less than three feet deep are not noted on the map. At many sites, these shallow targets are cobbles, debris, etc. rather than utilities which are typically at greater depths.

4.3 Field Methodology, South Pad Area

4.3.1 Survey Control, South Pad Area

Reference baselines were established at the South Pad Area using 300-foot tape measures and blue and yellow pin flags and/or spray paint. Reference baseline 0E was oriented north-south (grid orientation) parallel to and 4 feet east of the west edge of the large concrete pad. This baseline was marked with alternating yellow and blue flags at 20-foot intervals (e.g.: 0S = yellow, 20S = blue, 40S = yellow, etc.).

Baseline 0S was then oriented east-west and follows 10 feet south of the north edge of the large concrete pad. Baseline 0S was marked at 20-foot intervals using yellow paint or yellow pin flags. Additional east-west baselines were located along Lines 40S and 60S. Additional north-south baselines were oriented along 120W, 100E and 200E. Numerous reference flag locations were located using the GPS to within about 1 to 3 feet.

4.3.2 EM-31 Survey, South Pad Area

Both conductivity and in-phase data were digitally recorded at 4-foot intervals while walking along transects oriented north-south and spaced 10 to 20 feet apart (see Appendix, Figures C-1 and C-2). EM-31 transects were also oriented east-west and spaced 10 feet apart (see Appendix, Figures C-3 and C-4).

The EM-31 data were recorded without the GPS system over most of this area. The EM-31 station locations were referenced to the baseline flags placed in the field. The plotted station locations are estimated to generally be within 1 to 3 feet of the actual field locations over most of the area. The additional EM-31 transects west of Line 120W recorded the EM data and GPS locations simultaneously, and without the aid of any reference baselines. These locations are estimated to be within about 3 to 5 feet.

4.3.3 GPR Survey, South Pad Area

The GPR survey primarily used the 400 MHz antenna at this area. The 200 MHz antenna was evaluated but provided limited improvement in depth penetration and less resolution. The GPR survey was performed over the entire area of concern in areas with reasonable access. The GPR lines were spaced 10 feet apart and oriented north-south and east-west. The soils at the site limited the depth of signal penetration to about 4 feet.

5.0 SOUTH ROAD, TREE NURSERY AREA

5.1 Description of Area and Objectives

The South Road Area is composed of an asphalt road running east-west in the southern portion of the site, with brush and heavy trees to the south of the road (see Figure 4a, Site Sketch Map). North of the road is broken asphalt with grass and brush growing through the pavement. North of the broken asphalt is grass and brush, and finally a wooded area and dirt berm along the northern edge of the area.

The field reference grid is oriented with respect to the east-west road, and coordinates south and west of the origin are indicated by a "-" sign. (e.g.: 20S is –20). Relevant portions of the state plane coordinate system are overlain on the field reference grid.

The South Road Area is bordered by a dirt berm to the north (with the South Central Tree Nursery Area to the north of the berm). The southern property fenceline lies to the south of the site, and the chainlink fence and west perimeter greenhouse road is to the east. The South Pad Area is to the west and adjacent to the South Road Area. The location of the fenceline in the southeast portion of the South Road area is questionable.

A detailed electromagnetic (EM-31) survey was performed over the entire area of interest to delineate zones with buried metal debris, possible USTs, and underground pipes. A detailed GPR survey was also performed over most of the site to provide additional delineation of EM-31 anomalies, as well as to locate possible non-metal pipes.

5.2 Interpretation Results, South Road Area

The Interpretation Results Map (Figure 5b) shows the results of the geophysical investigation as well as observed features at the site. The EM-31 data contour maps are provided in the Appendix on Figures D-1 through D-4.

One relatively large High Anomalous Zone is located near the south-central portion of the site along the southern fence line. This anomaly includes a small gravel pile and is to the northeast of the former electrical panel adjacent to the utility pole. This anomalous zone indicates a concentration of buried metal (metal debris, drums, buried reinforced slab, or possibly a UST). This zone is within a heavy growth of heavy brush which prevented acquisition of GPR data over the anomalous zone.

A linear feature is interpreted to extend to the north from this High Anomalous Zone. A questionable linear feature is interpreted to extend to the east of this zone (dashed hachured line).

Several small Moderate Anomalous Zones are located in the wooded and brushy areas in the northern portion of the South Road Area. These zones probably indicate buried metal objects

or debris. The two Low Anomalous Zones indicate areas with smaller concentrations of possible buried metal.

The other primary anomalies observed in the data are two linear features that are oriented east-west across the site and probably indicate buried pipes or utilities. Both of these linear features extend into the South Pad area to the west.

A questionable linear feature is oriented north-south near the west end of this site, and may connect the two long linear features. A relatively short linear feature is also observed in the northeast corner of the site. The south end of this feature is interpreted to end near the northern edge of the asphalt. The north end of this shorter linear feature, and the north end of the nearby long linear feature both seem to terminate near the gully. This may indicate that these features are related to storm water drainage. However, the gully may not have even been present when these lines were active.

Several low amplitude and numerous moderate amplitude GPR targets were observed in the South Road Area, although only a few are associated with any EM-31 anomalies. The observed GPR targets unrelated to EM-31 anomalies probably indicate discrete non-metal objects such as construction debris or rocks. Many of the linear features interpreted from the EM-31 had very shallow (generally 1 to 2-foot deep) low amplitude GPR targets associated with them, but offset to the sides of the linear trends. These shallow targets (not shown on Figure 5b) may indicate edges of the pipe trench, with the actual pipe at some depth below.

5.3 Field Methodology, South Road Area

5.3.1 Survey Control, South Road Area

Reference baselines were established at the South Road Area using 300-foot tape measures, a Brunton compass, and blue and yellow pin flags and/or spray paint. Reference Baseline 0S was oriented parallel to the southern edge of the east-west road and marked at 20-foot intervals with yellow paint and pin flags. Reference Baseline 0E was then oriented perpendicular to Baseline 0S (using a compass). Baseline 0E was marked with alternating yellow and blue flags at 20-foot intervals (e.g.: 0N = yellow, 20N = blue, 40N = yellow, etc.). The origin (0E, 0N) of the South Road Area grid is at South Pad coordinate 200E, 80S.

An additional east-west baseline was located along Line 60N and marked with blue flags at 20-foot intervals. Additional north-south baselines were oriented along 40E, 120E, 180E, and 260E. Numerous reference flags were located using the GPS to within about 1 to 3 feet.

5.3.2 EM-31 Survey, South Road Area

Both conductivity and in-phase data were digitally recorded at 4-foot intervals while walking along transects oriented north-south and spaced 10 to 20 feet apart (see Appendix, Figures D-1 and D-2). EM-31 transects were also oriented east-west and spaced 10 feet apart (see Appendix, Figures D-3 and D-4).

The EM-31 data were recorded using the GPS system over most of this area. However, the close proximity of the woods to the north and south created some distortion in the GPS locations. The closely spaced reference baselines over this area were used instead to accurately locate the EM-31 station locations. The plotted station locations are estimated to generally be within 1 to 3 feet of the actual field locations.

5.3.3 GPR Survey, South Road Area

The GPR survey primarily used the 400 MHz antenna at this area. The 200 MHz antenna was evaluated but provided limited improvement in depth penetration and less resolution. The GPR survey was performed over the entire area of concern in areas with reasonable access. The GPR lines were spaced 10 feet apart and oriented north-south and east-west. The soils at the site limited the depth of signal penetration to about 5 feet.

6.0 FORMER UST, GREENHOUSE AREA

6.1 Description of Area and Objectives

The Former UST Area is bordered to the south and east by an asphalt road, and includes an asphalt area east of and adjacent to the concrete block building (see Figure 6a). South of the building and paved area is a brushy area that was the former location a 1000 gallon capacity UST. The field reference grid is oriented with respect to the building. Coordinates south and west of the origin are indicated by a "-" sign. (e.g.: 20W is –20). Relevant portions of the state plane coordinate system are overlain on the field reference grid.
A detailed electromagnetic (EM-31) survey was performed over the Former UST Area to delineate zones with buried metal debris, possible USTs, and underground pipes. A detailed GPR survey was also performed over the site, to provide additional delineation of EM-31 anomalies, as well as to locate possible non-metal pipes.

6.2 Interpretation Results, Former UST Area

The Interpretation Results Map (Figure 6b) shows the results of the geophysical investigation as well as observed features at the site. The EM-31 data contour maps are provided in the Appendix on Figures E-1 through E-4.

The main feature of interest is a utility in the southwest corner of the site. It seems to be related to the concrete and metal structure observed in the thick brush. This structure may be the former base of a light pole, or possibly a fuel pump. This utility was only observed on the EM-31 data, and may indicate a small pipe or electrical conduit.

Several GPR targets were observed in the Former UST Area, although all except one are relatively shallow (less than 2 to 3 feet deep). These GPR targets may indicate discrete non-metal objects such as construction debris or rocks. Some of the targets may indicate linear features such as pipes, but the features are relatively short, so determining if the targets are indeed from the same feature is difficult.

The east-west trending linear features interpreted from the GPR data in the southern portion of the site may be more likely to indicate utilities, but the data are still relatively sparse, making these features questionable. The Linear Feature crossing the road near Line 7S may be a shallow, non-metal culvert (about 0.5 feet deep).

6.3 Field Methodology, Former UST Area

6.3.1 Survey Control, Former UST Area

Reference baselines were established at the Former UST Area using 300-foot tape measures and yellow pin flags and/or spray paint. Reference Baseline 0E was oriented along the east edge of the concrete building and marked at 10-foot intervals. Baseline 60N was then oriented perpendicular to Baseline 0E using the southern edge of the building as a reference, and marked at 10-foot intervals. Additional east-west baselines were located along 110N and 0N,

and another north-south baseline was oriented along 40E. Numerous reference flag locations were located using the GPS to within about 1 to 3 feet.

6.3.2 EM-31 Survey, Former UST Area

Both conductivity and in-phase data were digitally recorded at 4-foot intervals while walking along transects oriented north-south and spaced 5 feet apart (see Appendix, Figures E-1 and E-2). EM-31 transects were also oriented east-west and spaced 10 feet apart (see Appendix, Figures E-3 and E-4).

The EM-31 data were recorded using the EM-31 digital recorder rather than the GPS unit. The closely spaced reference baselines over this area were used instead to accurately locate the EM-31 station locations. The plotted station locations are estimated to generally be within 1 to 2 feet of the actual field locations over the area.

6.3.3 GPR Survey, Former UST Area

The GPR survey used the 400 MHz antenna at this area. The GPR survey was performed over the entire area of concern in areas with reasonable access. GPR lines oriented north-south were spaced 5 feet apart, while lines oriented east-west were spaced at 10-foot intervals. The soils at the site limited the depth of signal penetration to about 4 feet.

7.0 WEST PERIMETER ROAD, GREENHOUSE AREA

7.1 Description of Area and Objectives

The West Perimeter Road Area runs north-south along the west edge of the Greenhouse Area. The Tree Nursery Area is to the west of the West Perimeter Road (and separated from the road by a chainlink fence). The road is asphalt in poor condition with brush and vines covering the road, and brush encroaching on both sides.

Two EM-31 lines were oriented along the road to delineate possible utilities oriented east-west below the road. These lines ranged from 4 to 8 feet apart depending on the vegetation. An additional EM-31 line was run along the baseline with the instrument oriented perpendicular to the road to better detect utilities oriented north-south. The primary utilities of interest are culverts and drain pipes that allow surface water to cross from the Greenhouse Area into the Tree Nursery Area Wetlands.

Two GPR transects were also oriented along the length of the road. Short GPR transects were oriented east-west and spaced about 100 feet apart to detect possible utilities running north-south below the road. These lines were extended to the east as far as possible along east-west roads and in areas with reasonable access.

7.2 Interpretation Results, West Perimeter Road Area

The locations of possible buried utilities are shown on Figure 7 (Greenhouse Utility Locating Areas, Interpretation Results Map). The primary linear features are shown in red, and probably indicate a culvert or other type of utility. Less distinct anomalies are shown in blue, and provide a conservative interpretation. Some of these weaker anomalies may only indicate debris in the road fill material.

These linear features were interpreted from both the EM-31 and GPR data, although not all features were observed with both instruments. PVC pipes were observed on the GPR data

but not on the EM-31 data. Small diameter pipes and conduit may have been detected by the EM-31, but not apparent on the GPR data.

The three northern-most PVC pipes were visually observed in the North Burn Pit Area (see Figure 2b). The northern-most PVC pipe is a surface pipe located west of a trailer. The buried pipe near 1145N was not observed in the GPR data. This pipe may not extend to the east far enough to cross under the GPR lines. It may also not have been detected due to soil changes and/or noisy data in the brushy field in this area.

7.3 Field Methodology, West Perimeter Road Area

7.3.1 Survey Control, West Perimeter Road Area

One Reference baseline was established at the West Perimeter Road Area using 300-foot tape measures and blue spray paint and blue flagging at 20-foot intervals. A single reference baseline was oriented north-south along the road and ranges from 12 to 15 feet away from the fence along the west edge of the road. The origin (0 N) of this baseline is 15 feet due east of the fence pole at the north edge of the east-west road going to the Tree Nursery Area (see Figure 7). Several reference flag locations were located using the GPS to within about 1 to 3 feet. The approximate State Plane northings are shown to provide a reference to the survey areas in the Tree Nursery parcel.

7.3.2 EM-31 Survey, West Perimeter Road Area

Both conductivity and in-phase data were digitally recorded at 4-foot intervals while walking along the transects oriented north-south. The EM-31 data and GPS data were recorded simultaneously during the survey. However, because of the limited number of transects, the data were referenced to the nearby reference baseline flags rather than using the GPS locations. The station locations are estimated to generally be within 1 to 2 feet of the actual distance along the baseline.

7.3.3 GPR Survey, West Perimeter Road Area

The GPR survey used the 400 MHz antenna at this area. The soils at the site limited the depth of signal penetration to about 5 feet. An example GPR profile is provided in the Appendix (Figure F-1), and is a portion of the transect along Line 13E. Distance is noted along the top of the profile as well as the edges of the EM-31 anomalous zones. The estimated depth is shown along the side, and is based on a one-way radar travel time of 3 ns/foot, which is in the range of silty to sandy coastal soils.

8.0 SOUTH PERIMETER FENCE, GREENHOUSE AREA

8.1 Description of Area and Objectives

The South Perimeter Fence Area runs to the south and east of the greenhouses at the southern end of the site (see Figure 7). A road runs east-west along the southern fenceline but is overgrown with brush and vines. To the east of the brick Boiler House there is only a narrow path through the vegetation. A single reference baseline was oriented along the road near the fence along the south property line. At a distance of 300E on this baseline, a second baseline was run to the north, and runs along the eastern edge of the property line.

Two EM-31 lines were oriented along these baselines, but separated by only a few feet in most areas. An additional EM-31 line was run along the baselines with the instrument oriented

perpendicular to the baseline to detect utilities oriented parallel to the baselines. The primary goal of this survey was to detect possible utilities coming on to the site.

One GPR transect was oriented along the length of the two baselines. Additional GPR transects were run between the south fence and the greenhouses where access allowed. These short GPR lines were oriented north-south to detect possible utilities oriented east-west.

8.2 Interpretation Results, South Perimeter Fence Area

The Interpretation Results Map (Figure 7) shows the locations of possible buried utilities. The primary linear features are shown in red. Questionable, less distinct anomalies are shown in blue.

Two utilities run north-south and extend from the southern fenceline to a greenhouse and the Boiler House. These utilities seem to tie in with a utility that runs along the fenceline. The line that runs along the fenceline was interpreted form the EM-31 data, but the interference from the fence makes this east-west oriented utility somewhat questionable.

The southwest corner of the site contains numerous utilities. The interpretation of such closely spaced features is difficult. Some of these features may be related to the Linear Feature delineated in the South Road Area (see Figure 5b). Two water manholes were located in this area in the wooded area north of the road and just west of the southwest corner of the greenhouse. A larger view of these manholes is provided on Figure 7, and shows the orientations of the pipes visually observed in the manholes.

8.3 Field Methodology, South Perimeter Fence Area

8.3.1 Survey Control, South Perimeter Fence Area

Reference baselines were established at the South Perimeter Fence Area using 300-foot tape measures and yellow pin flags and/or spray paint. Reference Baseline 0N was oriented east-west and runs 12 to 15 feet parallel to the southern fenceline, and marked at 20-foot intervals. The origin (0 E) of this baseline is 23 feet south of the southwest corner of the southwest greenhouse, and in line with the west edge of the greenhouse.

At a distance of 300E on this baseline, a second baseline was run to the north, and runs along the eastern edge of the property line. This baseline extends north to the Pumphouse. Numerous reference flag locations were located using the GPS to within about 1 to 3 feet.

8.3.2 EM-31 Survey, South Perimeter Fence Area

Both conductivity and in-phase data were digitally recorded at 4-foot intervals while walking along the transects oriented parallel to the two baselines. The EM-31 data and GPS data were recorded simultaneously during the survey. However, because of the limited number of transects, the data were referenced to the nearby reference baseline flags. The station locations are estimated to generally be within 1 to 2 feet of the actual distance along the baseline.

8.3.3 GPR Survey, South Perimeter Fence Area

The GPR survey used the 400 MHz antenna at this area. The soils at the site limited the depth of signal penetration to about 4 feet.

9.0 STICKFOOT SEWER PIPE TRACING AREA

9.1 Description of Area and Objectives

The Stickfoot Sewer Pipe Tracing Area is near the Stickfoot Sewer Manhole located east of the Pumphouse. A small diameter pipe (2 to 3 inches) was previously observed by others discharging water into Wetland 2 (see Figure 7). This pipe was observed to the east and south of the manhole in close proximity to the fence. It extends out from the surrounding slope about a foot or less. It was originally discovered by following the flow of water in the swale adjacent to and east of the Stickfoot Sewer (generally along the fenceline).

Numerous EM-31 lines were oriented both north-south and east-west in this area. Figure 7 shows a generalization of the EM-31 transects in this area. The purpose of the survey in this area was to locate the pipe, and then trace it back a few hundred feet to determine its direction. No GPR surveying was performed in this area because of the heavy brush.

9.2 Interpretation Results, Stickfoot Sewer Pipe Tracing Area

The pipe location was not interpreted from the EM-31 data, and the previously observed end of the pipe was not found. The swale was dry during the survey and no water could be followed back to the pipe. The presence of the *two* fences to the east of the Stickfoot Sewer, as well as the sewerline itself may have masked the location of the pipe in the vicinity of these features (within about 10 feet or so).

Three areas with disturbed soils were visible during the survey. A hole is located about 15 feet southeast of the manhole, and is on the eastern slope of the sewerline berm. It was covered with roots and a thin layer of soil during the survey until I stepped in it. I then cleared away the remain soil and root layer. The exposed hole was about two feet in diameter and three feet deep. It angled to the north, and may have extended in a northerly direction. The walls of the hole were gravelly.

A second hole was observed about 15 feet directly east of the manhole, and is a few feet east of the eastern toe of the sewerline berm. It is a few inches east of an old, rusty and broken chainlink fence. A new chainlink fence is located about 15 feet further east. The ground slopes up slightly to the east near this hole, and the hole seems to extend to the east at a shallow angle. This hole is about 1 foot in diameter and had a small, circular mounded ring of clean sand around it to the west. The circular, smooth nature of this mound looks like a rush of water coming out of the hole may have created it. About 15 feet north of this hole was another circular mounded ring of sand, but no holes were observed.

9.3 Field Methodology, Stickfoot Sewer Pipe Tracing Area

9.3.1 EM-31 Survey, Stickfoot Sewer Pipe Tracing Area

No reference baselines were established at the Stickfoot Sewer Pipe Tracing Area. The EM-31 was operated while visually monitoring the instrument for any anomalous data. White flagging was used to mark the survey lines to provide a reference during the scanning.

Although the instrument's meter was visually observed to detect the pipe, EM-31 and GPS data were simultaneously recorded as well. Both conductivity and in-phase data were digitally recorded at 4-foot intervals while walking along the transects.

10.0 CONCLUSIONS AND RECOMMENDATIONS

The use of the EM-31 and GPR provided a rapid and non-intrusive means of investigating the areas of concern for possible buried drums, debris, utilities and possible contamination. The combination of these two methods helps provide confirmation of the interpretation results. However, because of the numerous variables involved in geophysical investigations, there is a possibility that some subsurface features may not have been detected. Lower levels of soil and ground water contamination, non-metal objects and non-metal utilities are typically more difficult to detect using these methods than metal features.

The presence of surface metal debris, fences and other sources of interference on the EM-31 data affected the interpretation of the data in proximity to such features. Some of the effects of these interferences can be taken into account, but better results are obtained in areas free from visible sources of interference.

As with any geophysical investigation, only direct observations using test pits or other means can ultimately characterize the anomalies and other subsurface conditions. At these types of sites I typically recommend that test pits be located near the edges of the anomalous zones to provide confirmation of the geophysical results. Typically a variety of different types of anomalous zones (High, Moderate, Low, etc.) are investigated to help better characterize the types of buried material in each zone.

DESCRIPTION OF GEOPHYSICAL TECHNIQUES

ELECTROMAGNETICS (EM-31)

The Geonics, Ltd EM-31 Terrain Conductivity Meter measures subsurface conductance using the principles of electromagnetic induction. The EM-31 is portable, rapid and non-destructive. It has a fixed boom containing the transmitter and receiver coils, and uses a small digital recorder so that handling and data gathering is easily achieved by one operator. The EM-31 measures conductivity to a depth of about 18 feet under most conditions, and can detect large amounts of metal to greater depths.

Factors which may increase subsurface conductivities include higher moisture content, greater amounts of finer materials, increased clay and/or silt content, soil contamination and/or ground water contamination. The presence of buried metal can also affect the conductivity data.

The detectability of metal objects (buried pipes, drums, etc.) can be enhanced by measuring the change in the magnitude of the primary field (inphase component) of the induced magnetic field. The change in magnitude is measured in parts per thousand (ppt). The primary field is affected mainly by metal.

Several factors can affect the effectiveness of the EM-31 method including the proximity of cultural interferences (such as buildings, fences and reinforced concrete) the presence of highly conductive materials (such as clays and water), and the size, depth and conductivity contrast of the target.

GROUND PENETRATING RADAR

The Geophysical Survey Systems SIR-2000 GPR unit provides a continuous digital record of the GPR data. It has a display screen for viewing the GPR data in the field, and the data can be downloaded to a computer for further analysis and printing of the data.

Some of the uses of GPR include locating buried tanks and drums, delineating boundaries of landfills and trenches, and defining voids and geologic stratigraphy. Although other techniques can also provide this information, GPR is less affected by cultural interferences such as overhead powerlines, buildings, and fences. GPR can also provide higher resolution of the target in many cases.

The antenna can either be moved manually by an operator or towed by a vehicle. Depths of exploration can vary widely, from less than a few feet in water-saturated clayey materials to hundreds of feet in glacial ice. A variety of antennas (ranging from 80 to 900 MHz) can be used depending on subsurface conditions and the objective of the survey. Resolution of shallow objects requires higher frequencies, while lower frequencies work better for deeper investigations.

Several factors can affect the effectiveness of the GPR method including reinforced concrete at the surface, the presence of highly conductive materials (such as clays and water), the size, depth, and physical property of the target and; in stratigraphic investigations, the conductivity contrast between stratigraphic units. The presence of numerous buried objects may mask objects and/or stratigraphy below them. The GPR method is most effective in areas with even terrain and free of heavy brush.