OVERVIEW

Ground Penetrating Radar (GPR) is a great tool for a variety of applications from finding rock to discovering artifacts in archeology. Today you’ll find handheld GPR units for “seeing” what is inside a concrete wall and others mounted on the front of trucks to scan newly constructed road surfaces for voids and proper material depth. The flexibility of GPR units allows them to provide information before, during, or after something is constructed. Today these units are smaller and more powerful than ever making it easier to quickly obtain the information you’re looking for.

HOW GPR WORKS

GPR uses pulses of RF energy directed at the target being examined. For fiber-optic construction that area of interest is the underground route chosen to construct the fiber. The number of pulses can be set by the user and is determined based on the area of study. Often times the user will set the number of pulses per foot of movement. When a pulse is sent into the ground, reflections return to the antenna when a material change occurs in the ground – such as a transition from different soil types or simply an innerduct or pipe that is in the path.

One major factor in GPR performance is the frequency of operation. GPR antennas come in a variety of frequencies and choosing the right one requires careful research or consultation with a professional. Systems operating at higher frequencies will penetrate the sub-surface less. Systems that operate lower in frequency will allow deeper penetration of the sub-surface. But there are trade-offs to simply going with something that can “see” deeper. Units that are designed to penetrate the sub-surface less will typically give you a clearer picture at shallower depths. For fiber-optic construction it is sufficient to use something that operates best up to about 12’ in depth. These units are also more portable than low frequency systems which can be substantially larger.

COMPONENTS OF GPR SYSTEMS

There are typically four major components of a GPR system. Two mandatory components are the “controller” or “acquisition unit”. The other is the antenna. The “controller” is where you set the parameters for the survey such as scan rate, depth, gain, and much more. It’s also where you get visual feedback about what data is being collected. This is also where the data being collected is stored so it can be analyzed, reviewed, and shared. It’s important to note that a GPR “controller” collects data...not just an image. This means you can bring the data into software at a later time and change parameters as if you were out in the field. This can allow optimization of the data which allows the best possible images to be exported.
The antenna is often manufactured for a fixed frequency of operation. Some are designed to operate at multiple frequencies to capitalize on the benefits each frequency has. The antennas are larger at lower frequencies and smaller at higher frequencies. A handheld model operates in the thousands of Mhz, an antenna that fits neatly in a cart may run at 400Mhz, and something 200Mhz and lower might be pulled behind you or have some other method to move around a large antenna. Technology improvements are allowing these antennas to get smaller all the time…with the ability to analyze the sub-surface deeper. The image on the left is a 200Mhz analog antenna from GSSI. It has a handle and straps to pull the antenna over the area being reviewed. This antenna is ideal in fiber-optic construction for reviewing areas that require deeper bores…analyzing rivers to be bored under or other uncommon situations that require deeper bores. The antenna on the right is a 350Mhz digital antenna from GSSI that fits in the cart shown below. The 350HS is high resolution and is excellent at locating utilities or rock as deep as 15-20’. Both can be used with the SIR4000 which makes switching from one antenna to another an easy task.

Another component is software. Although not mandatory, it gives the user maximum flexibility when processing data and exporting images you can share with others. GPS information can also be recorded in parallel with geophysical data. This information can be invaluable for “running” a fiber route to find rock, heavy utilities, or even reinforced concrete that could cause headaches when coring. The software certainly has benefits worth purchasing it for. As mentioned earlier, the information collected by a GPR is data so if you want to adjust how the data is processed this software is the perfect way to do that after data has been collected in the field. The software works on current versions of Windows.

The last component(s) of a complete system are accessories. For sub-surface review of fiber routes it’s sufficient to use smaller GPR antennas. This size of antenna can conveniently fit in a cart and ultimately in your vehicle. A cart makes the job a lot easier – not only holding the antenna but your “controller” as well. In addition, the cart allows mounting of other accessories such as a GPS antenna or holding extra batteries. The cart shown to the right is a 3-wheel version which works well in a variety of terrains. There are other models of carts better suited for sidewalks and road surfaces. Carts are typically designed to fold up for easy transport.

**COMMON FIELD APPLICATIONS**

When planning underground work it’s important to know what you are dealing with in terms of existing utilities and rock. Fiber-optic construction typically occurs around 3’ in depth; occasionally deeper. In fact, a lot of other utilities are placed around this depth. This makes it even more important to know what is in your project area. Since planning the fiber route is the first step in the engineering phase it’s critical to know what you’re up against so the best route can be chosen from the start.

In some parts of the Midwest there is a need to know if rock is present before committing to a project. One way to investigate is to “pothole” certain spots along the route. “Potholing” is using a small backhoe or a hydro excavator to remove soil to see if rock exists at that location. While this might give you an idea if rock exists in certain places it isn’t reasonable to ask a contractor to pothole an entire route. GPR can scan every inch of the route in a fraction of the time and provide visual evidence of the rock contour below. This information allows an organization to properly plan a budget as opposed to guessing, over-budgeting to be safe, or needlessly killing the project altogether.
Another use is to verify existing fiber routes or review a project that has just been completed. If deemed necessary, a check can be done to ensure the construction occurred at the depth specified.

GPR can also be used to scan the floor of a building to know where utilities may exist under that building. This can be important to certain organizations that want to bring the fiber under and into the facility. Alternatively, GPR can be used to locate existing conduits that may enter a building.

**LIMITATIONS OF GPR**

GPR has some limitations – most of which are not a big problem for most projects. First, the soil type and moisture content can reduce the depth at which it can find what you are looking for. Salt can be a big problem but is normally found near the sides of roads in the spring. The salt is eventually diluted with rainwater. Another issue is the reception of man-made noise in the environment such as noisy power lines and cable TV systems. It is recommended to turn off your cell phone while using a GPR.

GPR also has limitations on the size of the object in relation to the depth of that object. A GPR can easily find a 1” pipe at a couple of feet deep. That same 1” pipe at 8 feet deep is going to be difficult and likely impossible to pick up. Although GPR is a great tool to locate with, it isn’t the end-all of locating. In many situations it’s best to call in traditional locates and use GPR to check for un-located and private utilities. GPR also can’t tell you what a particular utility is...just that it’s there. Often times it’s obvious with a little investigation. At the end of the day, any utility you find needs to be avoided anyway.

**EXAMPLES & IMAGES**

The image on the left shows a variety of underground utilities grouped together between 2 and 3’. This was near a riser pole where power, cable, and telephone were going under the sidewalk and servicing a couple of office complexes. In this particular survey there were many instances of a large number of utilities constructed this way. If the city government requires entire sidewalk slab replacement when constructing your new utility, the cost of sidewalk replacement would have to be considered. The green line is where the GPR estimates its deepest reliable data collection is possible.

This survey was for a short lateral to connect to existing infrastructure. The surface didn’t seem so bad but GPR shows a lot of broken rock and partial rock shelves that would increase the effort to get through with boring equipment. In this case the first 2’ looks clean but 2-5’ appears much more challenging. This information was provided to the customer so they were aware of the situation. Fortunately the rest of the route was relatively clean.
This survey is a good example of several things occurring. There is a rocky shelf with utilities above and below. The rock is between 4 and 5’ deep with gas above it and sanitary sewer below. What’s interesting is that you can see how the rock shelf loses some definition above the sanitary sewer. This is because that rock had to be broken up and disturbed to install that sewer pipe.

This is an image where two large storm sewer laterals were in a field and feeding to the sewer main at the road. The top of the sewer pipe is about 2 ½’ deep which places the pipe right in the 3’ depth that fiber would typically be placed. Knowing these two storm sewer laterals were right at that depth allows a contractor to make adjustments to their plan to get around them. In this case, the route was modified slightly to go completely around these.

**SUMMARY**

GPR is a great tool for reviewing fiber routes and providing information that can be used to plan a project in much greater detail and confidence. But GPR can do a lot more than plan fiber-optic construction projects. It works well for reviewing construction sites for buildings, towers, and road construction. It can be used for determining the best place for a shallow well in rocky areas, finding artifacts, time capsules, or forensic investigations. A common use for GPR is locating private utilities; utilities that Digger’s Hotline doesn’t have on file. Underground storage tanks and leach fields can also be reviewed with GPR.

Recently I evaluated a private property where the homeowner found an unknown pipe buried in the yard. The pipe was cut off at one end with the other going into the ground. Digger’s and the city were not able to determine what it was. After running the GPR over the area I discovered that the buried end disappeared after about 4’. Shortly afterwards I pulled the pipe out of the ground knowing it wasn’t connected to anything.

Livermore Technologies has GPR services to help you with locating anything underground in WI, MN, IL, and MI. Call for more information on how we can help you with your locating needs.