SENSORS & SOFTWARE
from RADIODETECTION

LMX200™

Ground Penetrating Radar

Operation manual

2015-00158-12



SPX
TECHNOLOGIES

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Name:	Company Name:	
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Component Serial Numbers (refer to packing list or the sticker on the component)

Comp:	Serial #	Comp:	Serial #
Comp:	Serial #	Comp:	Serial #
Comp:	Serial #	Comp:	Serial #
Comp:	Serial #	Comp:	Serial #
Comp:	Serial #	Comp:	Serial #
Vendor Name:		Date Received:	

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Product Warranty and Limited Liability

Please refer to the terms and conditions included, or referenced, in your order acknowledgement/invoice for full details of the product warranty together with the applicable exclusions and limitations of liability. Nothing in this manual amends or extends the applicable warranty or varies those exclusions and limitations of liability. Nothing in this manual excludes or limits any liability that cannot lawfully be excluded or limited.

Important Safety Information

Use the Display Unit only as specified in these operating instructions, or the protection provided by the unit may be impaired.

The battery charger/AC adapter must only be connected to a power outlet which provides a protective earth (ground).

Connect the AC power cord only to designated power sources as marked on the battery charger/AC adapter.

The battery charger/AC adapter is rated for indoors use only.

Do not replace detachable MAINS supply cords for the battery charger/AC adapter by inadequately RATED cords.

Do not position the Display Unit such that it is difficult to disconnect the 37-pin GPR connector.

The exterior of this product should be cleaned using a damp cloth.

Safety Symbols

 Consult this documentation in all cases where this safety symbol appears. This symbol is used to inform you of any potential HAZARD or actions that require your attention.

Do not attempt to open or dismantle any part of this equipment unless directed specifically by this manual. Doing so may render the equipment faulty and may void the manufacturer's warranty.

Use authorized accessories only. Incompatible accessories may damage the equipment or give inaccurate readings.

Follow your company and national safety procedures and or requirements when operating this equipment in any environment or workplace. If you are unsure what policies or procedures apply, contact your company or site's occupational health and safety officer or your local government for more information.

Table of Contents

1. Overview 1

2. Assembly 2

2.1. Out of the box 2
2.2. External GNSS (optional) 5
2.2.1. GNSS Supplied by GPR Manufacturer 6
2.2.2. Third-party GNSS 7
2.3. Fully Assembled 8

3. Getting Started 9

3.1. Powering Up 9
3.2. Shutting Down 10
3.2.1. Emergency Shutdown 10
3.3. Interacting with the Display Unit 10
3.4. Swipe Down Menu 11

4. Tools & Setup 13

4.1. Preferences 14
4.1.1. Language / Locale 14
4.1.2. Units 15
4.1.3. Date/Time 15
4.1.4. Volume 15
4.1.5. Brightness 15
4.1.6. Use 3rd party mapping apps 15
4.1.7. Wi-Fi Network 16
4.1.8. Email 18
4.1.9. Screen Saver 22
4.1.10. GPR Plot Options 23
4.1.11. Reset to Defaults 23
4.2 System Test 24
4.2.1 System Information 24
4.2.2 Keypad Test 25
4.2.3 Audio 25
4.2.4 Touch Screen 26
4.2.5 Sensor Test 26
4.2.6 Odometer Calibration 27
4.2.7 GPS 29
4.3 File Management 31
4.3.1 Screenshot Gallery 31
4.3.2 Delete Project 32
4.3.3 Export Data 32

5. GPR Concepts 33

5.1. Theory 33
5.2. Hyperbolas 33
5.3. Calculating Depth 34
5.4. Soil Calibration values 34
5.5. Air Waves 35

6. Line Scan 36

6.1. Selecting a line 36

6.2. Acquiring Data 38
6.3. DynaQ™ 38
6.4. Back-up Indicator 39
6.5. Flags 40
6.6. View Settings 41
6.6.1. Zoom 41
6.6.2. Color 43
6.6.3. Filter 43
6.6.4. Gain 44
6.6.5. DynaT™ 45
6.6.6. Soil Cal 46
6.6.7. Interp 48
6.7. Interps sent to 3rd Party Mapping Apps 48
6.8. Pause button (No Save Mode only) 49
6.9. Drawing arrows (No Save Mode only) 50

7. Pseudo-Grid Line Scan 51

8. MapView 53

8.1. Accessing MapView 53
8.2. MapView screen 54
8.2.1. Options (Layer views) 55

9. Line Scan Depth Slices 59

9.1. SliceView Lines Processing Settings 60
9.1.1. Project 60
9.1.2. Status 60
9.1.3. Soil Calibration 60
9.1.4. Processing Depth 61
9.1.5. Resolution 61
9.1.6. Edit 62
9.1.7. Back 62
9.2. Depth Slice Processing 62
9.2.1. Maximum Area Exceeded 62
9.3. Depth Slice Options 63
9.3.1. Depth 64
9.3.2. Color 64

10. SplitView 65

10.1. Adding Interps in SplitView 66
10.2. Displaying Depth Slices in SplitView 67

11. Grid Scan 68

11.1. Grid Parameters 68
11.1.1. Grid Number 68
11.1.2. Grid Size 69
11.1.3. Grid Resolution 69
11.1.4. Starting data collection 69
11.2. Laying out the grid 70
11.3. Data Collection 72
11.3.1. Physical Data collection 72
11.3.2. Data collection on the Display Unit 72
11.3.3. Obstacles in your path 73
11.3.4. Flags 74
11.3.5. LineView 75

11.3.6. Recollecting & skipping lines 75
11.3.7. Processing Grid Scan data 76

12. Grid Scan Depth Slices 77

12.1. Depth 77
12.2. LineView 78
12.3. Color 78
12.4. Options 80
12.4.1. Grid Lines 80
12.4.2. Flags 81
12.4.3. Interps 81
12.5. Recollecting lines 81

13. Screenshots, PDF Reports & Mini-Reports 82

13.1. Capturing Screens 82
13.2. Using the Hotspot on your Smartphone 83
13.3. Mini Reports 84

14. Transferring Data to a PC 85

14.1. Formatting USB Sticks for the LMX Display Unit 86
14.2. USB Drive Folder Structure 86

15. LMX Output Files 88

15.1. Google Earth™ KMZ file 88
15.1.1. Internal GNSS 88
15.1.2. External GNSS 89
15.2. Project PDF Summary Report 91
15.3. Field Interpretations CSV file 93
15.4. GPZ file for EKKO_Project Software 94
15.5. System Summary PDF Report 95
15.6. LOG File 96

16. Troubleshooting 97

16.1. Screen turns White After Powering Up 97
16.2. LMX Does Not Power Up or Sensor Not Detected 97
16.2.1. Test the Battery 98
16.2.2. Test the Power Cable 98
16.2.3. Check the LMX Sensor and Display Unit Connectors 99
16.2.4. Replace the Cable 100
16.2.5. Test the Cable 100
16.3. System Communications 101
16.4. System Overheating 101
16.5. Display Unit Problem 102
16.6. Loose Wheels 102
16.7. Creating a Test Line for Data Quality 102
16.8. Contacting the Vendor for Service 102

17. Care & Maintenance 103

17.1. Battery Care 103
17.2. Cable Care 104
17.3. Skid Pads 104
17.4. Odometer 104
17.5. Storage Cases 104
17.6. Upgrading Embedded Software on Display Unit 105
17.7. Spare Parts 107
17.8. Accessories 108

18. Technical Specifications 109
Appendix A: Regulatory & Compliance A-1
Appendix B: Calibration B-1

1. Overview

The manual references embedded software version V3 R1 and above. The serial number of the Display Unit listed on the back of the unit must start with 0124-xxxx-xxxx, which is the DVL-502 series.

To see which software version is installed on your system, see the Swipe Down menu in Section 3.4.

The LMX200™ is a Ground Penetrating Radar system, offering two modes for acquiring data: Line Scan and Grid Scan. Once the unit is assembled and powered up, you can quickly start conducting a GPR survey.

Features of the LMX200 include:

- High visibility, touch screen display
- Display depth slices from Line Scans positioned with an external GNSS, right in the field
- Display depth slices from collected grids, right in the field
- UWB (ultra-wide band) antenna
- Target attributes can be sent by **Bluetooth**® to supported mapping apps on a nearby device.
- Dynamic Target Enhancement (DynaT™), allows user to selectively view small, medium or large subsurface targets
- Lightweight fibreglass cart frame
- Built-in Wi-Fi capability
- Integrated GNSS receiver with optional external GNSS for increased positional accuracy for geo-referencing data
- Ability to mark surface flags and subsurface interpretations directly in the data
- Display your travelled path, interpretations, flags and depth slices in MapView
- Export of data to EKKO_Project™ software for further data analysis

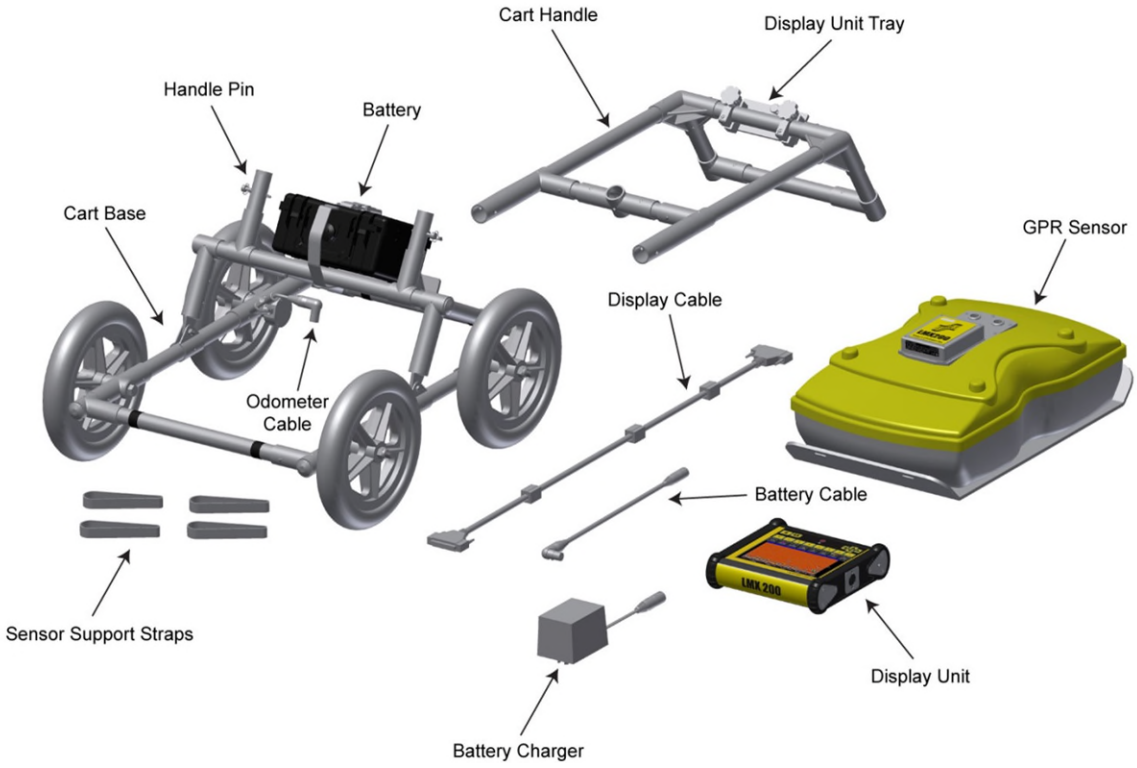
Online training videos for the LMX200 can be found on Sensors & Software's website at:

https://www.sensoft.ca/training-events/training/lmx200-training-videos

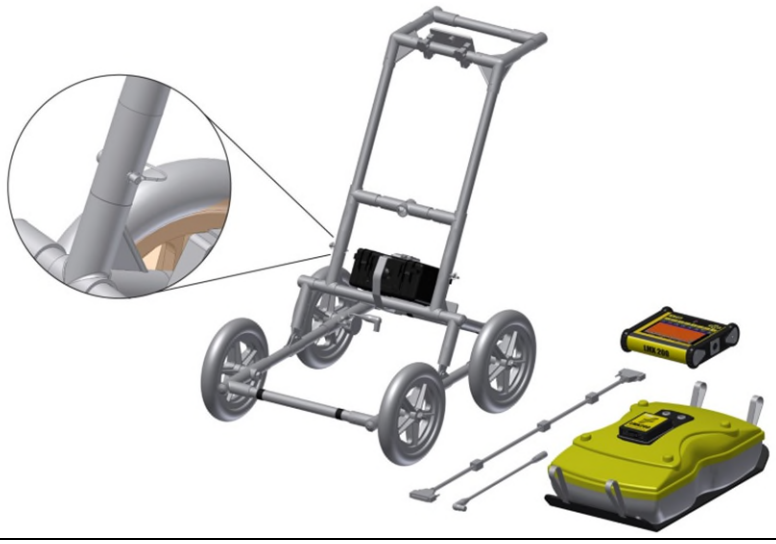
2. Assembly

2.1. Out of the box

You will find the following components in your LMX200 box. Some of these may already be assembled.



Attach the Cart Handle to Cart Base using the Handle Pins. Ensure the Display Unit Tray is facing the operator.



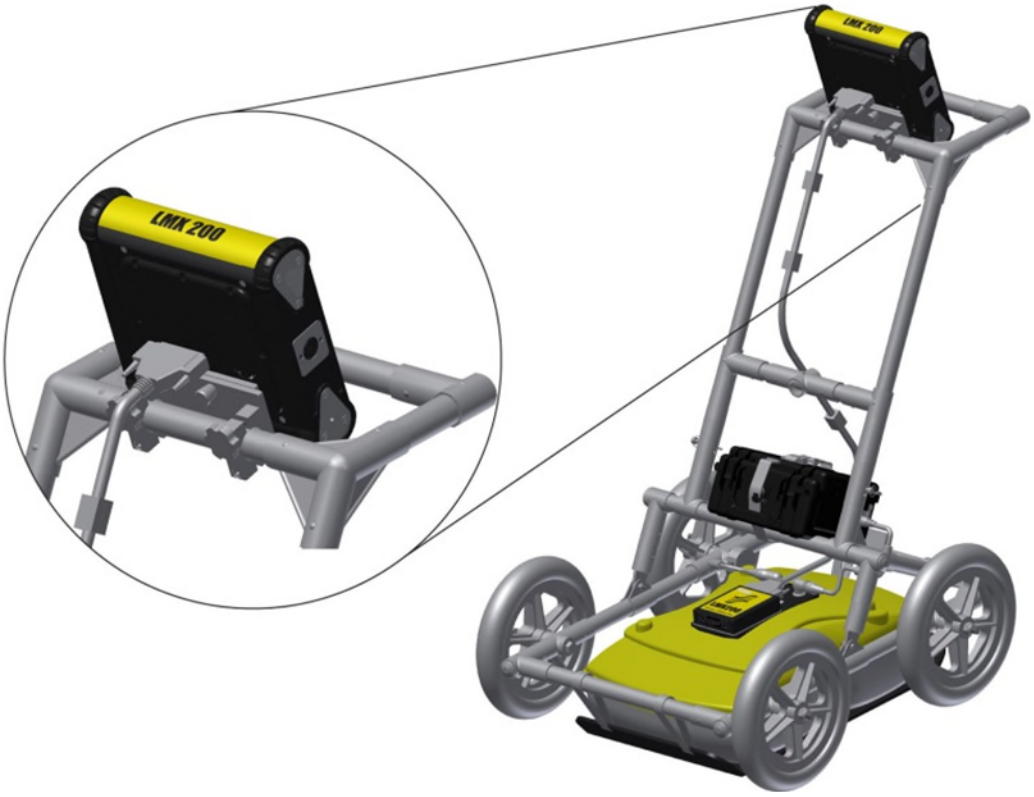
Attach the GPR Sensor to the Cart using the Sensor Support Straps. Ensure the Sensor is oriented the correct way with the cable connections toward the back of the Cart. Using the Sensor Support Straps, adjust the height of the Sensor so it is 1 cm (½ inch) above the ground. An easy way to get a uniform Sensor height is to place a couple of sheets of thick cardboard or thin particle board under the sensor before securing the Sensor Support Straps.



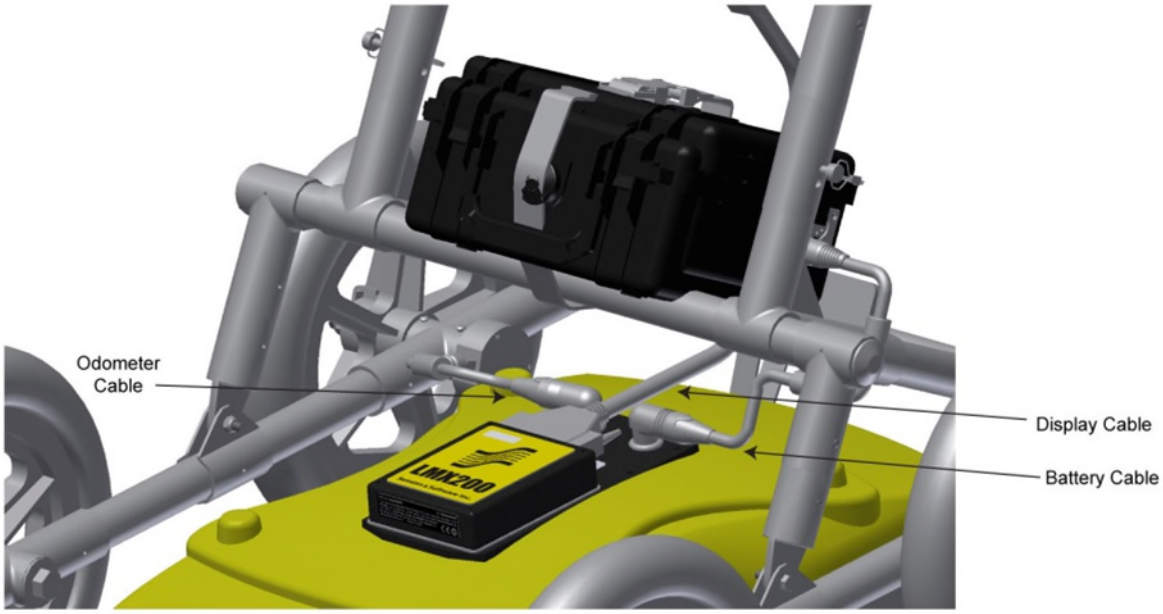
Attach the Display Unit onto the Display Unit Tray on the Cart. The Display unit slides down into the tray, catching on both sides of the mount and is held in place with the pull pin. When a click is heard, the Display Unit is firmly in place. Adjust the angle of the Display Unit by loosening the hand-screws underneath the Display Unit Tray, rotating the Display Unit to the desired angle and tightening the hand-screws. To remove the Display Unit, disconnect all cables, pull out the pull pin and lift the Display Unit up.



Attach the Display Cable to the back of the Display Unit with the jackscrews. Connect the other end of the cable to the Sensor. Ensure the cable is routed as shown below.



Attach the Odometer and Battery Cables. The Odometer Cable connects to the closest receptacle on the Sensor. Attach the Battery Cable to the Sensor and the Battery. The system is now setup and ready to use.



2.2. External GNSS (optional)

The instructions for connecting the GNSS, mount and cable are below.

GNSS Mount – The GNSS mount attaches to the crossbar frame above the battery, using a quick release pin. There is a pipe plug that needs to be removed first.



Ensure the right-angle pole is pointed up, then insert the GNSS mount into the opening where the plug was removed and secure with the quick release pin. This allows the GNSS to sit directly over the middle of the GPR sensor. It comes with 5/8-11 UNC-1A threads at the top of the pole.



2.2.1. GNSS Supplied by GPR Manufacturer

If you have purchased the Geode™ GNSS Receiver by Juniper Systems® with your GPR system, it comes pre-programmed for use with the LMX™ Display Unit.

Warning: NEVER press the Geode power button for more than 5 seconds. This will reset its programming, resulting in no communication with the LMX Display Unit. If this occurs, the Geode will need to be reprogrammed. Contact Sensors & Software for assistance.

Attach the Geode to the top of the LMX GNSS mount using the gold-colored adapter supplied with the Geode.

Ensure that the LMX Display Unit is powered down when connecting or disconnecting the GNSS cable.

Use the custom 9-pin (serial) cable labeled "GPR-Juniper Geode GNSS Cable"; it has internal wiring that is different than a standard serial cable. Using a different cable will result in unexpected behaviour.

Connect the 9-pin male end of the cable to the GNSS receiver, and the female end to the 9-pin serial port on the back of the Display Unit. This single cable is used to both power the GNSS and receive positional data from it.





Setting Up GNSS in Display Unit Menu

The GNSS must be enabled in the Display Unit's menu. Go to **Tools > System Test > GPS > GPS Setup** and set:

GPS Mode = External

Format = Lat/Lon

Serial Port Power = On (say Yes on the warning screen that appears).

Then press Exit/Back from each menu to return to the main menu.

For more details, see Section 4.2.7.

GNSS Internal Battery and Cable

The Geode GNSS has an internal battery that can be charged using the supplied USB-C cable and wall charger block, however this is not necessary when using the GNSS cable and settings listed above.

A standard 9-pin straight-through, Male/Female serial cable (not supplied) can be used to connect the Geode GNSS to the Display Unit, but if this cable is used:

1) The serial port power on the Display Unit **MUST** be turned OFF (see Section 4.2.7).
2) The Geode GNSS will be powered using its internal battery, so it will be necessary to charge it separately using the wall charger block and USB-C cable, supplied with the Geode.

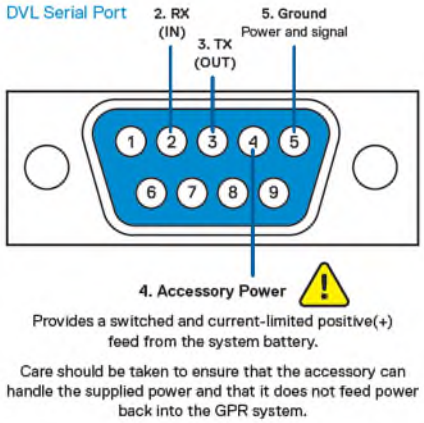
2.2.2. Third-party GNSS

If you choose to connect a 3rd party GNSS receiver, it must meet the following criteria:

- Be able to communicate over RS232 with a standard 9-pin serial output cable
- Output a NMEA GGA string in ASCII format, at a rate no faster than 20 Hz
- Have the following parameters set:
  - Baud rate = 19200 bps
  - Parity = None
  - Stop Bits = 1
  - Data Bits = 8
- If it cannot safely accept power via the serial port (as shown below), it must have its own battery or way of receiving power.
- GNSS must not expect any handshaking from the Display Unit

IMPORTANT: The serial port on the DVL supplies power (current=1A, voltage=12V). Exercise caution when connecting other GPS units to this port. Before connecting a GPS unit, you must check the pin assignments shown in the diagram below and confirm that they match the unit's

connections. Sensors & Software is not responsible for damage caused to a GNSS from using the serial port of the Display Unit.



See Section 4.2.7 to enable or disable power to the serial port.

2.3. Fully Assembled

The fully assembled LMX200 will look like the following.



Simply reverse directions to disassemble for transport.

3. Getting Started

3.1. Powering Up

When the battery is first plugged in, the LED goes green for 5 seconds then disappears.

To start the system, press the red power button on the display unit. The LED on the front panel will light up red.



Figure 3-1: Display Unit

Once boot up is complete, the colour of the LED will indicate the amount of battery power remaining:

- 100% to 20% = green
- 20% to 10% = orange
- 10% to 0% = red

The first time you turn on the LMX200, you will need to configure the system (Figure 3-1). A series of screen prompts will allow you to setup the language, units, date & time, and some other options. You will have to do this again anytime you update the embedded software (Section 17.6).

Every subsequent time the system boots up, you will see the main screen (Figure 3-2).

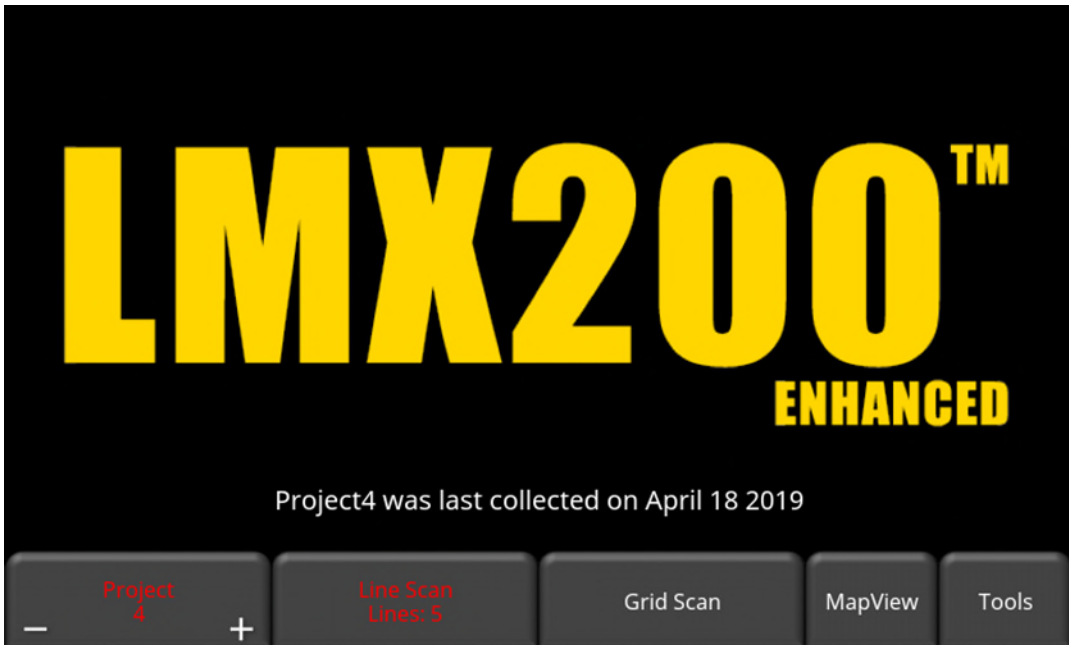


Figure 3-2: Main Screen for LMX200

From the main menu, select the project number to work in. Projects that contain data are in red color, whereas those with no data are in green. As you change projects, the main screen will also display the number of lines and grids collected in each project. These will appear under the Line Scan and Grid Scan buttons respectively.

3.2. Shutting Down

To power down, press the red power button on the display unit once. A confirmation message will appear, after which you can press **Yes** to proceed.

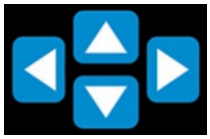
3.2.1. Emergency Shutdown

In the rare event that the display unit is unresponsive, a hard shutdown can be done by pressing and holding the red power button until the unit shuts down.

3.3. Interacting with the Display Unit

Data collection is controlled by the Display Unit. The Display Unit has embedded software to set survey parameters and collect, display and store data.
The Display Unit offers touch screen operation, as well as a water-resistant membrane keypad with a number of buttons that can be pressed to perform various tasks. Most operations can be done using either the touch screen or the keypad.

Use the following table as a guide to working with the keypad on the Display Unit:

Item	Description
Menu Buttons 	The yellow buttons labelled 1 to 8 correspond to menu choices that appear on the screen.
4-way directional keypad 	Controls Up/Down/Left/Right operations in certain menus.
Camera 	Saves a screenshot of line data, grid data or the MapView display.
Asterisk / Special Function 	Used to: 1) add Flags during data acquisition, 2) quickly enter the **No Save mode** for Line Scan data collection.

3.4. Swipe Down Menu

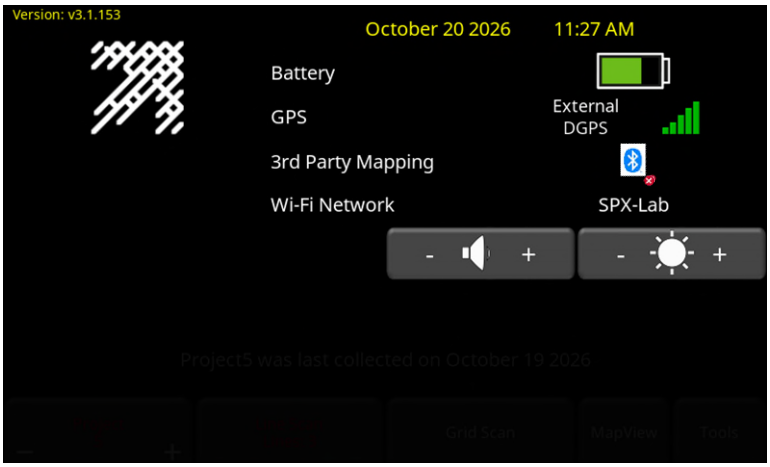


Figure 3-3: Swipe-Down menu

When the Display Unit is powered on, you can “swipe” your finger from the top of the screen towards the bottom, to display a Swipe-Down menu (Figure 3-3) with the following items:

Date and Time: The current date and time (12-hour clock). The time needs to be changed in areas that observe daylight-savings-time.

Battery: The battery icon displays the amount of power remaining in the battery.

GNSS: Shows which GNSS is being used (Internal or External) and the signal strength.

3rd Party Mapping: If 3rd Party Mapping in ON (4.1.6), the Bluetooth icon indicates the status of the connection.

Wi-Fi Network: Indicates if the system is connected to a wireless network and, if so, the name of the network. See Section 4.1.7 for details on connecting the system to a wireless network.

Volume: The Volume + and - buttons are used to increase and decrease speaker volume.

Brightness: The Brightness + and - buttons are used to increase and decrease the screen brightness. For example, increasing the Brightness setting may improve the visibility of the screen in bright sunlight. Note, however, that increasing the screen brightness also increases power consumption, thus reducing battery life.

To close the Swipe-Down menu, touch anywhere on the screen below the swipe-down menu.

4. Tools & Setup

To enter the **Tools** sub-menu, select it from the main screen shown in Figure 4-2.



Figure 4-1: Tools Menu

Here you can set preferences, adjust system settings, perform system tests and manage files. You will see the screen shown in Figure 4-2:

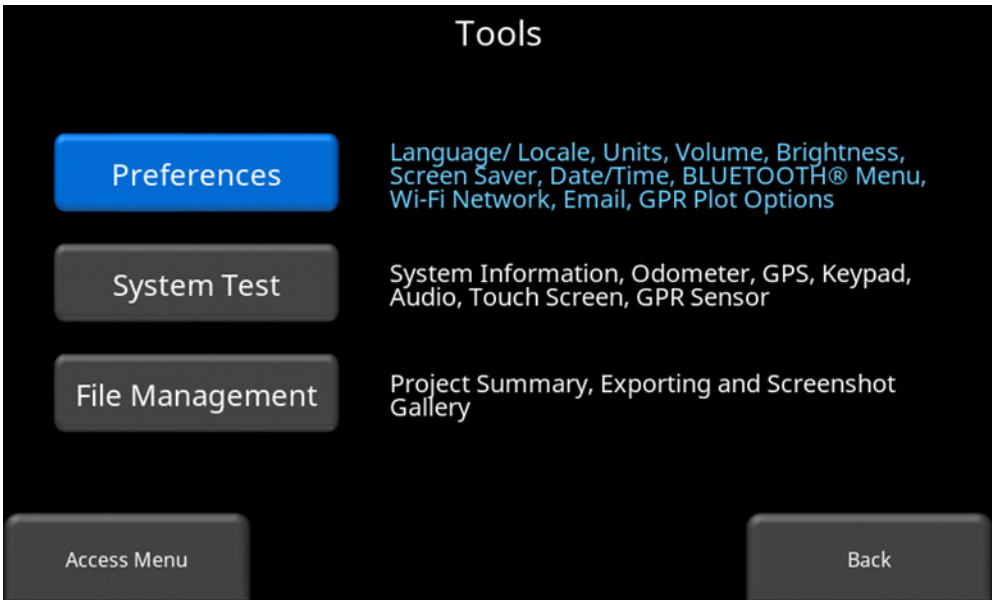


Figure 4-2: Tools Menu

4.1. Preferences

Selecting the **Preferences** option will take you to the sub-menu shown in Figure 4-3.

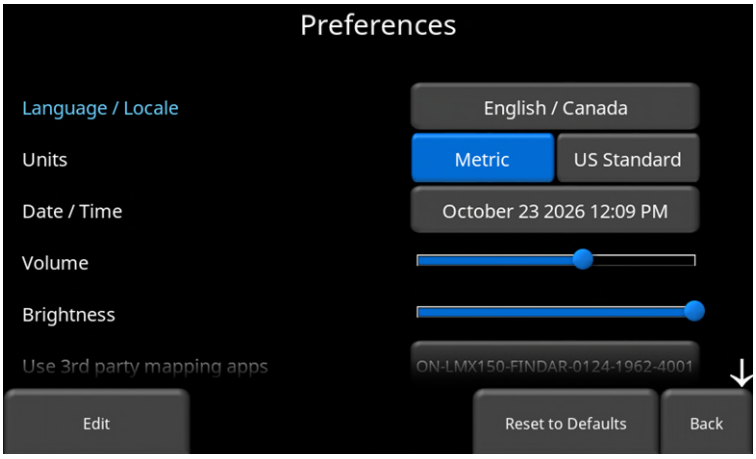


Figure 4-3: Setting Preferences

There are several parameters that can be modified. Touch the screen and swipe up or down to scroll and view additional parameters. To change a value, press the value on the right side of the screen. Alternatively, use the up and down arrows on the 4-way keypad to highlight the desired parameter, then press Edit. Each parameter is described in detail below.

4.1.1. Language / Locale

Selecting this option will display the screen in Figure 4-4. The current language is displayed; pressing the **+** and **–** buttons on either side of the language will cycle between the languages currently available. Below that, the Country/Region is displayed. Press the **+** and **–** buttons on either side of the displayed Country/Region to alphabetically move to the next or previous country or region.

Alternatively, both Language and Country/Region can be changed by pressing the **+** and **–** buttons on the bottom of the screen. Press **Back** when you are done.

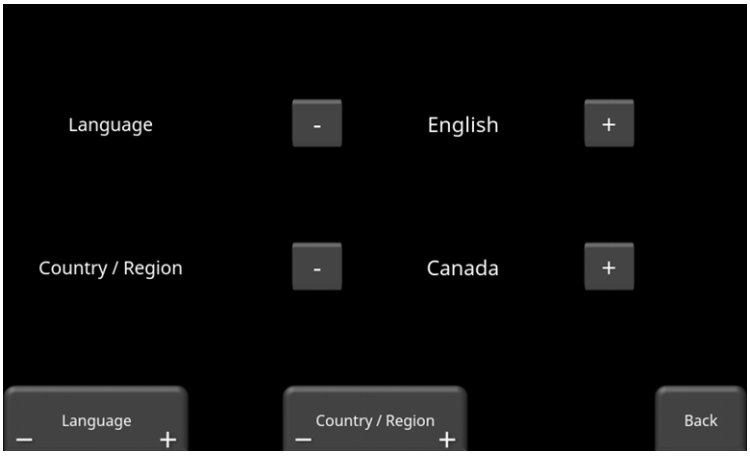


Figure 4-4: Changing Language and Country/Region

4.1.2. Units

Pressing **Units** will cycle between US Standard and Metric Units.

4.1.3. Date/Time

Selecting this option takes you to a screen where the date and time can be set. The time is manually set and will **not** automatically correct for daylight savings time.

4.1.4. Volume

Scroll bar for adjusting the volume of clicks and beeps heard during operation. This can also be changed by using the Swipe Down menu (Section 3.4) anytime the system is not collecting data.

4.1.5. Brightness

Scroll bar for adjusting the brightness of the screen. Note that increasing the brightness consumes more battery power. This can also be changed by using the Swipe Down menu (Section 3.4) anytime the system is not collecting data.

4.1.6. Use 3rd party mapping apps

GPR field interpretations, added to the GPR data by touching them on the Display Unit screen (6.6.7), can be sent by **Bluetooth** to 3rd party mapping apps, such as PointMan® or TerraFlow™.

Output to mapping apps is only available when the LMX200 GPR system has an external GNSS connected and enabled. See 2.2 for details on setting up an external GNSS.

In the LMX menu, select **Tools > Preferences**.

Turn **Use 3rd Party Mapping Apps** to **ON (**Figure 4-5**)**, taking note the Serial Number of the LMX system, which is a required input on the mapping app.

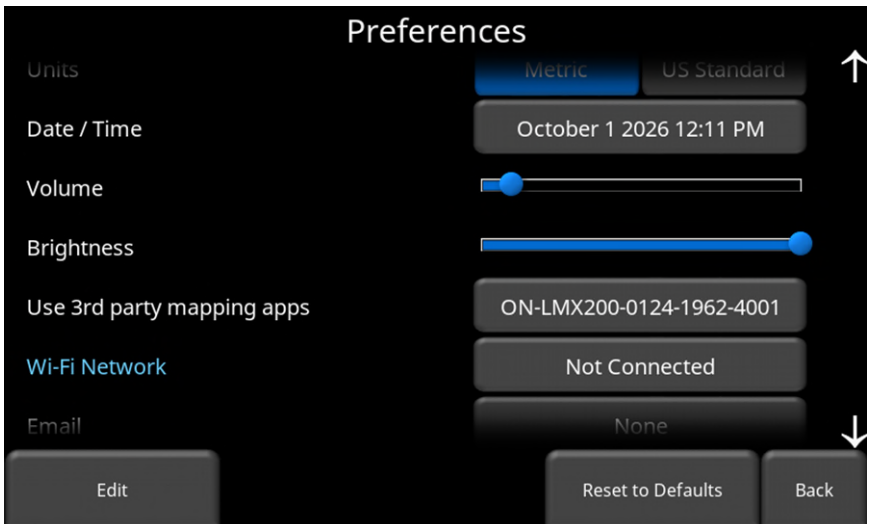


*Figure 4-5: Set the **Use 3rd party mapping apps** option to ON to output point interpretation attributes to be output by **Bluetooth**.*

With **Use 3rd Party mapping apps** ON, during LMX data collection, with the mapping app open on a nearby device, data interpretations added to the Display Unit screen are also sent, via **Bluetooth**, to the mapping app (Figure 4-6).



*Figure 4-6: Set the **Use 3rd party mapping apps** option to ON to send point interpretations to supported mapping apps.*

For details of how to use supported mapping apps with an LMX system, see: https://www.sensoft.ca/products/lmx200/resources/

4.1.7. Wi-Fi Network

Connecting to a wireless network allows you to send a mini-report to someone by e-mail. This connection can be through a standard Wi-Fi network or through a hotspot on your mobile device while in the field.

Note that LMX200 CANNOT connect to Public Hotspots (typically restaurants, hotels and airports) that require a web-based login and acceptance of their Terms & Conditions. It also CANNOT connect to unsecured networks (networks that do not require a password).

If you are already connected to a Wi-Fi network, the name of the network is listed beside the Wi-Fi Network field. Selecting **Wi-Fi Settings** takes you to a sub-menu (Figure 4-7) for connecting and configuring Wi-Fi settings.

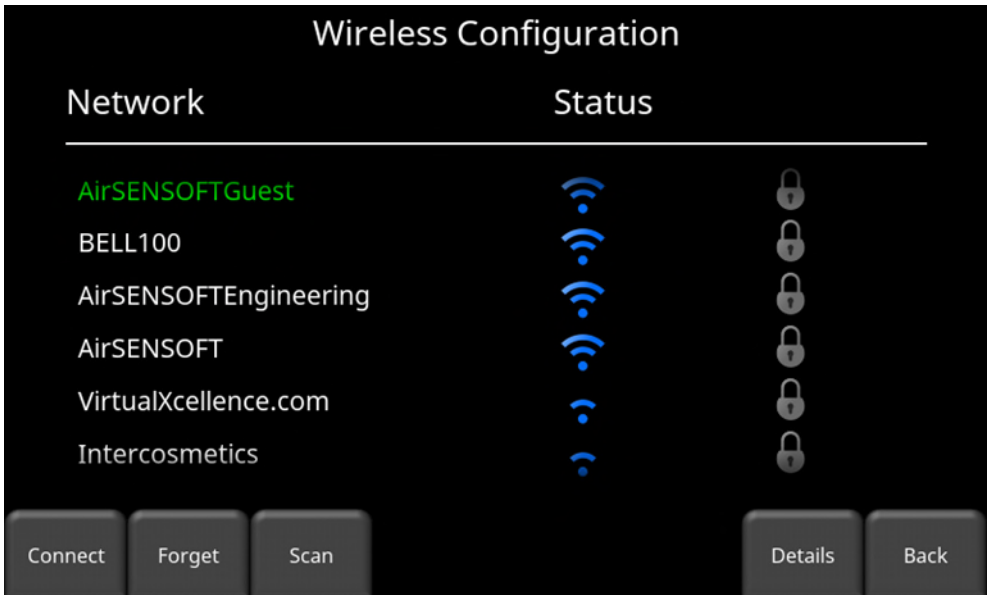


Figure 4-7: Configuring Wireless settings and E-mail address

Use the 4-way directional arrows or touchscreen to select the network. The color of the Network Name indicates the status:

- Green = Connected
- Yellow = Not currently connected but remembered from before when you previously connected and entered a password.
- White = Not connected

- **Connect** – Select the desired network and press Connect.
  If the connection is successful (this can take a minute or so) a screen appears asking for the password for that network. If the network name is yellow (from a previous connection to this network), it will not ask for a password because it is a remembered network. Once it connects the Network Name will turn green.
- **Forget –** Use the Forget button to remove the password for connected or remembered networks (text in green or yellow). Once the 'forget' button is pressed on a selected network it will remove the password, and the Network Name will turn white. You will also be disconnected if you are currently connected to that network.
- **Scan –** Scans for any available networks in the area and displays them in order of strength of signal. You may need to press this button a second time if you don't see the network you are looking for.
- **Details –** Pressing this button displays the security settings and device addresses related to the selected network.
- **Back –** Press this button to return to the System Settings screen.

4.1.8. Email

Press **E-mail** to arrive at a sub-menu where you can setup and configure a sending e-mail address. Ensure that this e-mail address already exists. This is the sending account where messages will originate from. All mini-reports received by the recipient will appear to come from this account.

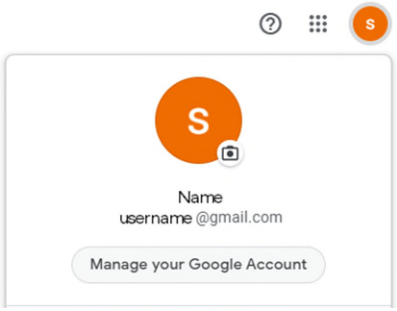
Using Gmail™

Using a Gmail address on the Display Unit requires “app specific password”. An app specific password is a 16 character randomly generated passcode that allows access to a portion of the overall Google™ account. These passwords can be deleted at any time if the user feels it has been compromised. Note that 2-factor authentication is required for the use of app specific passwords. Note that Sensors & Software Inc. is not responsible for any third-party services.

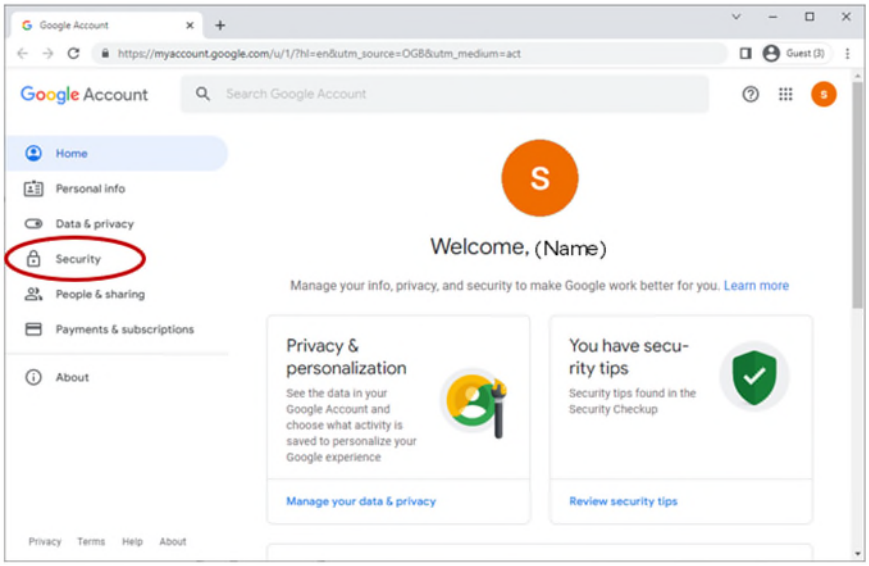
The following procedure details the steps required to enable and generate an app specific password:

1) Log into Google account on a desktop computer.

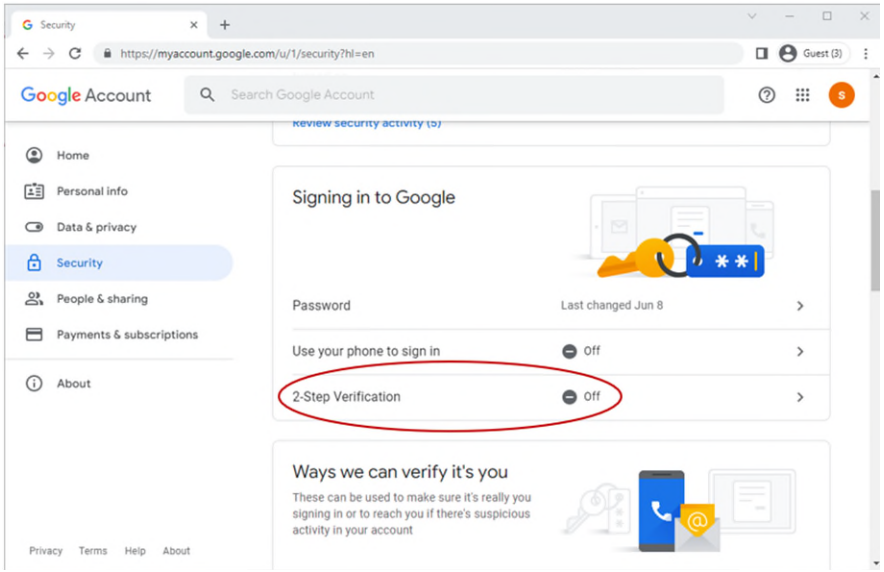
2) Click on the top right account icon and select **Manage your Google Account**



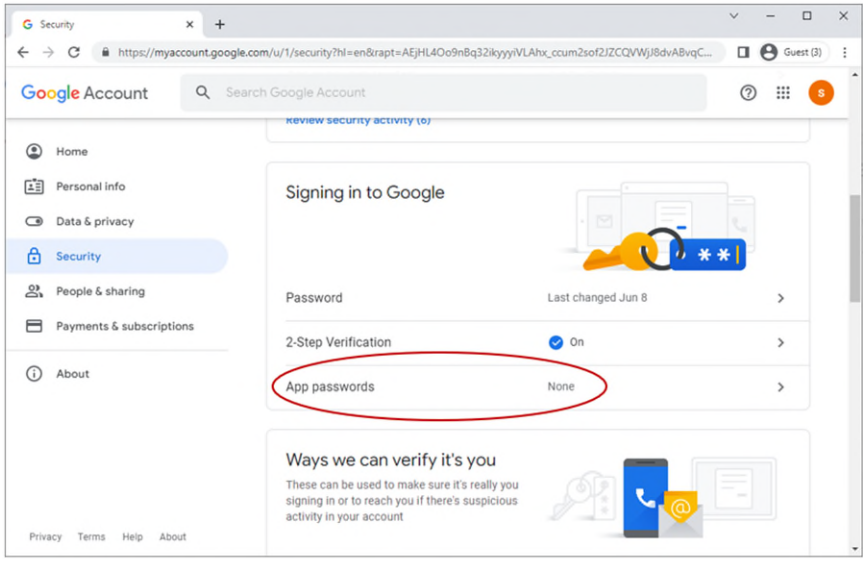
3) Select **Security** from the left menu



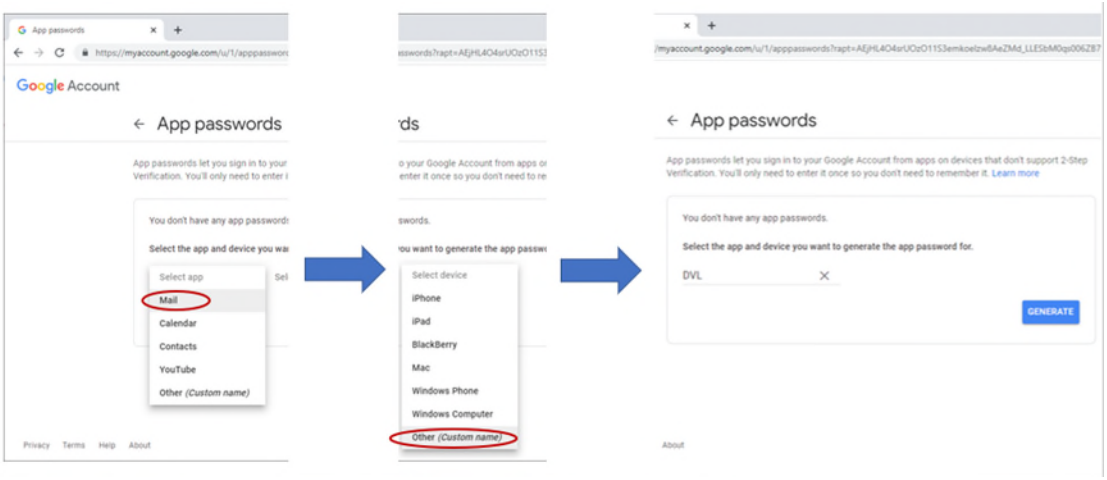
4) Scroll down to the **Signing into Google** section and turn on **2-Step Verification** (if it is not already enabled). Follow the onscreen instructions to add/verify your phone number



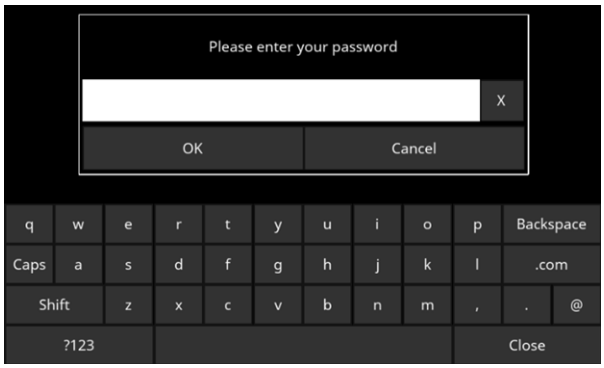
5) Return to the Security menu and you should now find the **App passwords** option under **Signing into Google**. Click on **App passwords**.



6) Under “Select app” choose **Mail**, and under “Select device” choose **Other** and enter an appropriate name (i.e., Display Unit). Click **Generate**.



7) Use the generated 16-character password (without spaces) when configuring your Gmail account on the Display Unit:



Once you have made the changes in your Google account, continue below (Figure 4-8):

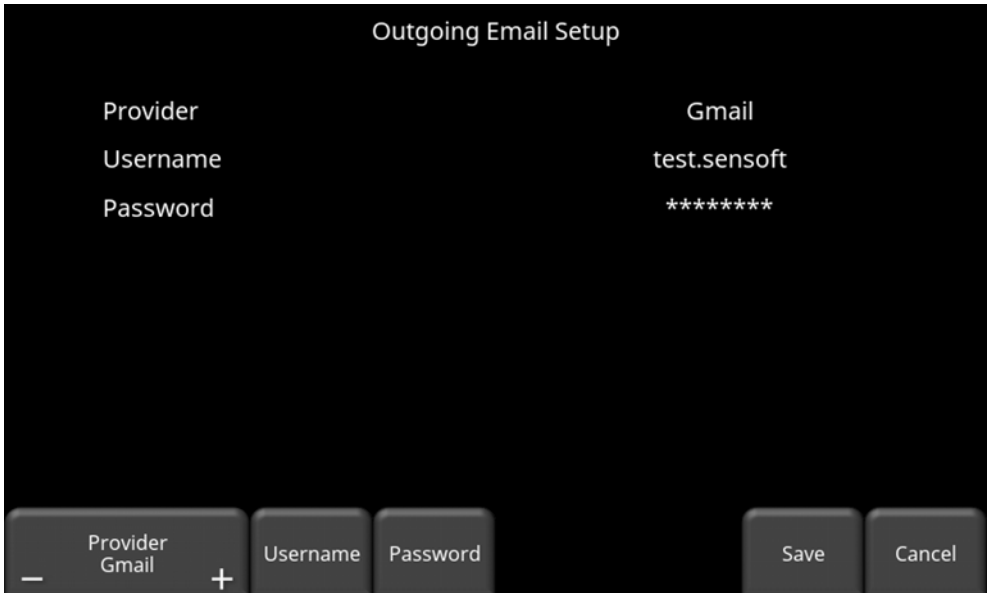


Figure 4-8: Using Gmail as e-mail provider

- Press **Username** to display a keyboard where you can enter your Gmail username only; you do **not** need to enter @gmail.com. Then press OK when done (Figure 4-9a)
- Press **Password** to display a keyboard where you can enter your Gmail password. Then press OK when done (Figure 4-9b)
- Press **Save** when both Username and Password have been entered.

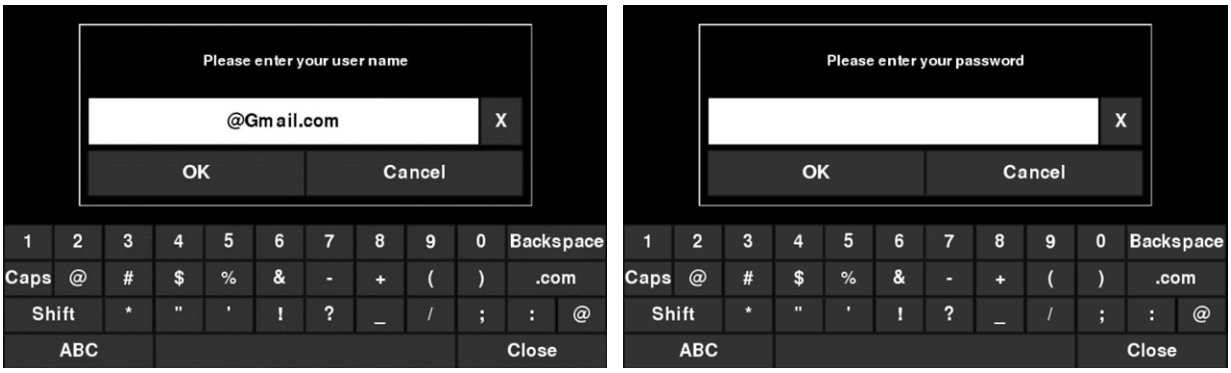


Figure 4-9: Entering e-mail address (a) and password (b) for Gmail

If there are no warning messages, the e-mail address is setup properly and you are ready to e-mail mini-reports from the field. If this does not work, see the Failed Setup section below

Using Another Provider

To use another e-mail provider, press the **+** and **–** buttons under **Provider** until it says **Custom.** This will display the screen shown in Figure 4-10 allowing you to setup and configure a different e-mail provider:

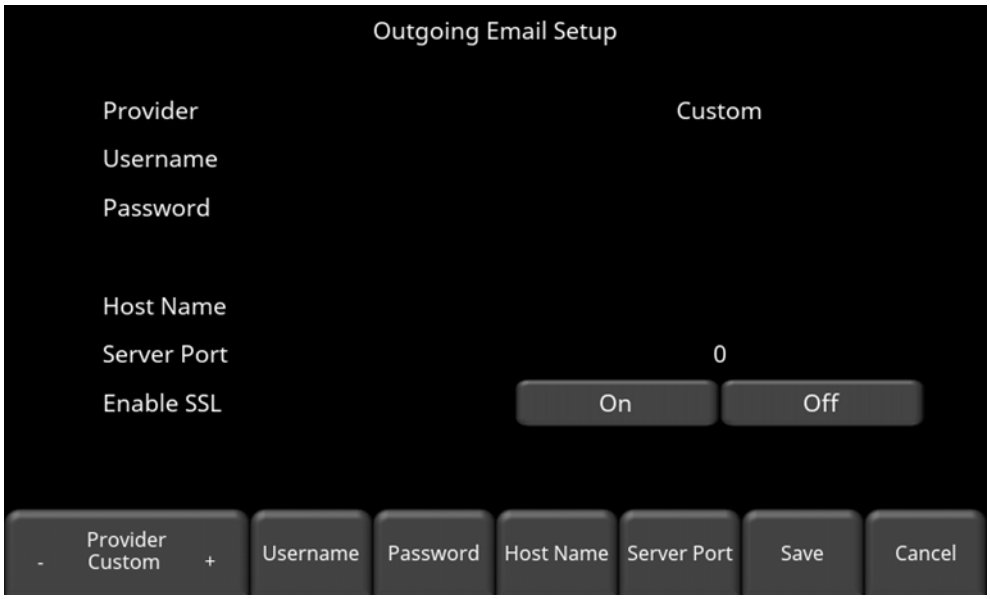


Figure 4-10: Entering e-mail address and password for another e-mail provider

- Press **Username** to display a keyboard where you can enter the complete e-mail address, then press OK when done.
- Press **Password** to display a keyboard where you can enter the password, then press OK when done.
- Press **Host Name** to display a keyboard where you can enter the name of the server address handling the outgoing mail. See chart below for some common e-mail providers. If your provider is not listed, it can usually be found by searching online for "SMTP host name <provider>", where provider is the host name e.g. Yahoo!® or AOL®. Press OK when done.
- Press **Server Port** to display a keyboard where you can enter the port number used by the email server. Searching online for host name will usually provide the port number for that e-mail provider. In most cases, it's usually 465 (if SSL is enabled, see next bullet point), or 587. See chart below for some examples. Press OK when done.
- Enable SSL – you can select **On** or **Off** on the display. SSL provides encryption security. Some e-mail providers require this set to ON. This will usually be indicated on the same online search page that was used above. See the chart below for examples.
- Press **Save** when all the information is entered and correct.

Below is the chart for some common e-mail providers:

Provider	Host name	Server Port	Enable SSL
Hotmail/Outlook	smtp.live.com	587	Off
Yandex	smtp.yandex.com	465	On

If there are no warning messages, the e-mail address is setup properly and you are ready to e-mail mini-reports from the field.

Failed Setup

If setup failed, possible reasons include:

1. No-Wi-Fi connectivity
2. Email address or password was entered incorrectly – try re-entering these fields.
3. Hostname, port or SSL setting are incorrect
4. Your email security settings **may need** to be adjusted to a more permissive setting, which may require you to login to your email account from a PC or mobile device.

4.1.9. Screen Saver

A screen saver can be setup to turn off the Display Unit screen after a period of inactivity to save power. The Screen Saver can be set to turn the screen off after 1 minute, 5 minutes or never (OFF setting). Pressing this button cycles between those three options. When the screensaver is activated and the screen shuts off, touch anywhere on the screen to turn it back on again.

4.1.10. GPR Plot Options

Selecting this option will display the screen in Figure 4-11.



Figure 4-11: GPR Line Plot Options

- **Auto-Hide Buttons** - If this is set to ON, then in Line Scan mode, the buttons at the bottom of the screen disappear shortly after data collection begins, effectively enlarging the area for data display. The buttons will re-appear after a couple of seconds whenever the sensor stops moving forward, is in back-up mode or any button is pressed on the keypad.

4.1.11. Reset to Defaults

Selecting this option at the bottom of the screen will reset all settings & preferences back to the default settings (Figure 4-12). Pressing this will ask you to confirm the Reset to Defaults. If **Yes** is selected, the next screen will ask if you would like to remove all saved wireless networks and e-mails addresses.

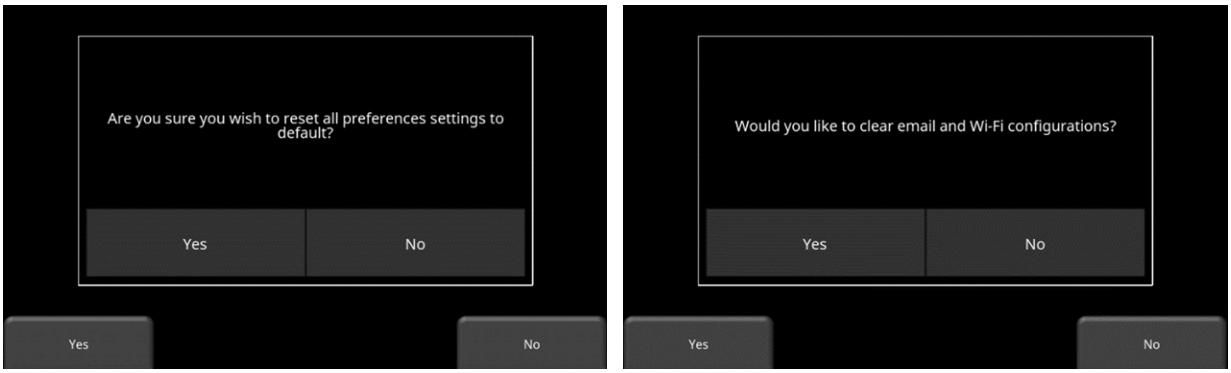


Figure 4-12: Reset to Defaults, a) Image on left is the first confirmation screen. b) If you press Yes, you will see the second confirmation screen on the right asking about deleting e-mails and Wi-Fi settings.

4.2 System Test

The System Test sub-menu (Figure 4-13) allows the user to perform certain tests to ensure proper operation of the system. Select the component to test then press **Start**. After completing a test there is an indication of whether the system passed or failed the test. Each test is described below in more detail.

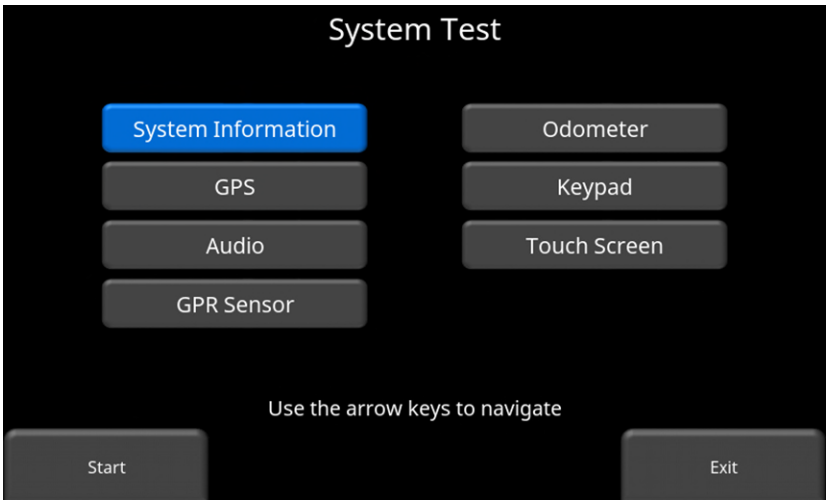


Figure 4-13: System Test menu

4.2.1 System Information

System Information is the only option in System Test which is not actually a test. Here information such as the version, serial numbers, temperature and battery power are displayed. (Figure 4-14). There are two options at the bottom of this screen:

- **Export** - If a USB key is currently inserted, pressing Export will just export the System Log and Summary Files

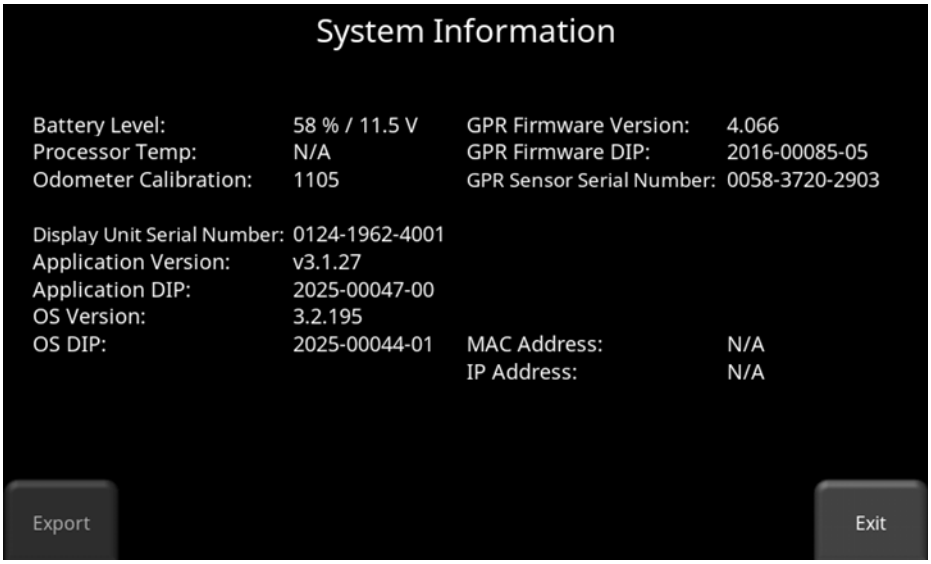


Figure 4-14: System Information

4.2.2 Keypad Test

The keypad test ensures that all buttons on the membrane keypad are working. Press **Start** to begin the test which requires the user to press each button once, within a 20 second timeframe (Figure 4-15).

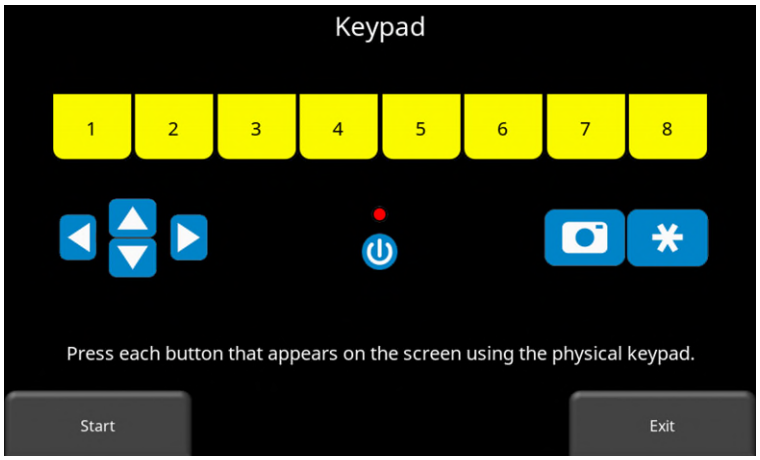


Figure 4-15: Keypad Test

Once that is complete, a short LED test will ensue, which checks the proper operation of the LED.

4.2.3 Audio

This test ensures that the speaking is operating properly. After starting the test, you should hear a sound with an increasing pitch.

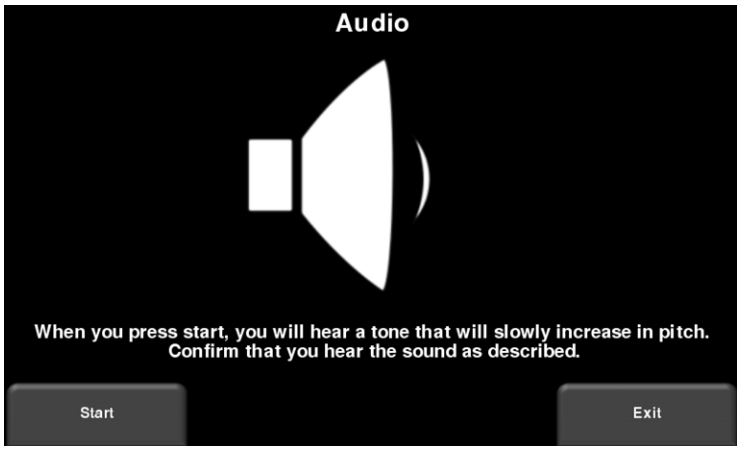


Figure 4-16: Audio Test

4.2.4 Touch Screen

The test checks proper operation of the touch screen (Figure 4-17). It allows you to test the screen (by pressing **Test**) or perform a quick calibration followed by a test (by pressing **Calibrate**). Both involve touching targets on the screen in the allotted time.

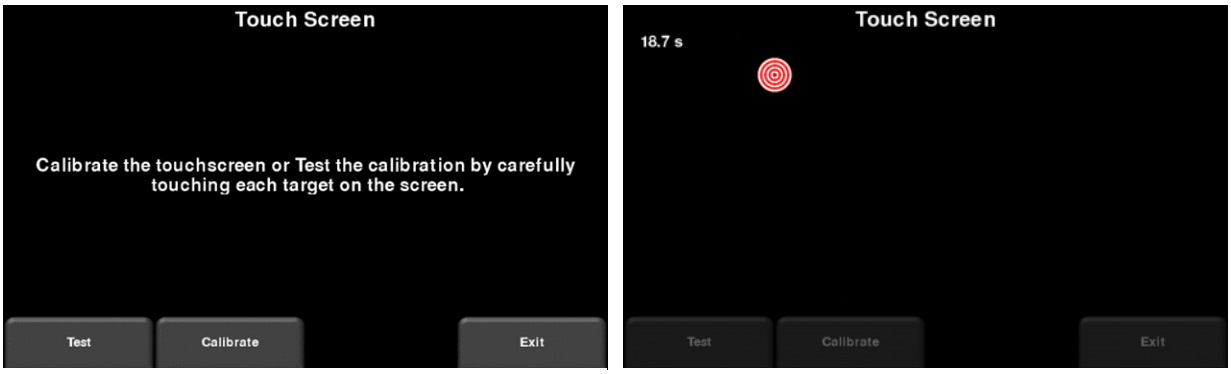


Figure 4-17: Touch Screen test on the left, Touch Screen calibration test on the right

4.2.5 Sensor Test

This test checks proper operation of the GPR sensor, including the amplitude of the pulse. Once the cart is tipped backwards and start is pressed, it will conduct the test (Figure 4-18). If there are any irregularities, the test will indicate failure. However, if the test passes, it doesn't mean the system is working perfectly. A test line should be setup as a baseline, and results compared to the test line to validate proper performance and operation (Section 16.7).

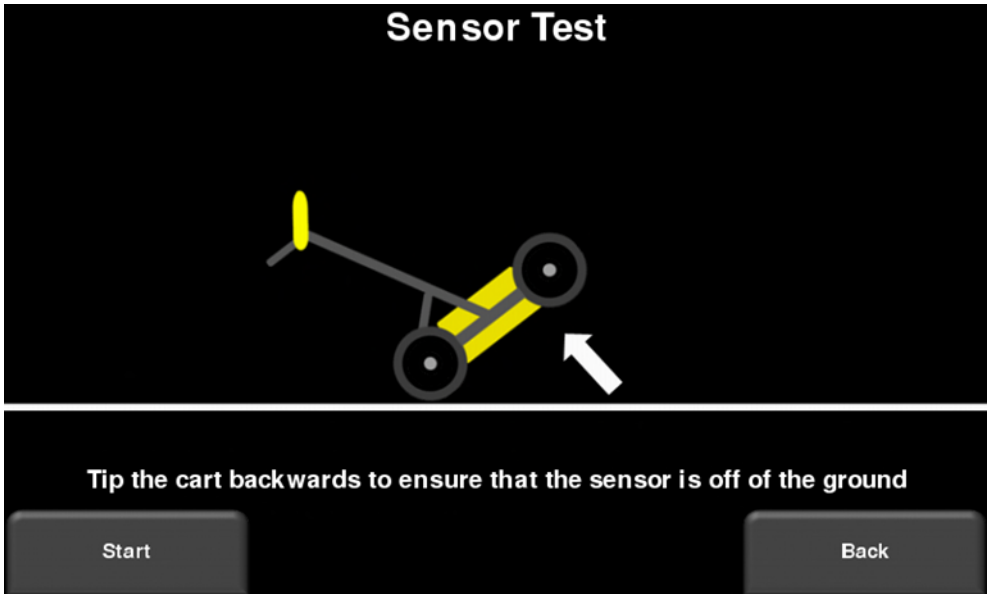


Figure 4-18: Sensor Test

4.2.6 Odometer Calibration

This test ensures that the odometer is measuring distance accurately. Even though the odometer is calibrated in the factory, you must calibrate it periodically to ensure accuracy. This is particularly important as the calibration can change with different surface materials.

When selecting this option, you will see the screen in Figure 4-19. The following options exist:

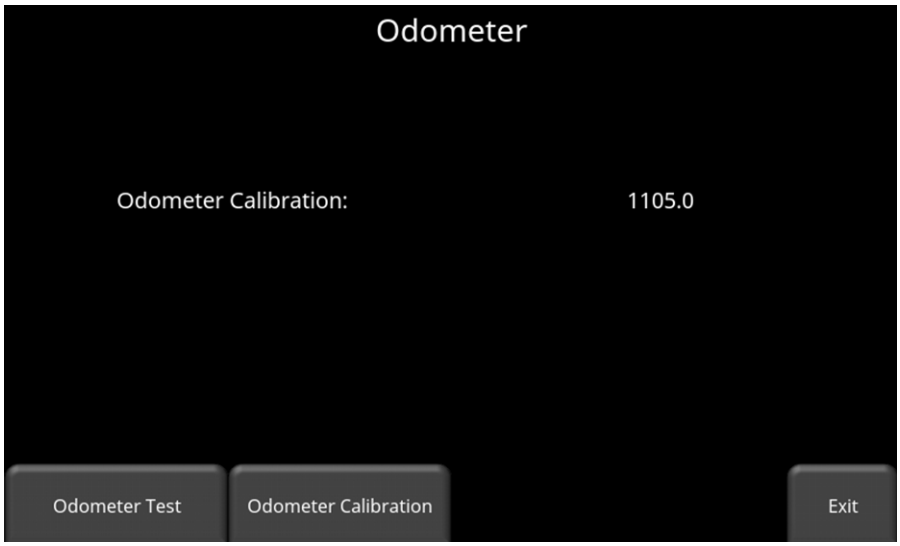


Figure 4-19: Screen displaying current odometer calibration

- **Odometer Test** – This test verifies the odometer is calibrated properly. It involves moving the system a set distance (5m or 10ft, depending on units used), and comparing the value obtained to a known value. The screen in Figure 4-20 will be displayed once Odometer Test is pressed. Press **Start** to begin and then press **Finish** when you've moved that distance. It will display a pass or fail, along with a percentage difference from the known value (Figure 4-21).

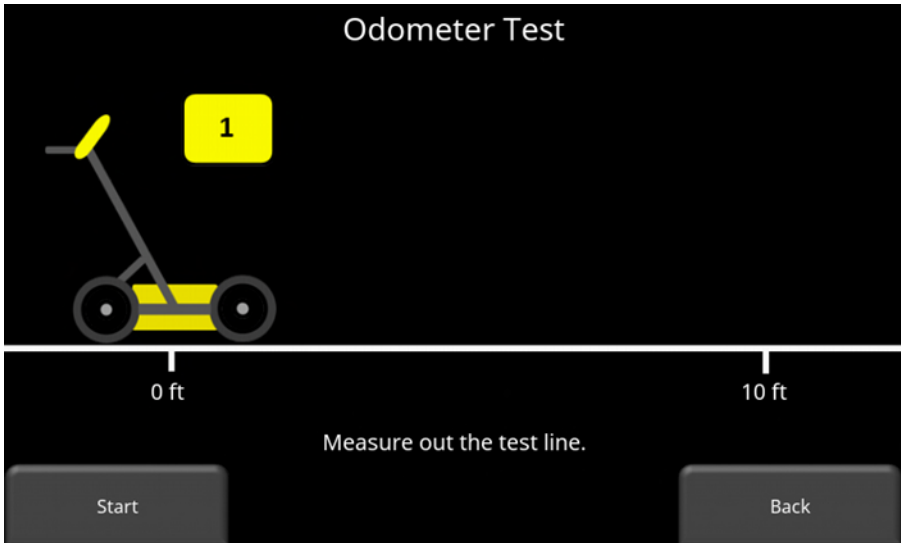


Figure 4-20: Doing an odometer test

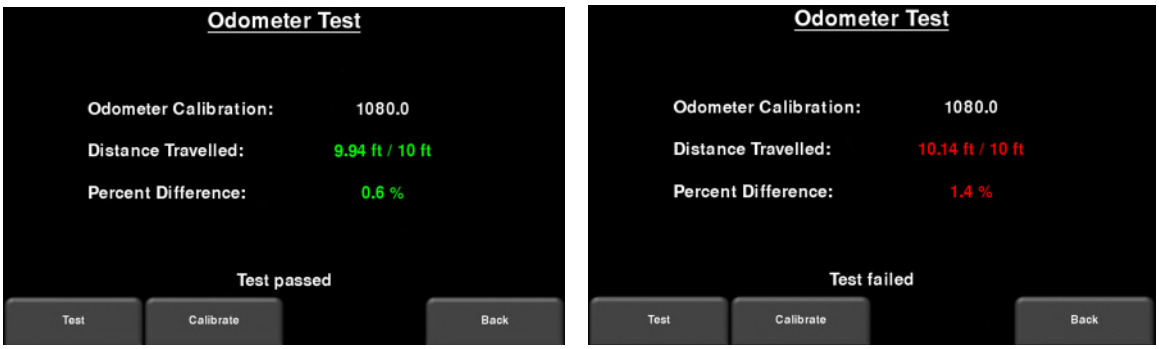


Figure 4-21: Odometer Test passed on left, failed on the right

- **Odometer Calibration** - This option actually calibrates the odometer (Figure 4-22). Choose a set distance from the screen or select **Custom**. Then press **Start** and move the system that exact distance, using a measuring tape or other known distance indicator. Press **Finish** when you have travelled that distance

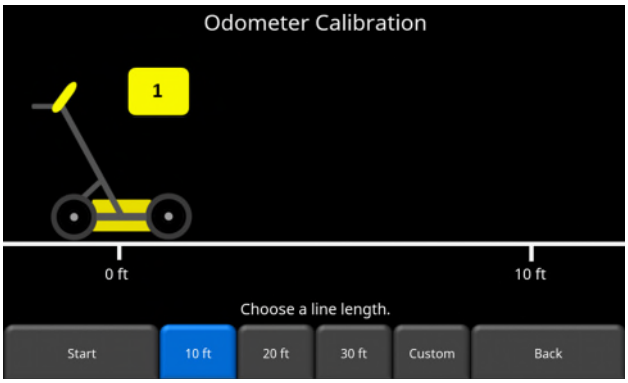


Figure 4-22: Odometer Calibration – select a distance and then press Start

Upon completion, it displays the screen in Figure 4-23 (left image). You can either accept the new value by pressing **Accept** or revert back to the previous value by pressing **Reject**. If the new value is significantly out of range, the test will fail Figure 4-23 (right image).

The odometer calibration value is stored in the Display Unit. If the Display Unit is changed, or swapped out, you will need to run the Odometer Calibration test again.

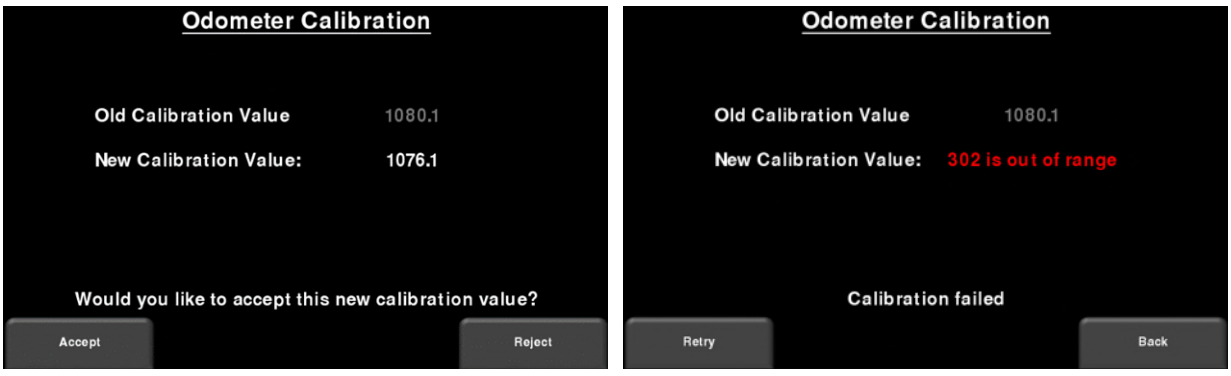


Figure 4-23: Results of successful Odometer Calibration (Left). Image on Right shows a failure, as calibration is out of range

4.2.7 GPS

The LMX Display Unit contains an internal GNSS, but you also have the option to purchase an external GNSS receiver from Sensors & Software (2.2.1). Alternatively, you may have your own GNSS that you want to connect to the system (2.2.2). The GPS test will ensure that the system is communicating properly with the GNSS and receiving data (Figure 4-24). It doesn't mean you are actually seeing satellites; the GNSS test can still pass indoors with zero satellites visible. If the test fails, check the GNSS cable is connected securely at both ends and the GNSS is receiving power.

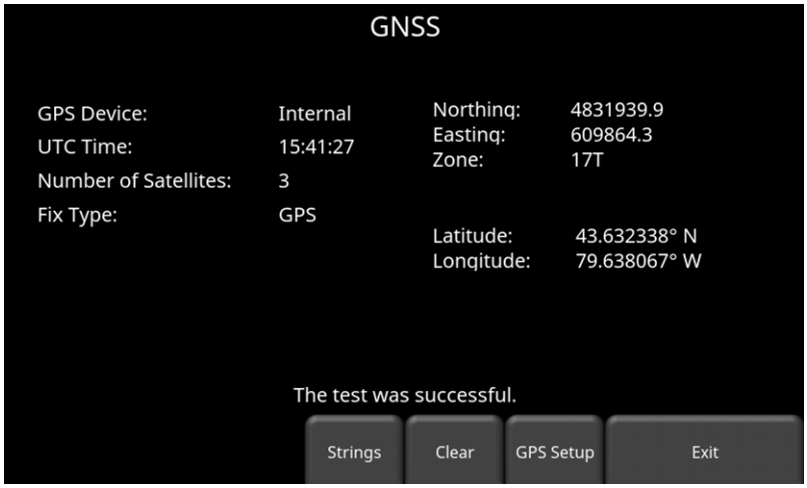


Figure 4-24: GNSS Test

The basic position and time information is displayed on the screen. On the screen, the Fix Type notes if there are any corrections being applied, such as DGPS. When first going outside, give it a few minutes to track, or lock onto satellites.

Pressing **Strings** will display the raw data strings that are outputted by the GNSS (Figure 4-25) as they scroll down the screen. The user may select this option to verify the GNSS is outputting the proper NMEA string format.

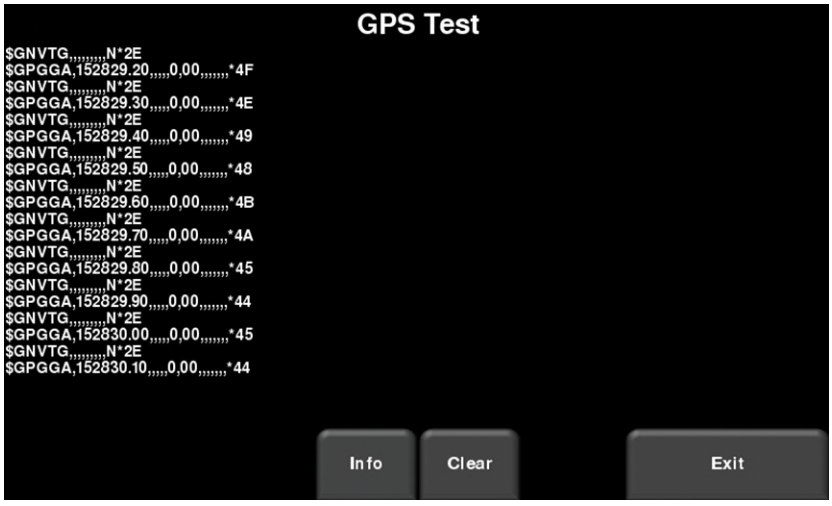


Figure 4-25: GNSS Strings

Pressing **Clear** will clear the strings. Pressing **Info** will return to the main GPS test menu.

Press **GNSS Setup** to see the current GNSS(GPS) setup (Figure 4-26).

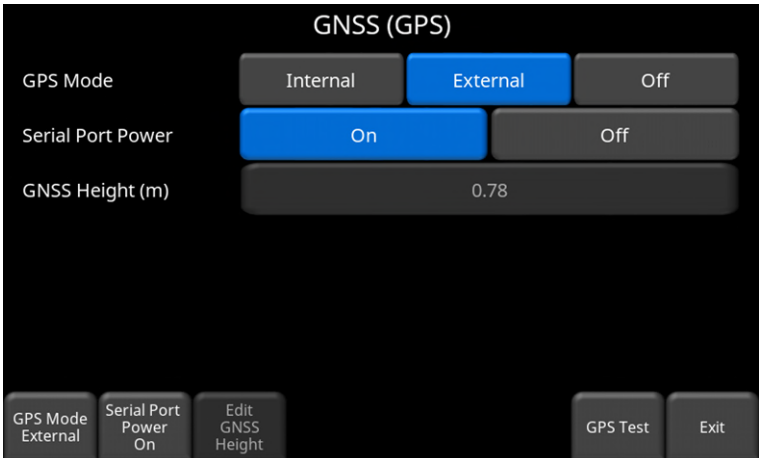


Figure 4-26: GNSS (GPS) Setup screen

The following buttons are explained below:

- **GPS Mode** –you can select whether to use the **Internal** GNSS, **External** GNSS or no GNSS at all (Off).

  Note that, due to limited accuracy, the Internal GNSS cannot be used to position Line Scans in MapView; only an External GNSS will do this.

  Ensure that you have the right **GPS Mode** selected prior to your survey.

- **Serial Port Power -** the serial port on the back of the Display Unit can output power, thereby enabling a single cable to be used for the GNSS (power and data). When you purchase the GNSS from Sensors & Software, this cable is included. However, if you use a 3rd party GNSS, you need to determine if the GNSS can accept power via the serial port. Check the pin-out diagram in Section 2.2.

  Pressing the **On** button will turn power to the serial port on, but it will display a warning message first Figure 4-27. Press **Off** to disable power through the serial port.

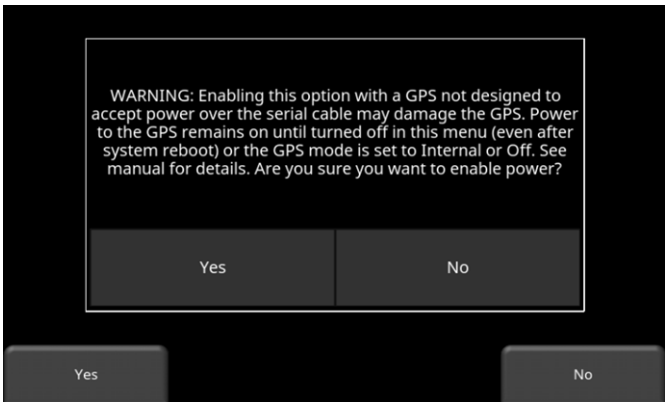


Figure 4-27: Warning message about enabling power to the serial port

- **GNSS Height –** this is the height of the GNSS unit when placed on a standard LMX GPS mount (Section 2.2). It is fixed at 0.78 meters (2.56 feet) and cannot be edited. This height is used to correct the elevations of GPR interpretations added to the GPR data.

4.3 File Management

Press **File Management** to enter this sub-menu. From here, the user can view screenshots, export data and delete all data Figure 4-28.

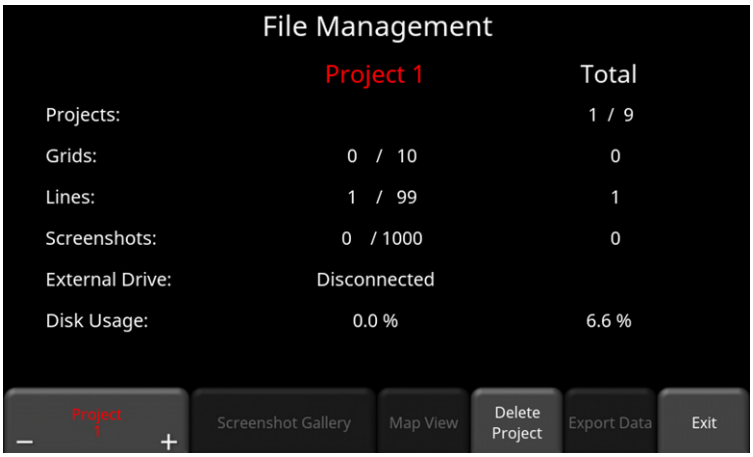


Figure 4-28: File Management displays the lines, grids and screenshots for a given project in the middle column. The right column displays the total for each that are saved on the system.

A description of each of the buttons is given below:

4.3.1 Screenshot Gallery

This allows the user to view all screenshots that were saved by pressing the Camera button (Section 13.1). The display will show a Tile View of four screenshots per page (Figure 4-29). If there are more than four screenshots, swipe the screen from right to left to view the rest. Alternatively, you can also use the **Left** and **Right** arrow keys on the 4-way directional keypad

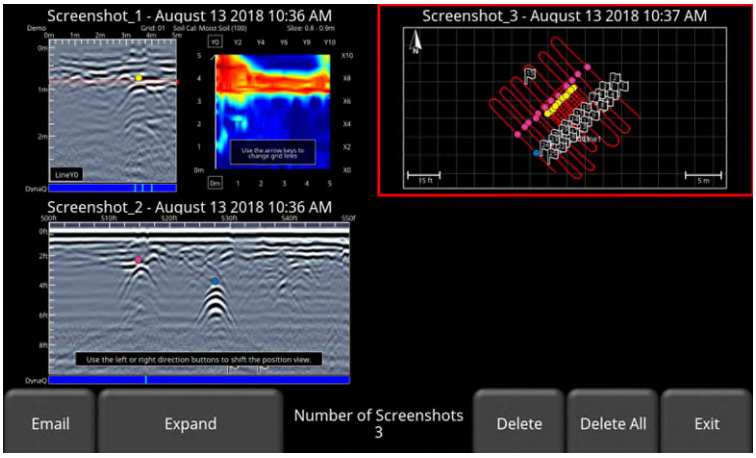


Figure 4-29: Tile View in Screenshot Gallery

From the Tile View, the user has the following options:

- **E-mail** – pressing this button will e-mail the selected screenshot (provided you are connected to a wireless network and have setup an account to send from). You will be prompted to enter a destination e-mail address, or you may use the most recent one which will be listed by default. Pressing the "**…**" button to the left of the e-mail address displays the last 5 e-mail addresses used, allowing the user to easily select a recently used email address, rather than re-entering it.

- **Expand** – press this button to show the selected screenshot as a full screen image. On the subsequent screen, press **Tile View** to return to the screen displaying four screenshots per page.

- **Delete** – pressing this button will delete the displayed screenshot. There will be a confirmation message asking if you are sure. Press **Yes** to proceed.

- **Delete All** – pressing this button will delete all screenshots. There will be a confirmation message asking if you are sure. Press **Yes** to proceed.

4.3.2 Delete Project

Pressing this will delete the currently selected project. There is a confirmation window asking if you are sure; press Yes to continue deleting, press No to cancel.

4.3.3 Export Data

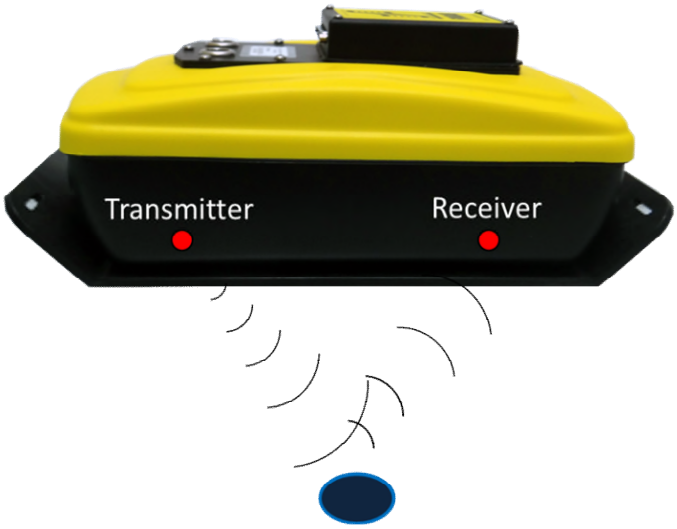
Screenshots and data are always saved to the internal memory of the Display Unit. If a USB-drive (memory stick) is inserted into the USB port on the Display Unit, the Export Data button will be available (otherwise it will be greyed-out).

Pressing the **Export Data** button will copy all the data files in that particular Project to the USB drive.

5. GPR Concepts

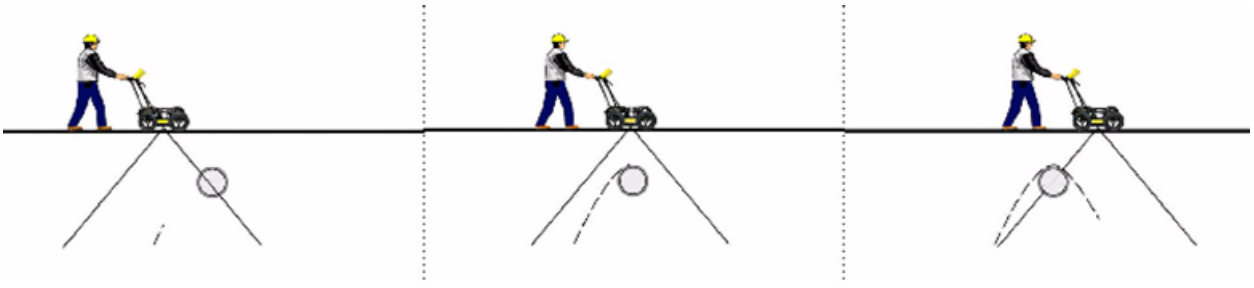
5.1. Theory

Ground penetrating radar (GPR) technology uses radio waves to image objects in the subsurface. The subsurface may consist of soil, rock, asphalt and other materials. GPR systems emit high frequency radio wave pulses and detect the echoes that return from objects within the subsurface. Echoes are produced when the target material is different from the host material (e.g. PVC pipe in gravel)

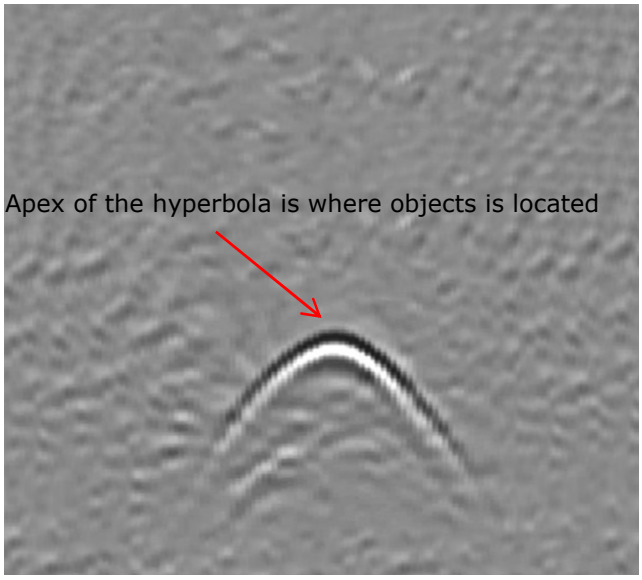


5.2. Hyperbolas

The GPR display shows signal amplitude versus depth (time) and sensor position along a line. This is called a “Line Scan”. Since radar energy radiates in a 3D cone shape rather than a thin beam, a ***hyperbola*** (or inverted U) is the GPR response from a small point target like a pipe, rock, or a tree root. The radar wave hits the object before and after going over it and forms a hyperbolic reflection that can appear on the record even though the object is not directly below the radar:



Hyperbolas are best viewed when subsurface targets are crossed perpendicularly (at a 90-degree angle). The actual position of the object is located at the apex of the hyperbola.



5.3. Calculating Depth

Ground penetrating radar records the time it takes a radio wave to travel to a target and back; it does not measure the depth to that target directly. Depth to target is calculated based on the velocity with which the wave travels to the target and back.

To calculate depth:

$$D = V\ x\ T/2$$

$$Where\ D\ is\ Depth$$

$$V\ is\ Velocity$$

$$T\ is\ the\ Two-way\ travel\ time$$

For the LMX200, velocity is indicated by the Soil Calibration Value, known as Soil Cal. Once the Soil Cal value is set for a survey site, the measured depths are more accurate than using the default Soil Cal value, 100, or a random Soil Cal value (Section 6.6.6).

5.4. Soil Calibration values

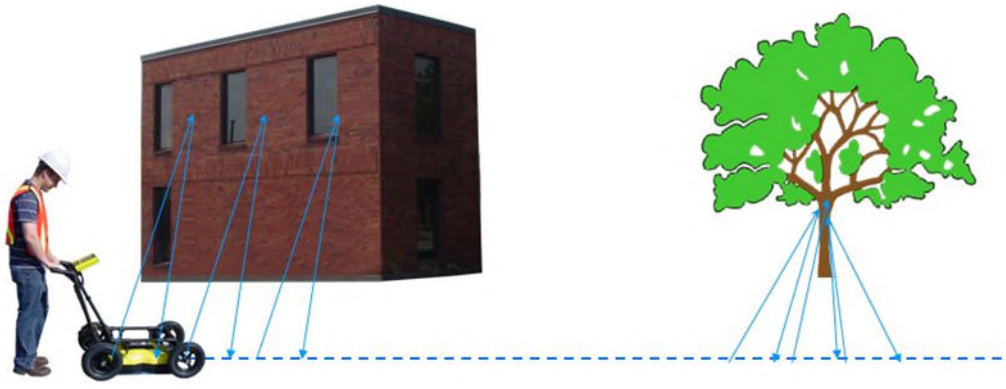
Below is a table of common subsurface materials and their corresponding Soil Cal. This is only a guideline and there is some variation based on the fact that there can be a mixture of different materials in the subsurface. By far, the soil water content has the biggest influence on Soil Cal values.

Material	Soil Cal
Air	300
Ice	160
Dry Soil	140
Dry Rock	120
Soil	100
Wet Rock	100
Concrete	100
Pavement	100
Wet Soil	65
Water	33

5.5. Air Waves

Some hyperbolas are caused by air wave reflections from objects above ground, such as posts, fences, overhead wires, and trees.

The following image displays how air wave reflections affect data:



An important part of understanding the data image is learning to recognize these unwanted "air" targets and distinguish them from the targets in the ground. Good field notes are indispensable for helping identify unwanted events on the data.

The recommended way to identify air reflections is the target hyperbola method. Hyperbolas from above ground objects are wider than objects in the ground and will have a Soil Cal at, or close to, 300.

To learn more, see Soil Cal (Section 6.6.6).

6. Line Scan

Line Scan mode allows the operator to acquire data along a straight line and examine it as a cross-section image. The operator can locate a feature and easily back-up and mark the location of that object on the ground. Line Scan mode can be used to identify the alignment of subsurface features, check for linearity and assist with target of depth estimations.

From the main screen, press the **Line Scan** button; you will see the screen shown in Figure 6-1.

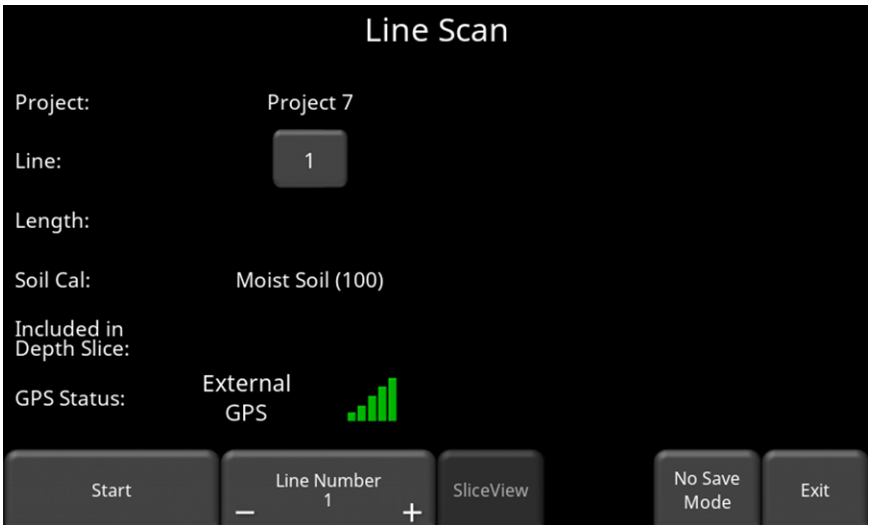


Figure 6-1: Preparing to Line Scan

The GNSS Status indicates which GNSS is currently selected, as well as the quality of the GNSS signal, which is based on the number of satellites that it sees. The chart below explains what the colours and bars mean:

Indicator Color	# of bars	# of Satellites
Red	1	4
Orange	2	5
Green	3	6,7
Green	4	8,9
Green	5	10+

Note that if you select Internal GNSS, it does NOT position any line scans in MapView; only the External GNSS will do this. Ensure that you have the right GNSS selected prior to your survey.

6.1. Selecting a line

To select the desired line, press the **+** and **-** buttons under **Line Number** on the bottom of the screen. Alternatively, pressing the line number button itself will show the screen in Figure 6-3. From here, you can go directly to any line number. If the line number is white, then that line is empty, whereas lines that already contain data are shown in red.

To collect data without saving it, press **No Save Mode**. Any data collected will NOT be saved, but screen shots can still be taken with the **Camera** button. These screen-shots get placed in the currently selected project. Two features that are only available in **No Save Mode** (the **Pause** button and the ability to draw arrows) are described in Section 6.8 and Section 6.9 respectively.

If the line number is white (Figure 6-1), Press **Start** to enter data acquisition. All data collected will be saved under this line number.

If the line number is shown in red (Figure 6-2), you will see the data preview on the right side of the screen. If it's a long line, only the last part of the data will be shown. From this screen, you will have the following options available:

- **View –** press this button to load the currently displayed line. Longer lines will take a few extra seconds to load.
- **Delete** – pressing this will delete the line. It will prompt you to confirm before deleting.

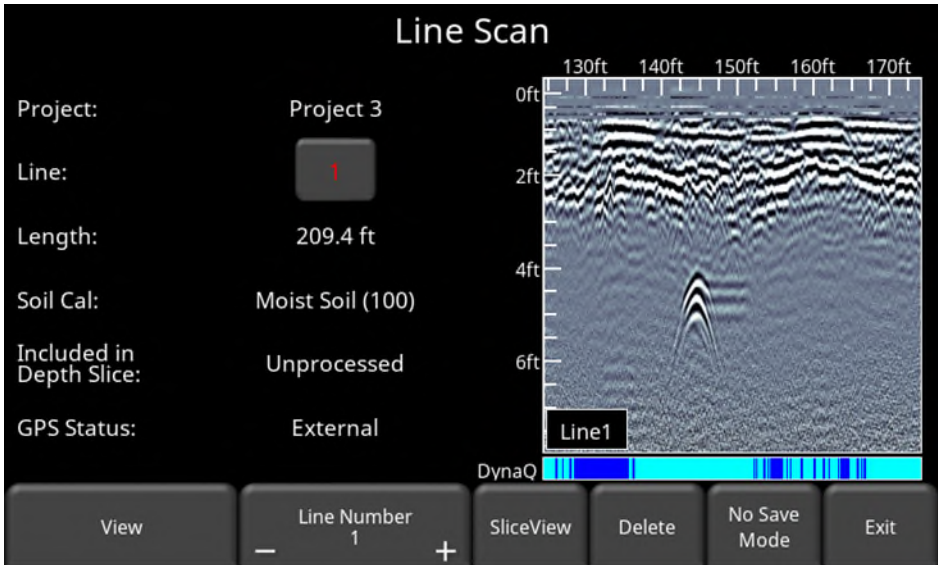


Figure 6-2: Line Scan mode, showing the preview of a line that was previously collected.

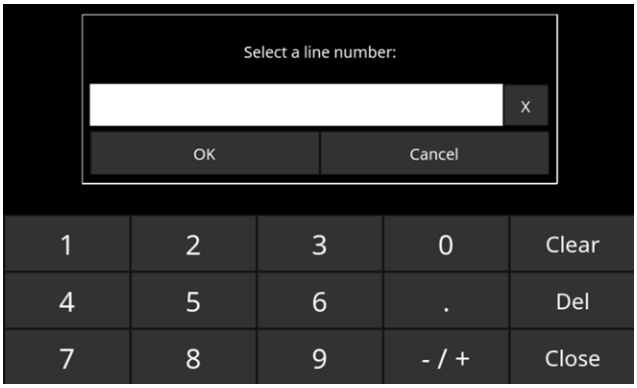


Figure 6-3: When the button showing the line number is pressed, this screen allows the user to directly input the line they wish to go to

6.2. Acquiring Data

Press the **Start** button to begin collecting data. The screen will change to the data acquisition screen. As the system is pushed forward, the collected GPR data scrolls onto the screen from the right and moves to the left (Figure 6-4).

The depth scale along the side of the GPR Line image and the position scale along the top of the image are set to Metric or US Standard units based on the setting in the Preferences menu (Section 4.1)

A single line cannot be longer than 1000m or 3000 ft. You will receive a warning about line length just before it hits that limit. If you continue to that limit, data collection will automatically be stopped, and the line will be saved.

If Auto-Hide Buttons is set to ON (Section 4.1.10), the menu at the bottom of the screen disappears as soon as you start collecting new data, thereby maximizing the data display area. When the user stops, backs up or presses a button on the keypad the menu reappears.

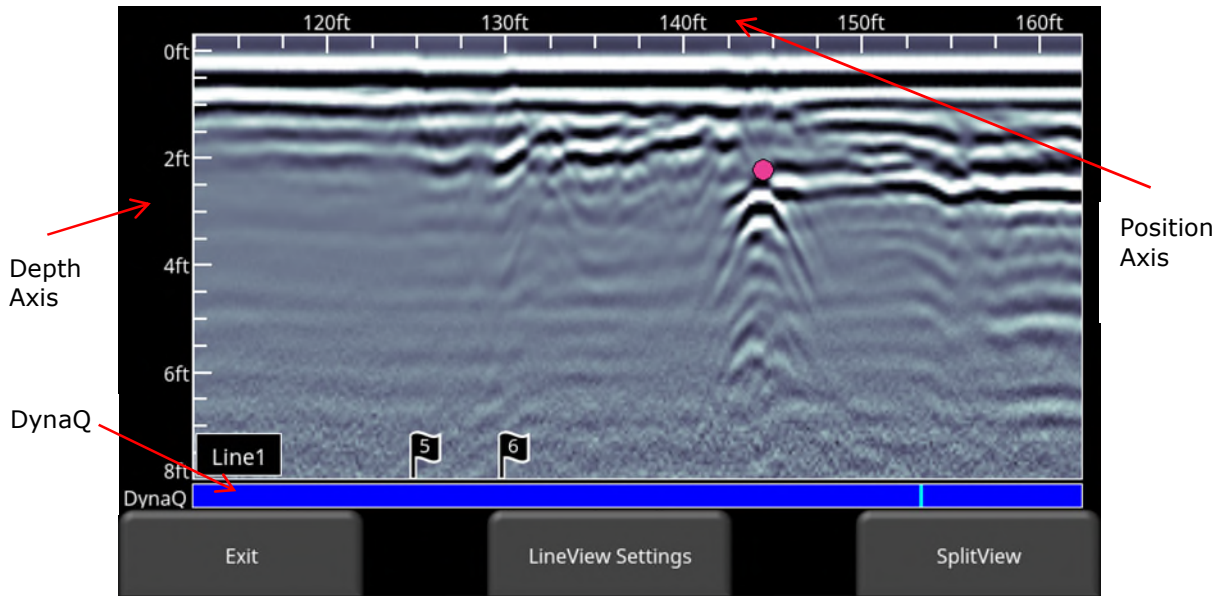


Figure 6-4: Line Scan acquisition mode, showing collected data and axis labels. DynaQ indicator is shown at the bottom above the menu options. If the LMX has an external GNSS attached, the SplitView option is available.

6.3. DynaQ™

The LMX200 uses DynaQ, a technology that adjusts data quality as the system movement speed varies. In most situations, moving the system at a comfortable walking speed generates data of good quality. In situations where target resolution or maximum penetration depth is critical, moving slower increases data quality.

As the Line Scan data scrolls on the screen, the DynaQ Index Bar is displayed along the bottom of the screen (Figure 6-4). The color of the bar indicates the quality of the data at that point along the line:

White	= No Data (too fast!)
Yellow	= Moderate quality
Light blue	= Better quality
Dark Blue	= Highest quality

In general, avoid collecting data at extremely high speeds.

6.4. Back-up Indicator

Line Scan mode incorporates a back-up feature to enable you to accurately locate targets and mark them on the ground. After acquiring some data on the screen, move the system backwards (Figure 6-5a). During back-up mode, there will be two indicators:

- **Position Indicator**: The red vertical line corresponds to the location at the center of the GPR sensor. As you pull the cart backwards, the Position Indicator moves to mark the current location of the cart in the image and a box appears with the current position, relative to the start of the line, listed as the top number.

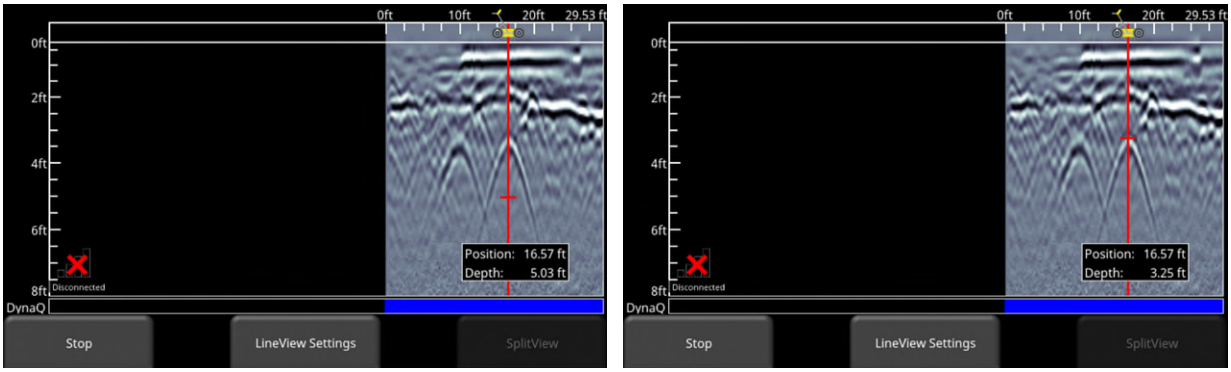


Figure 6-5: a) Back-up Indicator, b) Moving the Depth Indicator to the top of the hyperbola

- **Depth Indicator**: A short red horizontal line corresponds to the current depth value, as shown in the bottom number in the box. To determine the depth of an object, move the indicator up or down by dragging the horizontal line to the desired location (Figure 6-5b). Alternatively, you can also use the **Up** and **Down** arrows on the 4-way directional keypad. Note: make sure you have done a Soil Cal to ensure depth accuracy (Section 6.6.6).

To locate a feature, simply roll the system back along the same path until the red vertical line is exactly over the response (usually a hyperbola). You can mark the location of the object on the surface and continue data collection. Once you reach the point where you initially started backing up, the system will continue acquiring new data.

You can also obtain depth and position information anywhere on the Line Scan by touching the screen, holding for a second, then releasing. A crosshair appears where you touched the screen, with a box displaying the position and depth (Figure 6-6). To get the position and depth information about a different point on the screen, simply touch and drag the box or crosshair to the desired position.

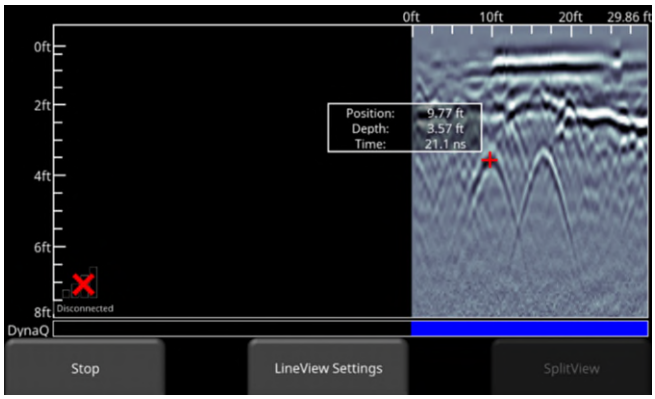


Figure 6-6: Touch screen for one second to get depth and horizontal position at any point

Pressing **Stop** ends the line. This line is saved internally on the system and cannot be added to. Use the Left and Right directional arrow buttons to scroll and view data not currently displayed on the screen.

6.5. Flags

Flags are often inserted to mark noteworthy surface features, such as poles, sidewalks, changes in terrain etc. These markers may help you correlate subsurface targets with above ground features. Pressing the **asterisk** button on the keypad will insert a flag at your current position, either during forward data acquisition or when backed-up (Figure 6-7). Flags are sequentially numbered.



Figure 6-7: Press the Asterisk (star) button to add a flag to the data

6.6. View Settings

From the screen shown in Figure 6-4, press the **LineView Settings** button to see options at the bottom of the screen (Figure 6-8). These options (described below) change the way the data is viewed on the screen. They do not alter the saved data in any way. These settings can be changed while you are still collecting data, after you have pressed **Stop**, or when viewing a previously saved line.

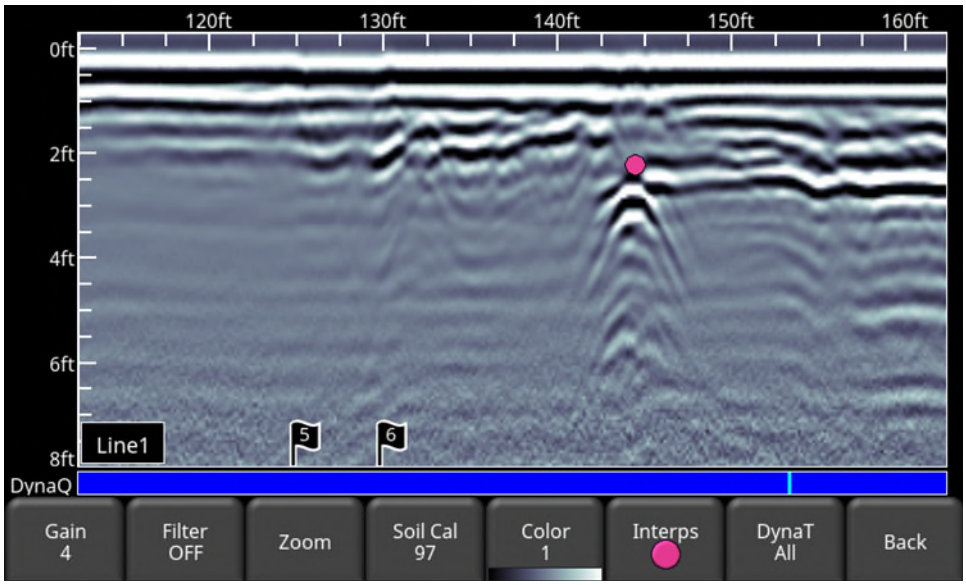


Figure 6-8: Menu at bottom of screen, after pressing View Settings

6.6.1. Zoom

This button controls the horizontal and vertical scaling of the displayed GPR data. Pressing the **Zoom** button changes the buttons on the bottom menu, which are explained below:

- **Depth** – Pressing **+** and **-** under the **Depth** button allows you to change the display depth of the data. This is commonly referred to as the depth window. The pre-set values range from 1m to 8m (3ft to 25ft, see Figure 6-9), depending on the Soil Cal value (6.6.6).

  If the data was collected with a shallower display depth, the depth setting can still be increased after the fact, when reviewing the data. In general, it's a good idea to set your displayed depth to 1.5 - 2 times the depth you expect the deepest target to be.

- **Position** – Pressing **+** and **-** under the **Position** button allows you to change the length of data displayed on a single screen. This is also known as horizontal scaling. The pre-set values range from 10m to 30m (25ft to 100ft), see Figure 6-10.
-

  One reason for setting this to 30m would be to fit more data on the screen and look for consistency among hyperbolas that were crossed.

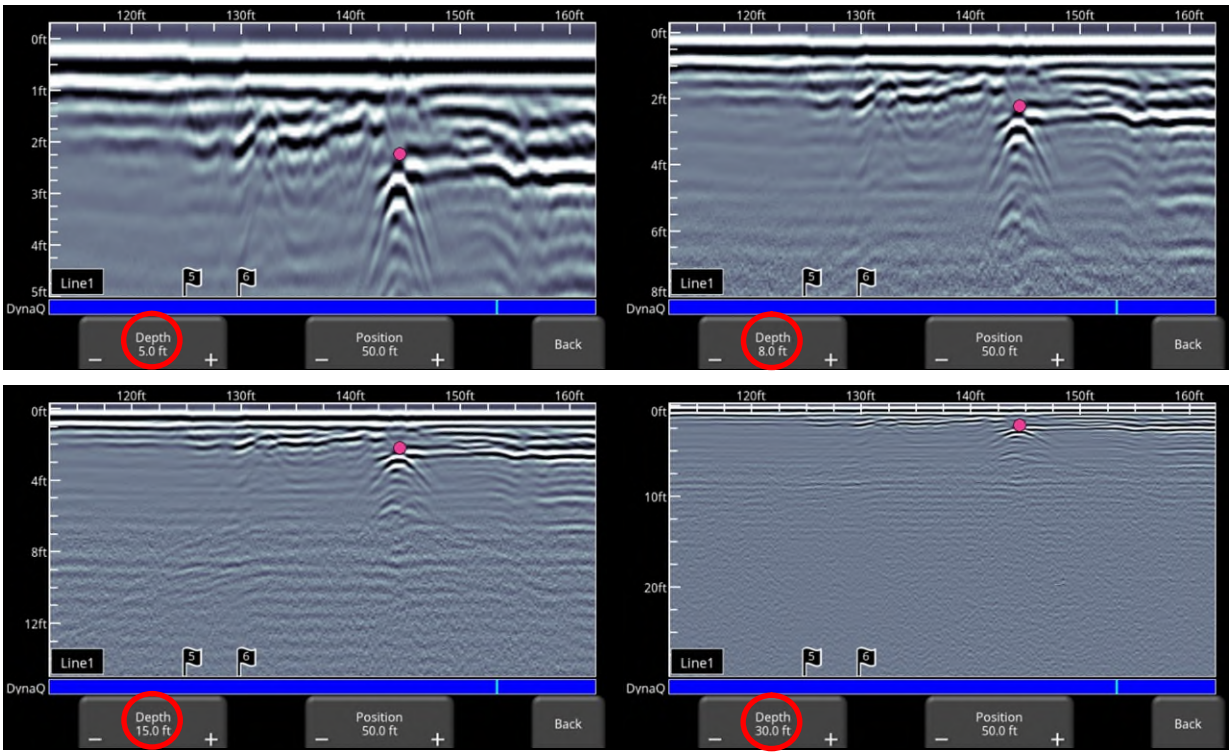


Figure 6-9: Varying displayed depth

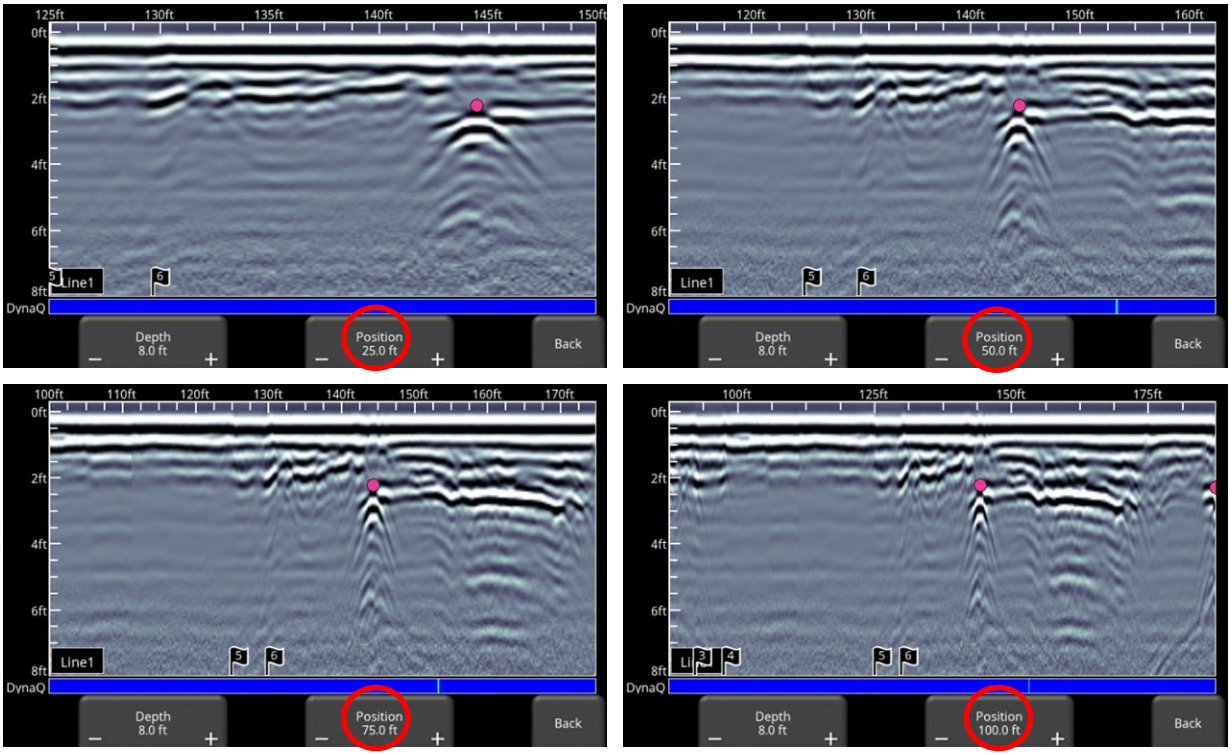


Figure 6-10: Varying position, or horizontal scaling

6.6.2. Color

Pressing this changes the color palette for the GPR Lines. There are 9 different color palette options. Pressing this button increments the color number and re-displays the image; once you reach 9 it cycles back to 1. A few sample color palettes are shown in Figure 6-11.

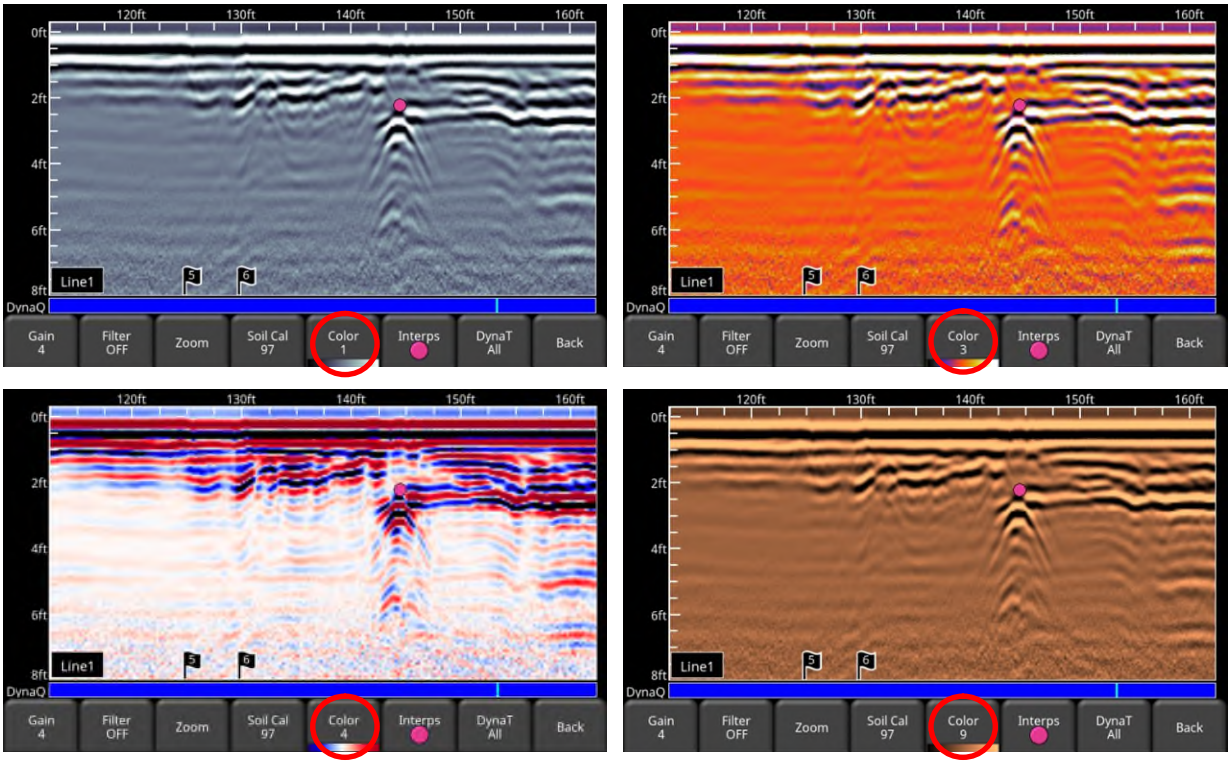


Figure 6-11: Changing Color palettes

6.6.3. Filter

The Filter is a background subtraction filter used for removing flat-lying responses in the data. Filtering helps identify shallow targets that might be masked by the strong signals at the top of the image, as well as possibly enhancing the visibility of hyperbolas further down in the data. However, it will also filter out other flat-lying responses, such as soil boundaries, so be careful when using this option if your target is flat.

It works by applying a running-average background subtraction to the data set, defined by the filter width or a window. This window “moves” across the data, and the result is subtracted for every trace in the data set. The Filter is variable and pressing this button cycles between **OFF** and values **1** to **5.** Variable filter lengths are shown in Figure 6-12

The lower the number, the longer the filter width, and the more “relaxed” the filter. Only the longer flat-lying features get removed.

The higher the number, the shorter the filter width, and the more “aggressive” the filter. This results in the removal of long and short flat-lying features.

Pressing **OFF** turns the filter off completely.

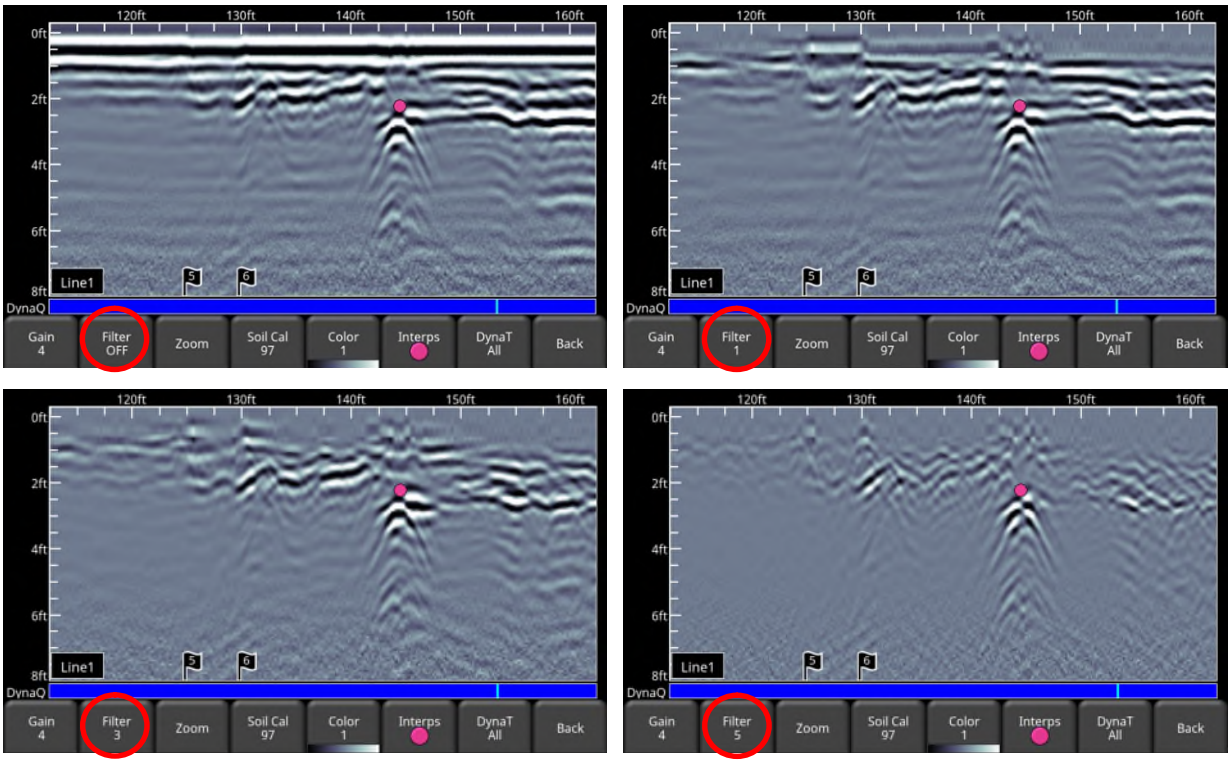
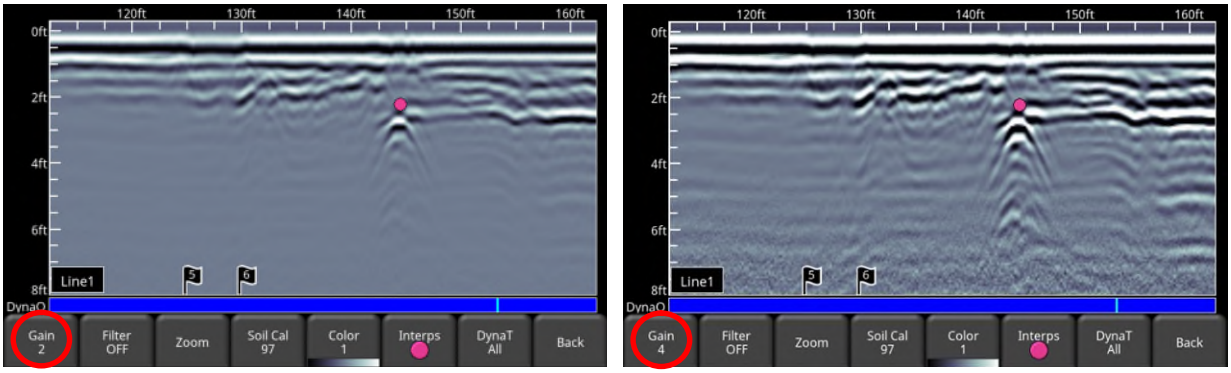


Figure 6-12: Showing variable filter lengths, and Filter Off

6.6.4. Gain

Since the material being scanned absorbs the GPR signal, deeper targets return weaker signals. Gain acts like an audio volume control, amplifying signals and making deeper targets appear stronger in the image. Gain values vary from 1 to 9 where 1 means a minimal amplification has been applied and 9 means that maximum amplification has been applied. Pressing this button increments the gain; once you reach 9 it cycles back to 1. Avoid over-gaining the data as it can make interpretation difficult (Figure 6-13). In general, soils that are more electrically conductive (e.g. clays) will require a higher gain compared to soils that are less electrically conductive (e.g. sand).



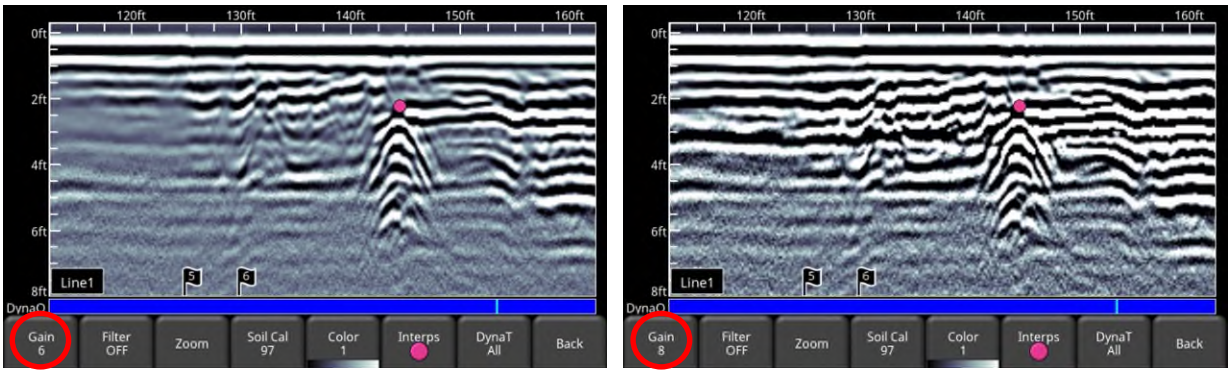


Figure 6-13: Varying the Gain

6.6.5. DynaT™

DynaT is a feature that can selectively enhance small, medium or large-size targets for easier viewing and detection (Figure 6-14). Pressing **DynaT** cycles between options: **All**, **Small**, **Medium** and **Large**. Each option allows the user to enhance part of the ultra-wide band (UWB) spectrum to focus on those desired features.

Selecting **Small** will show more of the smaller hyperbolas and more detail, whereas **Large** will focus more on the larger targets with better depth penetration. Selecting **All** will show a combination of small, medium and large targets.

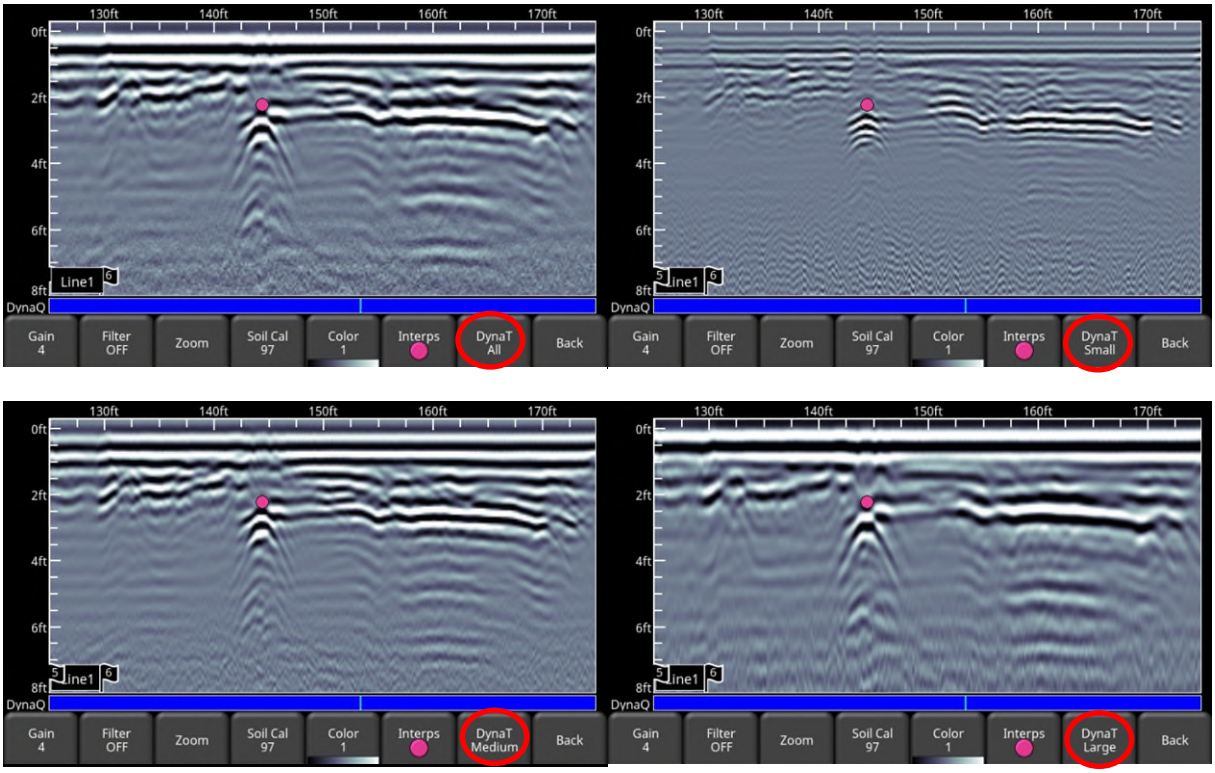


Figure 6-14: DynaT settings: a) Top left shows All. b) Top right set to Small targets. c) Bottom left set to Medium targets d) Bottom right set to Large targets

6.6.6. Soil Cal

The Soil Cal (also known as velocity) is a parameter used to help achieve accurate measured depths. The recommended way is to use the hyperbola-fitting method, since it is based on data collected in the area.

Crossing linear targets like pipes or cables at a 90-degree angle produces a hyperbola suitable for soil calibration. The Soil Cal value obtained will be used to compute a depth estimate of a target. These depths will be *incorrect* if the soil type is calibrated on a target hyperbola produced at an oblique angle, rather than 90 degrees.

Once you have a hyperbola on the screen from a subsurface target, press **Soil Cal**. The menu at the bottom of the screen will change, giving you the option of specifying a Soil Type or adjusting the Soil Cal using the hyperbola-fitting method (Figure 6-15). These options are explained below:

- **Soil Types** – If there are no targets to calibrate to, and you know the type of soil, press this button to vary between the following mediums, with the pre-set Soil Cal value shown in brackets:
    - very wet soil (60)
    - wet soil (80)
    - moist soil (100)
    - dry soil (120)
    - very dry soil (150)
    - air (300) – this value can be used to check for air waves, but it cannot be applied as a Soil Cal value
- **Soil Cal** – allows you to use hyperbola-fitting to determine a more accurate Soil Cal. The options are slightly different, depending on whether or not you are in backup mode.

  If the back-up indicator is on screen, it is presumed you have backed up the LMX200 and you're right over the hyperbola. Move the horizontal line to the align with the top of the hyperbola by touching and dragging it. Pressing Soil Cal will display a hyperbola that is locked to the position where the back-up indicator meets the horizontal line (Figure 6-15).

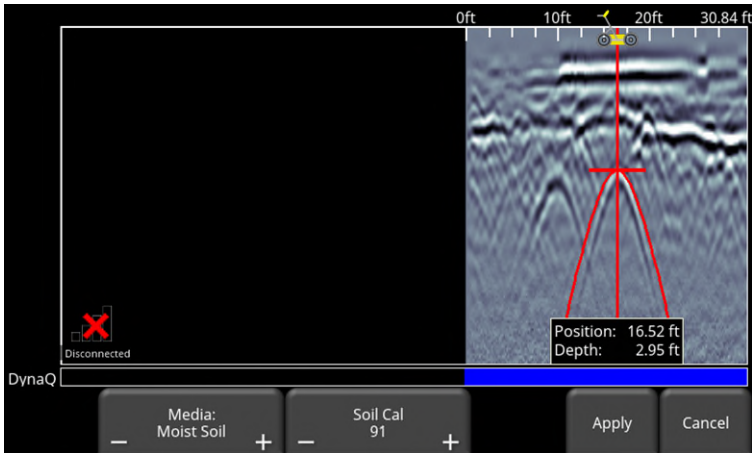


Figure 6-15: Adjusting Soil Cal while in backup mode

On the other hand, if you press **Soil Cal** while you are collecting data or have pressed **Stop**, you will see a red hyperbola in the middle of the screen. Drag the hyperbola such that it lies over a real hyperbola from the ground (Figure 6-16). You can use the 4-way keypad arrows to fine tune the movements.

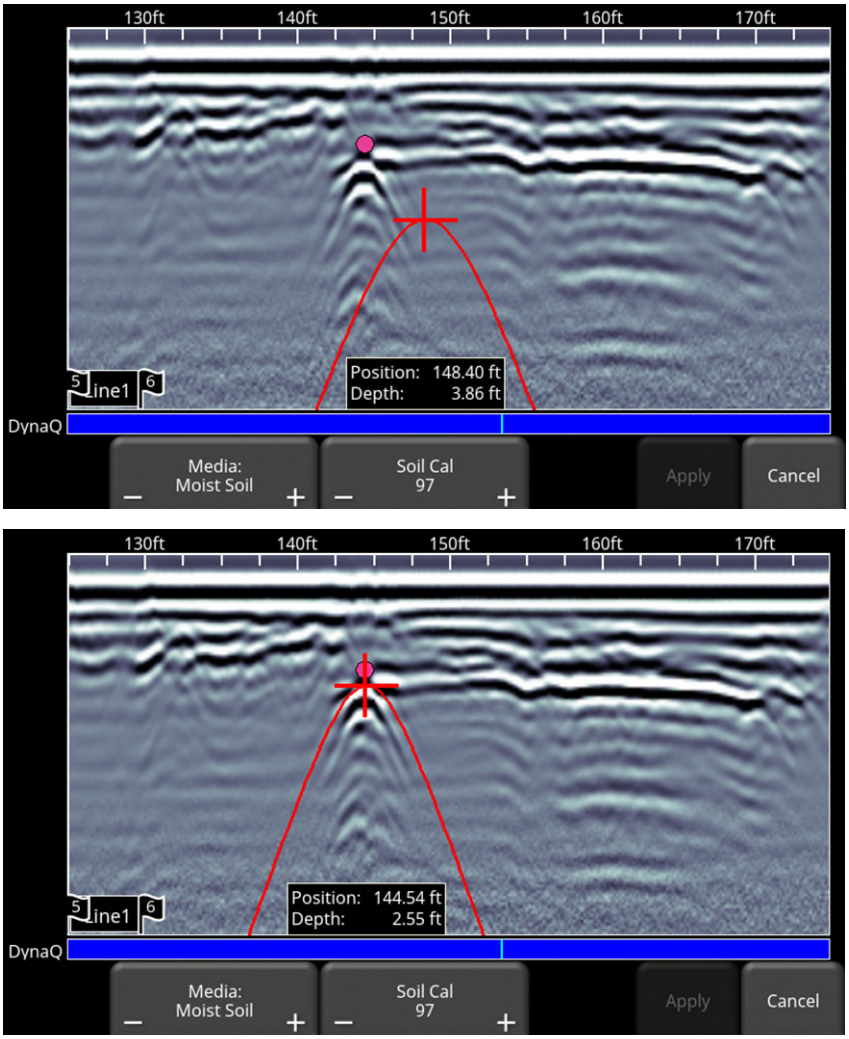


Figure 6-16: Adjusting Soil Cal, without backing up

For either scenario above, once the red hyperbola is properly positioned, you can now use the **+** and **–** buttons on the **Soil Cal** button to widen or tighten the shape. Once the shape is matched (Figure 6-15 and bottom image of Figure 6-16), you now have the correct Soil Cal, and the measured depths will be most accurate. Press **Apply** to use this value.

If you get a Soil Cal near 300, this could be an Air Wave (Section 5.5), and you should calibrate to a different hyperbolic response.

6.6.7. Interp

Short for field interpretation, Interps are used to mark subsurface features. Seven colours are available, which allow you to designate different types of subsurface objects.

Either during collection, back-up or review, you can simply touch anywhere on the screen to add an Interpretation. This appears as a dot of whatever colour is selected. To change the color, press the **Interp** button to see a selection of colours and to select a new one (Figure 6-17).

To remove an Interp, ensure the same color is currently active and simply touch the Interp to delete it.

These field interpretations get exported with the data as a .CSV file, which show the positional information of all interps. They can be used to check if a feature is linear (in SplitView, MapView or in Google Earth™), but only if an external GNSS is used.

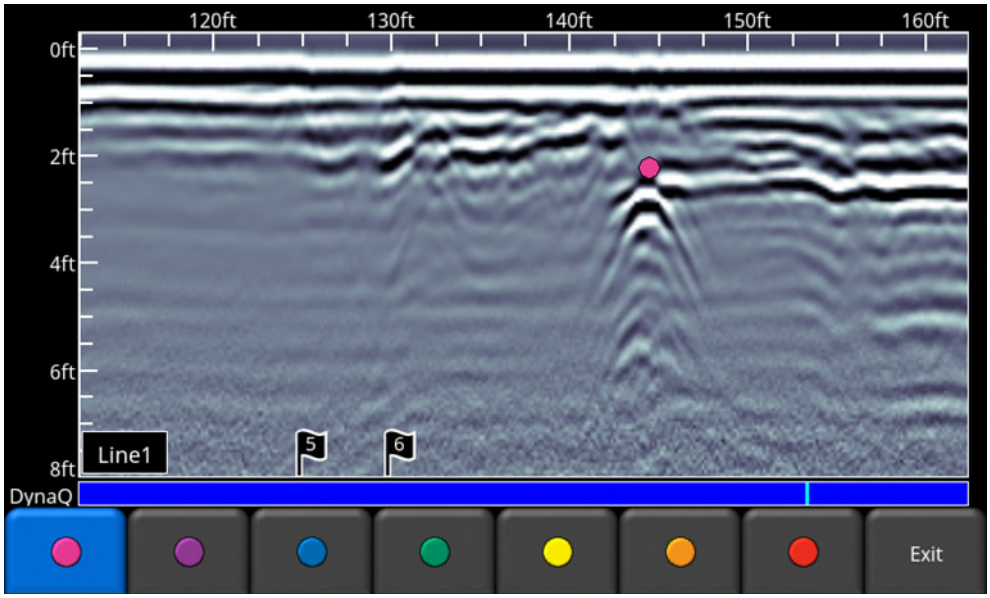


Figure 6-17: Available colors for Interps

6.7. Interps sent to 3rd Party Mapping Apps

If the **Tools > Preferences > 3rd party mapping apps** option is set to ON (see 4.1.6), when a field interpretation is added to the LMX screen, attributes, including the Latitude, Longitude and depth, are sent by **Bluetooth** to the mapping app and plotted on that app's map.



If the mapping app is cloud-based, utilities and other object located using the LMX GPR can then be available to anyone with access to the project data in the mapping app – back at the office or on the other side of the world.

For details of how to use supported mapping apps with an LMX system, see: https://www.sensoft.ca/products/lmx200/resources/

6.8. Pause button (No Save Mode only)

The Pause button allows you to temporarily stop data collection and resume again, without clearing the data from the screen. This might be useful if you want to collect a series of parallel lines over a target and show all the passes on the screen for comparison.

Once you collect some data, press **Pause.** You can now move the LMX200 without data scrolling on the screen. When you are ready to resume collecting data, press Start. You will see a thick, red vertical line, corresponding to when you hit the Pause button and then restarted (Figure 6-18).

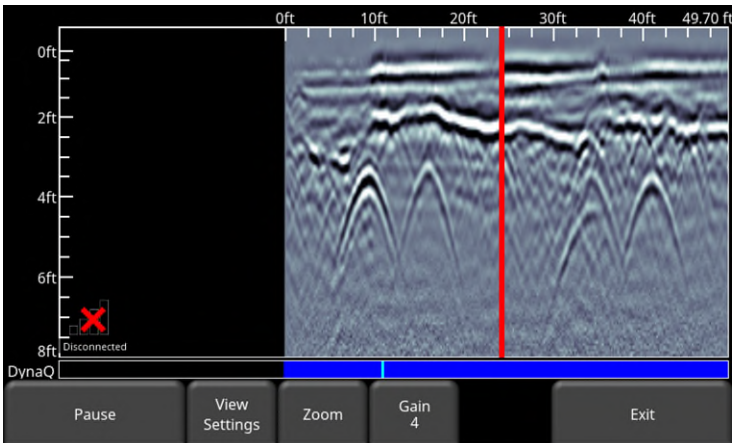


Figure 6-18: Pressing Pause and resuming data collection.

6.9. Drawing arrows (No Save Mode only)

There is no option for Interps (6.6.7) in this mode, as the data is not being saved. However, you do have the ability to draw arrows on the screen (Figure 6-19).

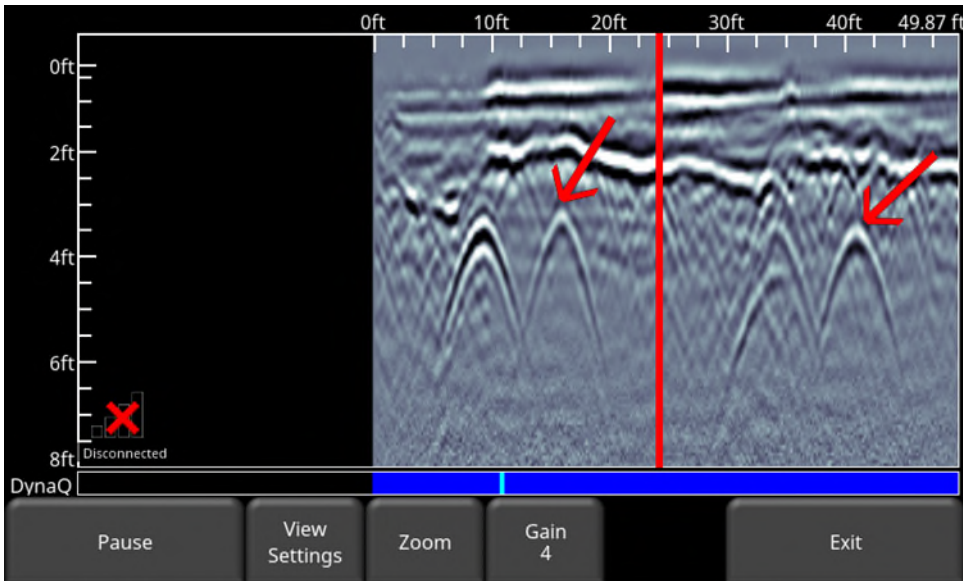


Figure 6-19: Drawing arrows on the screen to highlight targets and features

Touch the screen where you want the head of the arrow to appear and then swipe away in the direction of the shaft. In the example in Figure 6-19, the user touched near the hyperbola, then swept their finger towards the top left to create the arrow. Just like Interps, any number of arrows can be drawn on this screen. Touch any arrow to remove it.

Remember that pressing the Camera button will take a screenshot and save it in the currently selected project.

7. Pseudo-Grid Line Scan

Pseudo grids are a special type of Line Scan collected by zigzagging back and forth to cover an area (Figure 7-1). GPR data collected over an area with a tight line spacing is used to generate depth slices. Depth slices are map views of the area at different depths, useful for locating subsurface objects, as well as their orientation, in a graphical manner that makes the data easier to interpret.

In general conditions, pseudo-grids are likely to be simpler to collect than a Grid Scan (11.) because the positioning of every GPR trace is recorded using an external GNSS (2.2).

Use Line Scan mode (6.) with the SplitView screen (10.) when collecting a pseudo-grid. Collect the zigzagging GPR line scan with a tight line spacing, recommended to be 0.5m or 2 feet or less, as this tighter line spacing helps generate better depth slices.

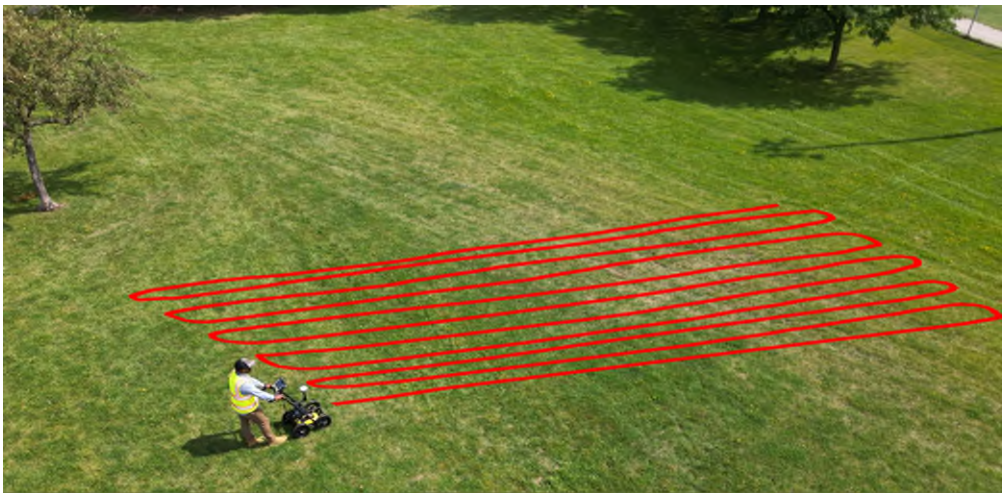


Figure 7-1: Pseudo-grid data collection uses the GNSS to position the GPR data traces

One of the most effective ways to achieve a tight line spacing is, when turning the system around to collect the next pass, pivot the cart on the rear wheel.

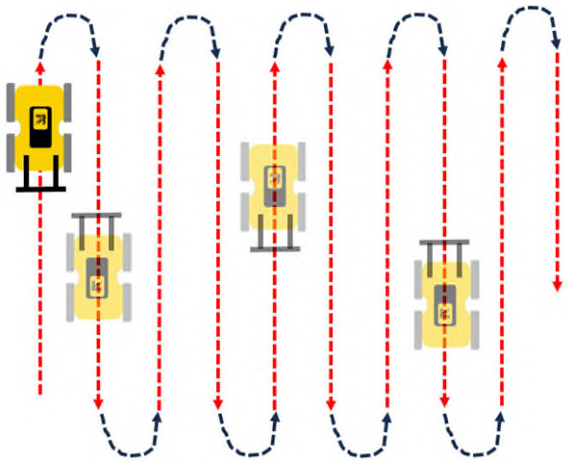


Figure 7-2: Collecting data with a tight line spacing, preferably lines that are the width as the LMX cart, helps provide better depth slices. Pivoting the cart 180 degrees on the rear wheel is a good way to achieve this.

When collecting data, zigzag in both directions to ensure every linear object is crossed at a right angle or, worst case, a 45-degree angle. Data can be collected in both directions in one Line Scan or multiple Lines Scans, providing they are all collected in the same project:

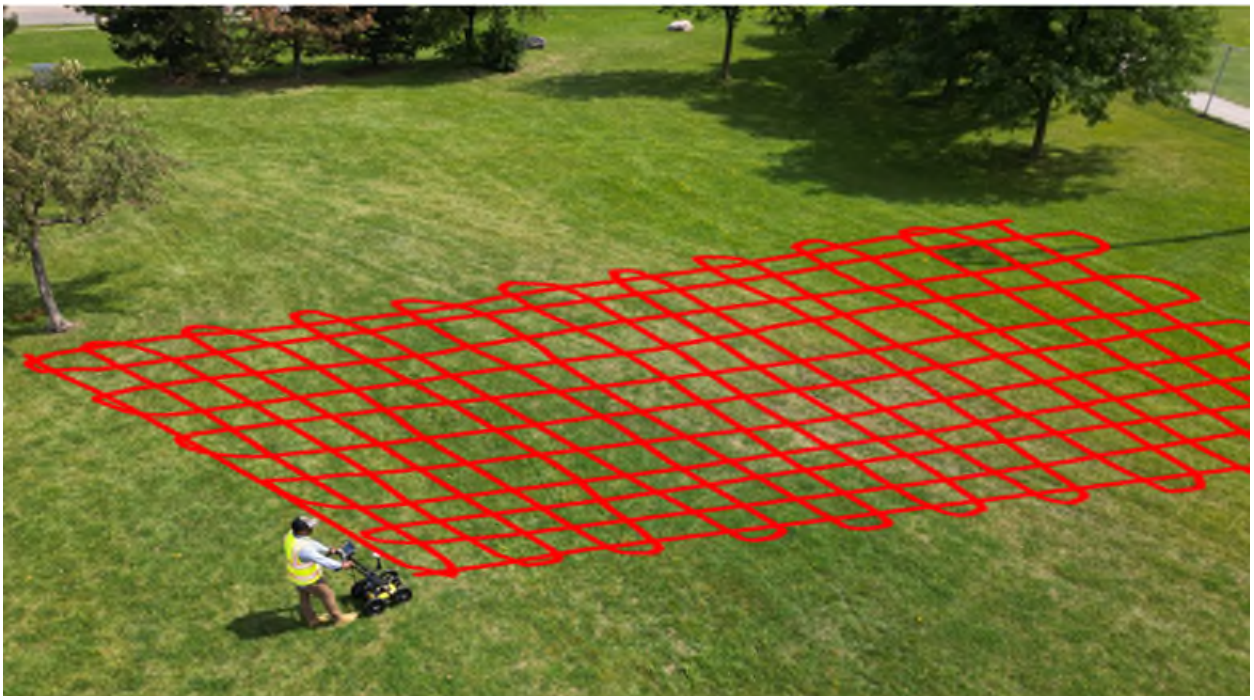


Figure 7-3: Drawing arrows on the screen to highlight targets and features

8. MapView

MapView is a feature that allows the user to graphically view the path travelled by the system, and any flags or interpretations made. This is helpful in determining the linearity and consistency of buried objects. It will also display depth slices from a grid collection.

A common use of this feature is to snake back and forth over a given area. Each time you cross a target producing a hyperbola, click on the top of the hyperbola to add an interpretation. If the object is a linear feature, all the interpretations will line up when viewed in MapView.

MapView only works if GNSS data is collected with the GPR data. This is what allows the lines and/or grids to be positioned correctly (with the right orientation).

If you use the internal GNSS, only grid data will be shown in MapView. If an external GNSS is connected, both line and grid data will be shown.

8.1. Accessing MapView

MapView can be accessed the following ways:

- From the main Project screen (Figure 8-1). MapView is *project*-based, meaning it will display all Line Scans and Grid Scans that are present in a given project.

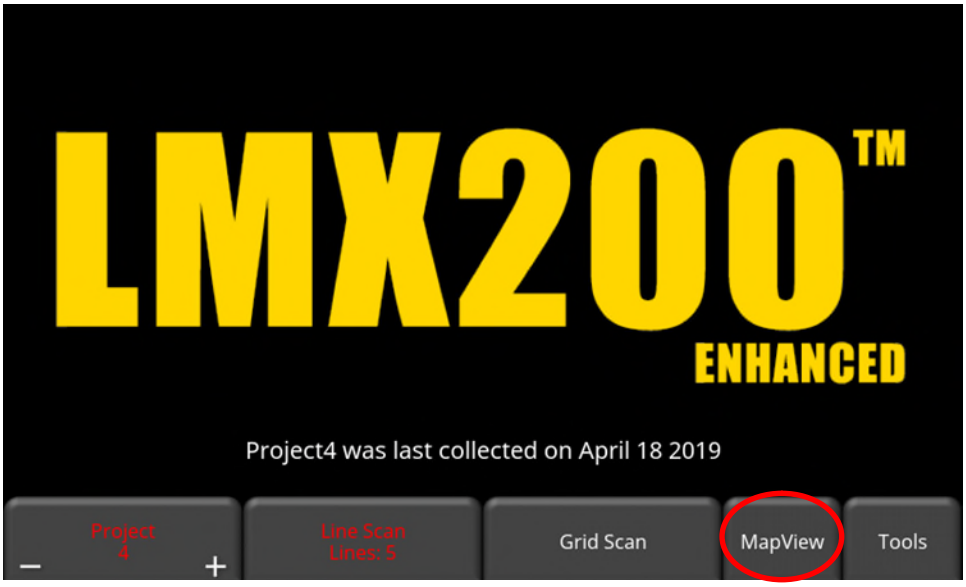


Figure 8-1: Accessing MapView from the main screen

- From the Line Scan screen, using the SplitView feature. Details of SplitView are explained in Section 10. .

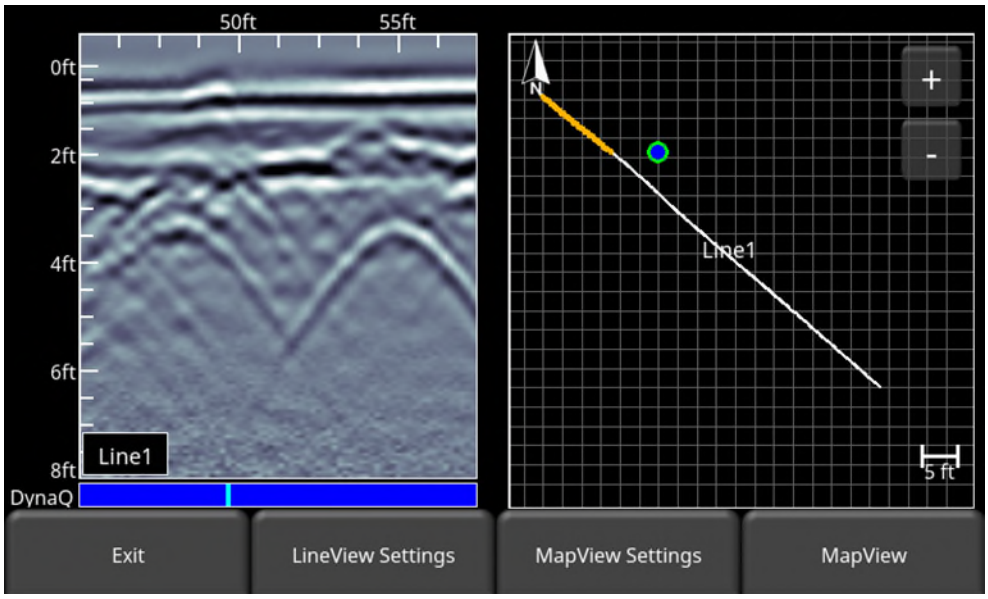


Figure 8-2: Accessing MapView from the SplitView screen in Line Scan

8.2. MapView screen

Regardless of how you enter MapView, you will see an image similar to the one in Figure 8-3. The available options are described below.

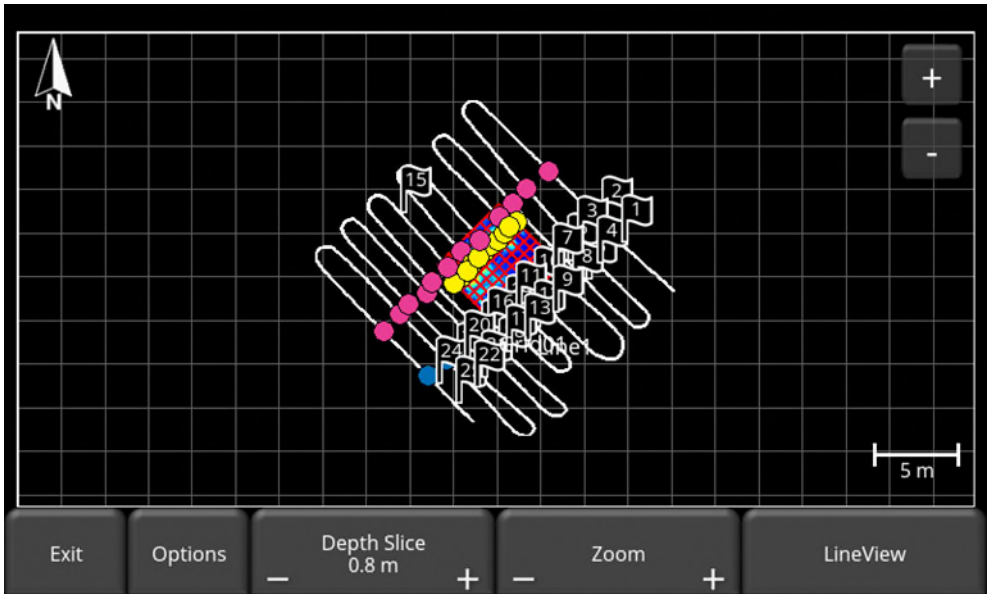


Figure 8-3: MapView screen

- If a grid was collected and depth slices have been processed (11.3.7), the Depth Slice +/- button is available (otherwise it is greyed out). Pressing the **+/-** buttons under Depth Slice will increase or decrease the depth of the depth slice currently displayed.

- Pressing the **+/-** buttons under **Zoom** will zoom the image accordingly. Alternatively, you can also press the **+/-** buttons in the top right of the screen. To reposition the image in the middle of the screen, simply swipe the screen until the image is positioned properly.
- Pressing **LineView** will take you to LineView display (Figure 6-4). It will always take you to the highest line number for that project.
- Pressing **Options** will display the screen shown in Figure 8-4 allowing the layers plotted on the MapView screen to be customized. This is explained in the section below.

To reposition the image at any time, simply swipe the screen until the image is positioned properly.

8.2.1. Options (Layer views)

Pressing the **Options** button will allow you to customize what is shown in the MapView display. The screen will be split between the Layer options on the left and the MapView display on the right ().

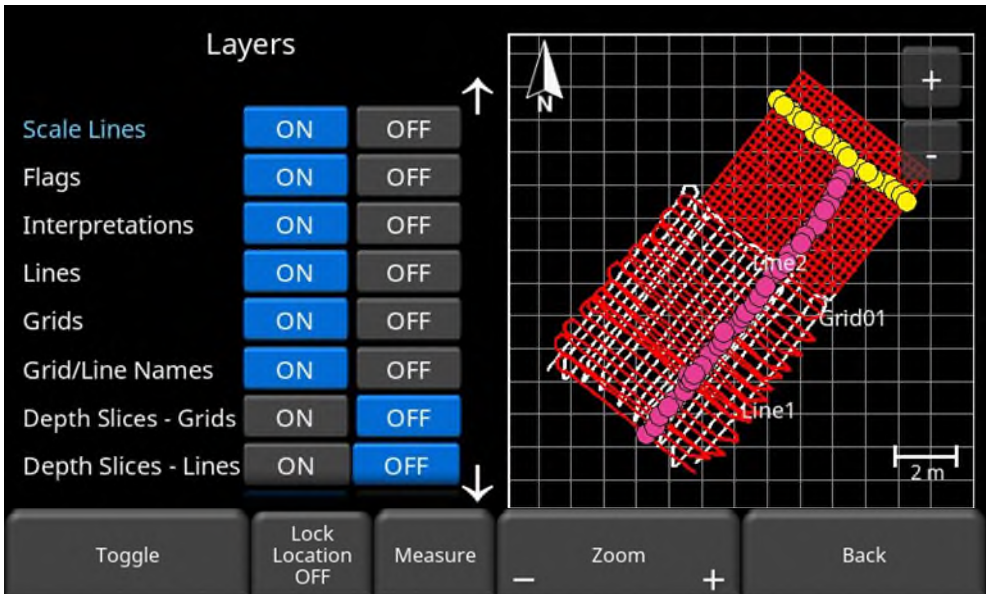


Figure 8-4: Setting layer options in MapView

Press the **ON** or **OFF** button beside each option to show or hide that particular feature on the display on the right. Alternatively use the Up and Down arrows on the 4-way directional keypad to select the desired feature, then press the **Toggle** button on the bottom of the screen to turn that feature on or off.

Each layer feature is described below:

- Scale Lines – controls the display of the background grid lines. These are used as a scale reference.
- Flags – controls the display of flags
- Interpretations – controls the display of all interpretations

- Lines – turning this off will remove all the paths of collected lines from the display (white lines in Figure 8-2**,** Figure 8-3 **and** Figure 8-4).
- Grids – turning this off will remove all grids (red grid in Figure 8-4).
- Grid/Line Names – the name of each line and grid is shown beside it. Turning this off will remove this name display
- Depth Slices – Grids – if the grid depth slices have been processed on the Display Unit (11.3.7), they can be displayed or turned off. A depth slice generated from a Grid Scan is shown in Figure 8-5.
- Depth Slices – Lines – if depth slices from Line Scans have been processed on the Display Unit (9.2), they can be displayed or turned off. A depth slice generated from Line Scans is shown in Figure 8-5.
- Current position – during data collection and review, the current position is indicated on the screen by a blue dot with a green circle. Press OFF to hide the current position.

For example, the image in Figure 8-4 shows most layers are turned off, with the exception of lines and interpretations.

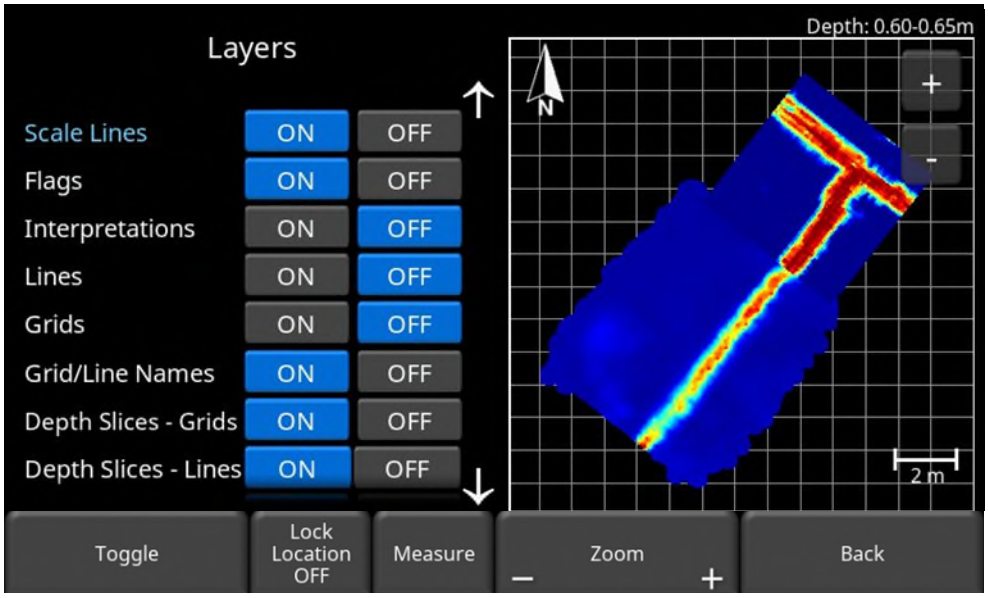


Figure 8-5: Example of hiding some layers

When collecting data in the SplitView screen, the **Lock Location** button is available. This button controls whether the display in the MapView window is locked or moves with the user's position. If **Lock Location** shows OFF, the current status is ON, and pressing the button will turn the status to OFF. When the status is ON, the MapView window is "locked", so if you move outside the limits of the displayed window, the screen will not center itself. Instead, a green arrow will appear in the window indicating that your current position is off the screen (Figure 8-6). The direction of the arrow points towards your current position. You can still move the screen position by touching it and using your finger to pan the window in the desired direction.

If the button shows **Lock Location** ON, the display is "unlocked". This means the MapView display centers itself on your current position as you are moving, such that the position indicator

(blue dot with the green circle) always remains in the center of the window. In this mode, however you cannot touch and move the MapView window position.

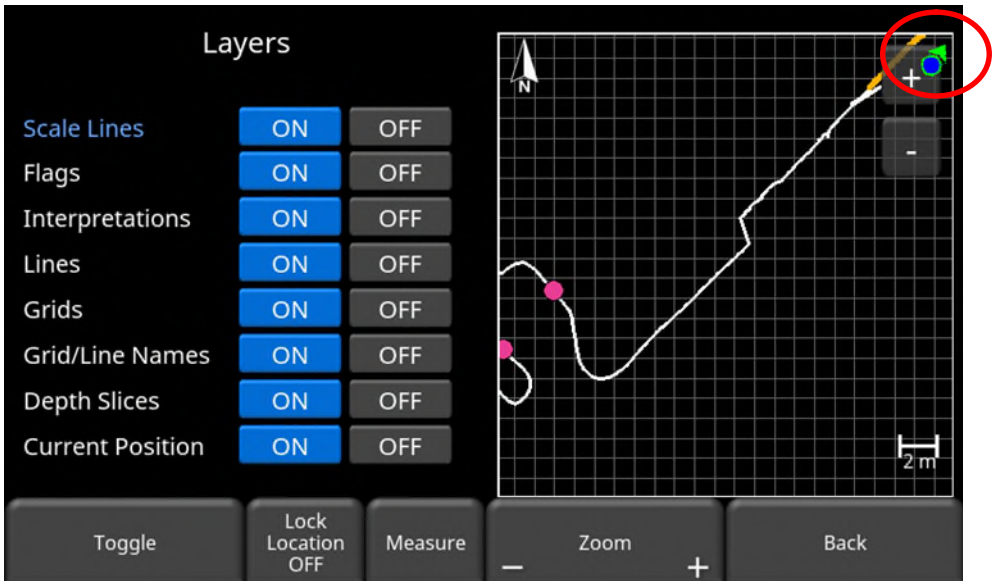


Figure 8-6: With the Lock Location enabled, the MapView display is locked. It shows an icon (in the red circle) when the user's current position is outside of the display.

When the **Measure** button is pressed, it is highlighted in blue. During this time, you can touch the screen and drag your finger a certain distance to get a measurement value for that distance. The distance value is displayed in the bottom left corner in yellow of MapView (Figure 8-7). Pressing the Measure button again exits from Measure mode and removes the yellow measured line and the measured value.

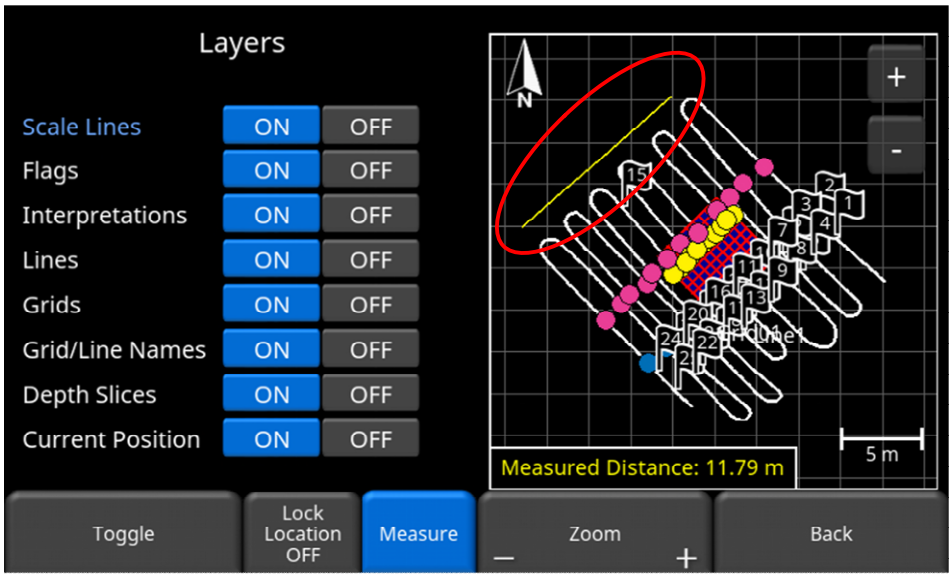


Figure 8-7: Using the Measure tool to draw a line on the screen

Where there are multiple lines and grids, the MapView could look like the example in Figure 8-8.

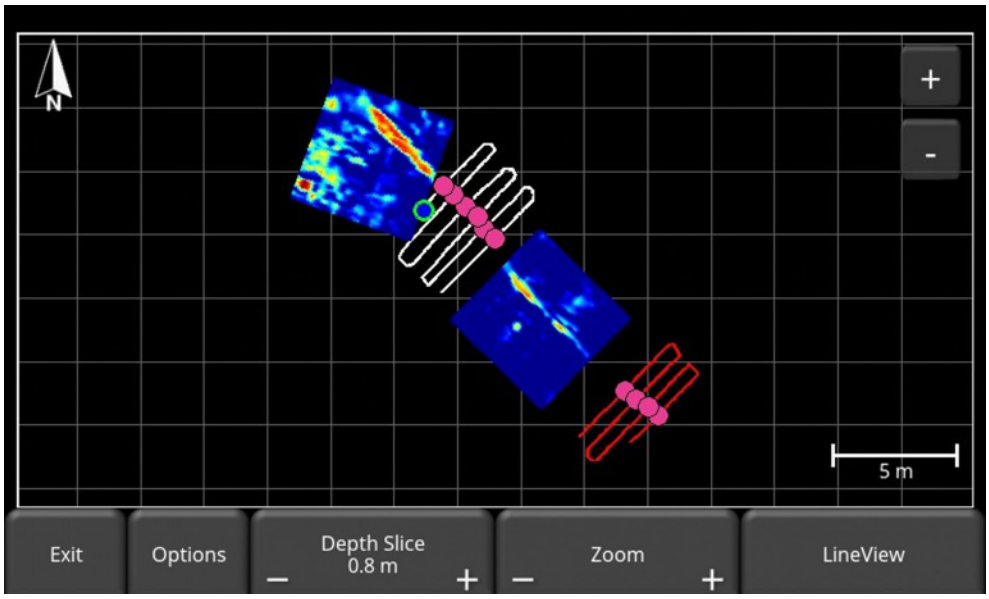


Figure 8-8: MapView showing multiple grids and lines

However, if lines/grids in a project (or any lines/grids in an LMX200) are collected far apart, MapView will only display them if they are collected within a 2.5km radius of the currently selected line. In this case, the data shown in the MapView display will follow the rules in the order below:

- Centre around the currently selected line or
- Centre around the highest line number collected with GNSS or
- Centre around the highest grid number collected with GNSS

If data exists outside the 2.5km radius, it will display the error message shown in **Error! Reference source not found.**.

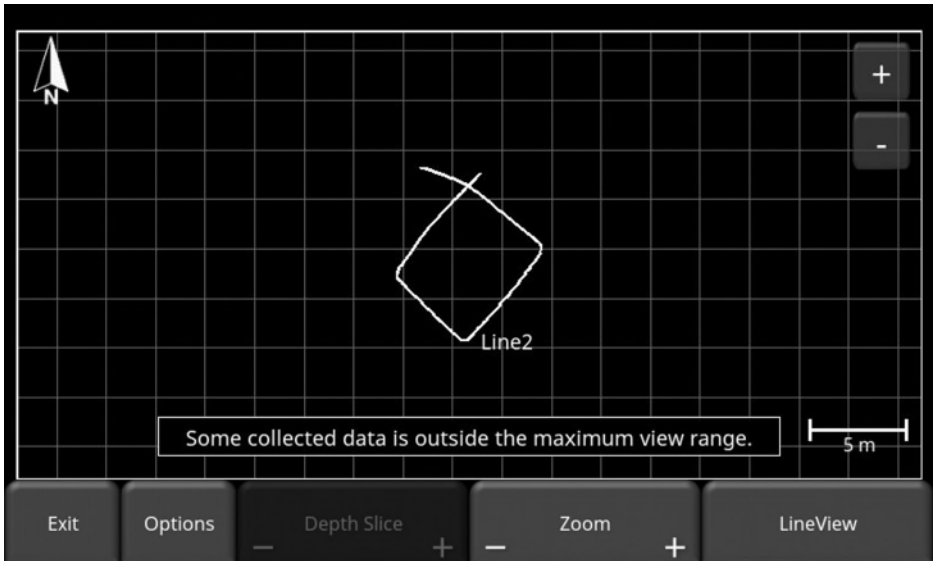


Figure 8-9: Warning message that some data is outside the MapView display range

9. Line Scan Depth Slices

After collecting the pseudo-grid Line Scans that you want to process into depth slices (in one Project number), in the Line Scan screen (Figure 9-1), press the “SliceView” button.

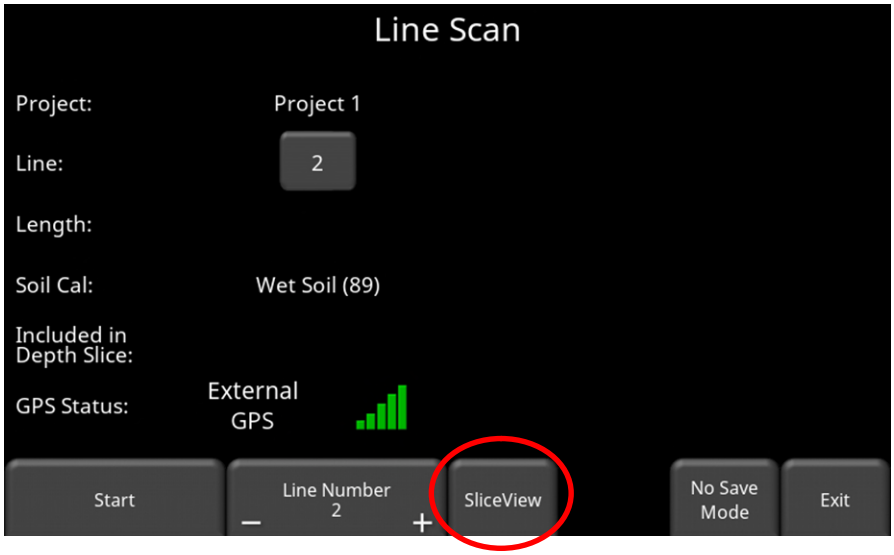


Figure 9-1: After collecting at least one Line Scan with GPS positioning, the SliceView button is enabled to generate Depth Slices.

The SliceView processing screen opens (see Figure 9-7). Then, in the SliceView Lines screen you need to set a few processing parameters.

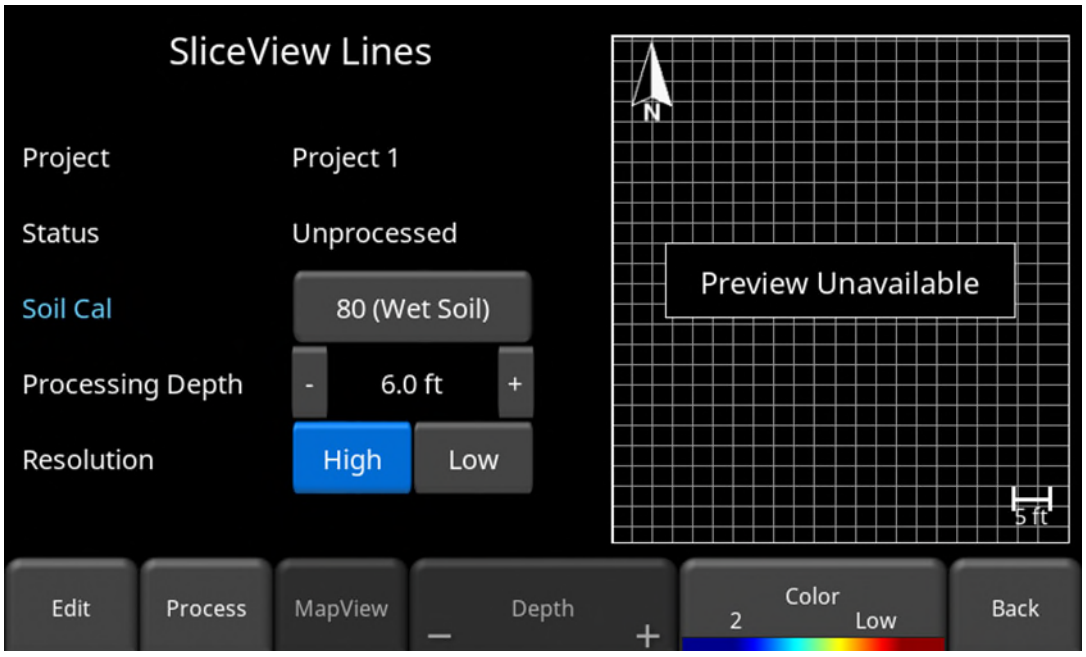


*Figure 9-2: The SliceView Lines menu sets the processing parameters Soil Cal, Processing Depth and Resolution before processing the Depth Slices by pressing the **Process** button.*

9.1. SliceView Lines Processing Settings

9.1.1. Project

The Project number being processed.

9.1.2. Status

The current status of the project depth slices. Options are:

- **No GPS** – depth slices have not been generated for this project because there is no GPS positional information available. The **Process** button is greyed out and not available.
- **Unprocessed** – depth slices have not been generated because at least one Line Scan has not been included
- **Processed** – depth slices using all lines in the project have been generated
- **Processed Max Area** – the Line Scan data exceeded the maximum area for the resolution selected so the depth slice is only partially processed.

9.1.3. Soil Calibration

It is important to ensure the Soil Cal is accurate to generate the best depth slices.

The Soil Cal value will default to the last Soil Calibration performed on the data (Section 6.6.6). If you want to change that value, select the button with the current Soil Cal value and change the value using the buttons in the Soil Cal sub-menu:

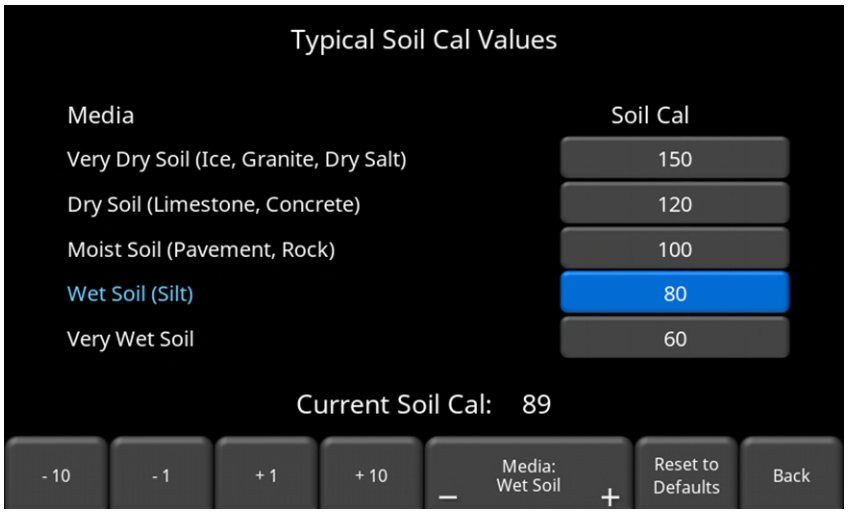


Figure 9-3: Soil Calibration screen for Line Scan Depth Slice processing.

Press the numbered buttons to increase or decrease the Current Soil Cal by the listed values. Press the + and – buttons under Media to select between the different soil media options shown or directly touch the velocity value button on the screen corresponding to that media.

Once the desired Soil Cal value is listed, press **Back** to return to the SliceView Lines Processing screen.

9.1.4. Processing Depth

This value sets the maximum depth of the depth slices. The LMX200 collects data to approximately 8 meters or 26 feet (variation occurs with the Soil Cal setting), however, the depth of GPR signal penetration is usually much less than that, so it does not make sense (and takes more time) to process depth slices to the maximum depth.

Set the Processing Depth to a value where you see the background random noise starts. For example, in Figure 6-2, that is about 6 feet and in Figure 6-9, about 2 or 3 meters.

9.1.5. Resolution

There are two resolutions available: High and Low. They vary in the width of the swath. For the LMX200, High resolution is a 0.6m wide swath (the same as the width of the LMX200 cart wheelbase). Low resolution is a 1.2m wide swath, twice the width of the LMX200 wheelbase.

If data was collected at a line spacing the same width as the LMX cart, as recommended in Figure 7-2, process the depth slices in High resolution.

If data was collected at a wider line spacing, processing the depth slices with High resolution will result in gaps in the depth slices (Figure 9-4).

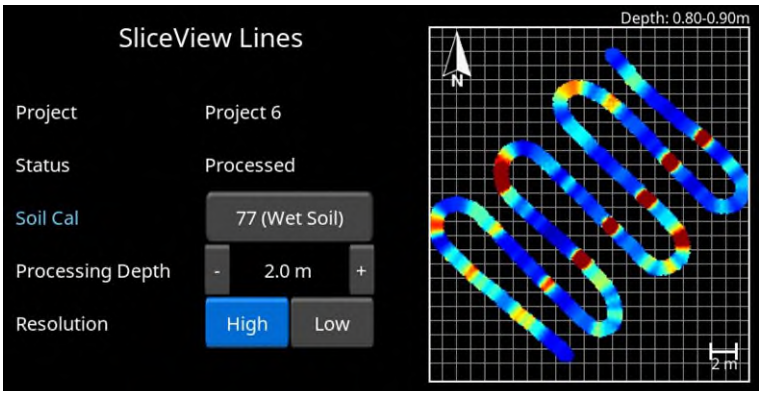


Figure 9-4: Depth slice generated with the Resolution set to High. The interpolation swath is 0.6 meters (2 feet) wide.

In this case, use Low resolution to try and fill the gaps in the data as much as possible (Figure 9-5).

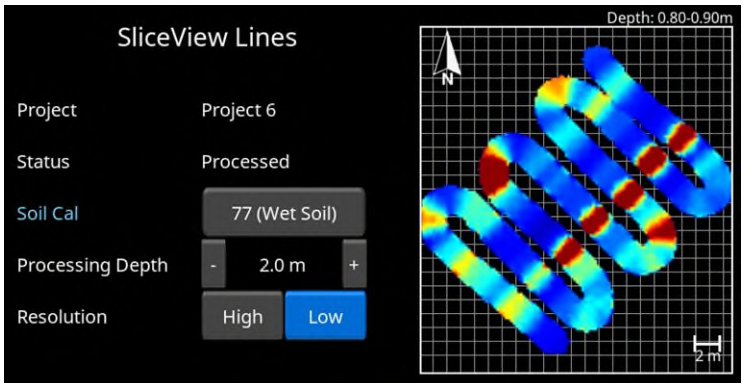


Figure 9-5: Depth slice generated with the Resolution set to Low. The interpolation swath is 1.2 meters (4 feet) wide.

However, the better solution, if possible, is to collect another Line Scan and collect data in the gaps to increase the data density so depth slices can be reprocessed in High Resolution with no gaps.

An example of High-resolution depth slices with a line spacing equal to or less than the width of the LMX cart is shown in **Error! Reference source not found.**.

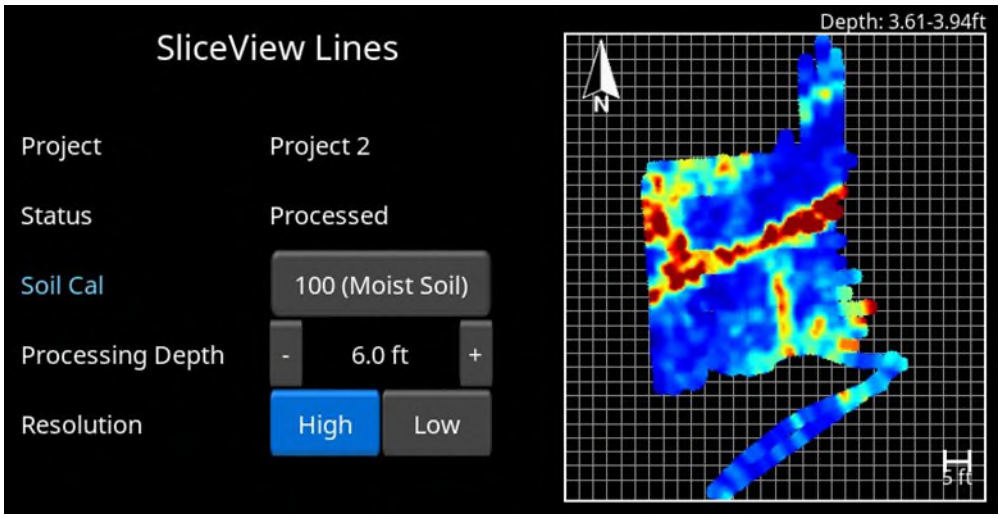


Figure 9-6: Depth slice generated with the Resolution set to High when the line spacing is tight results in a depth slice with no gaps. This is the goal for depth slice processing.

9.1.6. Edit

Use the Edit button to scroll between editing the Soil Cal, Processing Depth and Resolution values.

9.1.7. Back

Use the Back button to return to the Line Scan screen (Figure 9-1).

9.2. Depth Slice Processing

Once the Depth Slice settings are finalized, press the **Process** button at the bottom of the screen to process all the Line Scans in the project into depth slices.

A message indicating the approximate time required to process the data. This is in 5-minute increments. Smaller data volumes process faster, and processing may be less than the estimated time. Then select **OK** to proceed or **Cancel** to abort the depth slice processing. The data can always be transferred to a computer and the EKKO_Project Reveal software used to process it into depth slices.

9.2.1. Maximum Area Exceeded

High Resolution

If the Resolution is set to High and the area covered by all the Line Scans exceeds 900 square meters or 10,000 square feet, a message is displayed giving the option to proceed with partially processing the data or cancelling the depth slice processing.

If the data is partially processed, the highest density of GPR data inside a box with dimensions of 30x30m (or 100x100 feet) oriented North-South-East-West is processed (Figure 9-2).

Low Resolution

If the Resolution is set to Low and the area covered by all the Line Scans exceeds 3600 square meters or 40,000 square feet, a message is displayed giving the option to proceed with partially processing the data or cancelling the depth slice processing.

If the data is partially processed, the highest density of GPR data inside a box with dimensions of 60x60m (or 200x200 feet) oriented North-South-East-West is processed (Figure 9-11).

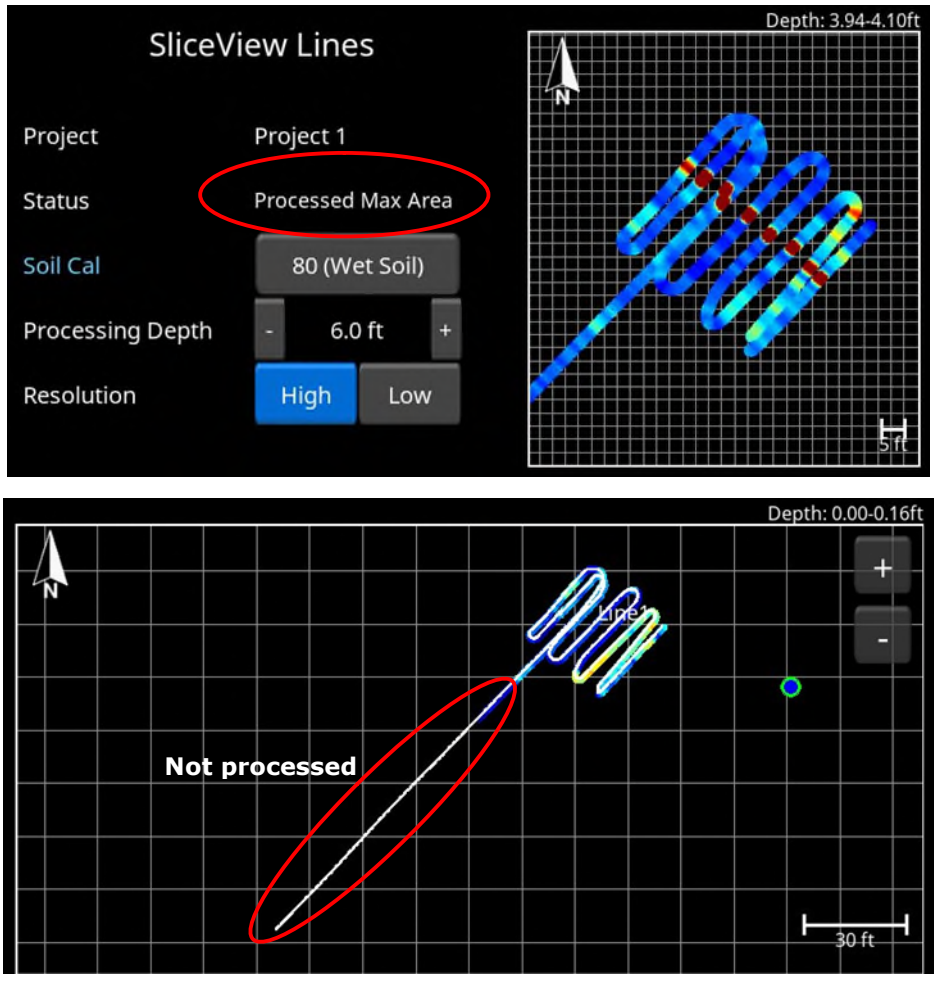


Figure 9-7: Partially processed depth slice displayed in SliceView-Lines (top) and MapView (bottom). The line is only partially processed because it exceeded the Maximum Area for the resolution selected. This is indicated in the Status (top).

9.3. Depth Slice Options

After the depth slices have been processed, use the buttons along the bottom of the edge of the screen to scroll through the slices and make changes to the color palette or view different

9.3.1. Depth

Use the Depth + and – buttons to scroll down and up through the depth slices. The current depth range is displayed in the top right corner.

9.3.2. Color

This option has two button functions beneath it:

a) **Color Palette** - The number corresponds to the color palette used for the depth slice image. Pressing this button cycles between the 9 available color palettes available on the system.

b) **Color Contrast** - cycles between **LOW**, **MEDIUM** and **HIGH**. A setting of HIGH is useful for revealing weaker targets which can sometimes be difficult to see. Setting to LOW will help "clean up" the data and only show the strong targets but will hide some of the weak signals so be careful when setting to LOW. Figure 9-8 shows the variations in color contrast.

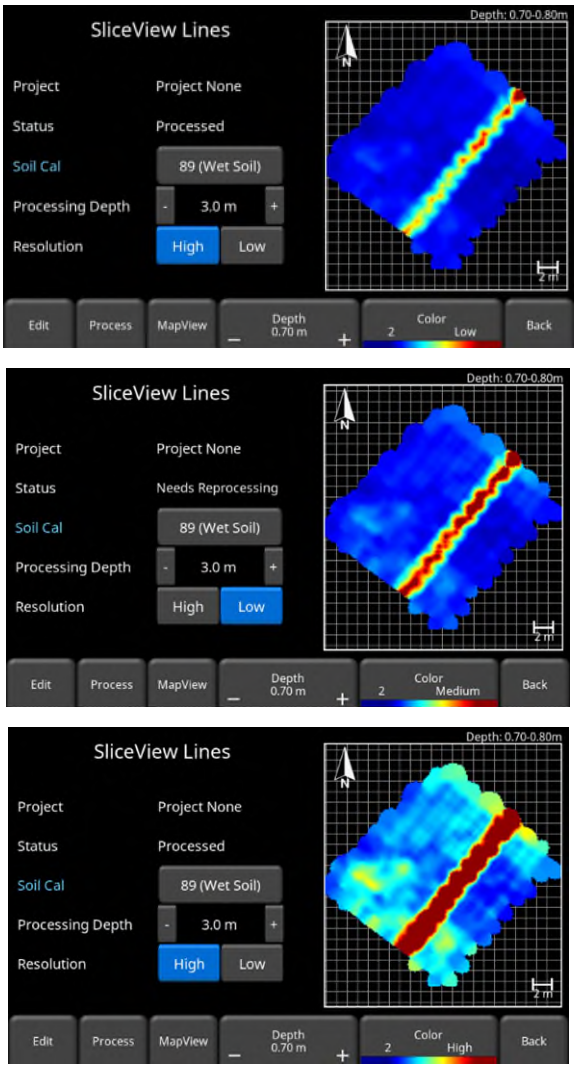


Figure 9-8: Depth slice with the Color Contrast set to Low (top), Medium (middle) and High (bottom).

10. SplitView

When an external GNSS is connected to the LMX, a user collecting a Line Scan (6.) can split the screen to show both the Line Scan data being acquired, as well as the MapView display. Press the **SplitView** button from the Line Scan menu to see this view (Figure 6-4).

The quality of the GNSS signal received is always shown in the lower left of the LineView display; this is explained at the beginning of this chapter.

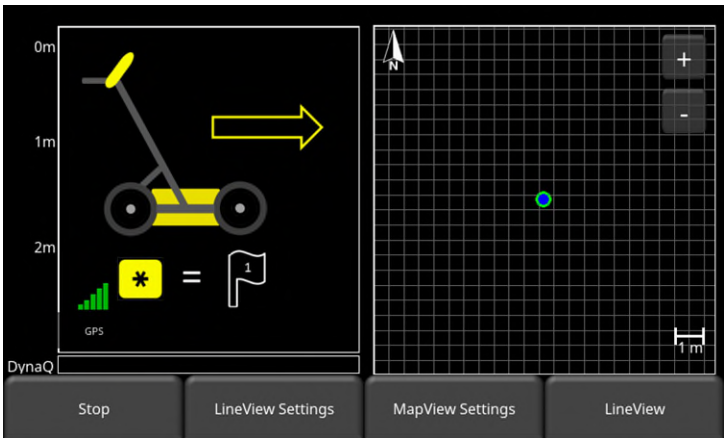


Figure 9-9: SplitView display, showing LineView on the left half and MapView on the right half

The current position of the system is shown as a blue dot with a green circle around it on the MapView display. As the system is moved and data is collected, your position is updated on the MapView side of the display, The path travelled is initially shown as an orange line. As more data is collected, part of the line will turn white, while a small section remains orange. This orange section corresponds to the data shown in LineView on the left side. Pressing the left and right arrows on the 4-way directional keypad will display different sections of the data collected; this will also update which section you are viewing on the MapView display (Figure 9-5).

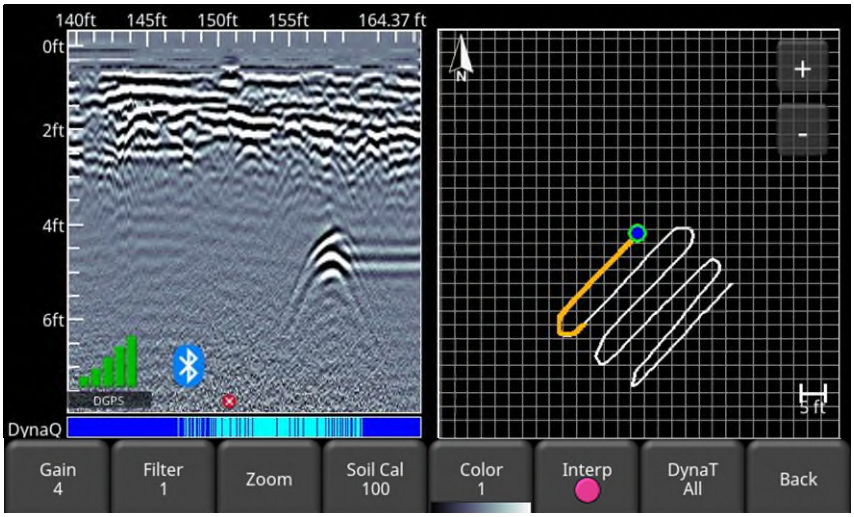


Figure 9-10: Collecting data in SplitView mode

MapView will display all lines (collected with an external GNSS) and grids (collected with internal or external GNSS) collected in a single project.

However, if lines/grids in a project (or any lines/grids in an LMX200) are collected very far apart, MapView will only display them if they are collected within a 2.5 km radius of the currently selected line (Figure 8-9).

Pressing the **LineView Settings** button will display menu options for the LineView side of the SplitView screen. These are explained in Section 6. .

Pressing the **MapView Settings** button will display menu options for the MapView side of the SplitView screen. These are explained in Section 8.2.1

If you are collecting data in real-time you can press the **LineView** button to return to full screen LineView. If you are reviewing previously collected data, you will see the **MapView** button instead. Pressing this will take you to a full screen MapView display, which is also explained in Section 8.

10.1. Adding Interps in SplitView

A strategy to use SplitView most effectively for tracking linear targets, such as utilities, is to scroll through the Line Scan, moving the orange line, using the left and right arrow buttons on the Display Unit. When you see a hyperbola, add an interpretation to it. Move the orange line to the next pass and see if there is another hyperbola. If so, add an interpretation to it and confirm in the MapView screen that the interpretations line up. If so, keep moving the orange line, adding interpretations to hyperbolas and see if they all line up in MapView, as shown in Figure 9-11.

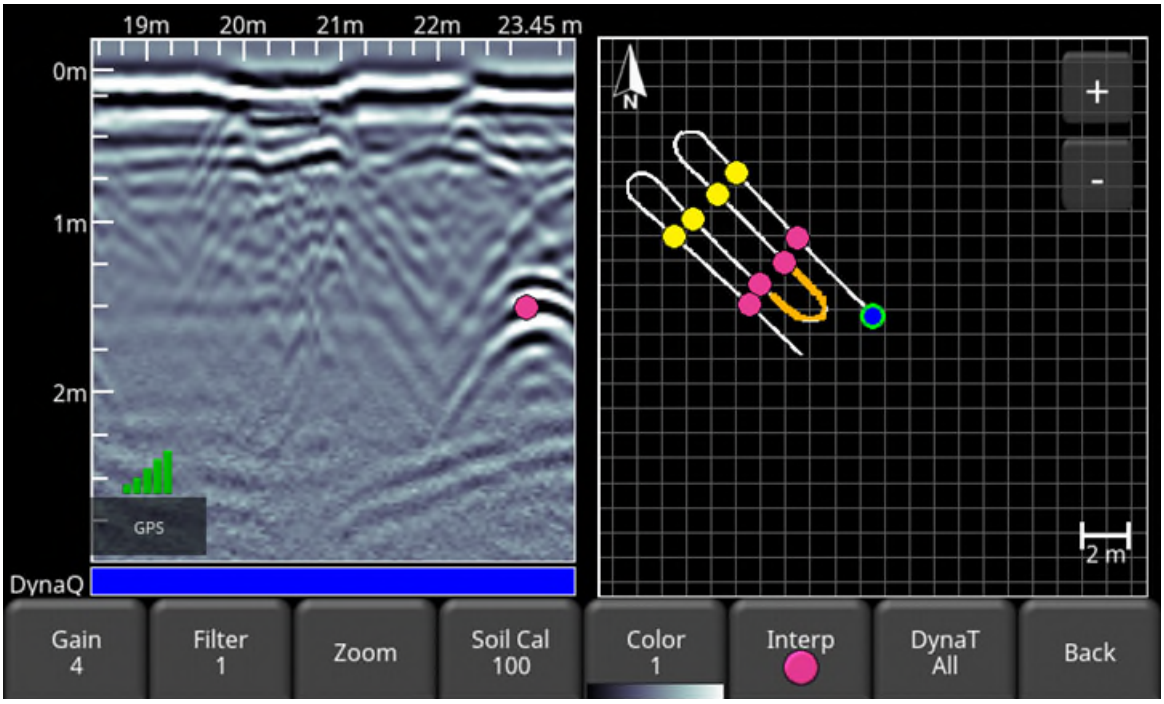


Figure 9-11: Tracking two linear targets in SplitView

If you add an interpretation to hyperbola and it does not line up with other interpretations in MapView, it may be a second target. Change the color of the interpretation and use the same strategy as described above to the move the orange line to the next pass and see if there is another hyperbola that lines up with the first. This is the way the pink and yellow utilities were mapped in Figure 9-11.

10.2. Displaying Depth Slices in SplitView

If the current project has processed depth slices, these can be displayed on the MapView side of the SplitView screen by turning them ON in the MapView Options (8.2.1).

Pressing the **+** and **-** buttons on the **Depth** button will increase or decrease the depth of the depth slice currently displayed. You can also use your finger or a stylus and drag the depth slice indicator on the Line Scan image (two horizontal red lines). This allows the user to "slice through" the ground and locate features that appear at different depths.

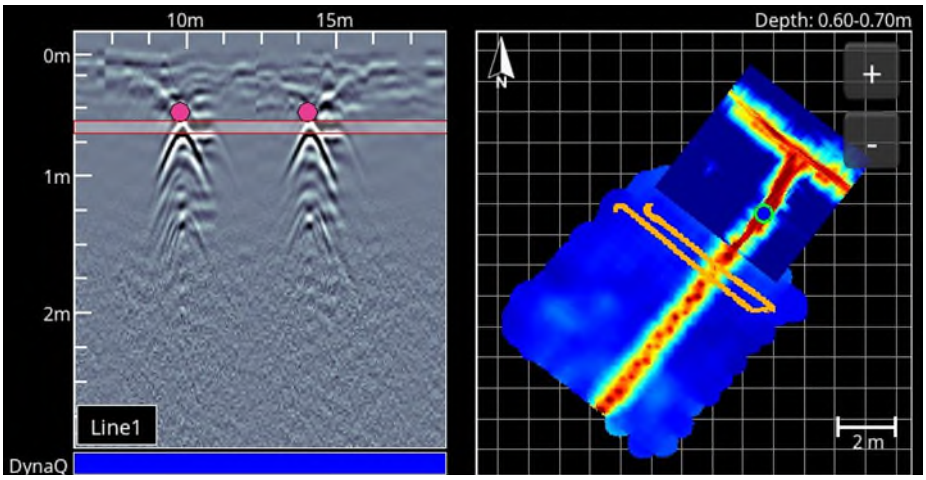


Figure 9-12: Using SplitView to correlate the strong response on a depth slice to a reflector in the LineView. In this case, the orange line crosses the strong red response in the depth slice twice, corresponding to the hyperbolas marked with pink interpretations.

Plotting depth slices in SplitView makes it easy to correlate a strong reflector in the depth slice to the GPR response in LineView. Scroll through the Line Scan, moving the orange line, using the left and right arrow buttons on the Display Unit. When you see the orange line intersect a strong response in the depth slice, look on the LineView side to see what caused it (Figure 9-12). If desired, add an interpretation to it by touching the response on the Line Scan. For example, see the 2 pink interpretations added to the top of the hyperbolas in Figure 9-8. Note that Interpretations are a layer in the MapView window that can be turned ON or OFF (8.2.1).

11. Grid Scan

Grid scans are conducted to generate depth slices over a given area. This is useful for locating all known and unknown objects, as well as their orientation, in a graphical manner that may be easier to interpret.

From the main menu (Figure 3-2), press the **Grid Scan** button to enter the Grid setup menu.

11.1. Grid Parameters

The screen in Figure 11-1 will allow you to set parameters for the grid, before data acquisition begins.

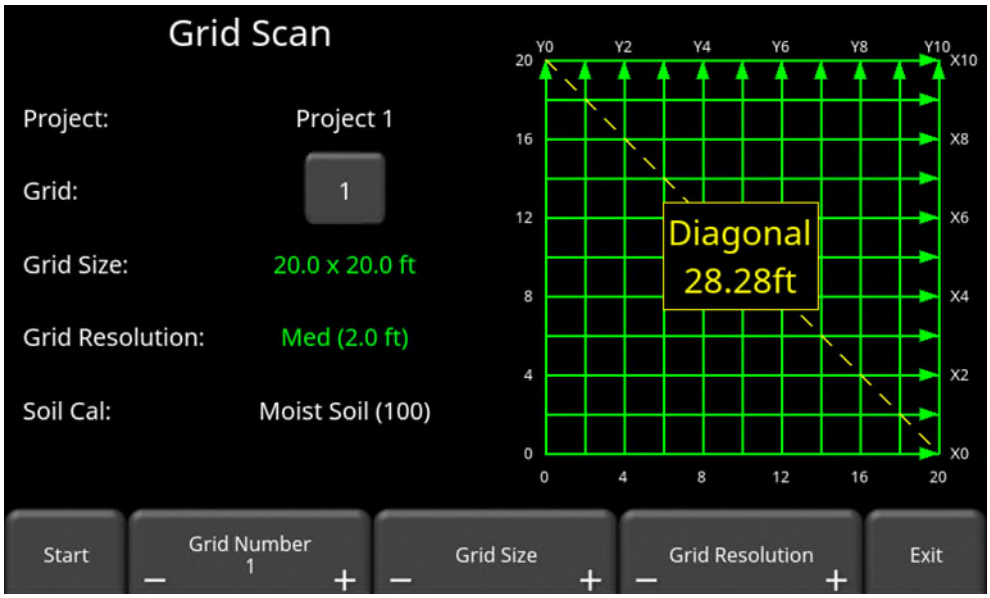


Figure 11-1: Grid Scan setup

11.1.1. Grid Number

To select a grid number, press the **+** and **-** buttons under **Grid Number** at the bottom of the screen. Alternatively, pressing the grid number button itself will show the screen in Figure 11-2. From here, you can go directly to any grid. Grids that contain no data will have the text shown in green.

If a grid already contains some data, it will be shown in red, and you will not be able to change the size or resolution. You will just have the option to select:

- **SliceView** – view the depth slices
- **Delete Grid** – delete all the data in this grid

You can press Start to enter a previously collected grid, either to view data or recollect a line.

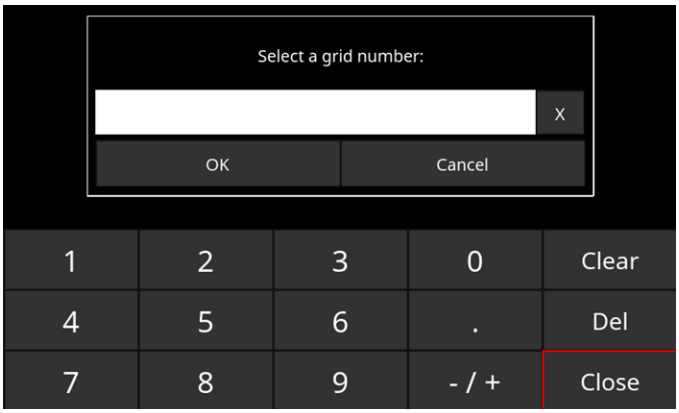


Figure 11-2: When the button showing the grid number is pressed, this screen allows the user to directly input the grid they wish to go to

11.1.2. Grid Size

Press the **+** and **-** buttons under **Grid Size** at the bottom of the screen to change the dimensions of the grid. Alternatively, you can press the **+** and **-** buttons on the screen beside **Grid Size** on the upper part of the screen.

In metric units, the available grid sizes are 5m x 5m, 10m x 10m and 15m x 15m.

In US standard units, the available grid sizes are 10ft x 10ft, 20ft x 20ft and 50ft x 50ft

11.1.3. Grid Resolution

Grid resolution determines the spacing between grid lines. This can be varied by pressing the **+** and **-** buttons under **Grid Resolution** at the bottom of the screen. Alternatively, you can press the **+** and **-** buttons on the screen beside **Grid Resolution** on the upper part of the screen.

Available options are 0.25m (High resolution), 0.5m (Medium resolution) and 1.0m (Low resolution) in metric units and 1ft (High resolution), 2ft (Medium resolution) and 5 ft (Low resolution) in US standard units. The best depth slice images result when high resolution is used; it is recommended to set this to 0.25m or 1 foot.

Calculating Resolution

The size of target will determine line spacing. The system must pass over a target to detect it; line spacing needs to be on the order of the size of the target or smaller when practical. This can be adjusted to a larger spacing for larger targets or targets that are linear. As well, these rules may have to be bent for practical purposes such as survey production rates. Tighter line spacing takes longer to collect and may not be economically possible in all circumstances.

Note that the system will not allow you to select a 10x10 foot grid with a low resolution of 5ft, as this resulting image will be very poor due to inadequate data collected.

11.1.4. Starting data collection

Press **Start** when all the parameters are setup and data collection is ready to begin.

11.2. Laying out the grid

Positional accuracy of each line is vital to locating targets of interest once data has been processed. Follow the steps below to layout the grid.

Step 1 – Define the axis- Lines parallel to the Y-Axis are called Y-Lines. Similarly, lines parallel to the X-axis are called X-Lines (Figure 11-3). Pick the origin of the grid such that it is the furthest corner away from any obstacles. This way, all the lines start properly, but they can be ended early if there is an obstruction.

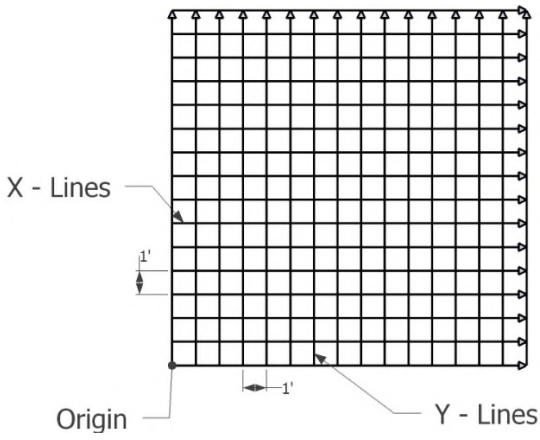


Figure 11-3: X-Lines and Y-Lines relative to the Origin.

Step 2 – Layout the Grid – to improve positional accuracy, it's recommended to establish a right-angle triangle (Figure 11-4). This can be done by using a single tape measure and referring to the diagram below. Start at the origin, walk out the desired distance for X-axis (A) and mark that point. Then then turn 90 degrees and walk out the desired distance for the Y-axis (B) and mark that point. Determine the hypotenuse side (C) from the screen (Figure 11-4), then close in the triangle (C - hypotenuse side) back to the origin, making sure you meet the origin at the distance for C. If not, move that last point in tandem with the origin, such that both sides of the tape measure are taut.

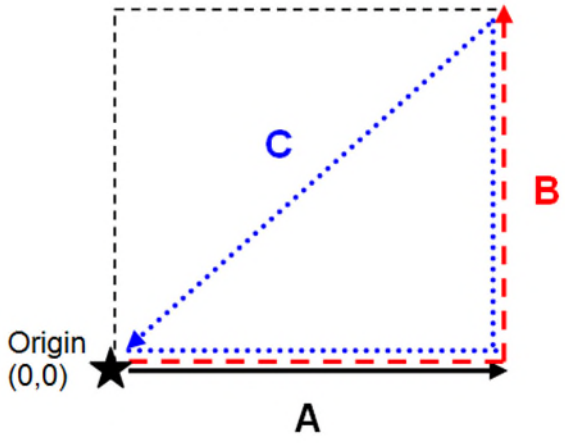


Figure 11-4: Forming a right-angle triangle

Step 3 – Mark the Line Start Positions – with the tape measure still on the ground, mark the line start positions based on the line spacings (Figure 11-5). Usually flags or paint work for grass, and chalk or paint on concrete. It is also recommended to paint a distance measurement every so often, in case you forget which line you're on.

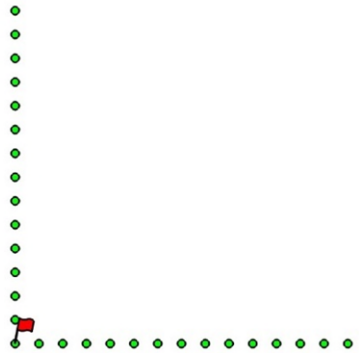


Figure 11-5: Marking the line spacing and starting positions for every line

Step 4 – Mark the End Positions – if you are doing a forward only grid, it is recommended to mark the end positions (Figure 11-6). You will need to aim for something to make sure your line is straight.

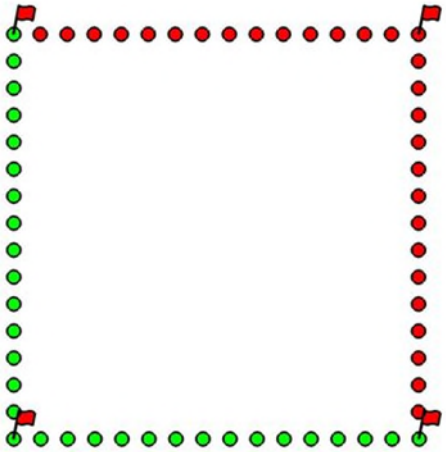


Figure 11-6: Marking ending positions

For linear targets such as pipes and utilities, GPR responses are generally clearer when the survey line crosses the target at a right angle. Keep this in mind when laying out the grid and the orientation. Sometimes, laying out a grid with straight lines and corners at 90-degree angles can be difficult.

An example grid layout is shown in Figure 11-7.



Figure 11-7: Example of a grid survey. The red lines are superimposed just to illustrate the concept.

11.3. Data Collection

11.3.1. Physical Data collection

It is critical that the starting position is consistent on every line. Line up the middle of the unit with the starting line and then push the system straight towards the end of the line. It is helpful to have a marker at the end, so you have something to aim for.

11.3.2. Data collection on the Display Unit

The data collection screen is shown in Figure 11-8. The right half of the screen is a graphic representation of the grid, illustrating the size of the grid and the lines that need to be collected. The left half of the screen will display the last grid line collected.

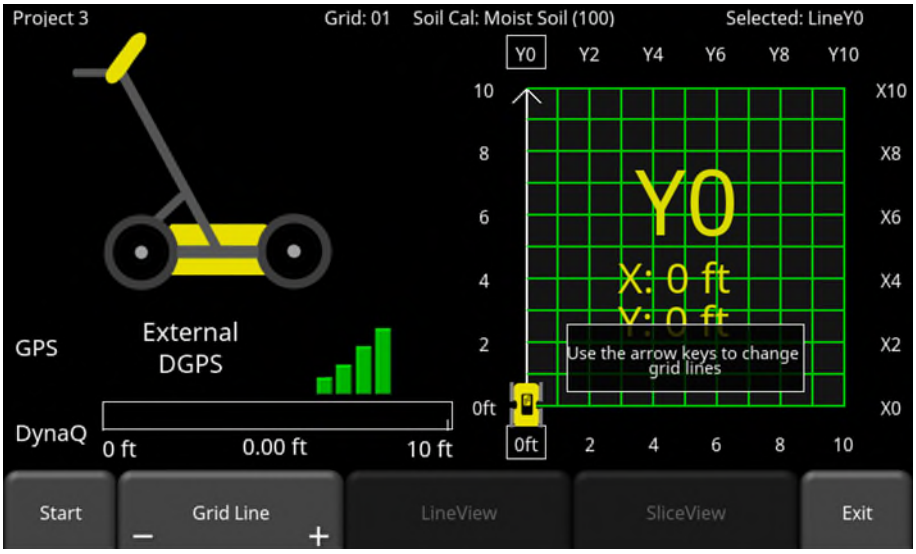


Figure 11-8: Grid collection screen prior to any data collection

Press **Start** when you are positioned at the start of the line. The system will beep once. If you don't hear the beeps, check the volume setting, 4.1.4. Push the system in a straight line towards the end of the line. The system knows the length of each line and will automatically stop acquisition once that distance has been covered. If the data acquisition ends prior to reaching the end of the line, or continues noticeably past it, you likely need to do an Odometer Calibration (Section 4.2.6).

Once data is collected, the Grid Line will turn red, and the system will beep twice. The current line will now advance to the next one and is shown in white. The remaining lines to be collected are shown in green (Figure 11-9).

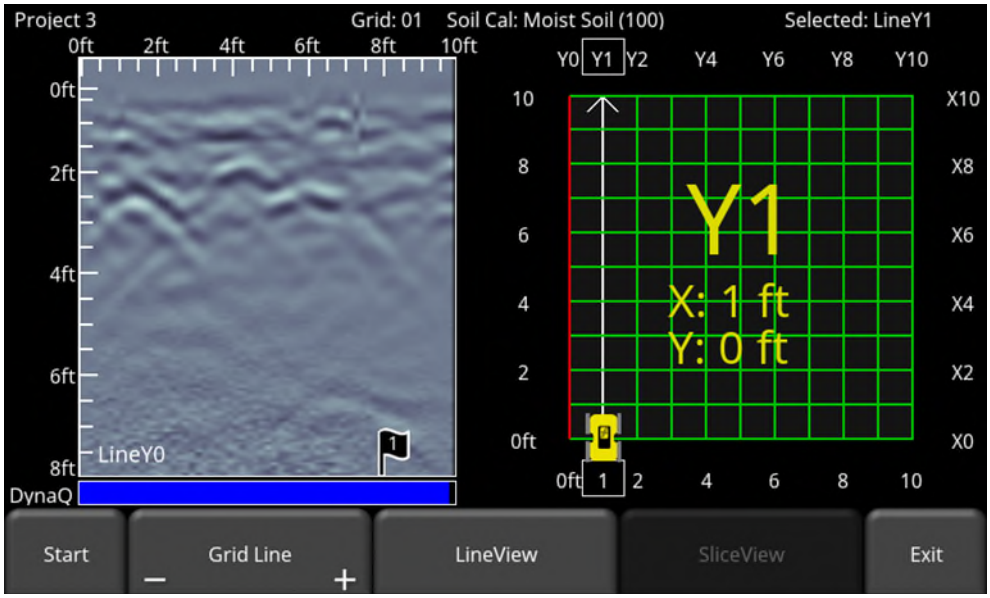


Figure 11-9: Display after the first grid line is collected

Move back to the start of the next line and repeat the process. Once all the lines are done in one direction, it will automatically prompt you to collect lines in the other direction.

Not all lines have to be collected. If your area of interest is only 4m x 4m, set the Grid Size to 5m x 5m, but just don't collect the outer lines.

11.3.3. Obstacles in your path

If there is an obstruction preventing you from finishing the line (such as a tree or rock), do not try to steer the system around the obstruction, as this will throw off the positioning of the data. When you approach the obstruction, end the line by pressing **End Line**. The software will move you to the start of next line.

You now have the option to collect a "reverse" line from the other direction. Press the Grid Line **minus** button to move to the previous line, but in the reverse direction. Alternatively, you can also press the left or down arrow (depending which axis you're on) on the 4-way directional keypad to move to the previous line in the reverse direction. The name of the line will now

contain an R at the end. Press **Start** to collect this line and then **End Line** to end the line when you hit the obstruction.

The example in Figure 11-10 shows that line Y3 was not complete, so a reverse line was added to it.

You can also choose not to collect a reverse line right away. Once you are done all the lines in that direction (e.g. Y lines), the software will automatically return to any incomplete lines in that direction and give you the opportunity to collect a reverse line.

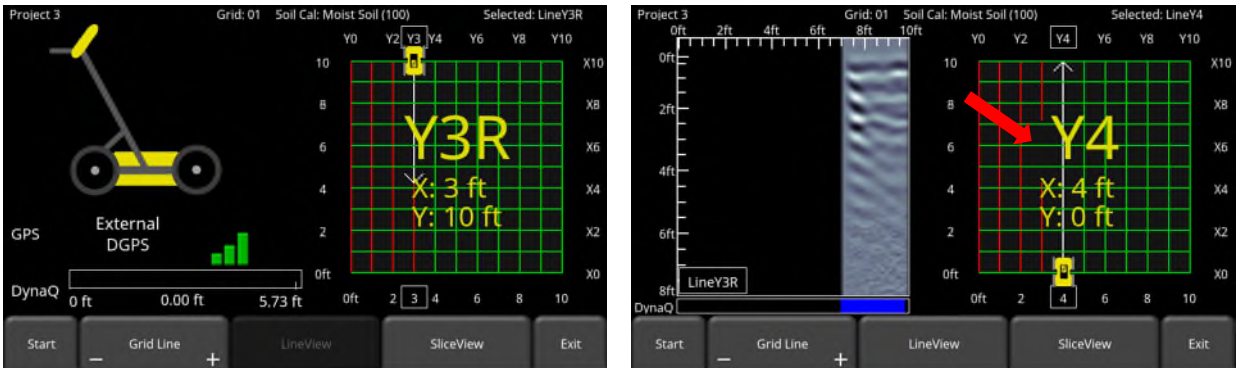


Figure 11-10: Collecting a reverse line around an obstacle

A completed grid with an obstacle in the middle, might look like the image in Figure 11-11.

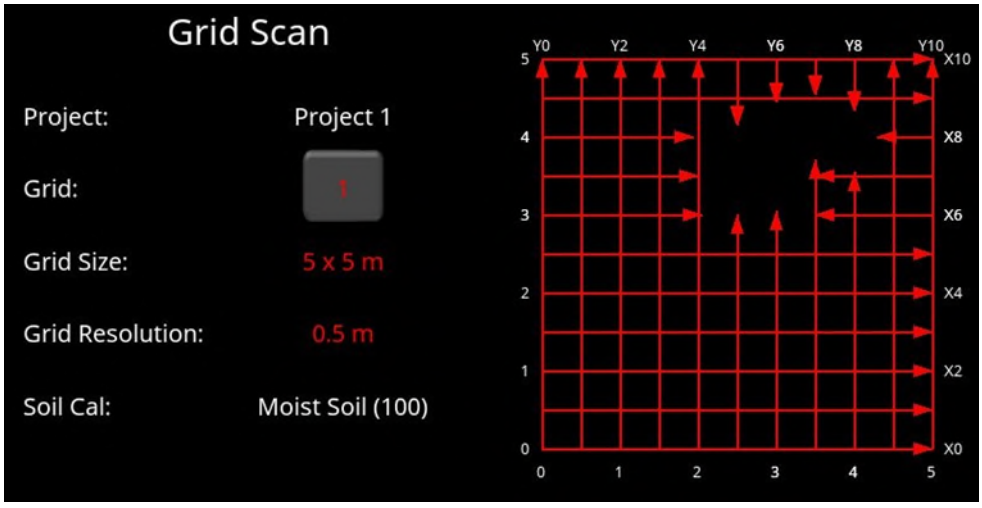


Figure 11-11: Completed grid with obstacle

11.3.4. Flags

Flags are often inserted to mark noteworthy surface features, such as poles, sidewalks, changes in terrain etc. These markers may help you correlate subsurface targets with above ground features.

Pressing the **asterisk** button on the keypad will insert a flag at your current position. The flag is displayed on the line scan image (Figure 11-9), and will also show up on the depth slices in SliceView (Section 12.). Flags are sequentially numbered.

11.3.5. LineView

To display the currently selected grid line on the full screen, press the **LineView** button (Figure 11-12). In this view, you have the option of modifying the image by changing the Zoom, Color, Filter, Gain and Soil Cal values. It is also possible to display other collected grid lines using the keypad arrow buttons.

To exit from the LineView screen and return to Grid View, press the **Back** button. The Grid View screen respects any display settings changed while in LineView. If the Soil Cal is changed, the depth slices will be reprocessed.

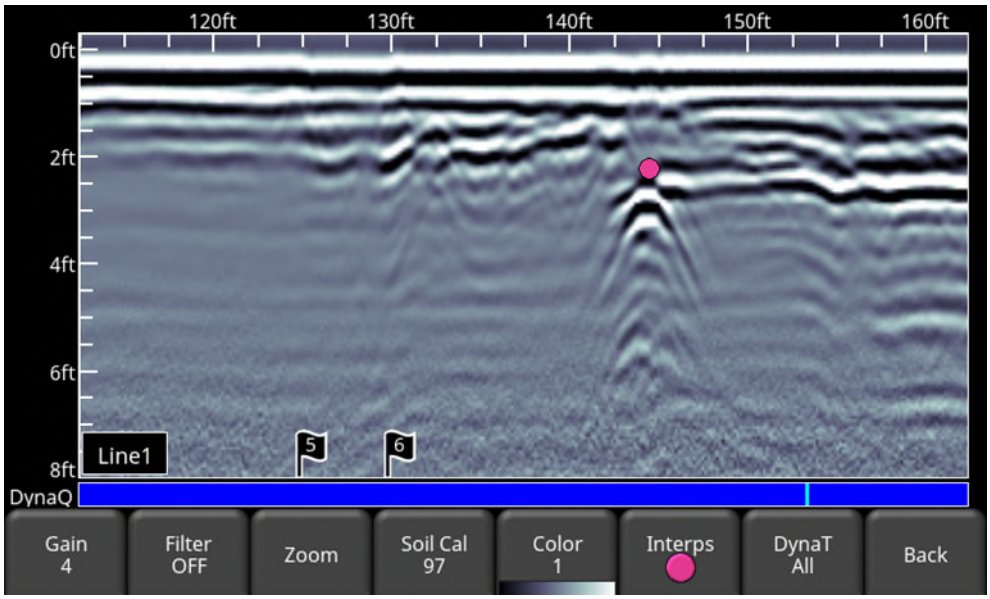


Figure 11-12: LineView screen

11.3.6. Recollecting & skipping lines

You may want to recollect a line if you make a mistake. To move to a different line:

- Press the **+** and **-** buttons under **Grid Line** OR
- Touch any **line** on the grid image on the right OR
- Use the **4-way directional keypad**

Then simply hit **Start**. You will be prompted with a message asking if you want to overwrite that line (Figure 11-13). Press **Yes** to proceed.

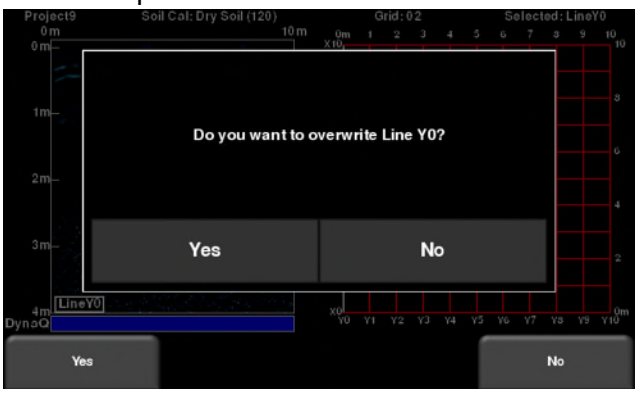


Figure 11-13: Overwriting a line

11.3.7. Processing Grid Scan data

Once you have finished collecting all the data, press **SliceView** at the bottom of the screen. Before the data is processed and depth slices created, you must ensure the Soil Cal is properly set (6.6.6; this will help to achieve the most accurate and sharpest images.

A message will display advising the Soil Cal that will be used (Figure 11-14). If you have adjusted this already for the ground you are on, you can press **OK** to proceed and create the depth slices. If not, then it is recommended to press **Cancel** and adjust the Soil Cal by using a good hyperbola on one of the collected lines. Then return and press **SliceView** and press **OK** to proceed and create the depth slices.

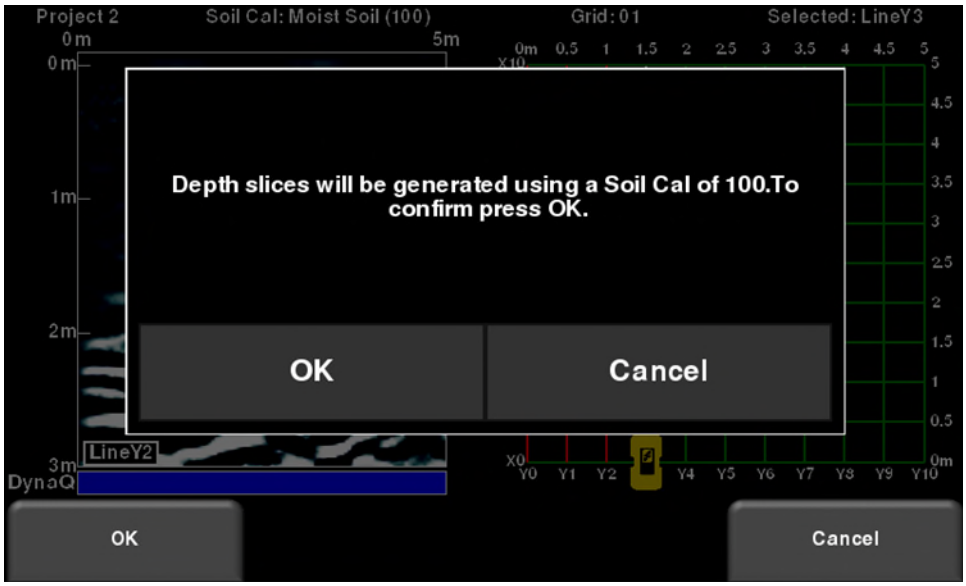


Figure 11-14: Processing with Soil Cal value

Now see 12. Grid Scan Depth Slices.

12. Grid Scan Depth Slices

SliceView displays data collected in a grid as a series of depth slices moving deeper into the subsurface. Objects and features appear in a map view, which can be an easier way of visualizing the data.

Upon entering SliceView, the screen will be displayed as shown in Figure 12-1.

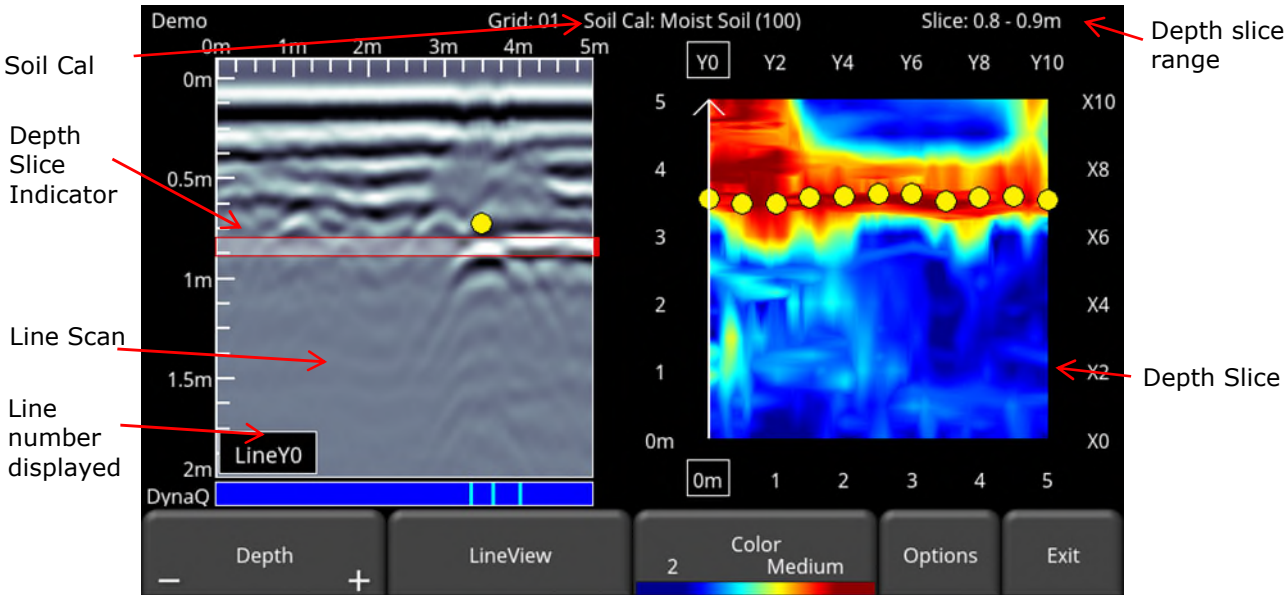


Figure 12-1: SliceView screen

The right half of the screen shows one of the depth slices. These slices are 10cm or 4" thick. The top and right sides of this image show the dimensions of the grid while the left and bottom sides show the line numbers.

The left half of the screen displays one of the grid lines, and any flags or interpretations that were made. The shaded area in between the horizontal red lines corresponds to the depth slice shown on the right. To move to another grid line, use the 4-way directional keypad on the Display Unit.

At the top of the screen, the grid number is listed, along with the Soil Cal value and slice thickness range.

The button functionality is explained below:

12.1. Depth

Pressing the **+** and **-** buttons on the **Depth** button will increase or decrease the depth of the depth slice currently displayed. You can also drag the depth slice indicator on the line scan

image. This allows the user to “slice through” the ground and locate features that appear at different depths.

12.2. LineView

Pressing this button displays the currently selected GPR line as a full screen image. All the functionality of Line Scan (such as Depth, Color, Filter, Gain, DynaT, Soil Cal, Interps) are available here (Figure 12-2). Use the **4-way directional keypad** to change to a different line.

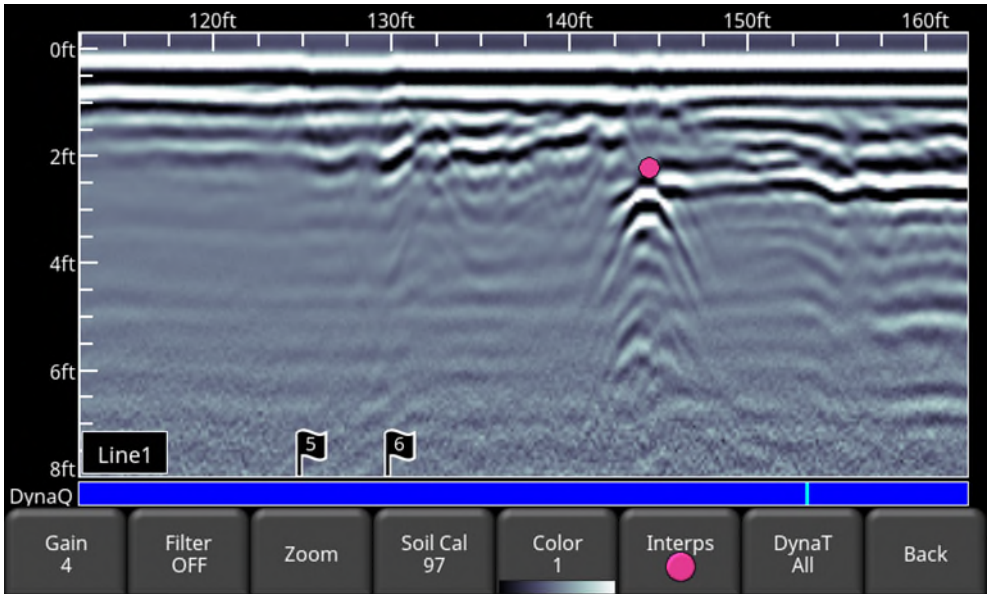


Figure 12-2: Changing LineView settings from within SliceView.

Press **Back** to return to SliceView. Any changes made will be reflected on the GPR line in SliceView mode. If you change the Soil Cal or Zoom (depth), this will cause the depth slices to be re-processed.

Users may want to change these display settings to make it easier to correlate line scan data with depth slices.

12.3. Color

This heading has two button functions beneath it:

c) **Color Palette** - The number corresponds to the color palette used for the depth slice image. Pressing this button cycles between the 9 available color palettes available on the system.

d) **Color Contrast** - cycles between **LOW**, **MEDIUM** and **HIGH**. A setting of HIGH is useful for revealing weaker targets which can sometimes be difficult to see. Setting to LOW will help “clean up” the data and only show the strong targets but will hide some of the weak

signals so be careful when setting to LOW. Figure 12-3 shows the variations in color contrast.

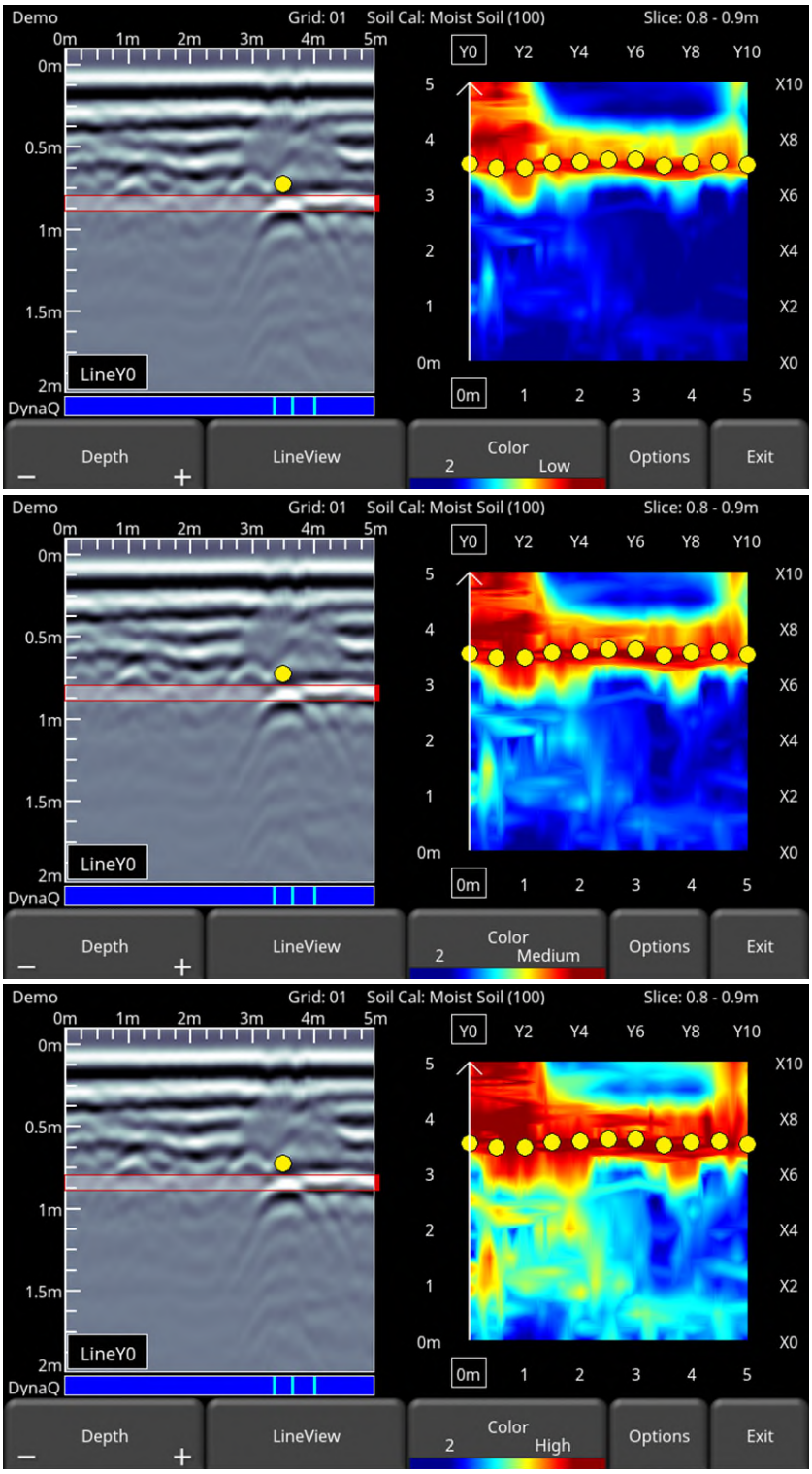


Figure 12-3: Varying the Color Contrast, from top to bottom: Low, Medium and High settings. High shows more subtle targets but may sometimes appear cluttered while the Low setting only displays the strongest targets so be cautious when using it.

12.4. Options

12.4.1. Grid Lines

Pressing this button overlays grid lines on the depth slice image, and cycles between **ON**, **PARTIAL** or **OFF**. When set to ON, all the collected lines are displayed. When set to PARTIAL, only some of the grid lines are displayed. This may be necessary for some larger grids as having all the grid lines ON tends to obscure the image beneath (Figure 12-4). The currently selected line is always shown in white.

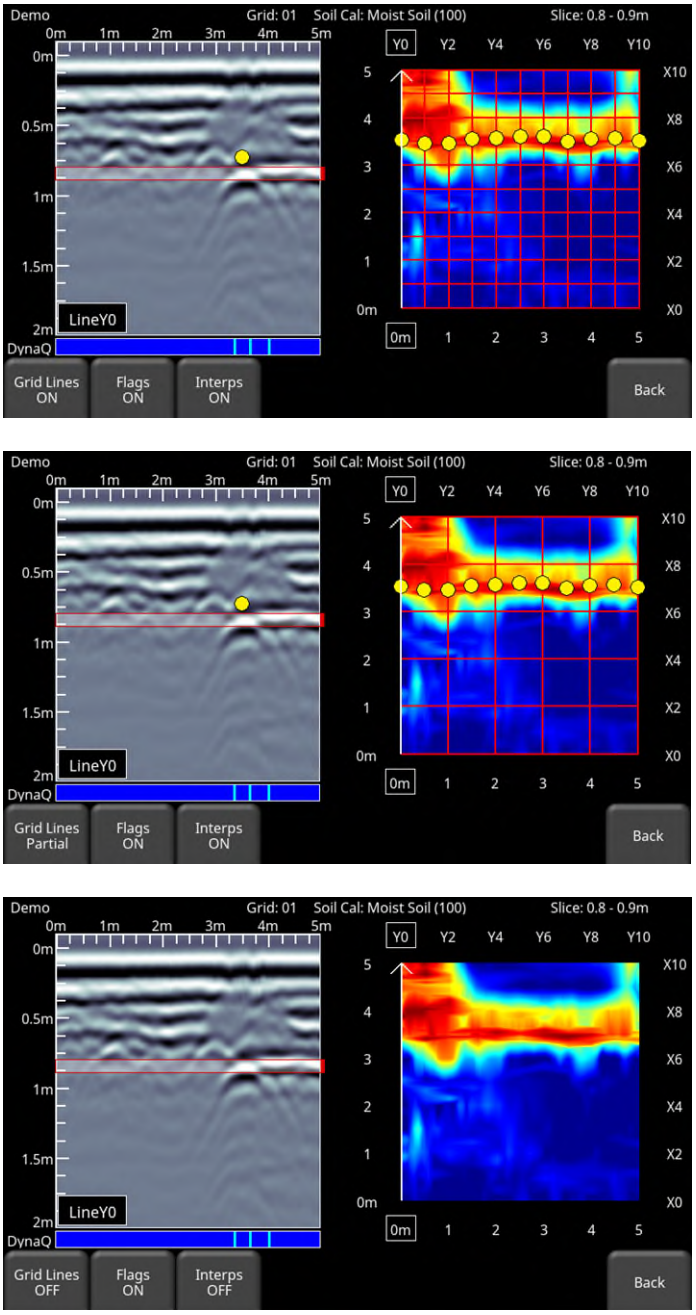


Figure 12-4: Varying the Grid Lines, from top to bottom: ON, PARTIAL and OFF settings.

12.4.2. Flags

Pressing this button toggles on and off between displaying flags on the line scan data and the depth slice.

12.4.3. Interps

Pressing this button toggles on and off between displaying Interps on the line scan data and the depth slice.

12.5. Recollecting lines

After looking at the grid data in SliceView you may discover that one or more grid lines need to be recollected (for example, maybe the starting position was offset). If so, you will need to enter the Grid Scan menu again and select the appropriate grid number and press Start (the grid number will be in red, since data exists).

Select the grid line that needs to be recollected. When you press **Start**, it will display a prompt confirming if you want to overwrite the line. After recollecting the grid line(s), press the **SliceView** button to re-process the grid data.

13. Screenshots, PDF Reports & Mini-Reports

13.1. Capturing Screens

If you would like to save an image of the current screen in Line Scan, Grid Scan, SliceView or MapView, press the **Camera** button on the Display Unit. This saves the screen as a Screenshot image, accessible in these ways:

1) PDF Summary Report: Screenshot images are displayed in the PDF Summary Report, automatically generated when transferring data to a USB memory stick. (14.).
2) JPG Images: a folder containing JPG images, one for each screenshot, is saved to the Screenshots folder, saved to the USB memory stick when data is transferred. JPG files can be viewed in any third-party viewing software.
3) KMZ (Google Earth) file:
4) If any GNSS is enabled, Internal or External (see Section 4.2.7) the screenshot image for depth slices will also contain a geo-tagged reference.

If you are not connected to a Wi-Fi network, a message appears confirming the filename of the saved image (Figure 13-1).

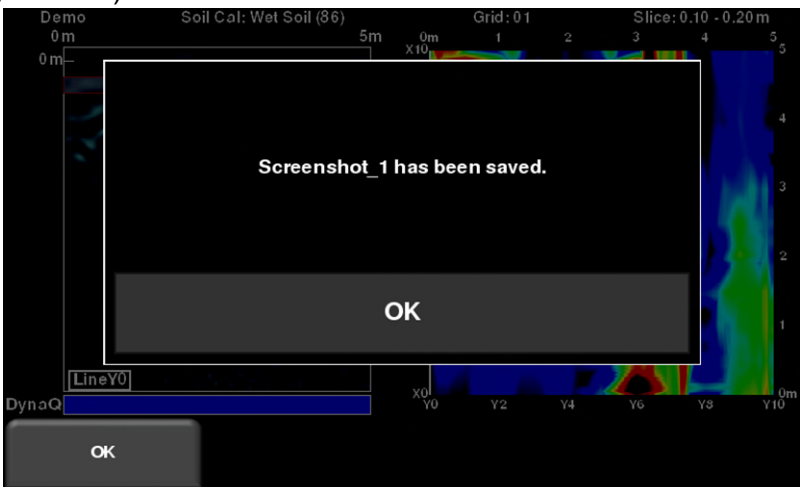


Figure 13-1: Message displayed after pressing the camera button on the Display Unit to capture the screen (no Wi-Fi present).

If you are connected to a wireless network and have a sending e-mail address configured, the user will see the message in Figure 13-2, asking if you would like to email the screenshot and prompts you to enter the email address. The email address defaults to the last one entered. Tapping on the address box brings up an on-screen keyboard and allows you to enter a new email address. Pressing the "**…**" button to the left of the e-mail address displays the last 5 e-mail addresses used, allowing the user to easily select a recent email address, rather than re-entering it.

Screenshots can always be e-mailed at a later time from the Screenshot Gallery (Section 4.3.1).

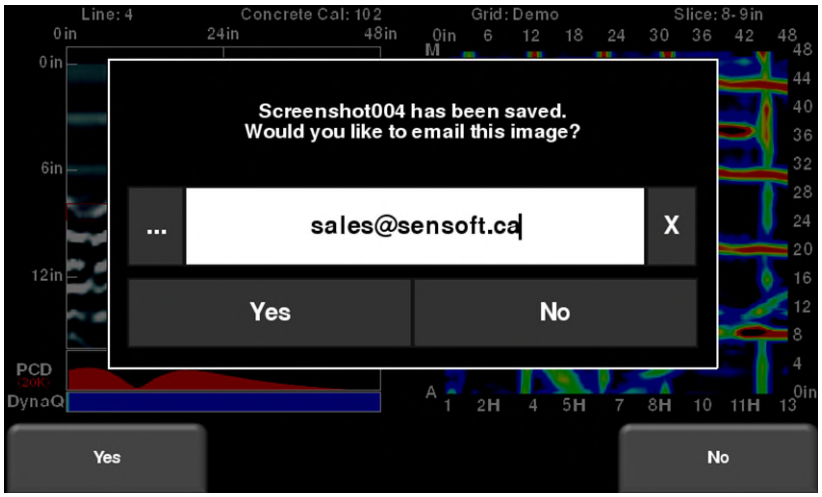
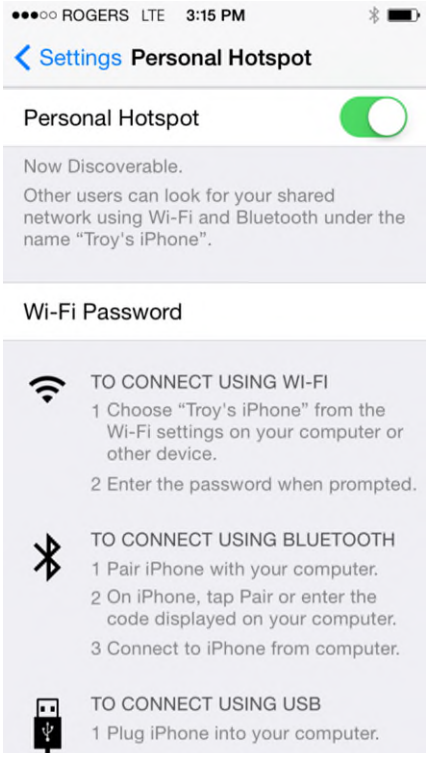


Figure 13-2: Message after pressing the Camera button on the Display Unit to capture the screen with Wi-Fi enabled and a connection to a wireless network. The user can enter an email address to send the mini report to.

13.2. Using the Hotspot on your Smartphone

If a Wi-Fi signal in unavailable, you may be able to use your Smartphone as a Wi-Fi access point, by creating a Personal Hotspot. If you are experiencing difficulty connecting to a cell phone Personal Hotspot, ensure that the phone is in discovery mode while connecting. On iPhone (iOS 9.0), for example, this involves going to **Settings - Personal Hotspot**. Ensure that the Personal Hotspot setting is turned on and wait on this screen until the LMX200 connection has been established. Once you have received confirmation on the Display Unit, the cell phone can resume normal use.



Note that when setting up a Personal Hotspot, you may be disconnected from any Wi-Fi networks. Vice-versa, if you have a Personal Hotspot setup, attempting to connect to a Wi-Fi network may disconnect your personal hotspot.

13.3. Mini Reports

When a screenshot is e-mailed, it is sent as part of a mini report. This mini report also contains a table with information about the collected data including the settings used, date & time (Figure 13-3)

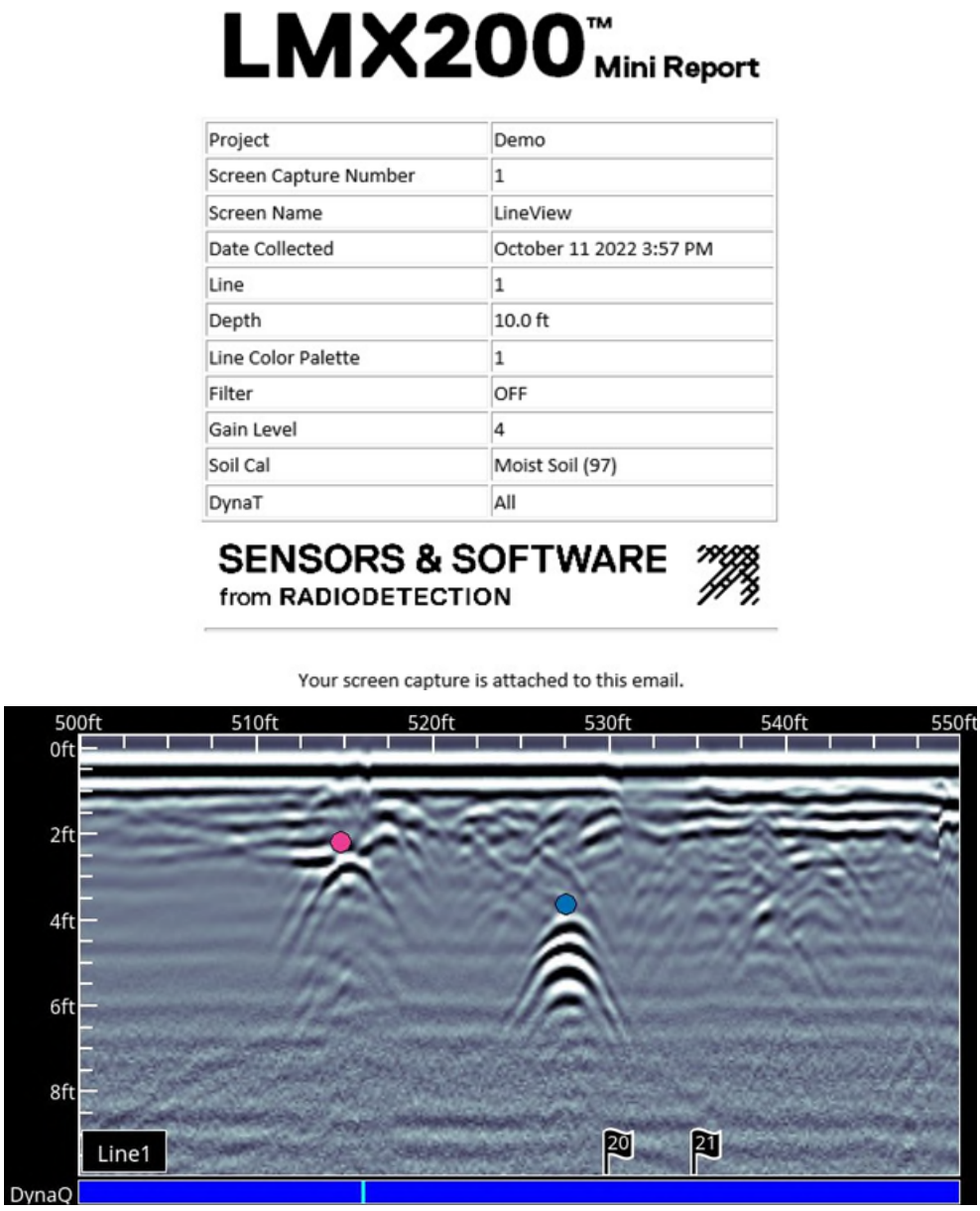


Figure 13-3: Example of a Mini-Report

14. Transferring Data to a PC

Data can be exported to a PC by inserting a USB drive into the USB port (Figure 14-1).



Figure 14-1: Insert a USB memory stick into the USB port on the Display Unit to export data.

Once the USB drive is recognized, a message will appear telling you that a drive has been inserted and if you wish to export your data to it (Figure 14-2). Click **Yes**.

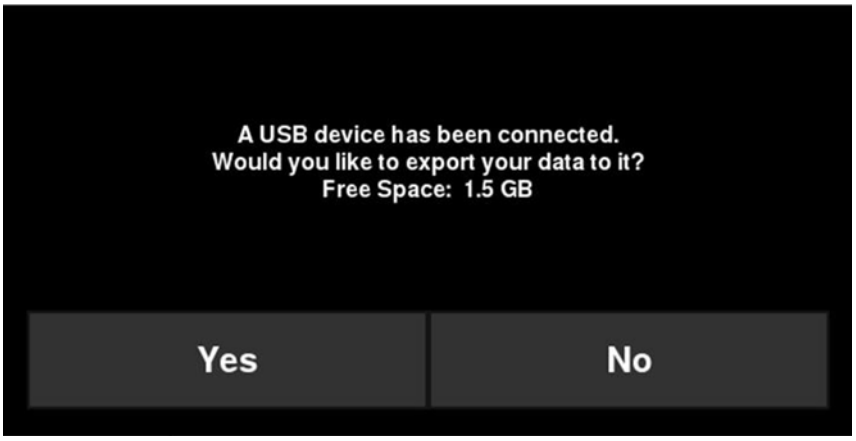


*Figure 14-2: When a USB drive is connected to the Display Unit, a message opens asking if you would like to export all your data to it. Select Yes to transfer immediately. If you select No, you can export the data later by going to the **Setup > File Management** menu option.*

If there are grids that were collected, but not processed (11.3.7), it will alert you after you select **Yes** to exporting the data (Figure 14-3). This is important, as unprocessed grids will not automatically show up in EKKO_Project as depth slices (you will need an additional module to view them) – see Section 15.4.

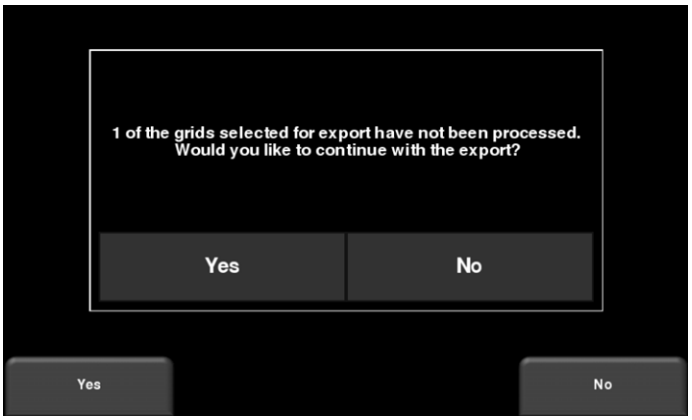


Figure 14-3: Insert a USB memory stick into the USB port on the Display Unit to export data.

Alternatively, if you want to export data from a specific Project, you can select No for the time being. Later on, when you are ready to export your data, from the main menu select **Setup > File Management** and press **Export Data** (Section 4.3.3)

14.1. Formatting USB Sticks for the LMX Display Unit

There may be times when a USB stick is not recognized by the LMX200. In this case, you may need to format the USB stick. Ensure that it's formatted as FAT/FAT32 (NTFS will not work). Also ensure that there are no hidden or write-protected partitions on the USB drive.

If the problem persists after formatting, try another USB stick.

14.2. USB Drive Folder Structure

The directory structure on the USB drive can be viewed on your PC, and will look as follows:

- GPR Data
  - LMX200
    - Export01
      - Project1
        - Screen Shots
          - All Screenshots as .JPG files
        - Project1.GPZ file
        - Project1.KMZ file
        - Project1 Project Summary Report PDF file
        - Project 1 Field Interp Report.CSV
      - Project2
        - Screen Shots
          - All Screenshots as .JPG files
        - Project2.GPZ file
        - Project2.KMZ file
        - Project2 Project Summary Report PDF file
        - Project 2 Field Interp Report.CSV
      - System Info
        - LOG file
        - System Summary PDF Report

- Exportxx
  - Projectx
    - Screen Shots
      - All Screenshots as .JPG files
    - GPZ file
    - KMZ file
    - PDF file
    - CSV file
  - System Info
    - LOG file
    - System Summary PDF Report

Each successive export of data will create a new directory called ExportXX, where XX is incremented by 1 from the previous directory.

If data was collected with GNSS (internal or external), a .KMZ file is also generated. This contains positional information and can easily be opened in Google Earth.

If any Field Interpretations were added during data collection, these are saved in a .CSV file. This is a spreadsheet file, which shows the positional information of any Interps made.

Some of the output files are described and shown below.

15. LMX Output Files

15.1. Google Earth™ KMZ file

Anytime a GNSS (Internal or External) is used with the LMX, a .KMZ file is included as part of the exported data.

15.1.1. Internal GNSS

If the internal GNSS was used, you will only see screenshots and a layout of the grid (if a grid was collected). Clicking on the yellow camera icon in Google Earth will display the screenshot image (Figure 15-1).

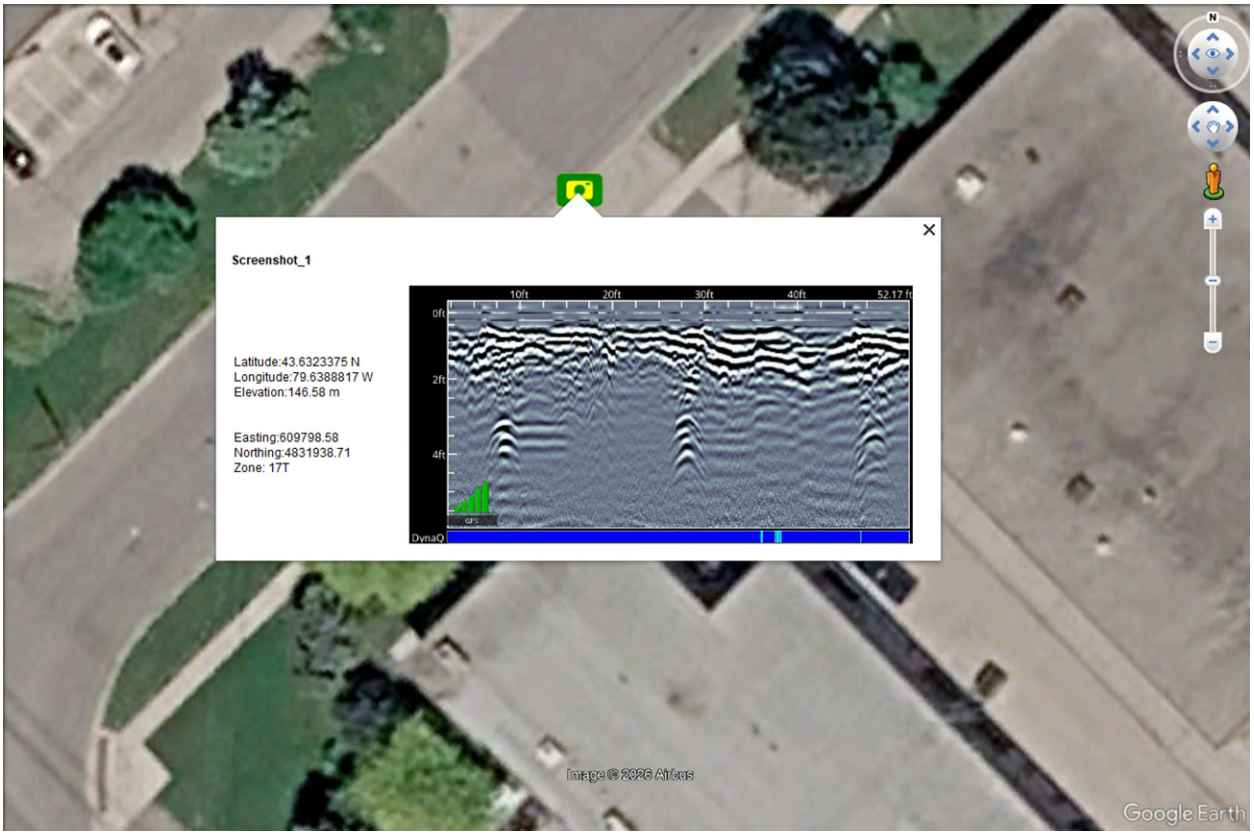


Figure 15-1: Google Earth image, showing the locations of screenshots (Maps Data: Google, Image ©2026 Airbus).

15.1.2. External GNSS

Data collected with an external GNSS shows screenshots and grids but will also show the path walked for any line scan data as well as any Interpretations and flags (Figure 15-2).



Figure 15-2: KMZ file opened in Google Earth displaying the LMX path with Interpretations, collected using an External GNSS (Maps Data: Google, Image ©2026 Airbus)

The attributes of each interpretation are displayed when clicked on (Figure 15-3).

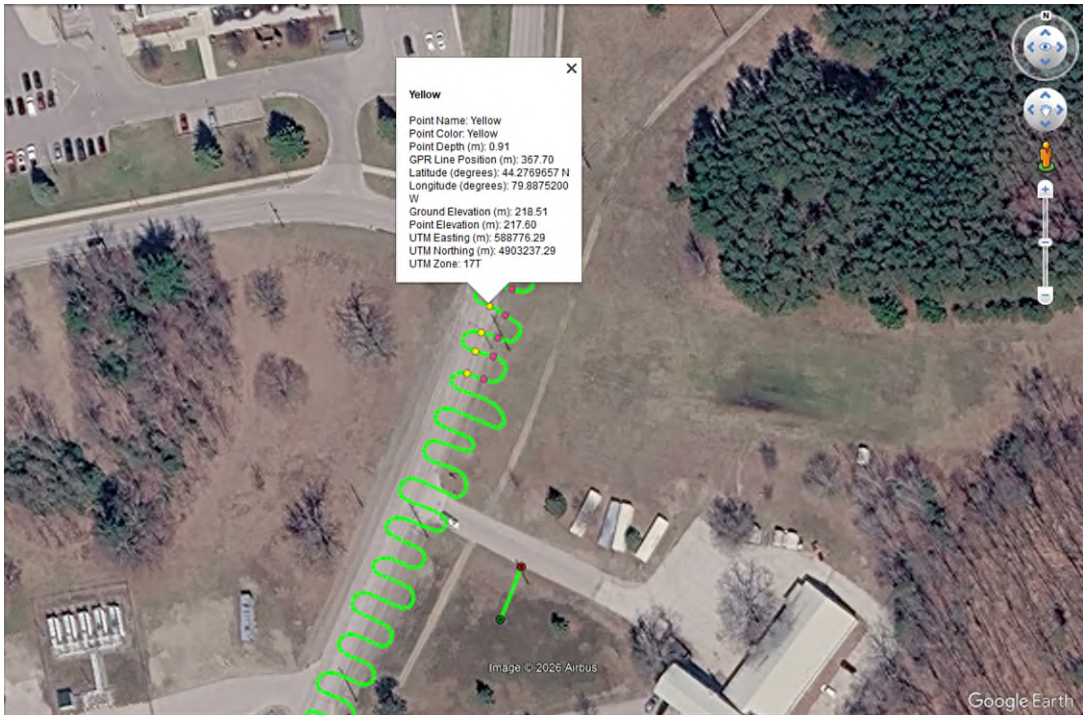


Figure 15-3: KMZ file opened in Google Earth. The attributes of each interpretation are displayed by clicking on them (Maps Data: Google, Image ©2026 Airbus).

Depth slices generated from Line Scans (9.) on the LMX are saved to the KMZ file and are displayed as a layer in Google Earth (Figure 15-4).



Figure 15-4: KMZ file opened in Google Earth displaying depth slices from Line Scans (Maps Data: Google, Image ©2026 Airbus).

For Grids Scans, opening the data in EKKO_Project (Section 15.4) and creating Grid Scan depth slices will allow you to export those slices to Google Earth (Figure 15-5).



Figure 15-5: Grid Scan depth slice displayed in Google Earth after processing in the EKKO_Project software (Maps Data: Google, Image ©2026 Airbus).

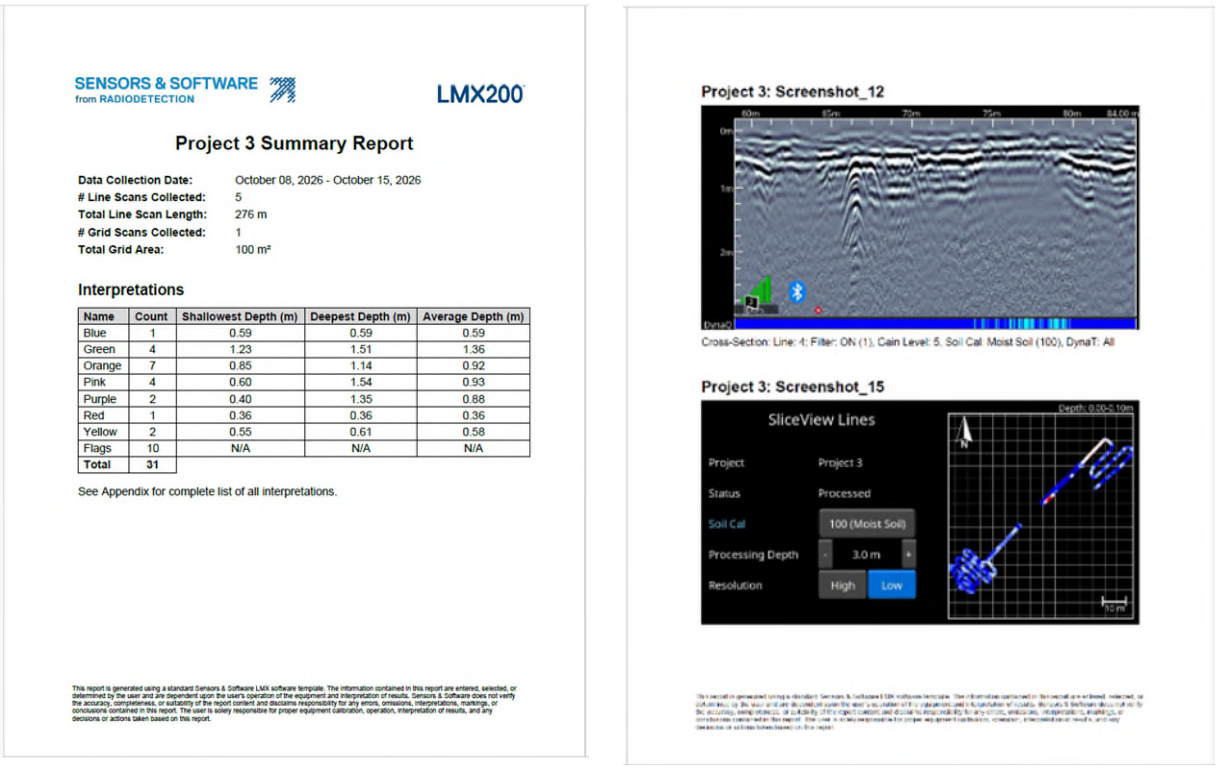
15.2. Project PDF Summary Report

For all LMX projects, a Project Summary Report in PDF format is automatically generated. The report is most useful if screenshots and/or interpretations were added to the data in a project.

The report consists of:

1) Basic information about the data in the project:
    a. Date
    b. Number of Line Scans
    c. Total length of all Line Scans
    d. Number of Grid Scans
    e. Total area of Grid Scans
2) Statistics of the interpretations and flags added to the project:
    a. Number of Interpretations of each color
    b. Shallowest depth of each color of interpretation
    c. Deepest depth of each color of interpretation
    d. Average depth of each color of interpretation.
3) Plots of all screenshots saved in the project
4) Appendix listing details of all interpretations including:
    a. Interpretation color
    b. Line name
    c. Position along the line
    d. Depth
    e. Elevation (corrected for GNSS height and depth of the interpretation)
    f. Latitude
    g. Longitude
    h. GNSS Quality

An example PDF file is shown in Figure 15-6.



SENSORS & SOFTWARE
from RADIODETECTION

LMX200

Project 3 Summary Report

Data Collection Date:	October 08, 2026 - October 15, 2026
# Line Scans Collected:	5
Total Line Scan Length:	276 m
# Grid Scans Collected:	1
Total Grid Area:	100 m²

Interpretations

Name	Count	Shallowest Depth (m)	Deepest Depth (m)	Average Depth (m)
Blue	1	0.59	0.59	0.59
Green	4	1.23	1.51	1.36
Orange	7	0.85	1.14	0.92
Pink	4	0.60	1.54	0.93
Purple	2	0.40	1.35	0.88
Red	1	0.36	0.36	0.36
Yellow	2	0.55	0.61	0.58
Flags	10	N/A	N/A	N/A
Total	**31**			

See Appendix for complete list of all interpretations.

This report is generated using a standard Sensors & Software LMX software template. The information contained in this report are entered, selected, or determined by the user and are dependent upon the user's operation of the equipment and interpretation of results. Sensors & Software does not verify the accuracy, completeness, or suitability of the report content and disclaims responsibility for any errors, omissions, interpretations, markings, or conclusions contained in this report. The user is solely responsible for proper equipment calibration, operation, interpretation of results, and any decisions or actions taken based on this report.

Project 3: Screenshot_12

Cross-Section: Line: 4; Filter: ON (1), Gain Level: 5, Soil Cal: Moist Soil (100), DynaT: All

Project 3: Screenshot_15

This report is generated using a standard Sensors & Software LMX software template. The information contained in this report are entered, selected, or determined by the user and are dependent upon the user's operation of the equipment and interpretation of results. Sensors & Software does not verify the accuracy, completeness, or suitability of the report content and disclaims responsibility for any errors, omissions, interpretations, markings, or conclusions contained in this report. The user is solely responsible for proper equipment calibration, operation, interpretation of results, and any decisions or actions taken based on this report.

Appendix: Interpretation Details

Color	Line	Position (m)	Depth (m)	Elevation (m)	Latitude (degrees)	Longitude (degrees)	GNSS Quality
Green	1	28.61	0.84	145.36	43.6325611	-79.6380093	RTK Float
Green	1	33.82	0.82	145.36	43.6326966	-79.6378692	RTK Float
Green	1	59.47	0.79	144.86	43.6330187	-79.6376592	RTK Float
Green	1	83.28	0.73	145.05	43.6330393	-79.6376275	RTK Float
Pink	1	54.80	0.77	145.01	43.6330095	-79.6376737	RTK Float
Purple	2	98.06	0.59	145.45	43.6326488	-79.6376613	RTK Float
Purple	2	97.51	0.51	145.23	43.6326398	-79.6376743	RTK Float
Red	1	183.36	0.72	145.48	43.6330972	-79.6376720	RTK Float

This report is generated using a standard Sensors & Software LMX software template. The information contained in this report are entered, selected, or determined by the user and are dependent upon the user's operation of the equipment and interpretation of results. Sensors & Software does not verify the accuracy, completeness, or suitability of the report content and disclaims responsibility for any errors, omissions, interpretations, markings, or conclusions contained in this report. The user is solely responsible for proper equipment calibration, operation, interpretation of results, and any decisions or actions taken based on this report.

Figure 15-6: Example LMX Project PDF Report.

15.3. Field Interpretations CSV file

If any interpretations are made a Field Interp Report file is created. This file is a CSV (Comma separated values) format, most commonly opened with Microsoft® Excel®.
The file will list any Interps and Flags added to data in the field. The position, depth and colour of each Interp is listed, along with GNSS positions (if a GNSS was connected). A sample output for this file is shown in Figure 15-7.

Name	Count											
Pink	6											
Yellow	6											
Tool	Interpretation	GPR Line	GPR Line Position (m)	Point Depth (m)	Point Elevation (m)	Soil Cal	UTM Easting (17T) (m)	UTM Northing (17T) (m)	Latitude (deg)	Longitude (deg)	GNSS Elevation (m)	Ground Elevation (m)
Point	Pink	Lineset/line1	1.14	0.82	147.07	Moist Soil (100)	609805.38	4831939.15	43.632341	-79.6387973	148.67	147.89
Point	Pink	Lineset/line1	12.91	0.85	147.03	Moist Soil (100)	609804.23	4831938.02	43.63233	-79.6388117	148.66	147.88
Point	Pink	Lineset/line1	17.44	0.89	146.98	Moist Soil (100)	609802.87	4831936.68	43.632319	-79.6388288	148.65	147.87
Point	Pink	Lineset/line1	29.96	1.03	146.91	Moist Soil (100)	609801.39	4831935.3	43.632306	-79.6388475	148.72	147.94
Point	Pink	Lineset/line1	33.25	1	146.98	Moist Soil (100)	609799.78	4831933.78	43.632293	-79.6388678	148.76	147.98
Point	Pink	Lineset/line1	46.04	0.9	147.07	Moist Soil (100)	609798.49	4831932.41	43.632281	-79.638884	148.75	147.97
Point	Yellow	Lineset/line1	5.08	0.61	147.14	Moist Soil (100)	609802.35	4831941.69	43.632364	-79.6388342	148.53	147.75
Point	Yellow	Lineset/line1	9.05	0.63	147.18	Moist Soil (100)	609801.46	4831940.62	43.632354	-79.6388456	148.59	147.81
Point	Yellow	Lineset/line1	21.14	0.59	147.19	Moist Soil (100)	609800.14	4831939.16	43.632341	-79.6388622	148.56	147.78
Point	Yellow	Lineset/line1	26.28	0.59	147.25	Moist Soil (100)	609798.78	4831937.86	43.63233	-79.6388794	148.62	147.84
Point	Yellow	Lineset/line1	36.98	0.61	147.24	Moist Soil (100)	609797.21	4831936.33	43.632316	-79.6388991	148.63	147.85
Point	Yellow	Lineset/line1	42.34	0.57	147.33	Moist Soil (100)	609795.86	4831934.94	43.632304	-79.6389161	148.68	147.9

Figure 15-7: Contents of a sample Field Interp Report file

15.4. GPZ file for EKKO_Project Software

Any line and grid data collected in a project are saved as a single .GPZ file (e.g. Project1.GPZ). This file can be opened with the EKKO_Project PC software.
EKKO_Project is powerful software that allows you to view, edit, process and ultimately create reports from your GPR data. Grid data that is processed in the field will immediately show up as depth slices in EKKO_Project, as well as the path travelled in MapView.
From the main screen (Figure 15-8), you can access various views and launch modules that give you access to further functionality. Some features shown here are not part of the standard EKKO_Project base software. For more information, consult your EKKO_Project manual or contact Sensors & Software.

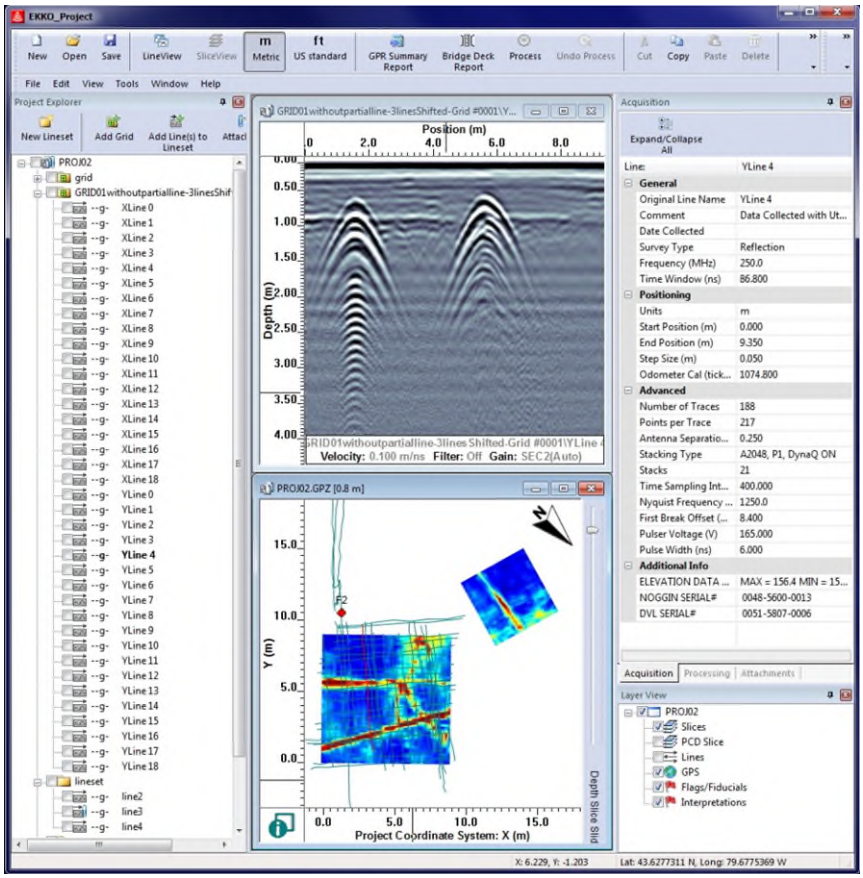


Figure 15-8: Main screen of EKKO_Project

15.5. System Summary PDF Report

The System Info folder contains a System Summary diagnostic report. The System Summary report is a PDF file, which lists system usage information, serial numbers and when system tests were done and their pass/fail status. An example file is shown below:

LMX200™

System Usage Summary

April 18 2019

Usage Statistics

Data Exports	2
Grids Collected	4
Average Grid Area	12.5 m² / 134.5 ft²
Average Grid Collection Time	1 minutes 52 seconds
Total Grid Area	50.0 m² / 538.2 ft²
Total Grid Line Distance	140.0 m / 459.3 ft
Lines Collected	46
Average Line Length	251.2 m / 824.3 ft
Average Line Collection Time	3 minutes 36 seconds
Total Line Collected	11557.1 m / 37917.2 ft
Screenshots Saved	30
Wi-Fi Reports Sent	19
System Power Cycles	35
Operation Time	10 hours
Total Distance Collected	11697.1 m / 38376.5 ft

System Information

Display Unit (DVL) Serial Number	0070-7906-0001
GPR Sensor Serial Number	0077-7547-0024
Application Version	v1.7.796 (2015-00154-06)
OS Version	2.08.512 (2017-00041-08)
GPR Firmware Version	2.004 (2013-00001-01)
Hardware ID	001EC0AF2D9B
Licenses	Enhanced

System Tests

Odometer Test	18 April 2019	Passed - 1101.0 t/m
GNSS Test	18 April 2019	Passed - External
Keypad Test	18 April 2019	Passed
Audio Test	18 April 2019	Passed
Touch Screen Test	18 April 2019	Passed
GPR Sensor Test	18 April 2019	Passed

15.6. LOG File

The System Info folder contains an APP.LOG file which contains important information about system operation and may be requested by Sensors & Software to help troubleshoot any issues.

16. Troubleshooting

The LMX200 is designed for reliable operation, but faults can occur in any electronic device. Performing the System Tests may help identify the component causing the problem. If the system does not operate as expected, please refer to the troubleshooting guidance below.

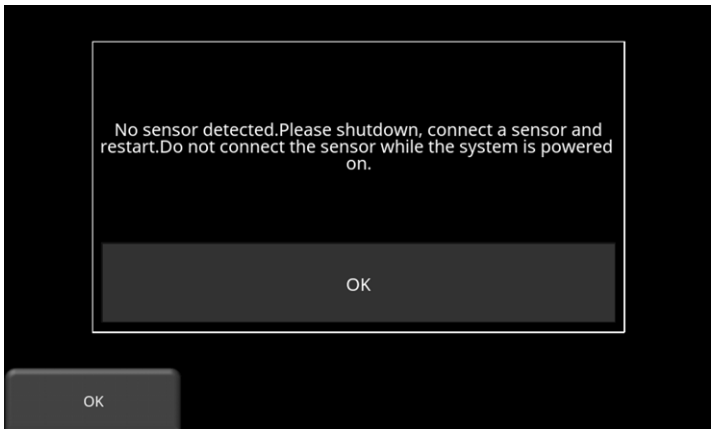
16.1. Screen turns White After Powering Up

If the Display Unit screen turns completely white after powering up the system, the battery does not have enough voltage to completely power the system. Recharge or replace the battery

16.2. LMX Does Not Power Up or Sensor Not Detected

If you have connected the cables to the LMX Sensor, Display Unit, and the battery, pressed the **Power** button on the Display Unit and:

• The Display Unit does not power up, or
• The LMX Sensor is not detected, and you get the following messages:

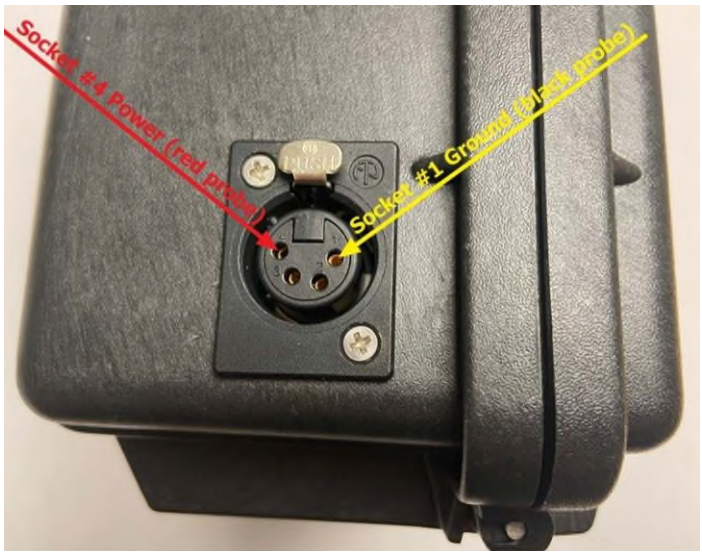




1) Wait at least 1 minute and see if the Display Unit starts up. Sometimes the Power LED on the Display Unit fails but the Display Unit is otherwise OK. If the application starts but the LED on the Display Unit does not turn on, test the operation of the LED using the **System Test > Keypad** test under **Tools** (Section 4.2.2).

16.2.1. Test the Battery

- Check that the fuse inside the battery case, has not blown. If so, replace the 10 Amp fuse with one of the spare fuses inside the battery case.
- Use a multimeter with fine tipped probes (1mm or 0.04 inches) to measure the battery voltage at the connector on the outside of the battery case. Measure the voltage between socket #1 (ground, using the black probe) and socket #4 (power, using the red probe). If the voltage is less than 10.5 volts, there is a problem with the battery.



16.2.2. Test the Power Cable

Insert the power cable into the battery and test the power cable. Use a multimeter to measure the battery voltage at the connector at the end of the power cable. Measure the voltage between socket #1 (ground, using the black probe) and socket #4 (power, using the red probe). If the voltage is less than 10.5 volts, there is a problem with the power cable.



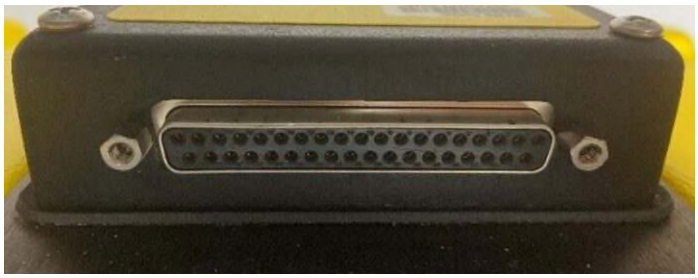
16.2.3. Check the LMX Sensor and Display Unit Connectors

Turn off the LMX system and disconnect the battery before disconnecting the cable that connects the Display Unit to the LMX Sensor.

a) On the back of the Display Unit, check that none of the 37 pins are missing, bent, or recessed. Look at the pins on an angle to confirm they are all flush with one another. If one is bent or recessed, gently bend the pin back straight and flush with the other pins. Then reconnect the cable and try powering the LMX system again.



b) Check all 37 sockets at the LMX connector, ensuring that none are blocked with debris. If so, clean out the debris, reconnect the cable and try powering the system again.



16.2.4. Replace the Cable

If you have a spare cable, replace the current cable. If the system does not power on or if the LMX Sensor is not detected with either cable, please contact your GPR supplier for further assistance.

16.2.5. Test the Cable

a) On the end of the cable that connects to the LMX Sensor, check that none of the 37 pins are missing, bent, or recessed. Look at the pins on an angle to confirm they are all flush with one another. If one is bent or recessed, gently bend the pin back straight and flush with the other pins. Connect the cable to the LMX Sensor and try powering the LMX system again.

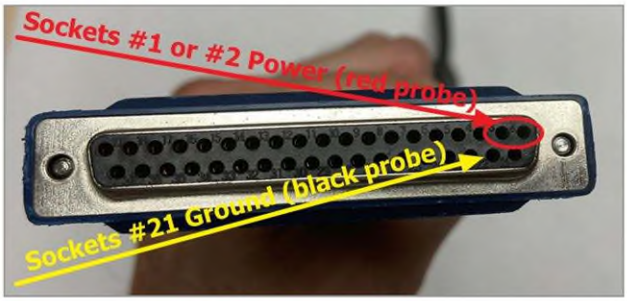


b) Disconnect the end of the cable that connects to the back of the Display Unit.

c) Check all 37 sockets at the end of the cable, ensuring that none are blocked with debris. If so, clean out the debris, reconnect the cable and try powering the Display Unit again.



d) With the cable connected to the LMX Sensor and the battery connected to the system, check the power from the battery is reaching the Display Unit through the cable by using a multimeter to measure the voltage between socket #21 (ground, using the black probe) and sockets #1 or #2 (power, using the red probe) on the end of the cable. If the voltage is zero, there may be a problem with the cable. If the voltage is at least 10.5 volts, the problem may be the Display Unit. Please contact your GPR supplier for further assistance.





16.3. System Communications

If the battery is OK and the Display Unit turns on, but the GPR sensor does not scan, there may be a communication failure between the Display Unit and the GPR sensor. If an error occurs, an error message will appear. Power Off the system and disconnect the battery.

Make sure the display cable is not damaged, all pins are straight, and there is no dirt or debris in the connector. Ensure that the cable connections are tightly secured. Sometimes vibrations cause the cable connections to slightly loosen and break contact leading to errors. Disconnecting the cable and reconnecting it may provide a better contact and solve the problem. Plug in the battery, turn on the system and try scanning again.

If the Battery, Battery Cable and Display Cable are OK, the problem is either a failure of the Display Unit or the GPR sensor. These units have no user-serviceable parts so they will have to be returned to the vendor for inspection and repair.

16.4. System Overheating

The GPR system is designed to operate to a maximum *internal* temperature of 70°C or 158°F. In situations of high ambient temperatures or long exposure to direct sun, this maximum internal temperature may be exceeded and cause the system to fail.

If you suspect that the GPR sensor is overheating, shut it off and give it a chance to cool down in a shady location before trying to run it again.

If the situation is such that the high temperatures or direct sun cannot be avoided, it may be a good idea to put some sort of shade over the GPR sensor.

16.5. Display Unit Problem

If the Display Unit does not power up, check the battery power and all cable connections. If that doesn't work, contact the manufacturer.

16.6. Loose Wheels

If, over time, a wheel becomes loose, the wheel nut will need to be manually tightened.

For the rear right wheel only (which is connected to the direct drive odometer), insert a large, slotted screwdriver into the end of the axle (there's already a slot there for it) and use a large wrench to slightly tighten the wheel nut. The nut only has to be turned slightly, 1/8th -1/16th of a turn is usually enough. Spin the wheel to make sure it's still free and not too tight.

16.7. Creating a Test Line for Data Quality

After receiving the system and getting comfortable with its operation, the recommended way of detecting any problems is to collect a line of data at a convenient, easily accessible location. The line does not have to be too long, but one screen is a good guide. This data line should be saved electronically and perhaps plotted out on paper and dated. If there is a suspected problem with the system, this test line could be collected and compared with earlier tests. When comparing data, take into account weather and environmental conditions, which could skew the comparisons slightly.

16.8. Contacting the Vendor for Service

When returning the system to the Vendor, have the following information available:

1) GPR sensor Serial Number displayed at the top of the **System Settings Screen (4.2.1)**.
2) A brief description of when the error is happening and the operating conditions (temperature, humidity, sunshine, system settings, etc.).
3) Include photos and/or videos to document the occurrence of error messages.
3) APP.LOG file – this is downloaded to your computer during data export (15.6).

17. Care & Maintenance

17.1. Battery Care

The LMX200 uses a 9-Amp-hour, 12-Volt sealed lead acid battery. It is fused with a 10 Amp fuse to protect it from short circuit damage.

The battery unit should run the LMX200 continuously for 6 hours before recharging is necessary. If long days of data surveying are typical, a second battery unit may be useful.

The battery is strapped onto the cart base and is normally recharged without removing it from the cart. However, the battery can be easily removed for maintenance or for recharging, if required.

If batteries are maintained in a charged condition, they will give long life and reliable service. Improper use and lack of maintenance will greatly reduce their life.

Sealed lead acid batteries should **NEVER** be left in a discharged condition for any period of time. Charge the batteries as soon as possible after use.

Charge the battery at room temperature whenever possible.

The LMX200 has a voltage monitoring circuit that will turn off the unit when the input voltage drops below 10.5 volts.

If a battery has been deeply discharged or left in a discharged condition for some period of time it may not accept charge immediately when it is connected to the charger (the fast charge light will not illuminate). If the fast charge light does not come on within 6 hours the battery should be considered damaged and should be discarded.

Do not assume that a battery that is still charging after 8 hours is nearing the end of its charge cycle. Typical charging time for an empty battery is 12-14 hours from the start of fast charge.

Ensure that the batteries are fully charged before storing. If practical, store the batteries in a cool place, 10°C, but make sure the temperature is not likely to drop below -30°C or the electrolyte may freeze and possibly split the case.

17.2. Cable Care

With the use of this product in rough, dusty and outdoor environments, users can minimize potential downtime if they care for cables and treat connectors with respect.

1) The cable connectors as well as the connectors on the GPR Sensor and Display Unit need to stay clean and free of dust and moisture. Use a brush or air spray to clean dust, lint and other foreign particles from these connectors.
2) The power and odometer receptacles on the top of the LMX200 are watertight, but do not allow water to get into the receptacle by connecting the battery and odometer cables in the rain
3) After working in rainy conditions, disconnect the cables and check for water in the receptacles. Remove the water or allow to air dry, if necessary. Never allow the system to sit in rainy conditions for long periods of time.
4) When the system is not being used, make sure the connections are protected to prevent dust and moisture from collecting inside. If the connectors are exposed, cover them with some sort of dust cap.
5) Cables and connectors are not designed to suspend or tow or otherwise carry the weight of systems. They are part of the electronic circuit and should be treated accordingly. When not in use they should be placed in their storage box.

17.3. Skid Pads

The bottom of the GPR Sensor is covered with one large wear-resistant skid pad. The skid pad is designed to take the majority of the abrasive wear. If the pad wears down enough, the less-resistant plastic housing may start to wear. If this occurs, it is recommended the skid pad be replaced. It is easily removed with a screwdriver, and a new one can be purchased from the vendor.

17.4. Odometer

The odometer should be periodically calibrated over a known distance (refer to Section 4.4.6) to ensure accuracy.

17.5. Storage Cases

Equipment that is transported and stored loosely is more susceptible to damage. All equipment should be stored in its shipping case or a storage box. Sensors & Software has optional shipping cases available for all LMX200 systems.

17.6. Upgrading Embedded Software on Display Unit

From time to time, Sensors & Software may release new software for the Display Unit on our website here: https://www.sensoft.ca/gpr-user/gpr-system-software/. The instructions below describe how to update this software. Please note that this procedure will **erase all GPR data** from the system, so export any valuable data before continuing.

1 Download

the zip file provided by Sensors & Software into a folder on your PC.

2 Insert

a clean USB stick into your PC.

3 Unzip

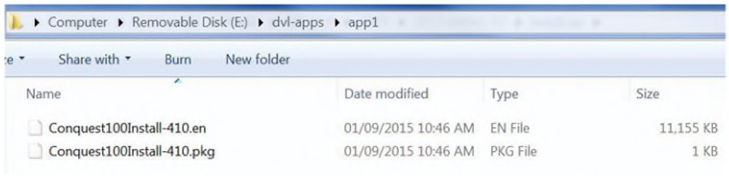
the file by double clicking the file in Windows Explorer.

4 Copy

the unzipped folder to the root of the USB key. The resulting folder structure on the USB key should be:

dvl-apps
app1
PACKAGE_NAME.en
PACKAGE_NAME.pkg

where PACKAGE_NAME is the name of the item to be installed.
An example of the Conquest 100 installation files are shown below:



5 Turn off

the Display Unit. Remove the USB stick from your PC and insert it into the USB port on the side of the Display Unit.



6 Turn On

the Display Unit. You will see a list on the screen showing all software installations. The USB key may hold one or more packages which are displayed as numbered items:

Select app to run:
1. PACKAGE_NAME

7 Select

the package to run by pressing the associated numbered key on the Display Unit. The selected software will now be installed. The process may require multiple reboot cycles initiated by the system. When complete, the system will shut down, and the red light on the front of the Display Unit will turn off.

8 Remove

the USB stick from the Display Unit.

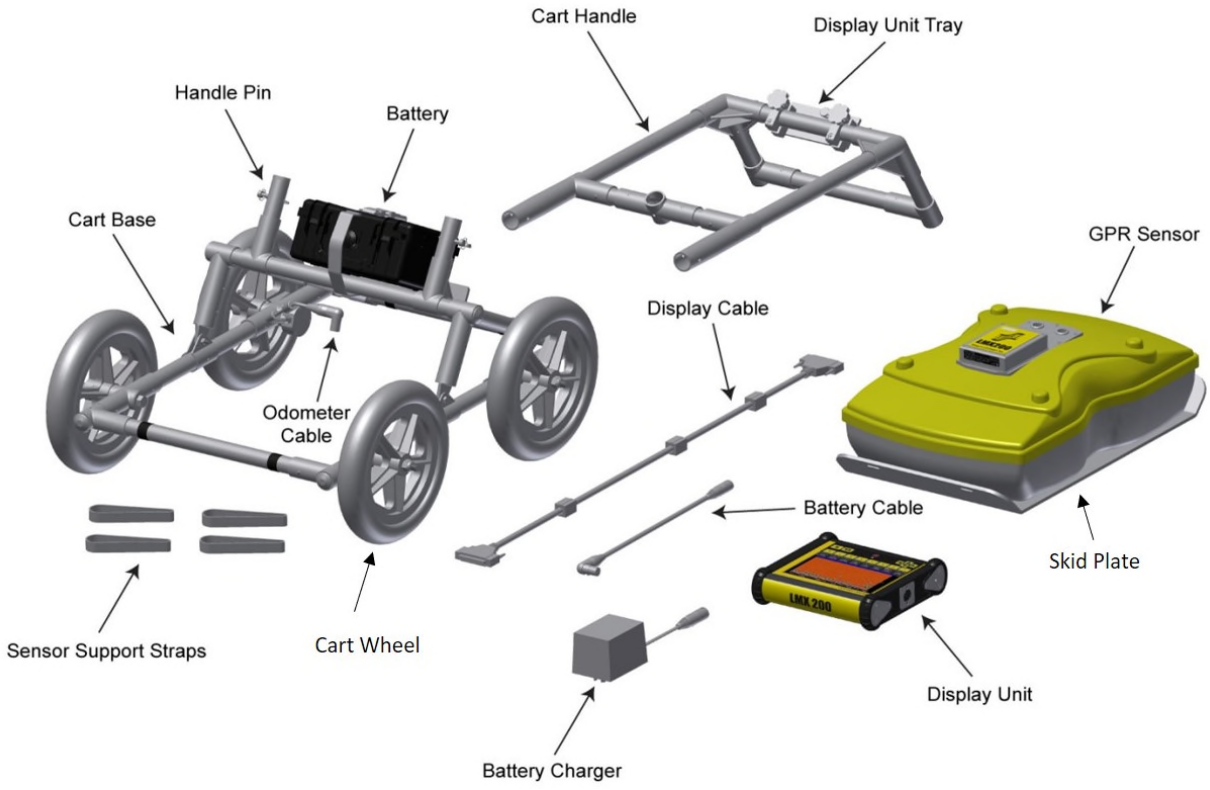
9 Turn On

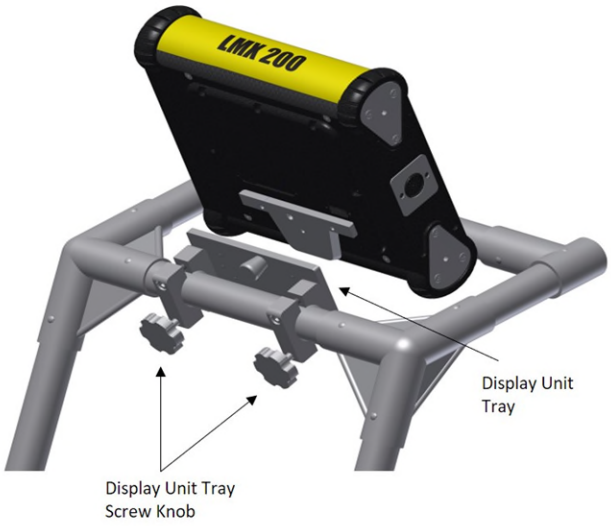
the Display Unit and access the System Info screen to verify the newly installed version number.

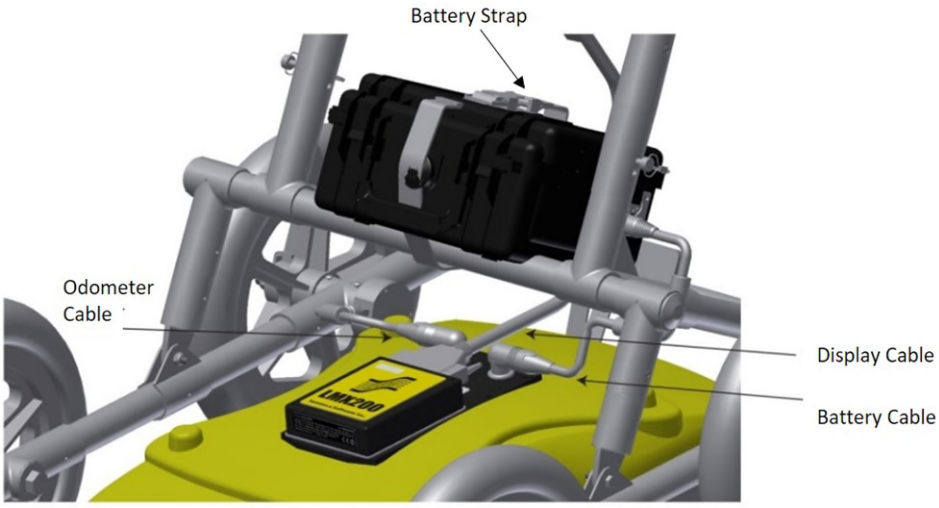
17.7. Spare Parts

The following is a list of spare parts available for purchase, with labelled diagram below that:

100-22-0126	Display Unit
100-53-0098	Display Unit Tray
100-52-0108	Display Cable
100-55-0023	Battery with Case
126-77-2010	Battery Cable
100-55-0028	Battery Charger
100-22-0084	GPR Sensor
126-77-1450	Skid Plate
126-85-0670	Cart Handle
126-81-1600	Cart Base
122-10-2377	Cart Wheel
100-54-0154	LMX Spare Parts Kit consisting of: • Safety Locking Pins (1) • Display Unit Tray Knob & Screw (1) • Sensor Support Straps (4) • Standoff hex (2) • Sensor to Display Unit cable jack screws (2)







17.8. Accessories

To see the latest list of LMX200 accessories go to
https://www.sensoft.ca/products/lmx200/accessories/

18. Technical Specifications

The LMX200 technical specifications are available at
https://www.sensoft.ca/products/lmx200/specification/

Appendix A: Regulatory & Compliance

General

This product is a Ground Penetrating Radar (GPR) system with ultra-wideband (UWB) RF emissions and integrated Wi-Fi connectivity. It has been tested by independent accredited laboratories and found to comply with applicable radio, EMC and RF-exposure regulations in the USA, Canada, the European Union and other major jurisdictions. Where national rules impose additional licensing or operating restrictions on GPR/UWB devices, those requirements remain the responsibility of the end user to observe.

No user serviceable RF or safety-critical parts are contained inside the product. Modifications to the RF hardware, antennas, cabling or enclosure are not permitted and may invalidate approvals and the user's authority to operate the equipment.

United States – FCC

FCC Part 15 statement (GPR and DVL/Wi-Fi)

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.[2]

This equipment has been tested and found to comply with the limits for a Class A digital device, and, where applicable, for an ultra-wideband (UWB) device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio-frequency energy and, if not installed and used in accordance with this manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

WARNING: Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment. This equipment was certified using approved cables and peripheral devices; the use of non-approved or modified cables and peripherals is considered a change or modification under this warning.

The FCC IDs for Sensors & Software GPR products are listed on our website:
https://www.sensoft.ca/resources/regulatory-documents/

FCC operating restrictions for UWB GPR

Operation of this device is limited to purposes associated with law enforcement, firefighting, emergency rescue, scientific research, commercial mining or construction. Parties operating this equipment must be eligible for licensing under the provisions of FCC Part 90. In line with FCC DA 02-1658, "construction companies" is interpreted broadly and includes inspection of buildings, roadways, bridges and runways, even when construction work is ultimately not required, provided the purpose of operation is to determine whether construction or repair is necessary.

The device may be operated by contractors or other third parties acting on behalf of eligible entities, provided the operation is for one of the permitted purposes above. Use of the GPR as a through-the-air or through-the-wall imaging device is prohibited in this configuration: the GPR antenna must remain in contact with, or immediately adjacent to, the surface being surveyed.

FCC UWB coordination requirements (47 CFR 15.525)

UWB imaging systems require prior coordination through the FCC before the equipment may be used. The operator must comply with any constraints on equipment usage resulting from this coordination. Users of UWB imaging devices must provide the FCC Office of Engineering and Technology (OET) with:

- User name, address and contact details
- Desired geographical areas of operation (counties, states or specific locations)
- FCC ID and model identification of the UWB device.

This information should be submitted to the FCC OET Frequency Coordination Branch, which will coordinate with NTIA as required. Once coordination has been completed for the declared areas of operation, no further FCC coordination is required unless the area of operation changes.

RF exposure – FCC/OSHA

All Sensors Software / Radiodetection GPR products are normally operated at least 1 m from the user and are classified as “mobile devices” according to FCC definitions. Typical plane-wave equivalent power density at a distance of 1 m or more from the equipment is less than 10^{-3} mW/cm², which is 200 to 10 000 times lower than the most restrictive FCC and OSHA maximum permissible exposure limits in the 30–300 MHz band. When used as instructed, the product is not expected to present a health or safety risk due to RF exposure.

Canada – ISED (Industry Canada)

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada’s license-exempt RSS standards. Operation is subject to the following two conditions:

1. This device may not cause interference; and
2. This device must accept any interference, including interference that may cause undesired operation of the device.

The ISED/Industry Canada IDs for Sensors & Software GPR products are listed on our website: https://www.sensoft.ca/resources/regulatory-documents/

GPR/UWB conditions of use (RSS-220) - English

Ground Penetrating Radar devices under RSS-220 are license-exempt but subject to specific operating conditions.

- This Ground Penetrating Radar device shall be operated only when in contact with, or within 1 m of, the ground.

- This Ground Penetrating Radar device shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.

If the device is operated in a wall-penetrating radar imaging mode:

- The device shall be directed at the wall and in contact with, or within 20 cm of, the wall surface.
- It shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.

Because operation is on a license-exempt basis, users must accept any interference, including interference that may cause undesired operation of the device.

Règlement d'Industrie Canada - Français

Industrie Canada a publié des règlements pour les appareils géoradar (GPR) le 29 mars 2009, dans le cadre du RSS-220 intitulé "Dispositifs utilisant la bande ultra-large (UWB)".

Industrie Canada a faite une exception unique pour GPR en n'exigeant pas de licence par utilisateur. L'utilisateur doit se conformer aux directives suivantes:

Ce géoradar périphérique doit être utilisé que lorsqu'il est en contact avec ou moins de 1 m du sol.

Ce géoradar périphérique doit être utilisé que par les organisations d'application de la loi, les instituts de recherche scientifique, des sociétés minières commerciales, entreprises de construction et de secours d'urgence ou des organisations de lutte contre les incendies.

Si le géoradar est utilisé dans un mode de pénétration au mur, la restriction suivante est à noter par l'utilisateur:

Ce dispositif d'imagerie radar doit être utilisé lorsque l'appareil est orienté vers le mur et en contact avec ou dans les 20 cm de la surface du mur.

Ce dispositif d'imagerie radar doit être utilisé que par les organisations d'application de la loi, les instituts de recherche scientifique, des sociétés minières commerciales, entreprises de construction et de secours d'urgence ou des organisations de lutte contre les incendies.

Parce que l'exploitation de GPR est sur une base exempte de licence, l'utilisateur doit accepter le texte suivant:

La fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne peut pas provoquer d'interférences et (2) cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositive

European Union – Radio Equipment Directive (RED)

This equipment is intended for professional use as a Ground Penetrating Radar (GPR) / UWB imaging system and associated digital video logger. It is designed to comply with the essential requirements of Directive 2014/53/EU (Radio Equipment Directive – RED):

- Article 3(1)(a): Health and safety of the user and any other person, including the objectives of the Low Voltage Directive but with no voltage limit

- Article 3(1)(b): Electromagnetic compatibility
- Article 3(2): Effective and efficient use of the radio spectrum so as to avoid harmful interference.

A Declaration of Conformity (DofC) for each GPR Sensors & Software GPR system is listed on our website: https://www.sensoft.ca/resources/regulatory-documents/ and can be obtained by contacting Sensors & Software.

This equipment bears the CE marking to indicate conformity with Directive 2014/53/EU. National regulations may still require frequency-management coordination or licenses for GPR use; users must ensure they have any necessary authorizations before operating the system.

United Kingdom – UKCA and UK radio regulations

For the UK market, this product is designed to meet the equivalent essential requirements of the UK Radio Equipment Regulations 2017 (as amended), which implement RED-derived provisions into UK law. The same technical standards as applied under RED are used as the basis for UK conformity assessment.

The equipment bears the UKCA marking when placed on the market in Great Britain, together with the name and address of the UK importer where required. A UK Declaration of Conformity (UK DoC), listing the applicable UK-designated standards and regulations, is available from the manufacturer or UK representative at the address provided on the product label or packaging.

Use of GPR/UWB equipment in the UK is subject to additional Ofcom licensing or coordination conditions. Users must ensure that operation is in accordance with current Ofcom rules for GPR and UWB devices, including any restrictions on user categories, frequency bands, maximum power and deployment scenarios.

Wi-Fi module notices (FCC / ISED)

The digital video logger (DVL) incorporates an embedded Wi-Fi radio module. For this module, the following statements apply in addition to the GPR-specific notices above.

FCC Notice – Wi-Fi module (Class A)
This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio-frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

Industry Canada Notice – Wi-Fi module
This device complies with ISED's license-exempt RSS standards. Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Appendix B: Calibration

This Ground Penetrating Radar (GPR) system has been manufactured according to Sensors & Software's quality control procedures. All components used in the manufacture of this product are obtained from qualified vendors.

This product has been through production tests to ensure quality requirements are met which includes final system calibration and configuration.

This system is equipped with built-in diagnostic tests. By running the tests and getting a passing result, you can be confident that the system is operating within specification.

The odometer in these systems is factory-calibrated and should be periodically calibrated to maintain positional accuracy on different terrain. See section 4.2.6 for details.

There are no other prescribed calibrations or recalibrations necessary for the ongoing effective operation of the GPR.

SENSORS & SOFTWARE
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