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## Millbury Cemeteries Project

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## **Millbury Cemeteries Interactive Qualifying Project**

An Interactive Qualifying Project Report

Submitted to the faculty of the

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of **Bachelor of Science**.

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## Abstract

This project examined and documented two inactive cemeteries in Millbury, Massachusetts, in collaboration with the Millbury Cemeteries Commission. Utilizing Ground Penetrating Radar, the team sought to determine the exact location of interments in the cemeteries and any free space remaining. The issue of diminishing burial space was researched as well as the individuals buried in the cemeteries. A public website with an interactive map and a database containing information about the individuals was also created.

## Acknowledgments

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## Chapter 1: Introduction

### 1.1 Introduction and Goals

The Town of Millbury, Massachusetts operates three cemeteries of which only one is active, Central Cemetery located on Waters Street Extension. The remaining two are Country Bridge Cemetery located on Providence Street and Dwinell Cemetery located on Dwinell Road. This project dealt with the two inactive sites in hopes that the practices may be carried over to the active site. Project objectives were established at the request of, and in collaboration with the Millbury Cemetery Commission.

There were two main objectives for the Millbury Cemeteries IQP. The first was to confirm and catalogue all interments in both sites. The cemeteries have interments ranging from 1700 to 1900, with a few possibly older. As these sites predate modern documentation practices, there is limited information about the people buried in them. Also, there is some likelihood that over this extended period of time, headstones may have moved or been lost. With current technology, it is sometimes possible to confirm the exact locations of remains in cemeteries. The team used Ground Penetrating Radar equipment to attempt to locate and record all remains. Next, the team procured data from the headstones and from public records to determine who is interred at these sites and researched their background, particularly those carrying historical significance, as many were Revolutionary and Civil War heroes. This research was compiled into an interactive document or website on which people are able to search through and learn about anyone buried at these sites.

The second objective of this project was to consider and compare possible resolutions to the issue of burial space. As the population of Millbury is growing, burial space is shrinking. This poses a serious concern as to what can be done to reduce the rate at which space is

consumed in the future. One possible solution to this arises from the previous objective. If it could have been proven that there is enough unused space in the two inactive sites to accommodate new interments, this space may be used to lighten the load being placed on Central Cemetery. Additionally, the team researched alternatives to traditional burials. There has been much consideration in recent years towards the concept of ‘green burials,’ in which the body is not prepared with preservatives, but instead buried in a manner that will allow for it to naturally recycle back into the earth. There are other alternatives, including cremation, which the team also looked into.

In the following pages of this document, the team provides an in-depth description of the process by which the aforementioned objectives were accomplished. It lays out a repeatable procedure for any and all field work performed at the sites. It outlines the progression of the team’s research and presents conclusions based on the data acquired throughout.

## **1.2 Methodology**

One of the first steps towards achieving the goals of this IQP was to collect and document as much information as possible from the tombstones in the two cemetery sites, Dwinell Cemetery and Country Bridge respectively. The procedure was the same for both cemeteries. The team started out by taking general photos of the whole cemetery and then moved on to taking individual photos of the headstones and footstones. Photos were taken of the front and backs of the headstones. Information written on the tombstones such as name of person buried, age of death, and any other information was recorded. The team moved from one tombstone to the next according to the numbers the group put on the maps of the cemetery to keep track of all the tombstones. Tombstones that needed cleaning before they could be read were marked as

“Need Cleaning” so that they can be revisited at a later time to be cleaned with a biological solution and then reread.

Another important focus of the fieldwork was the use of the Ground Penetrating Radar system to scan the cemeteries and see if remains could be detected under the headstones. After doing research on cemetery mapping and consulting with experts on the use of the Ground Penetrating Radar System, the necessary equipment was borrowed from WPI’s Civil Engineering Department and the remaining equipment was rented from Geophysical Applications, a surveying company, in order to perform the site work in the cemeteries. The detailed methodology of the fieldwork such as setting up the equipment, surveying the cemetery and data analysis is later discussed in Chapter 2: Site work.

The final goal of this IQP was to create an Interactive Website where people are able to view information about those buried in the cemeteries. The Millbury Cemetery Commission officers have access to add or edit information that is displayed on the website. The research portion of this project, as well as data collected from the fieldwork, is incorporated into the interactive map, which displays information on everybody such as date of birth, date of death, and family information. More information is provided if the deceased person is a well-known historical figure. The photos and images taken at the cemetery sites are stored on a server so that viewers can see pop up images of the tombstones on the website. The complete methodology on how the interactive map was designed and developed will be provided in chapter 4.

## Chapter 2: Site Work

### 2.1 Ground Penetrating Radar Background

The site work consisted of using ground penetrating radar to proof the ground, or essentially to verify whether or not bodies were where they are supposed to be. Before this could be done, ground penetrating radar needed to be studied in detail so it could be used properly. Ground penetrating radar is an instrument that enables one to study the underground topography and characteristics of different areas. It consists of an antenna, a handle to pull the antenna, and a data collection device, which can be a laptop or an integrated panel.



Figure 1: Two types of Ground Penetrating Radars <sup>[3,4]</sup>

The radar emits electromagnetic waves that penetrate the ground and reflect back up to the antenna. These waves are in the radio frequency of the electromagnetic spectrum. <sup>[1]</sup> The depth of the measurement depends on the frequency of the antenna and the conductivity of the ground being studied. <sup>[2]</sup> The lower the frequency, the deeper the waves travel. However, higher frequency antennas tend to get better image resolution. <sup>[2]</sup>

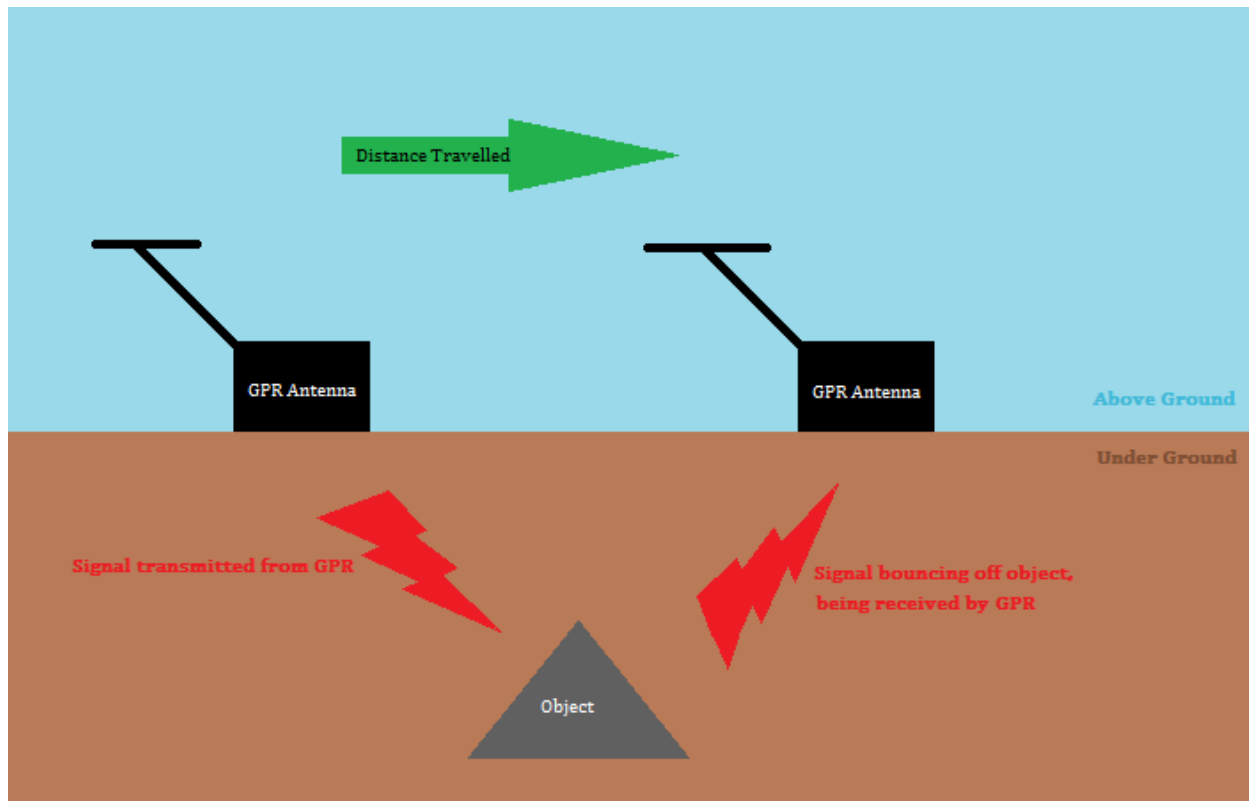


Figure 2: How ground penetrating radar works

By using a digital survey wheel these radar measurements can be made to correspond to horizontal distance travelled, allowing the user to pull the radar over several sites of interest and study the ground at various points. An example of a digital survey wheel can be seen attached to the radar to the left in Figure 1. Below is an example of a ground penetrating radar measurement that did take horizontal distance into account. The y-axis corresponds to depth in nanoseconds, the time it takes for the signal to go out and come back to the antenna. This is also sometimes in units of meters. The x-axis corresponds to horizontal distance travelled.

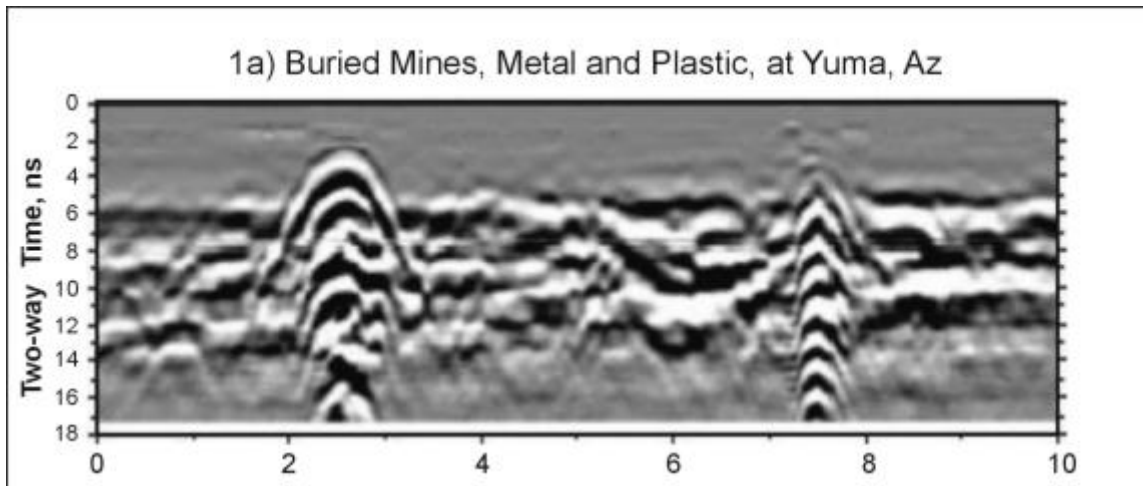


Figure 3: A basic set of ground penetrating radar data <sup>[5]</sup>

The quality of the measurement depends on the soil and ground consistency and make up, as this plays a key role in its conductivity. <sup>[1]</sup> In addition, weather plays a big role in collecting data. Dew on grass and rain makes the measurements ineffective.

Ground penetrating radar has several applications. It is commonly used to survey highways and different types of pavement, archaeological features such as bedrock, and to determine locations of pipelines and also mines. <sup>[1]</sup> It also is sometimes used for surveying cemeteries, which is a difficult application of the radar due to the varying soil make-up and the decomposition of the buried remains.

For the survey work for this project, Worcester Polytechnic Institute supplied the tough book laptop for the data collection. A surveying company called Geophysical Applications, a company of Geophysical Survey Systems, Inc., was consulted to rent the remaining radar equipment. Below shows a man using ground penetrating radar to conduct site work, which will be discussed in further detail in the next section.



Figure 4: A man conducting site work using survey lines and a ground penetrating radar <sup>[6]</sup>

## 2.2 Methodology of Site Work

### 2.2.1 Connecting the equipment with the antenna

Step 1: Connect the car battery to the laptop through an inverter shown in the following picture.

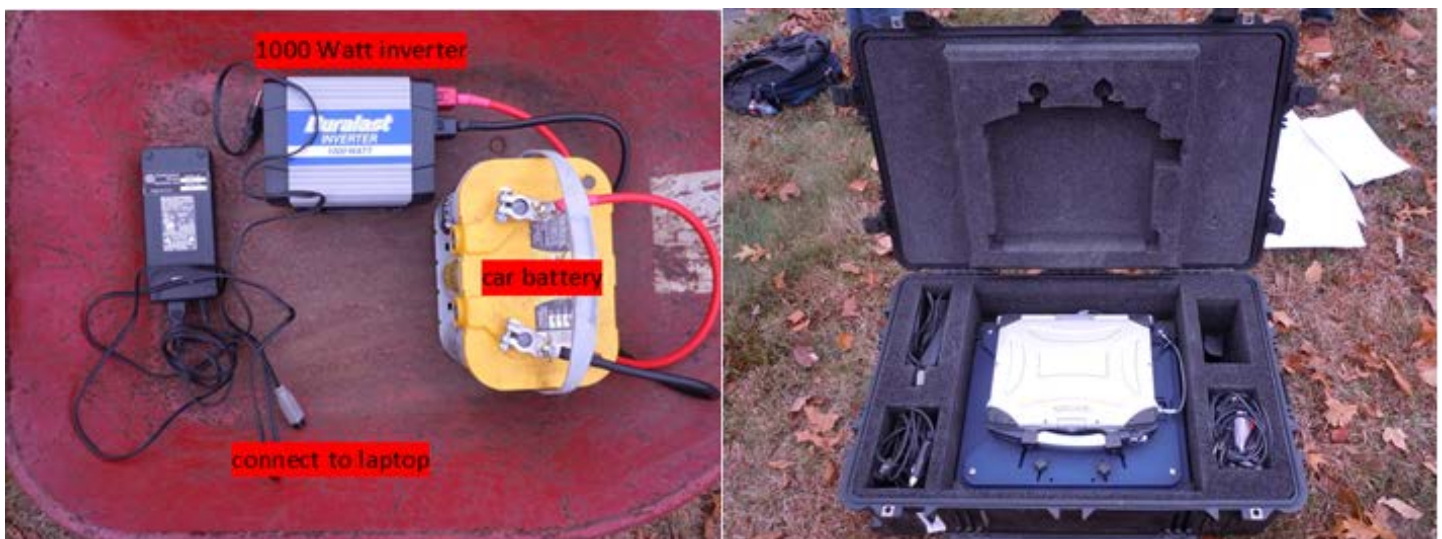


Figure 5: GPR Equipment



Step 2: Connect the antenna to the laptop through a thick 8 foot cable shown in the following picture. Also connect the cable to the antenna itself.



Figure 6: Connecting laptop to antenna

### 2.2.2 Setting up software for the antenna on the laptop

Step 1: Calibrate the following parameters when in the program:

- samples/scan needs to be set to “256”
- scans/sec needs to be set to “ 100”
- scans/ft needs to be set to “8”
- ft/mark needs to be set to “5”
- Dielectric constant needs to be set to “8”. This is related to the soil that the machine will detect through. User should use a reasonable assumption for this dielectric constant.
- Position – used default setting.
- Range needs to be set to “50ns”. It is measured in time and is related to how deep the machine will scan into the ground.

- An Infinite Impulse Response (IIR) filter with a low Pass of 800MHz and high pass of 100MHz is also used. This essentially filters out anything in the signal below 100 and above 800MHz, which would likely be attributed to noise.

Step 2: Ensure that files save to proper folder.

Consult professionals about detailed configurations to setup the software's parameters.

### 2.2.3 Survey the ground and then make passes with ground penetrating radar to collect data.

First, choose left bottom point as an origin from which to start, as shown in Figure 8 below.



Figure 7: Origin mark on the ground and the map

Second, make physical grid lines based off of the origin by using a 100-foot measuring tape and white spray paint, as shown in Figure 2. Mark the ground every 5 feet. Then walk perpendicular to the dash marks created and again using the spray paint and measuring tape, mark every 10 feet. Now a grid has been created to follow with the radar.



Figure 8: Use the measuring tape and spray paint to mark the gridlines

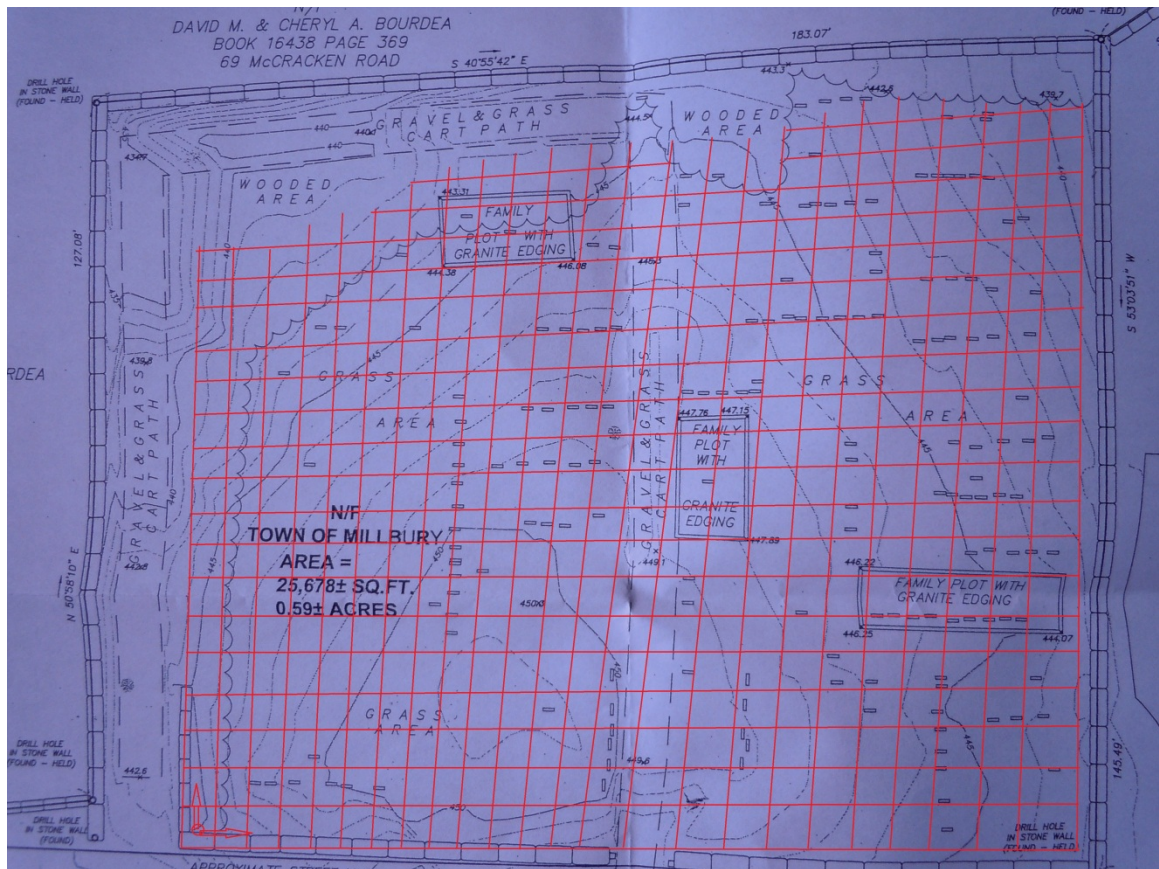


Figure 9: The complete net grid after marking

(Note: Bring two or three spray paint just in case. Get permission to use the spray paint to mark on the cemetery.)

Third, starting from the origin, go along with the red line perpendicular to the street from one end to the other to complete the radar passes. To start the antenna before starting to drag the antenna, initialize the scanning software on the laptop to run the image capture function at the one end of the line and terminate the function and save the file at the other end of the line named by the order of the red line.

Drag the antenna on the ground along the vertical red lines according to the directions marked as white arrows in Figure 4.

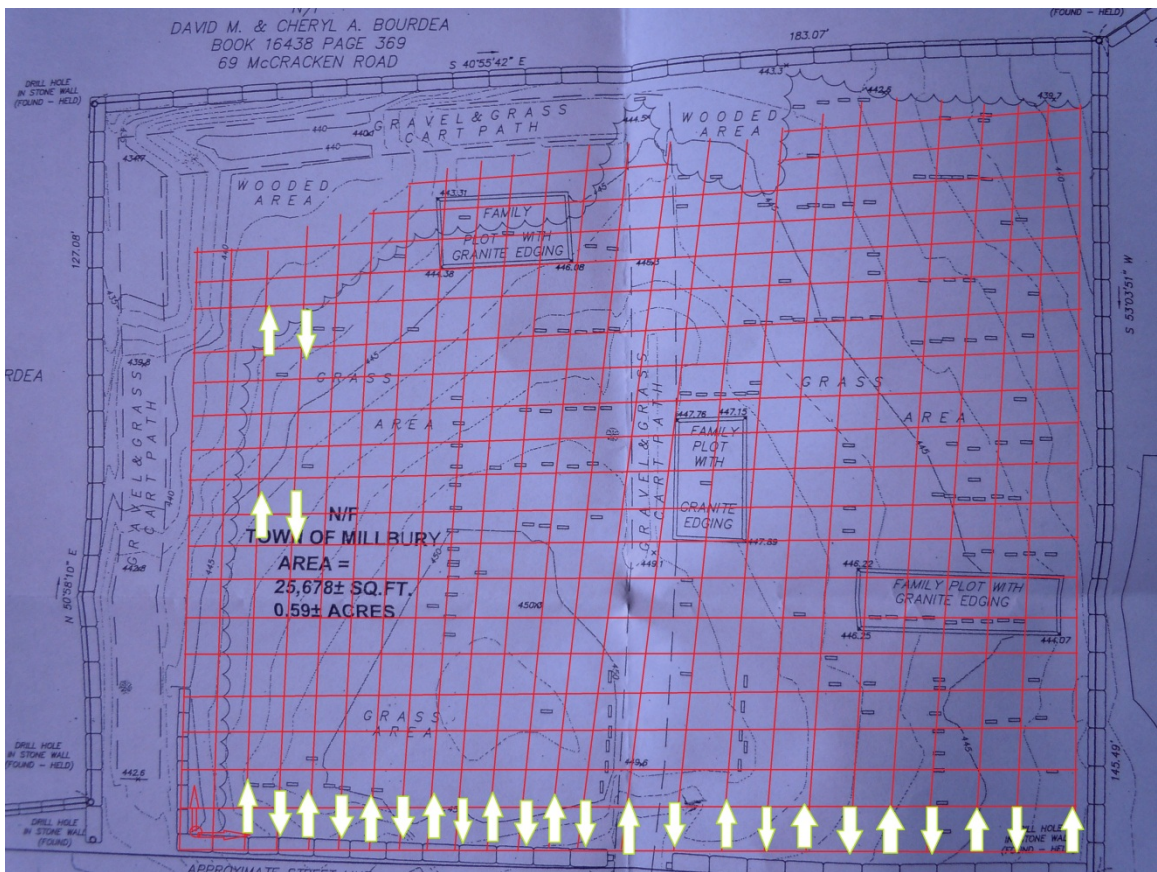


Figure 10: The directions for dragging the antenna

When dragging the antenna over the ground, make sure the bottom of the antenna box touches the ground as close as possible to get an accurate feedback image. When passing a grave stone, click the button on the arm of the antenna to record the positions of tombstone location in the images.

After finishing dragging along all the vertical lines, do the same operations to the horizontal lines.

After covering all the lines of the grid with antenna, samples of the underground situation are captured in the files stored in the laptop. This data will be used for analyzing the underground situation later.

## **2.3 Ground Penetrating Radar Analysis**

### **2.3.1 Data Analysis**

After completing the field work using the GPR, the next step was to analyze the data collected and attempt to mark the absolute locations of any remains. There were some test passes made to get a sense for what should be seen where there are remains. One of them was deemed satisfactory by the expert assisting the team. It clearly depicted 5 locations where objects, assumed to be remains, correlated to headstone positions. However, the second test pass was completely inconclusive, as it did not at all correspond to expected results. After this observation, the team realized the data may not be as straight-forward as originally desired and thus definite ground proofing might not be attainable. Regardless, 29 more passes were made to cover the entirety of the site in one direction, and the results interpreted to the best of the team's ability.

The image below is of a test pass performed before the actual survey. The purpose was

to travel a short distance over several newer plots in an attempt to get a sort of baseline for what could be expected during the survey. The smaller image above the graph was clipped from the map of the cemetery, and shows the spacing of the headstones which are represented by rectangles. The bottom is a screenshot of the GPR data received for this pass.

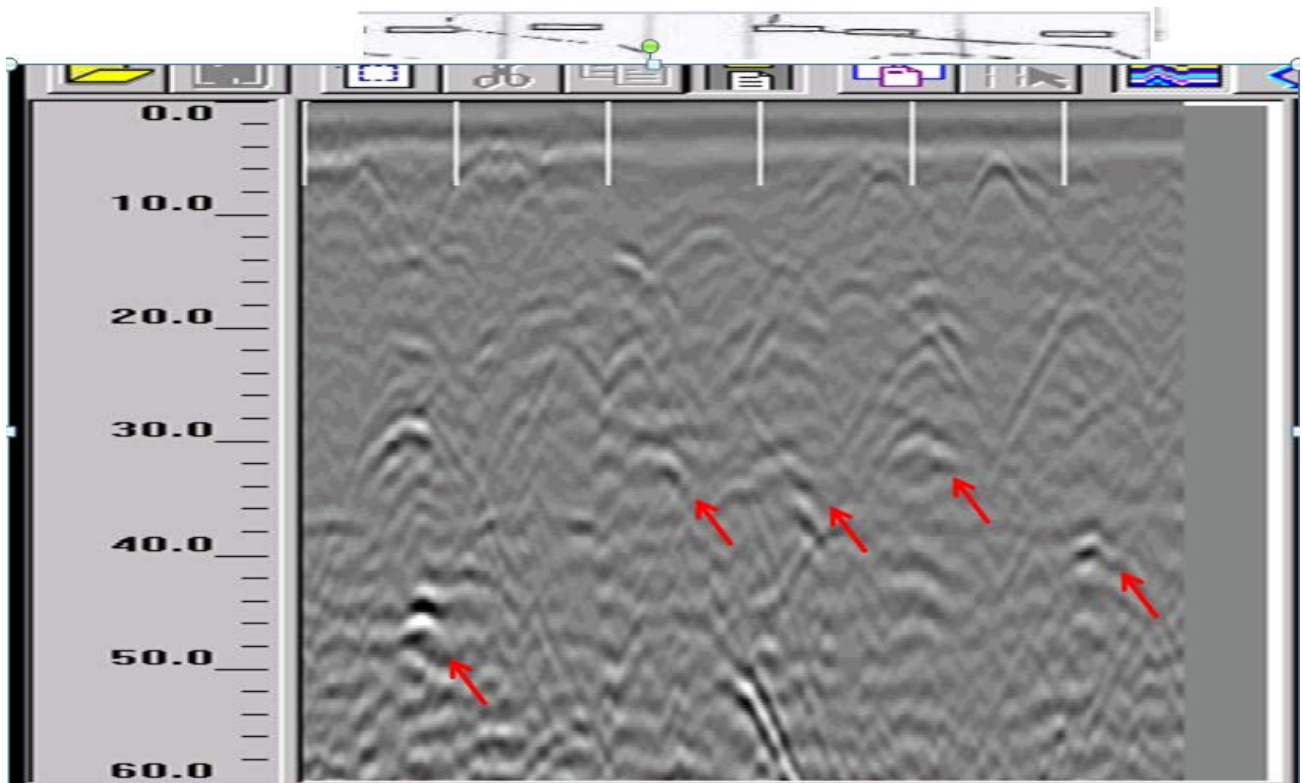


Figure 11: GPR Test Pass 1 (5 plots)

Looking at the graph above, the Y-axis shows depth, with the top of the image being the ground surface. The numbers actually represent the amount of time the signal traveled, but it is relevant to depth. Since a 400MHz antenna was used, the overall readable depth is roughly 8 feet (variances in material properties of soil only allow for approximations of actual depth). The X-axis is the distance the antenna traveled across the surface, starting from the left. The white dash marks represent 5 feet of spacing in real life. So in this example it went about 30 feet.

The upside-down hyperbolic shapes pointed out by red arrows represent interruptions in

the signal, meaning there is likely some kind of disturbance in the soil at those points. This data is consistent with the number of plots traveled over, and approximately with the spacing of the plots. Also, they are all roughly 4-6 feet deep which would make sense for hand-dug graves of the time period. With this in mind, it was determined that this was a good pass to use for comparison of other passes.

Another test pass was made over a family plot that was surrounded by a granite wall, which made it obvious where any remains would have to be placed. The results are shown in the graph below. Above it, again, is an image of the area that the pass took place, showing the headstone locations and spacing.

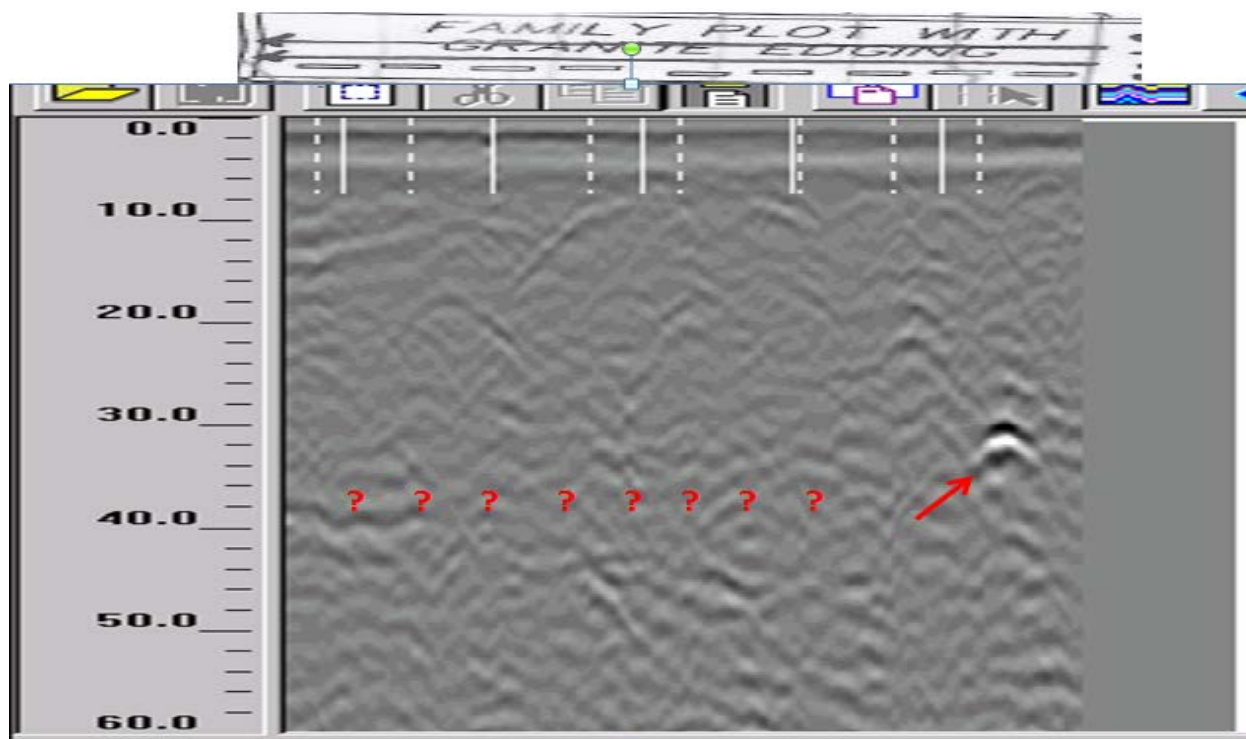


Figure 12: GPR Test Pass 2 (9 plots)

This pass was far less conclusive than the first one. There is only one spot that looks like there might be remains being detected, even though 9 graves were covered. Both this pass and

the first test pass include graves from the same general time period, 1850's - 1880's, so it is unlikely that there had been more decomposition here. It was determined that this data was not going to be helpful, and also that the rest of the data needed to be analyzed with the possibility of uncertainty kept in mind.

With the test passes analyzed and expectations set, the team began to examine the actual survey passes. It became clear quite quickly that there was large variance in results, and thus would be difficult to draw solid conclusions. Nonetheless, each pass was examined closely to locate and highlight interesting points.

The first example shown will be one of relatively satisfactory results. The image below shows the twenty-fifth pass. In this pass, the GPR antenna traveled by several headstones over the course of about 90 feet.



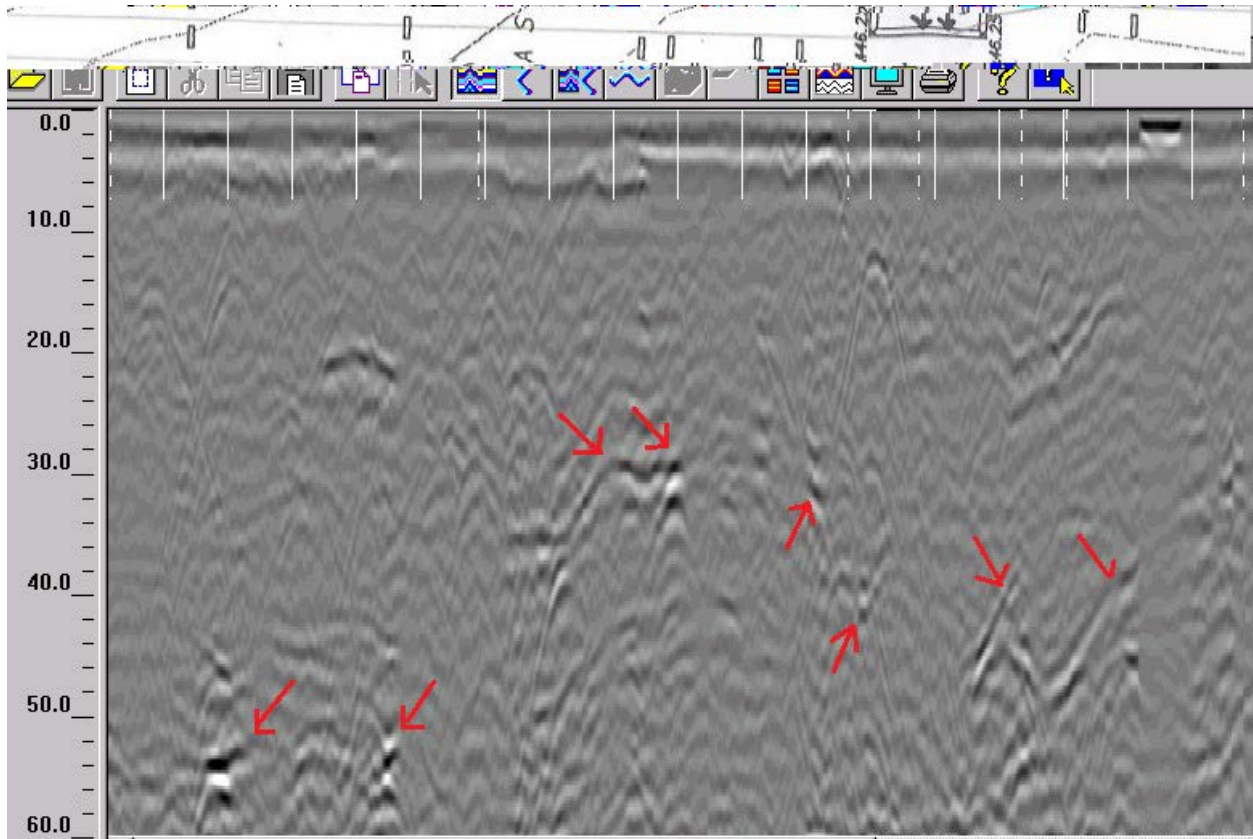


Figure 13: GPR Pass 25 of survey

As mentioned above, these results are somewhat consistent with expectations. There are disturbances at roughly the correct depths, spaced apart in a manner that correlates to the headstones' spacing. It is safe to assume that most of the places marked by red arrows here are locations of remains.

The next example below shows mixed results, in that the data correlates with what was expected in some areas, and not as much in others. This pass again covered about 90 feet, and passed several headstones.

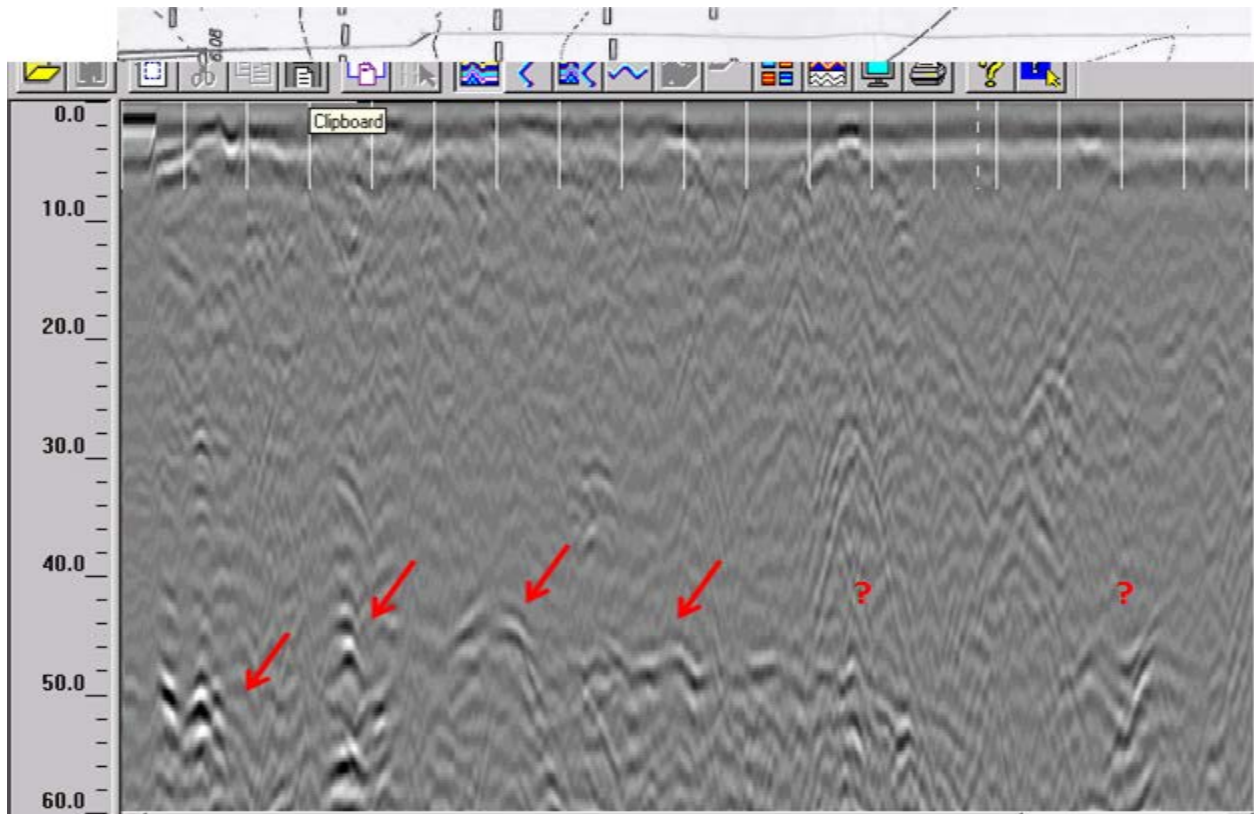


Figure 14: GPR Pass 15 of survey

On the left, there are some definite disturbances that resemble those in the first test pass. They are spaced correctly for the headstones in the map above, and they seem to be relatively close to the expected depth. However, on the right there are similar disturbances in unanticipated locations. This could be attributed to many factors, from faulty readings to rocks. There is a possibility of unmarked graves, but with the level of uncertainty experienced throughout the survey it is difficult to defend such a hypothesis.

The final example below shows completely unexpected results. As seen in the map above the graph, this pass traveled directly by 15 headstones. Also note that the headstones for this section are incorrectly depicted as vertical rather than horizontal on the map. Thus, these headstones are all placed side to side and not front to back as shown on the map. This means that the GPR antenna actually traveled directly over where the remains would be.

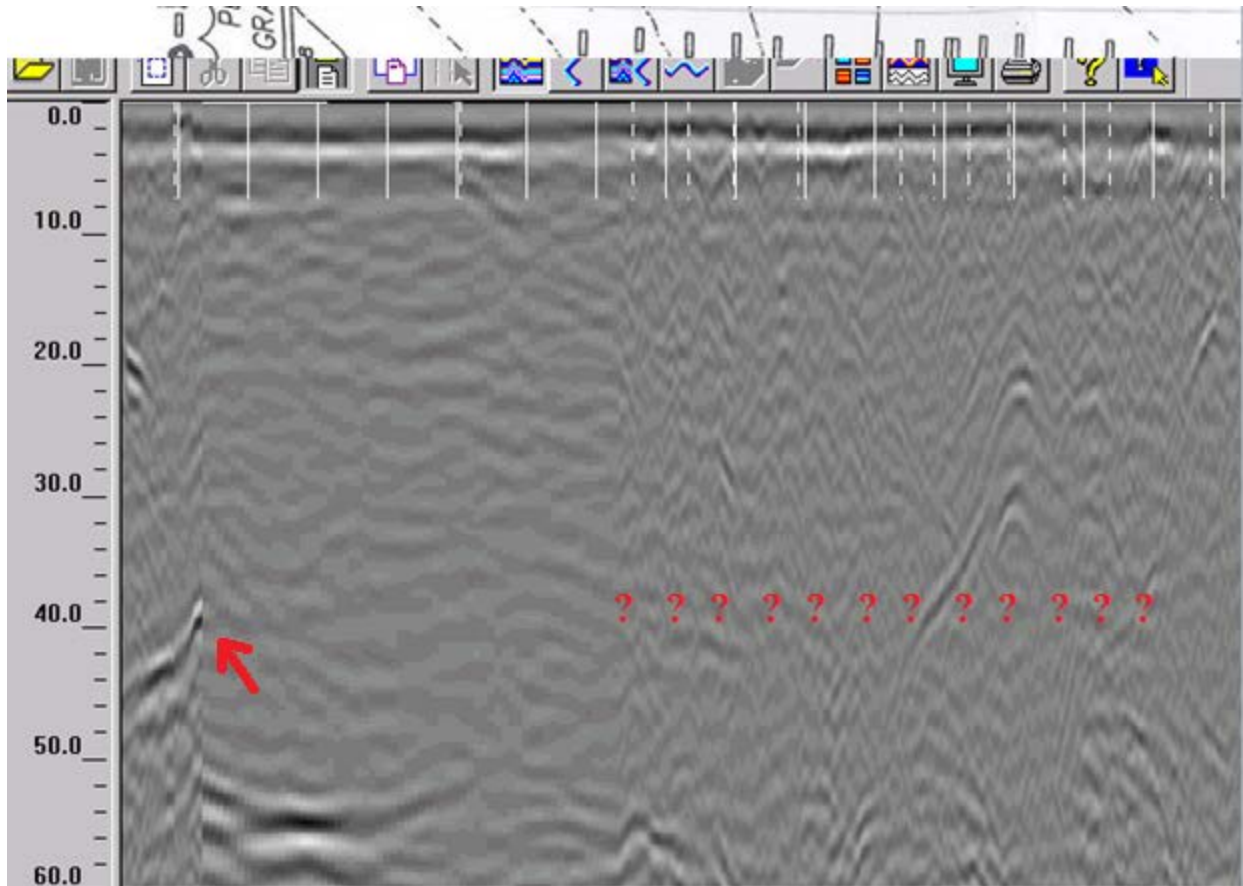


Figure 15: GPR Pass 10 of survey

Again, the GPR results do not match the expected results. On the far left it looks like there could possibly be something, but even that is questionable, as right at the point the data begins to look blurry as if there was an error in the reading. On the right half, after the error seems to have stopped, over a dozen plots are covered and the data does not show any indication of remains. This was expected to be a very revealing pass as it was similar in orientation to the first test pass which yielded great results. However, again it shows the uncertainty of the data and proves that there will not be enough confidence in the results to make statements of where free space is available.

### 2.3.1 Results and Conclusions

After studying the remaining data, it was determined by the team that it would not be conclusive enough to support a definite ground proofing. Thus, the remainder of the data will not be analyzed closely in this report. However, all remaining GPR data screen caps can be found in Appendix A.

Although the data did not turn out to be sufficient for the ground proofing originally desired, it was an excellent learning experience for each member of the team. Working hands on with an advanced system such as the GPR, with an experienced professional in the field teaching the basics, was a valuable experience for all. The list of applications for this important piece of technology is continually growing. Cemetery ground proofing is actually considered one of the more difficult applications of the GPR, but it can be done. The following are recommendations for any following teams if it is decided to repeat this procedure for better results.

First, time management is very important. Since some of the equipment needed to be rented, it was important to perform the work as quickly as possible to avoid additional costs. One thing this team noticed in regards to time was how long it took to mark out the grid lines each pass would follow. A couple hours were spent doing this instead of taking radar readings. It would be a good idea to go to the site ahead of time and get all of this work done, so that everything is ready come the day of the radar work.

Also, it is recommended to try to get an expert to assist with interpreting all of the results. The expert that helped this team was absolutely invaluable in getting the team started as well as pointing out useful things about the equipment and data. However, the team tried to interpret the majority of the results alone. This is not advisable, as much of the anomalies in the readings need a specialist's eye in order to draw any useful conclusions.

Also, the frequency of the antenna might be something to think about before checking it out from the respective rental. The team used a 400 MHz antenna, which could detect up to 8 feet as mentioned above. However, the results were not conclusive enough. The average depth of a burial is six feet so a higher frequency antenna might give better, and less coarse results with less noise, but the depth to which it can detect will be lower (e.g. a 500 MHz antenna can still cover up to 6 feet roughly). Therefore, it is advisable to check on other antennas, and make the best choice.

## Chapter 3: Research

### 3.1 Issue of Burial Space

One of the objectives of this project is to investigate the issue of burial space. In the town of Millbury there is only enough room for six more years of burials. It is not an uncommon occurrence for towns to run out of room for burying their dead. Thus, other burial methods are being explored to solve this problem.

The above-ground burial method involves burials in manmade structures above the ground. These could be simple coffin like containers that are built on top of graves or intricate mausoleums. The problem with this method is it requires much more maintenance and thus more money. Also, space still quickly runs out. The following methods are more viable solutions to this issue.

One such solution is the reuse of graves. The idea is that land would be reused once a person's remains had disappeared, after about 100 years. With the “lift and deepen” method, old remains will be removed from a grave, and then replaced once it has been dug deeper to allow for more burials <sup>[13]</sup>. In 1994, over seventy burial authorities together funded research on public response to the reuse of graves. The research team interviewed 1603 members of the public, and found that the majority of respondents would not object to this system if it was well-regulated, and if disturbance took place only after one hundred years <sup>[11]</sup>.

Another way to gain more space is to remove paths and plants in the cemetery and use those as burial space <sup>[13]</sup>. This method is known as cramming. However, cramming could damage the overall landscape of the cemetery and so should be considered carefully before deciding to adopt this method.

The last option is to promote cremation. One reason to consider cremation is because it tends to be much less expensive than burials and burial plots can become even more expensive in the future due to the lack of space. Cremation is also more environmentally friendly than burial, largely due to the amount of chemicals generally used for preserving the body <sup>[12]</sup>. In fact, there are even biodegradable urns that decompose over time, freeing up more space. Some people are in favor of having one average sized single person plot being made into a family plot by placing these urns in the single plot. Since several urns could be placed within a single plot, space is saved as is money and other maintenance costs. The problem with this method is its social stigma, but perhaps as more time goes on the public will realize the benefits of cremation.

### **3.2 Readability of Tombstones**

A grave of a loved one can become unreadable and thus lost to future generations. Having tombstone or a grave marker made for the grave is an expense that some families cannot afford. During the research on the two cemeteries, the IQP team found out that while a few tombstones still had sharp-looking clear names on them, the names on some other stones were not comprehensible. Some have become totally illegible. In the two cemeteries studied, about 40% of the tombstones of both cemeteries were completely unreadable or only partially readable. This of course is due to most of the stones being 100-200 years old and braving harsh New England weather that whole time. But this also points to the quality of tombstones available back in the 1800s. High quality gravestone markers would have been more expensive during the 1800s and thus it can be assumed that many of the currently legible stones in these cemeteries either were bought by wealthy individuals or donors. Contrarily some of the illegible stones have a high probability of being bought by poorer citizens. Since the technology of tombstones was not as advanced back then, the stones would not last as long anyway. Consequently, only a few

upper-class rich families could manage to pay to have their loved ones' names engraved properly, and sustain for as long as they have.

There are two ways to address the readability of the tombstones or lack thereof. If a tombstone is not readable, the most common method to get data from it is the rubbing or etching method. This involves taking a piece of paper and then a crayon, pencil, or other writing utensil and rubbing the paper with the utensil over the stone. The change in elevation due to the etching on the tombstone causes the name and data from the stone to be white on the page while the rest is blacked out.

Another more expensive method is to use a biological solution on the stones. Since several of the stones have moss and shale growing on them, this solution would clean up the stone without harming it. However, as mentioned this is more expensive and time consuming.

The problem with several of the stones in the cemeteries is that the weather has completely shaved the surfaces of the stones completely flush. Thus, neither of these methods would work. There are probably several state of the art optical devices capable of seeing the previous markings on the tombstone, but this was not researched. Since such a high percentage of the stones were illegible beyond repair, their results were not included in the research for this project.

### **3.3 War Veterans of Dwinell Cemetery**

Several of the people interred in Dwinell Cemeteries were veterans of various wars. A table at the end of this section notes prominent veterans buried in Dwinell.

One of the more prominent war veterans was William Bond. There is a possibility that the parents of the famous war hero, Colonel William Bond, are buried in Dwinell Cemetery.



They are Jonas Bond and Hanna Bond. Jonas Bond served in the expedition against Canada under Sir William Phillipps in 1690. He was Justice of the Peace, a member of General Court, and was also active in military affairs. He was a soldier of the Revolution. <sup>[16]</sup>

His son, William Bond, lived in the Massachusetts Bay Colony in 1768. He was a captain in the military in 1774. In July, 1775, he held the rank of lieutenant colonel, second-in-command, in the 37th Regiment of Foot (infantry) in General George Washington's Continental Army. After the death of the regiment's commander, Colonel Thomas Gardner, Bond was promoted to colonel and took over command. After November, 1775, Bond's regiment was renamed the 25th Regiment and remained camped at Prospect Hill, Massachusetts, during the winter of 1775-1776. <sup>[16]</sup>

William Bond and the 25th Regiment participated in the campaign to conquer Canada during 1776. Congress had requested that General Washington send four regiments to reinforce the army in Canada. On March 15, 1776, the 5th and 25th Regiments received orders from General Horatio Gates to march to Norwich, Connecticut. On March 30, the Massachusetts regiments led by William Bond, John Patterson and John Greateon, along with the New Hampshire regiment led by Enoch Poor, arrived in New York. On April 21, the four regiments sailed in sloops up the Hudson River to Albany under the command of General William Thompson. <sup>[16]</sup>

In early May, the 25th Regiment was preparing to cross into Canada by boat and reached Sorel by June 14, Chamblee by June 17, Isle aux Noix by June 18, and Crown Point by July 11. On August 10, the 25th Regiment was camped at Mount Independence, a hill near Fort Ticonderoga. The stagnant lakes and swamps around Mount Independence contributed to the

diseases already suffered by the regiment, including smallpox. Desertions and discharges for medical reasons severely reduced troop strength. On August 31, 1776, Colonel William Bond died of illness at Mount Independence. <sup>[16]</sup>

<b>Veteran</b>	<b>War</b>	<b>Rank</b>
Edmund Barton	French Indian War	N/R
Shepard Davis	Civil War	N/R
Nathan Greenwood	Civil War	Corporal
Solomon Dwinell	Revolutionary War	Sergeant
Elisha Goddard	Revolutionary War	Captain
James Greenwood	Revolutionary War	Captain
Robert Goddard	Revolutionary War	Major
Thomas Bancroft	Revolutionary War	Lieutenant
Joseph Bancroft	Revolutionary War	Captain
Thomas Bancroft	Revolutionary War	Captain

Figure 16: Prominent War Veterans buried at Dwinell Cemetery

### 3.4 Prominent Families of Dwinell Cemetery

#### 3.4.1 Goddard

There are several interments in the Dwinell Rd. cemetery with the last name Goddard. Although a connection to the Robert Goddard famous for his work with liquid-fuel rockets was unable to be determined, it is reasonable to assume that there may have been some relation. A

few of the interments shared the first name Robert, and he also grew up in this area. Regardless, despite the minimal data about most of them, the information that was found proved that they were respected and prominent members of Worcester County. Below is some of the history found about these men.

Captain Elisha Goddard was born on July 13, 1719 in Watertown, MA. His parents were Robert Goddard and Mehitable Spring. His first wife, Anna Haven of Framingham, died just 8 years after being married at the age of 24. Elisha served as a captain during the Revolutionary War, after which he married Mary Thatcher of Sutton, MA where the two resided. He was a selectman there in the years 1764 and 1765, and on March 3, 1773 he was chosen to be on the committee of correspondence, inspection and safety. Captain Goddard died on June 19, 1789 at 69 years old. <sup>[14]</sup>

There were several Robert Goddard's noted in the history book of the Town of Sutton, MA. Although most personal information was more difficult to come by, including the years of births and deaths, there were several notable references to things they did in the community. In 1756, the elder Robert Goddard was chosen to be on the "committee to make sale of ye ministerial land and to treat or agree with ye several ministers concerning ye same." He also was a selectman in 1731, 1732, and 1739. The younger Robert Goddard, possibly the son of the man mentioned above, served as a major in the Revolutionary war. <sup>[7]</sup>

### **3.4.2 Park**

One of the prominent persons of the Park family was Moses Park who was born in Sutton, June 26, 1790. He worked as a mechanic in the armory of Mr. Waters where he contracted for gun-stocking from Mr. Waters. Not pleasing his people in his trade or his wife, he was cut off from any share in the ancestral homestead. As his work at the armory ceased, he

turned his attention to farming and, sold his house and lot and he bought the Willard and Wesson farms on the Worcester road, near Dorothy Pond. He moved to the farm in 1835 and he died in Sept. 13, 1875. He served the town as assessor and in various other minor offices. He was a charter member of King Hiram Council of Charlton and Worcester. He was also a member of the old Millbury Lyceum and delivered several talks on the topic of Natural Philosophy, as Physics was then called. From 1808 until 1838 he was a member of the old militia. <sup>[7]</sup>

Hervey Park was born in Millbury on Oct. 12, 1831. Though he spent most of his life on the farm, Mr. Park was also, like his father Moses Park, a mechanic. He was greatly interested in the Farmers' and Mechanics' Association of the town and served as its president and occupied that position through the whole life of the Association until the Grange came to take its place. He was a Royal Arch Mason, a member of The Council, and also of the Knights Templars. Besides serving the town in several other positions, he served long upon the Board of Assessors, being its chairman for ten years. He died on November 26, 1900. <sup>[7]</sup>

### **3.4.3 Bancroft**

There are several members of the Bancroft family buried in Dwinell Cemetery. Some notable members of the Bancroft family are Lieutenant Thomas Bancroft, born in England in 1622 and emigrated to America, and Captain Thomas Bancroft, born in Reading in 1673 who both served as soldiers in the Revolutionary War. Captain Joseph Bancroft who was born in Sutton on Jan 13, 1756 was also a Revolutionary War hero. His son Solomon Bancroft was born in Sutton Mar 15 1796 in Millbury and married Harriet Livermore of Weston on Aug. 25, 1820. He died in Millbury on Nov. 14, 1829. <sup>[7]</sup>

One of the most prominent members of Bancroft family was George Bancroft who was born on October 3, 1800 in Worcester Massachusetts. He was an American historian that was

often referred to as the “father of American history”. Among his best-known writings is the magisterial series, *History of the United States, from the Discovery of the American Continent*.

<sup>[15]</sup> He was educated at Harvard and several German universities. He initially pursued an academic career for an eight-year experiment in elementary education at Round Hill, his private school for boys at Northampton, Massachusetts. He then turned to anti-Masonic and Democratic politics in Massachusetts and received his first patronage post as collector of the Port of Boston in 1838. He also became U.S. secretary of the navy from 1845 to 1846 and then became minister of England from 1846 to 1849. In 1850, Bancroft broke with the Democrats over the slavery issue and shifted his support to the Republican Party. As a result, he served as minister to Prussia from 1867 to 1871. He died on January 17<sup>th</sup> 1891. <sup>[7]</sup>

#### **3.4.4 Barton**

Mr. Edmund Barton and his wife Anna (Flint) Barton are both interred in Dwinell Cemetery. Edmund Barton was a veteran of the French Indian War and was an influential figure in the town of Millbury after moving there. <sup>[7]</sup> He specifically was known for his involvement with town and church affairs. Edmund and Anna had several children, one of which was Dr. Stephen Barton, who was a physician. <sup>[7]</sup> He married Dorothy Moore and also had several children, another prominent one being Stephen Barton. <sup>[8]</sup> He is prominent because he was the father of Clarissa Harlowe Barton, known as Clara Barton. <sup>[9]</sup> Clara Barton was famous for founding the American Red Cross, a humanitarian institution. Thus, Edmund and Anna were the great grandparents of this influential person in history.

## Chapter 4: Website Design

### 4.1 Methodology

#### 4.1.1 Goal:

Design a website for both public viewers and cemetery officers. Public viewers are able to view an interactive map which contains pictures of the tombstones in the cemetery. For maintenance purposes, the cemetery officers can input and edit information in the database.

#### 4.1.2 Method:

Ruby Sinatra is used to generate a web application connecting to Postgres Database. By accessing the database system with a valid username, maintenance personnel will be able to operate on the database query by inserting, searching, deleting, editing, and displaying data gathered from the tombstones.

The website also stores the images of the tombstones in a server and will allow the web viewers to see pop-up images of each tombstone as part of an interactive map. Images had to be renamed prior to being uploaded into the database in order for them to correspond to the correct tombstone.

A free web application server called Heroku will satisfy the requirement for server and database functions for this project.

#### 4.1.3 Webpage flow chart:

The main home page is located at <http://wpicemetery.herokuapp.com>. From this main page, the user can go to either the interactive map or the database by clicking on the “Intermap” or “Database” tabs, or the user can manually type in the website address as shown below:

The address for the “Intermap” website: <http://intermap.herokuapp.com>

The address for the database input system website: <http://inputsystem.herokuapp.com>

The basic flow chart structure is shown below:

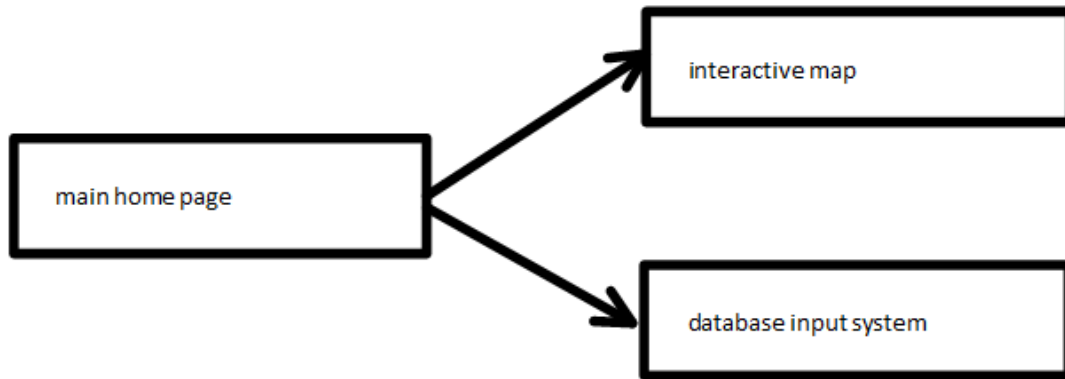


Figure 17: Webpage flow chart

The main home page is shown below. It has four tabs, which are “About”, “Research”, “Intermap”, and “Database”.

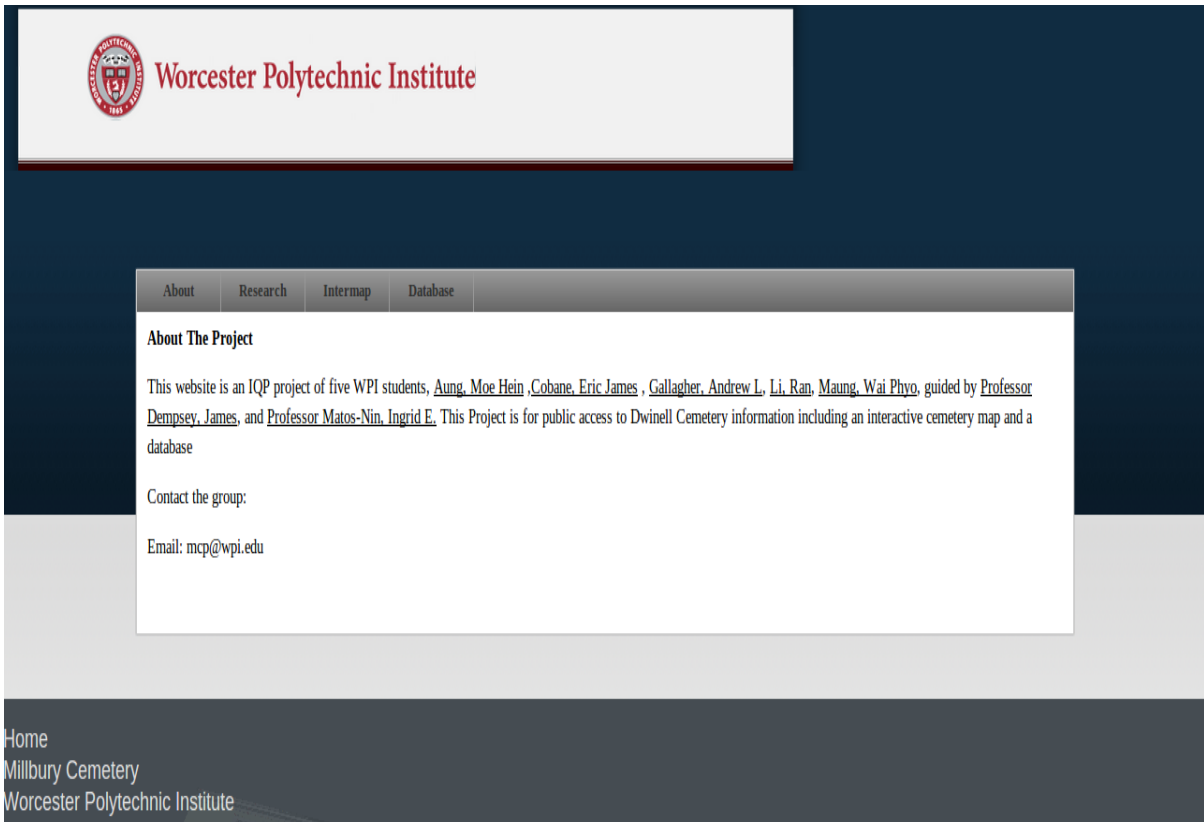


Figure 18: Home main page

The “About” tab has the basic information about this project including the names of the students and professors who contributed to the website. It also contains a brief introduction of what this project is about and what its purposes are.

The “Research” tab covers the content of the antenna detection and the site work data collection. The “Intermap” tab includes a link to a detailed interactive map website. It is shown in Figure 19.



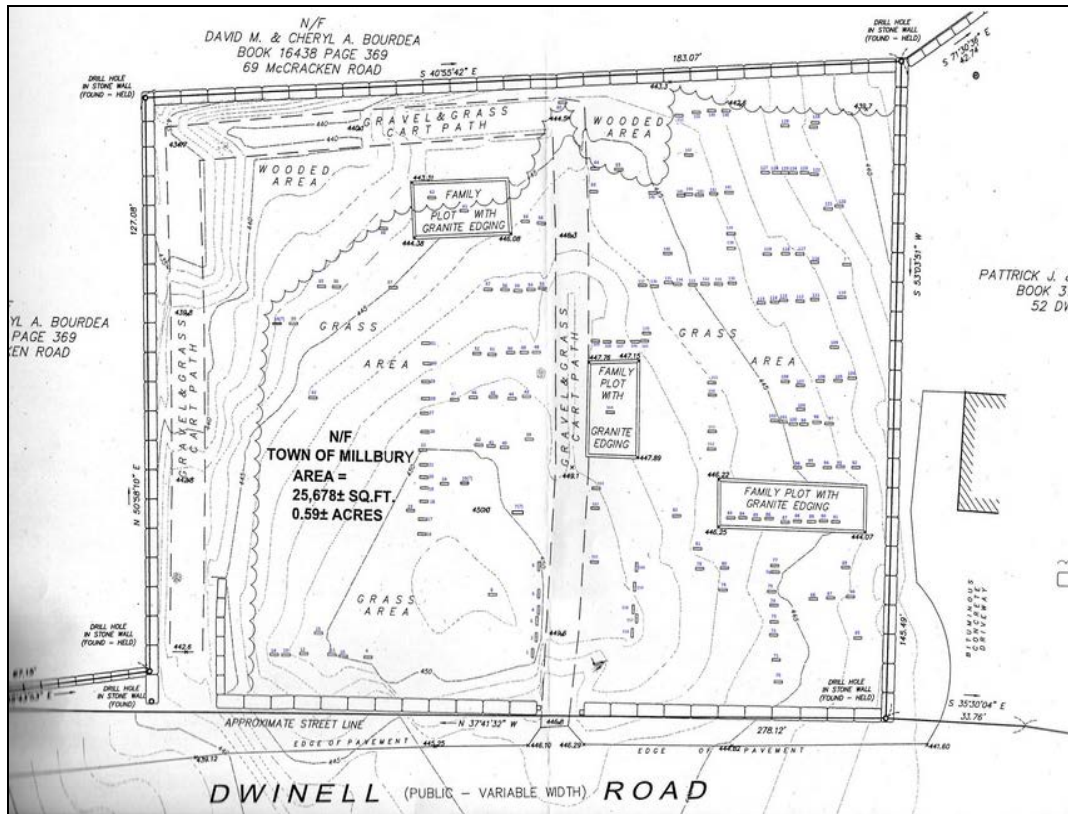


Figure 19: Interactive map

Initially, the “Intermap” tab opens up the map of the whole cemetery shown above. When the user hovers the mouse over a tombstone, an image of that tombstone will pop up to give the user more information, as seen in Figure 20. The pop-up image will stay open as long as the mouse pointer is over the tombstone. Otherwise it will disappear after about 3 seconds. The user can also click on the tombstone to get a larger image as seen in Figures 21 and 22.



Figure 20: Hover over the interactive map

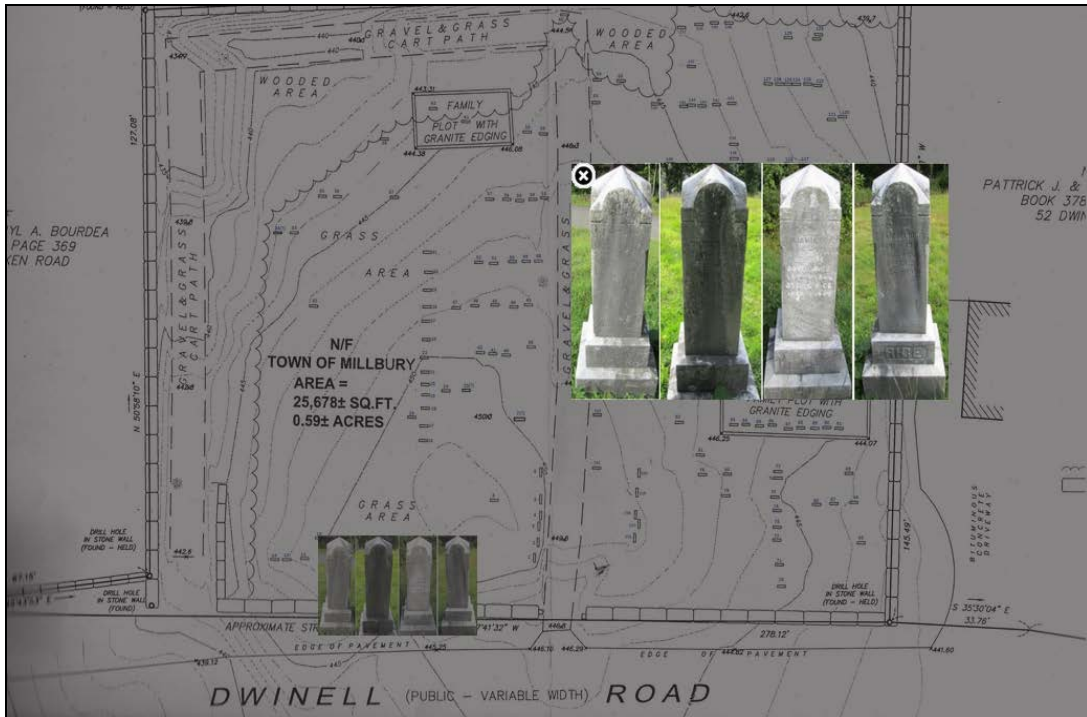


Figure 21: Click on the interactive map

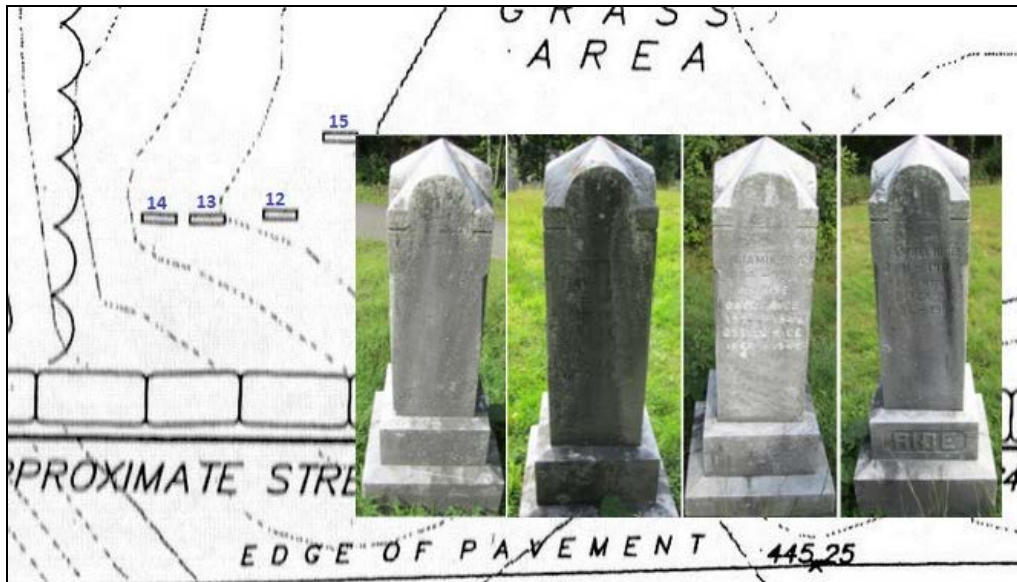


Figure 22: Zoomed in on the interactive map

The “Database” tab has a link that goes to the input database system. It brings the user to the login page shown in Figure 23. With a valid username, the maintenance personnel will be able to input data into the system and perform operations on the database. After they log into the database system, they are brought to the screen shown in Figure 24, where they can choose how they want to edit the database.

### Cemetery Information System

username :

Figure 23: Login page

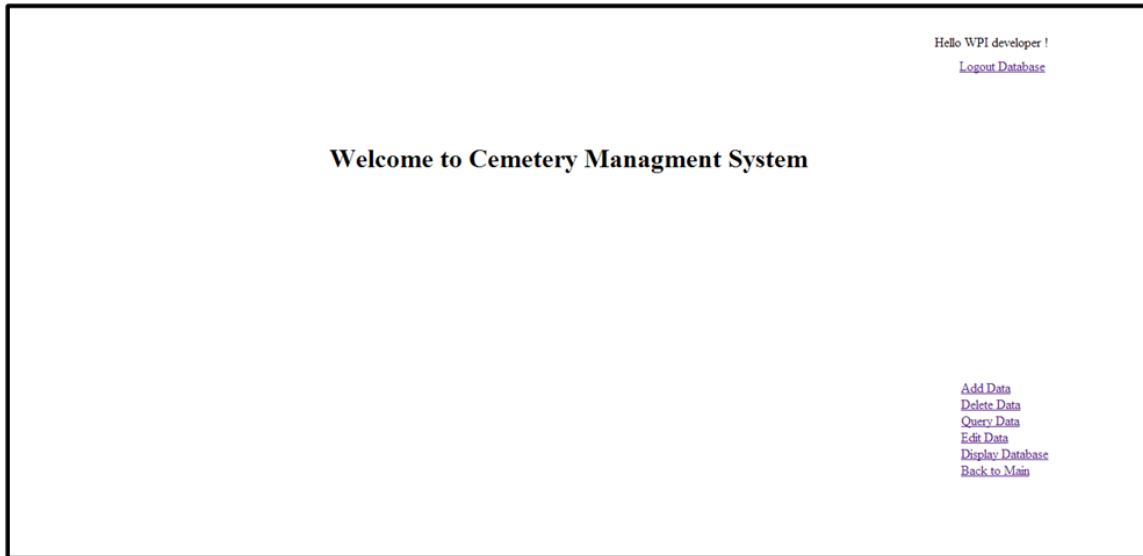


Figure 24: Main database page

There is a control panel with five operations on it. They are “Add Data”, “Delete Data”, “Query Data”, “Edit Data”, and “Display Database”, as shown below.

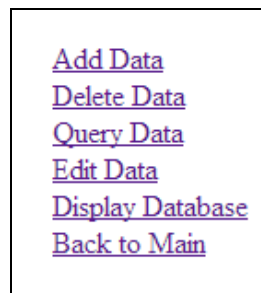


Figure 25: Control panel

The “Add Data” link leads to another webpage showing the interface below which allows the user to add data.

## Enter A New Tombstone Information.

Hello WPI developer !

[Logout Database](#)

Number From Map	<input type="text"/>				
First Name	<input type="text"/>				
Last Name	<input type="text"/>				
Middle Name	<input type="text"/>				
Birth Month	<input type="text"/>	Birth Date	<input type="text"/>	Birth Year	<input type="text"/>
Death Month	<input type="text"/>	Death Date	<input type="text"/>	Death Year	<input type="text"/>
Age	<input type="text"/>				
mother Of	<input type="text"/>				
father Of	<input type="text"/>				
son Of	<input type="text"/>				
wife Of	<input type="text"/>				
husband Of	<input type="text"/>				
Belong to Family	<input type="text"/>				
Other Info	<input type="text"/>				
Note	<input type="text"/>				

[Add Data](#)  
[Delete Data](#)  
[Query Data](#)  
[Edit Data](#)  
[Display Database](#)  
[Back to Main](#)

Figure 26: Adding data

The structure of the tombstone data is designed as follows:

```
{ "name": { "firstName": " ", "lastName": " ", "midName": " " },
  "numberOnMap": " ",
  "info": { "birthday": { "month": " ", "date": " ", "year": " " },
    "deathday": { "month": " ", "date": " ", "year": " " },
    "age": " ",
    "relatives": { "motherOf": " ",
      "fatherOf": " ",
      "sonOf": " ",
      "wifeOf": " ",
      "husbandOf": " " },
    "familyOf": " ",
    "note": " "
  },
  "otherInfo": " "
}
```

Figure 27: Data Structure

While inputting data, the user should not leave any field blank, as this will interfere with database functionality. The website will also check for the validation of the input for some fields to make sure that the data is unique in order to eliminate duplicates.

When “Query Data” link is selected, a new interface that requires the user to enter the number of the tombstone they wish to view will appear. When the number is entered, the website will display the information of the tombstone that the user is searching for.

Figure 28: Searching data

When the user intends to delete a record, they will be asked to input the number from the map to retrieve the data first. Then, a confirmation message will be displayed to ensure the user really wants to delete the record. An example of this is shown below.

number from map	first name	last name	middle name	birth month	birth date	birth year	death month	death date	death year	age	mother of	fatherof	son of	wife of	husband of	belongto family	other info	note
35	Jane	Greenwood	Kneeland	unknown	unknown	1845	unknown	unknown	1897	52	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown

Are you sure you want to delet this record?

Figure 29: Deleting data

To edit existing data in the database, the user just needs to click the “Edit Data” link from the panel and he will be allowed to change any necessary information, as seen in the figure below.

Hello WPI developer !  
[Logout Database](#)

### Edit A Existed Tombstone Information.

Number From Map	<input type="text" value="35"/>																
First Name	<input type="text" value="Jane"/>																
Last Name	<input type="text" value="Greenwood"/>																
Middle Name	<input type="text" value="Kneeland"/>																
Birth Month	<input type="text" value="unknown"/>	Birth Date	<input type="text" value="unknown"/>	Birth Year	<input type="text" value="1845"/>												
Death Month	<input type="text" value="unknown"/>	Death Date	<input type="text" value="unknown"/>	Death Year	<input type="text" value="1897"/>												
Age	<input type="text" value="52"/>																
mother Of	<input type="text" value="unknown"/>																
father Of	<input type="text" value="unknown"/>																
son Of	<input type="text" value="unknown"/>																
wife Of	<input type="text" value="unknown"/>																
husband Of	<input type="text" value="unknown"/>																
Belong to Family	<input type="text" value="unknown"/>																
Other Info	<input type="text" value="unknown"/>																
Note	<input type="text" value="unknown"/>																

[Add Data](#)  
[Delete Data](#)  
[Query Data](#)  
[Edit Data](#)  
[Display Database](#)  
[Back to Main](#)

Figure 30: Editing data

To display all of the information in the database, click on the “Display Database” link, and a screen similar to the one below will appear.

Hello WPI developer !  
[Logout Database](#)

### Tombstone Information Table.

number from map	first name	last name	middle name	birth month	birth date	birth year	death month	death date	death year	age	mother of	father of	son of	wife of	husband of	belong to family	other info	note
35	Jane	Greenwood	Kneeland	unknown	unknown	1845	unknown	unknown	1897	52	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
36	Nathan	Greenwood	Henry	unknown	unknown	1843	unknown	unknown	1901	58	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
37	Henry	Hall	S.	unknown	unknown	1829	unknown	unknown	1904	75	unknown	unknown	unknown	unknown	Alice E. Hall	unknown	unknown	unknown
38	Alice	Hall	E.	unknown	unknown	1829	unknown	unknown	1919	90	unknown	unknown	unknown	Henry S. Hall	unknown	unknown	unknown	unknown
39	Solemon	Dwinnell	unknown	unknown	unknown	1784	July	10	1867	83	unknown	unknown	unknown	unknown	Mary Dwinnell	unknown	Mary died August 9, 1871 at age 82	

[Add Data](#)  
[Delete Data](#)  
[Query Data](#)  
[Edit Data](#)  
[Display Database](#)  
[Back to Main](#)

Figure 31: Displaying data

Finally, there is another page that will be shown when the user has made an error. This error message page will tell the user the reasons why their previous operation failed according to what their last operation was.

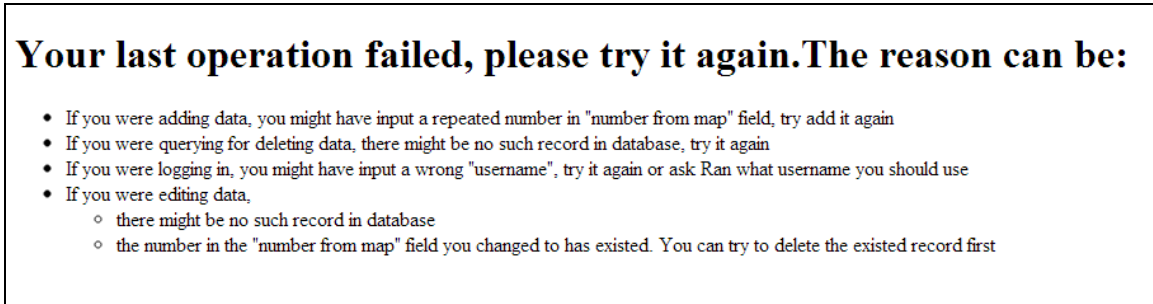


Figure 32: Error message

#### 4.1.4 Methodology for Renaming the Default Images Names

##### 4.1.4.1 Goal:

To rename the tombstone images' default names given by the camera so that the interactive map website will retrieve the right tomb stone image from the server. The new names for the pictures reference an ordered pair for an x-y coordinate system that associates the picture with its proper tombstone on the interactive map.

Prerequisite:

A excel sheet with the following information:

Numbers on the stone	Default names by camera	New names for picture	Team member to rename
1	DCSN3267	279_316	Adam
2	DCSN3268	281_308	Adam
3	DCSN3273	282_301	Adam
4	DCSN3275	283_295	Jeff
5	DCSN3277	282_287	Jeff



6	DCSN3295	282_274	Jeff
7	DCSN3293	269_248	James
8	DCSN3289	256_289	James
9	DCSN3291	189_320	James
10	DCSN3287	177_319	Fred
11	DCSN3285	170_318	Fred
12	DCSN3283	155_318	Fred

#### 4.1.4.2 Method:

1. Upload images of the tombstones to a file sharing website, such as Drop Box, after completing the site work so that the entire team has access to the files.
2. Download the images from the website and save them to the computer.
3. Rename the images to the new name provided.
4. Correct the direction of the image. (Demonstrated in the figure below. The program is the default windows program called Windows Photo Viewer)

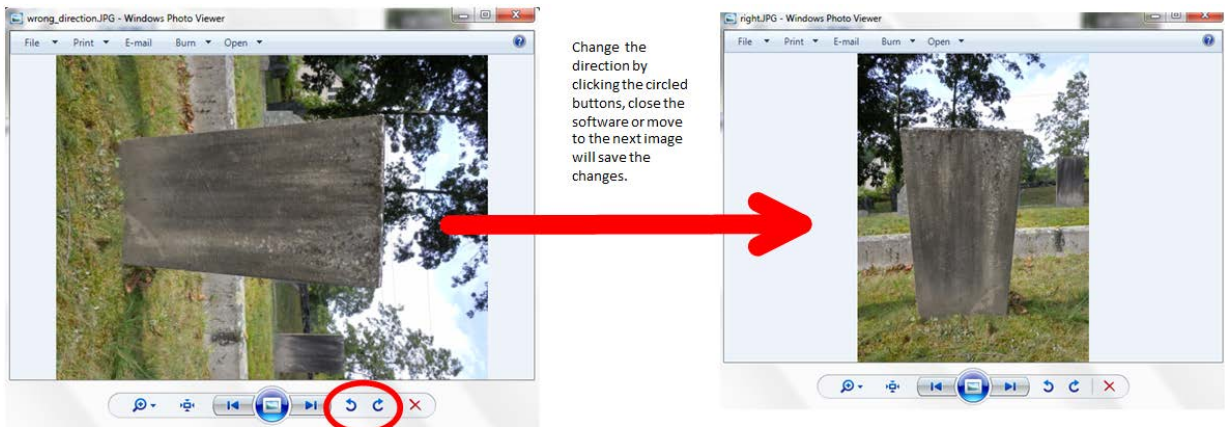


Figure 33: How to change the direction

5. If the image has people in it, edit them out as much as possible to just leave the tombstone in the image. Illustrated below.

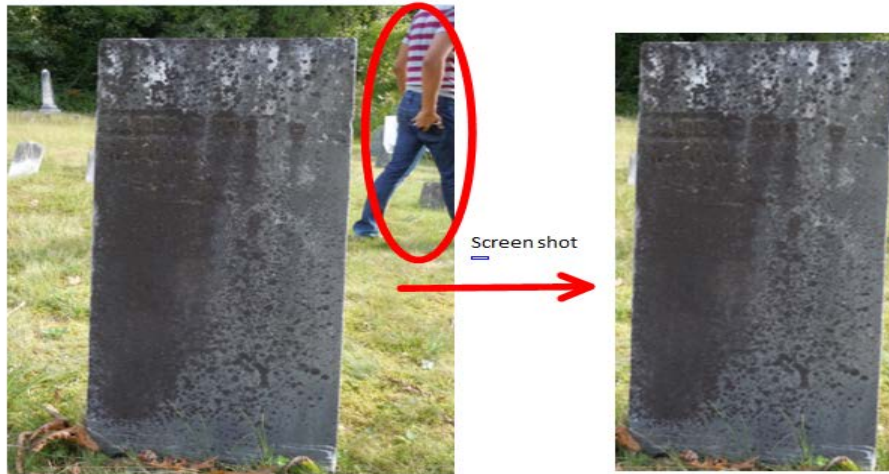


Figure 34: screen shot to filter out the people

6. Check the renamed images after renaming them to make sure that the information on the actual tombstone, like the names and the dates, correspond to the correct numbered stones.
7. Upload the renamed and edited image to a new folder in the file sharing website so that the renamed image is not confused with the old one.
8. After determining that the original images are no longer needed, the original images can be deleted to save space of the file sharing website.

#### ***4.1.4.3 Common errors:***

1. Rename the file directly in the file sharing website.
  - a. If there are errors when renaming the file, it is hard to recover and the original image is needed again.
  - b. Two editors may have a conflict when they accidentally rename the same image.
  - c. The file sharing website does not show the true orientation of the image (which might need to be edited).

2. Forget to correct the direction of the images. Images that were taken vertically by the camera are shown horizontally. This will result in a wrong orientation of the pop-up image in the interactive map.

## Chapter 5: Conclusion

### 5.1 Project Recap

This project sought to document two inactive graveyards in Millbury, Massachusetts and create an interactive online map detailing both sites. While both cemeteries were initially surveyed, only Dwinell Cemetery was documented for the final report. Ground-penetrating radar was used to ground proof Dwinell Cemetery. Based on the findings of the radar, the results were inconclusive so as to determine whether bodies remained interred in the graves or if they had decayed over the large period of time. This made it impossible for the team to conclude definitively if and where there may have been any free space, which was one of the initial reasons behind the radar work. Following this, the group researched the people interred in Dwinell Cemetery and other methods of burial. Prominent members of the community were noted here in the report. Finally, the results were compiled into an online database that utilized an interactive map of the cemetery. The website is open to the public, as is this project report.

### 5.2 Advice and Recommendations for Future Teams

At Worcester Polytechnic Institute, it is a common occurrence for new projects, whether Interactive Qualifying Projects such as this one or Major Qualifying Projects done during senior year, to continue over the course of several school years. In light of this, it is highly possible that this project will become a “legacy project,” or one that will be built upon in the coming years. Hence, the project group deemed it sensible to give future groups advice about what the group learned and would recommend for future iterations of the project.

The team learned much over the course of the 21 weeks for which this project lasted. One thing learned about the group itself was that it was highly beneficial to have a group of students studying different disciplines of science and engineering. This allowed each student to bring their

own thoughts, perspectives, and skills to the project, which ended up making it more successful. For example, without a computer science major it would not have been impossible to create the website with the database and interactive map.

The IQP project group also learned several things about the project process as well. It is important to write during the entire project opposed to all at the end. Doing this allowed the group to maintain detailed accounts of the different methodologies used for different aspects of the project. This also enabled the group to come back later to the write up and edit and change it after reflecting upon it. Thus, starting the writing as soon as possible is highly recommended. Furthermore, the group's weekly meetings and deadlines enable the team to finish the write up early and allowed for more time to edit the final result.

For specifics relating to the project itself, there is much to be said. The methodologies presented here are detailed for the purpose of the average reader and future groups to easily understand the processes that were necessary for the completion of this project. That being said, time must be taken into consideration for all of the site work in particular. The team underestimated how much time taking photos of the tombstones would take, how long it would take to set up the cemetery for the radar passes, and how long the radar passes would take themselves. It is recommended to allocate several days for the preparation of the cemetery for the radar work, and to always have a contingency plan about the weather and the equipment. For example, it was necessary to measure and mark out a uniform grid pattern over the cemetery for the radar passes. This is work that could have been done in advance which would have saved the team a few hours on the day of the radar work itself. This is important given the cost of renting some of the equipment required for the radar system.

Finally, the group learned the importance of communication, especially with regards to asking questions and presenting our findings. Future groups should not be afraid to ask for help, whether it is help from librarians on the research, or help from the cemetery commission, or help from WPI alumni. Several people were instrumental in the success of this project, and it is recommended to ask for help and advice.

### **5.3 Completion of Project Goals and Problems Encountered**

This project started off with several goals and objectives. The group was recommended not to have too many, but rather to excel at fewer goals. The group took this advice and narrowed down several of the goals of the project to the ones presented here. Even so, not everything the group set out to do was accomplished. Initially, the team desired to ground-proof both cemeteries with the radar. Due to the amount of time and coordination it took to schedule and to complete the work at the Dwinell site, there was not enough time to do Providence Street, especially with the onset of winter. In addition, the results of the radar were too inconclusive to deem it worthwhile. This was partially due to the soil inconsistency which was increased by rain around the time the team was doing the site work. Also, after learning the sophistication of ground penetrating radar and the skill it requires, it was determined that the team's inexperience with such equipment was a contributing factor to the indeterminate results. Although data from the tombstones from both cemeteries were documented, only Dwinell was posted into the online database and interactive map, again due to time constraints as each of the cemeteries had roughly 170 interments. The team also had difficulty trying to comprehend what was written on some of the gravestones that had poor quality markers. For such gravestones, only some of the information was recovered by researching Millbury's historical records.

Despite all these problems, this project was successful. It broadened the perspectives of the team to different fields of work and research that have potential for future work. It demonstrated the importance of the documentation process for deaths, as well as the issue of space in cemeteries. It also revealed the benefit of making record of the findings available to the public on a public website. Although this project did not complete all of its goals, it completed its main objectives of documenting a graveyard in Millbury, addressing the space issue, and creating an interactive online map.

## References

### Chapter 2: Site Work

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### Picture Credits

Figure 1: Two types of ground penetrating radar

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## Appendix A: GPR Radar Data for Dwinell Cemetery

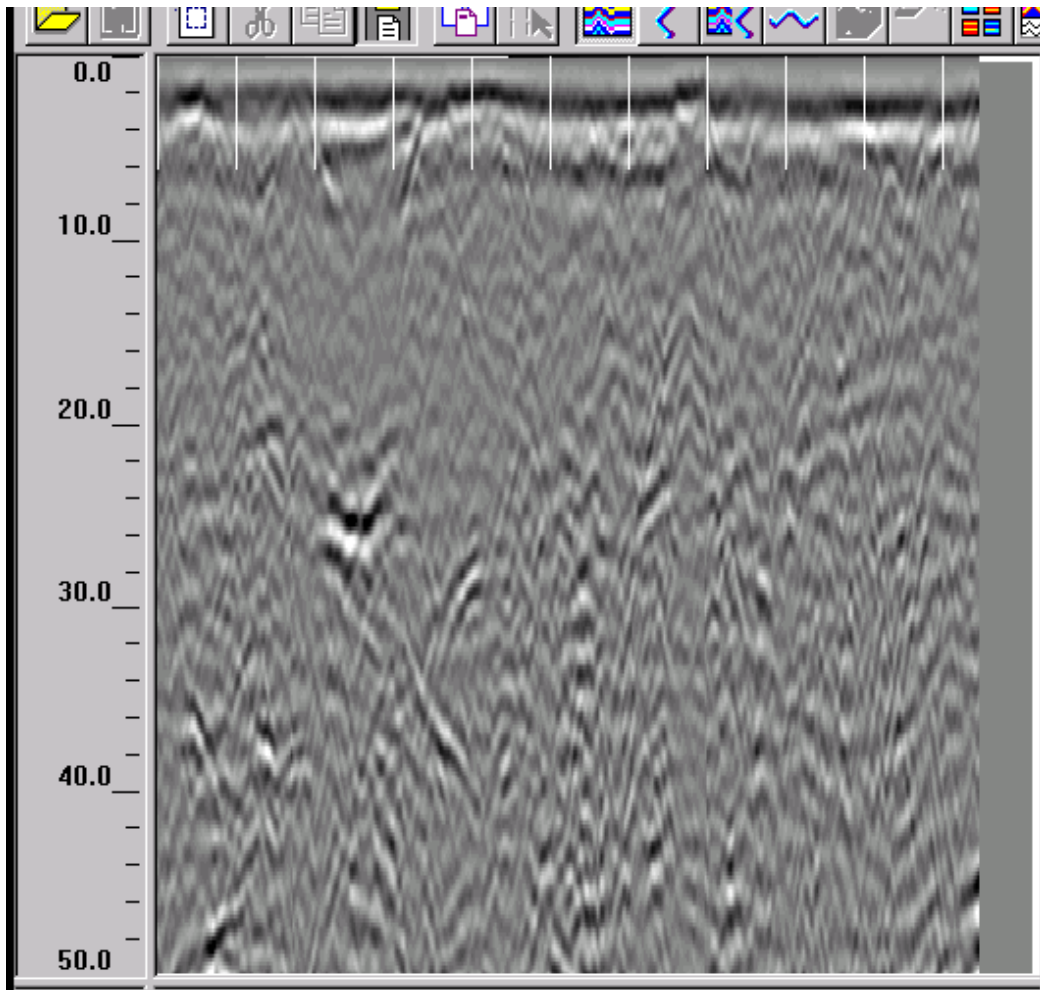


Figure 35: GPR Test Pass 1

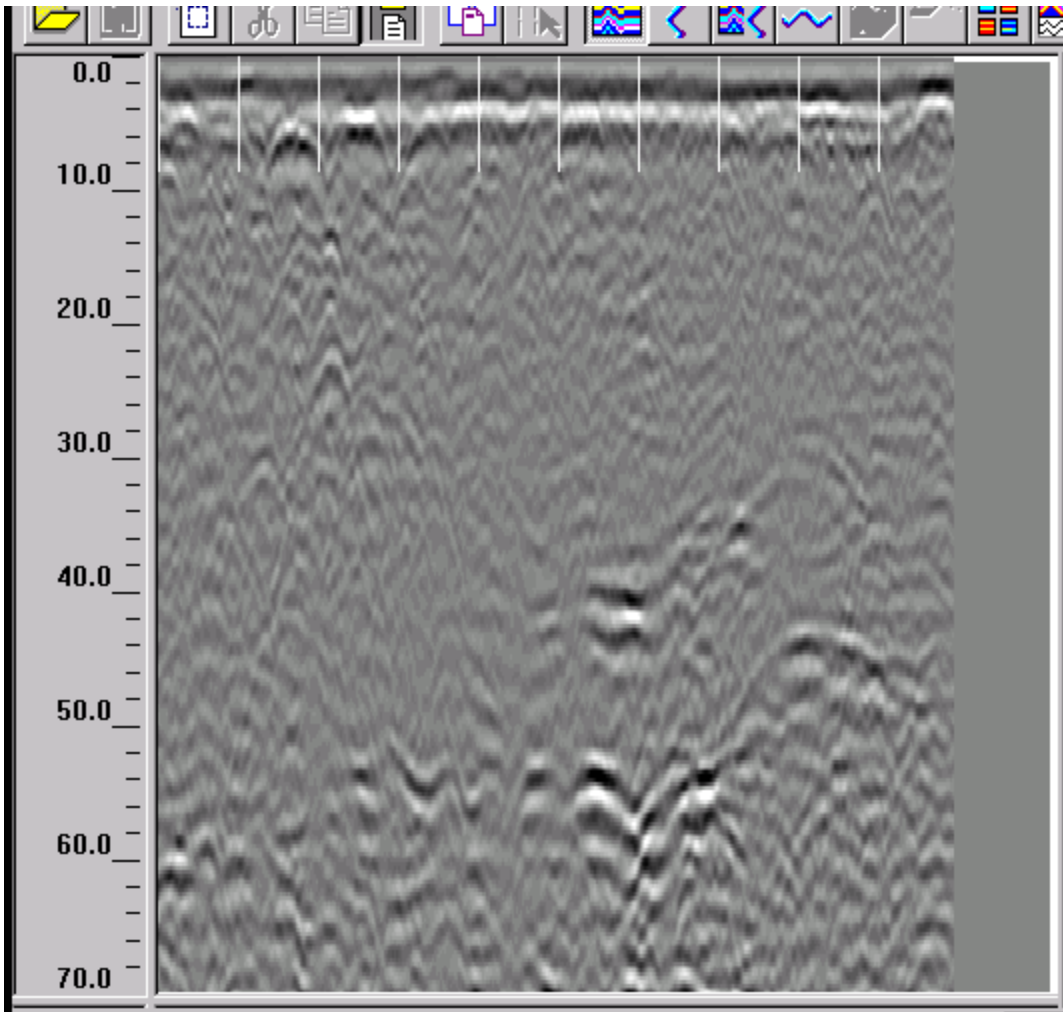


Figure 36: GPR Test Pass 2

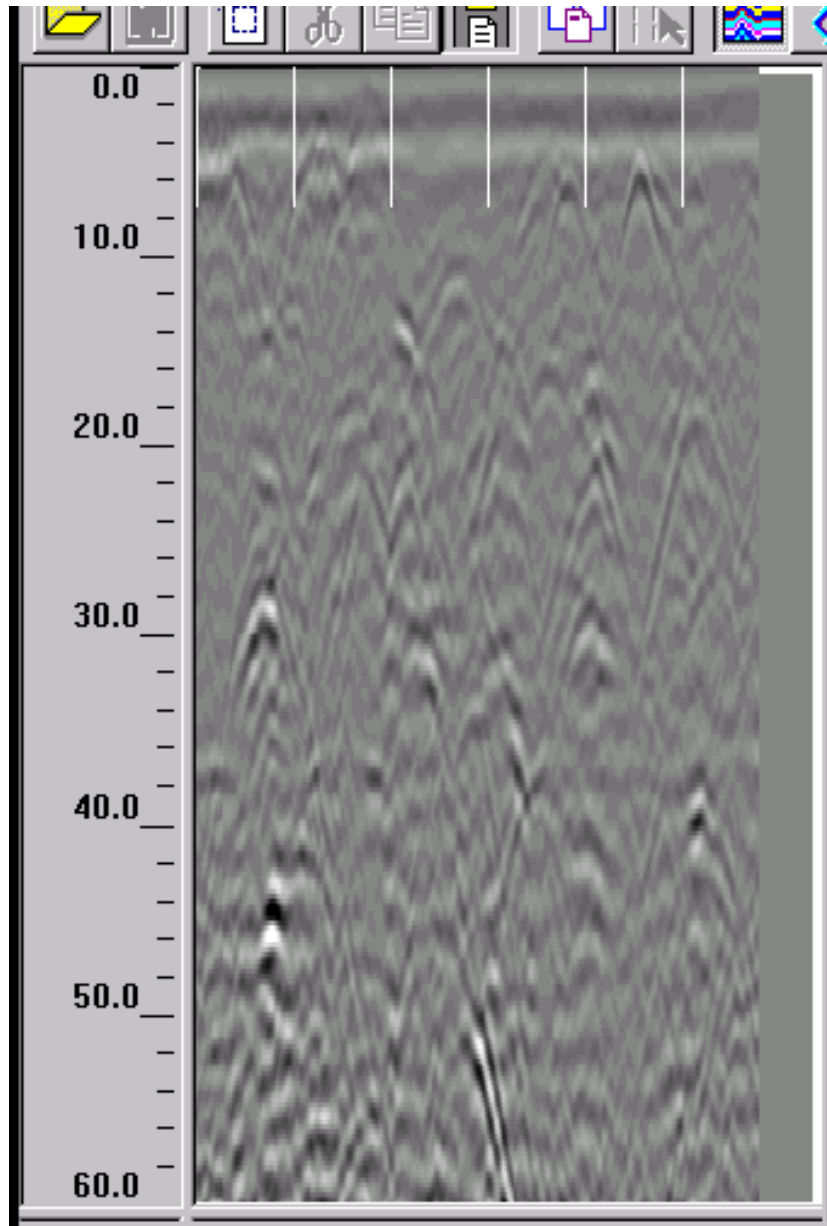


Figure 37: GPR Test Pass 3

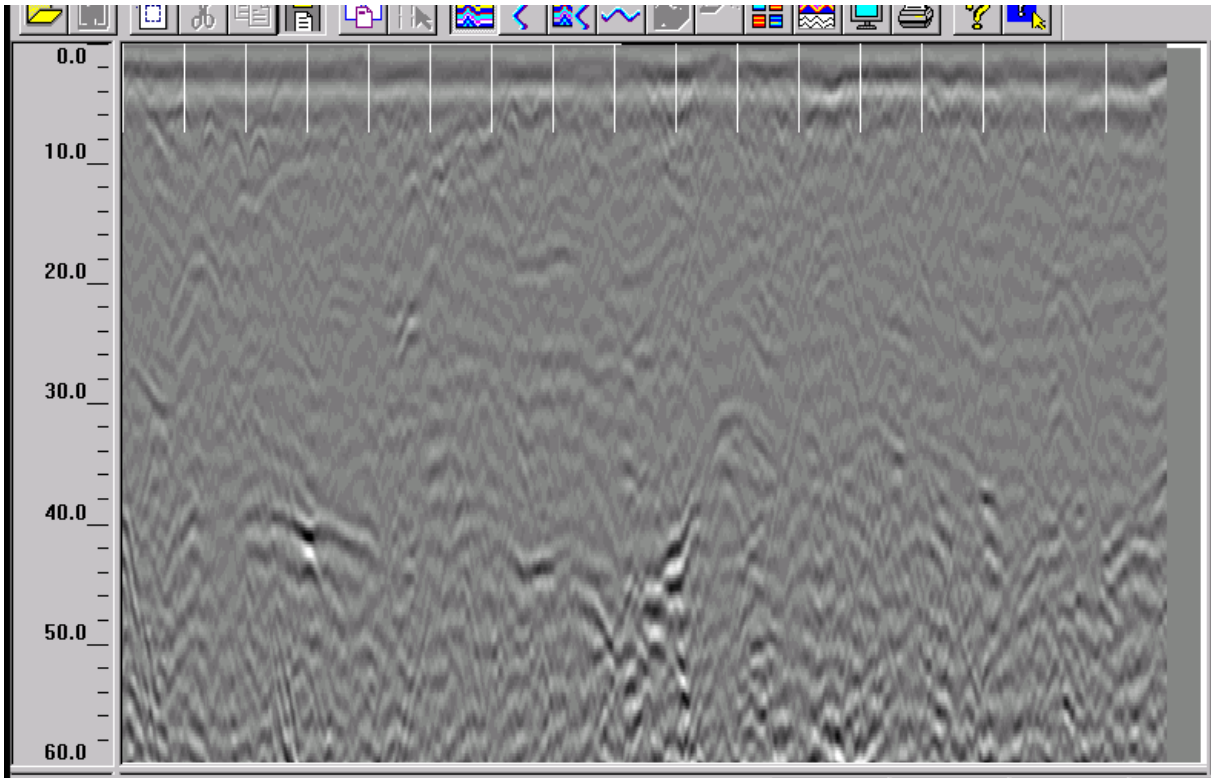


Figure 38: GPR Pass 1

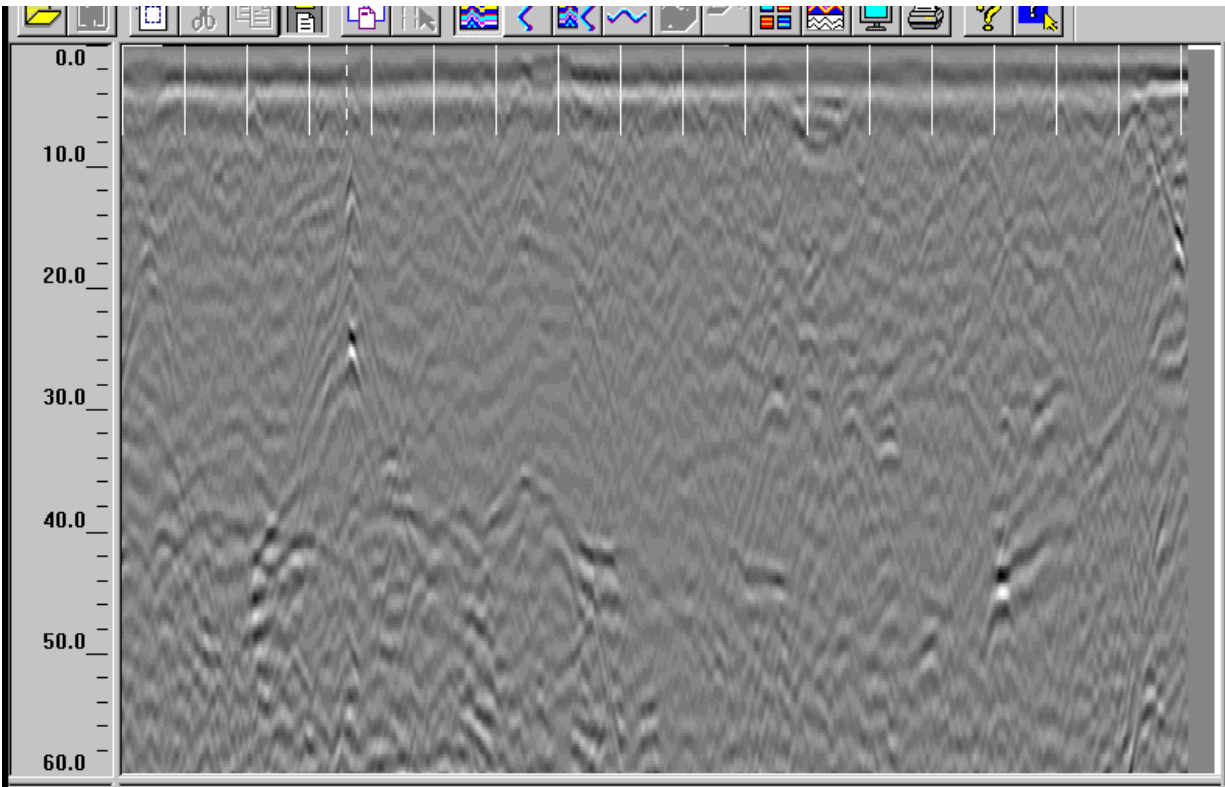


Figure 39: GPR Pass 2

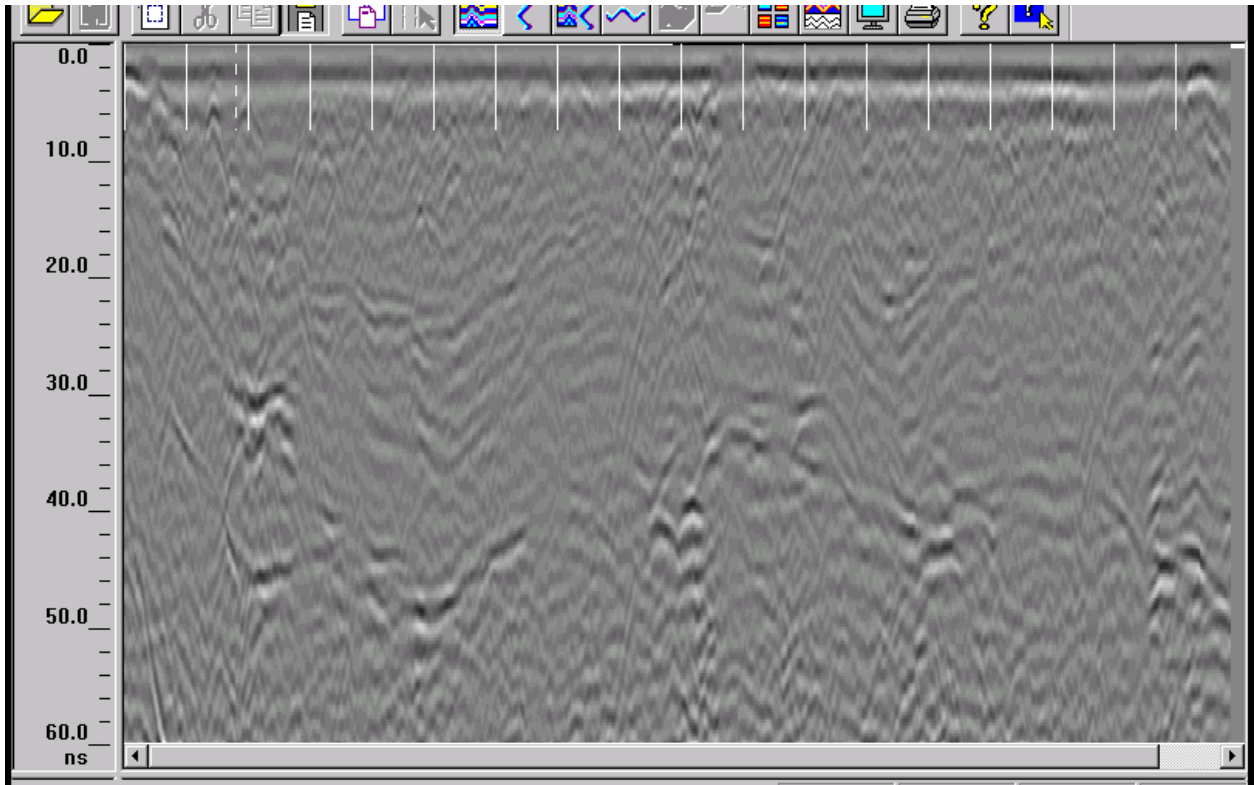


Figure 40: GPR Pass 3

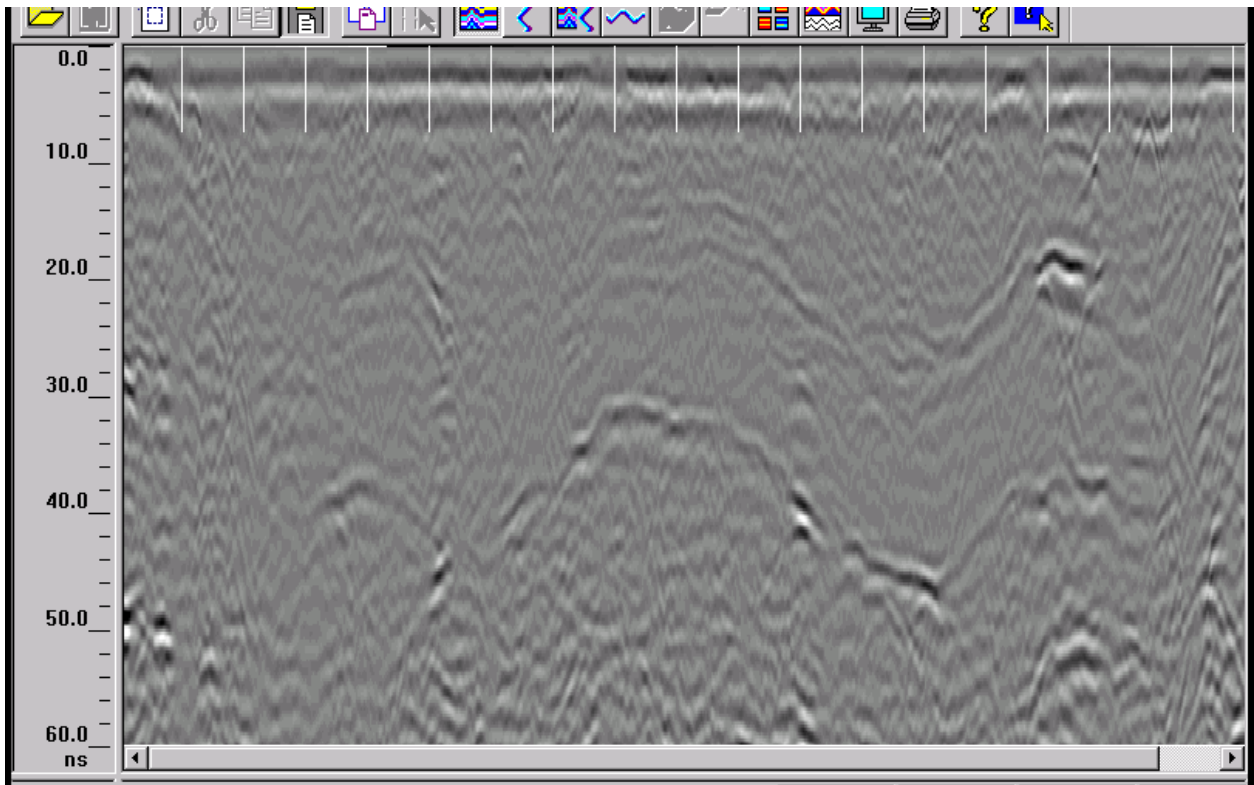


Figure 41: GPR Pass 4

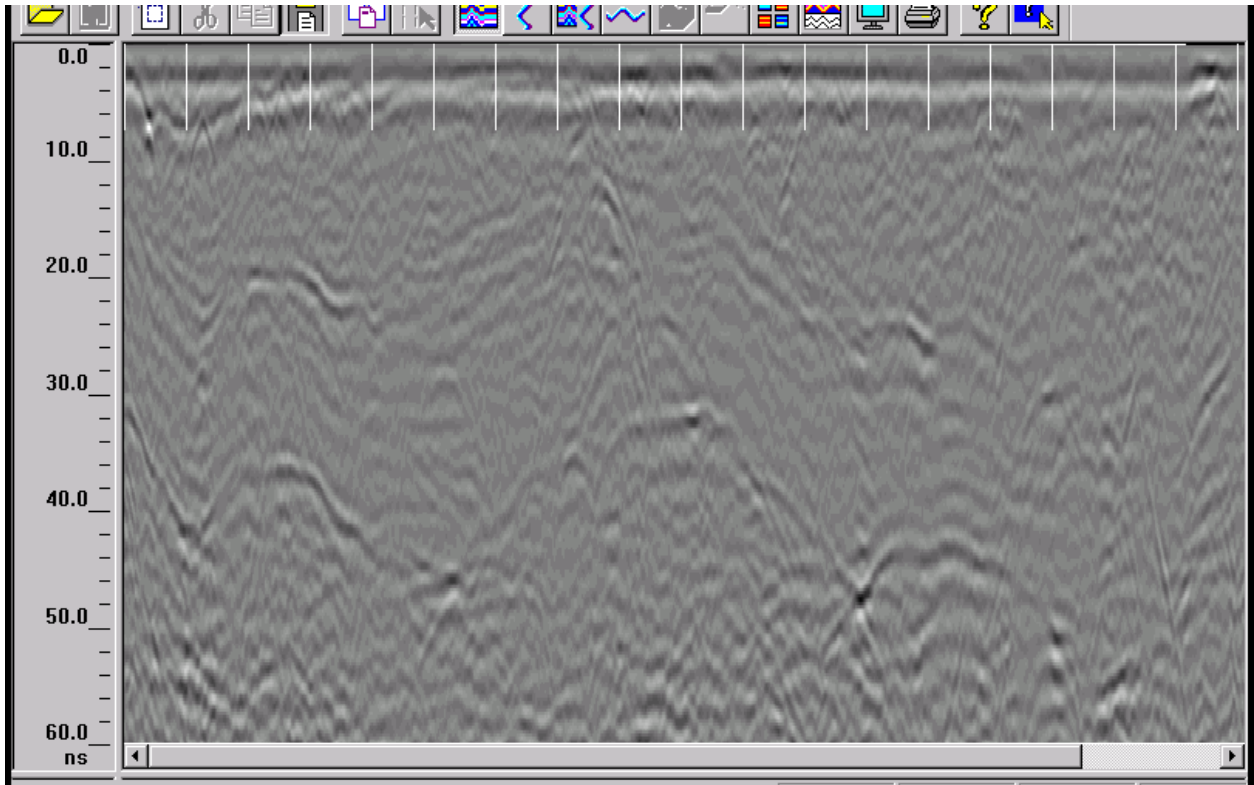


Figure 42: GPR Pass 5

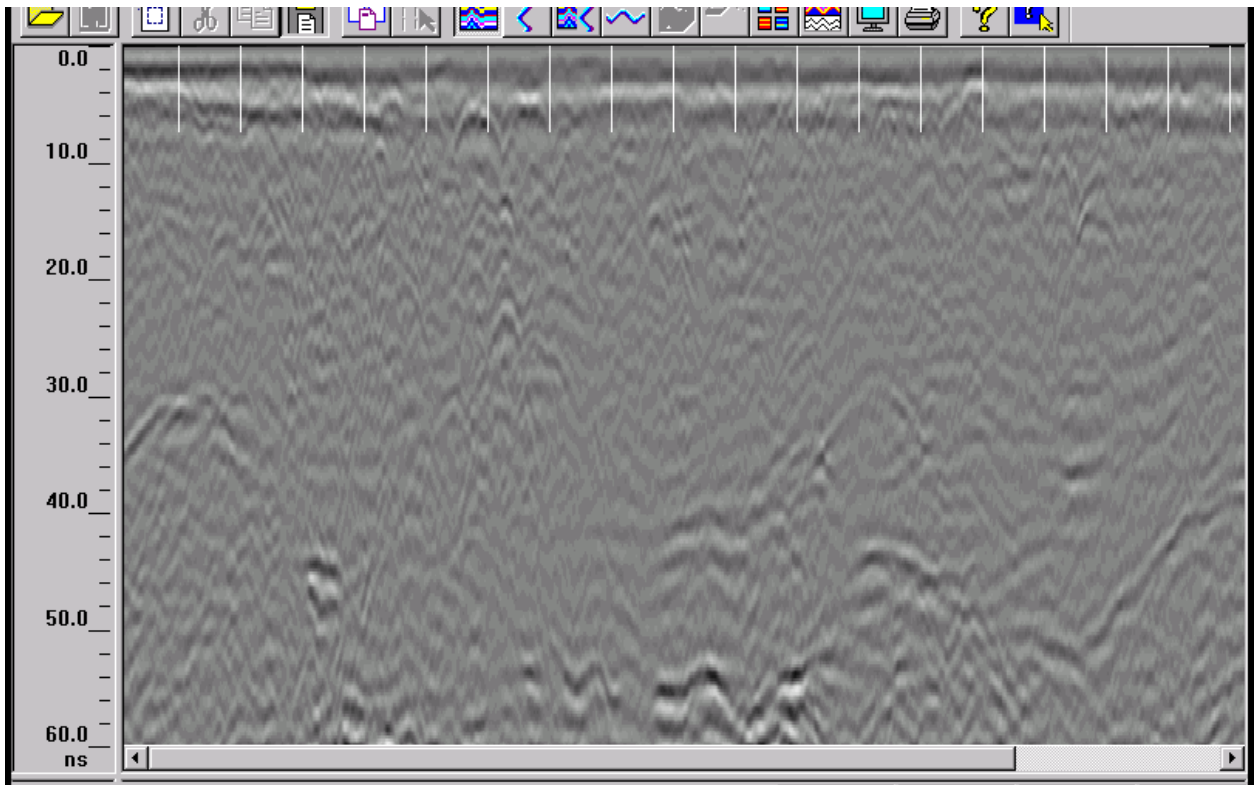


Figure 43: GPR Pass 6



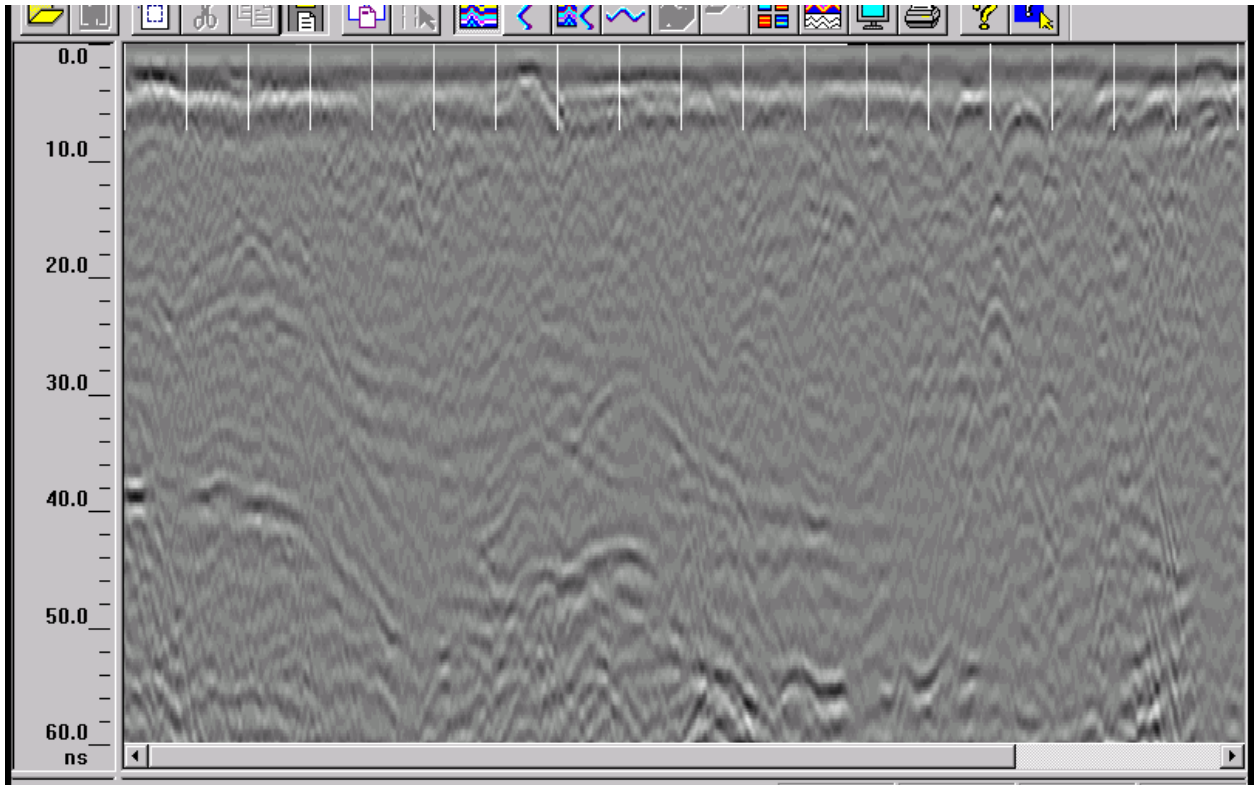


Figure 44: GPR Pass 7

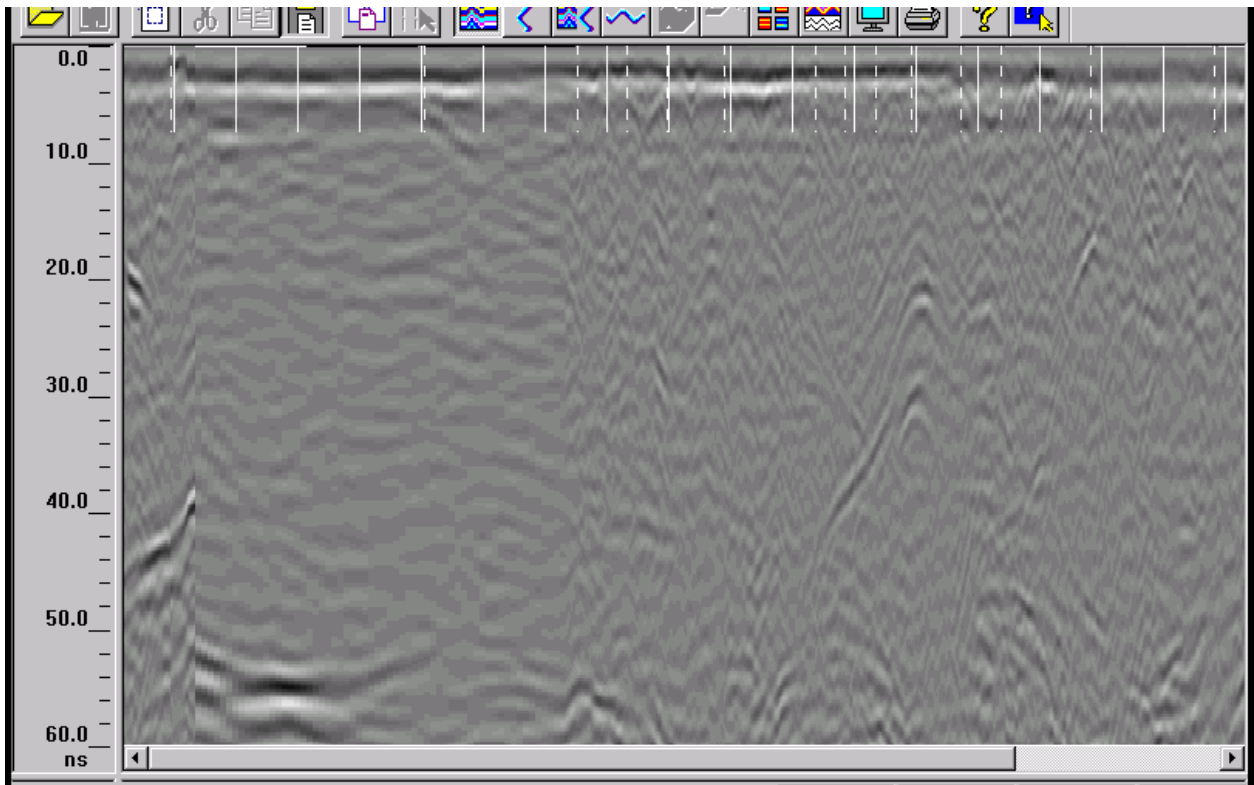


Figure 45: GPR Pass 8

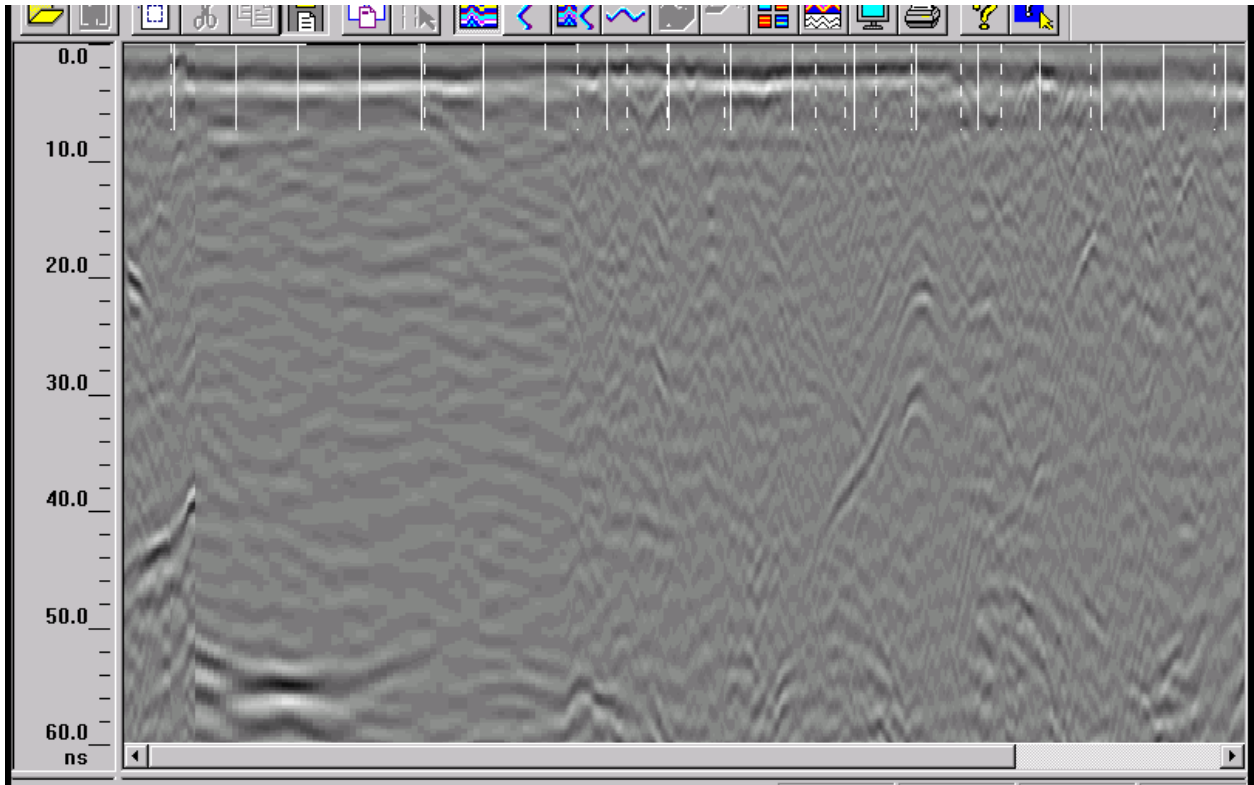


Figure 46: GPR Pass 9

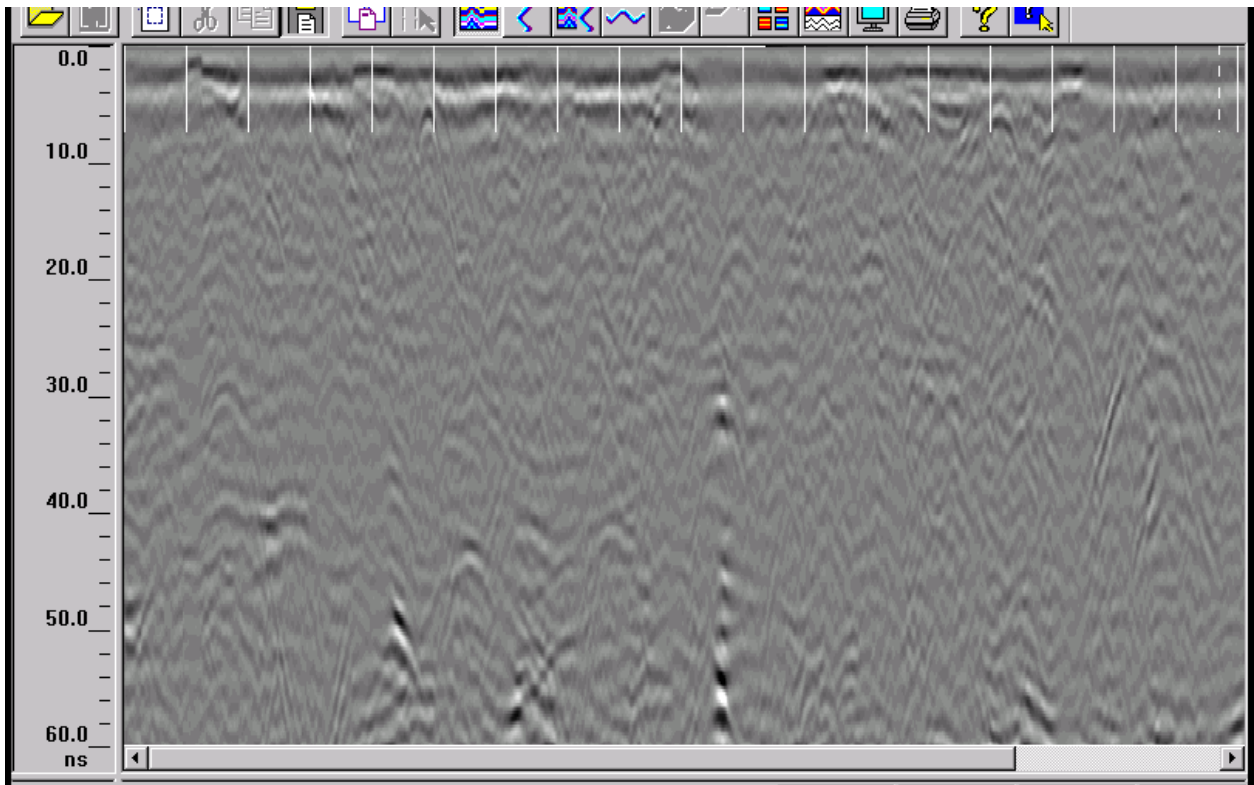


Figure 47: GPR Pass 10

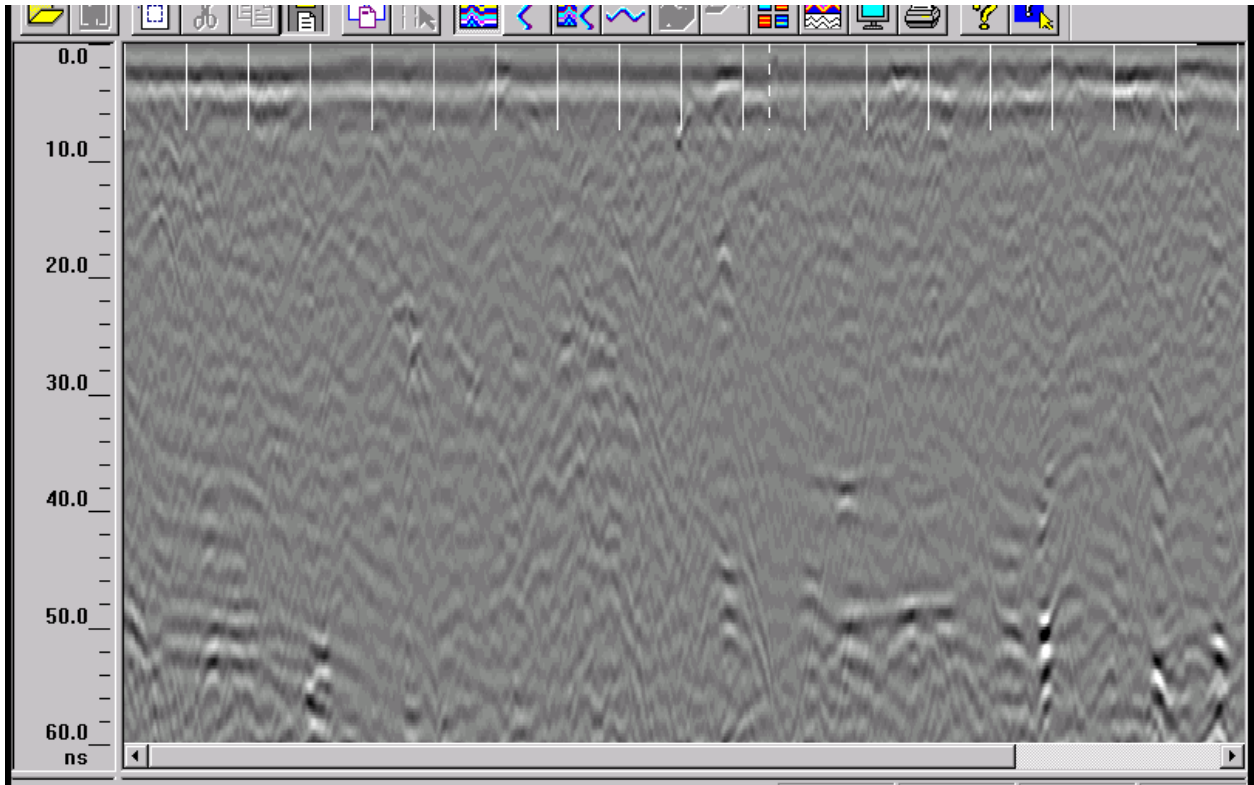


Figure 48: GPR Pass 11

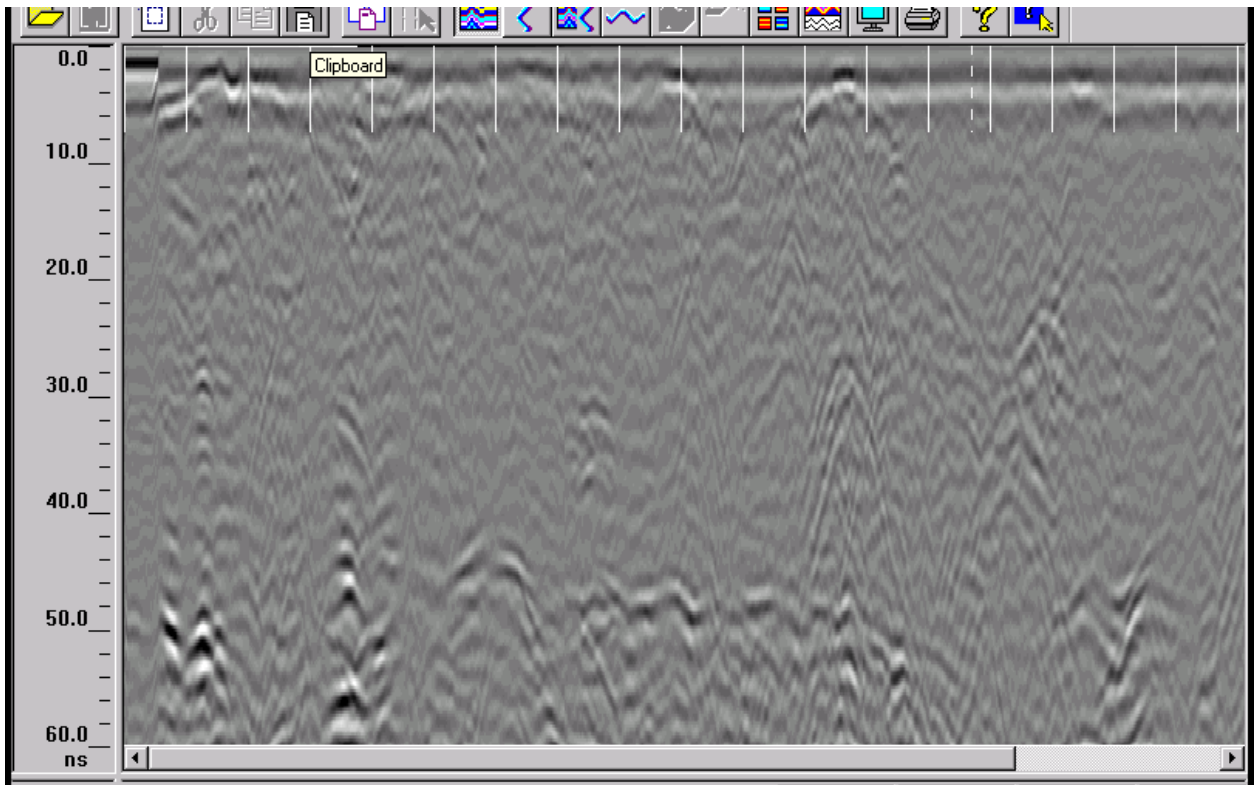


Figure 49: GPR Pass 12

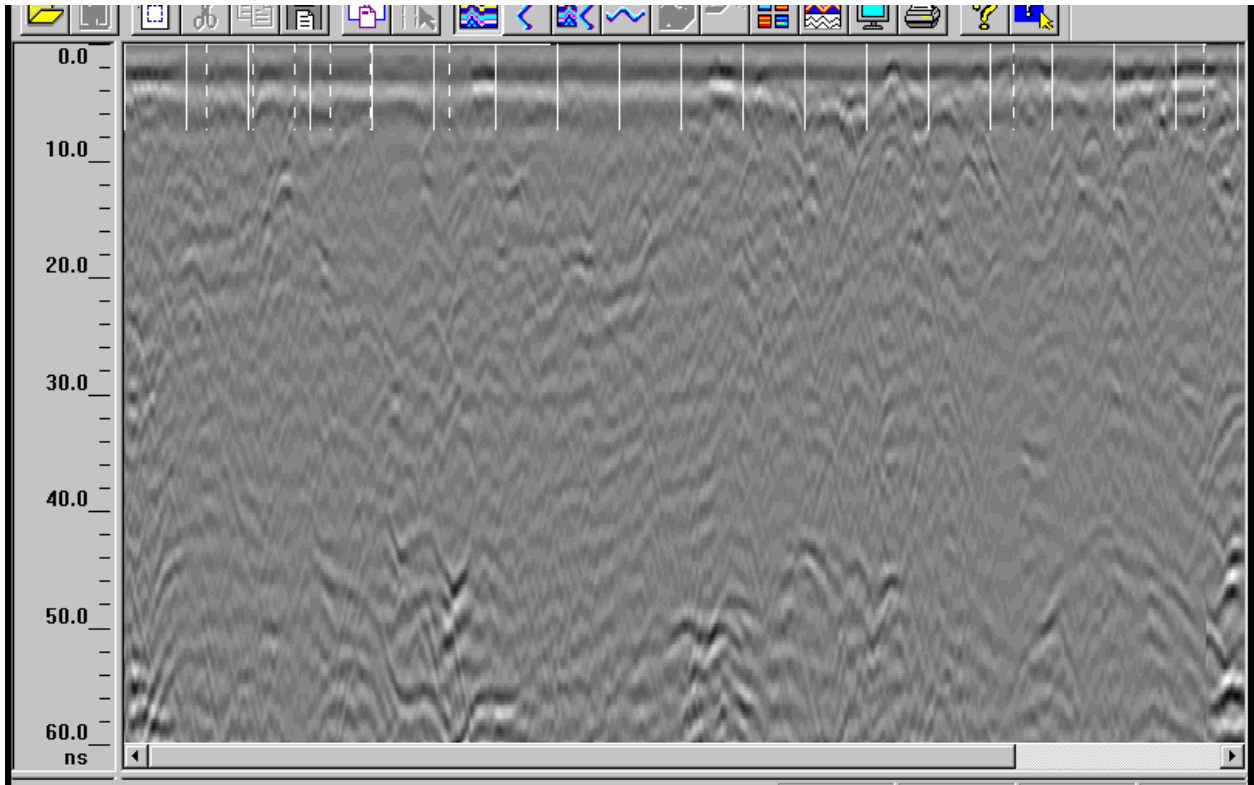


Figure 50: GPR Pass 13

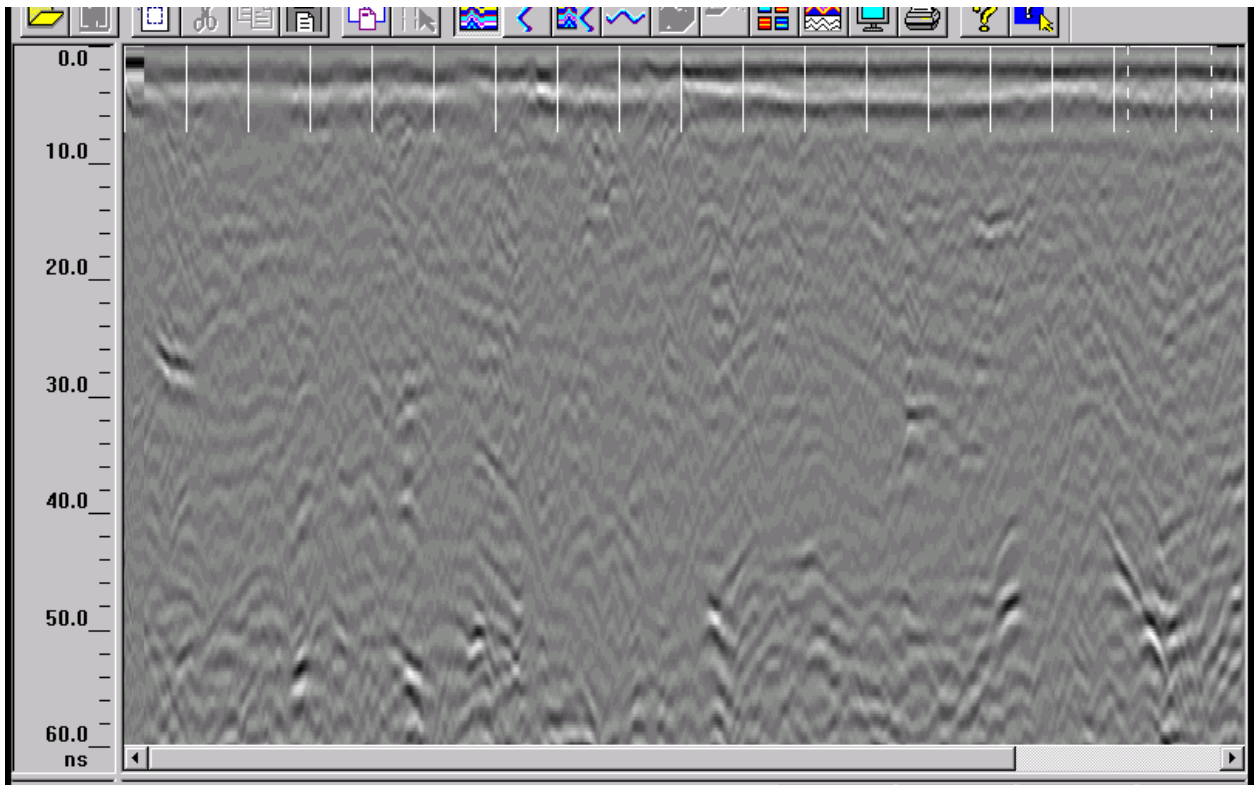


Figure 51: GPR Pass 14

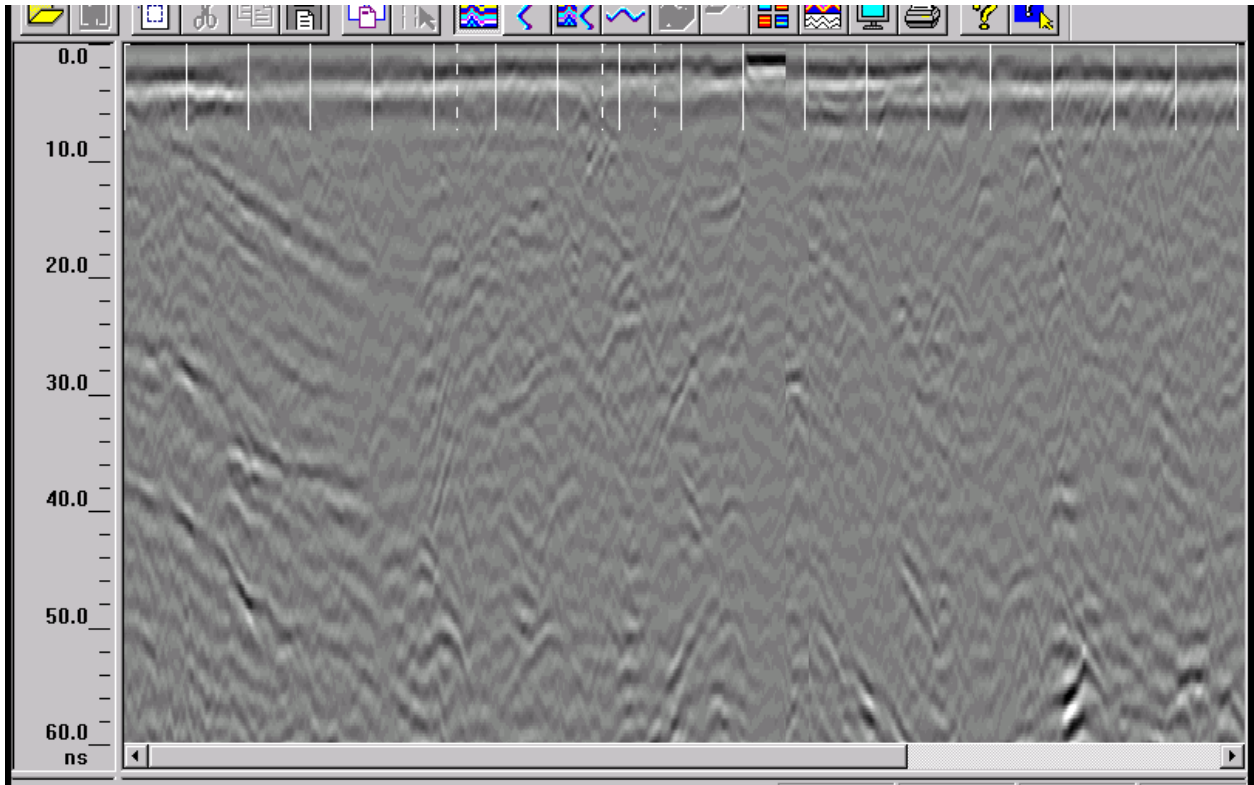


Figure 52: GPR Pass 15

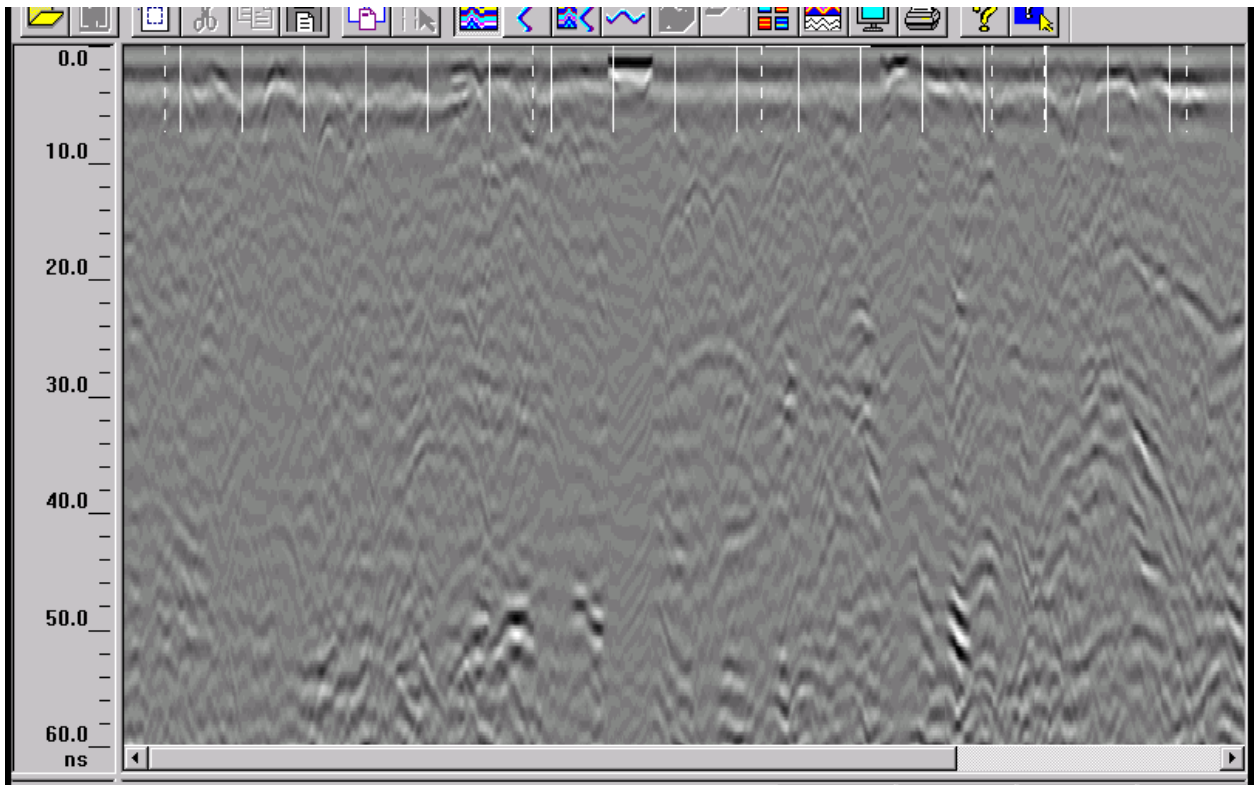


Figure 53: GPR Pass 16

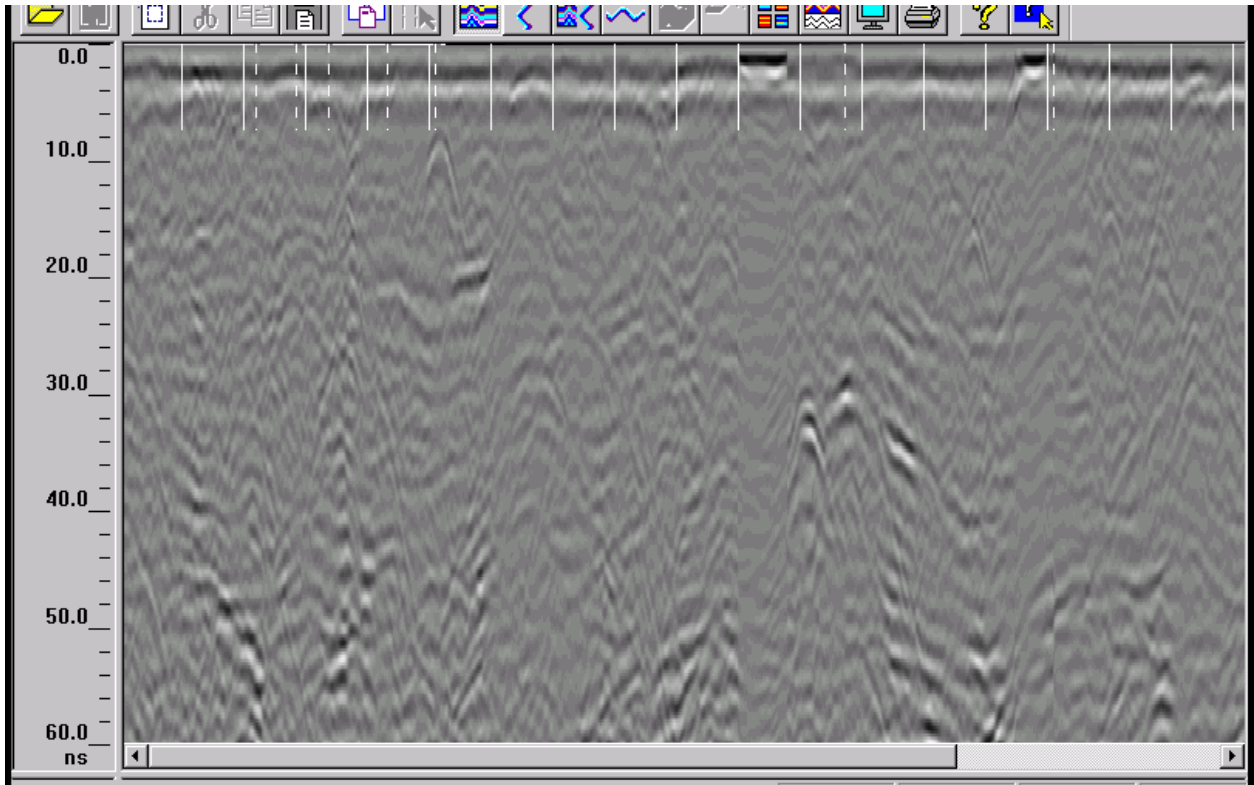


Figure 54: GPR Pass 17

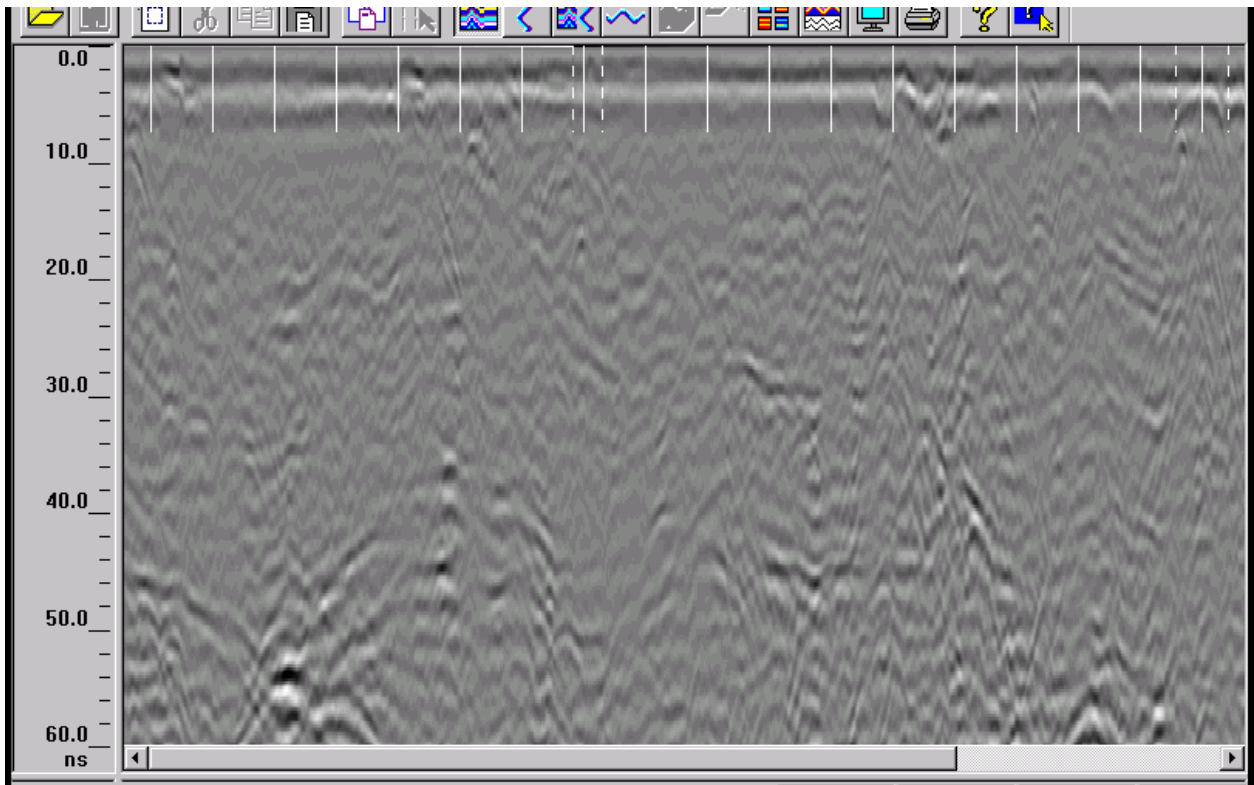


Figure 55: GPR Pass 18

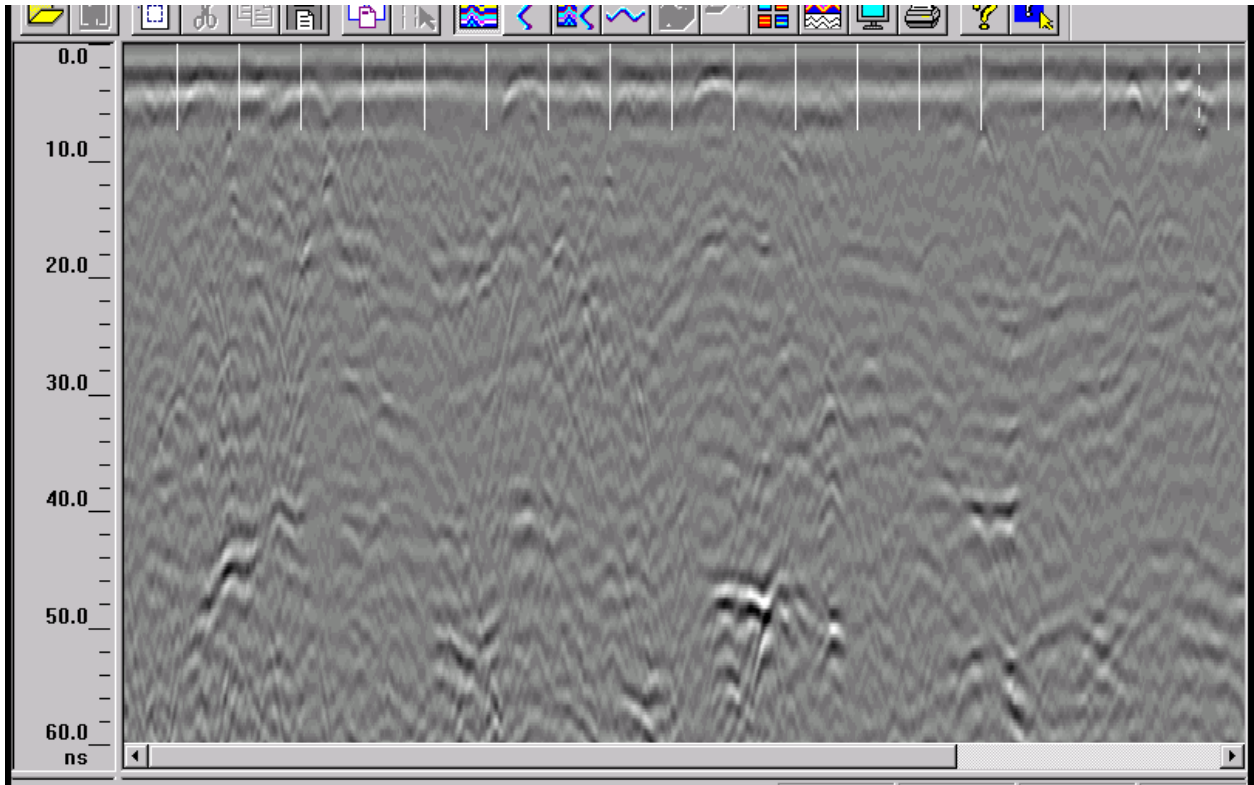


Figure 56: GPR Pass 19

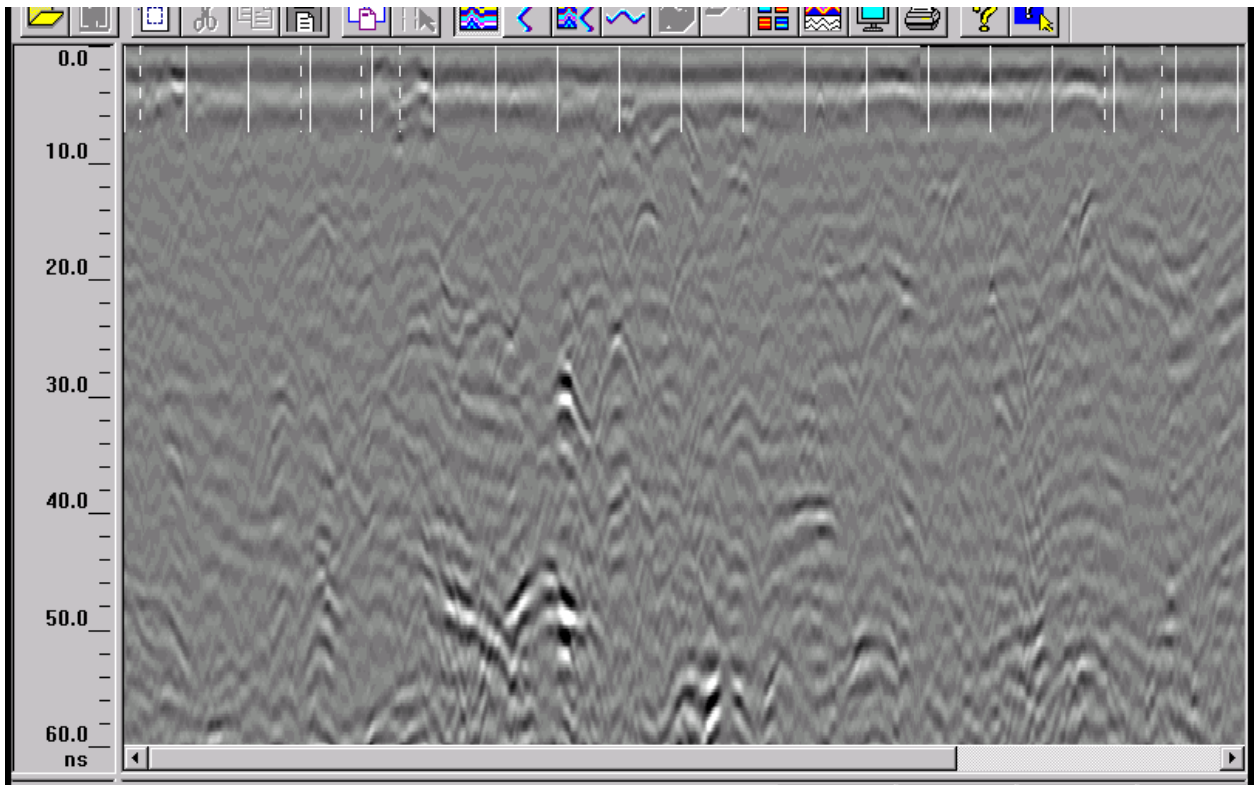


Figure 57: GPR Pass 20

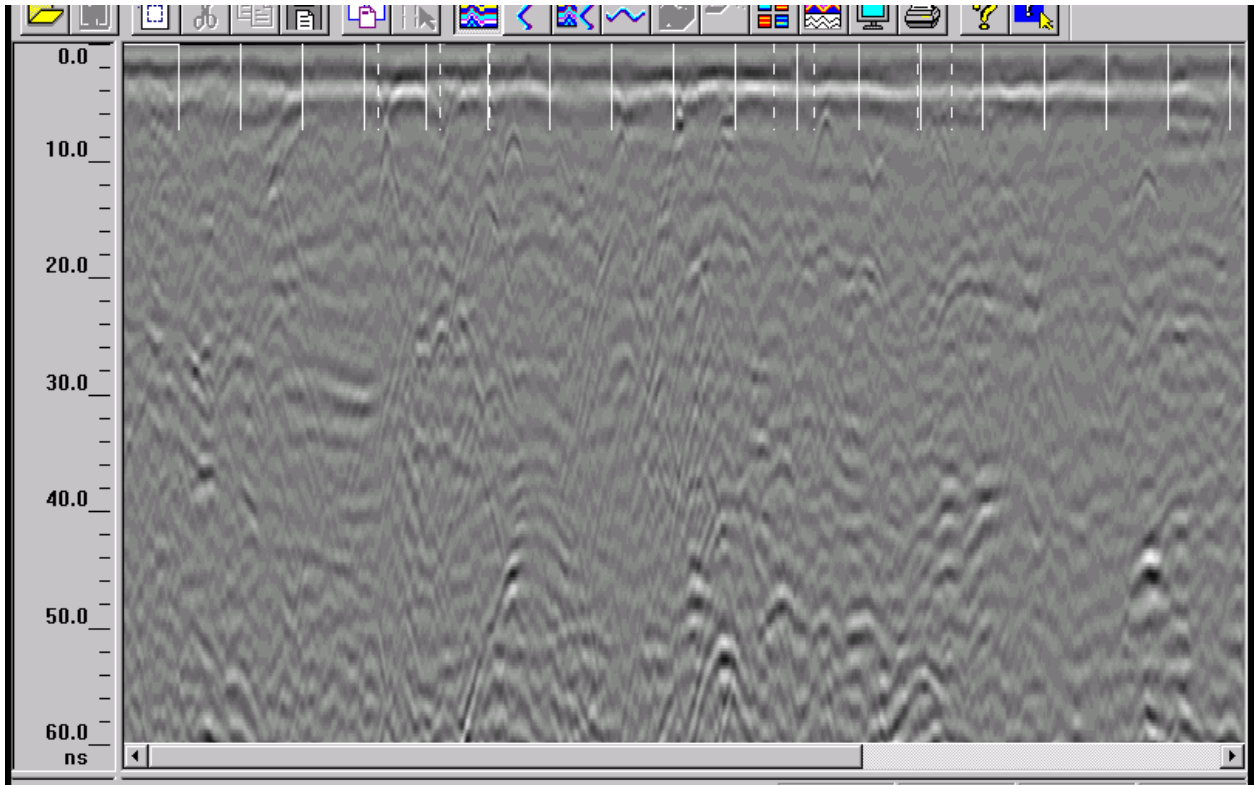


Figure 58: GPR Pass 21

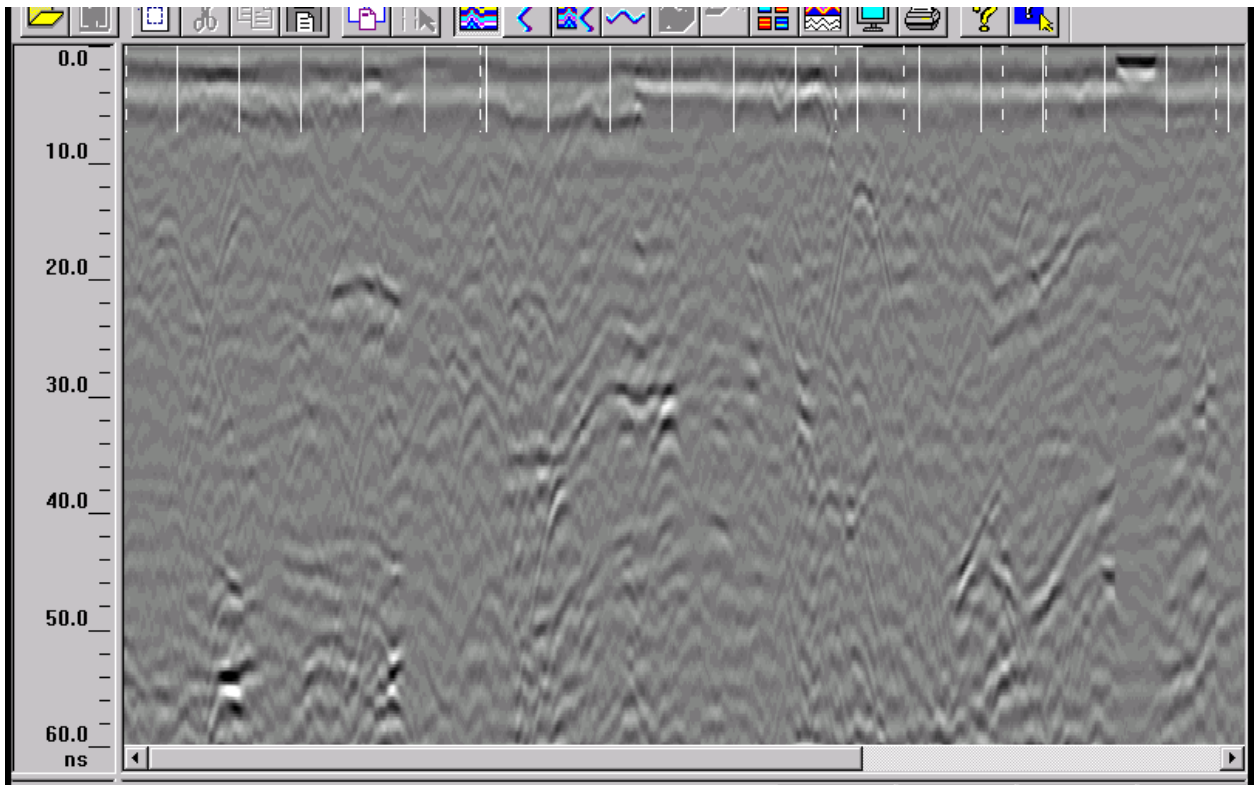


Figure 59: GPR Pass 22



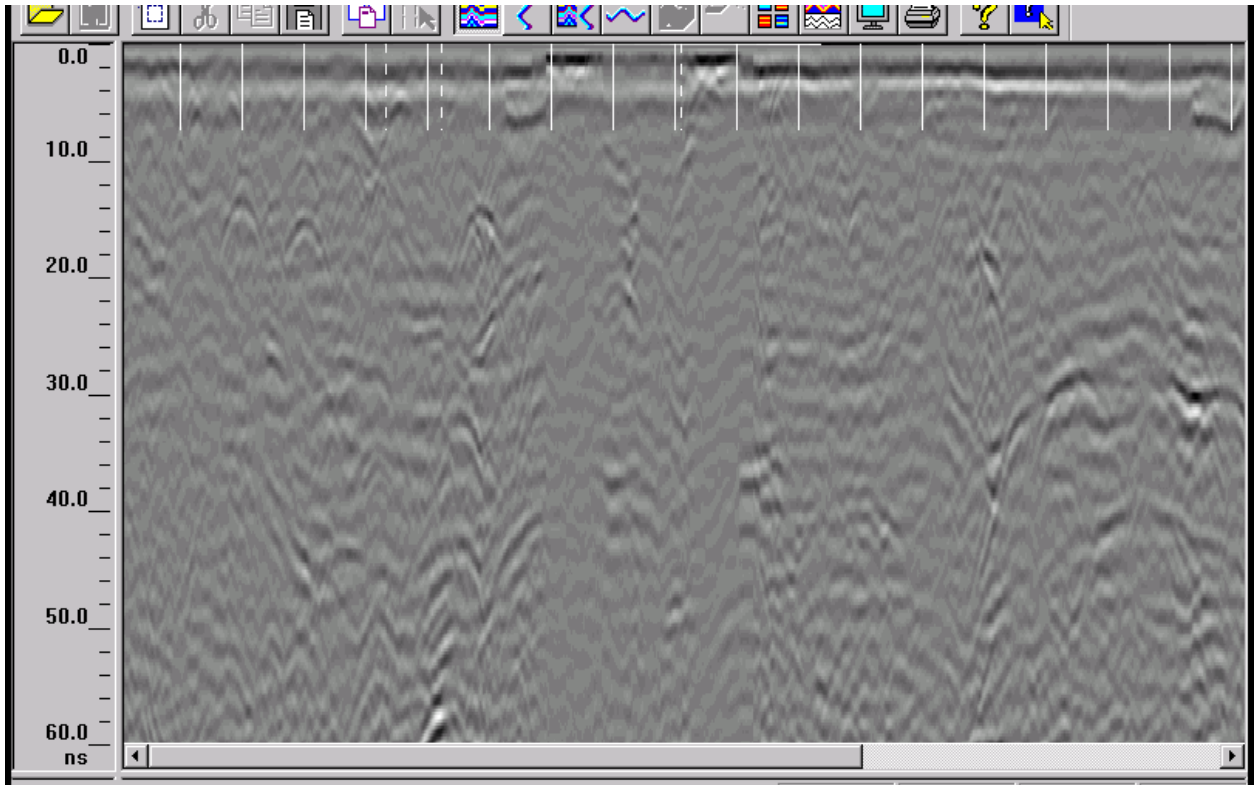


Figure 60: GPR Pass 23

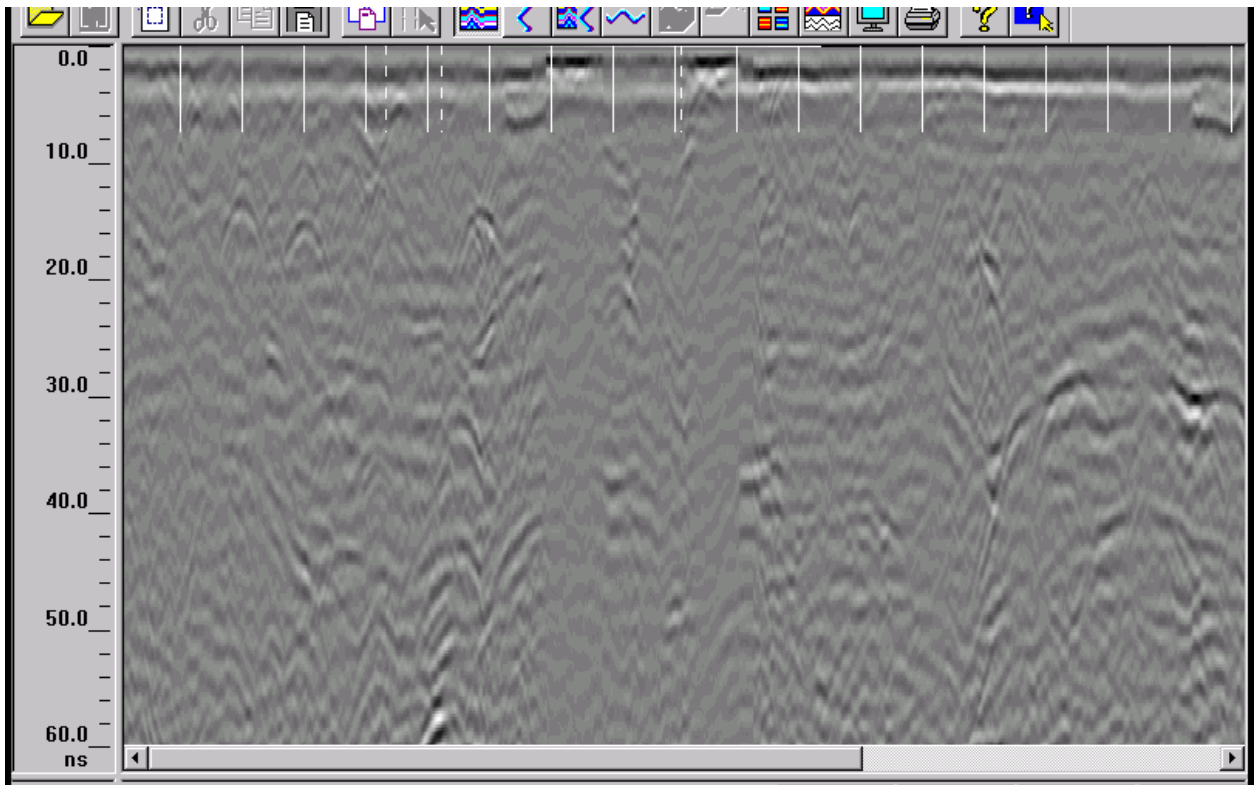


Figure 61: GPR Pass 24

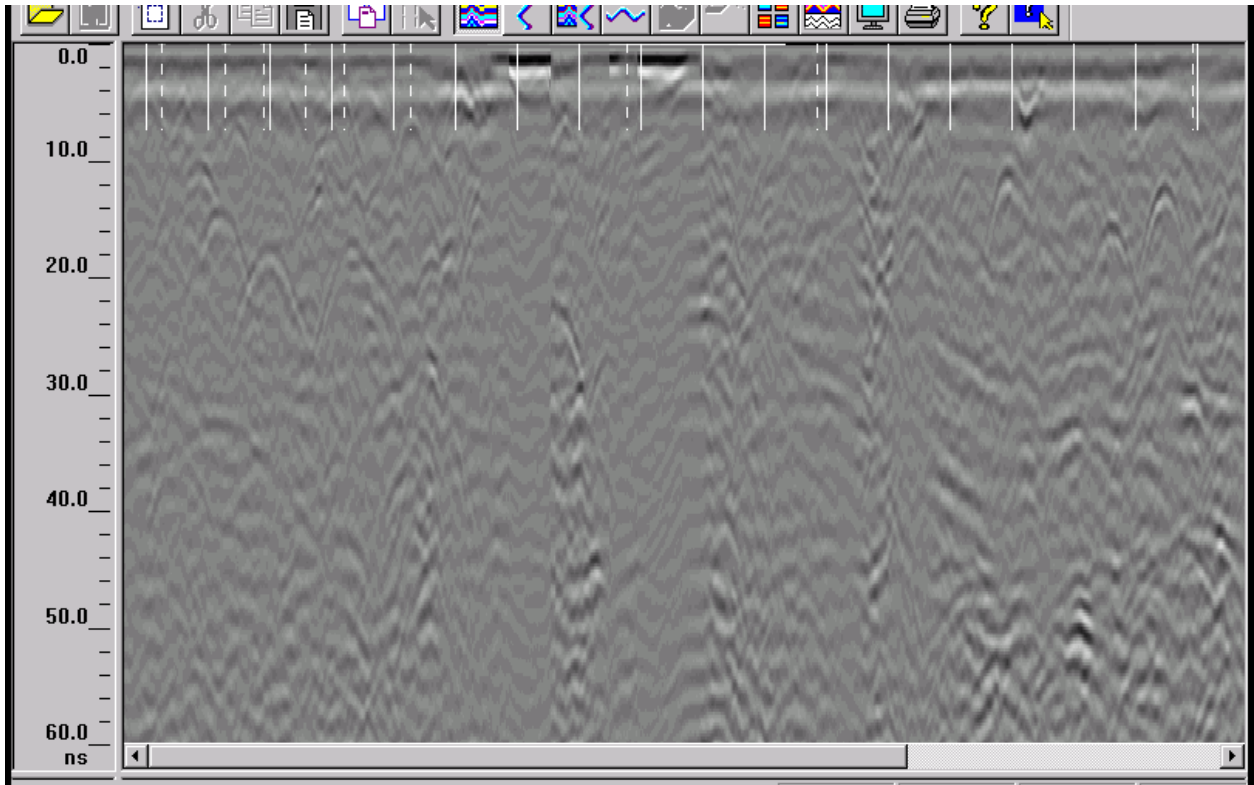


Figure 62: GPR Pass 25

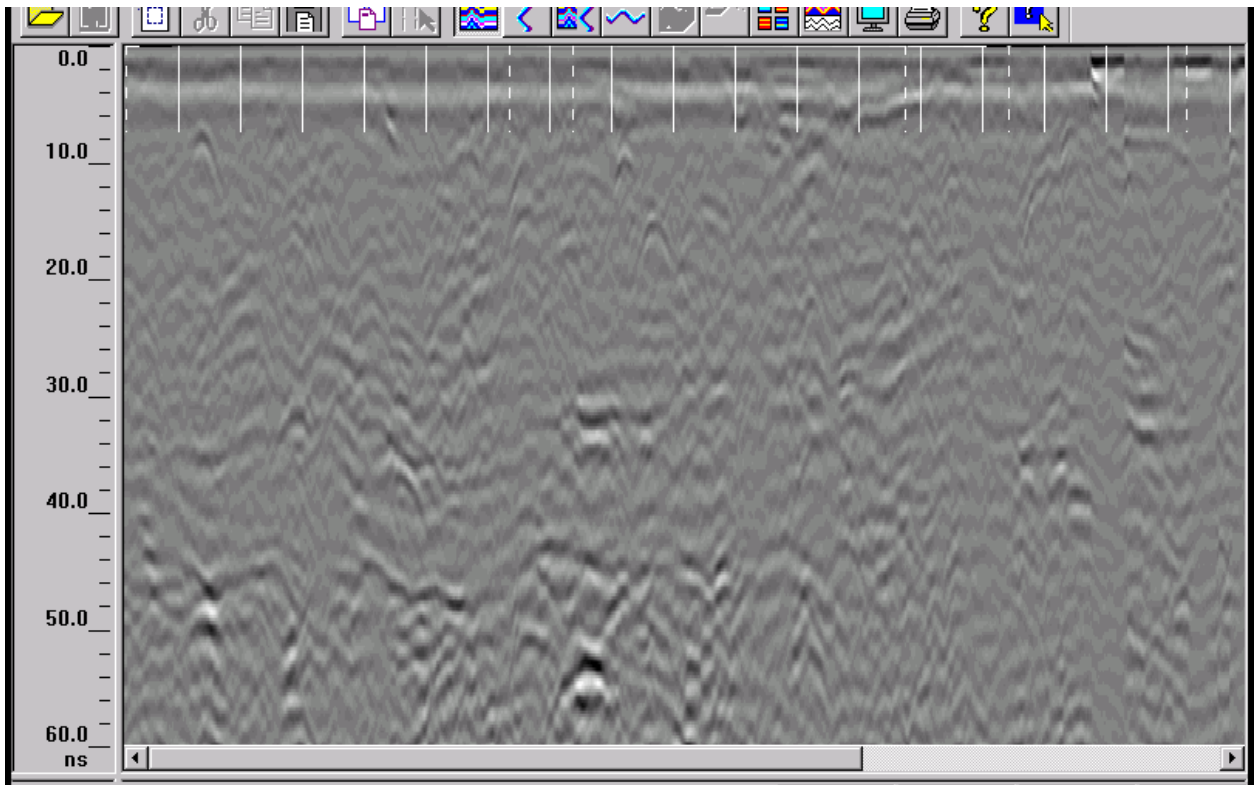


Figure 63: GPR Pass 26

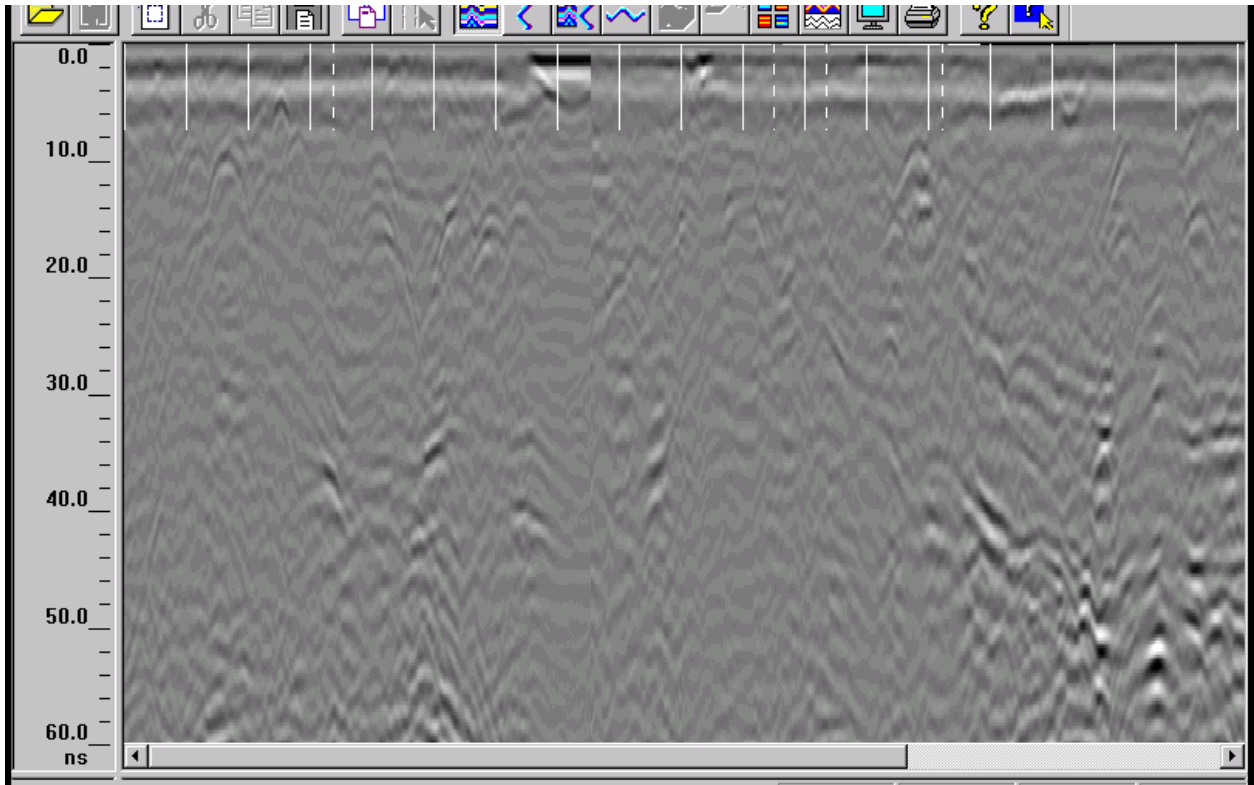


Figure 64: GPR Pass 27

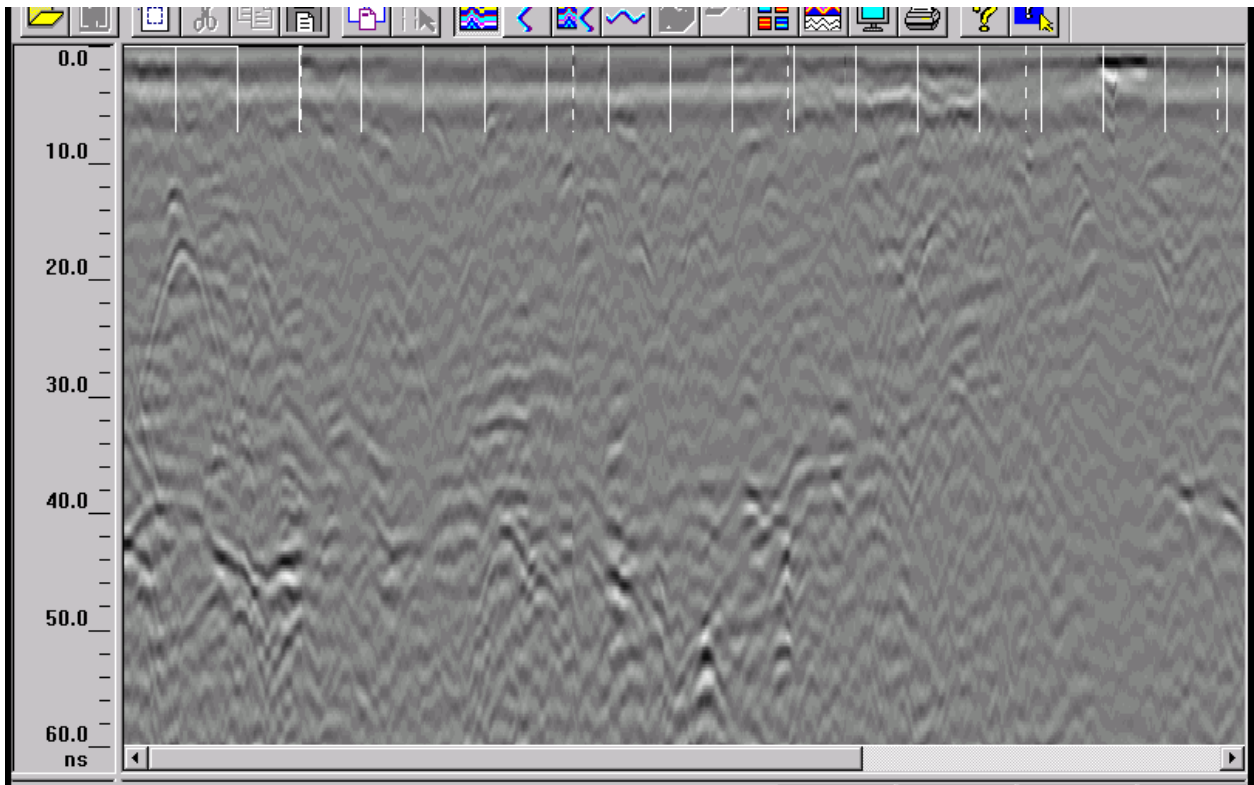


Figure 65: GPR Pass 28

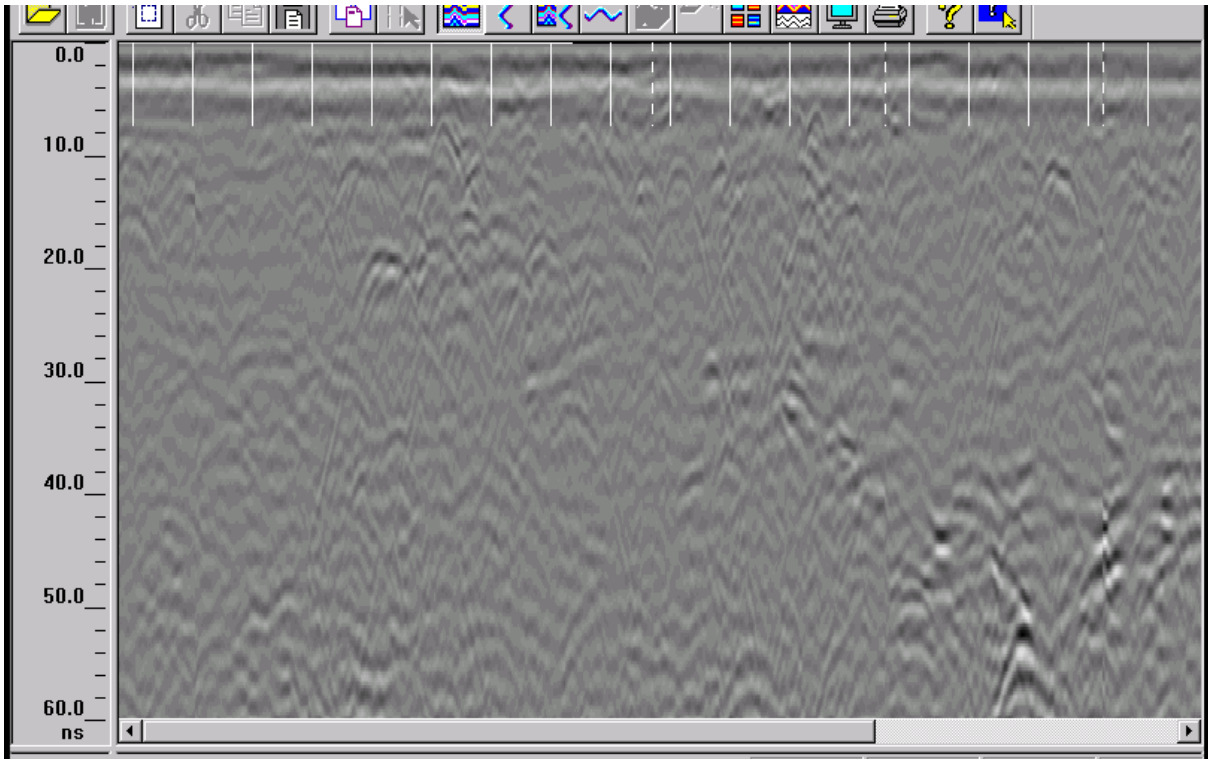


Figure 66: GPR Pass 29

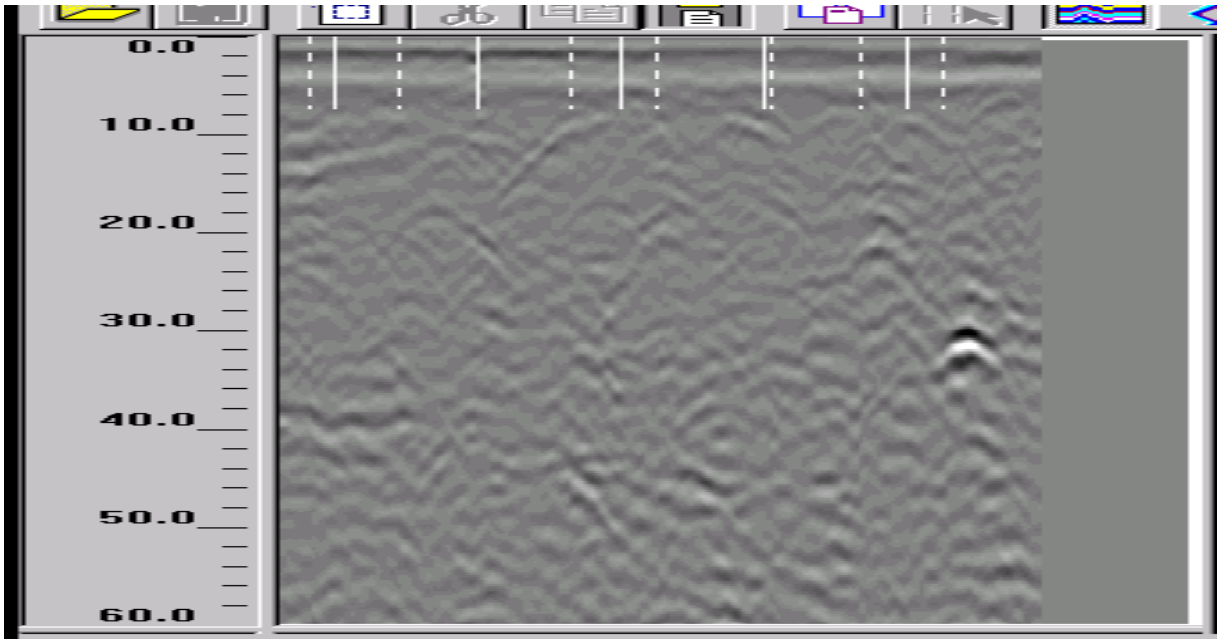


Figure 67: GPR Test Pass 4

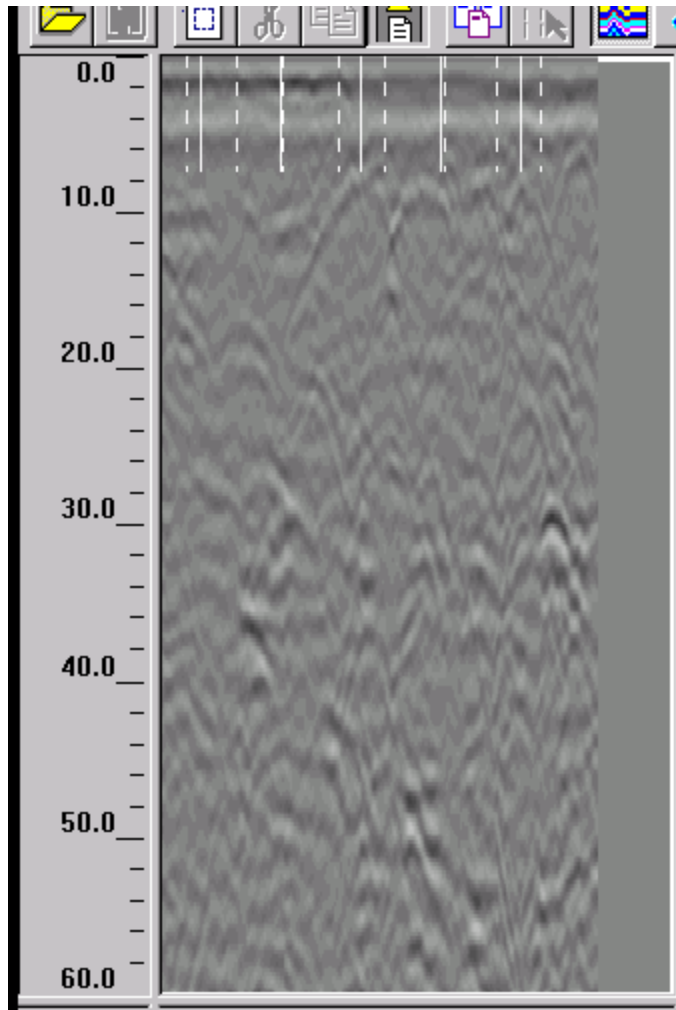


Figure 68: GPR Test Pass 5