Ground Penetrating Radar Survey Report:

City of David
Jerusalem, Israel

Data Acquired June 19 and June 29, 2003

Report compiled September 11, 2003

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Introduction

On June 19 and June 29, 2003, a Ground Penetrating Radar (GPR) survey was completed on several areas in the City of David, or Ir David, in the Old City of Jerusalem, close to the Temple Mount. This is an area which has been under intensive archaeological excavation, reconstruction, and restoration over the last several years.

As taken from the Israel Ministry of Foreign Affairs website: "The City of David, Jerusalem of ancient times, was located on a narrow ridge south of the present-day Old City. On the east it borders the deep Kidron Valley where the Gihon Spring, the city's water source, is located. The archeological exploration of the City of David began in the middle of the 19th century and continues to this day. ... The latest excavations were carried out between 1978 and 1985 and there is an ongoing process of updating and revising previous interpretations."

Actions Taken:

In collaboration with Eli Shukrun from Hebrew University, the head archaeologist in charge of the Ir David Site in Jerusalem in June 2003, some goals were established for this survey. The purpose of our survey was to glean as much sub-surface information as possible in the very short period of time allotted for the effort.

Two large features that lie somewhere deep beneath the surface which have had the interest of scholars for some time, are the exact location of the ancient water system, and the continuation of the large city walls which can be seen in full view up the hillside. It is presumed both these features would be fairly deep, so a 200 MHz antenna was used to view beneath the areas of excavation as deeply as possible.

Also, a major area of excavation exists next to a public parking lot. It would be of great assistance if it could be determined in which direction to continue the excavation, so as to cause the least amount of disturbance to the existing publicly accessed area. Therefore it was determined to survey the excavation pits and an area adjacent to it in the public parking lot to the north and east. This work was planned on June 19, 2003, and carried out on June 29, 2003.

As an adjunct to this survey, at the request of Yehoshua Peleg from Bar-Ilan University, a test area somewhat south of the excavation pits and parking lot was chosen for a comparison survey area. This was located behind the Chaver compound, in the yard of the Rechel family home. A small survey of this area was completed on June 19, 2003.

All these areas can be seen in the City of David excavation site map which is shown on page 6. This map (ir_map2a.jpg) and this report (irdavid.doc) are also on our website at http://www.mnemotrix.com/geo/irdavid.doc.

Caveat and Explanation of Signal Interference Encountered:

Upon post-processing of all the survey results, it was discovered that a significant amount of consistent interference in the GPR radar signal was present throughout all areas of the studies, extending even to the Rechel yard behind the Chaver compound. Before additional follow-up surveys can be done, further investigation of the source of this interference would be required. It is believed that what we were encountering was some sort of electronic interference broadly present in the area, and being picked up especially at the lower elevations, as this location was at a considerably lower elevation than some other surveyed Old City areas at a higher elevation which seemed clear of this type of interference.

While a 200 MHz antenna was used to send a pulse 10 to 15 or more meters down through the earth, a useful signal depth was seen only down to about 6-8 meters in the area of the excavation pits, and even shallower, just a few meters, at the lower elevation near the Rechel yard. This could be accounted for partially by whatever electronic interference we were encountering, and partially from the type of ground common in this area which at a certain depth simply absorbs, rather than reflects, the pulse.

In addition to this, random cell phone calls from the very public working area near the parking lot also interfered sporadically with the results found. In the next survey done, better area control and site preparation will need to be attended to. As a result of all these factors, we were unable to collect enough clean survey lines to build a 3D animated view of the whole area surveyed.

Nevertheless, we were able to separate and glean much good data from the survey and offer here interesting observations from vertical slices which did not contain the interference.

Observations and Results in Excavation Pit Areas:

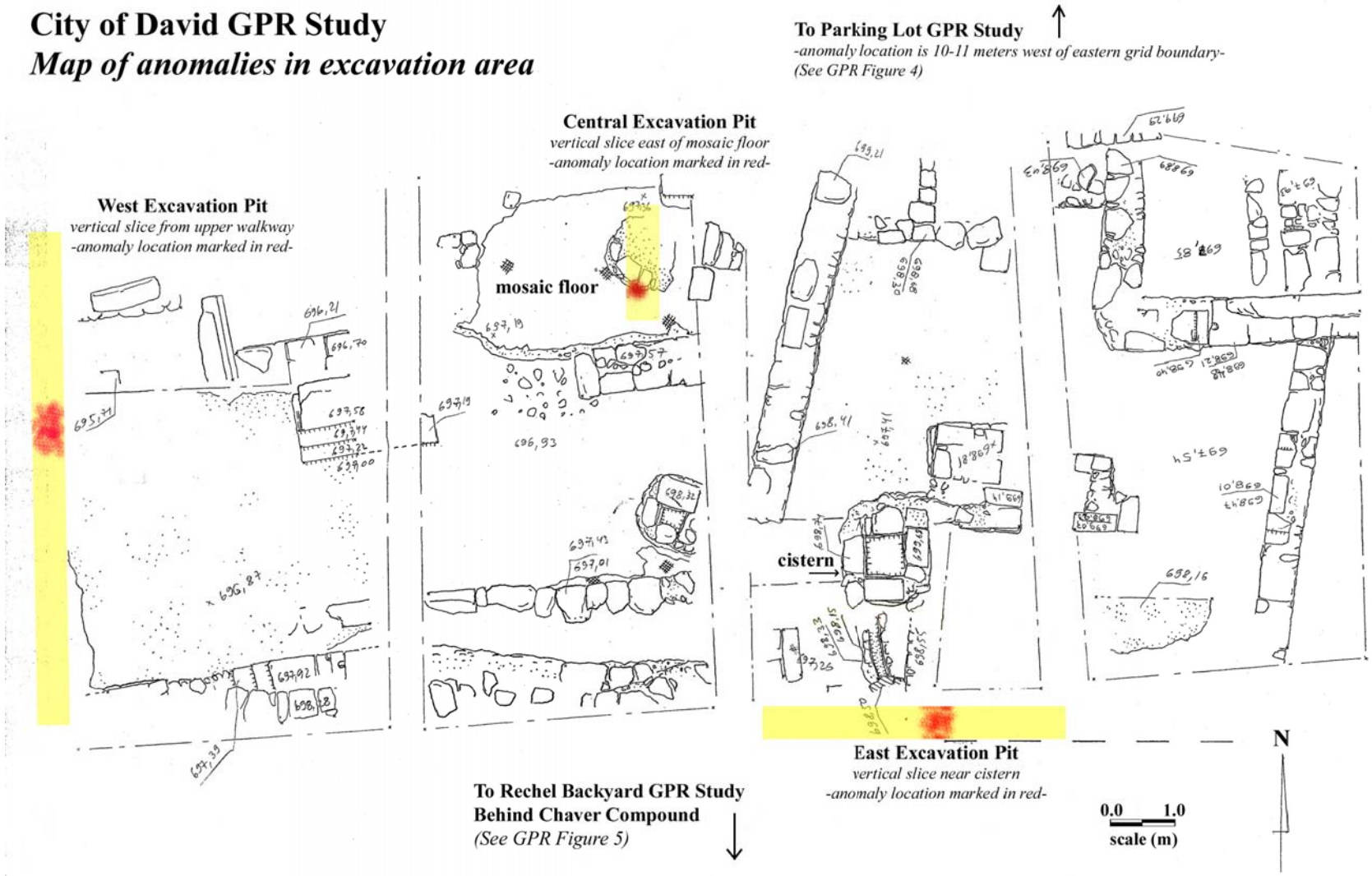
Of the GPR survey lines which were acquired in the test pits of the excavation areas, we were able to see some interesting correlation of anomalies found. It would appear that in three different areas a somewhat similar looking anomaly can be seen which could be hypothesized to be connected in some way to the known location of the excavated cistern.

An excavation site map was provided to us by Eli Shukrun and is shown below. The location of the cistern is labeled, as well as the location of an old mosaic floor, and the upper walkway marking the northern boundary of the pit area. In each of these areas, we have selected a slice which shows a similar pattern. These survey lines are highlighted on the map in yellow, as close as we are able to pinpoint them. The location within the survey line of the anomaly we are seeing is marked in red.

Note: The exact locations will have to be confirmed and verified by the site excavators, as we have had no opportunity to confirm these details since the survey was done in June, and are not completely certain that this map is an exact match to our own calculations of where the survey lines were acquired.

A detailed site map of the excavation pit areas is shown on the following page, where the anomalies found are highlighted in red, within the yellow highlighted area of the survey lines detailed later in this report. See closeup on our website.

City of David GPR Study
Map of anomalies in excavation area

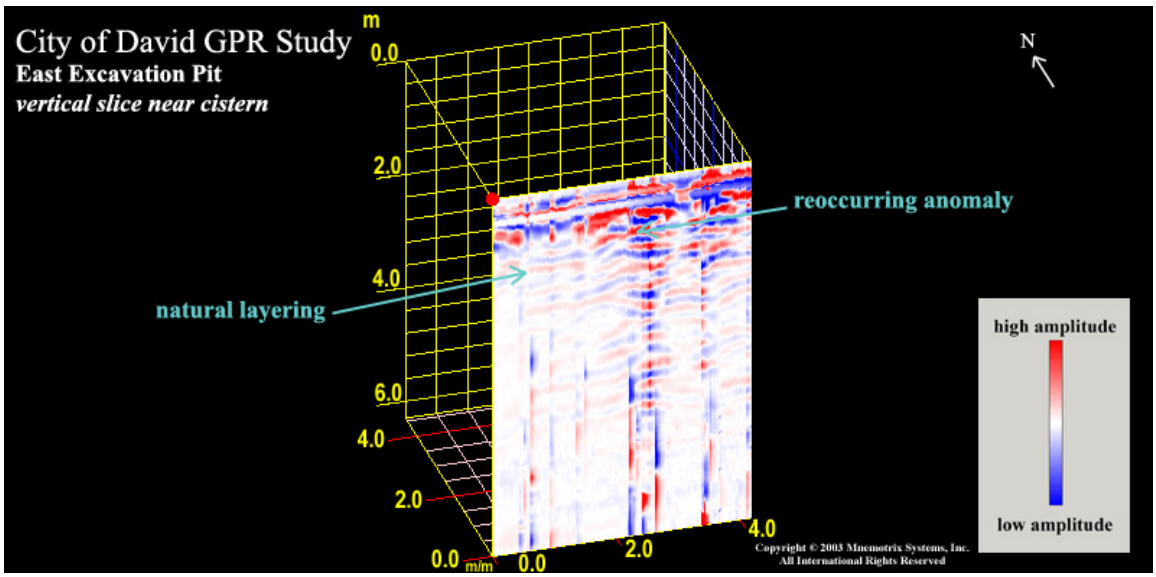


As will be seen in the following GPR Figures, it would appear that in each survey line shown one can see a natural layering indigenous to the land here. Interrupting this layering is an anomaly which could indicate a connection to the cistern, and therefore we are hypothesizing that we may be seeing traces of an old water system. A more thorough survey of this area under more controlled circumstances could confirm this hypothesis, and a ground-truth study in the specific areas might reveal what is in fact causing the anomalies to be seen.

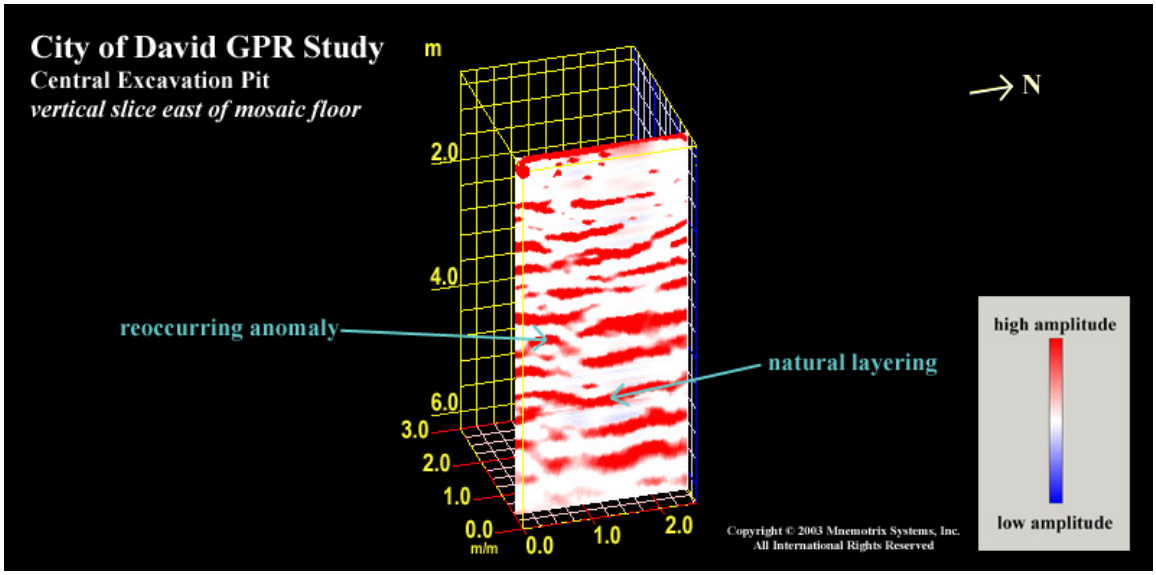
In a GPR study, high amplitude colors signify a strong reflection of the material, while low amplitude colors signify a weak reflection in the surrounding material or matrix. Therefore when using the color table shown in GPR figures 1-3, where the reddest hue is present, there exists a strong difference between layers of sub-surface materials, which can be viewed as an anomaly or natural layering depending on the particular context. Although a slightly more complex color table is used in GPR figures 4-5, the same principles of interpretation are used as mentioned above.

Details of the GPR signal data which are marked in on the excavation map above can be viewed in the following GPR Figures.

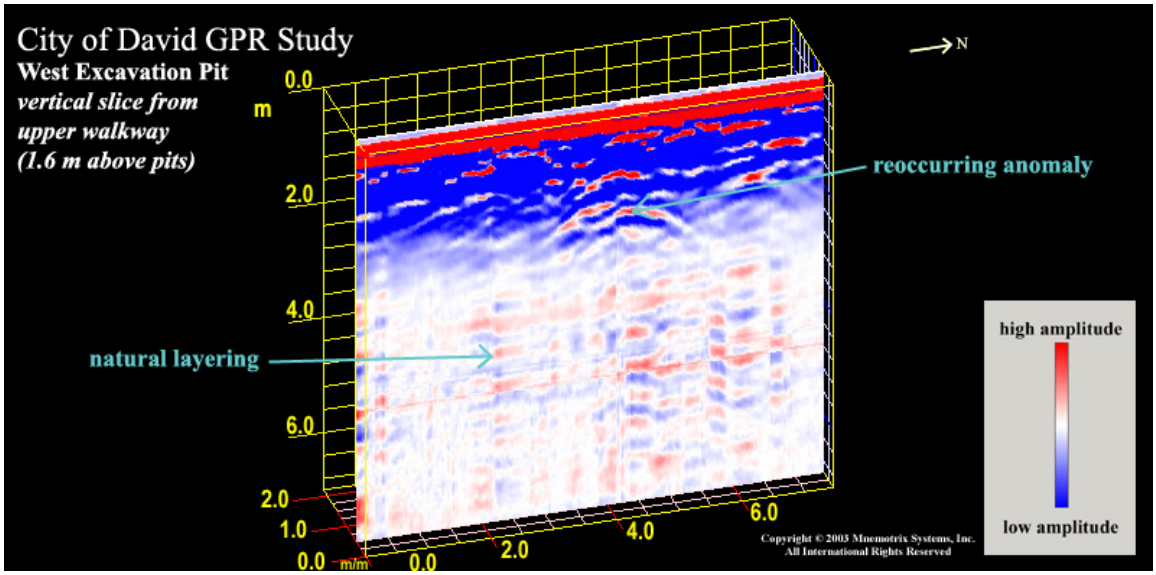
GPR Figure 1: ***Reoccurring anomaly in East Excavation Pit near cistern.***



GPR Figure 2: ***Reoccurring anomaly in Central Excavation Pit near mosaic floor.***



GPR Figure 3: ***Reoccurring anomaly in West Excavation Pit upper walkway.***

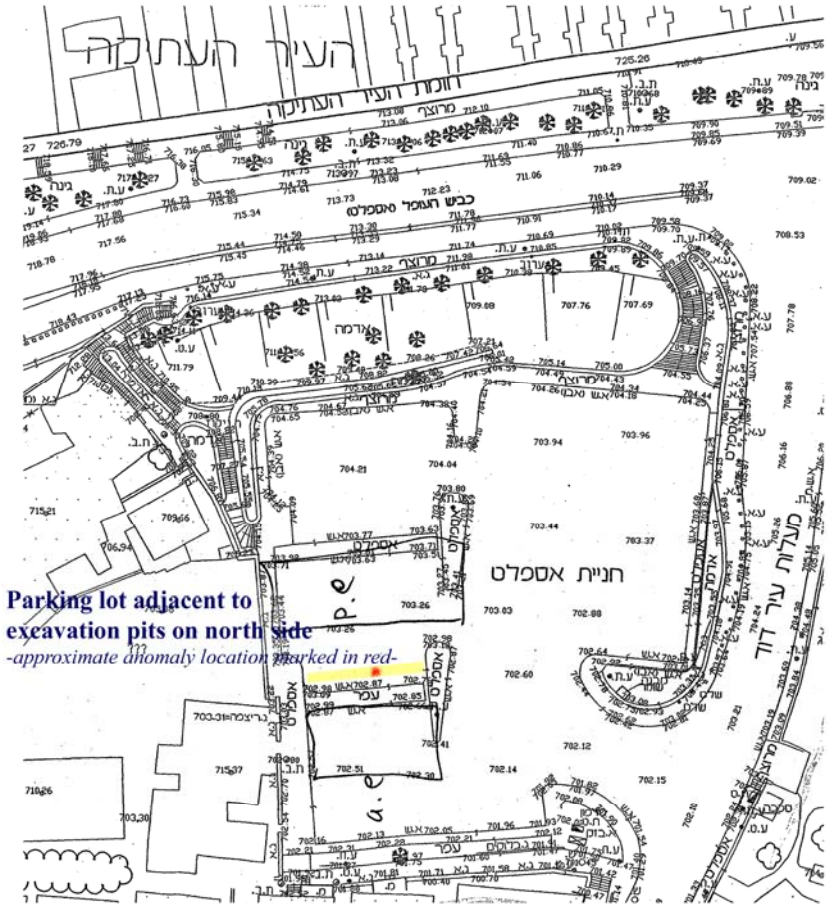


It can be seen that these anomalies in all cases occur a few meters deep and continue as far as we are able to see. We would suggest excavating these locations to discover what might be causing these anomalies to occur.

The source might be geologic shifts in the soil, or the presence of moister soil leftover from an underground water supply, or perhaps old channels dug to carry water or to store objects. They may be related, or have nothing to do with each other. A follow-up ground-truth study would shed light on all of this.

Observations and Results in Parking Lot:

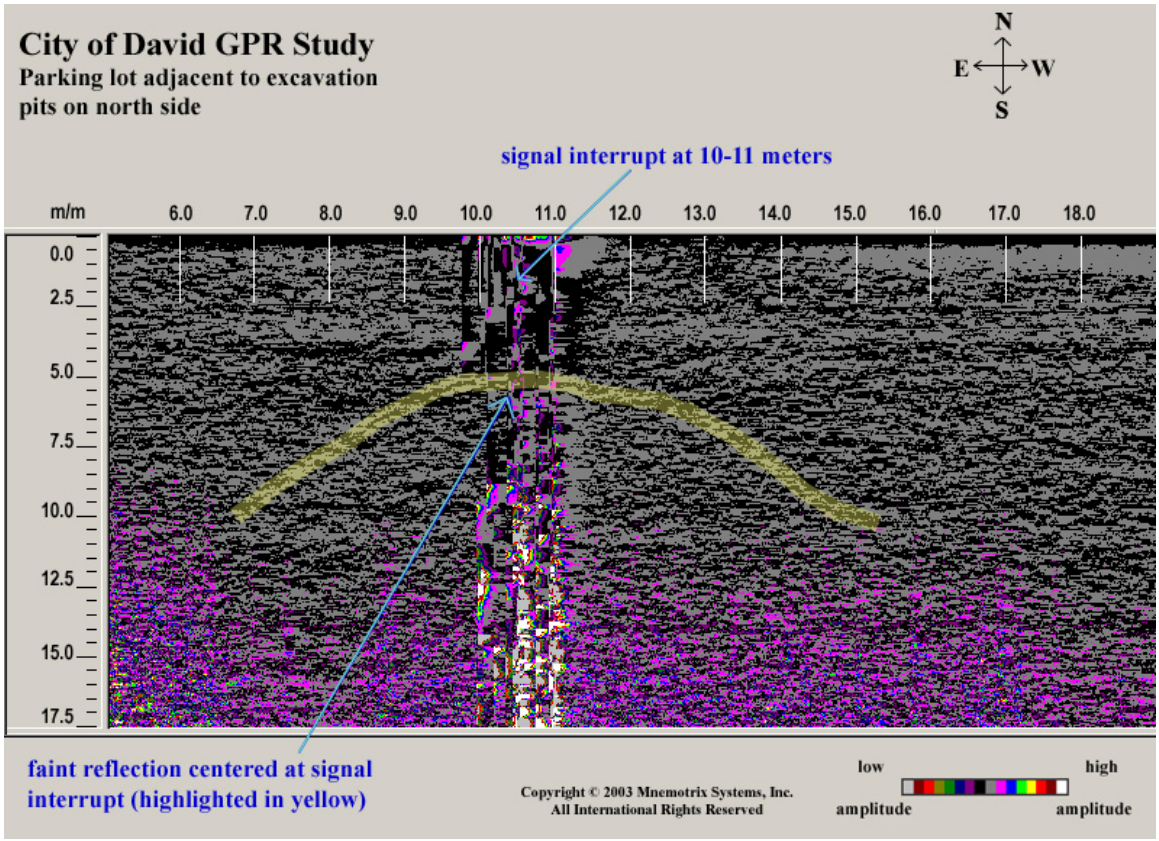
Just north of the excavation pits is a public parking lot, which can be seen in the figure to the right provided by Eli Shukrun. One reason we surveyed this area was to see if it might be possible to focus on any area of it that should be excavated so as not to disturb public areas which do not contain any archaeological importance.



Adjacent to the excavation pits on the northern side, we marked out a grid with the dimensions of 24.5 m (E/W) by 4.6 m (N/S). The approximate location of this parking lot grid is highlighted in yellow in the above map.

One vertical slice of this surveyed area is shown below. The area of anomaly which is seen on the figure about 10-11 meters from the eastern boundary is marked on the above map with a red dot.

GPR Figure 4: ***Parking lot adjacent to excavation pits on north side.***



What we discovered was that about 10 to 11 meters from the east boundary of our survey, we passed over something which was interrupting our signal consistently in the same area. Upon further study in post-processing, we discovered that while faint, there appeared to be a large reflection whose peak was at the precise point where we were encountering this anomaly. This could indicate something of large dimensions in the sub-surface. Or there could be some other source of interference at this point causing this phenomenon.

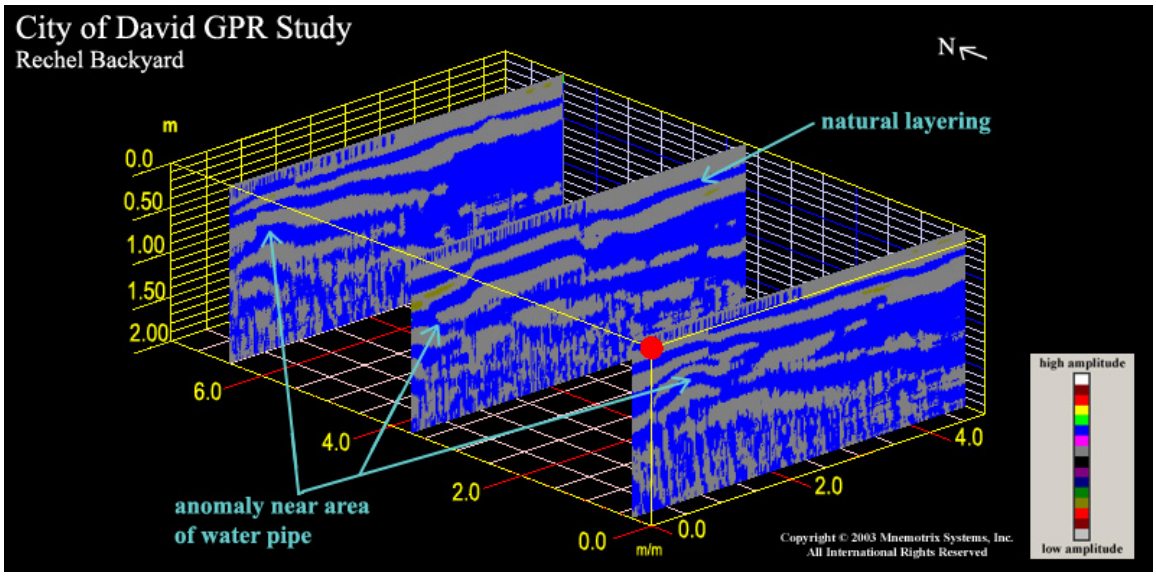
Observations and Results in Rechel Yard:

A short distance south of the excavation pits is a residential area, where with private permission, GPR surveys might be done. In this particular place the Rechel

family was kind enough to give us permission to survey their backyard to see what might be seen beneath this ancient area.

What we found was that the natural layering we were seeing in the excavation areas continues in similar fashion, though there was a significant amount of interference and we were only able to obtain a useful signal a few meters down. This can be seen in GPR Figure 5 below.

GPR Figure 5: ***Rechel Backyard.***



The color table used in this 3D view of a sampling of vertical slices highlights the geologic layering of the ground, which is similar in character to that of the excavation site. However these layers are more similar to each other in makeup, and are also thinner, indicating a more homogenous nature.

Of interest to us was that a known water pipe runs through the backyard, and an anomaly not dissimilar to what we are seeing around the cistern interrupts the more regular layering. This adds to our conjecture that perhaps what we are seeing in the

excavation pit area could be related to places beneath the earth where water was once channeled. All this, however, is only conjecture at this point.

Summary and Recommendations:

It seems that GPR can be quite useful in determining where to look for possible evidence of the old water system. Managers of the archaeology project may wish to include this in their thinking as they continue to excavate the area. Where it is possible to dig more deeply into the areas we have marked in on the site excavation map, we would suggest this be done to discover any evidence of such.

It also would appear that there is something of significance beneath the parking lot at the one point shown and described in the previous section. This area is certainly producing a curious phenomenon, and should be further investigated. We would recommend that after the source of the signal interference throughout this whole area is better understood, that a follow-up survey in the area of interest be conducted for confirmation and further elucidation of results.

Once the signal interference is resolved, we would suggest a more complete study of the parking lot area adjacent to the excavation pits so that clean signal data can be evaluated and we can recommend more specific excavation advice.

With this experience and data to hand, we would look forward to returning to Ir David to accomplish a more comprehensive and focused sub-surface study taking up the points of interest brought up in this report.