Underground Facility Locator's Field Task Competency Manual

CAPULC
CANADIAN ASSOCIATION OF PIPELINE AND UTILITY LOCATING CONTRACTORS

Version 3.0

UNDERGROUND FACILITY LOCATOR'S FIELD TASK COMPETENCY MANUAL

A manual developed for Underground Facility Locators (UFL) and endorsed by the Canadian Association of Pipeline and Utility Locating Contractors (CAPULC).

Version 3.0 – 2020

DISCLAIMER

The information provided in this field task manual is intended for general application only and is not intended for use as a complete reference. Terms used in this manual vary between facility owners and jurisdictions. It is not a definitive guide to government regulations nor is it a guide to the practices and procedures wholly applicable to every locate circumstance. The appropriate regulations, company-specific work practices and manufacturers' equipment instructions must be consulted and applied with due diligence. Canadian Association of Pipeline and Utility Locating Contractors (CAPULC), Locate Management Institute and advertisers assume no responsibility whatsoever, for any injury, loss or damage arising from its use. Locate Management Institute and CAPULC do **not** endorse or recommend any company or commercial products depicted in this manual.

ACKNOWLEDGEMENTS

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1 Locating Fundamentals and Facility Infrastructure

1.1 Theory of Electromagnetic Locating

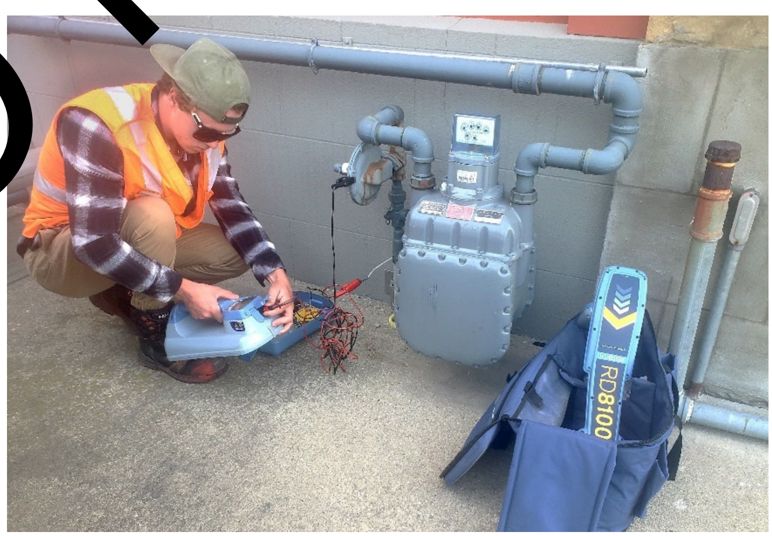
EM locators do **not** locate the buried pipes and cables — they detect the electromagnetic field or "*signal*" generated by an alternating current (AC) oscillating (moving back and forth) and flowing down or along the buried facilities.

EM fields are generated by directly or indirectly applying a signal to a metal conductor which then travels along the facility.

1-1 Applying signal

The main components of most EM locators are:

- transmitter,
- receiver,
- direct connection cables and ground rod, and
- inductive clamp



1-2 Connecting to tracer wire at a gas meter

1.2 Active Signals

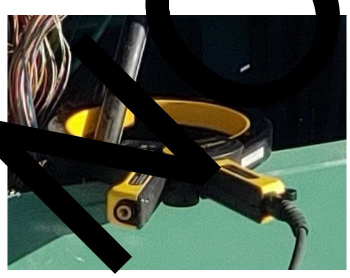
Active signals are deliberately applied to a facility from the transmitter.

There are three ways (methods) to apply an active signal:

1. Direct Hook-Up – the positive clamp is connected to a suitable access point and the negative clamp is connected to a ground rod.

1-5 Direct Hook-Up to a steel pipe

2. Inductive Clamp – the inductive clamp is placed around the facility.



1-6 Inductive clamp around a fibre optics cable

3. Inductive (Induction) – the transmitter is positioned above and in line with the suspected path of the facility.

1-7 Inductive (various transmitters)

1.3 Passive Signals

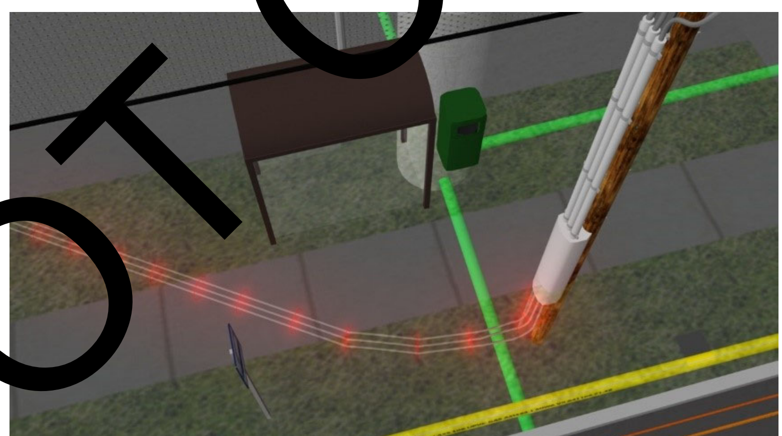
Passive signals originate from sources other than the transmitter (i.e., electrical power, broadcast waves).

The three common passive locating modes (methods) are:

1. Radio – to detect stray radio signals radiating from man-made technologies that re-radiate or couple (bleed/jump) onto buried facilities within the signal range.

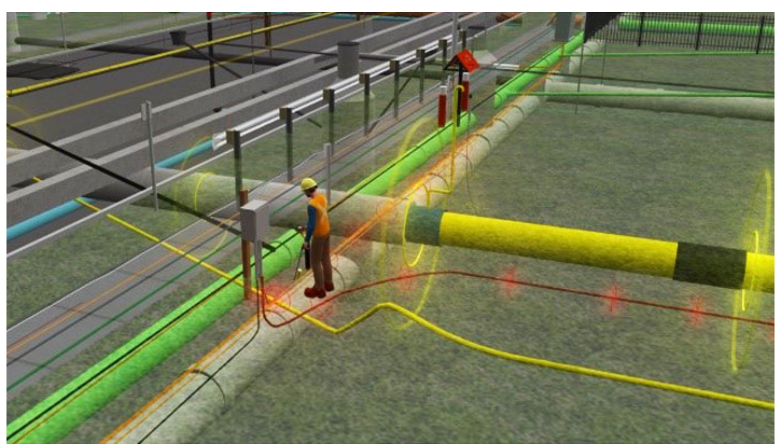
1-8 Radio Method

2. Power (Live AC Cable) – to detect live power cables that carry electric (AC) current.



1-9 Power Mode

3. CPS (Cathodic Protection System) – to detect cathodic protection currents used to protect conductive pipes.



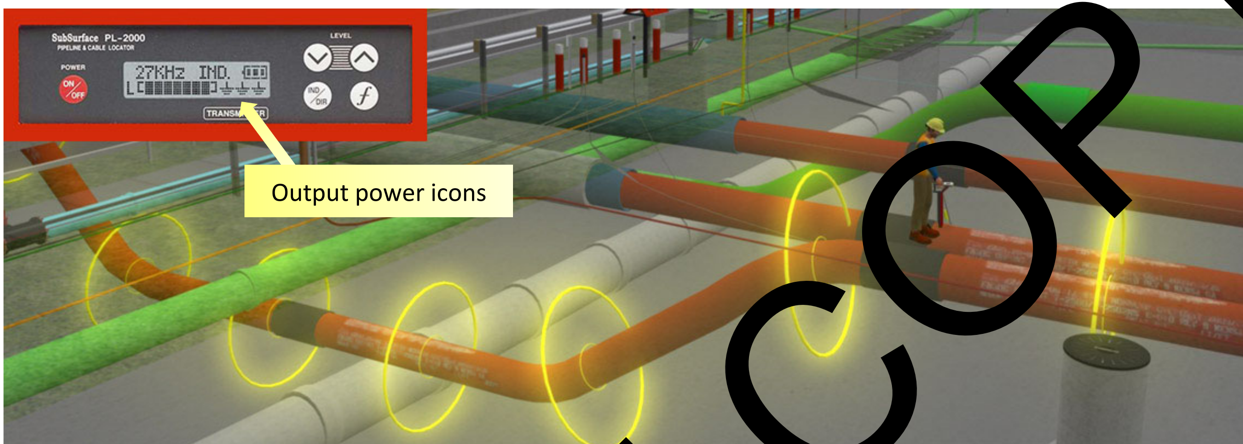
1-10 Cathodic Protection System

1.5 Output Power

Most transmitters have multiple output power settings that may range from 0.25W to 12W.

Output power level affects the intensity (amplitude) of the signal.

Higher output power signals are easier to detect and tend to travel greater distances. However, these are more prone to distortion when multiple conductors are present. High output power signals are generally better for detecting large diameter, deep or well insulated facilities.



1-14 Using high output power transmit a signal on a large diameter deep pipe

Lower output power signals are harder to detect due to conductor resistance and signal strength. However, these cause less distortion and may be better in areas of facility congestion.

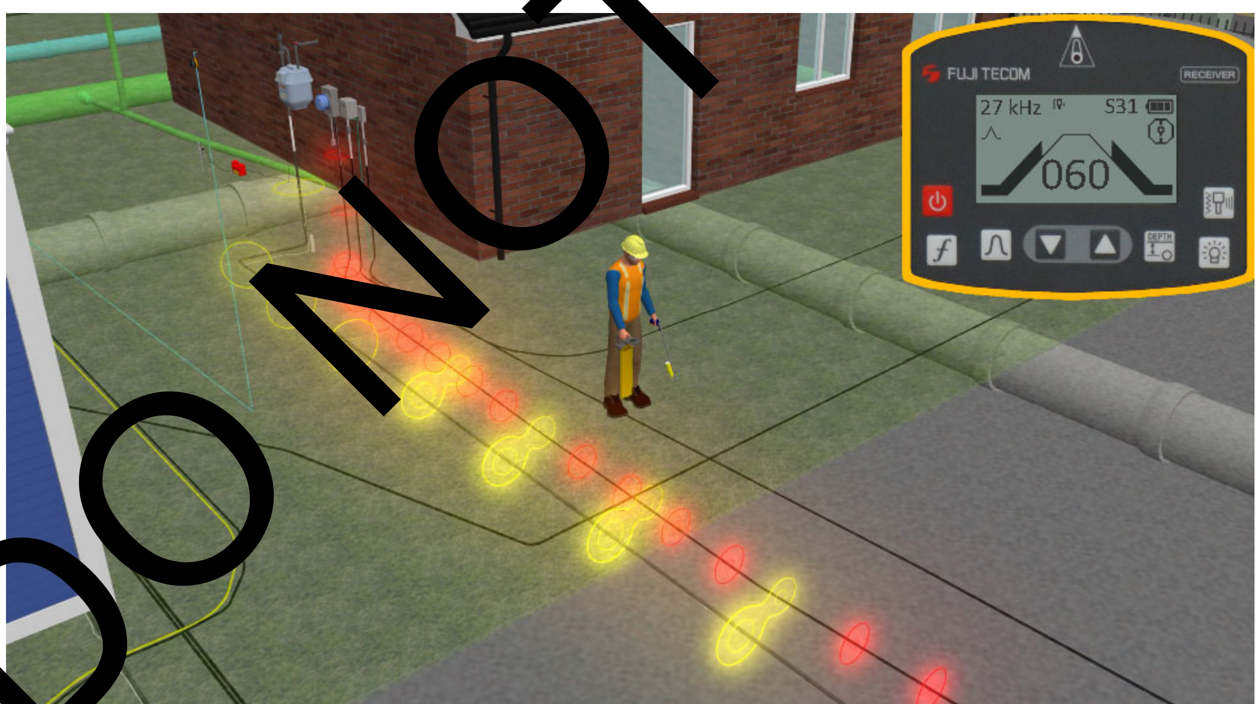
1-15 Using low output power in a congested area

1.6 Signal distortion

Current will always follow the path of least resistance. In some cases, the transmitter signal will use other conductive buried facilities in close proximity, or sharing a common bond, as a return path because they are less resistive than the surrounding soil.

1-16 Area of common bonds (left); four party trench under construction (right)

Unwanted return path signals can cause signal distortion, which can lead to the wrong facility being located or difficulty in determining the location of a target facility.

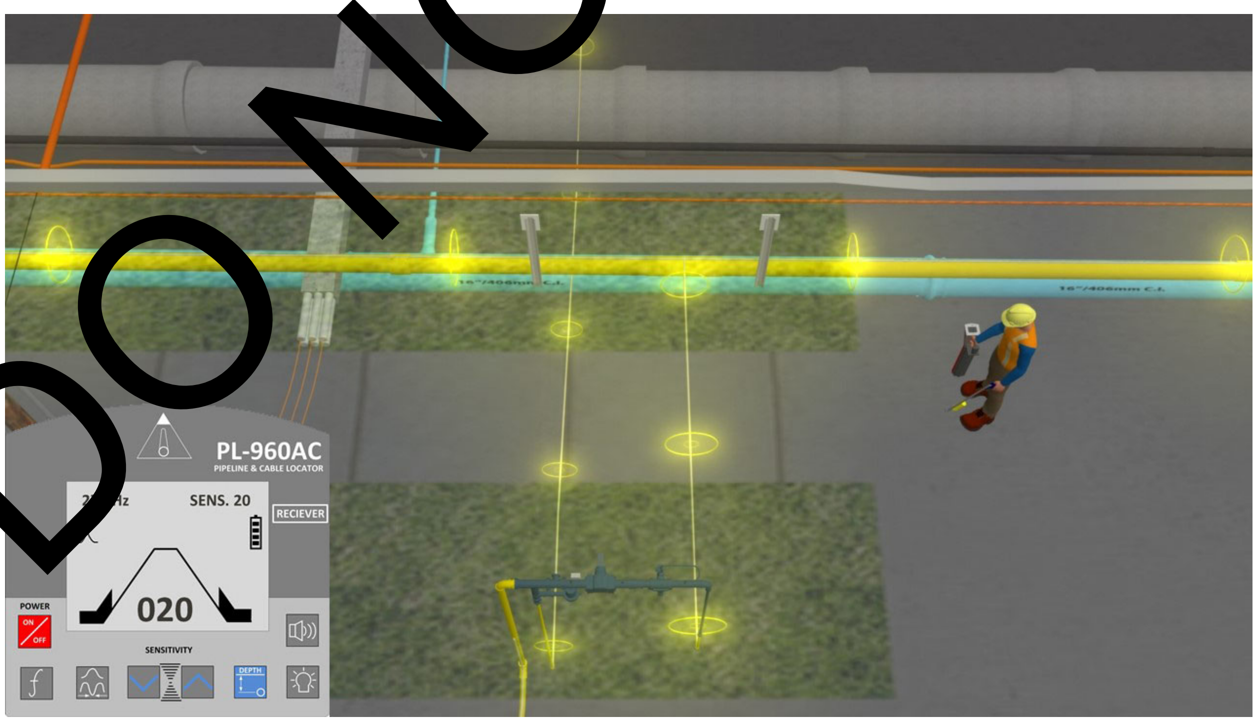


1-17 Signal distortion

2.1 Procedures for Locating - Start to Finish

Locators should perform locates after receipt of a locate notification ticket or ticket number from a notification service (one-call centre). There are times when Locators perform locates without receipt of notification from a notification service because not all buried facilities are registered with the notification service (i.e., privately owned or non-member facilities). There are other times when Locators are contracted to perform locates in addition to the notification service process.

2-3 Locating from a customer power meter



2-4 Locating at a gas Intermediate Regulating Station

 Acknowledgement by the UFL and the Assessor at the end of each task description indicates an understanding and a demonstrated capability of the subject matter.

2-15 Direct hook-up connection points for telecommunication cable

2-19 Direct connection to the meter and transformer

2-20 Direct connection to a transformer

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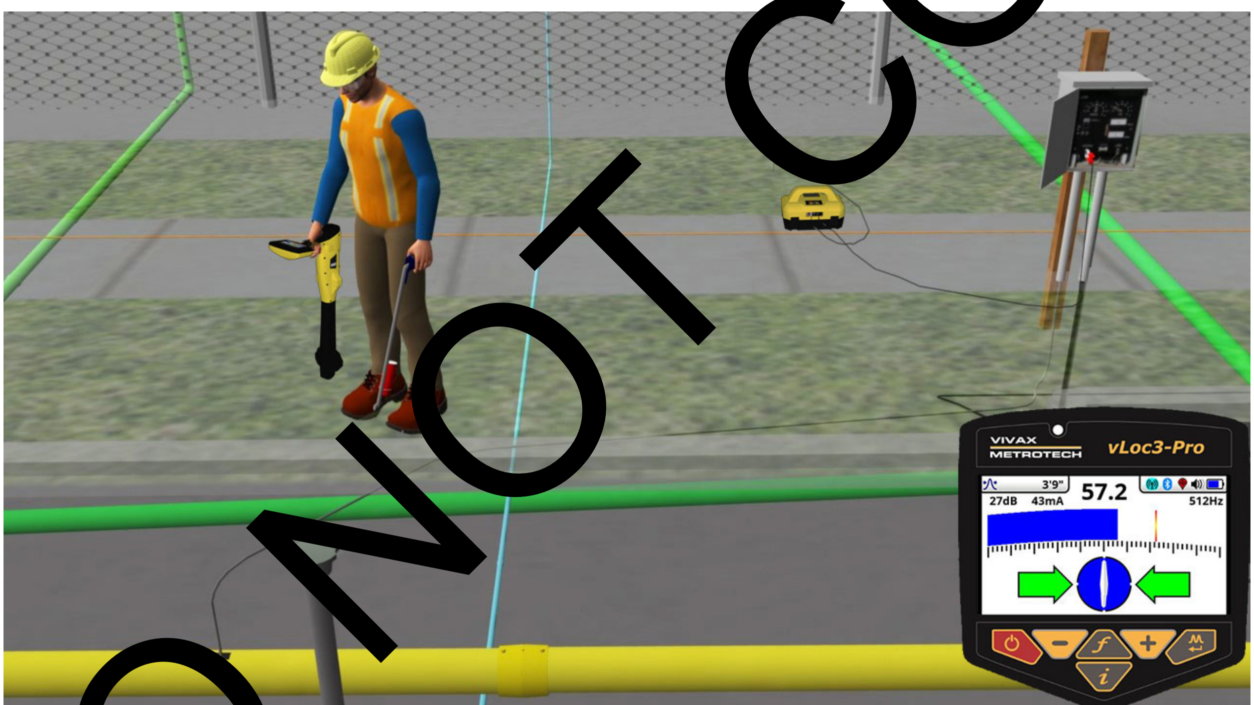
2-23 Direct hook-up to a structure cable (negative feeder cable)



2-24 Locating the structure cable (negative feeder cable) of a pipe

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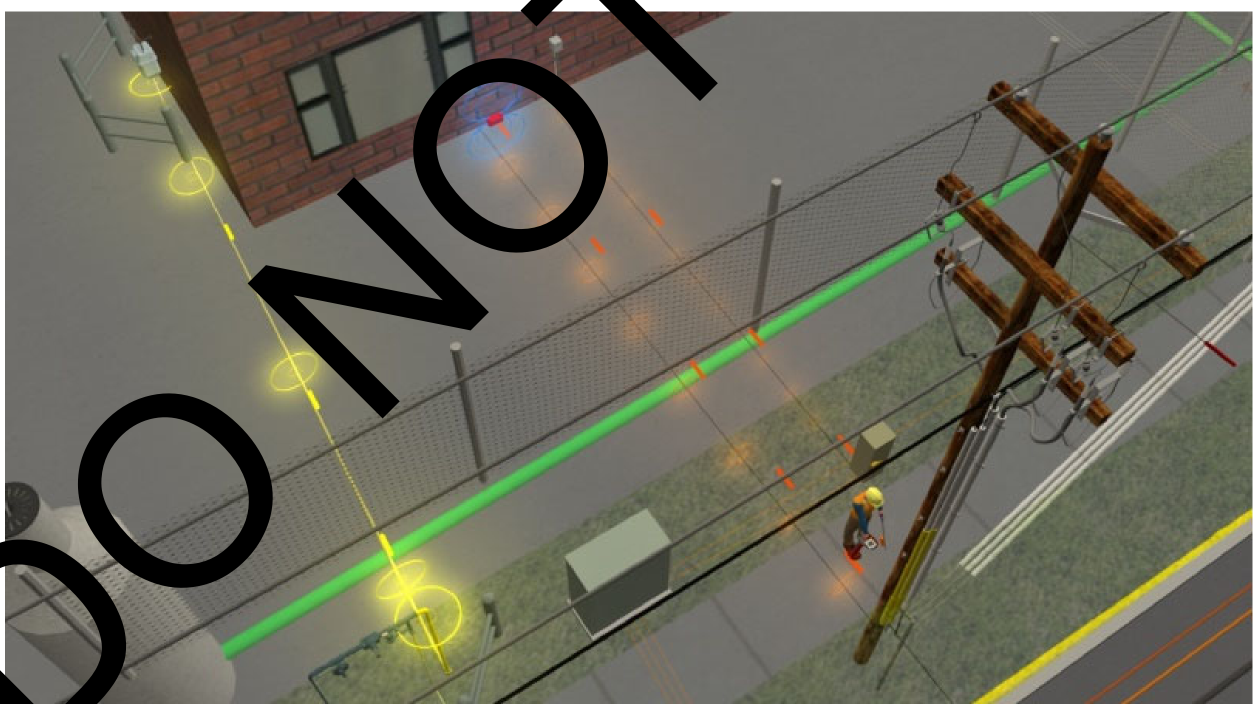
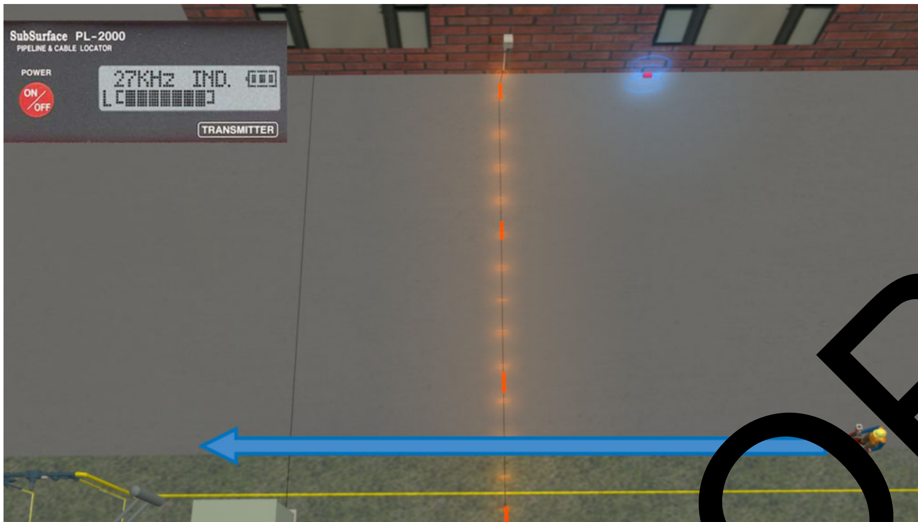
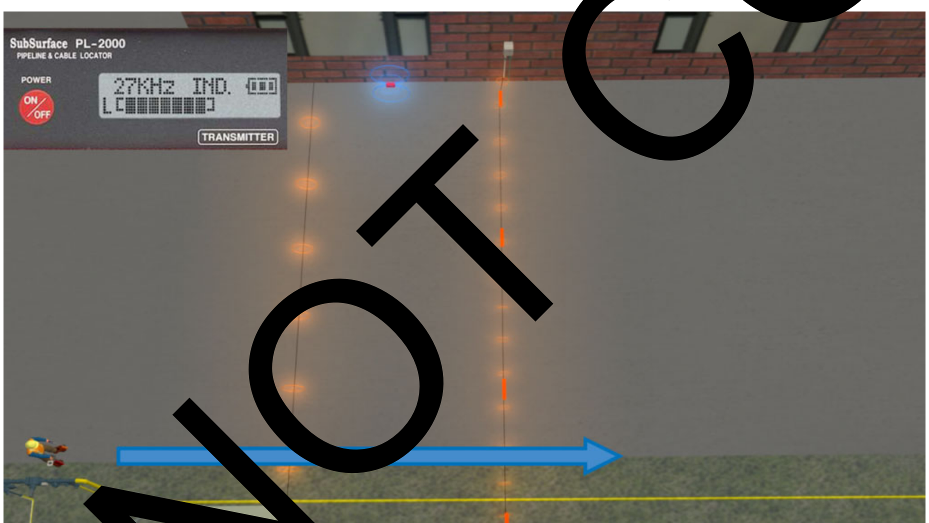
2-29 Inductive Method - broadcasted signal



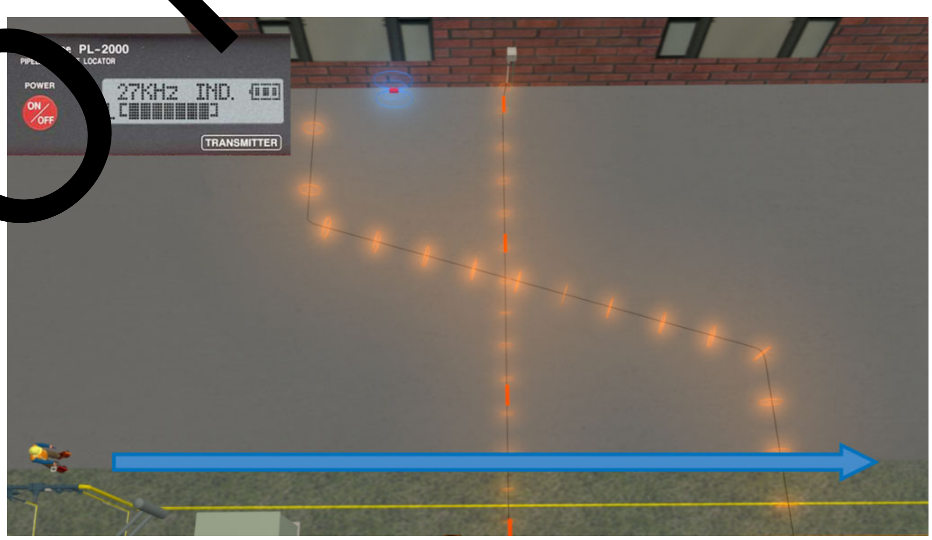
2-30 *Locating fibreoptic cable to the pole using induction*



2-34 Performing a Parallel Line Check (tranmsitter right of known line) – No Parallel Line Detected



2-35 Performing a Parallel Line Check (tranmsitter left of known line) –Parallel Line Detected



2-36 Parallel Line Check (tranmsitter left of known line) – Crossing Line Detected

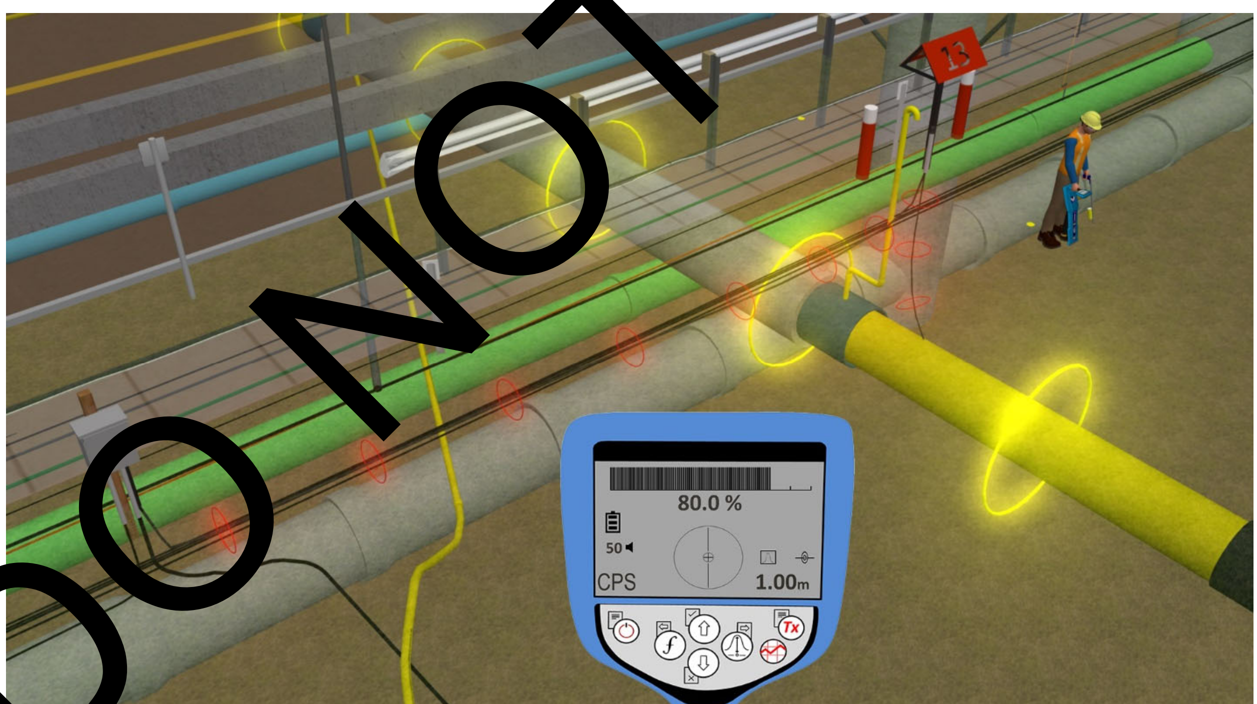
2.14 Task Description: CPS Mode

Cathodic Protection System (CPS) Mode does not require a transmitter. Some receivers have a passive CPS Mode tuned to the same frequency (120 Hz) as the cathodic protection system. This method can be used to locate cathodically protected pipelines. If searching for unknowns perform circle and grid patterns.

When cathodic protection is applied to a pipeline with a cathodic rectifier, an electromagnetic field radiates from the pipe which can be detected by a CPS Mode-equipped receiver. If there is sufficient signal and separation between pipes (e.g., 3 m [~10 ft.] or more) the CPS Mode can efficiently establish the approximate pipeline position. In areas where there is not sufficient separation the CPS signal will become distorted. Due to limitations and inconsistencies with the CPS Mode, it should be used in conjunction with and verified by other locating methods.

Note: *CPS Mode is a great starting point for locating a cathodically protected pipe when the approximate alignment is known, and no access points are readily available.*

1. Turn the receiver on.
2. Set the receiver to *CPS* Mode.
3. Set the sensitivity (gain) on the receiver to maximum.
4. Orientate the receiver as per the equipment manufacturer's specifications and walk towards the approximate alignment of the target facility.
5. Stop when the signal peaks.
6. Check signals.
7. Trace and mark target line.
8. Use an active locating method to verify any CPS locate.



2-49 CPS Mode

2.15 Task Description: Live Cable (Power) Mode

Live Cable (Power) Mode does not require a transmitter. Some receivers have a passive Live Cable (Power) Mode tuned to the same frequency (50-60 Hz) as the energized electrical cables. This method can be used to locate cables that are energized. Some live cables may be undetectable using this method due to the cable sheath and/or depth of the cable. Due to limitations and inconsistencies with the Live Cable (Power) Mode, it should be used in conjunction with and verified by other locating methods.

Note: *Live Cable Mode can also be used for scanning an area for a safe suitable ground location when performing the Direct Hook-up Method.*

1. Turn the receiver on.
2. Set the receiver to *Live Cable (Power)* mode.
3. Set the sensitivity (gain) on the receiver according to the equipment manufacturer's specifications.
4. Orientate the receiver and walk toward the approximate alignment of the target line. *If searching for unknowns, walk in circle and grid patterns.*
5. Stop when the signal peaks.
6. Check signals.
7. Trace and mark signals.
8. Use an active locating method to verify any Live Cable (Power) Mode locate.
9. Continue patterns, increasing the gain as you walk away from any marked line.
10. Stop each time there is a signal.
11. Repeat as necessary until the entire work area has been scanned.

2-51 Live Cable (Power) Mode

2.17 Task Description: Sondes

A sonde, or active duct probe (ADP), is a small waterproof transmitter that is used with an electromagnetic locator tuned to the same frequency to find the path of a nonmetallic facility or to find a blocked or collapsed facility. Sondes come in various sizes and can be attached to a rodding tool (flex rod) or fish tape (pull tape) and inserted into the buried facility. The transmitter is not required for this task as the sonde acts as a transmitter.

Refer to the equipment manufacturer's specification and procedures for operating sondes.

1. Activate (turn-on) the sonde and attach it to the rodding tool.
2. Propel or push the sonde into the conduit or duct.
3. Position the receiver parallel to the sonde. (Some receivers can also detect a sonde in both parallel and perpendicular orientation.)
4. Select the Sonde mode on the receiver and the correct frequency of the sonde.
5. Scan the area (parallel to the sonde) and stop when the signal peaks.
6. Check the signals and mark.
7. Propel the sonde further into the conduit or duct and repeat the locate process.

2-55 Using a sonde to locate a non-conductive facility

2.18 Task Description: Locate a Transmitting Coil

One type of rodding tool consists of a non-conductive flexible fiberglass line inside a plastic sleeve, with a threaded end on the line for attaching the transmitting coil. This method requires both a transmitter and receiver as these have a conductive wire running in a plastic sleeve with a transmitting coil at the end of the wire.

1. Identify the non-conductive conduit or duct to be located.
2. Attach the positive and negative transmitter clamps to terminals of the transmitting coil tool reel.
3. Plug the direct hook-up cables into the transmitter.
4. Turn the transmitter on.
5. Set the transmitter to direct mode.
6. Select the appropriate frequency on the transmitter.
7. Propel or push the transmitting coil into the conduit or duct.
8. Position the receiver in the same manner as locating a sonde – parallel to the transmitting coil. (Some receivers can also detect a transmitting coil in both parallel and perpendicular orientation.)
9. Scan approximate alignment of conduit or duct for transmitting coil and stop where signal peaks.
10. Check signals and mark.
11. Propel the transmitting coil further into the conduit or duct and repeat the locate process.

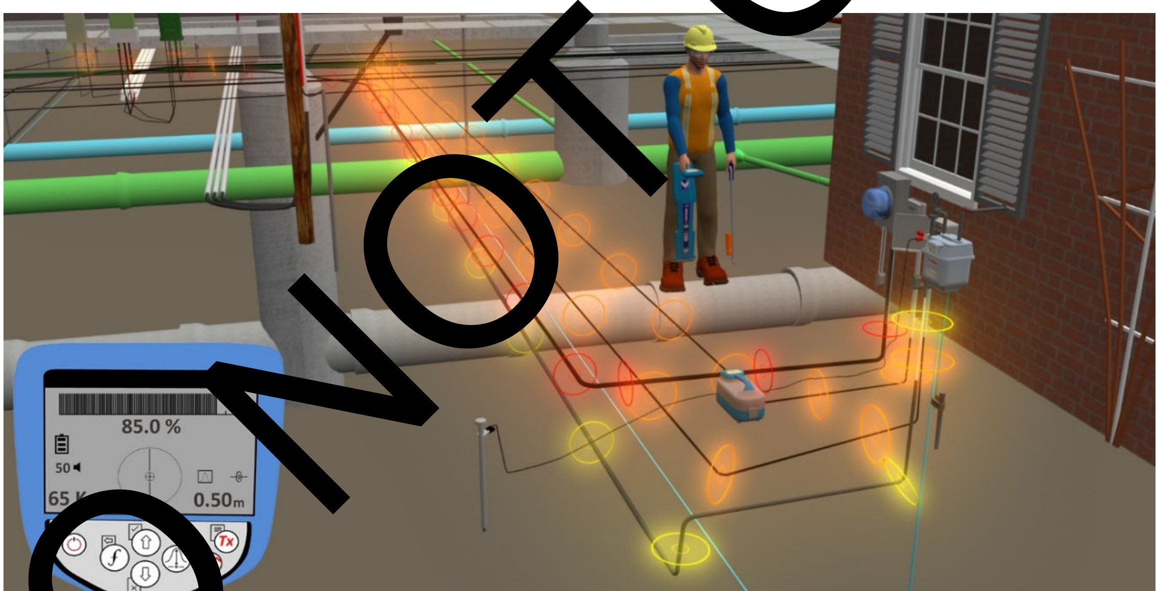
2-58 Propelling a transmitting coil into a conduit

3.7 Task Description: Unwanted Coupling

Electromagnetic signals follow the path of least resistance (i.e., shallower or stronger conductors) and can jump from the target facility to a non-target facility. This is known as unwanted coupling (also known as coupling, line jumping, line bleeding, and bleed-over). Unwanted coupling can occur where facilities are bonded or buried in close proximity to other conductive buried facilities.

- Signals can be misleading and therefore send a Locator down the wrong path (conductor).
- These can cause confusion and lead to mis-locates.
- Although unwanted coupling is inevitable there are ways to reduce its effects, thus increasing locate accuracy.
- Accurate records can help solve the problems associated with unwanted coupling. Depending on the accuracy of a record, signals should correlate with the record and visual inspection.

1. Locate the strongest signals first. If possible, connect to an access point away from the unwanted coupling area. Select a low frequency and low power output; and bring the signal into the unwanted coupling area.
2. If the signal is still too strong and couples to other facilities, try placing the ground cable on the ground at right angles to the target facility. This will create a weaker signal and minimize unwanted coupling.
3. If possible, trace and mark the signal beyond the unwanted coupling area until there is sufficient signal separation from other facilities or structures.
4. Move the transmitter to a position where there is sufficient separation from other facilities and retrace inductively. The Inductive Method may be the best locating method in unwanted coupling areas, especially if the transmitter has sufficient separation from other conductors.



3-6 Unwanted coupling

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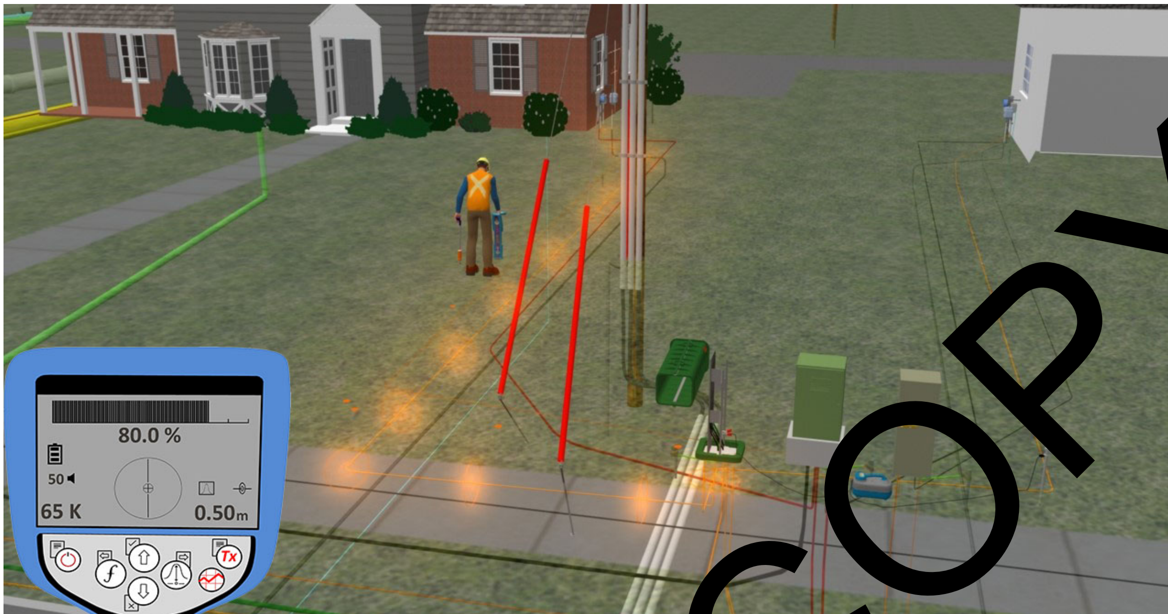

3-23 Locating into a common-bonded area (house)

3-24 Locating into a common-bonded telecomunication housing

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3.17 Task Description: Locating Short Facilities

Short facilities are those that are less than 20 m (~66 ft.) long. These facilities can be difficult to locate. In order to detect a short facility when performing an inductive sweep, both the receiver and transmitter need to be over and in alignment with the short facility.

Short facilities may tee or y-lay between structures or facilities. These short facilities may also be a future service (stub) or an abandoned section. Short facilities may be non-grounded and may not surface.

1. Hold the receiver in the approximate alignment of the short facility and walk parallel to the main line.
2. If signal is detected, trace and mark it away from the main line.
3. Perform the ALL Method.

It may be impossible to detect all the signals for short facilities. Using the record(s) may be the only viable option to mark the approximate alignment of short facilities. It may be impossible to account for all short facilities. Therefore, using information sources may be the only viable option to mark the approximate alignment. Document the finding and discuss them with the ground disturber and facility owner as other precautions may need to be implemented prior to the ground disturbance.

3-25 Locating short facilities

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3.19 Task Description: Procedures for Locating Facilities That Are Closer Than Normal

Facilities that are closer than normal – where there is little or no separation between facilities – will exhibit signal distortion resulting in difficulty to differentiate signals.

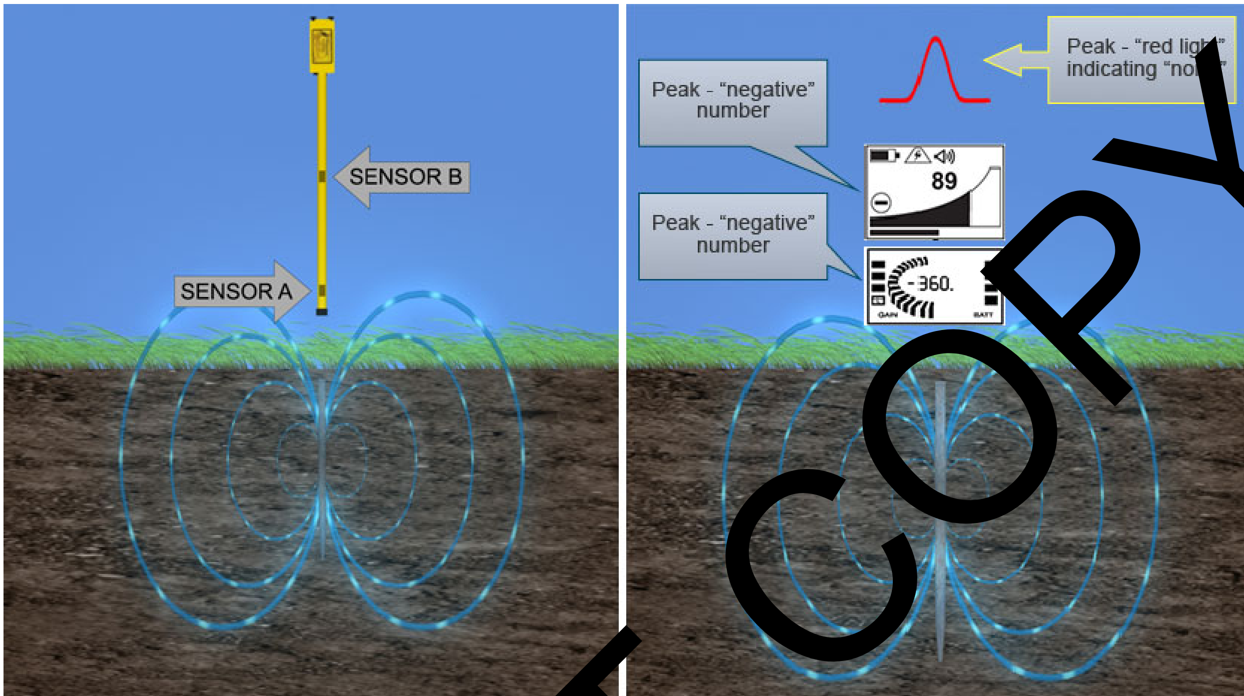
1. Locate the strongest signals first.
2. Locate the signal towards the closer than normal area.
3. When utilizing the Inductive Method, place the transmitter at a suitable location where there is sufficient separation from the other conductors and locate the signal towards the closer than normal area.
4. Perform the Parallel Line Check Method. Mark the outer edges of the closer than normal facilities (i.e., chevron).

It may be impossible to separate all the signals that are closer than normal.

Using the records may be the only viable option to mark the approximate alignment of facilities that are closer than normal.

3-28 Locating the strongest signal first

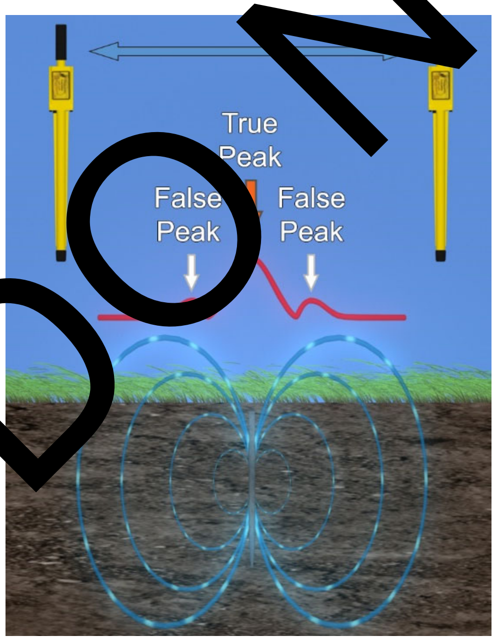
Sensors inside a pin finder detect and measure the differences in the shape of the (colliding) magnetic field. The pin finder responds with an audible “peak” signal tone and/or visual display.



4-3 Sensor locations (left) and peak indicators (right)

The characteristics of an object’s magnetic field will determine the appropriate scanning patterns, pin finder alignment, and sensitivity adjustments.

Prior to scanning, determine the approximate position and/or alignment of a target object by checking records and performing a visual inspection.



4-4 True and False Peaks

Scanning and searching for a target object may lead to the detection of other non-target ferrous objects. Some non-target objects may be at or above the surface of the ground. These may be larger, smaller, shallower, or deeper than the target object.

Therefore, it is important to understand the expected signal of the target object in order to distinguish it from other possible signals.

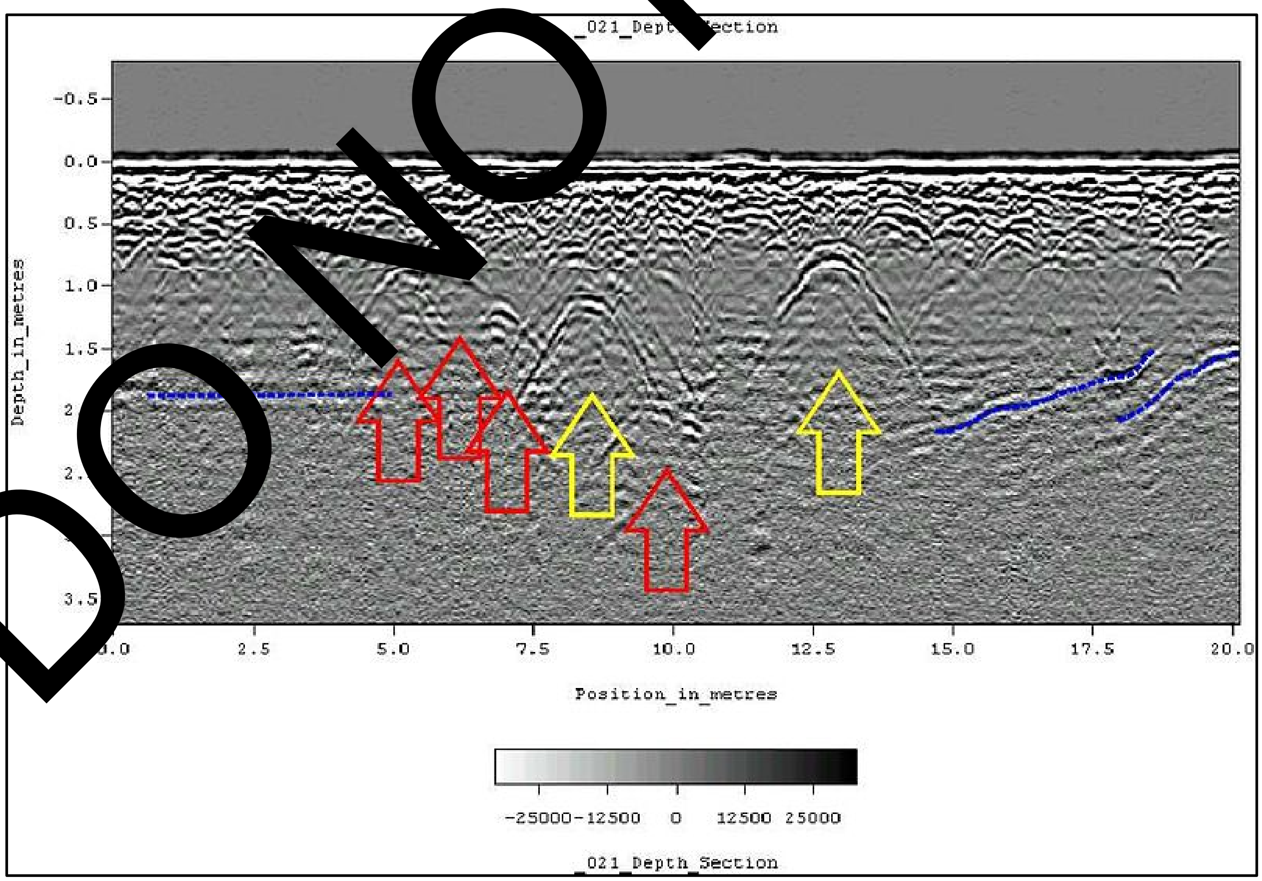
Magnetic fields often exhibit false peaks surrounding a stronger true peak. It is important to distinguish the true peak signal as depicted in this image.

4.2 Ground Penetrating Radar

Ground Penetrating Radar (GPR) can be used to locate buried facilities or objects. GPR devices emit radio waves (signals measured in Megahertz (MHz)) down through the ground, which then reflect back to the receiver (in varying degrees) off the matter that the signal encounters. This matter may include concrete, grass, snow, ice, dirt, rebar, facilities, and rocks.

4-17 Locating facilities with Ground Penetrating Radar

A GPR device is comprised of a control panel, antennae, battery, digital drive and encoder. The antennae transmit and receive the signals, the encoder then interprets the signals by measuring the time and strength of each returning pulse. The encoder stores this information on the digital drive and displays the data on the control panel for the user to interpret.



4-18 GPR scanning data

When a signal encounters an object that substantially differs from the surrounding soil or concrete, it drapes over the object like a ribbon on a branch. This can provide the location, and approximate depth and width (diameter) of the object.

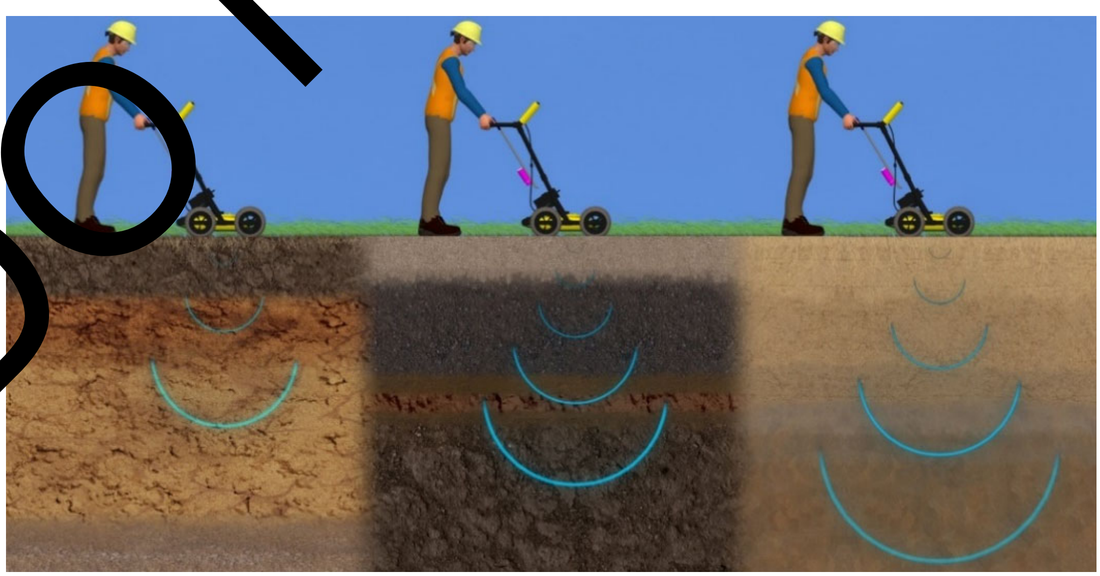
Signals reflect back at different speeds and strengths (depending on the density and composition of the matter within the ground through which they are transmitted. These signals progressively dissipate with depth.

4-19 Using GPR in an urban environment

GPR devices measure the changes in soil resistance from the reflected signals. Metallic objects reflect back stronger signals than non-metallic objects. Signals can travel as deep as 40 metres (~130 ft.), depending on the device; however, soils rich in clay or ferrous/metallic materials will limit the signal, possibly to 1 metre (~3 ft.) or less.

4.2.1 Soil Resistances

The image below shows 3 soil types with decreasing deposits of clay (left to right). The first soil type (left) has a high clay content, limiting signal depth, while the third image (right) has no clay content or other limiting factors and so the signal is able to travel deeper. The middle image has partial clay content and signals will travel moderately deep in this soil type.



4-20 GPR signals in different soil types

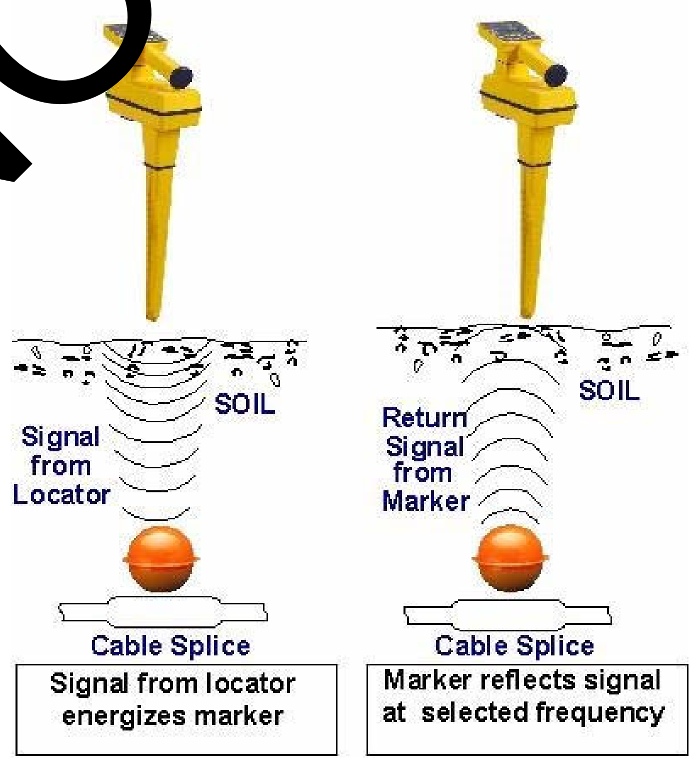
4.3.2 EMS Receivers

Generally, manufacturers of electronic markers also produce receivers with the ability to detect the markers.

Some EMS capable receivers are evident by their “hoop” attachment or dropdown, which serves as the EMS transponder.

Receivers send high frequency signals (not EM signals) into the ground and receive return signals from any markers below. Different markers respond to different frequencies.

4-28 Hoop attachment



4-29 Locator and marker signal interaction

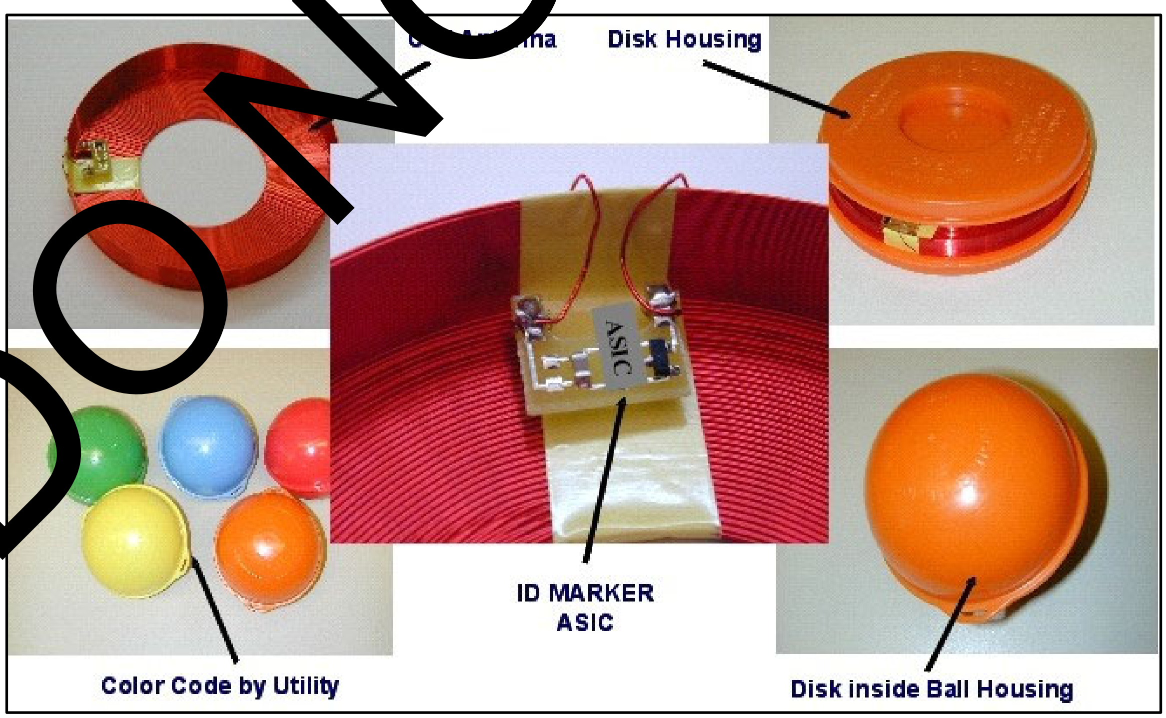
4.3.3 RFID Capabilities

Some EMS markers have Radio Frequency Identification (RFID) functionality and are sometimes referred to as RFID markers. RFID markers have data chips (storage devices) that, when energized by the receiver signal, relay stored facility information to the receiver. RFID markers can be programed with a unique identifier and facility details such as diameter, material, and purpose of the target facility (e.g., 6”, Plastic, Water Line). Some markers are not programmable and only offer the capability of detecting the marker location.

4-30 Marker ball placed at pipe weld

4.3.4 Types and Limitations

All EMS markers contain a round metal coil with a capacitor. Some ball markers are encased in liquid to maintain an internal vertical configuration. This allows a ball to be dropped into holes without worry for orientation. Other marker types must be correctly oriented when put in place. Markers are activated by the receiver signals and can last for multiple decades.



4-31 Components of various EMS markers