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from RADIODETECTION

EKKO_Project™ LineView & Interpretation Modules

Ground Penetrating Radar Software

User Guide

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EKKO_Project™ LineView & Interpretation Modules are included in the following bundles:

- EKKO_Project™ Examine
- EKKO_Project™ Reveal
- EKKO_Project™ 3D Reveal
- EKKO_Project™ Suite
- EKKO_Project™ 3D Suite

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1 Introduction

Ground Penetrating Radar (GPR) data are collected as two dimensional cross-sections of the subsurface. LineView is part of the EKKO_Project software package and is designed to plot cross-sectional GPR lines on a PC.

LineView features:

1) Display GPR lines in a variety of color palettes or as wiggle traces (or both).
2) Display GPR lines with tens to hundreds of thousands of traces.
3) Optimize the GPR line by adjusting the color palette Contrast and Sensitivity.
4) Apply Default, Auto or User Gains to the data.
5) Display multiple GPR lines at once.
6) Plot GPR lines with customizable position, time and depth axes and grid lines.
7) Apply same Gain and View Settings to all open GPR lines at once.
8) Plot GPR lines corrected for topography (if elevations integrated).
9) Zoom in/out and pan around GPR lines images.
10) Save GPR lines to graphics image files like BMP, JPG and TIF.
11) Save GPR lines to the clipboard and paste into reports.
12) Use cursor to display individual raw data traces, processed traces and the current Gain.
13) Simultaneous scrolling of linked GPR lines.
14) Use Hyperbola-fitting to extract velocity information from the GPR line.
15) Use Hyperbola-fitting to extract velocities from CMP (Common Mid Point) data.
16) Plot the depth axis based on an average velocity value.
17) Quickly change units from meters to feet or feet to meters.
18) Reverse the GPR line direction to easily compare lines collected in a zig-zag pattern.
19) Use the mouse cursor to determine the position, depth and signal amplitude of any point in the data image.
20) For data integrated with GPS, use the mouse cursor to determine the GPS position of any point on the GPR line.

21) For data integrated with GPS, right-click anywhere on the GPR line and Google Earth™ is launched (if installed) and "flies" to the global location of the mouse cursor.

22) Use the F8 hotkey to save the position, depth, signal amplitude, GPS, etc. at the mouse cursor to the Clipboard and Paste into other documents.

23) Display GPR lines with a legend with customizable GPR survey and processing parameters.

24) LineView retains the display settings from the last time that GPR line was plotted.

The LineView software also has the optional Interpretation add-on module (see Software Registration in the EKKO_Project User's Guide), that allows the user to draw interpretations onto GPR lines.

Interpretation module features:

1) Draw different types of interpretations onto the data image including points, polylines, boxes and annotations.

2) Interpretations can span multiple GPR lines.

3) Print the GPR lines with or without interpretations.

4) Extract quantitative interpretation information to the Interpretation Report accessed from EKKO_Project.

2 Quick Start

2.1 Using LineView

When LineView is called from the EKKO_Project program (see the EKKO_Project User's Guide), the main screen displays a project of one or more GPR lines in separate windows.

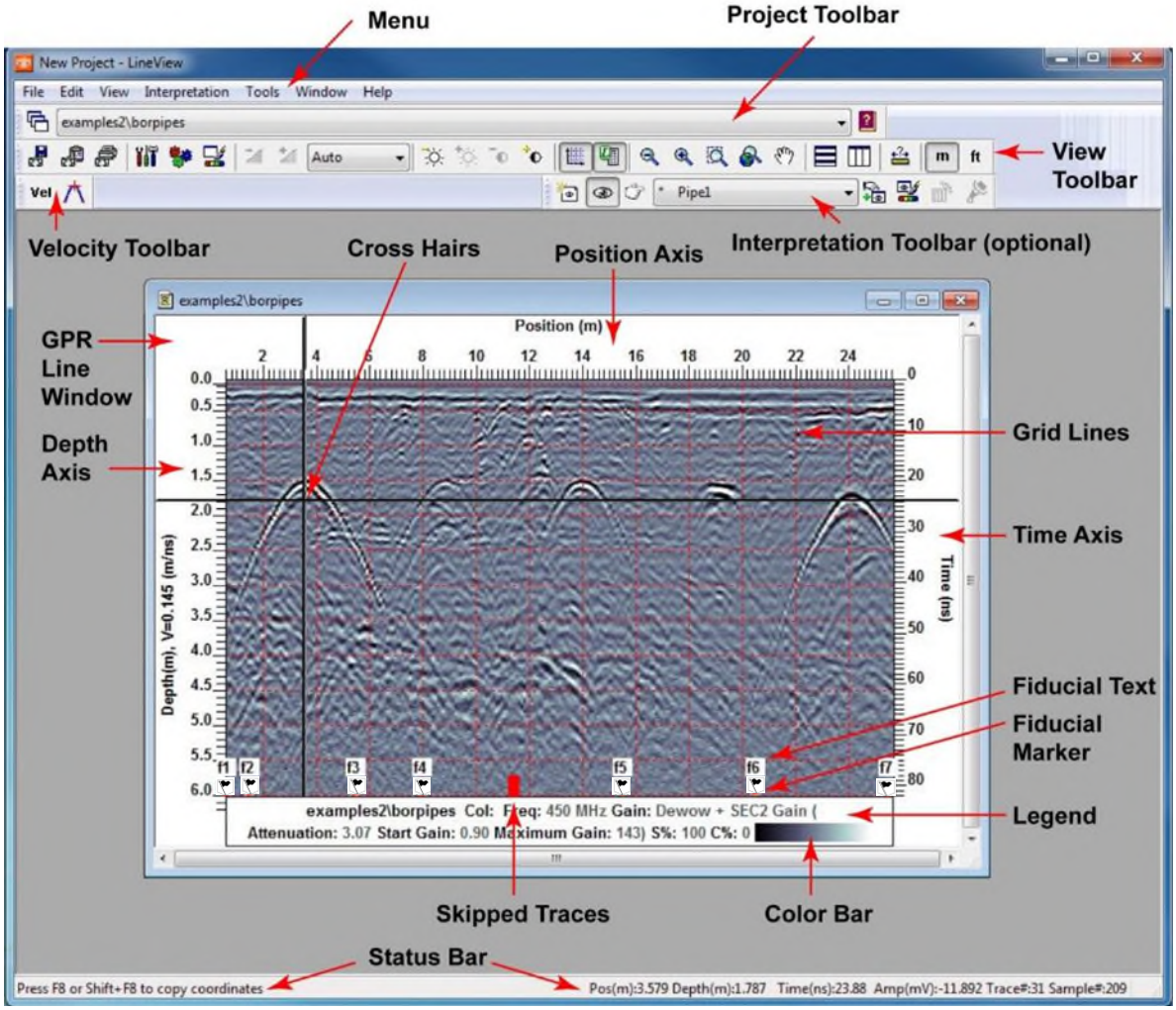
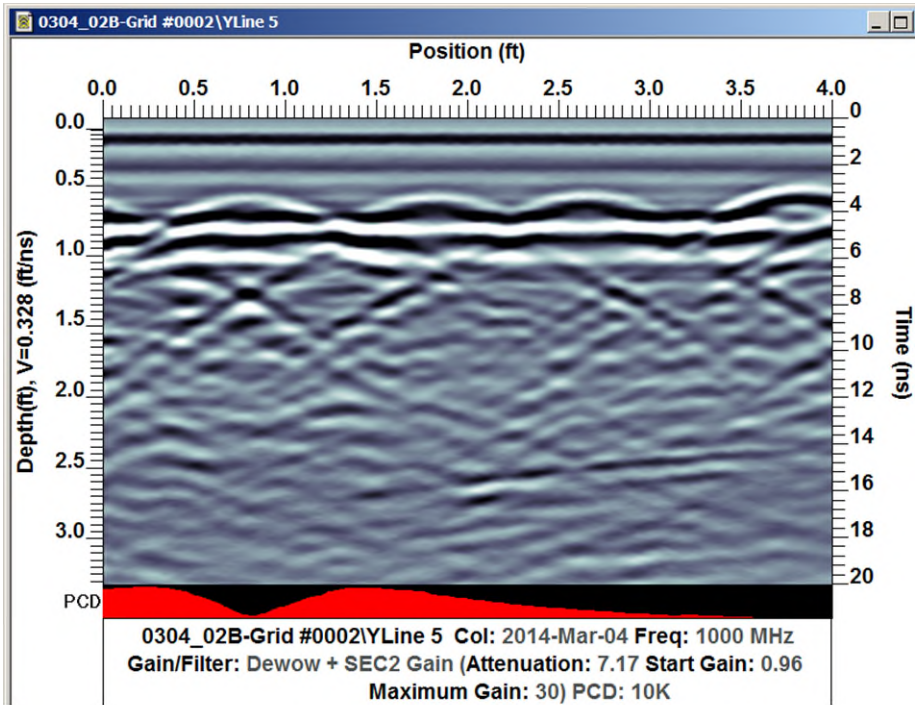


Figure 2-1: The LineView main screen with a GPR line displayed in a window.

If a Conquest Line Scan or a grid line from a Grid Scan is plotted in LineView, the Power Cable Detector (PCD) response is plotted under the line image. The vertical scale of the PCD plot is listed in the Legend.



Regardless of how many GPR Lines are in the Project, initially only GPR lines checked in Project Explorer in EKKO_Project are displayed (Figure 2-1). Other GPR Lines files can be displayed by:

1) Selecting the GPR Line name from the drop-down list on the Project Toolbar(2.4), or,

2) Opening all GPR Lines in the Project by selecting **Window > Open All GPR Lines** (10.6).

3) Clicking the **Open All Lines in Project** button on the Project Toolbar (2.4):



2.1.1 Displaying GPR Lines

GPR lines can be displayed in a Color Scale, Wiggle Trace, both or neither (6.7).

The Legend under the line image provides details of the current GPR line. The information specified in the Legend can be edited using the option under **View > Settings > Legend** Tab (6.12).

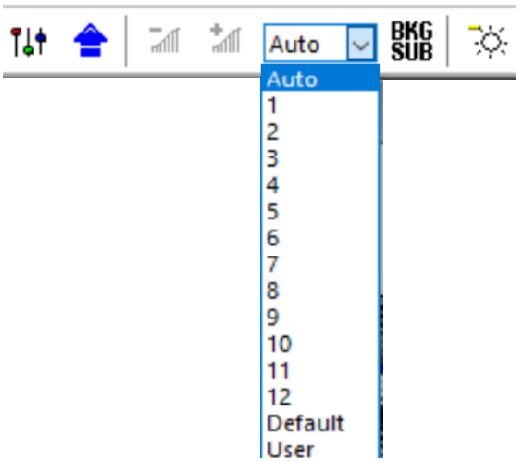
The Menus, Shortcuts and buttons on the **View Toolbar** allow the user to further modify and customize the line images (2.5).

The Color Palette can be changed under the **View > Settings > Color Palette** Tab from the menu (6.8) or by selecting the **Color Palette Settings** button from the **View Toolbar** (2.5):



Gain is the amplification applied to the GPR line. When a GPR line is opened in LineView for the first time, the **Auto** gain is applied to it.

The Gain can be changed using the Gain dropdown on the **View Toolbar**:



If the Gain Level is set to a Numbered Level (not Auto), the Gain Increase and Gain Decrease buttons on the **View Toolbar** (2.5):



can be used to quickly change the Gain Level.

The Gain Level can also be changed in the **View > Settings > Gain/Filter** Tab.

The **User** gain setting is the gain that was used in the field when the GPR data were collected. The User gain parameters can be changed in **View > Settings > Gain/Filter Tab** (SEC2).

The **Gain Type** can be changed by selecting **View > Settings > Gain/Filter Tab> Gain Type** (6.9.1.3).

Grid Lines corresponding to the major positions and depth labels can be superimposed on the GPR lines. Grid Lines are displayed by selecting **View > Grid Lines** (Section 7.15.8). The specific grid lines are selected under **View > Settings > Axes Tab** (Section 6.10.3).

The colors of the grid lines and wiggle traces can be changed under **View > Settings > General** Tab (6.7).

The font for the axes and legend can be changed under **View > Font** (7.14) or **View > Settings > General** Tab (6.7.9).

The Depth scale is based on the velocity set under **View > Settings > Axes Tab > Depth Axis** (6.10.3.3). The best way to determine this value is through the **Tool > Hyperbola Velocity Calibration** method (9.2.1).

If the data file has elevation data integrated with it, the GPR line can be plotted with topography by selecting **View > Settings > Axes > Elevation Axis** (6.10.3.4).

As the mouse cursor is moved over the GPR line, cross-hairs appear and information about the current position, depth, etc. of the cross-hairs in the GPR line are displayed on the Status Bar on the bottom of the main window (2.8).

2.1.2 Adding Interpretations and Flags (optional Interpretation module)

If the Interpretation module is enabled (see Software Registration in the EKKO_Project User's Guide), interpretations and flags can be drawn on top of the GPR line(s) using the mouse cursor.

By default, Flag is selected in the interpretation selector dropdown on the interpretation toolbar.

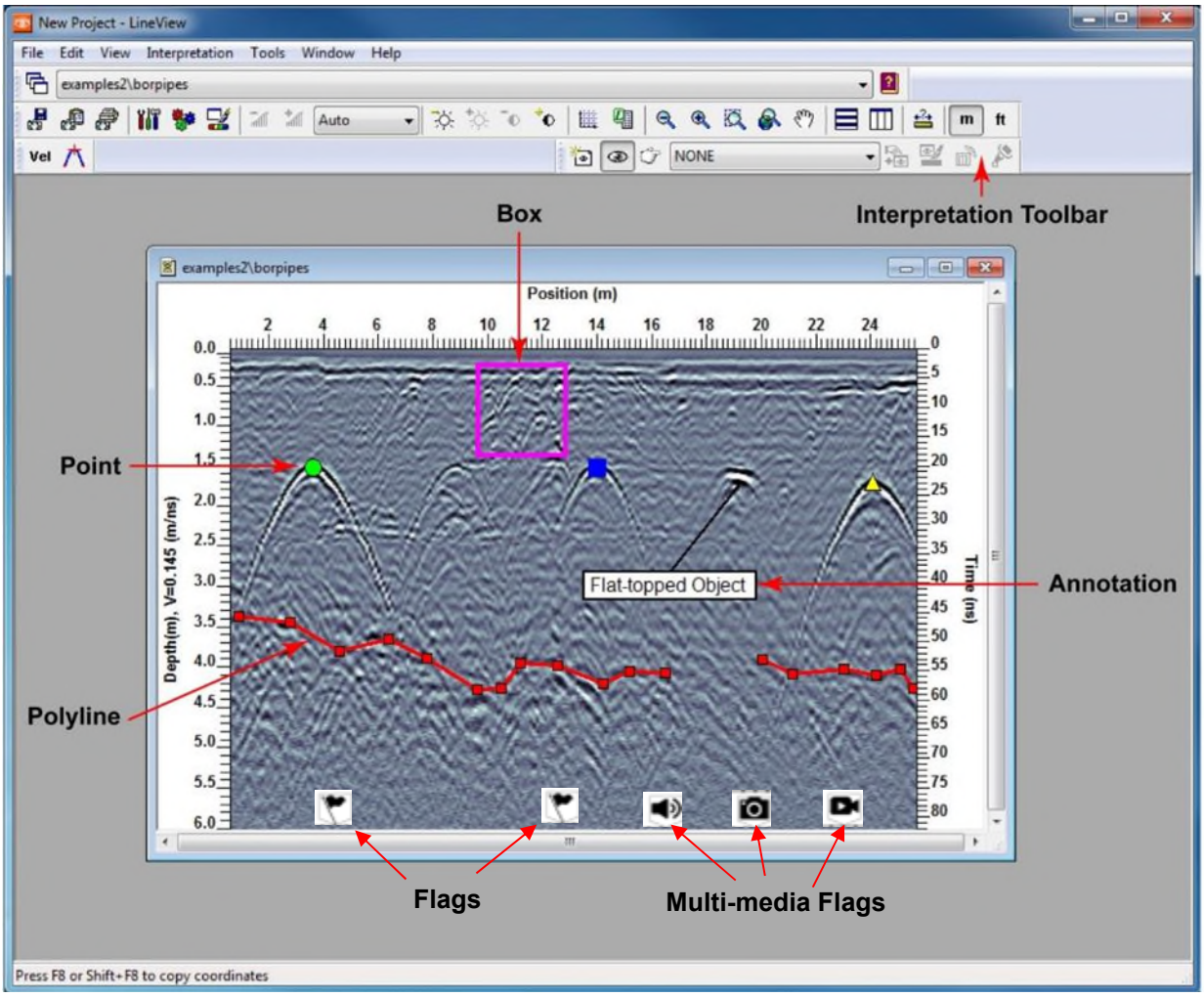


Figure 2-2: Interpretations are created and added to the GPR line.

To create a new interpretation, select **Interpretation > Create New Interpretation** (8.1) or select <New> from the dropdown list on the Interpretation toolbar.

In the **Create New interpretation** dialog, the new interpretation can either be based on an existing template (8.1.4) or created manually using the **Drawing Tool** (8.1.2). In both cases a **Name** (8.1.1) must be given to the interpretation before the OK button becomes active.

If using the **Drawing Tool** (8.1.2) to manually create an interpretation, select one of the Interpretation types: Point, Polyline, Box or Annotation. Then use the **Settings** (8.1.2.6) button to set the properties such as line color, marker style and text font manually.

Make the new interpretation the **Active Interpretation** (8.2.1) by selecting it from the drop-down list on the **Interpretation Toolbar** (2.7).

After creating a new interpretation, the newly added interpretation is shown in the Interpretation selector dropdown on the interpretation toolbar and LineView is automatically in **Add Observations** (8.3.1) mode (the Add Observations button on the **Interpretation Toolbar** is pressed). Use the mouse to add new observations on the GPR line(s). Interpretations are not restricted to a single GPR line; they can span multiple GPR lines to, for example, interpret the same pipe or the same horizon on several GPR lines.

Observations can also be moved (8.2.2.2) or deleted (8.2.2.1). Polylines can be cut (8.3.2), points inserted (8.3.5) and polylines joined together (8.3.4).

Often-used interpretations can be saved as **Templates** for use with other projects (8.5).

Interpretation details are written to the **Interpretation Report** available from the EKKO_Project program (see the EKKO_Project User's Guide). Note that if the user desires observation values in the Interpretation Report in elevations rather than depths, Interpretations should only be added **AFTER** the GPR line has been plotted with an **Elevation Axis** (6.10.3.4).

2.1.3 GPR Line Image Outputs

When satisfied with the GPR line display, select **File > Print Image** (4.3) to print a hard copy output or **File > Export Image** (4.1) to save the image to a graphics file.

Select **File > Save View** (4.2) to attach the image to the project to include in the **GPR Summary Report**.

To copy the GPR line to the clipboard, select **Edit > Copy Image to Clipboard** (5.1).

GPR lines can be output with or without the interpretations displayed (7.15.10.1).

It is also possible to only output the Interpretations graphically without the GPR data image (6.7.5).

2.2 Window Operations

2.2.1 Active Window

LineView may have two or more GPR line windows open. However, only one window at a time is "active" and can have changes made to it, for example, changing the Contrast value or enabling the Legend option. The Active Window is always indicated by its darker frame (Figure 2-3). Depending on the Windows settings, the difference may be subtle.

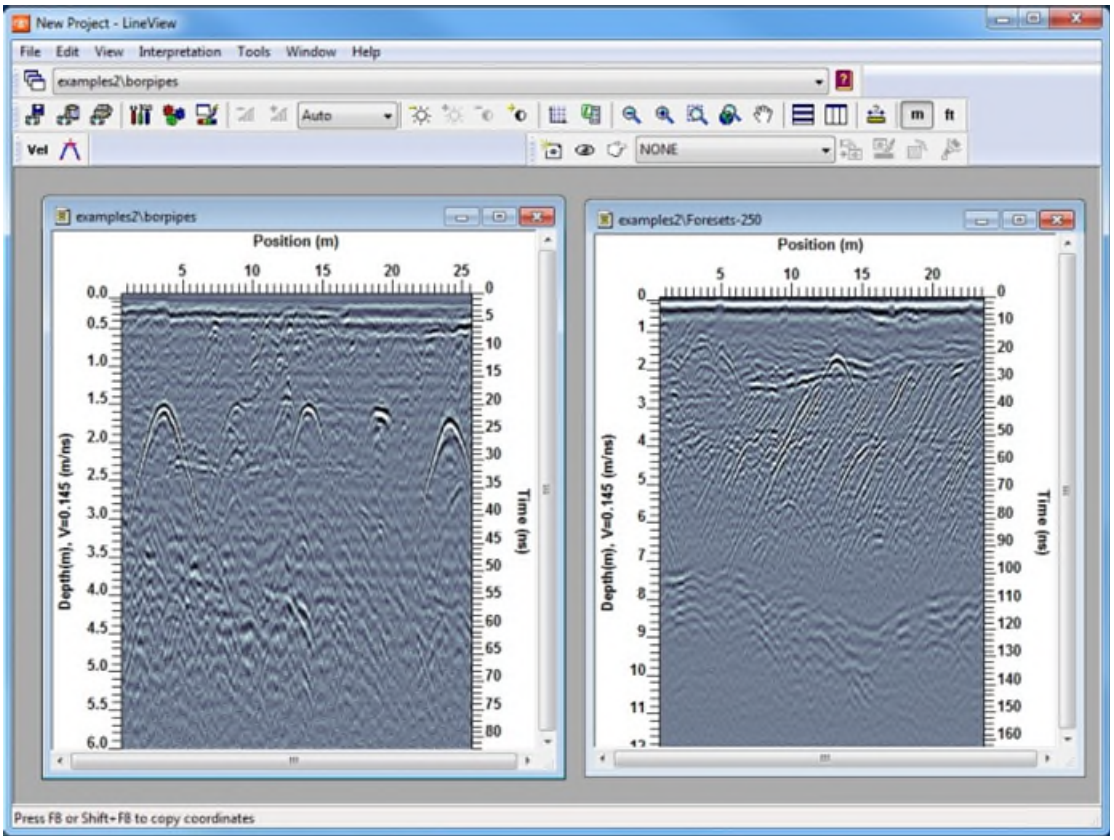


Figure 2-3: The Active Window is indicated by a more darkly-colored frame.

The current active window is listed in the Project List dropdown on the **Project Toolbar** (2.4) and checked in the list under the **Window** menu (10).

2.2.2 Resizing Windows

To change the size of a window, click and drag any frame or corner.

As the size of the GPR line window changes, the GPR line will resize to fill the maximum size within the window.

The windows can also be resized and closed using the buttons located in the upper right corner.

2.2.3 Tiling Windows

Use the menu option **Window > Tile Horizontally** (10.4) or the following **View Toolbar** button (2.5) to arrange the windows horizontally:



When tiling horizontally the current **Active Window** (2.2.1) will always appear on top.

Use the menu option **Window > Tile Vertically** (10.3) or the following **View Toolbar** button (2.5) to arrange the windows vertically:



When tiling vertically the current **Active Window** (2.2.1) will always appear on the left.

2.2.4 Opening a New Window

A second view of an already-open GPR line window can be made by selecting **Window > New** (10.1).

2.3 Legend

The data image has a legend that displays information about the GPR line (Figure 2-1).

The display of the legends can be enabled and disabled under the menu option View > Show/Hide > Legend or pressing or depressing the Toggle Legend Viewing button on the **View Toolbar** (2.5):



2.4 Project Toolbar

The Project toolbar has the **Project List** dropdown to allow the user to select a GPR line from the project to display in LineView.



The left-most button is used to quickly open ALL the GPR lines in the project.

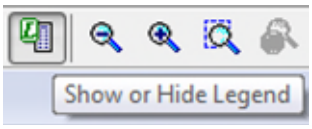
A brief description of the function of a button is displayed by hovering the mouse cursor over the button for about 1 second. A longer description of the button function can also be found on the **Status Bar** on the bottom of the screen (2.8).

2.5 View Toolbar

Most operations involving changing the GPR line can be performed using the buttons on the View toolbar.



A brief description of the function of a button is displayed by holding the mouse cursor on the button for about 1 second.



There is also a longer description of the button function displayed on the **Status Bar** (2.8) on the bottom of the screen.

The View Bar is made visible by checking it under **View > Show/Hide > Toolbar > View** (7.15.1.1).

2.6 Velocity Toolbar

The velocity for the depth or elevation axis can be changed using the Velocity Bar.

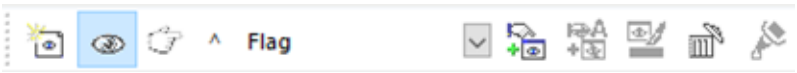


A brief description of the function of a button is displayed by holding the mouse cursor on the button for about 1 second. There is also a longer description of the button function displayed on the **Status Bar** (2.8) on the bottom of the screen.

The Velocity Bar is made visible by checking it under **View > Show/Hide > Toolbar > Velocity** (7.15.1.2).

2.7 Interpretation Toolbar

Operations for making new interpretations, picking the active interpretation, adding, or deleting observations or editing interpretation templates can be performed using the Interpretation toolbar.

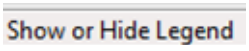


A brief description of the function of a button is displayed by holding the mouse cursor on the button for about 1 second. There is also a longer description of the button function displayed on the **Status Bar** (2.8) on the bottom of the screen.

The Interpretation Bar is made visible by checking it under **View > Show/Hide > Toolbar > Interpretation** (7.15.1.3).

2.8 Status Bar

As the mouse cursor is moved over buttons on the toolbars, the status bar, at the bottom of the screen (Figure 2-1), provides helpful descriptions of the purpose of the particular button. For example, holding the mouse over the Legend button will display the following on the Status Bar:



When the mouse cursor is located on the GPR line, the right side of the status bar displays information about the data at that location:



The status bar is visible on the bottom of the screen by checking it under the **View > Show/Hide > Status Bar** (7.15.2).

2.8.1 GPS

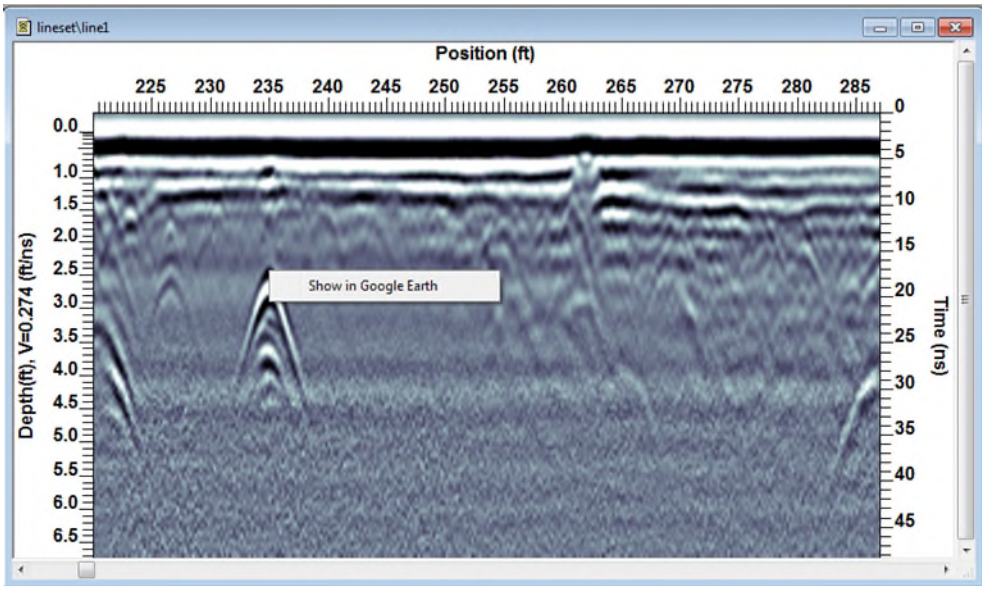
If the GPR data file has GPS information, the GPS position in Latitude-Longitude and/or UTM coordinates are also displayed on the Status Bar:



The format of the GPS information can be changed under **View > Settings > Legend Tab > GPS Configuration** (11)).

2.8.2 Google Earth™

If the GPR line has integrated GPS, right-clicking anywhere on the GPR line image opens a menu. Select the “Show in Google Earth” option to launch Google Earth™ (if installed) and “fly” to the global location of the mouse cursor.





This is an excellent feature for seeing where in the GPR survey area, a hyperbola or other GPR response is located. Remember that the accuracy of the target location is only as accurate as the GPS.

2.8.3 Exporting Status Bar Information to Other Documents

The data information text on the **Status Bar** can be copied to the Clipboard by pressing the F8 key. The text can then be Pasted into another document like a Microsoft® Word® or Excel® file.

Pressing the "Shift" key while pressing F8 will also save the text for the column headings.

Distance(m)	Depth(m)	Time(ns)	Amplitude(mV)	Trace#	Sample#	Latitude	Longitude
4.73	1.046	20.17	-32.228	96	75	36.1091593 N	115.1413538 W
5.591	0.732	13.98	3.302	113	60	36.1091528 N	115.1413557 W
7.304	1.445	28.09	-10.665	147	95	36.1091395 N	115.1413584 W
8.832	1.261	24.44	-8.09	178	86	36.1091275 N	115.1413620 W
9.91	0.73	13.93	3.929	199	60	36.1091190 N	115.1413632 W

To create a file like the one above, press Shift F8 and paste the first line into the document. Then press F8 for all the subsequent lines.

This feature is handy for extracting significant positions from the data image and writing them to other documents, especially if the optional Interpretation module is not enabled.

3 Menus and Shortcuts

The following sections describe the LineView menus.



Menu options can be accessed by clicking on them with the mouse cursor or by pressing the Alt key followed by the underlined letter.

Alt+F = File

Alt+E = Edit

Alt+V = View

Alt+I = Interpretation (if optional Interpretation module enabled)

Alt+T = Tools

Alt+W = Window

Alt+H = Help

Sub-menus can then be accessed by pressing the next underlined letter. For example, to select the Print sub-menu under the File menu, press Alt+F and then P.

Popular sub-menus can be accessed directly by pressing Ctrl key followed by a letter:

Ctrl+P = Print Image

Ctrl+C = Copy Image to Clipboard

Sensitivity can be increased by pressing the] key and decreased by pressing the [key. Pressing the Shift or Ctrl key at the same time changes the increment. For more details see **Sensitivity** (6.8.2).

Contrast can be increased by pressing the / key and decreased by pressing the . key. Pressing the Shift or Ctrl key at the same time changes the increment. For more details see **Contrast** (6.8.3).

Gain Level can be increased by pressing the + key and decreased by pressing the - key. For more details, see **Gain Level** (6.9.6.1).

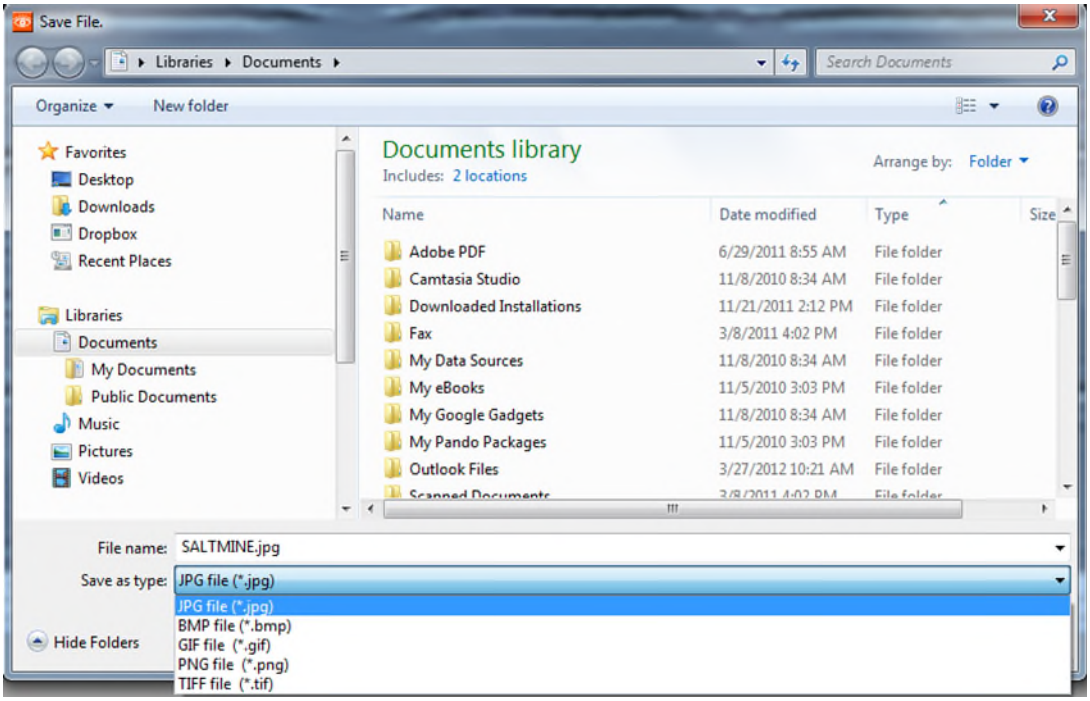
4 File Menu

4.1 Export Image

The **File > Export Image** option allows the user to save a graphics image file of the GPR line in the current **Active Window** (2.2.1) or all the open GPR lines. The plot can be saved in BMP, JPG, PNG, TIFF or GIF graphics file formats.

A message opens, asking if you would like to save the GPR line image in the currently selected window or all the open windows. Selecting all open windows saves all the GPR lines to one image file.

Select the graphics format file type from the drop-down list. Then input a filename and folder to save the image to.



The Export Image option can also be accessed from the **View Toolbar** (2.5) by clicking on the **Save Image As** button:



See **View Settings** menu for details on modifying the image (6). This menu is used for modifying the image by turning on or off the scales, grid lines, legend, flags/fiducial markers and flag/fiducial text. These options are useful if you want to add your own scales or annotations using a graphics program.

If the optional Interpretation module is enabled (see Software Registration in the EKKO_Project User's Guide), interpretations displayed on the image (see **Interpretation** (8)) are saved to the exported image. If interpretations are not desired on the exported image, they can be temporarily turned off by setting the **Active Interpretation** in the interpretation drop-down list on the **Interpretation Toolbar** (2.7) to

None and then unchecking the **View > Show/Hide > Inactive Interpretations** option (7.15.10.1) to turn off the display of inactive interpretations.

4.1.1 Image Resolution

To obtain the best resolution in the exported image, stretch your display window to the largest size possible with the desired aspect ratio. The image can also be stretched to extend outside of application window to obtain even better resolution for the exported image. Even though part of the image is not visible in the application window, it will still be preserved in the exported image.

4.2 Save View

The **File > Save View** option saves the GPR line image in the current **Active Window** (2.2.1) or all the open GPR lines and attaches it to the project file to include in the GPR Summary Report. The Save Image option can also be accessed from the **View Toolbar** (2.5) by clicking on the **Save Image As** button:



A message opens, asking if you would like to save the currently selected window or all windows.

Selecting Save View opens a dialog for naming the image. The default name is the name of the GPR line.

When the GPR Summary Report is selected in EKKO_Project, the user can select from the images attached to project to appear in the report (see GPR Summary Report in the EKKO_Project User's Guide).

See View Settings Menu (6) for details on modifying the image by changing the processing, turning on or off the scales, grid lines, legend, flags/fiducial markers and flag/fiducial text.

Interpretations displayed on the image (see **Interpretation** (8)) are saved with the image. If interpretations are not desired on the saved image, they can be temporarily turned off by setting the **Active Interpretation** in the interpretation drop-down list on the **Interpretation Toolbar** (2.7) to **None** and then unchecking the **View > Show/Hide > Inactive Interpretations** option (7.15.10.1) to turn off the display of inactive interpretations.

4.3 Print Image

The **File > Print** Image option allows the user to produce hard copies of the image in the current **Active Window** (2.2.1). After selecting this option, a standard print dialog opens which allows the user to select the printer they wish to print to as well as customize other printing parameters. For example, the user can select to print the data image to a Landscape rather than a Portrait orientation.

The print dialog can also be accessed by pressing the **Ctrl-P** keys or by clicking the **Print** button from the **View Toolbar** (2.5):



See View Settings Menu (6) for details on modifying the image by changing the processing, turning on or off the scales, grid lines, legend, flags/fiducial markers and flag/fiducial text.

If the optional Interpretation module is enabled (see Software Registration in the EKKO_Project User's Guide), interpretations displayed on the image (see **Interpretation** (8)) are saved to the printed image. If interpretations are not desired on the printed image, they can be temporarily turned off by setting the **Active Interpretation** in the interpretation drop-down list on the **Interpretation Toolbar** (2.7) to **None** and then unchecking the **View > Show/Hide > Inactive Interpretations** option (7.15.10.1) to turn off the display of inactive interpretations.

4.3.1 Image Resolution

To obtain the best resolution in the printed image, stretch your display window to the largest size possible with the desired aspect ratio. The image can also be stretched to extend outside of application window to obtain even better resolution for very large printed images. Even though part of the image is not visible in the application window, it will still be preserved in the printed image.

5 Edit

5.1 Copy Image to Clipboard

The **Edit > Copy Image to Clipboard** option copies the GPR Line image in the current **Active Window** (2.2.1) or all the open GPR lines to the Clipboard so it can be pasted into other documents like a Microsoft® Word® document or an e-mail message.

See **View Settings Menu** (6) for details on modifying the image by changing the processing, turning on or off the axes, grid lines, legend, flags/fiducial markers and flag/fiducial text. These options are useful if you want to add your own scales or annotations using a graphics program or if you want to tile several individual images together into one larger image.

The **View > Show/Hide** menu (7.15) can also be used to show or hide GPR line image options like axes, grid lines and the legend.

If the optional Interpretation module is enabled (see Software Registration in the EKKO_Project User's Guide), interpretations displayed on the image (see **Interpretation** (8)) are saved to the clipboard image. If interpretations are not desired on the clipboard image, they can be temporarily turned off by setting the **Active Interpretation** in the interpretation drop-down list on the **Interpretation Toolbar** (2.7) to **None** and then unchecking the **View > Show/Hide > Inactive Interpretations** option (7.15.10.1) to turn off the display of inactive interpretations.

This option can also be accessed by pressing the **Ctrl+C** keys or by clicking on the **Copy Screen to Clipboard** button on the **View Toolbar** (2.5):



The resolution of the image sent to clipboard is controlled by the size of the image on the screen. The bigger the image on the screen, the higher the resolution of the image sent to the clipboard.

5.2 Copy Interpretation to Clipboard

If the optional Interpretation module is enabled (see Software Registration in the EKKO_Project User's Guide), the **Copy Interpretation to Clipboard** menu option is available under the **Edit** menu.

The **Edit > Copy Interpretation to Clipboard** option copies details of the observations from the current **Active Interpretation** to the Clipboard so it can be pasted into other documents like a Microsoft® Word® or Excel® document.

Copy Interpretation to Clipboard can also be accessed by right-clicking on the data image and selecting it from the menu.

Tool	Interpretation	GPR Line	Position(m)	X(m)	Y(m)	Depth(m)	Time(ns)	Elevation(m)	Amplitude(mV)	Velocity(m/ns)	GPS-Latitude(deg)	GPS-Longtitude(deg)
Polyline	Polyline1	LINEX5.DT1	0.015			1.067	20.88		7.384	0.1	44.27614	-79.88716667
Polyline	Polyline1	LINEX5.DT1	1.126			1.183	23.2		-17.939	0.1	44.27614833	-79.88716167
Polyline	Polyline1	LINEX5.DT1	1.726			1.165	22.83		-4.572	0.1	44.27615333	-79.88715833
Polyline	Polyline1	LINEX5.DT1	2.282			1.155	22.65		-1.624	0.1	44.27615708	-79.887155
Polyline	Polyline1	LINEX5.DT1	2.807			1.244	24.41		2.821	0.1	44.27616167	-79.88715333
Polyline	Polyline1	LINEX5.DT1	3.543			1.253	24.6		-31.878	0.1	44.27616667	-79.88714889
Polyline	Polyline1	LINEX5.DT1	4.473			1.323	25.99		27.92	0.1	44.276175	-79.88714267
Polyline	Polyline1	LINEX5.DT1	4.909			1.244	24.41		19.304	0.1	44.27617833	-79.88713833
Polyline	Polyline1	LINEX5.DT1	5.689			1.225	24.04		9.148	0.1	44.276185	-79.887135
Polyline	Polyline1	LINEX5.DT1	6.38			1.253	24.6		19.869	0.1	44.27619	-79.88713167

Figure 5-1: Interpretation copied to the clipboard and pasted into Microsoft® Excel®

6 View Settings Menu

The **View > Settings** option allows the user to change various aspects of the GPR line images including processing, color palettes, axes, data limits, legend, contrast and sensitivity values.

The Settings option can also be accessed from the **View Toolbar** (2.5) by clicking on the Settings button:



The settings are displayed in various tabs in the dialog (Figure 6-1).

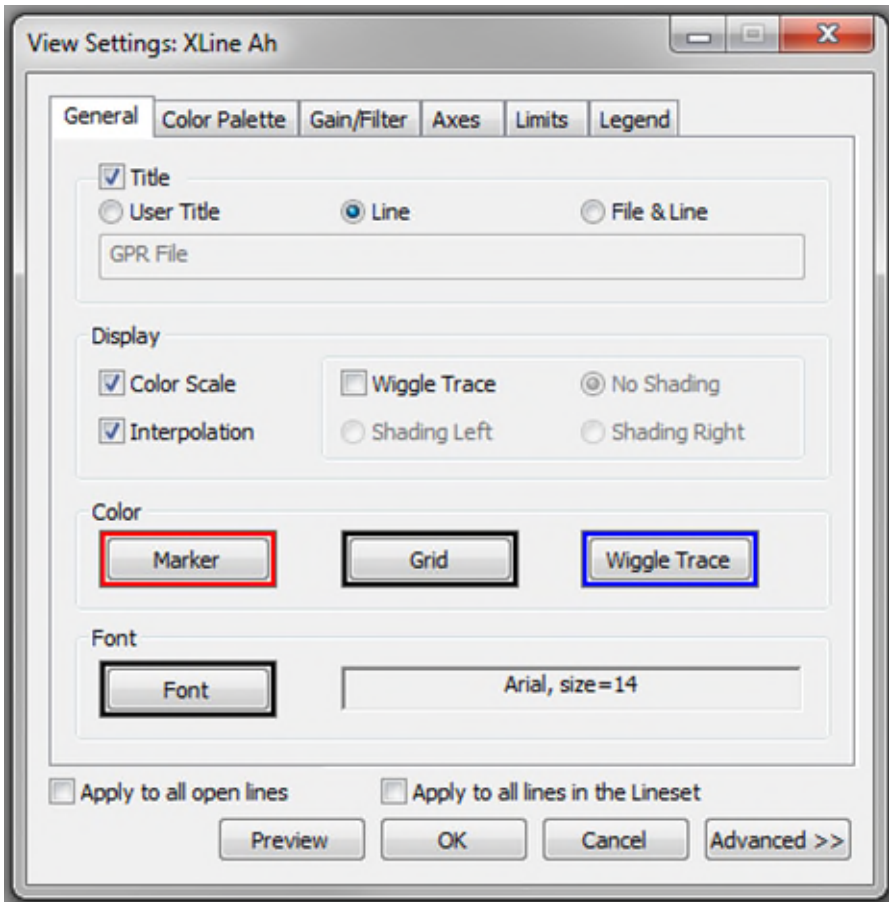


Figure 6-1: The View Settings dialog has 6 tabs for setting various parameters of the image display.

6.1 Preview

Clicking on the **Preview** button allows the user to see the effect of changes they have made to the View Settings before permanently applying those changes by clicking on the **OK** button.

For example, to interactively experiment with a variety of gain methods and settings, select the **Gain Type** and appropriate parameters and then select **Preview** to update the display.

6.2 OK

Clicking the **OK** button applies any changes to the settings for the GPR line in the Active Window (2.2.1) and closes the Settings dialog.

6.3 Cancel

Clicking the **Cancel** button closes the Settings dialog, ignoring any changes that may have been made to the settings, including any changes made using the **Preview** button (6.1).

6.4 Apply to all open lines

The **Apply to all open lines** checkbox (Figure 6-1) is used to apply all the current settings (on ALL the View Settings tabs) to all open GPR lines. Check the **Apply to all open lines** checkbox and then press **OK**.

Be cautious when using this option because there is no “undo” available once the settings have been changed by pressing OK.

If you press the **Preview** button (6.1), but then decide to abandon the changes, pressing **Cancel** will “undo” all the changes.

If the **Apply to all open lines** option is not selected, any changed settings only apply to the current **Active Window** (2.2.1).

6.5 Apply to all lines in the Lineset

The **Apply to all lines in the Lineset** checkbox (Figure 6-1) is used to apply all the current settings (on ALL the View Settings tabs) to all GPR lines in the current Lineset (lineset or grid). Check the **Apply to all lines in the Lineset** checkbox and then press **OK**.

The main purpose of this feature is to make it easy to change the view settings for a group of lines without having to open them all. One specific purpose is to change the view settings for all lines in a Conquest grid so they all display the same way in the **3D Preview** and **Line Preview** windows in EKKO_Project.

Be cautious when using this option because there is no “undo” available once the settings have been changed by pressing OK.

If you press the **Preview** button (6.1), but then decide to abandon the changes, pressing **Cancel** will “undo” all the changes.

If the **Apply to all lines in the Lineset** option is not selected, any changed settings only apply to the current **Active Window** (2.2.1).

6.6 Basic / Advanced

The Basic View Settings screen is shown in Figure 6-1.

Selecting the **Advanced** button adds five buttons for saving and loading View Settings Configuration files, loading and saving the Default settings as well as loading the Factory Defaults.

The Advanced View Settings screen is shown in Figure 6-2.

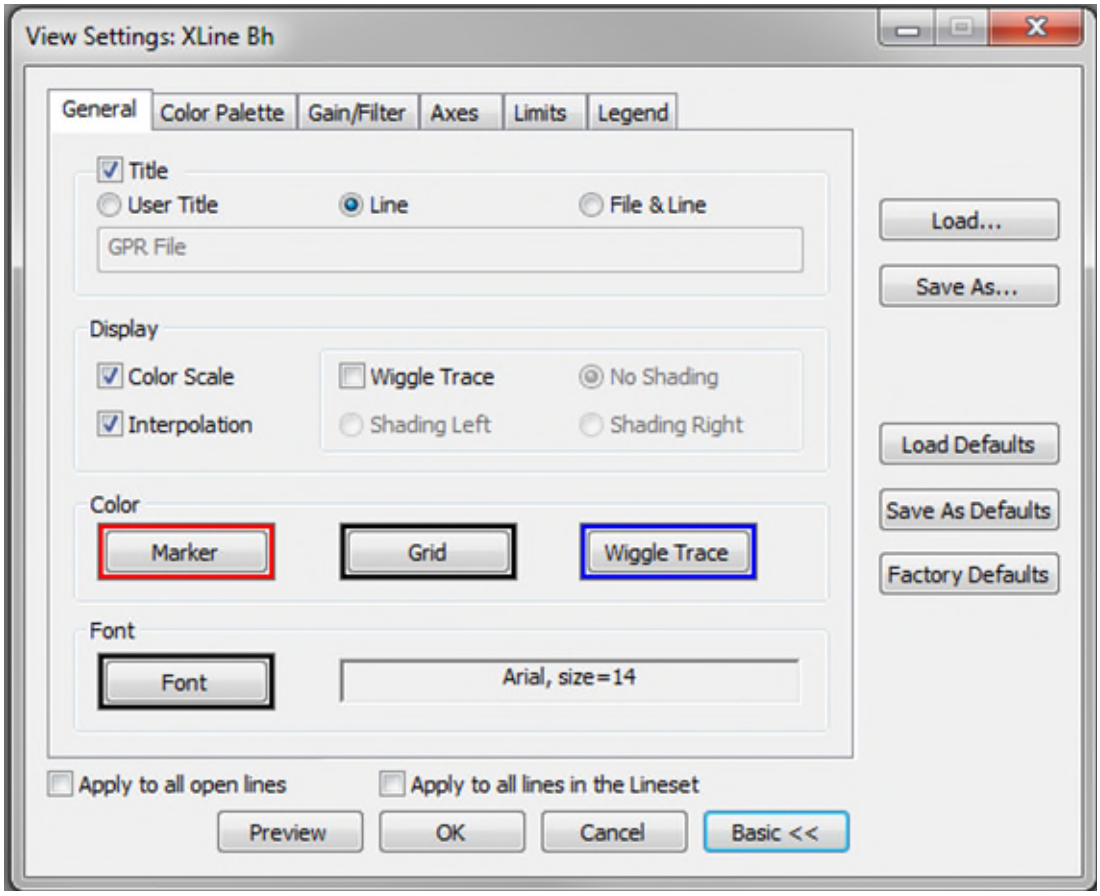


Figure 6-2: The Advanced View Settings dialog adds 5 buttons on the right side for configuration files.

Every GPR data file opened in LineView has a configuration file saved with it that saves all the display settings specified in the View Settings dialog box. The configuration file has the same name as the data file but has an .INI extension. Any settings changed in the View Settings dialog are automatically saved to the configuration file so that the next time the GPR data file is opened in LineView, it is displayed exactly the same as the last time.

The current View Settings can be saved to a configuration file by selecting the **Save As** button.

The current View Settings can be changed to previously-saved View Settings by selecting the **Load** button and selecting a configuration file.

The first time a GPR data file is opened in LineView, it uses the Default settings. The very first time that LineView is run, the Default settings are set to the same values as the Factory Defaults.

The user can define their own Default Settings, to be used with every GPR data file opened for the first time in LineView, by selecting the desired View Settings and then pressing the **Save As Defaults** button.

6.6.1 Load

The **Load** button loads a previously-saved View Settings configuration (.INI) file and applies it to the current View Settings.

6.6.2 Save As

The **Save As** button saves all the current View Settings to a configuration (.INI) file. Use this option to save the current View Settings to an .INI file to load and use in the future.

The user can specify the name and location of this configuration file but it is commonly kept in the same folder as the GPR line(s).

6.6.3 Load Defaults

Pressing the **Load Defaults** button overwrites the current View Settings with the Default settings.

6.6.4 Save As Defaults

The **Save As Defaults** button saves the current View Settings and makes them the Default settings. The Default View Settings are used with all GPR data files opened for the first time in LineView.

6.6.5 Factory Defaults

The **Factory Defaults** button resets the current and default View Settings to the default “factory” settings.

6.7 General Tab

The General tab under View Settings allows the user to edit the image title, display type, color of various features and the font for all the axes, titles and the legend.

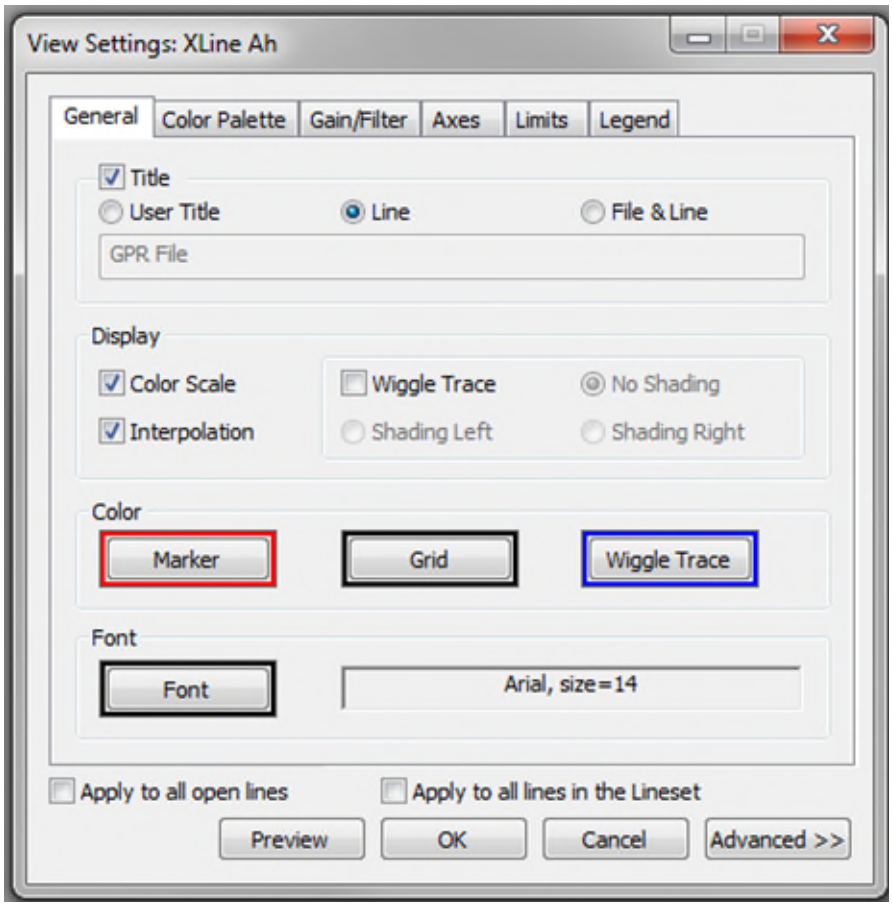


Figure 6-3: General tab.

6.7.1 Title

The Title option allows the user to change the title displayed in the Legend (Figure 2-1). Note that the Title must be selected in the Legend Tab (6.12).

Options for the title are: **User Title**, **Line Name only** or **Path & Line Name**. The default title is the GPR line name.

The Title will appear in the font specified under **Font** (6.7.9).

6.7.2 Color Scale

When selected, the GPR data will be displayed as a color scale image (Figure 6-4). This means that the GPR signal amplitude, which typically varies from negative to positive values, is displayed as different colors depending on the amplitude value.

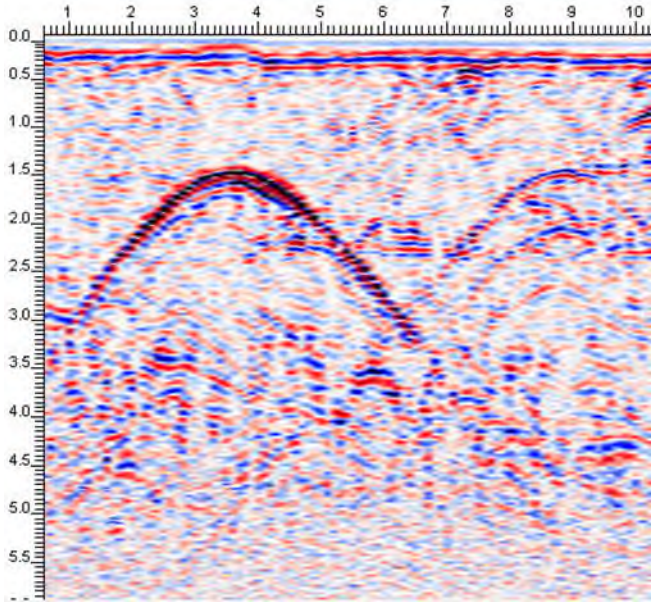


Figure 6-4: Color Scale image

A variety of color palettes can be chosen for the display (see **View > Settings > Color Palette Tab** (6.8.1)).

The data traces can be displayed interpolated (smoothed) or uninterpolated (6.7.3).

6.7.3 Interpolation

When Color Scale display is selected without interpolation selected, the data image may appear "blocky" or pixellated when zoomed in or if the traces were collected with a long step size between them. Selecting the Interpolation option (the default setting) smooths the appearance of the GPR line (Figure 6-5).

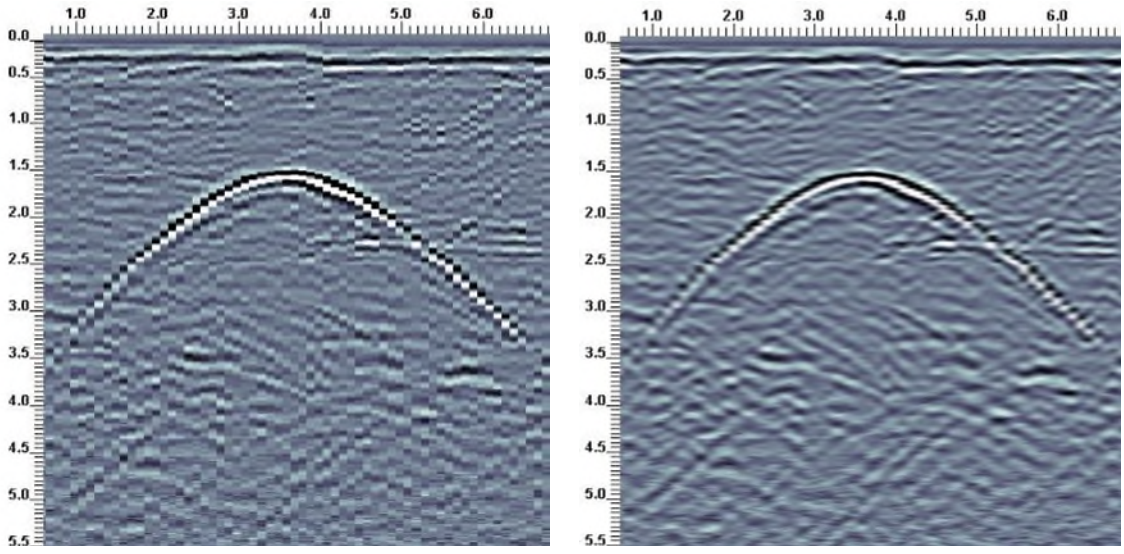


Figure 6-5: Interpolation is used to smooth the raw GPR line image on the left to the one on the right.

Interpolation is not available when only Wiggle traces (6.7.4) are displayed.

6.7.4 Wiggle Trace

When Wiggle Trace is selected, the GPR data are displayed in wiggle trace format. The GPR signal amplitudes of each trace are plotted in overlapping vertical columns with the center of the column representing zero signal amplitude, the left of the column representing negative amplitudes and the right of the column representing positive amplitudes. The trace is plotted as a line that oscillates with the direction and amount of deflection dependent on with the amplitude of the signal at that point (Figure 6-6).

Depending on the size of the display window, the total number of traces in the file and the current Zoom setting (7.9), not all traces will necessarily be displayed in Wiggle format. The number of wiggle traces displayed is optimized depending on the space available to avoid a crowded-looking image.

If only wiggle traces are displayed, interpolation is not enabled (see **Interpolation** above (6.7.3)).

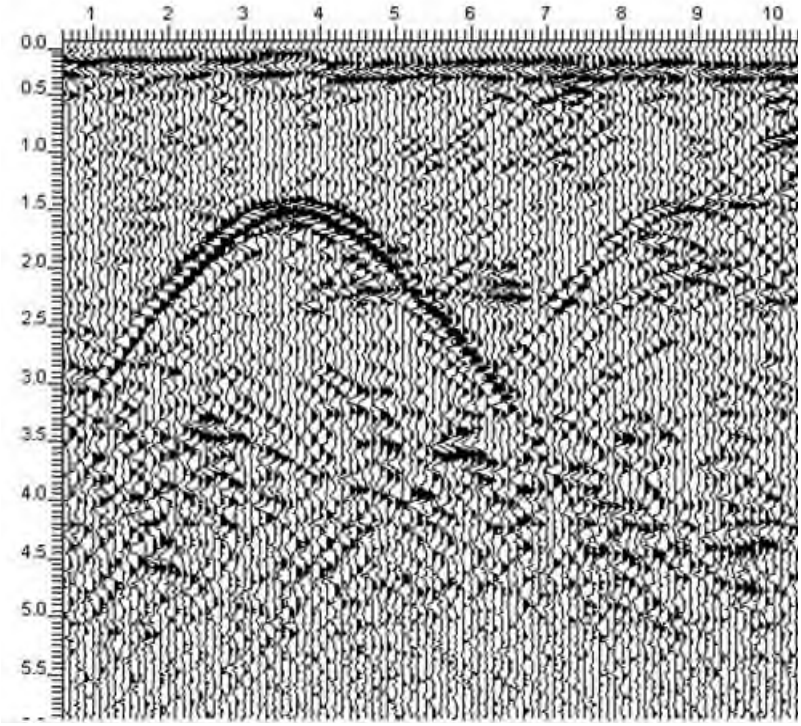


Figure 6-6: Wiggle Trace format with shading on the right.

Both Wiggle Trace and Color Scale can be displayed at the same time (Figure 6-7).

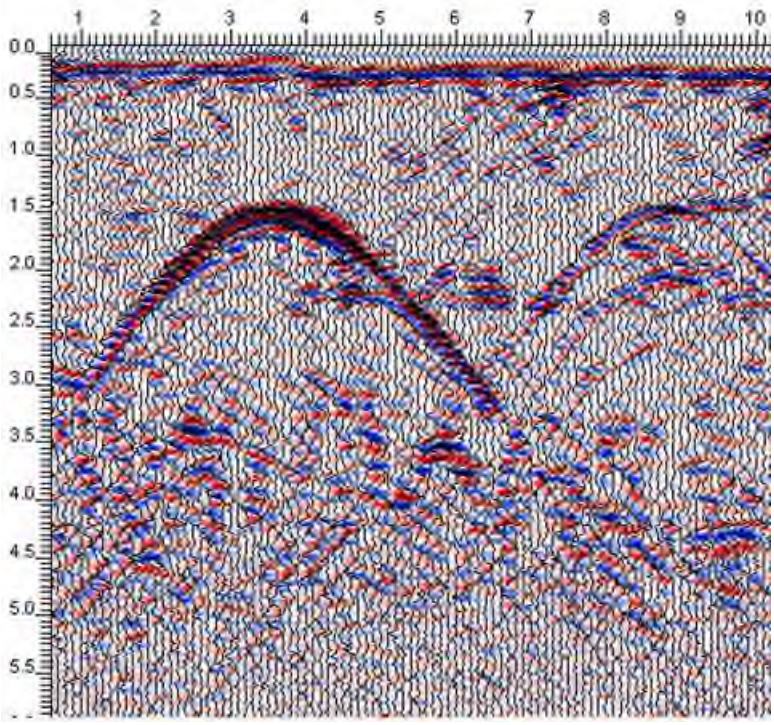


Figure 6-7: Color Scale and Wiggle traces plotted together. The wiggle traces can be plotted with or without shading (no shading in this example).

Wiggle trace requires more than one pixel (and usually 4 or more) to display the trace amplitudes whereas color scale only needs a single pixel width to display a trace. Therefore, more data can be viewed on a narrow image in color scale than in wiggle trace.

6.7.4.1 Wiggle Trace Properties

When the Wiggle Trace display is selected, the **Wiggle Trace Properties** can be edited so that the **Right** side (positive amplitude peaks) or the **Left** side (negative amplitude troughs) of the traces are shaded with color. **No Shading** is also an option. Figure 6-6 shows a wiggle trace display with shading on the right.

The color of the wiggle traces can also be changed using the **Wiggle Trace Color** option.

6.7.5 No GPR Image

If neither the Color Scale or the Wiggle Trace options are checked, no GPR line is displayed in the **Active Window** (2.2.1). This option is useful to show Interpretations with a white background and no GPR data image (Figure 6-8).

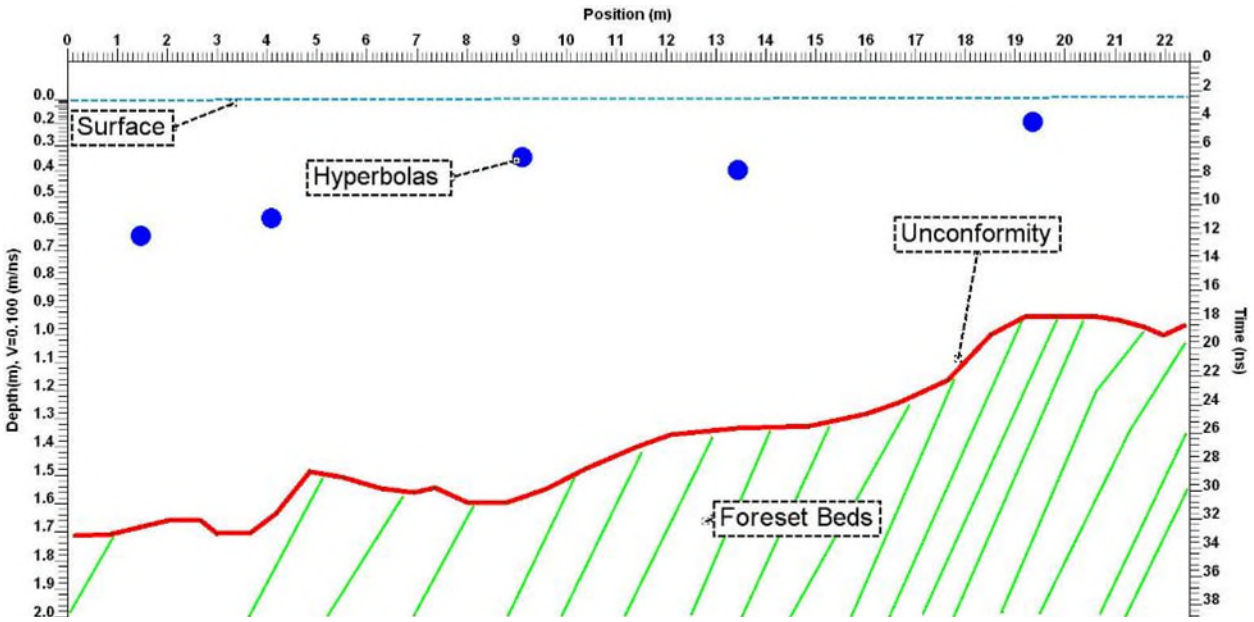


Figure 6-8: If both Color Scale and Wiggle Trace options are turned off, no GPR line is plotted. This is useful for plotting the interpretations without the data.

6.7.6 Marker Color

The **Marker** color sets the color of skipped trace flags, the Hyperbola Velocity Calibration tool (9.2.1) and the Measure tool (9.3).

Skipped Trace Flags displayed if there is skipped traces in the data and if the **View > Show/Hide > Skipped Traces** option is enabled (7.15.6). Skipped Trace Flags appear as rectangles at the bottom of the data image (Figure 2-1).

The color of the various markers can be changed by clicking the **Marker** button and selecting a color from the standard Windows dialog. It is recommended to choose a color that provides high visibility on the GPR line.

6.7.7 Grid Color

Grid Lines corresponding to the major positions and/or depth or time labels can be superimposed on the GPR line (Figure 2-1). This option is available by checking **Grid Lines** in the **Axes Tab** (6.10.3).

The color of the Grid Lines can be changed by clicking the **Grid** button and selecting a color from the standard Windows dialog. It is recommended to choose a color that provides high visibility on the GPR line.

6.7.8 Wiggle Trace Color

Wiggle Trace display is described above (6.7.4).

The color of the Wiggle Traces can be changed by clicking the **Wiggle Trace** button and selecting a color from the standard Windows dialog.

6.7.9 Font

The Font option determines the font used for the position, depth and time axes (6.10.3) as well as the text in the Legend (6.12). When selected, the standard Windows font dialog opens allowing the user to select the Font, Font Style and Size (Figure 6-9). Increasing the font size decreases the data image size but will improve the readability of printed images or graphics image files.

The font dialog is also available through the **View** menu (7.14).

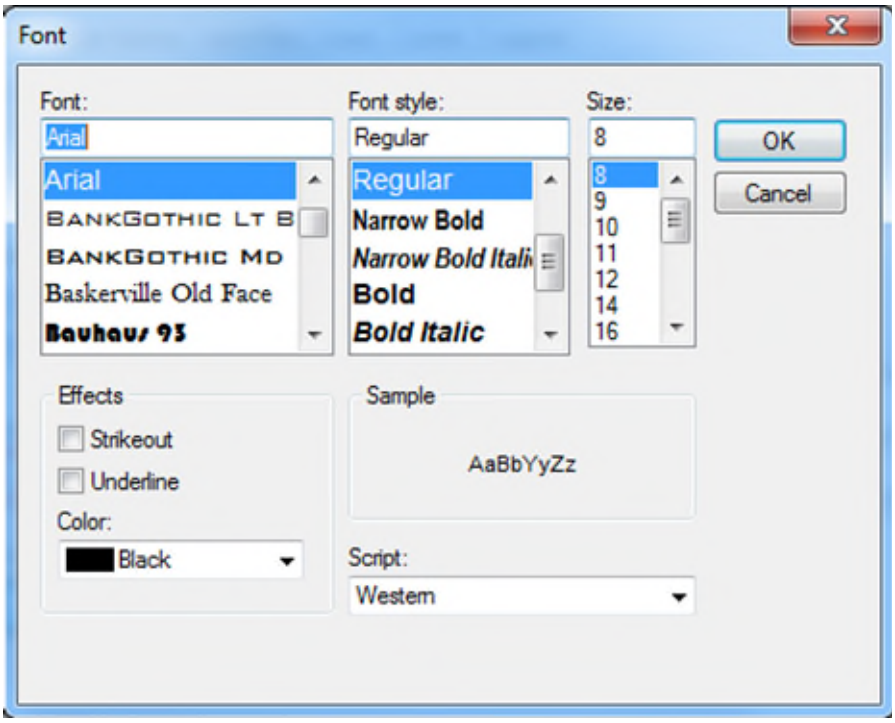


Figure 6-9: Font dialog

6.8 Color Palette Tab

The **Color Palette tab** under View Settings allows the user to change the color palette and edit the Sensitivity and Contrast values for the image.

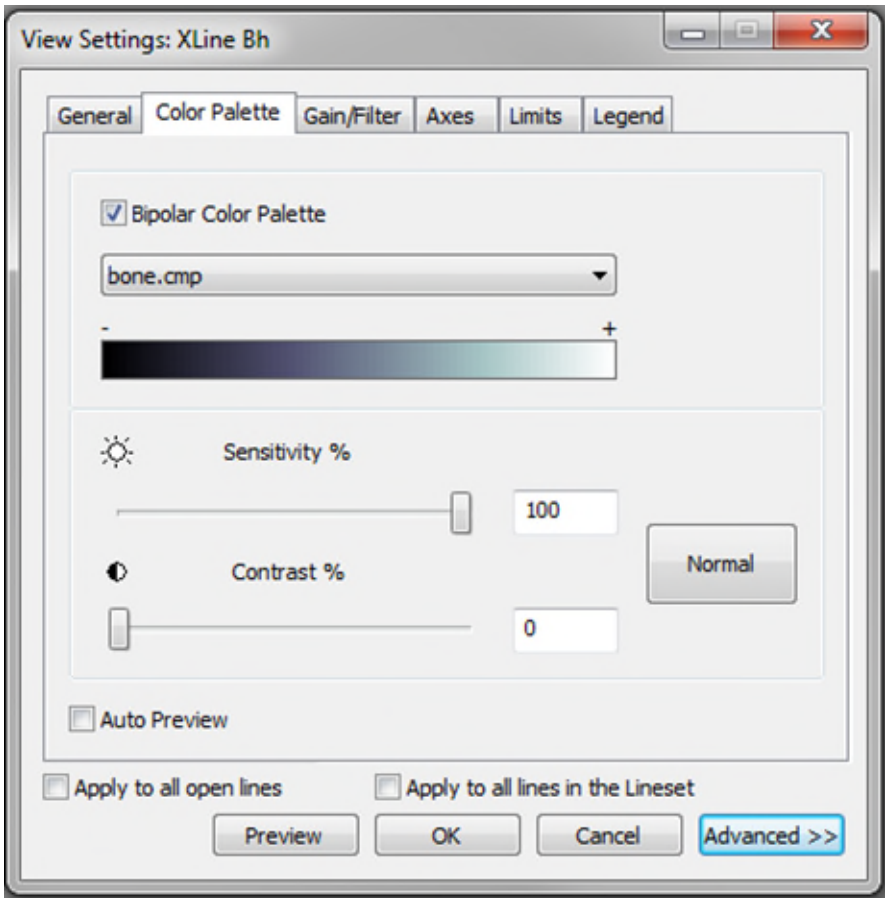


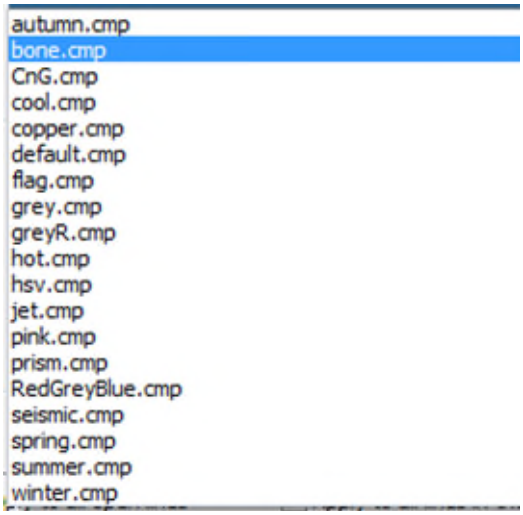
Figure 6-10: Color palette tab.

The Color Palette tab can also be accessed by selecting **View > Color Palette Settings** from the menu or clicking on the **Color Palette Settings** button on the **View Toolbar** (2.5):



6.8.1 Color Palette

The default color palette for GPR lines is Bone. The Color Palette option allows the user to choose from a number of pre-defined color palettes for the GPR line(s). Quite often one color palette may bring out features in a data set better than others (Figure 6-11) so some experimentation may be required to determine the optimal color palette for a particular data set. Most users find that “bone” allows for the easiest interpretation of a wide range of data.



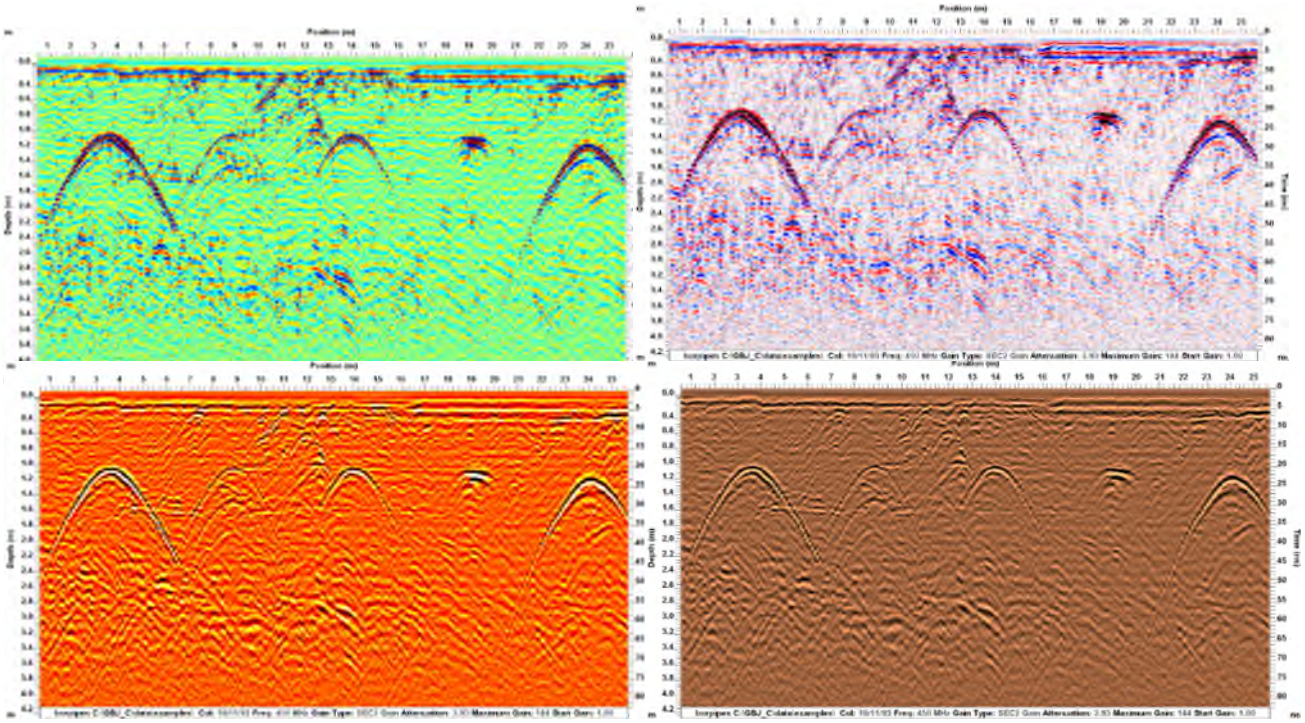


Figure 6-11: Data displayed with different color palettes.

6.8.2 Sensitivity

The Sensitivity setting controls how sensitive the image is to small signal variations. The sensitivity value is from 0 to 100%, least sensitive to most sensitive. The default setting is 100% (most sensitive). Pressing the **Normal** button (Figure 6-10) sets the Sensitivity to 100%.

Decreasing the Sensitivity from 100% widens the color palette around the zero signal level, removing the weaker signals in the image so only the strongest signals are visible.

GPR line signals vary from extreme negative values to extreme positive values with the zero signal in the middle. As the Sensitivity setting decreases, the color associated with the zero signal level in the middle of the color palette widens, resulting in the weaker signals being removed from the image.

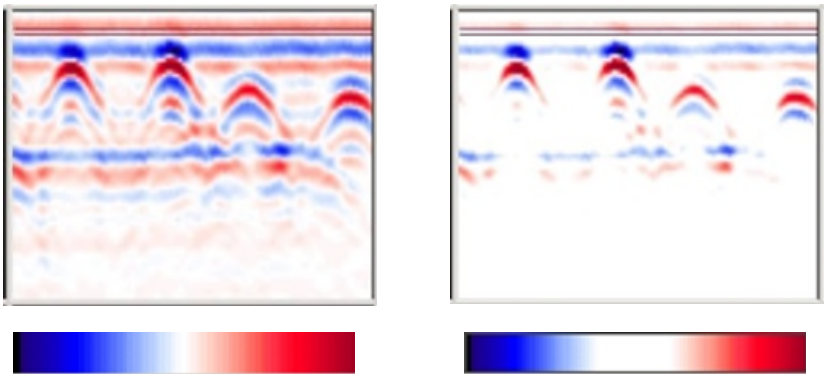


Figure 6-12: The Sensitivity value defaults to 100% (left) meaning the image is sensitive to weak signals. As Sensitivity is decreased, the color in the middle of the color bar associated with weaker signals around zero, widens, removing weaker signals from the image (right, Sensitivity=80).

The Sensitivity is changed using the appropriate slider bar in the dialog box.



The Sensitivity setting for the image can also be modified by clicking on the slider bar and then using the right and left arrows on the keyboard to increase or decrease the value respectively. If you select the **Auto Preview** checkbox beforehand (Figure 6-10), the changes made to the Sensitivity setting will be instantly visible on the image.

The Sensitivity is increased by five percent (5%) by selecting **View > Contrast & Sensitivity > Sensitivity Increase** or clicking the following button on the **View Toolbar** (2.5):



The Sensitivity is decreased by five percent (5%) by selecting **View > Contrast & Sensitivity > Sensitivity Decrease** or clicking the following button on the **View Toolbar** (2.5):



Sensitivity can also be increased by 5% by pressing the “]” key and decreased by 5% by pressing the “[” key on the keyboard.

Pressing the “Shift” key while increasing or decreasing the sensitivity will cause the value to increase or decrease by 10% rather than 5%.

Pressing the “Ctrl” key while increasing or decreasing the sensitivity will cause the value to increase or decrease by 1% rather than 5%.

6.8.3 Contrast

The Contrast setting controls how much of the image area is at the extremes of the color palette. The contrast ranges from 0 to 100%. The default setting is 0% (no added contrast). Pressing the **Normal** button (Figure 6-10) sets the Contrast to 0%.

As Contrast increases, more and more of the data is displayed at the extreme values of the color palette. Contrast can be useful for making weak targets more visible in the image.

GPR line signals vary from extreme negative values to extreme positive values with the zero signal in the middle. As the Contrast setting increases, the colors associated with the high positive and negative signal levels at the ends of the color palette widen, resulting in the weaker signals looking stronger in the image.

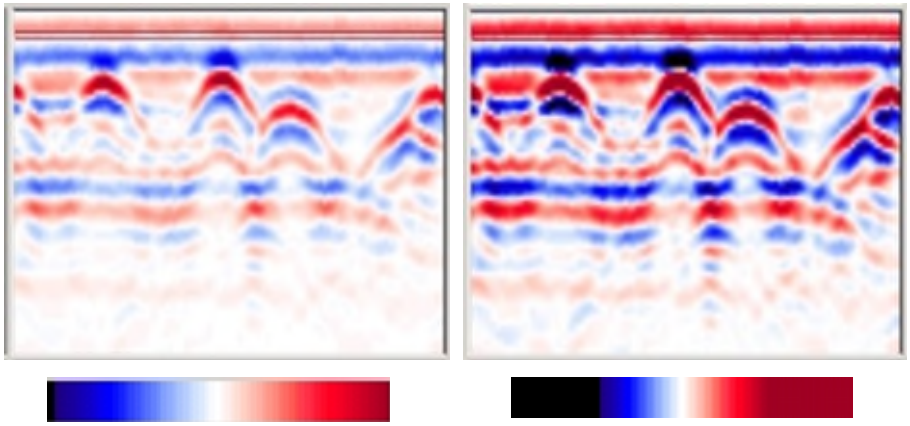


Figure 6-13: The Contrast value defaults to 0% meaning no contrast is added to the image (left, Contrast=0). As Contrast is increased, the colors on the left and right of the color bar associated with the strongest signals, widen into the middle, resulting in weaker signals looking stronger in the image (right, Contrast=50).

The Contrast is changed using the appropriate slider bar in the dialog box.



The Contrast setting for the image can also be modified by clicking on the slider bar and then using the left and right arrows on the keyboard to increase or decrease the value respectively. If you select the **Auto Preview** checkbox beforehand (Figure 6-10), the changes made to the Contrast setting will be instantly visible on the image.

The Contrast is increased by five percent (5%) by selecting **View > Contrast & Sensitivity > Contrast Increase** or clicking the following button on the **View Toolbar** (2.5):



The Contrast is decreased by five percent (5%) by selecting **View > Contrast & Sensitivity > Contrast Decrease** or clicking the following button on the **View Toolbar** (2.5):



Contrast can also be increased by 5% by pressing the "/" key and decreased by 5% by pressing the "." key on the keyboard.

Pressing the "Shift" key while increasing or decreasing the contrast will cause the value to increase or decrease by 10% rather than 5%.

Pressing the "Ctrl" key while increasing or decreasing the contrast will cause the value to increase or decrease by 1% rather than 5%.

6.8.4 Auto Preview

Selecting Auto Preview allows the user to instantly see the effect of changes made to the settings in the Color Palette tab, including Sensitivity, Contrast and the color palette. This is much faster than changing the settings and then clicking on the **Preview** button (6.1). However, it may be undesirable for large data files especially with Interpolation turned on (6.7.3) because the screen update may be sluggish.

6.8.5 Bipolar Color Palette

A bipolar color palette has colors for both positive and negative values with zero in the middle. Since GPR lines are normally displayed with amplitude values varying from negative to positive values, a bipolar color palette is the default and is not normally changed.

When the **Bipolar Color Palette** option is unchecked, the color palette becomes monopolar, meaning that zero amplitude moves from the middle of the color palette to the extreme left. The color palette only applies to the positive values of the signal amplitude; negative amplitudes are all colored the same color as zero amplitude data.

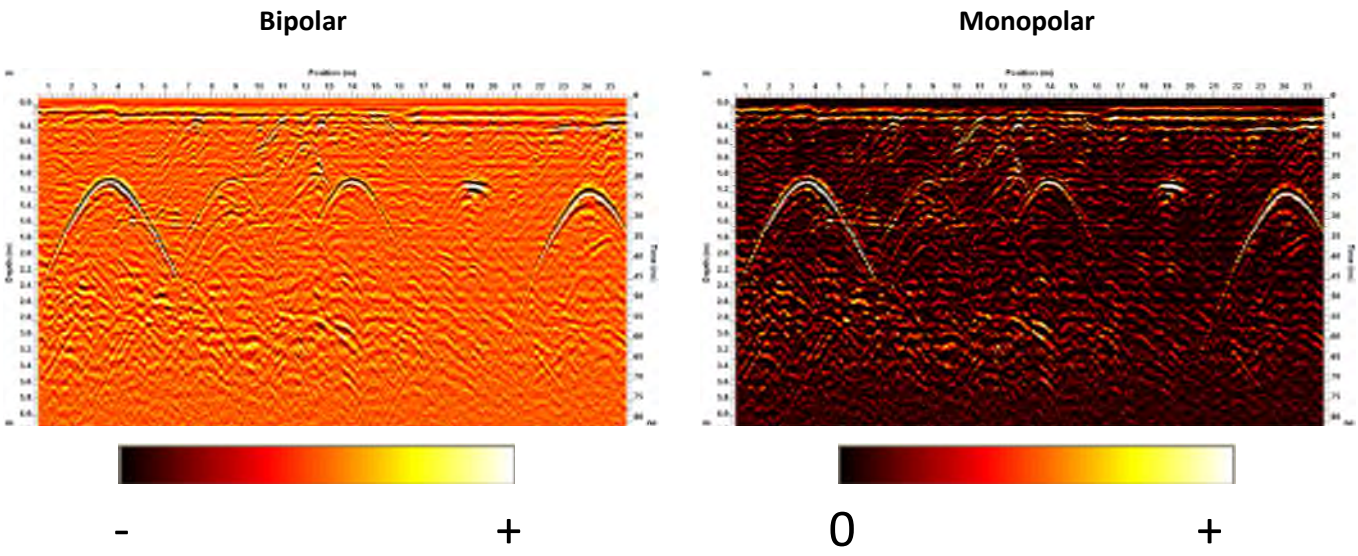


Figure 6-14: Bipolar color palettes (left) are typically used for displaying GPR data images. Both negative and positive signal amplitudes are displayed using the color palette. If a monopolar color palette is used (right), only positive signal amplitudes are plotted using the color palette. Any negative signal amplitudes in the data are all plotted with the color corresponding to zero (0) signal amplitude.

Processes available in the Processing module such as rectifying and enveloping GPR data as well as CMP Analysis, result in data with all positive amplitude values. In these cases, unchecking the **Bipolar Color Palette** option when viewing data allows the full color palette to be used for the positive values.

6.9 Gain/Filter Tab

The Gain/Filter Tab under View Settings is used to set the parameters for the processing of the GPR line, specifically, Dewow, Gain, Background Subtraction Filter and the DynaT Filter.

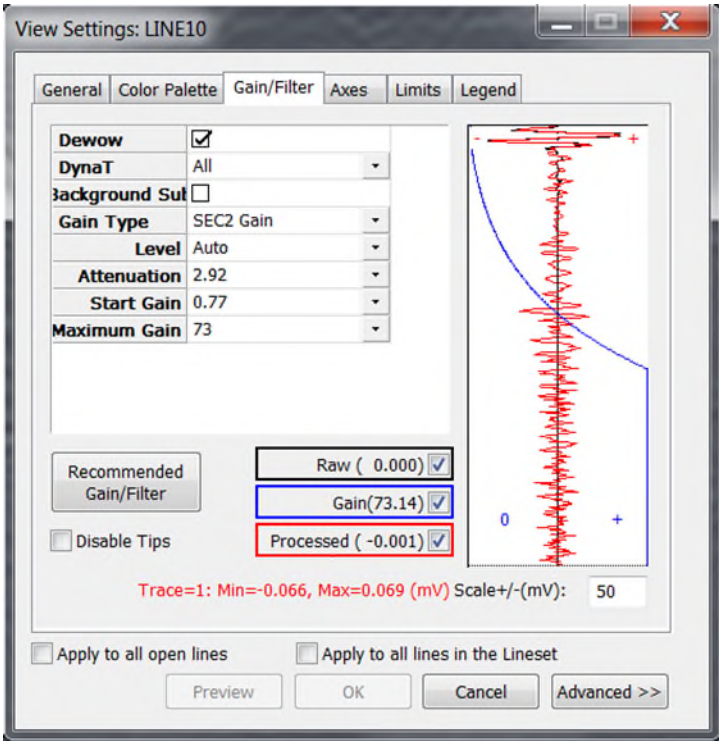


Figure 6-15: Gain/Filter Tab for setting the Dewow, DynaT, Background Subtraction filter and Gain. The Trace View on the right displays the Raw and Processed trace and the Gain.

A description of each parameter is displayed by holding the mouse cursor on the parameter input field. These descriptions are disabled by selecting the **Disable Tips** checkbox.

The Gain/Filter tab can also be accessed by selecting **View > Gain/Filter Settings** from the menu or clicking on the **View Settings** button on the **View Toolbar** (2.5):



6.9.1 Trace View

The Trace View is displayed on the right side of the dialog. It is a wiggle trace plot of the current trace at the mouse cursor position. A wiggle trace plot depicts the signal amplitude as a positive or negative deflection from zero (indicated by the + and - signs on the top corners).

After editing the Dewow or Gain parameters, the **Preview** and **OK** buttons become accessible. Pressing the Preview button re-displays the GPR line. It also re-displays the Processed trace in the Trace View using the new Dewow and Gain parameters.

Moving the mouse cursor horizontally to a different trace in the GPR line will display that trace in the Trace View.

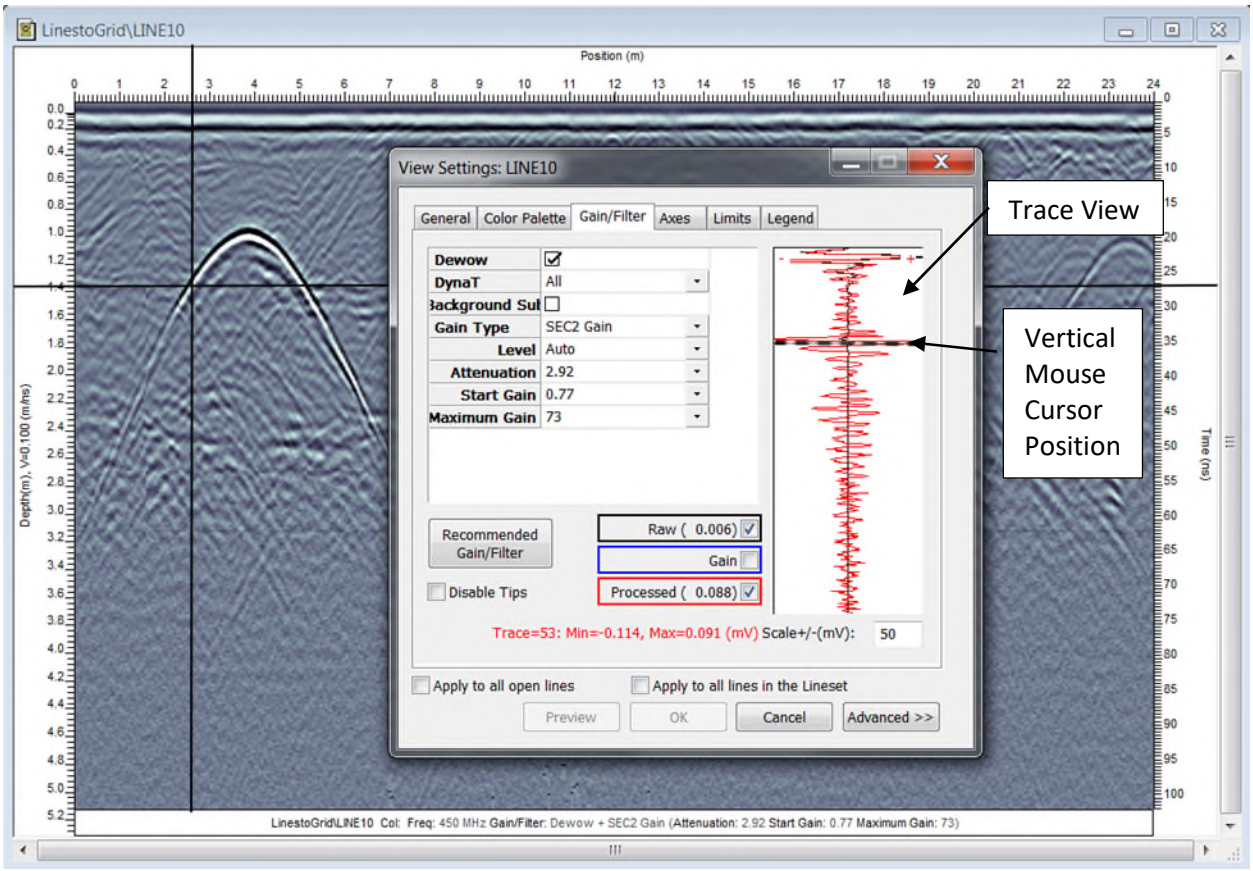


Figure 6-16: Moving the mouse cursor horizontally in the GPR line behind the Gain/Filter Tab will display the trace corresponding to the mouse cursor in the Trace View. Moving the mouse cursor vertically in the GPR line moves the Trace View cross-hair along the current trace. The raw and processed amplitudes are displayed to the left of the Trace View (if selected).

6.9.1.1 Trace Amplitudes

Using the checkboxes beside the Trace View, the user can select to display the **Raw** trace (in black), the **Processed** trace (in red) and the **Gain** (in blue).

Moving the mouse cursor vertically along a trace in the GPR line moves the corresponding horizontal cross-hair in the Trace View. The cross-hair makes it easy to see the signal amplitude at any point on the trace. The raw (in black) and/or processed (in red) signal amplitudes are displayed to the left of the Trace View (if checked).

6.9.1.2 Min and Max Trace Amplitude

Below the Trace View, the current trace number and amplitude information is displayed. The minimum and maximum amplitude values in millivolts (mV) for the trace at the current mouse cursor position is shown.

If the Raw checkbox is checked, the minimum and maximum amplitude values correspond to the raw trace and are displayed in black.

If the Processed checkbox is checked, the minimum and maximum amplitude values correspond to the processed trace and are displayed in red.

If both the Raw and Processed checkboxes are checked, the minimum and maximum trace amplitudes displayed are for the Processed trace (in red).

Change the scale of the Trace View plot by editing the Scale value to any number between 1 and 50 mV. The default scale is 50 mV.

6.9.1.3 Gain

The current Gain is displayed as a blue line in the Trace View by selecting the Gain checkbox (Figure 6-15). The shape of the gain will change depending on the **Gain Type** (6.9.4) and the gain parameters.

Gain values are always positive with zero on the left of the Trace View plot. The zero (0) and + in blue on the lower corners of the Trace View refer to the gain plot.

The Gain value at any point along the trace is displayed by moving the mouse cursor vertically along a trace in the GPR line and following the corresponding cross-hair in the Trace View. The cross-hair makes it easy to see the gain value at any point on the trace.

The Gain value is displayed in blue to the left of the Trace View.

The minimum and maximum values for the Gain function can only be displayed (in blue) under the Trace View if the Gain checkbox is checked and the both the Raw and Processed checkboxes are not checked.

When displaying the Gain function only, the Scale can be changed to any value up to 32767.

6.9.2 Recommended Gain/Filter

Pressing the **Recommended Gain/Filter** button will automatically set the processing for the current GPR line; Dewow is always selected and the **Gain Type** is set to SEC2 with a **Level** of **Auto**. Values for Attenuation, Maximum Gain and Start Gain parameters are calculated from the data and displayed.

To modify the Recommended Gain/Filter values, adjust the individual parameter values (see SEC2 (6.9.6.3)). Note that changing any of the parameter values automatically changes the **Level** from **Auto** to **User**.

6.9.3 Dewow

Depending on the proximity of the transmitter and receiver as well as the electrical properties of the ground, the transmit signal may induce a slowly decaying low frequency “wow” on the trace which is superimposed on the high frequency reflections.

The Dewow process is designed to remove this unwanted low frequency signal while preserving the high frequency signal. The removal of this wow in the data is also called the “signal saturation correction”.

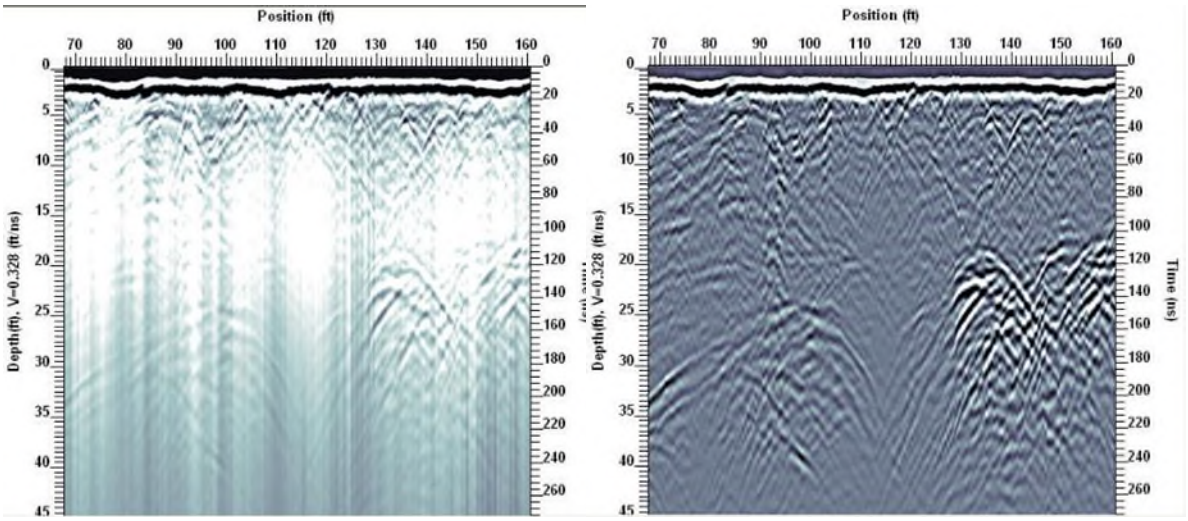


Figure 6-17: Data line showing raw data with the low frequency "wow" component (left) and after the Dewow process removes the low frequency component (right). The Dewow process is highly recommended when displaying GPR lines and slices.

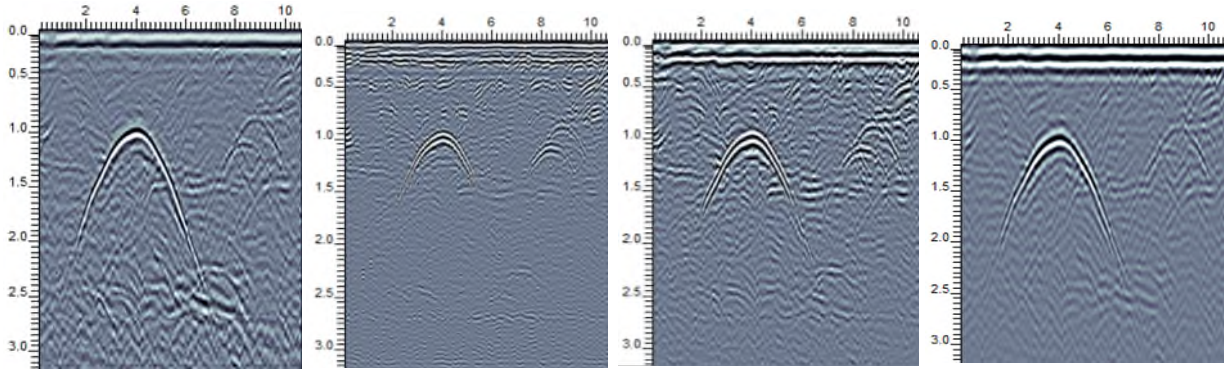
The wow is removed from the data by applying a running average filter on each trace. A window with a width the same as that of one pulsewidth at the nominal frequency is set on the trace. The average value of all the points in this window is calculated and subtracted from the central point. The window is then moved along the trace by one point and the process is repeated.

The Dewow process is highly recommended when displaying GPR lines.

6.9.4 DynaT

Dynamic Target (DynaT) preferentially enhances the response from targets of different sizes – small, medium and large. GPR signal amplitude is usually used to discern targets; small targets can be difficult to see in GPR data because they always produce smaller amplitude responses than larger targets.

The DynaT process exploits the fact that the frequency content of the returned signal varies with target size. The rate of change of signal amplitude with size varies especially strongly for small targets. Using the ultra-wideband frequency content inherent in the GPR signals generated by Sensors & Software GPR systems, DynaT differentiates the frequency-dependent GPR target responses to enhance the amplitude of targets based on relative size.



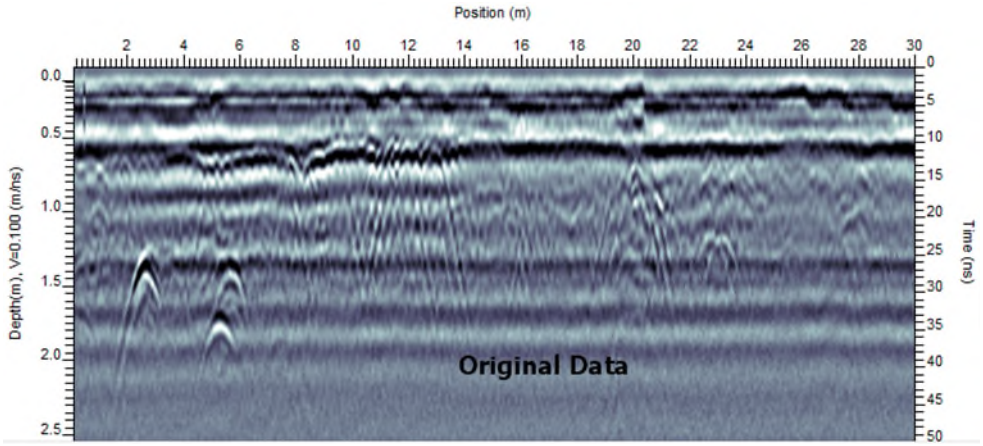
All Small Medium Large

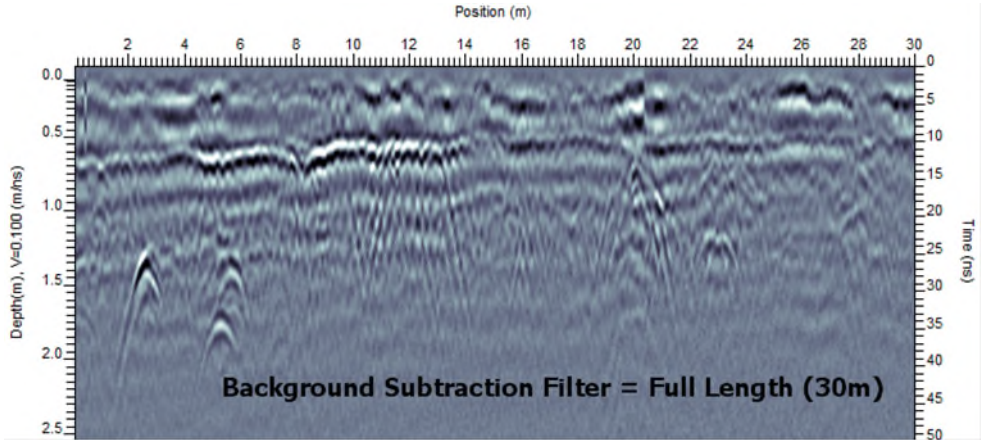
The DynaT parameter is All, Small, Medium or Large with the default set to All.

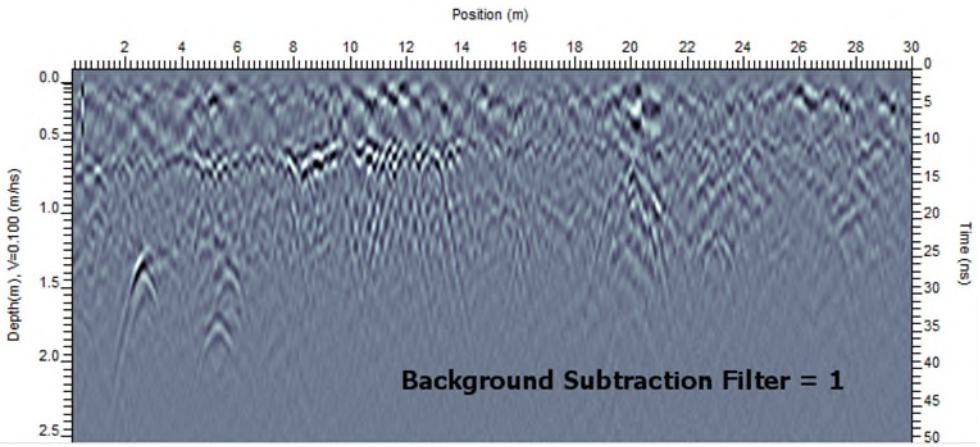
6.9.5 Background Subtraction

Background Subtraction is used to apply a running-average background subtraction filter to the GPR line.

The filter removes flat-lying events in the data to enhance dipping and hyperbolic reflections caused by utilities and other point targets. It can also assist in seeing very shallow targets that may be masked by the strong signals at the top of the GPR line.







Filter Width defines the length of the filter. A window of traces is averaged and the result is subtracted from the trace in the center of the window. The window moves along one trace and the process is repeated.

The longer the Filter Width, the longer the flat lying feature has to be for it to be removed. For example, setting the Filter Width to **Full Length** removes any local flat-lying reflections that are present in the whole GPR line, typically only the strong direct air and ground waves at the top of the line. The filter will remove these events but shorter, localized flat-lying reflectors will remain in the GPR line, although their amplitudes may be reduced.

The shorter the filter length, the shorter the flat lying feature has to be for it to be removed. For example, setting the Filter Width to 2 meters removes any local flat-lying reflections 2 meters long or longer. Flat-lying reflectors less than 2 meters long will remain in the data line, although their amplitudes may be reduced.

The background subtraction filter length must be set in the View Settings (Section 6.9.4) dialog but it can be quickly toggled on or off using the button on the View toolbar:



6.9.6 Gain Type

In general, GPR signals decrease rapidly with depth and in most cases it is necessary to amplify the signal using a "gain" function. Gain is used to amplify the strength of the GPR data signals in the GPR lines. Applying gain to GPR data is similar to adjusting the volume knob on a music stereo.

There are 5 Gain Types that can be applied to the GPR data:

1) None
2) SEC2
3) AGC
4) DVL
5) Constant

The current Gain **Level** is displayed in the Gain dropdown list on the **View Toolbar** (2.5). This dropdown list can be used to change the Level. The Gain Type is changed in the Gain/Filter Tab.

The current Gain Type and parameter values can be displayed in the Legend (6.12).

The shape of the current Gain is displayed in the Trace View by selecting the Gain checkbox (Figure 6-15).

Some data may have had a gain permanently applied using the EKKO_Project Processing module. If the data file is opened in LineView, a warning message will appear.



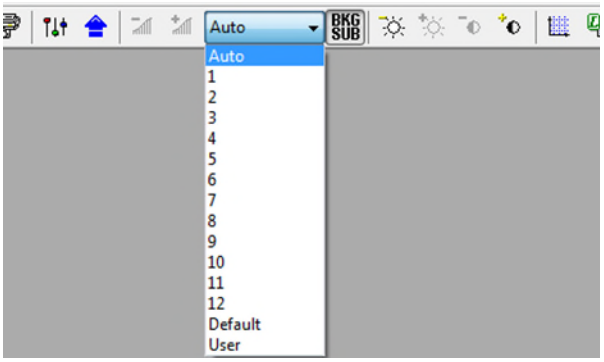
Typically, data that has already been gained should be plotted with the LineView Gain Type set to **None** (6.9.6.2).

6.9.6.1 Level

With the exception of No Gain (None), each Gain Type has one or more parameters that must be set. The Level option is used to set the gain parameter values.

Level options are: **Default**, **Numbered Levels**, **User** and, in the case of the SEC2 gain, **Auto**.

The Level is changed in this dialog but can also be changed using the Gain Level dropdown list on the **View Toolbar** (2.5):



Default: Sets the gain parameters to defined values that will work for most typical data sets but may not be optimized for the particular data being displayed.

When the Default Level is selected, the Gain buttons on the **View Toolbar** (2.5) are disabled.

Numbered Levels: Each gain also has up to 12 Numbered Levels. These are pre-defined gain parameter values that gradually increase the gain from Level 1 to the last level.

When the Level is set to a numbered level, it can be changed using the Gain buttons (7.7) or the Gain dropdown list on the **View Toolbar** (2.5). This makes it easy to quickly scroll through several pre-set gains and find one that makes the GPR line look the best.

User: Allows the user to input values for the gain parameters.

The best way to set the User gain parameters for the SEC2 gain type is to use the Recommended Gain/Filter button or the Default, Auto or Numbered Levels to determine the gain parameters close to

the gain you want. Then, simply select and edit the gain parameter you want to change and press Preview or OK. The **Level** automatically changes to **User** when the parameter value is edited.

When the User Level is selected, the Gain buttons on the **View Toolbar** (2.5) are disabled.

Auto: The SEC2 gain also has the Auto Level available. Using the GPR line, Auto uses the average decay curve of the GPR signal strength over time to calculate appropriate gain parameter values for Attenuation, Maximum Gain and Start Gain.

Implement those values by pressing Preview or OK.

When the Auto Level is selected, the Gain buttons on the **View Toolbar** (2.5) are disabled.

6.9.6.2 None (No Gain)

Selecting a Gain Type of None means that no gain will be applied to the GPR data before it is displayed. The “raw” data will be displayed.

This gain is not normally selected unless the material has very low attenuation and/or the targets of interest are shallow, for example, in ice profiling, snow and perhaps concrete.

As well, if the data has already had a gain permanently applied to the data (for example using the EKKO_Project Processing module), the Gain menu item should be set to **None** by the user or else the data will be gained a second time and may appear over-gained.

When a Gain Type of None is selected, the Gain buttons and dropdown list on the **View Toolbar** (2.5) are disabled.

6.9.6.3 SEC2

The Spreading Exponential Calibrated Compensation (SEC2) gain attempts to boost weaker signals by compensating for spherical spreading losses and exponential ohmic dissipation of energy in the radar data.

SEC Gain = Start Gain * Exponential

Since radar wave signal strength decays exponentially in the ground, the SEC gain represents the gain function closest to physical reality. The advantage of the SEC2 gain is that if correctly applied, relative signal strengths at different depths can be compared. This is not the case with other gains like AGC and Constant.

There are 3 input parameters for the SEC gain: Start Gain, Attenuation and Maximum Gain.

The strongest GPR signals come from shallow targets at the top of the GPR line while deeper targets lower in the GPR line have weaker signal strength. Therefore, the gain applied to the GPR line increases with increasing depth. The gain is a ramp that starts off at the Start Gain value at the top of the GPR line, ramps up on a slope with the steepness depending on the Start Gain and Attenuation value and levels off to a constant multiplier when the Maximum Gain value is reached.

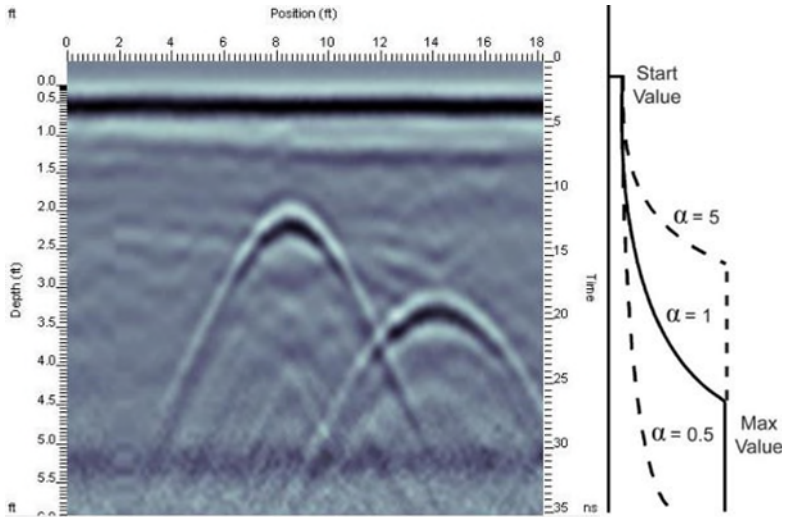


Figure 6-18: GPR line with the gain function shape and parameters on the right. In general, the Start Value is usually 1 or 0, attenuation (a), which controls the steepness of the slope is usually 0.0 to 20 and the Maximum Gain, which cuts off the exponential rise is usually 20 to 1000. Try to avoid over-gaining the data. Start with low values for Attenuation and Maximum Gain and increase as necessary.

Attenuation

The Attenuation represents the radar wave attenuation (in dB/m) and this determines the steepness of the ramp created for the SEC2 function. Lower values mean a more gradual slope while higher values are steeper. The ramp starts at the Start Gain value and ramps up to the Maximum Gain value.

Changing the attenuation usually has the biggest effect on the data display as compared to the Start Gain and Maximum Gain values.

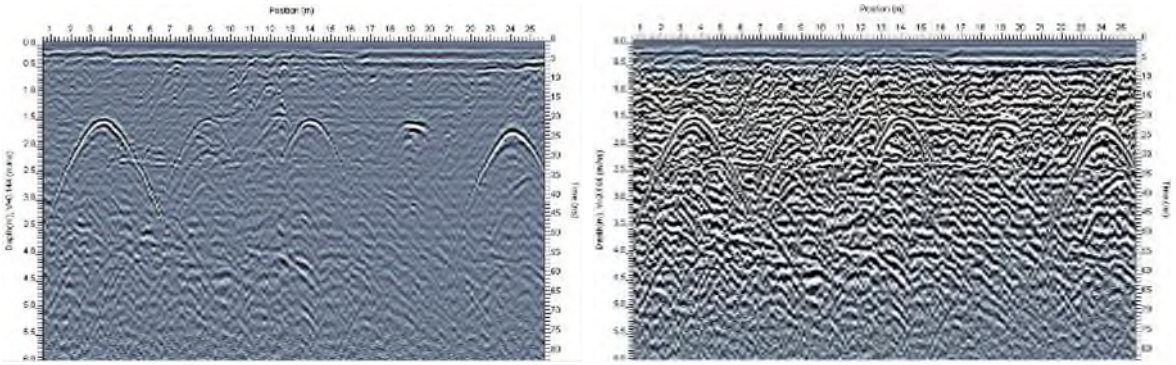


Figure 6-19: A low value for Media Attenuation makes the GPR line look good (left) while a high value over-gains the data, in this case (right).

Typical values for the Attenuation are 0 to 20 (selected from the drop-down list) but any value can be input by typing it directly into the field. Attenuation values over 20 may be necessary for materials with very high attenuation. The default value is 5.

Low values for Attenuation are typically used but higher values may help to improve the imaging of deeper targets. Try to use the lowest value possible as the data can be "over-gained" making it more difficult to understand.

Start Gain

The Start Gain is the gain value at zero depth at the top of the GPR line.

A Start Gain less than 1 can be used to reduce signal amplitudes prior to first-break time (also called time zero). If the Start Gain is 1 or more it is only applied after first-break time (leaving pre-first-break data unchanged).

Typically values for the Start Gain are 1 to 5 with 1 being the default value. Data with high attenuation may require a higher value for Start Gain, perhaps as high as 10.

Since the Start Gain is a multiplier for the exponential (Attenuation) value, the Start Gain value affects the steepness of the ramp associated with the Attenuation value. Higher values for the Start Gain will result in steeper ramps (more gain).

Maximum Gain

Since the SEC gain is an exponential function, it could go to infinity. The Maximum Gain is the highest multiplication factor for the GPR line. The ramp defined by the Attenuation stops increasing once it has reached the Maximum Gain value.

Typically values for the Maximum Gain are 20 to 1000 with 500 being the default value.

6.9.6.4 AGC (Automatic Gain Control)

The Automatic Gain Control (AGC) attempts to bring weak and strong signals to the same level by applying a gain function that is inversely proportional to the signal strength.

This type of gain is most useful for defining continuity of reflecting events. AGC does not preserve relative amplitude information hence, once the data have been AGC gained, one can no longer make reliable deductions concerning the strength of any particular reflector relative to other reflectors.

Each trace in the GPR section is processed such that the average signal is computed over a time window and then the data point at the center of that time window is amplified (or attenuated) by the ratio of the desired output value to the average signal amplitude.

Note that if a data point value multiplied by the gain value exceeds 50 mV absolutely, the new data point value becomes 50 or -50.

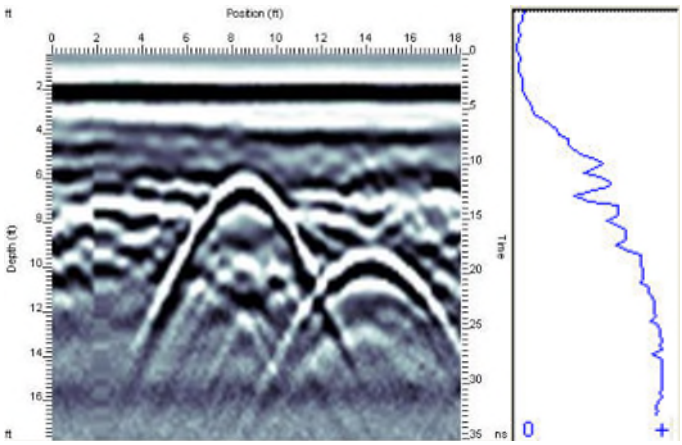


Figure 6-20: GPR line with an AGC gain applied. The AGC is calculated for each trace so varies for each trace. The AGC gain for the trace at position 1.5m is shown on the right. In general, the Window Width is usually 1.5 pulse widths and the Maximum Gain is 500.

There are two input parameters for the AGC gain, Window Width and Maximum Gain. Figure 6-20 shows the data with an AGC gain applied using a Maximum Gain value of 500 and a Window Width of 1.5.

Window Width

In computing the gain to be applied at each point, the program calculates the average signal level over a window of points given by Window Width and centered about the point. The Window Width is specified in units of pulse width based on the nominal antenna frequency. For example, for data collected at 100 MHz with a sampling interval of 0.8 ns, and a window width of 1.5, 28 points would be used to compute the average signal strength.

The Default of 1.5 for Window Width is perfectly adequate in most cases.

Maximum Gain

Since the AGC gain is inversely proportional to the signal strength, very small signals can produce very large gains. Therefore some type of gain limiting scheme must be applied. The Maximum Gain value represents an upper limit on the gain that can be applied to the data and weaker signals that would produce gains larger than this value, are capped at this maximum value.

The Maximum Gain can vary from 1 to 32767. The Default value is 500.

A typical value would be 50 - 2000 depending on the noise and average signal levels.

6.9.6.5 DVL Gain

The DVL Gain applies the same type of gain that is used on the DVL with Noggin systems. The DVL Gain is a two-staged gain.

First, it applies a linearly increasing gain (Beta) as a function of time. The second stage adjusts the sensitivity to smaller signals by an “S” curve gain (Alpha).

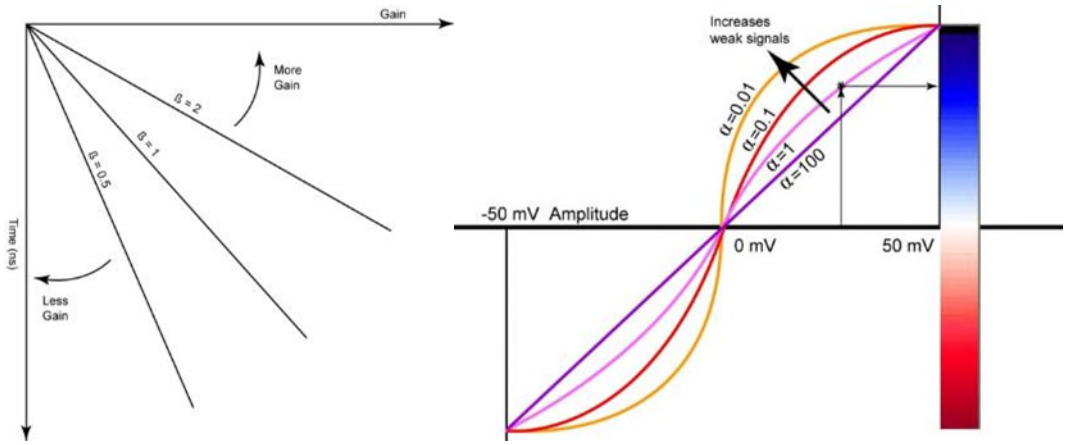


Figure 6-21: The DVL Gain is a two-stage gain. First, the Beta value applies a linear gain with a ramp (left). The higher Beta is, the steeper the ramp and the higher the gain. Then Alpha defines an S-shaped curve used to translate amplitude values to a color on the color palette (right).

There are two input parameters for the DVL Gain: Alpha and Beta:

Beta

Beta defines the linear gain as a function of time. The units are in gain per nanosecond. The higher the beta value, the steeper the slope and more gain applied to the data (Figure 6-21).

Beta varies from 0.01 to 100. The Default value is 0.04.

Alpha

Alpha defines the S shape of the second gain. If Alpha is 100, curve is linear and all signals have the same sensitivity. As Alpha decreases below 100, the S curve is larger, increasing the small signal sensitivity and decreasing the large signal sensitivity.

Alpha varies from 0.01 to 100. The Default is 1.0.

6.9.6.6 Constant

A constant gain will multiply all data by the user specified value. Thus if the user enters the number 10, all data points will be multiplied by a factor of 10.

Since both strong and weak signals are multiplied by the same amount, a constant gain factor has the potential to over-gain and clip the stronger signals shallow in the section and under-gain the weaker signals deeper in the section.

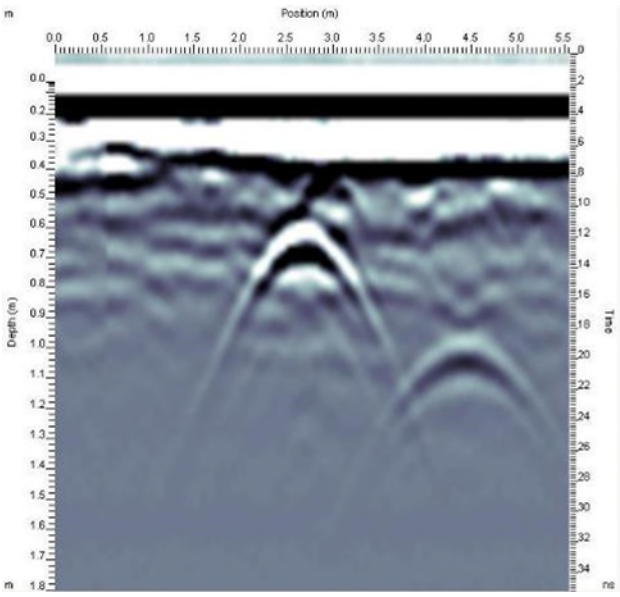


Figure 6-22: A Constant Gain of 20. The top of the section is over-gained while the bottom is under-gained.

The constant gain is the only parameter required:

Gain

The constant gain factor that the GPR data will be multiplied by.

Values can vary from 0.01 to 32767. Typical values for the Constant gain are in the range from 5 to 1000. The Default value is 100. A Gain value less than 1 will reduce the signal amplitudes.

6.10 Axes Tab

The Axes Tab under View Settings changes axes settings including units, titles, increment and grid lines. The image direction can also be changed.

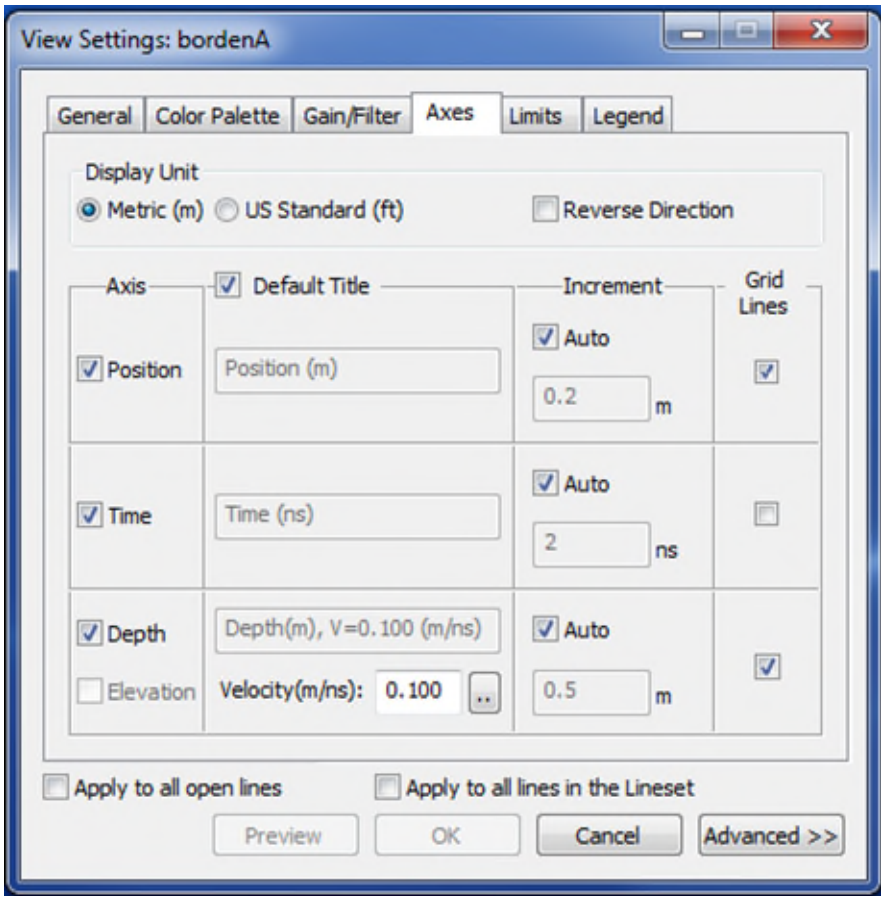


Figure 6-23: Axes tab to specify axes to display, grid lines, units and line direction.

6.10.1 Display Units

The **Display Units** setting determines the units that will be used for the Position and Depth axes; either meters or feet.

The units default to those used during the original data collection but can be converted and displayed in either meters (m) or feet (ft). For example, data collected in feet can be plotted in meters.

The display units can also be changed by pressing the “meters” or “feet” buttons on the **View Toolbar** (2.5):



6.10.2 Reverse Direction

The Reverse Direction checkbox is used to reverse the direction of the GPR line, for example, if the data positions go from 0 to 10m, reversing the direction will display the data from 10 to 0m.

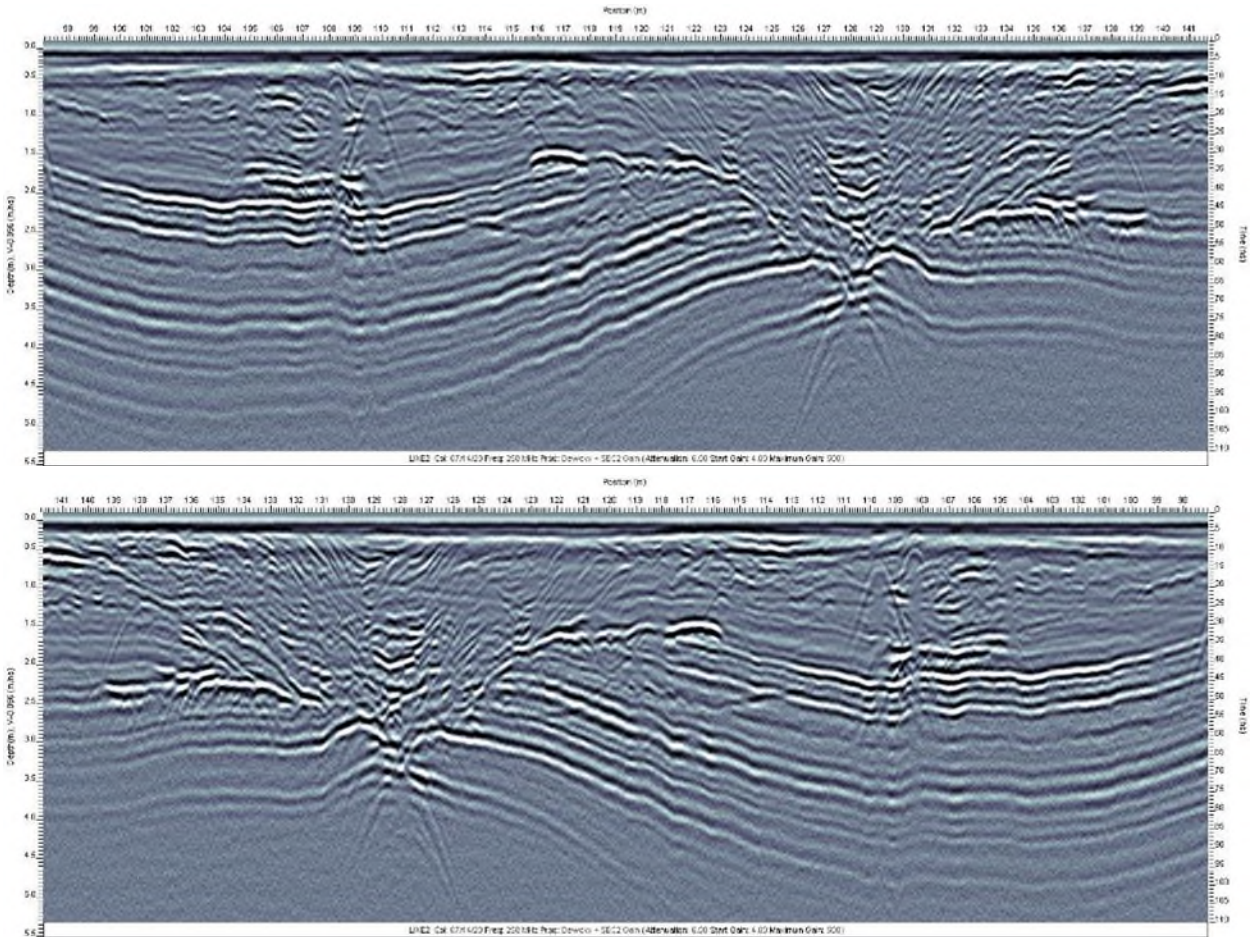


Figure 6-24: The Reverse Direction option.

Note that all features associated with position get reversed. This includes the position axis, GPS, flags/fiducial markers and skipped traces.

This option is designed to allow users to compare lines collected in a zig-zag (also called Forward - Reverse) survey format in the same orientation.

6.10.3 Axes

GPR lines are typically displayed with a position axis across the top, time axis on the right side and depth or elevation axis on the left side. The axes settings are changed in this tab.

The Axes tab can also be accessed by clicking on the **Vel** button on the **Velocity Toolbar**:



Features common to all axes are:

Any axis can be removed from the GPR line by unchecking the appropriate Axis checkbox.

- All Axes can be quickly displayed or removed from the GPR line by checking or unchecking the **View > Show/Hide > Axes** option (7.15.7).
- The position, depth and elevation axes units default to the units used during data acquisition but can be changed under **Display Units** (6.10.1).
- The Title for the axis can be left as the **Default Title** or the user can uncheck the Default Title checkbox and enter a custom title.
- The axis **Label Increment** is automatically set from the data limits if **Auto** is selected. The user can define the axis label increment by unchecking the Auto checkbox and entering a value. The axis labels are displayed with the number of decimal places specified in the input value; for example, a value of 10.00 will display axis label values of 0.00, 10.00, 20.00 etc.
- Grid lines associated with an axis can be removed from the GPR line by unchecking the appropriate **Grid Lines** checkbox.
- All Grid Lines can be quickly displayed or removed from the GPR line by checking or unchecking the **View > Show/Hide > Grid Lines** option (7.15.8).

6.10.3.1 Position Axis

The Position Axis is displayed along the top of the GPR line (Figure 2-1) if it is checked in this dialog box.

Vertical Grid Lines corresponding to the Position Axis labels are displayed on the GPR line if the **Grid Lines** option is checked (Figure 2-1).

6.10.3.2 Time Axis

The Time Axis is displayed in nanoseconds (ns) along the right side of the GPR line (Figure 2-1) if it is checked in this dialog box. If, however, the Depth axis is unchecked and removed from the image, the Time axis moves to the left side of the GPR line.

Horizontal Grid Lines corresponding to the Time Axis labels are displayed on the GPR line (Figure 2-1) if the **Grid Lines** option is checked. Note that only time OR depth horizontal grid lines can be displayed; not both.

If the **Time Scale Offset** value is not set to the First Break (Section 7.4), the time offset value, in nanoseconds (ns), is displayed in the time axis title.

6.10.3.3 Depth Axis

The Depth Axis is displayed on the left side the GPR line (Figure 2-1) if it is checked in this dialog box. The depth axis is non-linear (squished on the top) to correct for the antenna separation.

GPR data are measured in time and to convert time to depth, a velocity value for the material scanned must be entered in the **Velocity** field on the Axes tab. This velocity value is displayed in the Depth Axis title.

Depth Axis Velocity

If you need help selecting an appropriate velocity, click on the ".." button beside the velocity value and a table of typical velocity values for various materials is displayed. The velocities are listed in meters per nanosecond or feet per nanosecond depending on the setting for units (0); the default velocity is 0.10 m/ns or 0.328 ft/ns.

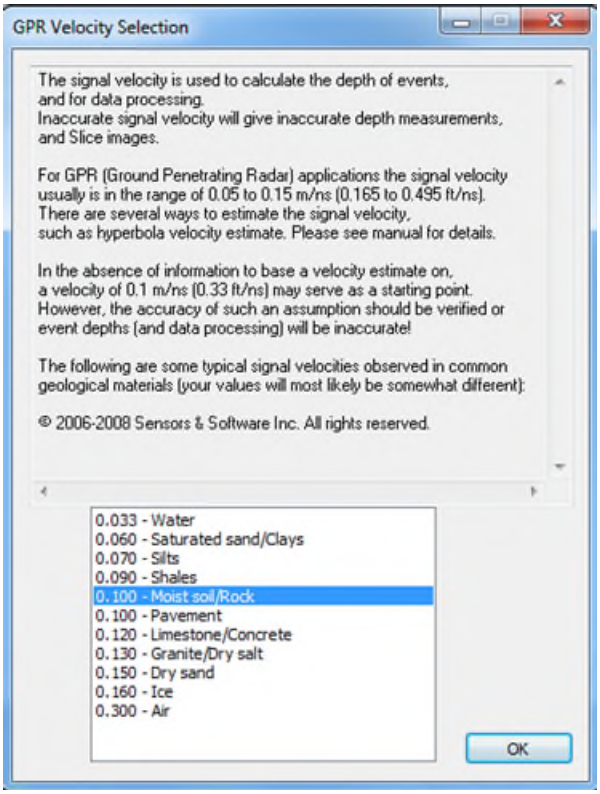


Figure 6-25: Velocity Table

An inaccurate velocity value will result in an inaccurate depth scale. If a hyperbolic response is observed in the data, the velocity can be extracted from the data by performing a Hyperbola Velocity Calibration (9.2.1). Velocity can also be extracted if you have GPR data over a target that is at a known depth in the subsurface (9.2.2) or from CMP/WARR data (9.2.3)

Horizontal Grid Lines corresponding to the Depth Axis labels are displayed on the GPR line (Figure 2-1) if the **Grid Lines** option is checked. Note that only time OR depth horizontal grid lines can be displayed; not both.

6.10.3.4 Elevation Axis

If topographic data were added to GPR data, the GPR line can be shifted to compensate for topography and plotted with an elevation axis.

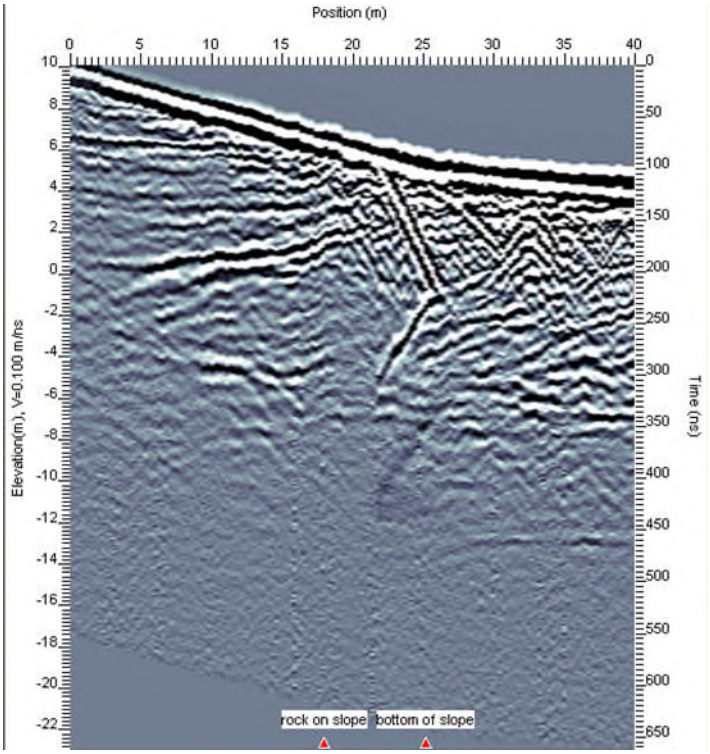


Figure 6-26: GPR line displayed with an elevation axis.

The Elevation Axis is displayed on the left side the GPR line (Figure 6-26) if it is checked in the dialog box under **View > Settings > Axes tab**.

GPR data are measured in time and to convert time to elevation, a velocity value for the material scanned must be entered in the **Velocity** field on the Axes tab. This velocity value is displayed in the Elevation Axis title. An inaccurate velocity value will result in an inaccurate elevation scale.

Elevation Axis Velocity

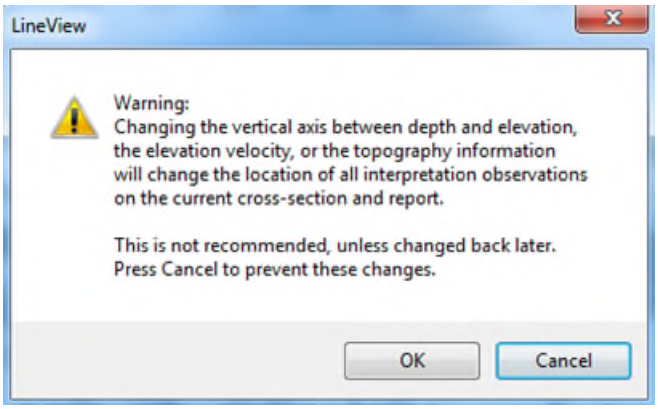
If you need help selecting an appropriate velocity, click on the ".." button beside the velocity value and a table of typical velocity values for various materials is displayed (Figure 6-25). The velocities are listed in meters per nanosecond or feet per nanosecond depending on the setting for units (0); the default velocity is 0.10 m/ns or 0.328 ft/ns.

Horizontal Grid Lines corresponding to the Elevation Axis labels are displayed on the GPR line if the **Grid Lines** option is checked. Note that only time OR elevation horizontal grid lines can be displayed; not both.

On a normal depth plot, the depth axis is non-linear (squished on the top) to compensate for the antenna separation. When plotting data with topography, part of the topographic shifting of the data file includes correcting for the antenna separation so the elevation axis is linear. This correction results in the upper part of the GPR line being slightly stretched.

Interpretations and Depth/Elevation Axes

When interpretations are added with one type of axis (depth or elevation) and the user tries to switch to the other type of axis, a warning message is displayed:



It is best to decide whether you want the data plotted with a depth axis or an elevation axis BEFORE adding interpretations.

If the user desires observation values in the **Interpretation Report** (available in EKKO_Project) in elevations rather than depths, Interpretations should only be added after:

1) the GPR line has Topographic data added that will not be changed and
2) the GPR line is plotted with an Elevation Axis using a velocity value that will not be changed.

Changing either of these AFTER adding interpretations shifts the vertical positions of the interpretations and is NOT recommended.

6.11 Limits Tab

The **Limits Tab** under View Settings changes depth, elevation or time limits for the GPR line.

If data are plotted with a **Depth Axis** (6.10.3.3), the limits of the data image can be set using time and/or depth limits; Elevation limits are not accessible (Figure 6-27).

If data are plotted with an **Elevation Axis** (6.10.3.4), the limits of the data image can be set using time and/or elevation limits; Depth limits are not accessible (Figure 6-30).

The **Available Data Range** box shows the depth and time ranges. Depth ranges from zero (0.0) to the maximum depth of the data based on the velocity set under the **Depth Axis** (6.10.3.3). Time ranges from the start time (which is usually negative) to the end time in nanoseconds.

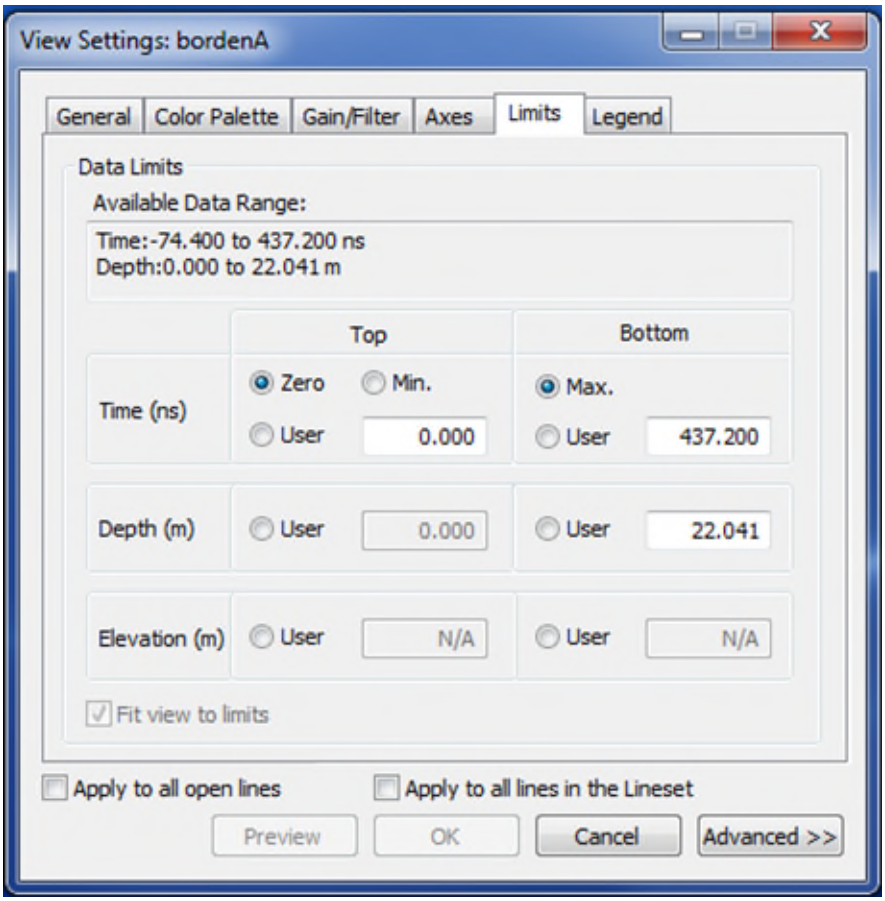


Figure 6-27: The View Settings > Limits Tab when the axis under the Axes Tab is set to Depth. In this case the Elevation limits are not accessible.

The **Limits** option and the **Apply to All** checkbox (6.4) are useful for plotting multiple data files, even those with different time window lengths, with the same limits so they can be easily compared on-screen.

6.11.1 Time Limits

6.11.1.1 Top Time

The Top Time Limit option allows the user to set the minimum time displayed on GPR lines (Figure 6-28). There are 3 options for this setting:

1) **Zero Time** (the default) displays data starting at the first break.

2) **Min Time** displays the GPR line starting at the minimum time; usually a negative time that includes all the data before the first break. The Min Time could be a positive time if the GPR line has been cropped.

3) **User Time** allows the user to input the minimum time to be displayed in the GPR line. Be cautious when using a positive top User Time because it will remove data at the top of the GPR line (Figure 6-28, bottom image).

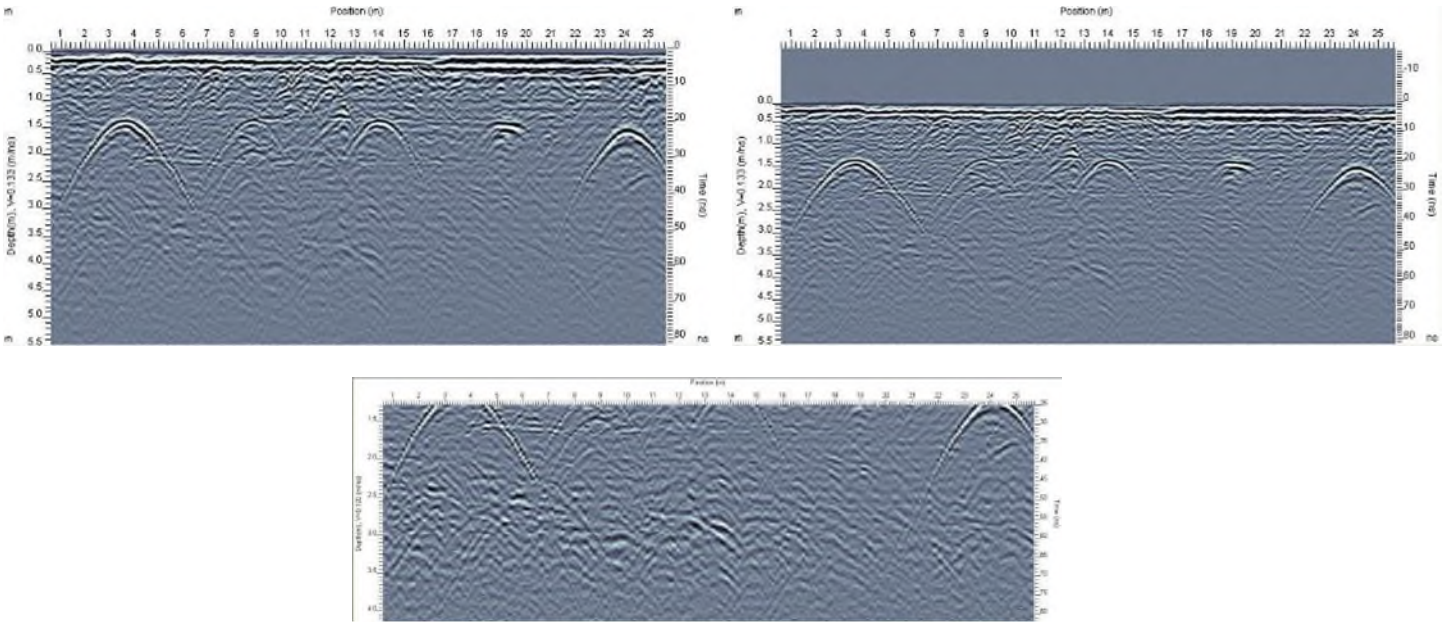


Figure 6-28: Zero Time (top left), Min Time (top right) and User Time (bottom) settings for the Top Time Limit.

6.11.1.2 Bottom Time

The Bottom Time Limit option allows the user to set the maximum time displayed on GPR lines.

There are 2 options for this setting:

1) **Max** (the default) displays the full time range of the GPR line,

2) **User Time** allows the user to input the maximum time to be displayed in the GPR line. A User Time less than the Max time will crop data from the bottom of the image.

If the Bottom User Time is set to a value larger than the maximum time of the GPR line, the GPR line will show the time axes but the data below the Maximum time will be blank (Figure 6-29, middle image).

6.11.2 Depth Limit

The Bottom Depth Limit option allows the user to change the maximum depth displayed on GPR lines.

If the maximum depth value is less than the maximum depth in the data, the bottom of the GPR line is cropped. If the maximum depth value is greater than the maximum depth in the data, white space is added to the bottom of the GPR line (Figure 6-29, middle image).

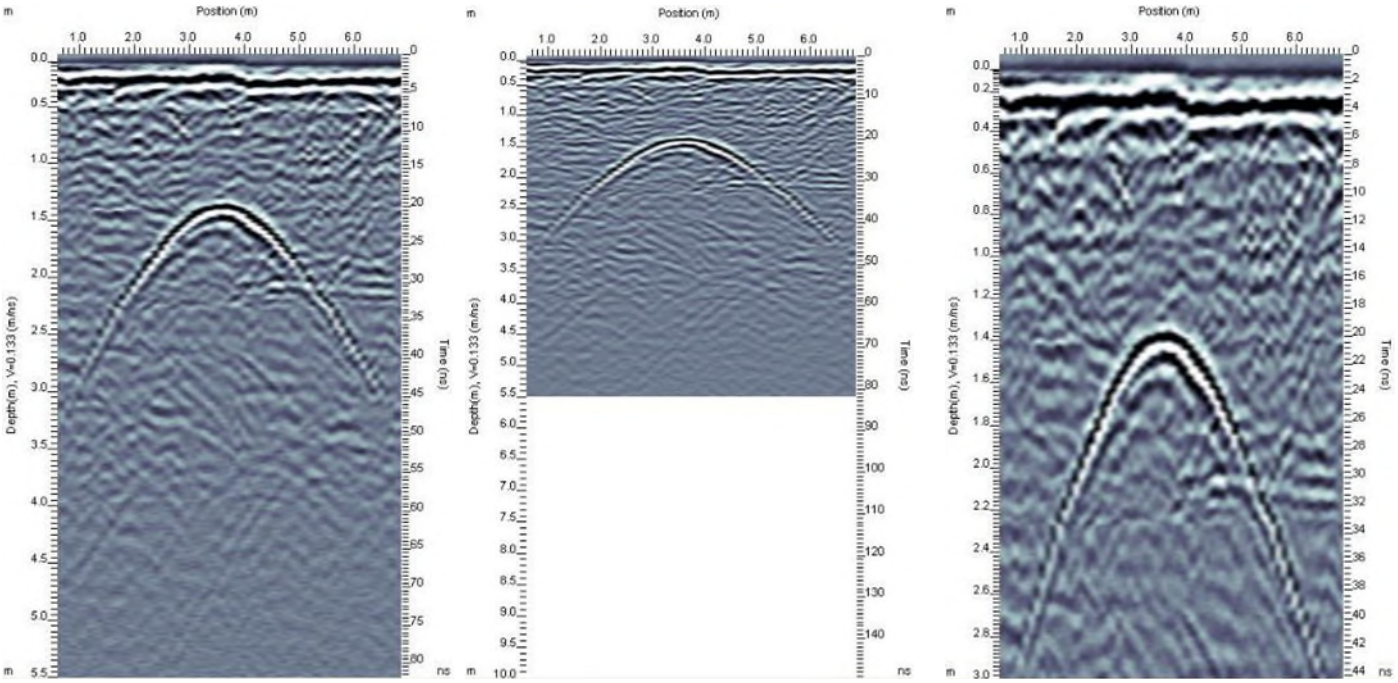


Figure 6-29: The Bottom Depth/Time Limit (left) shows the full depth/time of the GPR line (left) while the User Depth and User Time options can be set to show more (middle) or less (right) data.

6.11.3 Elevation Limit

The Elevation Limits are only accessible if data are plotted with an Elevation Axis (6.10.3.4).

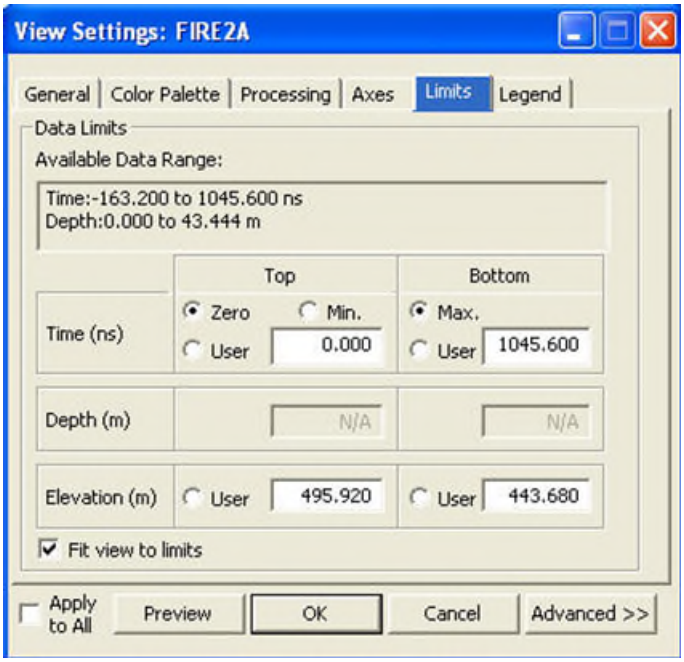


Figure 6-30: The View Settings > Limits Tab when the axis under the Axes Tab is set to Elevation. In this case the Depth limits are not accessible.

The Elevation Limits allow the user to change the maximum and minimum elevations displayed on GPR lines.

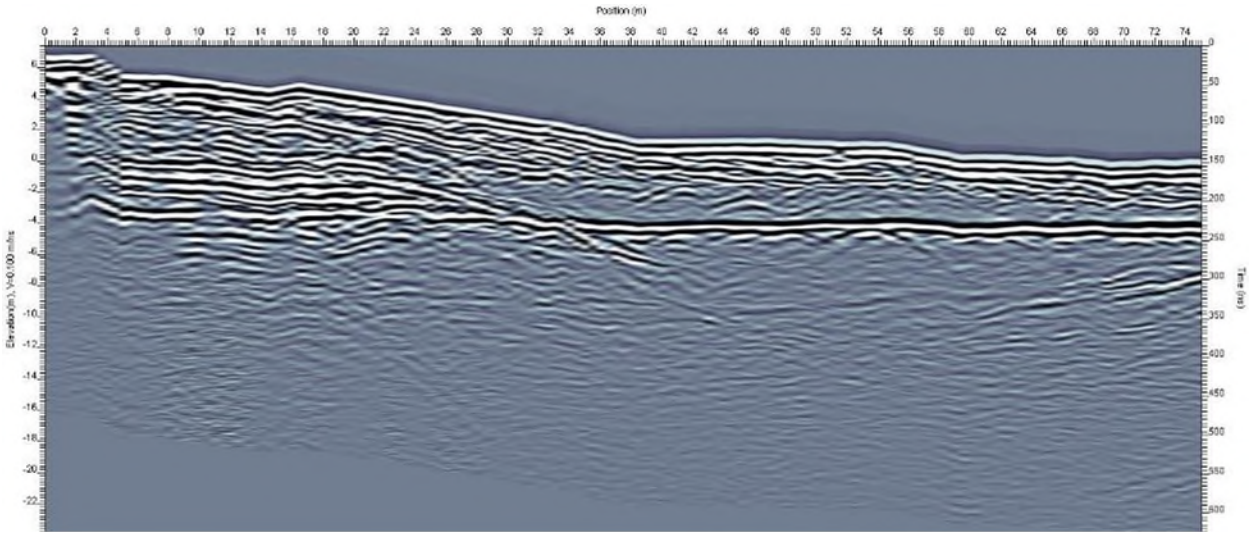


Figure 6-31: The elevation limits default to the highest and lowest elevations in the data file. These values can be edited in the Limits dialog.

6.11.3.1 Top Elevation

The Top Elevation defaults to the highest elevation value in the data file (Figure 6-31).

If the Top Elevation is set greater than the highest elevation in the GPR line, the full elevation axis is displayed but white space is added to the top of the GPR line (Figure 6-32).

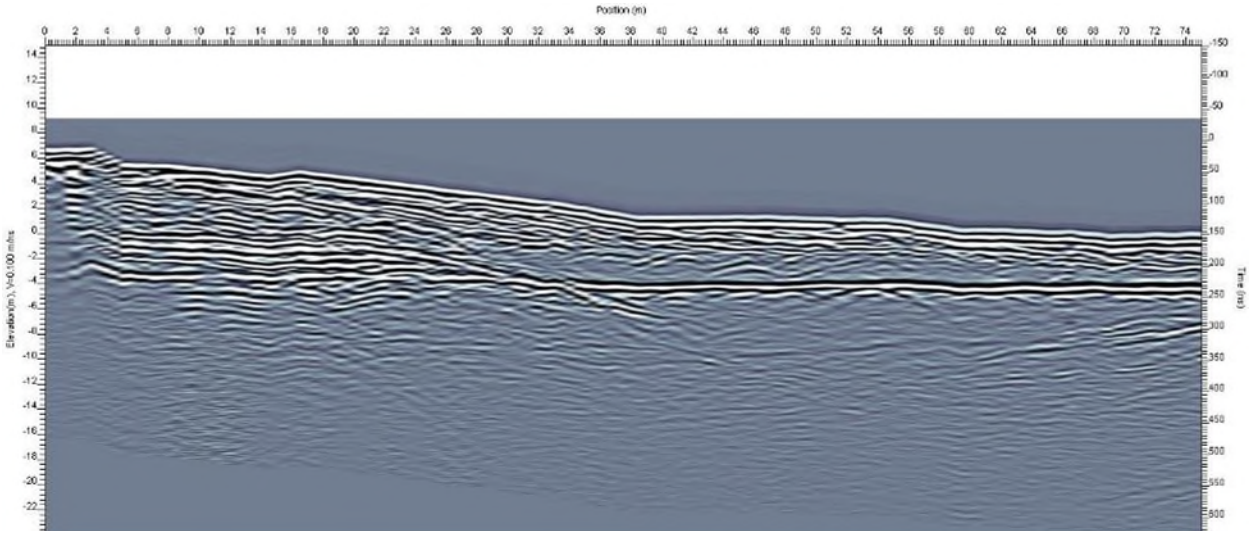


Figure 6-32: If the Top Elevation value is higher than the highest elevation value in the data file, white space is added to the top of the image.

Be cautious when using a Top Elevation that is set less than the highest elevation in the data because it will remove data at the top of the GPR line (Figure 6-33).

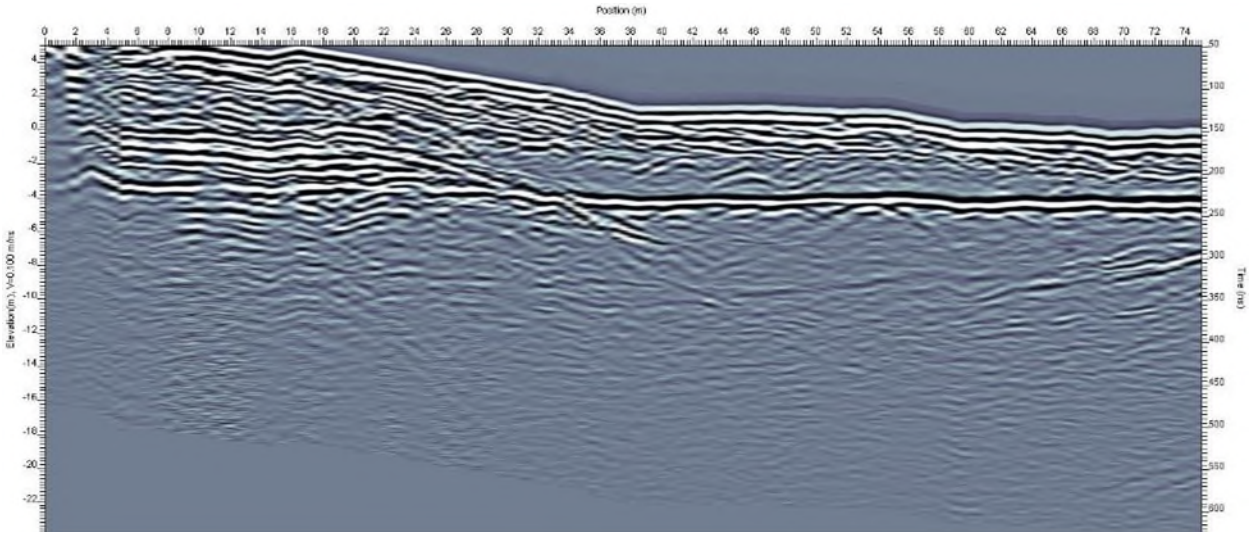


Figure 6-33: If the Top Elevation value is lower than the highest elevation value in the data file, data at the top of the image is cut off.

A popular use of the Top User Elevation value is to set a common datum value for a number of related GPR lines so they can be easily compared.

6.11.3.2 Bottom Elevation

The Bottom Elevation defaults to the lowest elevation value in the data file (Figure 6-31).

If the Bottom Elevation is set less than the lowest elevation in the GPR line, the full elevation axis is displayed but white space is added to the bottom of the GPR line.

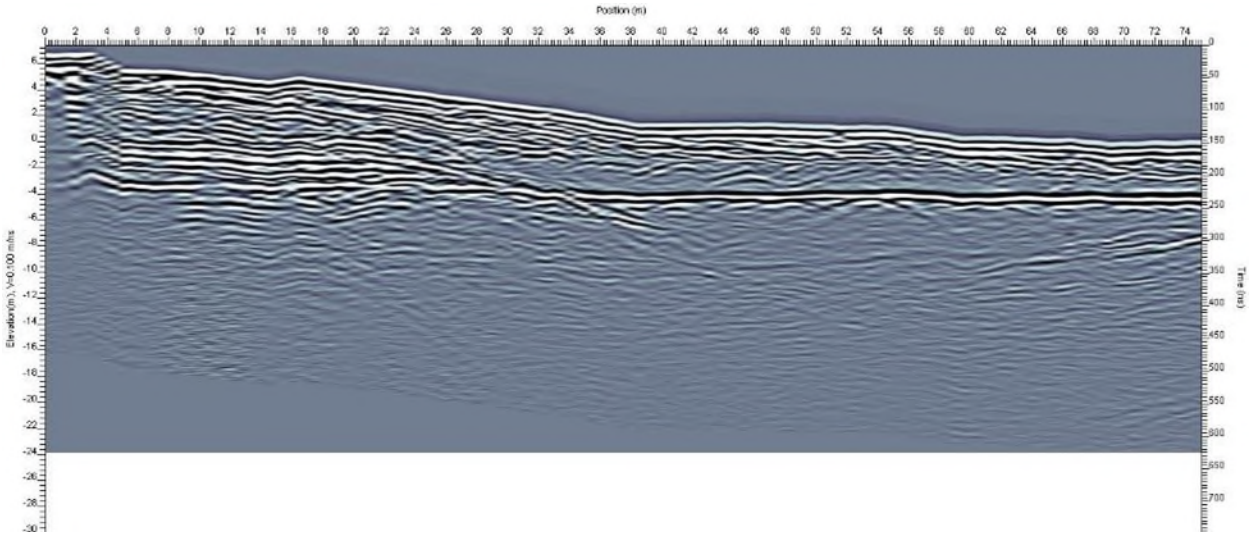


Figure 6-34: If the Bottom Elevation value is lower than the lowest elevation value in the data file, white space is added to the bottom of the image.

If the Bottom Elevation is set greater than the lowest elevation in the GPR line, data is cropped off the bottom of the image.

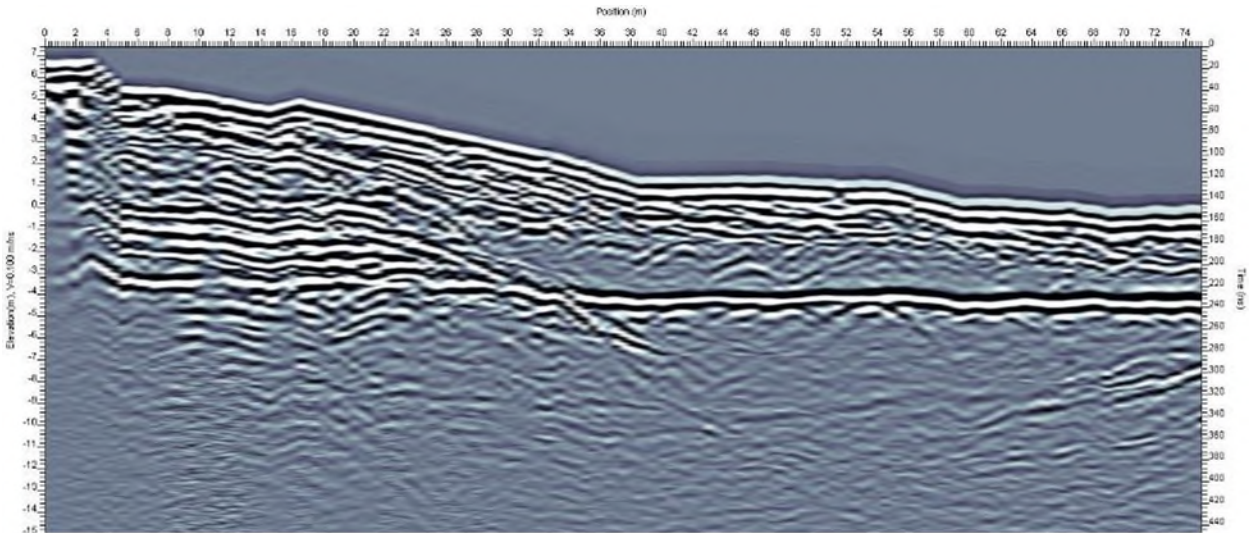


Figure 6-35: If the Bottom Elevation value is higher than the lowest elevation value in the data file, data at the bottom of the image is cut off.

6.11.4 Fit to View Limits

If the Fit to View option is selected, the Top and Bottom Limits defined are displayed in the full window.

For example, the original data has a Bottom Limit set to the Max of 9.5m. If the Bottom Limit is changed to 5m, the data image is expanded vertically to fill the full window (Figure 6-36).

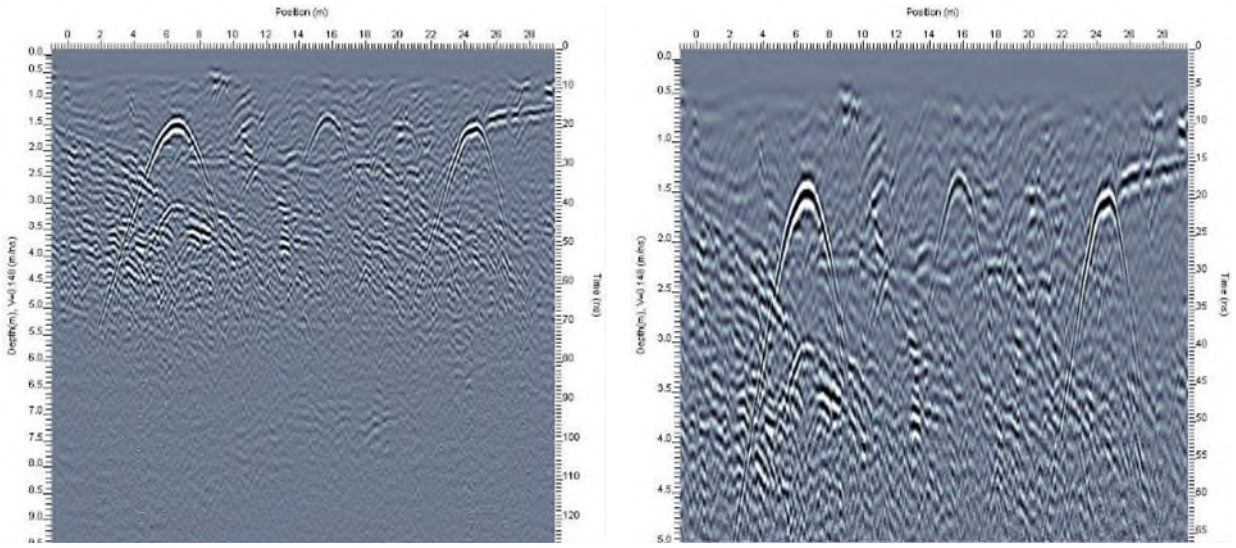


Figure 6-36: Fit to View On: The Bottom Limit is set to the maximum of 9.5m (left). If the Bottom Limit is changed to 5m and Fit to View is on, the data image is expanded vertically to fill the window with a maximum depth of 5m (right).

If the **Fit to View** option is not selected, the Top and Bottom Limits are displayed in the window at the original vertical scale and the data will be truncated and white space will appear at the bottom of the image. For example, the original data has a Bottom Limit set to the Max of 9.5m. If the Bottom Limit is changed to 5m, the vertical scale remains the same as the original and the data image is truncated at 5m (Figure 6-37).

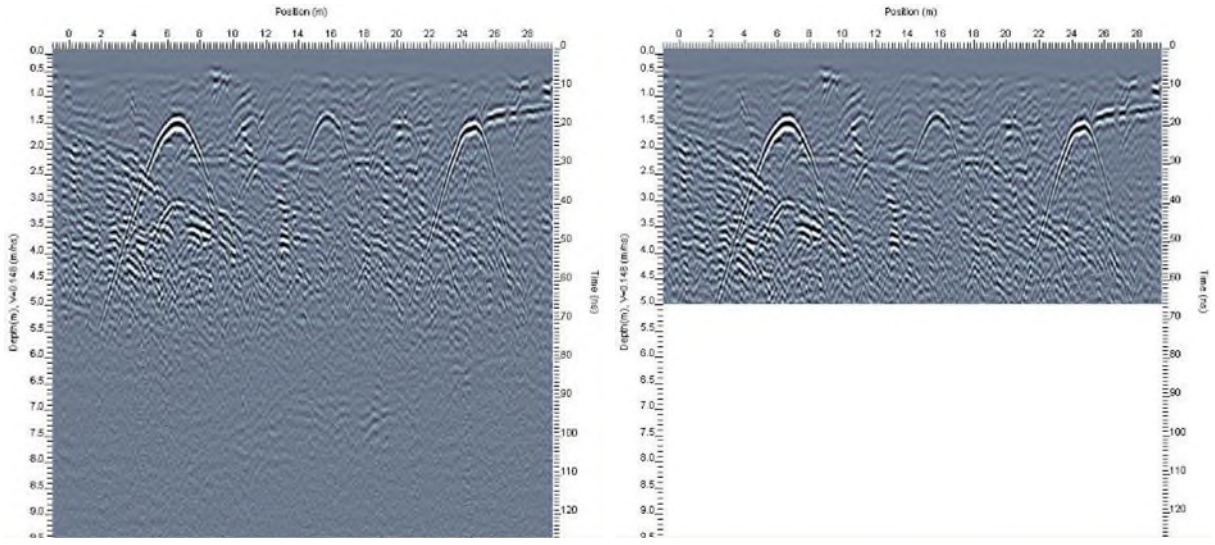


Figure 6-37: Fit to View Off: The Bottom Limit is set to the maximum of 9.5m (left). If the Bottom Limit is changed to 5m and Fit to View is off, the vertical scale does not change and the data image is truncated at 5m (right).

6.12 Legend Tab

The Legend Tab is used to select the options and order of the options displayed on the legend (Figure 2-1).

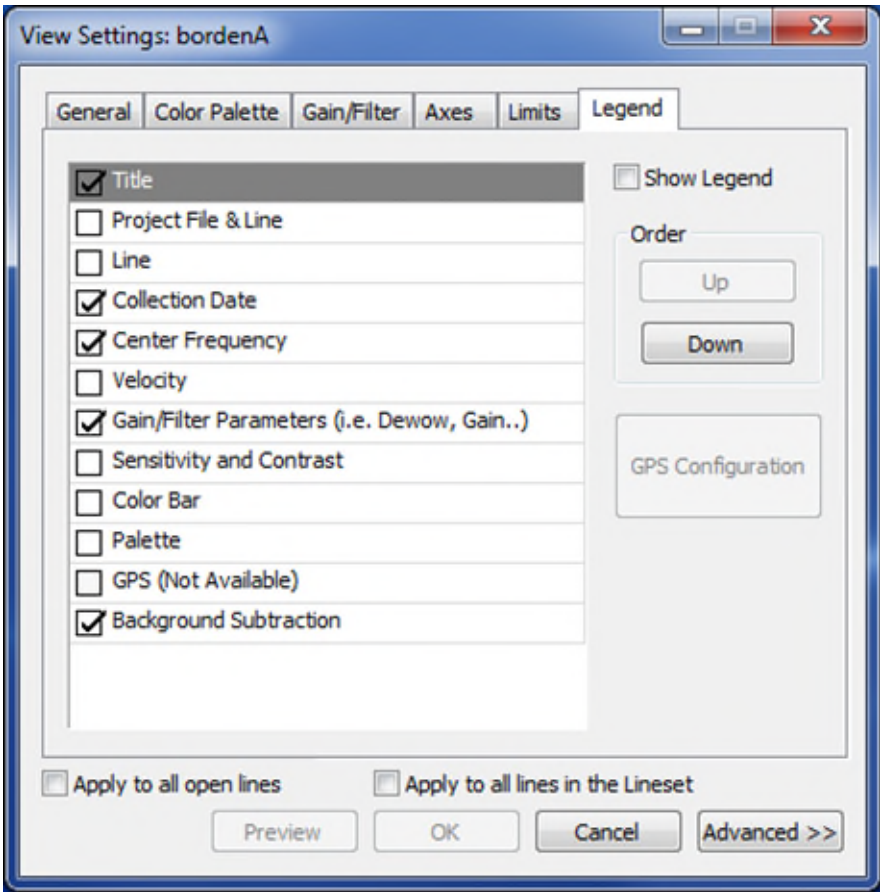


Figure 6-38: The Legend tab controls the options and order of the options displayed on the legend under the data image.

The Legend appears on the bottom of the data image if:

1) the Show Legend checkbox is checked in this dialog,

2) the Show Legend button on the **View Toolbar** (2.5) is pressed, or

3) the Legend option under the View menu is selected (7.15.9).

To show the legends for multiple data images at once, check the **Show Legend** and **Apply to All** checkboxes and then press OK. To hide the legends for multiple data images at once, uncheck the **Show Legend** checkbox, check the **Apply to All** checkbox and then press OK.

Check the options that you want to appear in the legend. Change the order by highlighting the option and then using the Up and Down buttons to move the option.

The legend options are:

1) **Title**: as defined in the **View > Settings > General Tab** (6.7.1). The default Title is the GPR Line name, so if that Project File & Line (below) is selected in this dialog, the GPR line name will appear twice in the Legend.

2) **Project File & Line**: the name of the Project file followed by the PC sub-folder path and GPR line name.

3) **Line**: the PC sub-folder path and the GPR line name.

4) **Collection Date**: the date the data file was collected.

5) **Center Frequency**: the antenna frequency the data file was collected with.

6) **Velocity**: in meters/nanosecond (m/ns) or feet/nanosecond (ft/ns) as listed under View > Settings > Axes > Depth Axis (6.10.3.3). The Velocity is also automatically displayed on the Depth Axis. The velocity can be calculated using the option under Tool > Hyperbola Velocity Calibration (9.2.1).

7) **Gain/Filter Parameters**: Indicates if the Dewow filter is on (6.9.3). Also lists:

    a. The Gain Type and gain parameters applied to the GPR lines (6.9.4).

    b. If the GPR line has a Background Subtraction filter applied to it (Section 6.9.4), this is indicated along with the filter length.

8) **Sensitivity and Contrast**: (S) in percent listed under View > Settings > Color Palette Tab > Sensitivity (6.8.2) and (C) in percent listed under View > Settings > Color Palette Tab > Contrast (6.8.3).

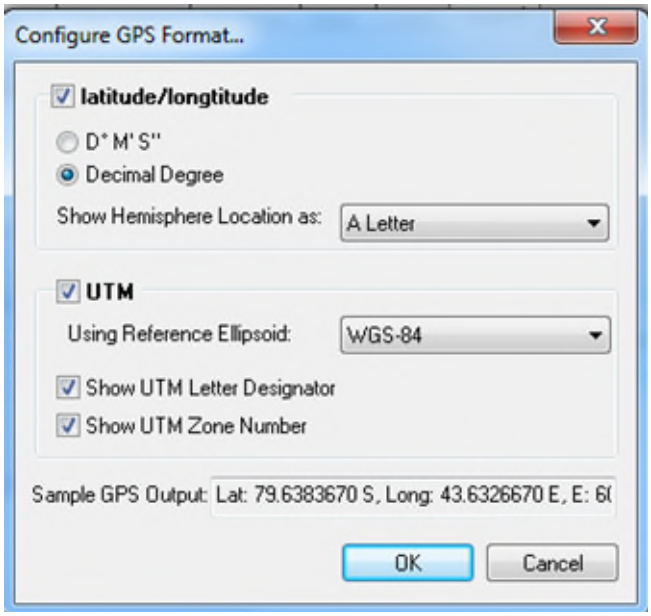
9) **Color Bar**: displays a graphic image of the color bar used for the data image and listed under View > Settings > Color Palette Tab > Color Palette (6.8.1).

10) **Palette**: the name of the Color palette used for the data image and listed under View > Settings > Color Palette Tab > Color Palette (6.8.1).

11) **GPS**: if the data file contains GPS information, this option displays the GPS start and end positions. The format is set by pressing the GPS Configuration from the Legend Tab.

6.12.1 GPS Configuration

If the GPR data file contains GPS data, the GPS Configuration dialog box is available.



6.12.1.1 Latitude/Longitude

If Latitude/Longitude is selected with the checkbox, the display options are:

1) **Degrees Minutes Seconds**
2) **Decimal Degrees**

The options for the Hemisphere are:

1) **Do not show**
2) Show as a **plus or minus sign**. A plus (+) sign if Latitude is in the Northern hemisphere or Longitude is in the Eastern Hemisphere and a minus (-) sign if Latitude is in the Southern hemisphere or Longitude is in the Western Hemisphere.
3) **Letter**: For latitude, “N” for North or “S” for South. For Longitude, “E” for East or “W” for West.
4) **Word**: For latitude, “North” or “South”. For Longitude, “East” or “West”.

A sample of the current GPS output is shown at the bottom of the dialog box.

6.12.1.2 UTM

If UTM is selected with the checkbox, the Reference Ellipsoid can be selected from the drop-down list. The default is WGS-84.

To display the UTM Zone Number and/or the UTM Letter Designator, select those options.

A sample of the current GPS output is shown at the bottom of the dialog box.

7 View Menu

The View menu option allows the user to change various aspects of the images including increasing and decreasing gain, sensitivity, contrast, zoom, pan, link views, change units, font and showing or hiding color scale images, wiggle traces, flags/fiducials, skipped traces, axes, grid lines, the legend, toolbars and Status Bar.

7.1 Settings

The View > Settings options are described in the **View Settings Menu** (6).

7.2 Gain/Filter Settings

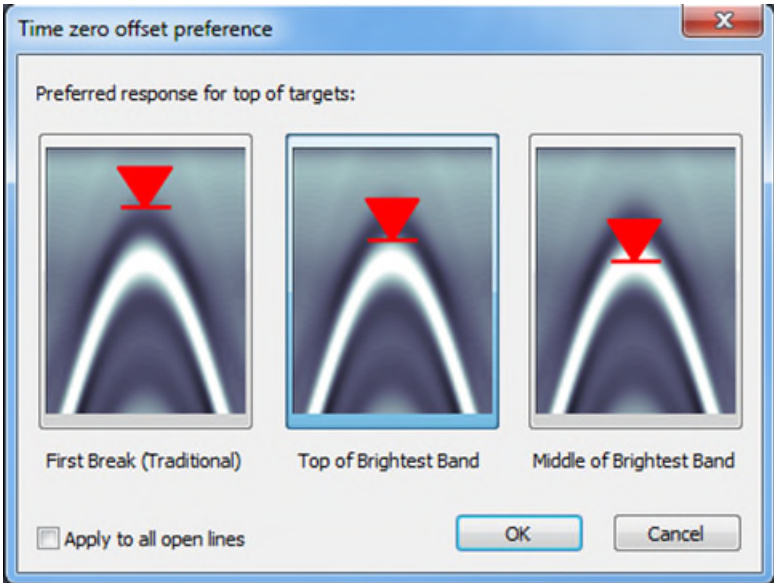
The View > Gain/Filter Settings menu option provides a shortcut to the **View > Settings > Gain/Filter Tab** (6.9).

7.3 Color Palette Settings

The View > Color Palette Settings menu option provides a shortcut to the **View > Settings > Color Palette Tab** (6.8).

7.4 Time Scale Offset

The Time Scale Offset allows the user to decide what part of the GPR response coincides with the top of the target.



There are 3 positions in the GPR response for the top of target to coincide with:

1) First Break (Traditional): top of the first band
2) Top of Brightest: top of the strongest band
3) Middle of Brightest Band: middle of the strongest band

If option 2 or 3 is selected, the time offset value is displayed on the Time axis title (Section 6.10.3.2).

When viewing multiple GPR lines at once, it is a good idea to make sure all the lines are using a consistent time scale offset.

Note even after interpretations have been added to the data, the **Time Scale Offset** preference can be changed; Interpretation Reports will still list the correct depth of the object.

7.5 GPR Line Properties

The View > GPR Line Properties option displays the header (.HD) file for the GPR data line displayed in the current **Active Window** (2.2.1). This is a text file saved with data (.DT1) file when data are collected. It contains survey parameter information as well as details of any editing or post-processing performed on the data file. An example is shown in Figure 7-1.



Figure 7-1: Header (.HD) file display.

This header file can also be printed from this dialog box by pressing the Print button.

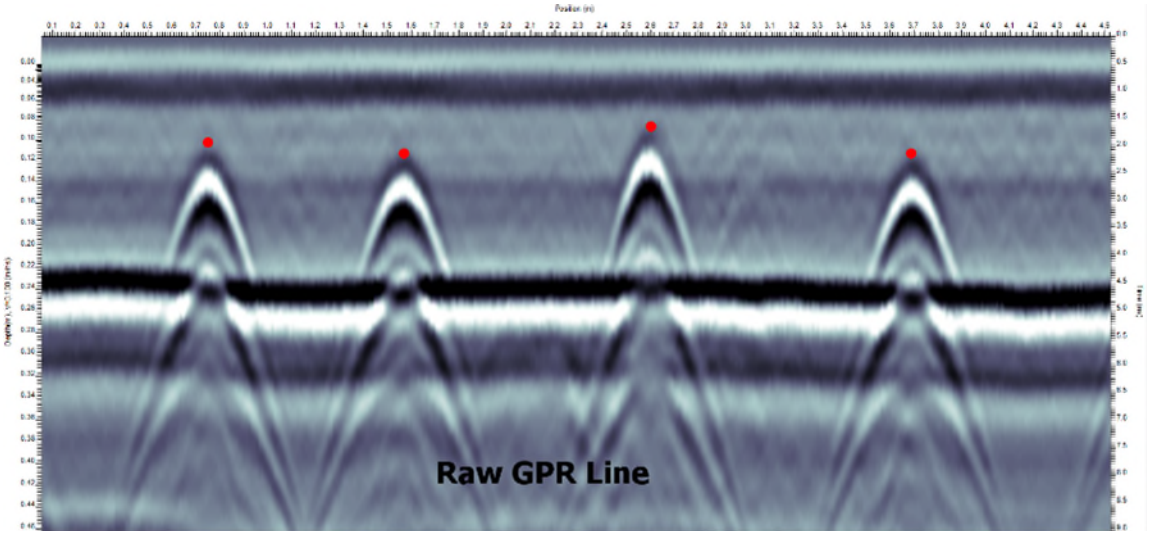
7.6 Assisted Pick Processing

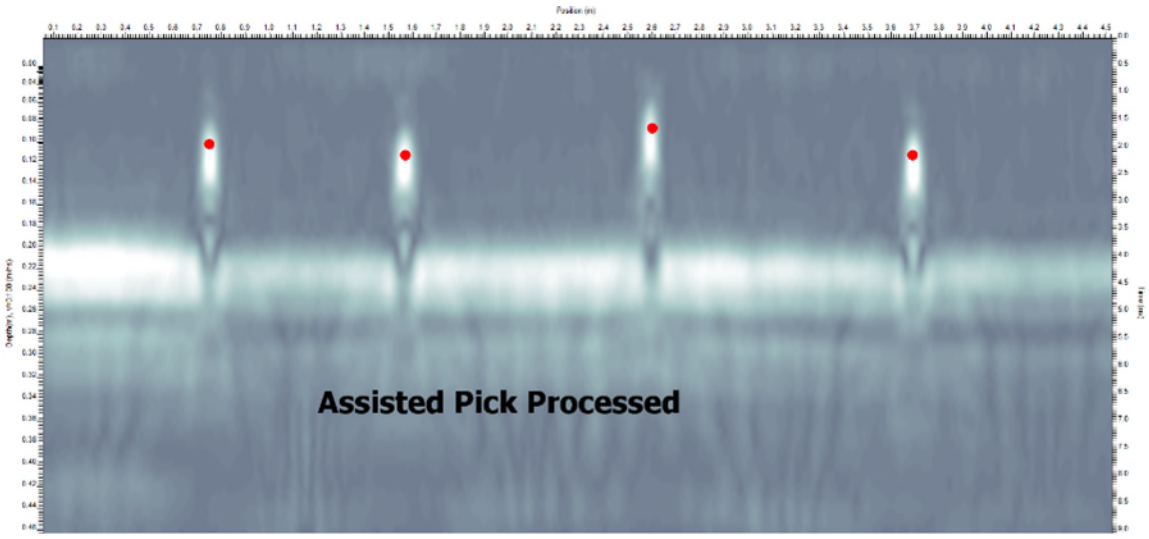
If the Interpretation module is enabled, Assisted Pick Processing can be turned on to assist in adding point interpretations on hyperbolic responses in the GPR line.

Assisted Pick Processing applies two processes to the current GPR line:

1) Migration uses the current velocity setting to collapse the hyperbolic response to a point.
2) Enveloping eliminates the negative parts of the GPR signals by rectifying and smoothing them.

Here is the effect of applying this processing on a GPR line with hyperbolic responses from rebar in concrete:





Together, these processes turn a hyperbolic response into a high amplitude point target that may be easier to pick then the hyperbola. In this mode, place the observation at the center of the point to get the correct depth or use Smart Points (Section 8.3.2) to ensure consistent picks.

Pressing the hot keys **Ctrl+T**, toggles the Assisted Pick Processing on and off.

7.7 Gain Increase / Decrease

Gain is described in detail under View > Settings > Gain/Filter Tab > Gain Type (6.9.4).

The options in the View menu are shortcuts for quickly changing the Gain Level.

The gain level is increased by selecting View > Gain Increase or clicking the following button on the **View Toolbar** (2.5):

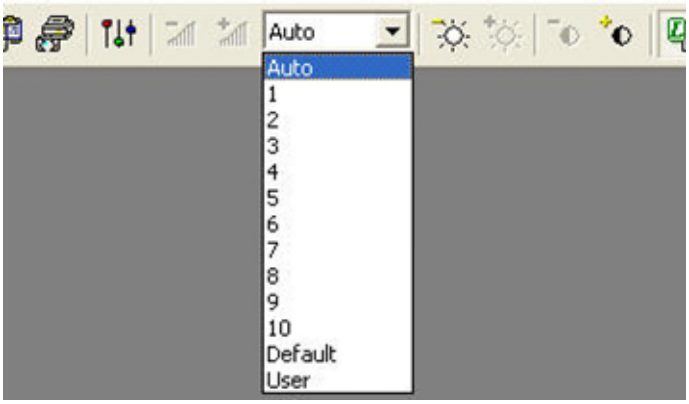


The gain level is decreased by selecting View > Gain Decrease or clicking the following button on the **View Toolbar** (2.5):



These buttons will be disabled if the Gain Level is set to Auto, Default or User. To enable them, set the Gain Level to a numbered value.

The Gain Level can also be changed using the Gain Level dropdown list on the **View Toolbar** (2.5):



The possible options are: Numbered Level, Default, User and Auto.

The Level Gain can also be increased by pressing the “+” key and decreased by pressing the “-” key on the numeric key pad on standard keyboards.

7.8 Contrast & Sensitivity

Contrast and Sensitivity are described in detail under **View > Settings > Color Palette Tab** (6.8).

The options in the View menu are shortcuts for quickly changing the Contrast and Sensitivity values using the menus.

The Contrast and Sensitivity values can also be changed using the buttons on the toolbar (2.5) or pressing keys on the keyboard (6.8.2 and 6.8.3).

7.8.1 Sensitivity Decrease / Increase

Sensitivity is increased by 5% by selecting the **View > Contrast & Sensitivity > Sensitivity Increase** option.

Sensitivity is decreased by 5% by selecting the **View > Contrast & Sensitivity > Sensitivity Decrease** option.

If the **Ctrl** key is pressed at the same time, the value changes by 1%.

If the **Shift** key is pressed at the same time, the value changes by 10%.

7.8.2 Contrast Decrease / Increase

Contrast is increased by 5% by selecting the **View > Contrast & Sensitivity > Contrast Increase** option.

Contrast is decreased by 5% by selecting the **View > Contrast & Sensitivity > Contrast Decrease** option.

If the **Ctrl** key is pressed at the same time, the value changes by 1%.

If the **Shift** key is pressed at the same time, the value changes by 10%.

7.8.3 Apply Normal Settings to Contrast & Sensitivity

The **View > Contrast & Sensitivity > Normal Settings** option sets the Contrast and Sensitivity values for the **Active Window** (2.2.1) to the defaults of zero (0) and 100 respectively.

7.9 Zoom

The Zoom options zoom in and out of the GPR line in the position direction.

Before zooming, make sure that the GPR line you want to zoom is the **Active Window** (2.2.1).

There are 4 ways of using the Zoom option:

1) Zoom in to an area 50% of the current image size by selecting View > Zoom > In or by pressing the Insert key or the following button on the **View Toolbar** (2.5):



Zoom in only applies to the position direction. It does not apply to the time or depth direction.

2) Zoom out to an area 200% of the current image size by selecting View > Zoom > Out or by pressing the Delete key or the following button on the **View Toolbar** (2.5):



Zoom out only applies to the position direction. It does not apply to the time or depth direction.

3) Draw a box around the area to zoom to by selecting **View > Zoom > Select Area** or by pressing the following button on the **View Toolbar** (2.5):



After selecting the option to zoom to an area, draw a box on the image by clicking and dragging from one corner diagonally to the opposite corner. A box will be superimposed on the image as you drag it. Dropping the box will cause the image in the box to zoom to the full window size.

4) Zoom to the full window size by pressing the Home key or by selecting **View > Zoom > Fit to Window** or by pressing the following button on the **View Toolbar** (2.5):



This option is usually selected to quickly return to the full image view (as determined by the data limits in the Limits Tab) after zooming in.

After zooming into an image, use the scroll bars to move around and view different areas. The width of the scroll bar gets narrower each time the image is zoomed in to indicate that a smaller percentage of the full image range is displayed.

When zoomed in on an image, the **Page Up** and **Left Arrow** keys scroll to the left and **Page Down** and **Right Arrow** keys scroll to the right.

Page Up and **Page Down** moves one whole screen to the left and right respectively while the **Left Arrow** and **Right Arrow** scrolls the image a little bit to the left or right.

If your mouse has a wheel, the image can be scrolled left or right using the wheel.

The **Up Arrow** key scrolls the image up and the **Down Arrow** key scrolls the image down.

A zoomed in image will still display the position, depth and time scales.

If you scroll beyond the limits of the data into an area with no data, press the Fit to Window button to return to the data view.

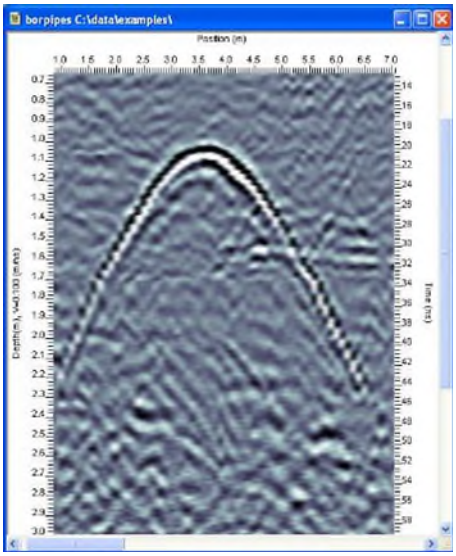


Figure 7-2: Zoomed image. Use the scroll bars on the right and bottom to move the zoomed area around the image.

7.10 Pan

Pan allows the user to move around a zoomed in image. In Pan mode, the mouse cursor becomes a hand that can be dragged and dropped to view different areas of the image.

It can be selected under **View > Pan** or by pressing the following button on the **View Toolbar** (2.5):



Once in Pan mode, click and drag the data image to a new location.

To exit from Pan mode, select the option again under **View > Pan** or depress the same button on the Toolbar.

7.11 Link View Position Range

Two or more data images can be linked together and scrolled together horizontally in the position direction. This option is very handy for comparing long, parallel lines.

The Link View Position Range option is most useful when the data files were collected with different frequencies so that you want to scroll the positions but keep the depth range for each window different (Figure 7-3).

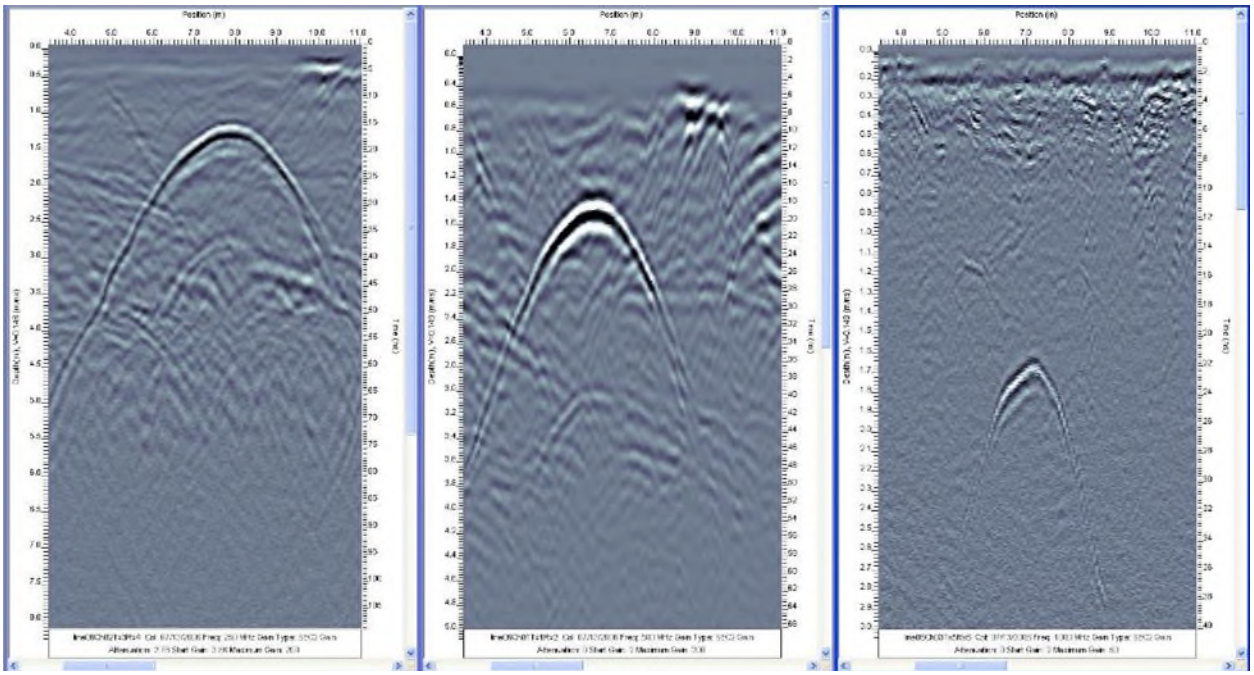


Figure 7-3:250, Parallel lines linked by positions and scrolled together. Note that since only the positions are linked, the vertical time/depth scales can be different.

7.12 Link View Position and Time/Depth Range

All open data images can be linked together and scrolled together horizontally in the position direction and vertically in the time/depth direction. This option is very handy for comparing parallel lines.

7.12.1 Linking GPR Lines with the Same Frequency

The Link View Position and Time/Depth Range option is most useful when the data files were collected with the same or similar frequencies so that you want to be able to scroll horizontally in the position direction and also vertically in the time/depth direction (Figure 7-4).

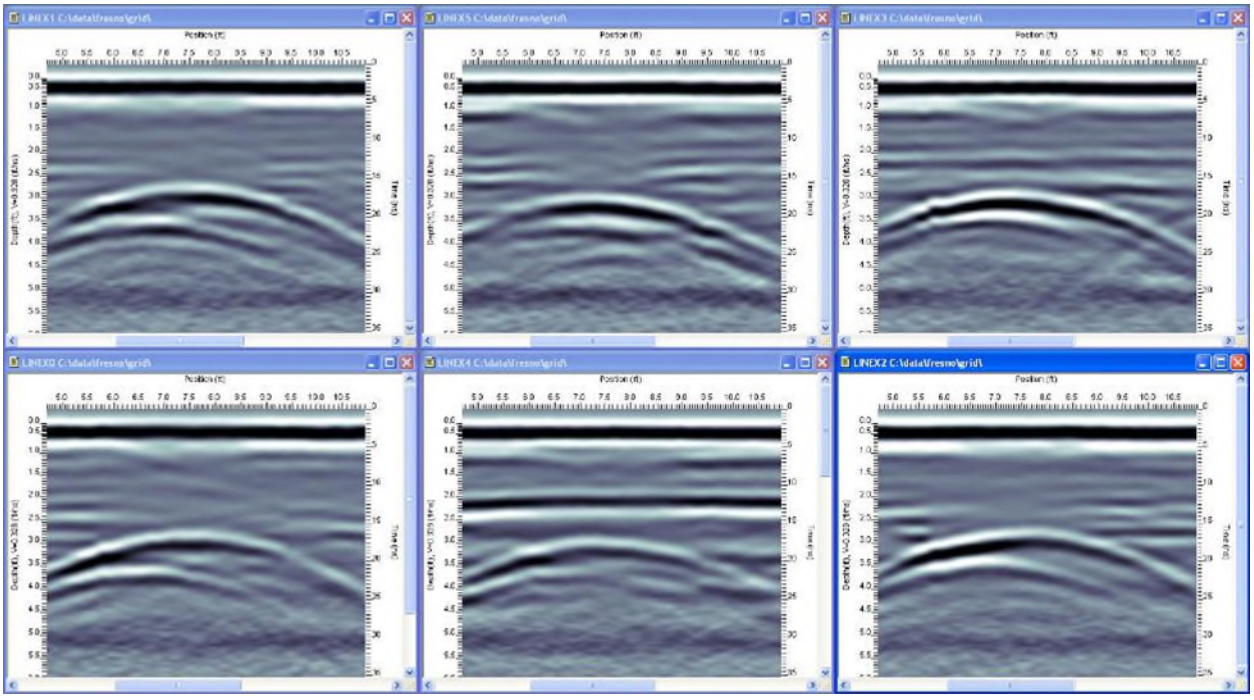


Figure 7-4: Six 250 MHz parallel lines linked by positions and scrolled together.

7.12.2 Linking GPR Lines with the Different Frequencies

If the data files are different frequencies, i.e., 100 MHz and 1000 MHz, all GPR lines are plotted with the same vertical scale so the shallower, high frequency image may be difficult to see (Figure 7-5).

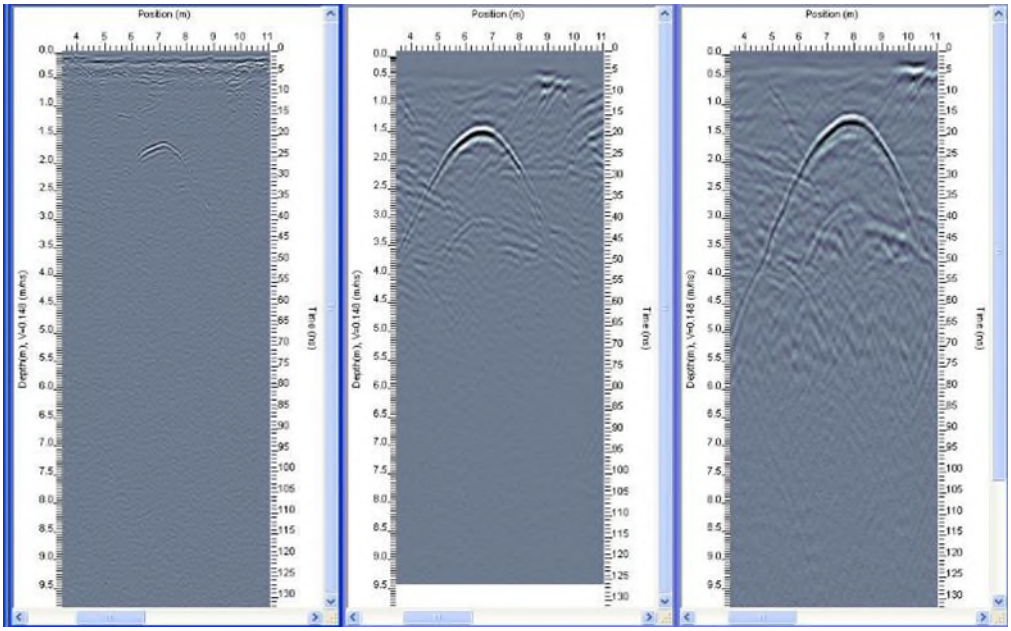


Figure 7-5: 1000, 500 and 250 MHz parallel lines linked by position and time/depth and scrolled together. Note that since both position and time/depth are linked, the vertical scales for each data image is identical. This has resulted in the higher frequency data on the left being concentrated at the top of the image compared to the low frequency data on the right.

7.12.3 Zooming into Linked GPR Lines

The Link View Position and Time/Depth Range option is also effective for zooming into the same box area on two or more GPR lines. Simply draw a Zoom box (7.9) in one GPR line and the zoom is applied to all the linked lines.

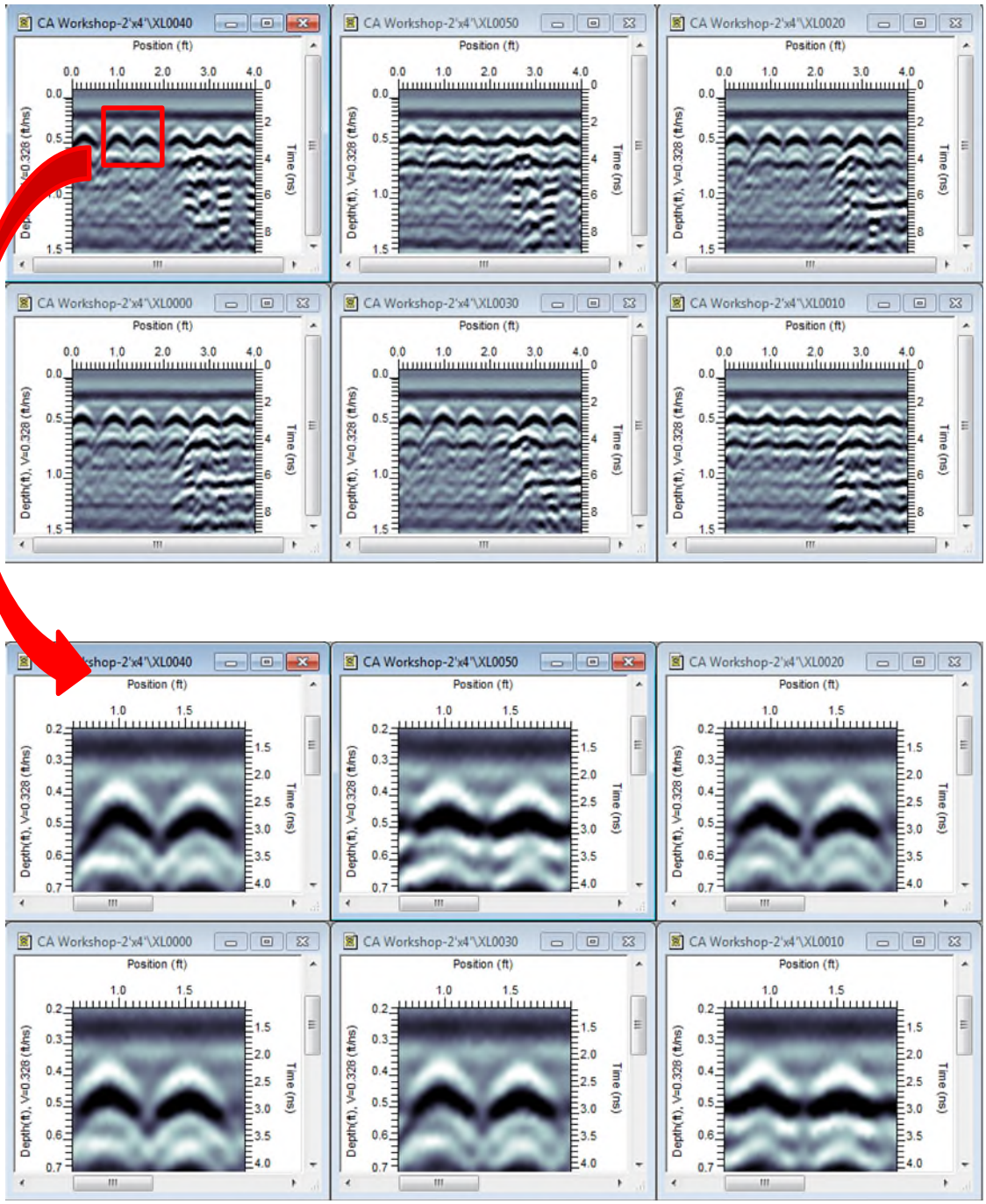


Figure 7-6: Six 1000 MHz GPR lines are displayed on the top image. When the GPR lines are linked in Position and Time/Depth, zooming in on one line zooms into the same position and time/depth range on all the linked lines (bottom image).

7.13 Units

The units of the position and depth axes can be set to meters or feet. **Select View > Units > Feet** or **View > Units > Meters**.

The units can also be changed using the buttons on the **View Toolbar** (2.5):



Note that the option selected in the View menu changes the option under **View > Settings > Axes > Display Units** (6.10.1).

7.14 Font

The Font option is described in more detail under **View > Settings > General Tab > Font** (6.7.9).

The View > Font option is a shortcut to the font dialog used for the position, depth and time axes as well as the text in the Legend.

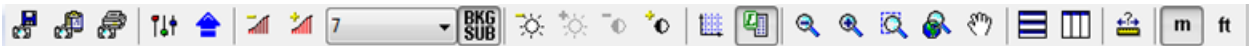
7.15 Show/Hide

7.15.1 Toolbar

The View > Show/Hide > Toolbars allows the user to show or hide the toolbars.

7.15.1.1 View

If View > Show/Hide > Toolbar > View is checked, the **View Toolbar** (2.5) appears below the menu bar (Figure 2-1).



7.15.1.2 Velocity

If View > Show/Hide > Toolbar > Velocity is checked, the Velocity Toolbar appears at the top of the LineView Window (Figure 2-1).



7.15.1.3 Interpretation

If the optional Interpretation module is enabled (see Software Registration in the EKKO_Project User's Guide), the **Interpretation toolbar** (2.7) is available.

If the View > Show/Hide > Toolbar > Interpretation is checked, the **Interpretation toolbar** (2.7) appears at the top of the LineView Window (Figure 2-1).



7.15.2 Status Bar

If View > Show/Hide > Status is checked, the **Status Bar** appears along the bottom of the LineView Window (Figure 2-1).

The information text that appears on the right side of the Status Bar corresponds to the mouse cursor position within the data image (Figure 2-1). This text information can be copied to the Clipboard by pressing the F8 key. For more details see **Status Bar** (2.8.2).

7.15.3 Flags/Fiducials

Flags/Fiducials are markers and/or comments added during data acquisition at specific trace positions along the line.

If the GPR Line contains Flags/Fiducials, they are displayed on the data image if the View > Show/Hide > Flags/Fiducials option is checked.

The flags/fiducials will appear as black and white icons of flags on the bottom of the GPR line (Figure 2-1). Flags with media files attached to them appear as photo, audio or video icons.

If View > Flag/Fiducial Text is checked (7.15.4), the text associated with the Flag/Fiducial is also displayed.

If the data file does not contain any flags/fiducials, this option is greyed out and not accessible.

7.15.4 Flag/Fiducial Text

If Flags/Fiducials is enabled, the View > Show/Hide > Flag/Fiducial Text option is accessible. This option displays the text associated with the flags/fiducials (Figure 2-1).

The font size of the Flag/Fiducial Text is the same as the Axis and is changed in View > Font (7.14) or View > Settings > General Tab > Font (6.7.9).

If the DT1 file does not contain any flags/fiducials, this option is greyed out and not accessible.

7.15.5 Color Scale / Wiggle Trace

Data images are displayed as a Color Scale image (Figure 6-4), a Wiggle Trace image (Figure 6-6), both (Figure 6-7) or none.

If the View > Show/Hide > Color Scale Image option is checked, the Color Scale image is displayed in the **Active Window** (2.2.1).

If the View > Show/Hide > Wiggle Trace option is checked, it shows the Wiggle Trace image in the Active Window.

If both the **Show Color Scale Image** and the **Show Wiggle Trace** (7.15.5) options are checked, both images are displayed in the Active Window.

If neither the Show Color Scale Image nor the Show Wiggle Trace options are checked, no GPR line is displayed in the Active Window. This option is useful to show Interpretations with a white background and no GPR data image (Figure 6-8).

For more details, see Color Scale (6.7.2) and Wiggle Trace (6.7.4).

These options are tied to the associated checkboxes in the General Tab. To change the data image display for multiple GPR lines, use the Apply to All option (6.4).

7.15.6 Skipped Traces

If the data file contains positions where traces were skipped during data collection, this can be indicated on the data image by selecting **View > Show/Hide > Skipped** Traces.

Skipped traces appear as colored rectangles on the bottom of the GPR line (Figure 2-1). The color of the skipped traces can be changed in View > Settings > Marker Color (6.7.6).

Skipped traces are filled in with interpolated or repeated traces.

7.15.7 Axes

Checking the View > Show/Hide > Axes option displays axes around the data image (Figure 2-1).

The depth scale is displayed on the left side of the image, the time scale is displayed on the right side of the image and a position scale is displayed across the top of the image.

Before selecting the Show Axes option, make sure that the image you want to display or hide the axes is in the **Active Window** (2.2.1).

This option is tied to the axis currently selected in the Axes Tab (6.10.3).

To change the axes display for multiple GPR lines, use the Apply to All option (6.4).

7.15.8 Grid Lines

Checking the View > Show/Hide > Grid Lines option superimposes a grid of dashed lines onto the GPR line (Figure 2-1).

Horizontal grid lines appear at time or depth label increments (6.10.3.2). Vertical grid lines appear at the position label increments (6.10.3.1).

Show Grid Lines is greyed out and not available unless grid lines are selected under View > Settings > Axes Tab (6.10.3).

Before selecting the Show Grid Lines option, make sure that the image you want to add the grid lines to is in the **Active Window** (2.2.1).

The Show Grid Lines option is also available by selecting the Toggle Grid Lines button from the View toolbar:



This option is tied to the vertical axis (depth or elevation) selected in the View > Settings> Axes Tab (6.10.3).

To change the Grid Lines for multiple GPR lines, use the Apply to All option (6.4).

The grid color can be changed under View > Settings > General Tab > Grid Color (6.7.7).

7.15.9 Legend

Checking the Show Legend option adds a legend to the GPR line (Figure 2-1).

The Legend appears as lines of text below the GPR line. It contains user-defined information about the GPR line including the line name, velocity, data processing, gain, color palette, contrast and sensitivity, etc. (6.12).

Before selecting the Show Legend option, make sure that the image you want to add the legend to is in the **Active Window** (2.2.1).

The Show Legend option is available by selecting View > Show/Hide > Legend from the menu or by selecting the Toggle Legend button from the View toolbar:



This option is tied to the associated checkboxes in the Legend Tab (6.12).

To change the Legend for multiple GPR lines, use the Apply to All option (6.4).

7.15.10 Additional View Menu Options with Optional Interpretation Module

If the optional Interpretation module is enabled (see Software Registration in the EKKO_Project User's Guide), the following menu options are listed under the View menu:

7.15.10.1 Inactive Interpretations

The View > Show/Hide > Inactive Interpretations menu option shows or hides the Inactive Interpretations. Inactive Interpretations are all the interpretations other than the Active Interpretation (8.2.1).

The purpose of this option is to allow the user to quickly hide or show all the Inactive Interpretations on the GPR line in a Project.

The Show/Hide Inactive Interpretations option is also available by clicking the Show/Hide Inactive Interpretations button on the **Interpretation Toolbar** (2.7):



When the option is checked, Inactive Interpretations are shown (default). When the option is not checked, Inactive Interpretations are hidden.

If the **Active Interpretation** is set to **None**, all Interpretations on the GPR line can be quickly removed using the this button. This allows the GPR line to be displayed with no interpretations visible.

7.15.10.2 Hidden Interpretations

The View > Show/Hide > Hidden Interpretations menu option shows or hides Interpretations with the **Hide when not active** property (8.1.7) set to on.

If Hidden Interpretations is checked, Interpretations are displayed even if the **Hide when not active** Property is on.

If Hidden Interpretations is not checked, Interpretations with the **Hide when not active** Property on are not displayed.

The purpose of this option is to allow the user to quickly hide or show all the Hidden Interpretations on a GPR line without having to change the **Hide when not active** property for each one.

7.15.10.3 Annotations

The View > Show/Hide > Annotations menu option shows or hides the Annotations.

The default setting is to show the annotations. If Annotations is set to Hide (unchecked), annotations are not displayed unless it is the **Active Interpretation** (8.2.1).

The purpose of this option is to allow the user to quickly remove all the Annotations on a GPR line which may clutter up an interpretation display without having to change the **Hide when not active** property (8.1.7) for each one.

8 Interpretation

An interpretation is one or more observations drawn on the GPR data image or images using the mouse cursor and a specific drawing tool (points, polylines, boxes or annotations).

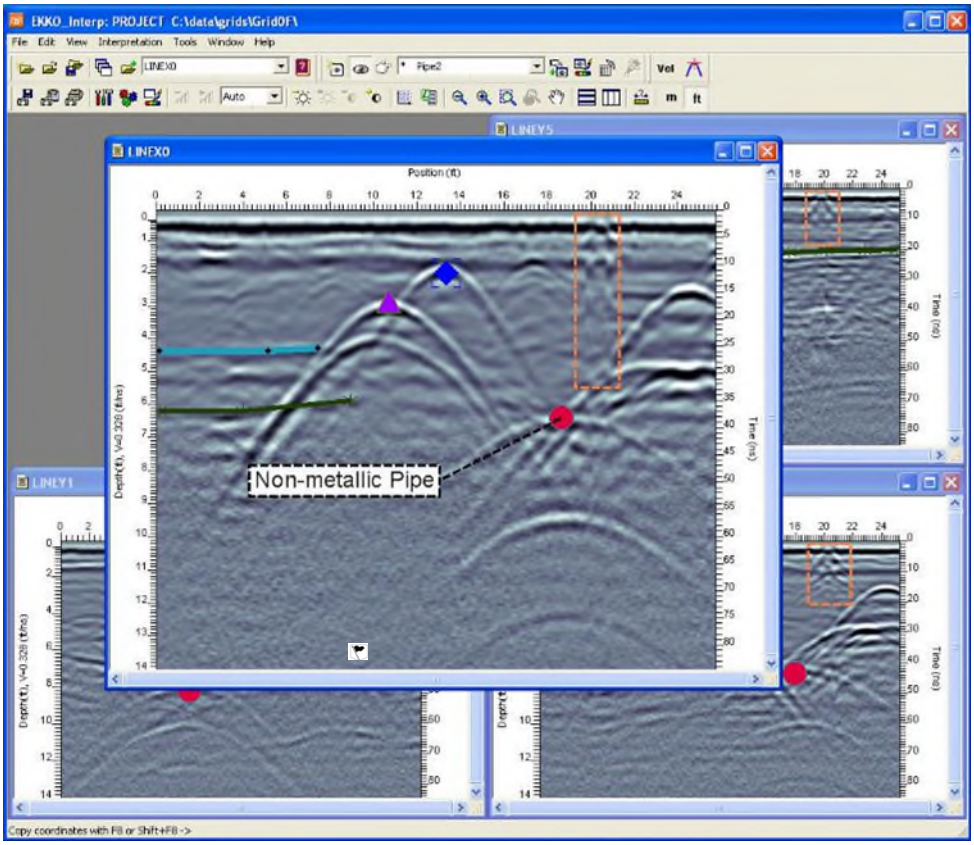


Figure 8-1: Interpretations

Flags added to the GPR data during collection or in post-processing are also interpretations and will appear in lists of interpretations.

The Interpretation menu has options to create new interpretations, pick the active interpretation, add or delete observations, change the properties of an existing interpretation and edit interpretation templates.

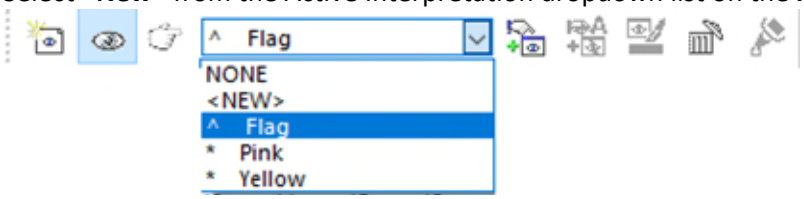
8.1 Create New Interpretation

There are several ways to create a new interpretation:

1) Select **Interpretation > Create New Interpretation** from the menu,
2) Select the New Interpretation button from the **Interpretation Toolbar** (2.7):



3) Select **<New>** from the Active Interpretation dropdown list on the **Interpretation Toolbar** (2.7):



The Create New Interpretation dialog is shown in Figure 8-2.

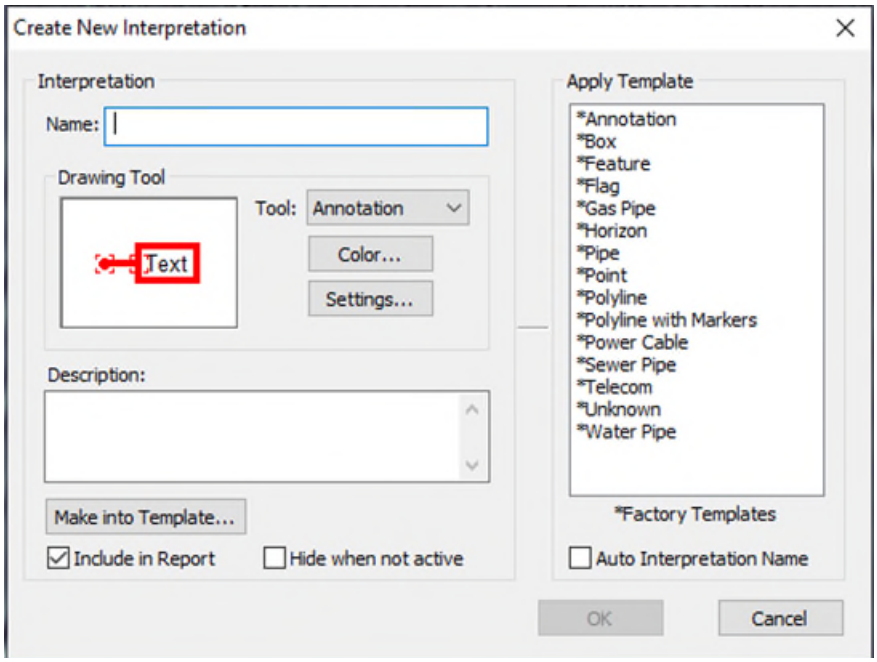


Figure 8-2: Create New Interpretation dialog

The user creates a new interpretation by setting the Name, Drawing Tool, etc. properties on the left side of the dialog. To quickly create a new interpretation with automatically generated properties, select a template from the Apply Template list on the right side of the dialog.

Pressing the OK button automatically puts LineView into Add mode (the Add Observations button on the **Interpretation Toolbar** (2.7) is pressed) allowing the user to immediately start adding observations on the GPR line.

8.1.1 Name

When creating a new interpretation, enter a name in the Name field. This name will appear in the Active Interpretation dropdown list on the **Interpretation Toolbar** (2.7) and in the Edit.

If a template is selected for a new interpretation, the name is automatically generated if Auto Interpretation Name is enabled.

8.1.2 Drawing Tool

Under Drawing Tool, select the Tool for drawing the interpretation. The options available from the dropdown list are point, polyline, box or annotation.

8.1.2.1 Point

The Point tool draws one or more points on the GPR line.



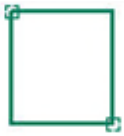
8.1.2.2 Polyline

The Polyline tool draws a line consisting of one or more points.



8.1.2.3 Box

The Box tool draws a rectangular box.



8.1.2.4 Annotation

The Annotation tool writes text in a box. The box includes a line to connect the text to a specific location within the GPR data or interpretation image.



Figure 8-3: Annotations consist of two parts: the annotation box containing the text and the annotation line that connects the annotation box to a point in the data image.

8.1.2.5 Color

The color option is used as a quick way of setting the color of the interpretation. When selected, the standard Windows color selection dialog opens, and the user selects a color.

Unlike the Settings option, which allows different colors for marker borders, marker fill and lines, the Color option sets all these to the same color.

8.1.2.6 Settings

The Settings option edits the Interpretation Properties including the marker style, marker border color, marker fill color, marker size, line style, line color, line weight and text font.



Figure 8-4: Interpretation Settings

All interpretations use the same Settings dialog to set Marker, Line and Text but not all settings are available for all interpretations. For example, the Line settings are not accessible for Point Interpretation and Marker settings are not accessible for the Box Interpretation. However, Markers are optional for Polyline interpretations. The details of what settings are available for each type of interpretation is summarized in the table below.

Interpretation	Marker	Line	Text
Point	Yes	No	No
Polyline	Optional	Yes	No
Box	No	Yes	No
Annotation	Optional	Yes	Yes

Markers: Markers are used for points and are optional for Polylines and Annotations. There are several options for Marker styles including squares, circles, diamonds and crosses. Sizes vary from 1 to 20 points. Solid marker styles like squares have a Border color and Fill color while other marker styles like crosses and X's only use the Border color.

Lines: Lines are used for Polylines, Boxes and Annotations. There are several options for Line styles including solid and various dashed lines. The Line Color can be selected from the color list. There are 20 different weights (thicknesses) for the line.

Text: Text is only used for Annotations. The font, font size and font color are selected from the standard Windows font dialog. The Background Color can be selected from the color list.

Preview Box: As the interpretation settings are edited, the Preview box displays a graphic of the current interpretation settings.

8.1.3 Description

The description provides space for the user to add text describing the Interpretation. The Description text is written to the Interpretation Report generated from EKKO_Project (see EKKO_Project User's Guide).

8.1.4 Apply Template

The user can quickly create a new interpretation with automatically generated properties by selecting a template from the Template list on the right side of the dialog (Figure 8-2).

The properties of interpretations, including those created from templates, can be edited by selecting the Settings button.

There is only one Flag interpretation. A new one cannot be created or the properties changed.

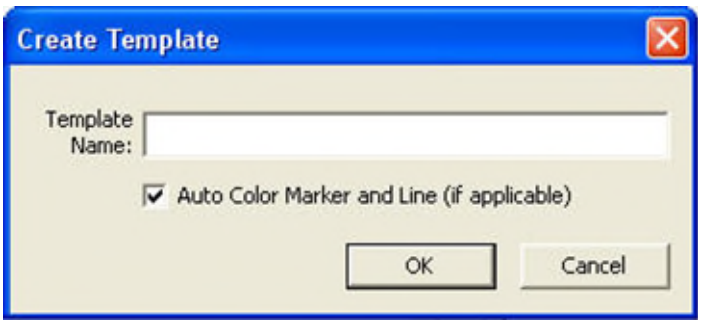
8.1.4.1 Auto Interpretation Name

If Auto Interpretation Name is enabled, when a template is selected for a new interpretation, the name is automatically generated. The name can be edited, if desired.

8.1.5 Make into Template

The current interpretation and its properties can be made into a template to be used in the future by selecting the Make into Template button.

If selected, the user is prompted to enter a name for the template. This name will appear in the Apply Template list.



A check box allows the user to decide whether the template properties are fixed with the current properties or will automatically change whenever the template is selected (the default).

8.1.6 Include in Report

The **Include in Report** checkbox allows the user to decide if the interpretation values are included in the Interpretation Report output by the EKKO_Project software (see the EKKO_Project User's Guide).

This option allows the user to quickly remove the results of an interpretation from the Interpretation Report without having to delete the whole interpretation.

8.1.7 Hide when not active

The **Hide when not active** checkbox allows the user to hide the interpretation, so it is not displayed, unless it is the Active Interpretation. The Active Interpretation overrides any setting to hide the interpretation.

Hidden Interpretations are also displayed if the View > Show/Hide > Hidden Interpretations option (7.15.10.2) for individual GPR lines is set to Show (checked).

8.2 Pick Active Interpretation

8.2.1 Active Interpretation

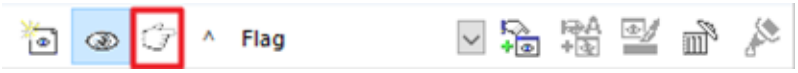
The Active Interpretation is the only interpretation that can be edited to Move, Add or Delete observations.

The Active Interpretation is selected in one of two ways:

1) Selecting the interpretation name from the interpretation drop-down list on the **Interpretation Toolbar** (2.7), or



2) Using the Pick Active Interpretation button on the **Interpretation Toolbar** (2.7):



After clicking the button, the mouse cursor, when it is over the data image, turns into a hand with a pointing finger and a dot. Move the mouse cursor and position the dot on any observation and the dot turns red. Clicking will make the interpretation associated with that observation the Active Interpretation.

Picking the Active Interpretation lists the name of that interpretation to the Active Interpretation list on the **Interpretation Toolbar** (2.7).

It also depresses the Pick Active Interpretation button. To select another Active Interpretation, the Pick Active Interpretation button must be pressed again.

The Pick Active Interpretation button is handy when there are numerous interpretations and you have forgotten the name of the interpretation you want to select but recognize it from the data image.

The Active Interpretation is indicated by corner handles around the markers (Figure 8-5):

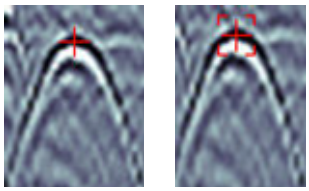


Figure 8-5: Interpretation Markers, in this case, a cross (left), have corner handles added when they are the Active Interpretation (right).

Using the interpretation drop-down list on the **Interpretation Toolbar** (2.7), the Active Interpretation can be set to "None". This displays all the interpretations without the corner handles. Setting the Active Interpretation to None is desirable before saving the image to the Clipboard (5.1) or saving the image to a graphics file (4.1) so the interpretations in the data image do not have corner handles.

Active Interpretations are ALWAYS displayed, even if the **Hide when not active** attribute of the interpretation is on. The Active Interpretation overrides any setting to hide the interpretation.

To hide all interpretations, use the interpretation drop-down list on the to set the Active Interpretation to None and then Hide the Inactive Interpretations using the View > Show/Hide > Inactive Interpretations menu option or by pressing the Hide Inactive Interpretations button on the **Interpretation Toolbar** (2.7).

8.2.2 Selecting and Editing Observations

Single observations from the Active Interpretation are selected by clicking on them.

Selected Observations are indicated by two concentric solid squares around them (Figure 8-6).

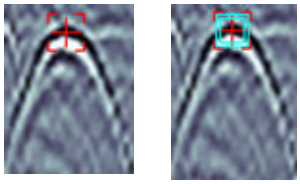


Figure 8-6: Markers for the Active Interpretation (left) are highlighted by concentric squares when selected (right). Selected observations can be moved or deleted.

Selected flags are indicated by inverting colors (black flag turns white)



Figure 8-7: Active Flags (left) invert in color when selected (right). Selected flags can be edited.

Multiple observations are selected by clicking on them while pressing the Control (Ctrl) on the computer keyboard.

Multiple observations can also be selected by clicking and dragging a box around one or more observations (Figure 8-8). Selecting multiple flags like this is not possible.

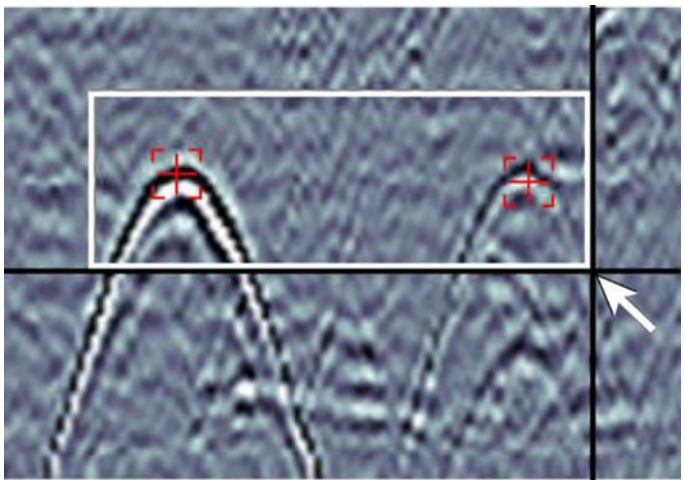


Figure 8-8: Multiple observations are selected by dragging and dropping a box around them. Selected observations can be moved or deleted.

8.2.2.1 Delete

To delete the selected observations:

1) Press the Delete key on the computer keyboard.
2) Right-click and selecting **Delete Selected**.

8.2.2.2 Move

A selected observation is moved by using the mouse cursor and dragging it to a new location. Ensure that you are NOT in Add, Delete or Join Polylines mode when moving an observation.

Moving a Box

There are two ways of moving a Box:

1) Resize the box by clicking and dragging one of the handles on the box. Note that the other handle stays fixed while the box resizes.

2) Move the entire box by clicking and dragging anywhere in the middle of the box.

Moving Annotations

Annotations consist of two parts: the annotation box containing the text and the annotation line that connects the annotation box to a point in the data image (Figure 8-3).

There are three ways of moving an Annotation:

1) Move just the annotation box by clicking and dragging the end point of the annotation line where it attaches to the annotation box. Note that the end-point of the annotation line stays fixed while the annotation line stretches to stay attached to the box.

2) Move just the end-point of the annotation line by clicking and dragging the end point of the annotation line. Note that the annotation box stays fixed while the line stretches.

3) Move the entire annotation including the box containing the text and the annotation line by clicking and dragging the middle of the annotation line or the middle of the annotation box.

8.2.2.3 Edit Text

To edit the text on a flag, right-click and select **Edit Text** from the menu.

A dialog box opens to change the flag text.

8.2.2.4 Add/Edit Attachment

Image, audio, and video files attached to the GPZ can be attached to the flags. These files can provide context for the data which help when interpreting the data.

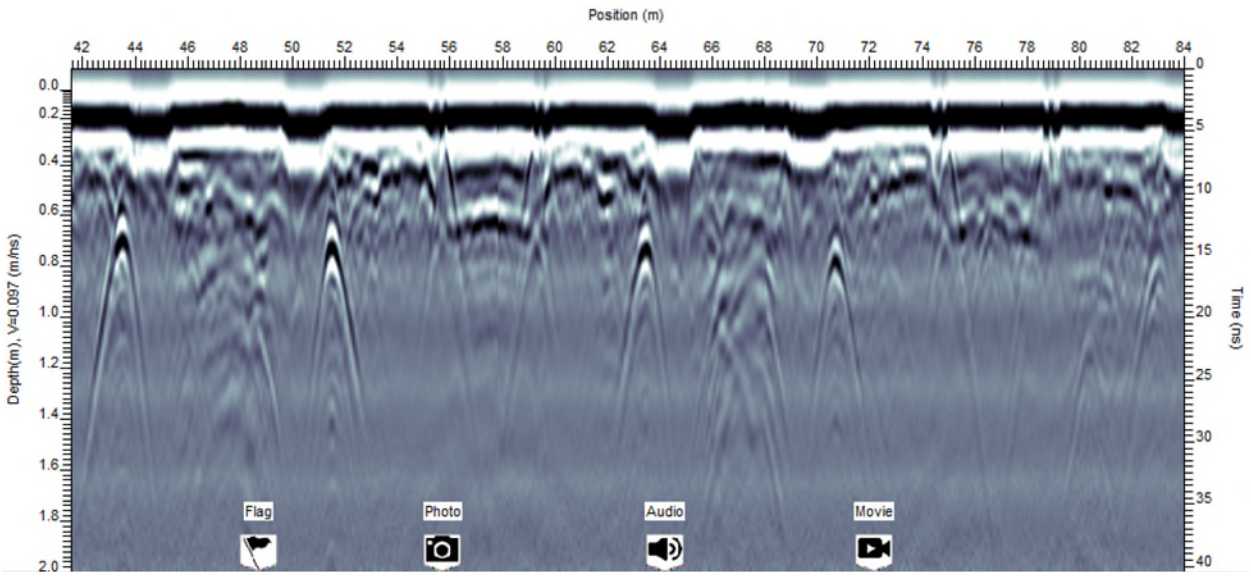
To add or edit the flag attachment, select a flag, right-click and select **Add/Edit Attachment** from the menu.

A dropdown menu opens with a list of all the files that have been attached to the project file. See the EKKO_Project User's Guide for details on how to attach a file to the project (GPZ) file.

Select a file from the list to attach to the flag.

A file can only be attached to one flag so if you select a file that has already been attached to another flag, a warning message appears.

Depending on the type of file attached, the flag icon may change into a multi-media flag with an image, audio, or video icon:



After selecting the flag, double-clicking on the icon will open the attached file (providing there is software installed on the computer that opens that type of the file).

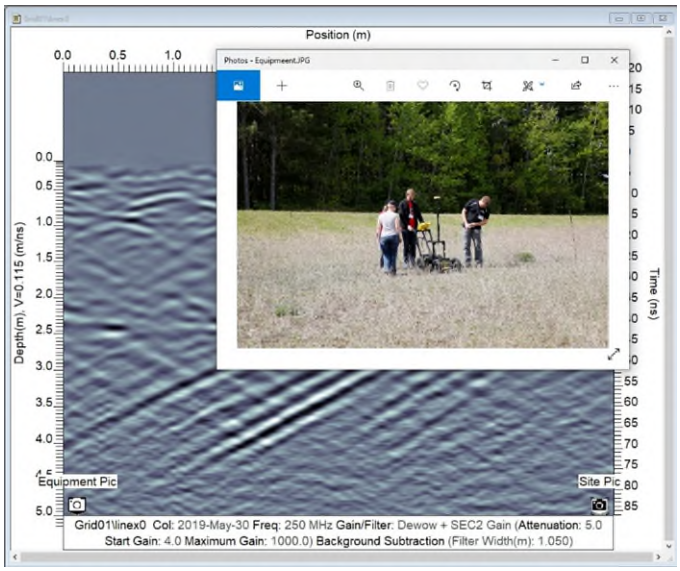


Figure 8-9: After selecting a multi-media flag, double-clicking opens the attachment file, in this example a photo of the survey site.

Images files supported: BMP, JPEG, JPG, PNG, TIF, TIFF

Audio files supported: WAV, MP3, AAC, FLAC, MP2, WMA

Video files supported: MOV, ASF, AVI, MPG, WMV, MP$, M4A, M4V

Files cannot be attached to multiple flags.

8.2.2.5 Delete Attachment

To edit the text on a flag, select the flag, right-click and select **Delete Attachment** from the menu.

8.3 Observation

Observations are the “building blocks” of an interpretation. For example, a Point Interpretation consists of one or more point-observations at specific positions on the data image.

The Interpretation > Observation menu option allows the user to add and delete observations and, in the case of polyline interpretations, insert points or join two polylines together.

8.3.1 Add

The Interpretation > Observation > Add menu option is used to add new observations to the current Active Interpretation.

Add observation mode can also be accessed by selecting the Add Observations button on the **Interpretation Toolbar** (2.7):



When selected, the mouse cursor turns into cross-hairs when over the data image. Add observations by clicking the mouse at the desired positions. For higher precision when adding observations, use Zoom.

Poor observations can be quickly deleted in the reverse order they were added by pressing the **Delete** key one or more times.

Observations can be quickly edited by moving the mouse cursor cross-hairs back to a previously added observation. When the cross-hairs get close to the observation, it automatically switches to Edit mode (8.2.2) so the observation can be moved.

Interpretations are not restricted to a single GPR line. Observations for the same interpretation can be added to more than one GPR line, for example, to interpret the same pipe or the same horizon on several images (Figure 8-1).

When finished adding observations, exit Add mode by:

1) depressing the Add Observations button,

2) pressing the Esc key on the keyboard or

3) selecting the Interpretation > Observation > Add menu option again.

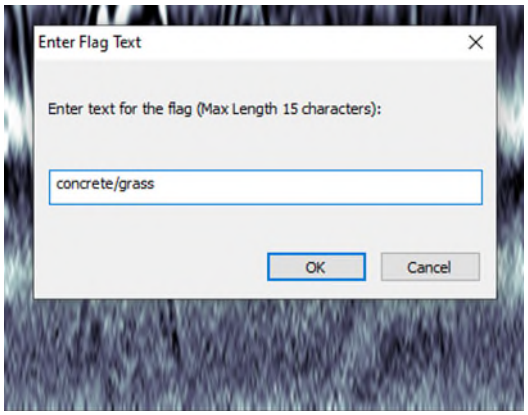
Note that when a new interpretation is created (8.1), LineView automatically enters Add mode to allow the user to quickly start adding observations for the new interpretation without having to press the Add Observations button first.

Points are added by simply clicking at the desired cross-hair positions.

See Move for moving a point.

8.3.1.1 Flags

Flags are added by simply clicking at the desired cross-hair positions. A dialog opens to add text to the flag:



Flag text cannot be blank.

8.3.1.2 Polylines

Polylines are added by clicking the mouse at the desired cross-hair positions to create one or more points linked by a line (Figure 2-2). End a polyline by double-clicking on the end point.

Start a new polyline (of the same Interpretation) by clicking at a new cross-hair position. A new line can be started by right-clicking and selecting Insert New Line from the menu.

Polylines cannot form closed loops.

See Move for moving a point in a polyline.

8.3.1.3 Box

Boxes are added by clicking at one corner of the box position and dragging the mouse cursor to the opposite corner. A “ghosted” box will appear and turn permanent when the mouse cursor is dropped.

See Moving a Box to move a box.

8.3.1.4 Annotation

Annotations are added by clicking at the desired cross-hair position. A dialog box opens to enter text. Clicking OK creates the annotation box containing the text with the end-point of the annotation line at the original cross-hair position.

If you click and drag, the end of the annotation line is placed at the original cross-hair position and the annotation box is placed at the final drag position.

See Moving Annotations to move the annotation, the annotation box or the annotation line.

8.3.2 Add Smart Points

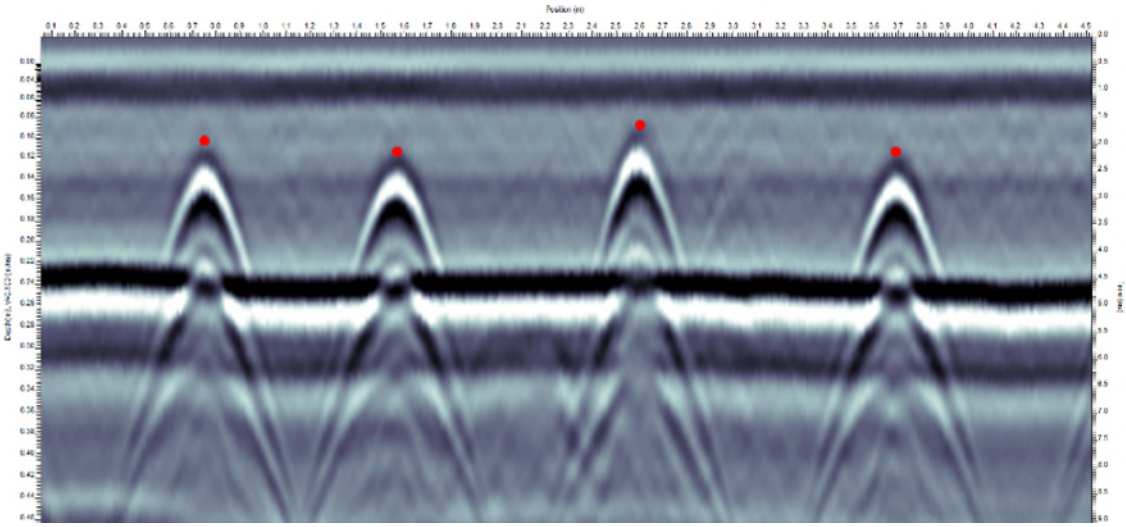
The **Interpretation** > **Observation** > **Add Smart Points** menu option is used to add new point observations to the current Active Interpretation. Smart Points is only available for Point interpretations, so this item is greyed out and not accessible for other types of interpretations. Smart Points allows users to be more consistent in where the point observations are placed relative to the hyperbolic response, giving a more consistent depth and position of targets.

Using Smart Points is strongly recommended when picking multiple similar targets such as rebar on a bridge deck, to ensure consistency.

Add Smart Points mode can also be accessed by selecting the button on the **Interpretation Toolbar** (2.7):



When selected, the mouse cursor turns into cross-hairs when over the data image. Add point observations by clicking the mouse near the top of hyperbolic responses in the GPR line. The pick is automatically positioned at the “best” location near the cross-hair positions.



Poor observations can be quickly deleted in the reverse order they were added by pressing the **Delete** key one or more times.

Interpretations are not restricted to a single GPR line. Observations for the same interpretation can be added to more than one GPR line, for example, to interpret the same pipe on several images (Figure 8-1).

When finished adding observations, exit Add mode by:

1) depressing the Add Smart Points button,

2) pressing the **Esc** key on the keyboard or

3) selecting the Interpretation > Observation > Add Smart Points menu option again.

Note that when a new interpretation is created (8.1), LineView automatically enters Add Smart Points mode to allow the user to quickly start adding observations for the new interpretation without having to press the Add Smart Points button first.

8.3.3 Delete

The Interpretation > Observation > Delete menu option is used to delete observations from the current Active Interpretation.

Delete mode can also be accessed by selecting the Delete Observations button on the **Interpretation Toolbar** (2.7):



When selected, the mouse cursor turns into a garbage can with small dot. When the dot in the mouse cursor is close to an observation from the Active Interpretation, it turns red and the garbage can lid

opens, indicating that the observation will be deleted by clicking the mouse or pressing the Delete key on the computer keyboard.

When in Delete mode, Points, boxes annotations and points in a polyline are deleted by clicking on them.

The line between markers in a polyline can also be deleted. When a polyline is the Active Interpretation, garbage can cursor turns into scissors when moved over the line between polyline markers. Clicking the mouse will delete the line and separate the polyline into two segments (Figure 8-10).

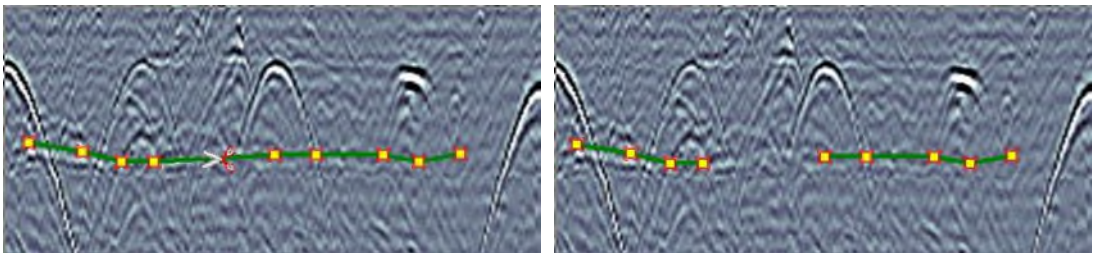


Figure 8-10: When in Delete mode, the mouse cursor is a pair of scissors when it is over the line between 2 points of a polyline (left). Clicking deletes the line and cuts the polyline into two segments (right).

To delete more than one observation:

1) Click and drag a box to select one or more observations (Figure 8-8) and then press the Delete key on the computer keyboard.

2) Select the Delete Observations button on the **Interpretation Toolbar** (2.7). Then click and drag a box around the observations.

When finished deleting observations, exit Delete mode by:

1) depressing the Delete Observations button,

2) pressing the Esc key on the keyboard or

3) selecting the Interpretation > Observation > Delete menu option again.

Even when NOT in Delete mode, any observation from the Active Interpretation can be deleted by selecting it with the mouse cursor and then pressing the Delete key on the computer keyboard.

8.3.4 Join Polylines

If the current Active Interpretation consists of two or more separate polylines, the Join Polylines option is used to join two polylines together into one continuous polyline.

Select Join polylines by either:

1) The Interpretation > Observation > Join Polylines menu option,

2) Right-clicking and selecting Join Polylines from the menu, or

3) Selecting the Join Polylines button on the **Interpretation Toolbar** (2.7):



When selected, the mouse cursor, when located on the data image, turns into a glue bottle. When the tip of the glue bottle is over an end-point of a polyline that could be joined to another end-point, the glue bottle turns red. Click and drag the glue bottle from one end-point to the other one to join to and drop the mouse cursor (Figure 8-11). This will join the two ends of the polyline together.

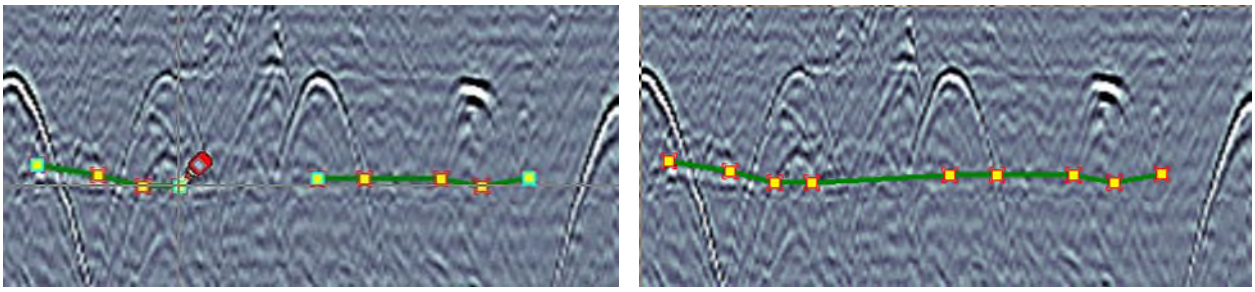


Figure 8-11: When Joining Polylines, the mouse cursor is a glue bottle that turns red when over the end point of a polyline (left). Clicking and dragging to another end point joins the two polylines into one polyline (right).

Polylines cannot form closed loops so the two end points from a polyline cannot be joined together.

The Join Polylines option CANNOT be used to join polylines from different polyline interpretations together; the polylines joined together MUST be from the same interpretation.

When finished joining polylines, exit Join Polyline mode by:

1) depressing the Join Polylines button,

2) pressing the Esc key on the keyboard,

3) selecting the Interpretation > Observation > Join Polylines menu option or

4) right-clicking and selecting Join Polylines.

Join Polyline mode is automatically exited when the polyline consists of one segment.

8.3.5 Insert Point in Polyline

The Interpretation > Observation > Insert Point in Polyline menu option is used to insert new points between existing points or on the ends of a polyline that is the current Active Interpretation (Figure 8-12).

Enter Insert Mode by either:

1) Right-clicking and selecting Insert from the menu or

2) Pressing the Insert key on the computer keyboard.

The mouse cursor turns into a small cross-hair with the “Insert” to indicate Insert mode. Move the cross-hair to the position between points in the polyline where a new point is desired and click the mouse.

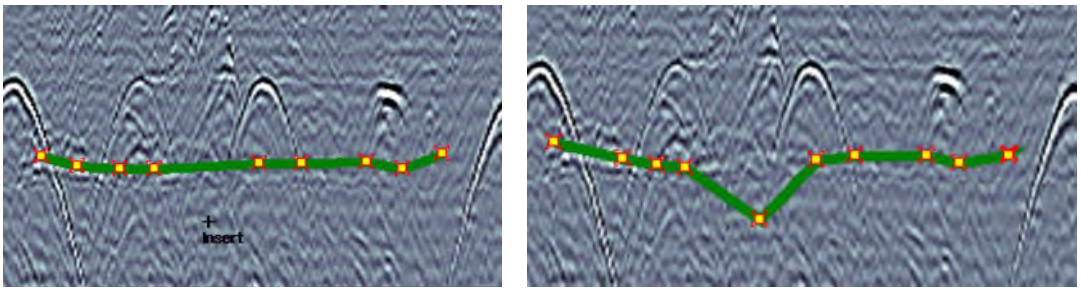


Figure 8-12: Insert mode is used to insert points in a polyline. Insert mode can also be used to add points to the ends of a polyline.

Note that new points are added between the CLOSEST two points in the polyline. There may be times when other points in a polyline are closer than the two points you want to insert a new point between. In this case it will be necessary to insert a point between the two points and then **Move** (8.2.2.2) that point to the desired position.

Insert Mode can also be used to add new points to the ends of the polyline.

When finished inserting points in a polyline, exit Insert Mode by either:

1) Right-clicking and selecting Insert from the menu,

2) Pressing the Insert or Esc key on the computer keyboard or

3) selecting the Interpretation > Observation > Insert Point in Polyline menu option.

8.4 Properties

The properties of the Active Interpretation are accessible by:

1) Selecting the using the Interpretation > Properties menu item or by

2) Selecting the Properties button on the **Interpretation Toolbar** (2.7):



3) Right-clicking on the interpretation in the data image and selecting Properties from the menu.

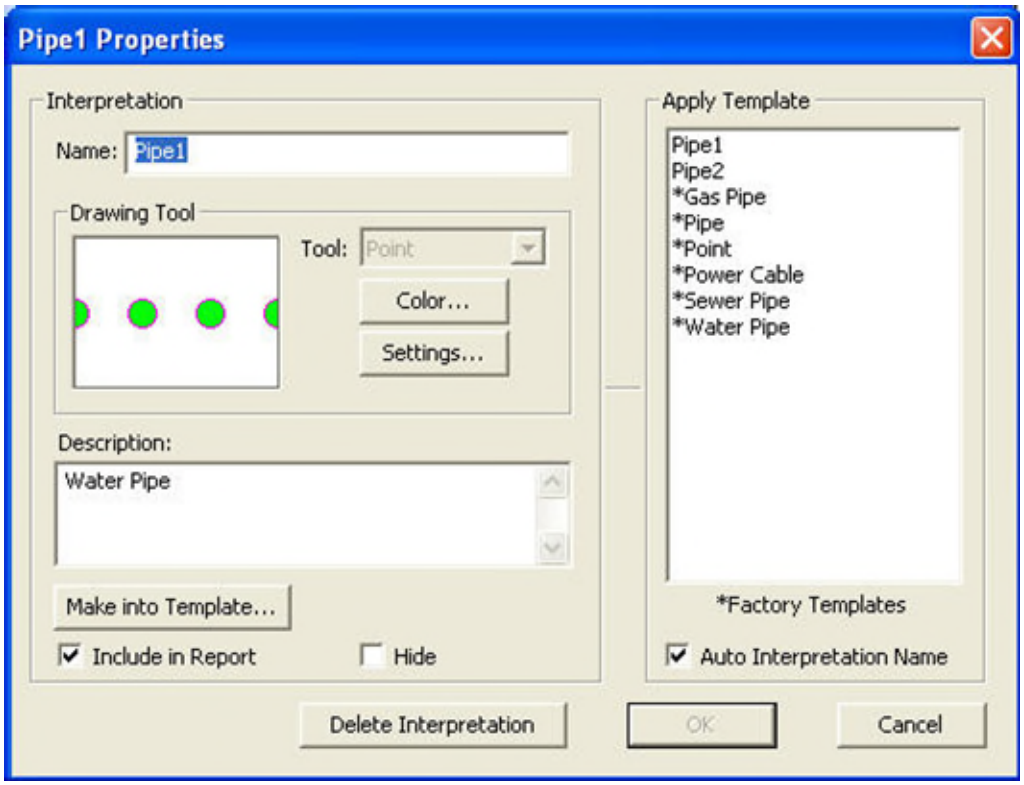


Figure 8-13: The Properties dialog is used to modify the interpretation.

The Interpretation Properties dialog has most of the same options as the Create New Interpretation dialog (Figure 8-2) except the option to select a different Drawing Tool or a Template based on a different Drawing Tool. These properties are not available when editing the Properties of an existing Interpretation.

The Properties dialog has a Delete button to delete the interpretation. Selecting Delete will delete the interpretation from the Active Interpretation dropdown list on the **Interpretation Toolbar** (2.7) and delete all observations using this interpretation in the GPR project. The user is asked to confirm the deletion of the interpretation.

The properties of Flags cannot be changed, so when Flag is the Active Interpretation, the Properties button on the toolbar and the Interpretation > Properties menu option is not accessible.

8.5 Templates

The Interpretation > Templates menu option manages the current templates.

A list of the all the current interpretation templates is displayed (Figure 8-14). The user can delete or rename a custom template or reset the templates list back to the factory default templates.

For more details about creating a custom template, see Make into Template (8.1.5).

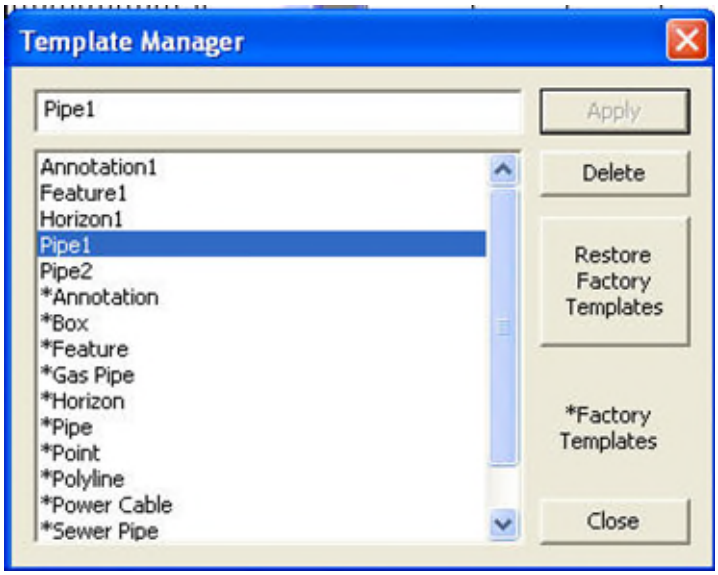


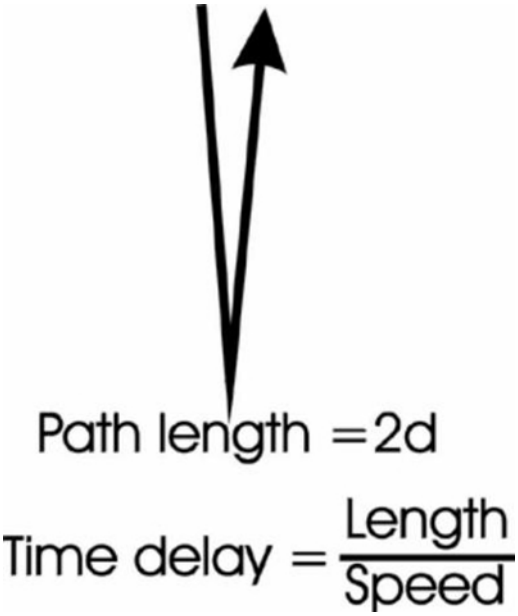
Figure 8-14: Use the Template Manager to delete or change names of custom templates. Factory templates, indicated by a star (*) can be deleted from the list but cannot be renamed.

9 Tools Menu

The Tools menu has tools to calibrate GPR velocity and measure distances on the GPR line.

9.1 How Depth is Determined

Ground penetrating radar systems record the time for a radio wave to travel to a target and back. The depth to that target is calculated based on the velocity at which the wave travels to the target and back.



In simple terms, it is calculated as:

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

where: D is Depth (meters or feet)

V is Velocity (meters/nanosecond or feet/nanosecond)

T is Two-way travel time (nanoseconds)

The finite separation between antennas complicates this calculation, especially for shallow depths. Correcting for the antenna separation is why the depth axis appears non-linear at the top (see Depth Axis (6.10.3.3)).

To calculate the depth to a target, it is critical that the velocity of the material be known.

Velocity can be measured using the Velocity Calibration for Depth Determination described below but if depth data is desired but radar velocity cannot be measured, it must be estimated. The table below gives typical radar velocities for many common materials. If the material is unknown, a good average velocity to use for geological materials is 0.10 m/ns or 0.328 ft/ns.

9.1.1 Typical GPR Velocities of Common Materials

Material	Velocity (m/ns)	Velocity (ft/ns)
Air	0.30	0.98
Ice	0.16	0.53
Dry Soil	0.15	0.49
Granite	0.13	0.49
Dry Salt	0.13	0.43
Dry Rock	0.12	0.39
Limestone	0.12	0.39
Wet Rock	0.10	0.33
Concrete	0.08-0.12	0.26-0.39
Pavement	0.10	0.33
Shale	0.09	0.30
Silt	0.07	0.23
Wet Soil	0.06	0.20
Clay	0.06	0.20
Fresh Water	0.033	0.11

A velocity can be input in the View > Settings > Axes Tab > Depth Axis velocity field or selected from the Velocity Table (Figure 6-25) accessed by clicking on the ".." button

9.2 Velocity Calibration for Depth Determination

The correct velocity is necessary for accurately determining the depth of an object from the GPR lines.

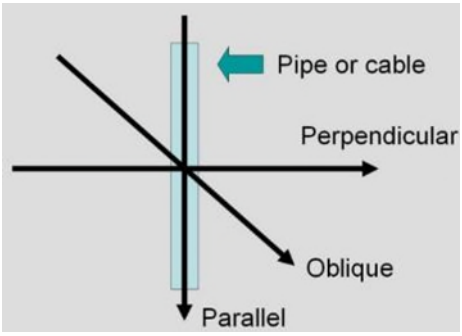
The velocity defaults to a typical average velocity of 0.100 m/ns or 0.328 ft/ns.

Velocity can be determined by calibrating to a hyperbola in the GPR line data. This method requires the user to fit a typical response curve (a hyperbola) to the raw data to extract the velocity.

Select the Tool > Hyperbola Velocity Calibration from the menu or the Hyperbola Velocity Calibration button from the **View Toolbar** (2.5):



It is very important that hyperbola fitting only be performed on target responses where the GPR system has crossed the target perpendicularly. Hyperbola-fitting on a target that was crossed at an angle will result in a poor velocity value and inaccurate depth measurements.



When Hyperbola Velocity Calibration is selected, a hyperbola is superimposed on the current GPR line. The details of fitting the hyperbola to the data are described below.

If necessary, the user can also change the Gain Type value used for the GPR line to make the hyperbola more visible.

9.2.1 Hyperbola Velocity Calibration

The objective for hyperbola fitting is to move the hyperbola superimposed over the data on top of a hyperbola in the GPR line and match the shape by dragging the handles on the end of the hyperbola tails.

To determine the velocity, the superimposed hyperbola does not necessarily need to be placed at the very top of hyperbola in the image. Try to choose the top edge of a colored band on the hyperbola that has the longest tails and looks the most complete.

The superimposed hyperbola can be moved by clicking on the position on the GPR line where you want the apex (top) of the hyperbola to go. The hyperbola will immediately jump to this location.

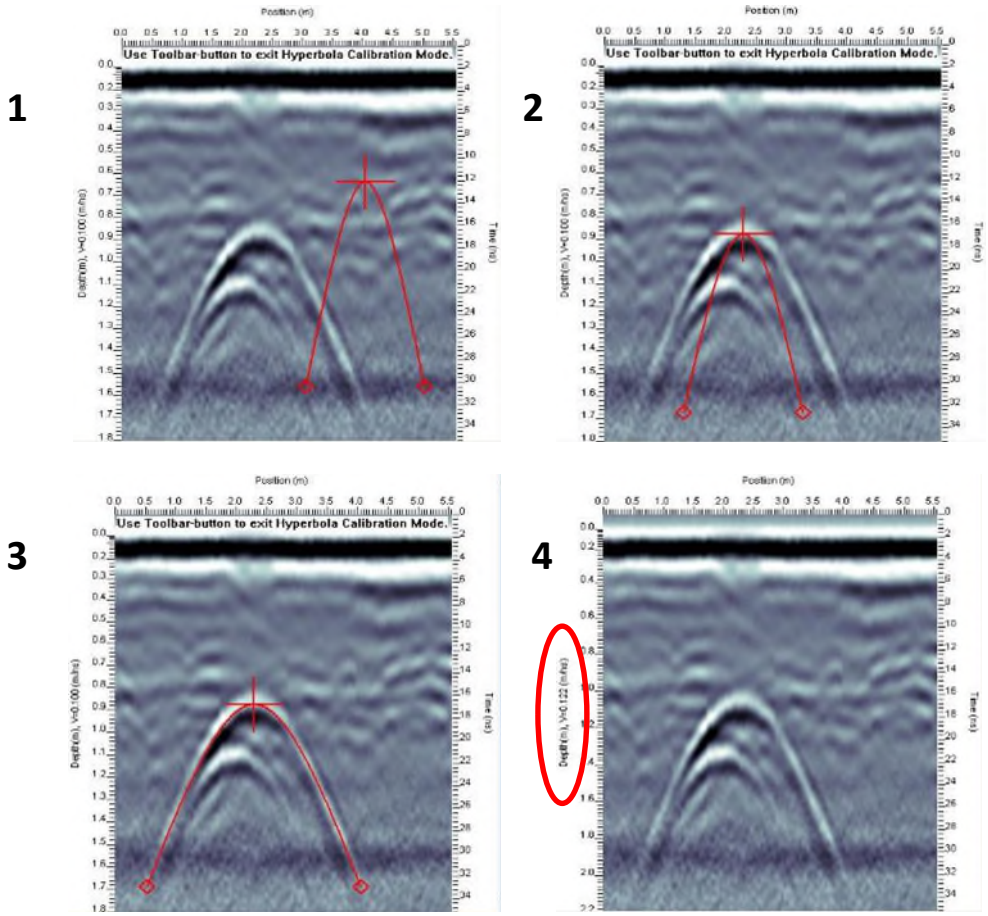


Figure 9-1: Hyperbola-fitting (1) is done by first clicking or dragging the superimposed hyperbola onto one of the colored bands on the hyperbola in the data (2). Choose the band that has long tails. This is not necessarily the top band. Then, click and drag one of the diamond-shaped handles on the ends of the hyperbola until the shape matches (3). During this process, the velocity, depth and time are displayed on the Status Bar on the bottom of the screen. After the process is complete, the depth axis is updated using the new velocity value (4).

After the hyperbola has been positioned at the apex of the hyperbola in the GPR line, the next step is to match the shape. The shape of the hyperbola can be changed by clicking on either diamond-shaped handle on the ends of the hyperbola tails and dragging it to the position that best matches the shape of the image hyperbola.

After the calibration is complete, press the Hyperbola Velocity Calibration button again to exit from velocity calibration mode.



The message “Use Toolbar button to exit Hyperbola Calibration Mode” appears on the upper left of the image to remind the user.

After exiting from Hyperbola calibration Mode, if the velocity value has changed, the user is prompted to answer Yes or No to changing the velocity value and updating the depth axis.

During the hyperbola velocity calibration, the **Status Bar** (2.8) along the bottom of the LineView screen displays information including the velocity, depth and time of the hyperbola. As the hyperbola shape is changed, the velocity and depth also change.

9.2.2 Target of Known Depth

The Hyperbola Velocity Calibration window can also be used to determine the velocity using a target at a known depth.

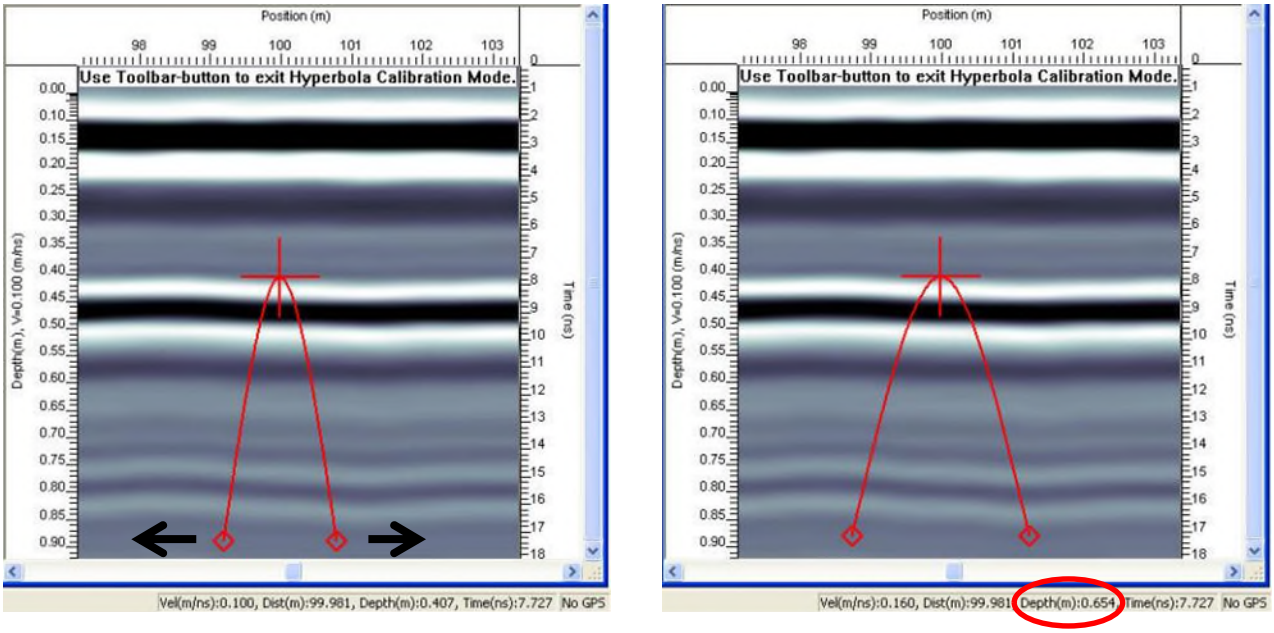


Figure 9-2: For a target at a known depth, like in this case the known thickness of ice, the apex of the hyperbola is placed on the top band of reflection of the target (left) and the velocity adjusted by dragging the hyperbola handles in or out (left) until the depth value listed at the bottom of the screen matches the known depth (right). The velocity will then be listed on the bottom of the screen as well.

For example, if the reflection from the bottom of the ice is visible in the GPR line and the depth of the ice is known, the apex of the hyperbola can be positioned on that reflection and the velocity changed until the depth value displayed on the **Status Bar** (2.8) at the bottom of the window matches the known depth.

Target depth should be measured at the top of the highest band in the GPR response.

9.2.3 CMP/WARR Velocity Calibration

Common Mid Point (CMP) and Wide Angle Reflection and Refraction (WARR) are different types of GPR surveys compared to reflection mode surveys typically plotted with LineView.

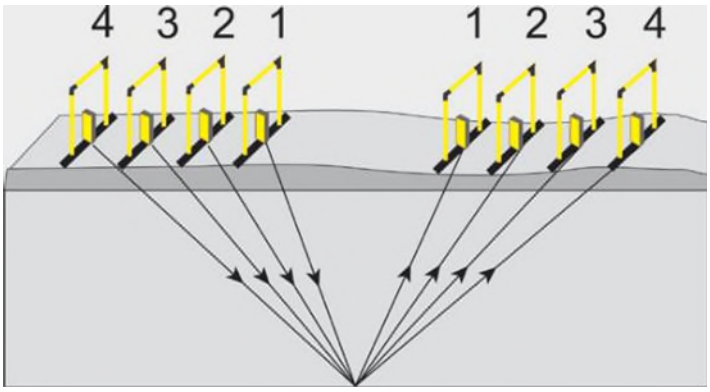


Figure 9-3: CMP data collection method.

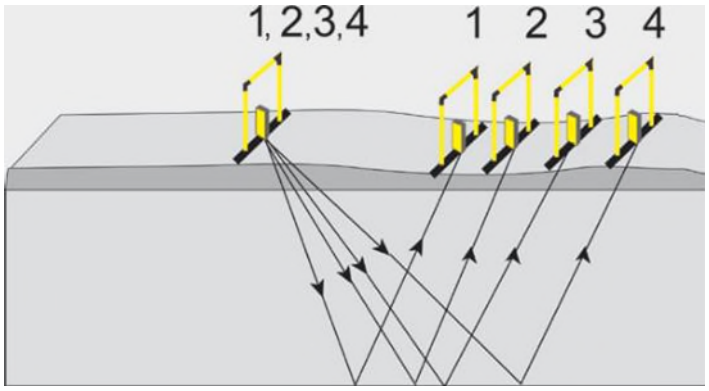


Figure 9-4: WARR data collection method.

The data can only be collected with fully bi-static GPR systems like the pulseEKKO and is used for subsurface velocity determinations. For more information on CMP or WARR data collection, see the pulseEKKO PRO User's Guide.

When Hyperbola Velocity Calibration is selected for a CMP/WARR file, the superimposed hyperbola can be moved to the top of one of the data hyperbolas at the approximate zero antenna separation point at the edge of the image (for data with a relatively large starting separation, it may be necessary to scroll the image slightly to the right to see the zero antenna separation point). The shape of the hyperbola can then be changed by clicking on either diamond-shaped handle on the ends of the hyperbola tails and dragging it to the position that best matches the shape of the image hyperbola (Figure 9-5).

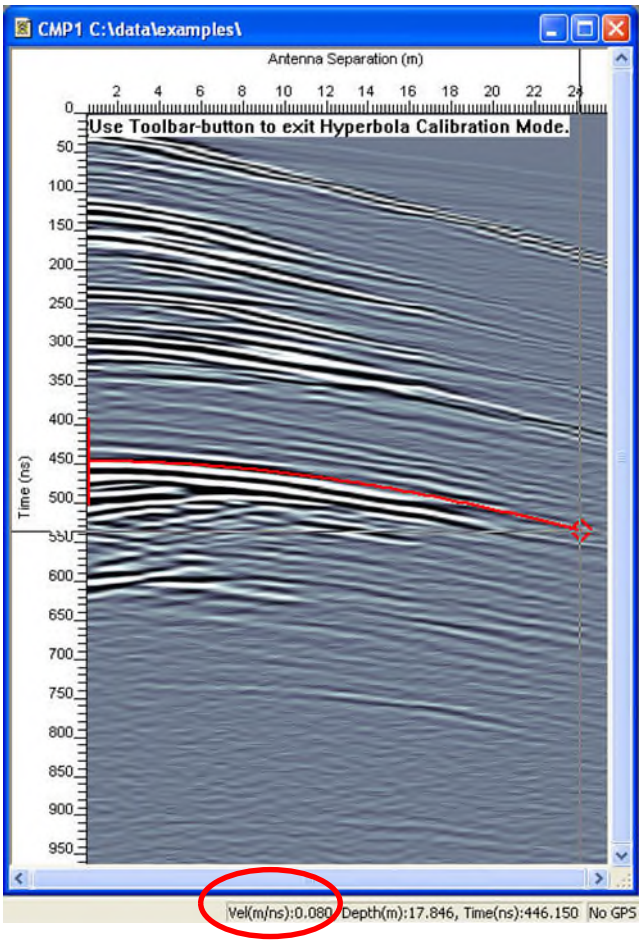


Figure 9-5: When determining velocity from a Common Mid Point (CMP) data file, move the superimposed hyperbola to the zero antenna separation point near the edge of the screen so only half is visible. Click and drag the diamond-shaped handle until it fits the curve in the data image. The average velocity for all the material above that reflector is displayed on the Status Bar at the bottom of the screen.

During the hyperbola velocity calibration, the **Status Bar** (2.8) along the bottom of the LineView screen displays the velocity of the hyperbola. As the hyperbola shape is changed, the velocity value changes.

After the calibration is complete, press the Hyperbola Velocity Calibration button again to exit from velocity calibration mode.



The message “Use Toolbar button to exit Hyperbola Calibration Mode” appears on the upper left of the image to remind the user.

The velocity extracted from a CMP/WARR file can then be used as the velocity for reflection mode survey lines collected in the same area as the CMP/WARR data (6.10.3.3).

9.2.4 Determining Target Depth

After measuring the GPR velocity using the Hyperbola Velocity calibration described above, the depth axis, depth grid lines and mouse cross-hairs can be used to determine the depths of targets in the GPR line.

It is important to understand that the depth of the target should always be measured from the highest band in the GPR response from that target; not necessarily the strongest band.

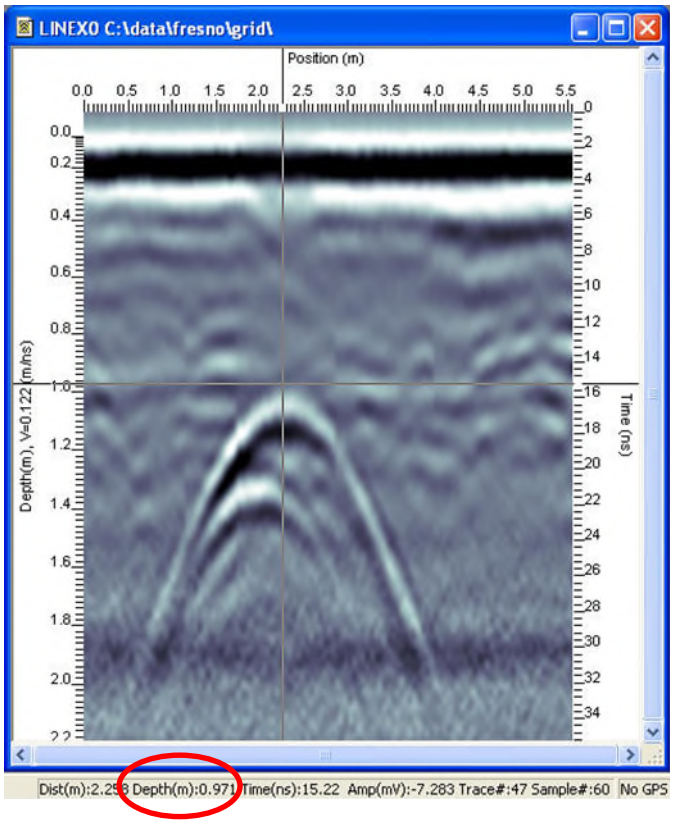


Figure 9-6: The depth to a target should always be measured from the highest band in the GPR response from the target. This band may not necessarily be the strongest. In this case, the depth of the pipe is determined by placing the mouse cross-hairs on the top of the white band.

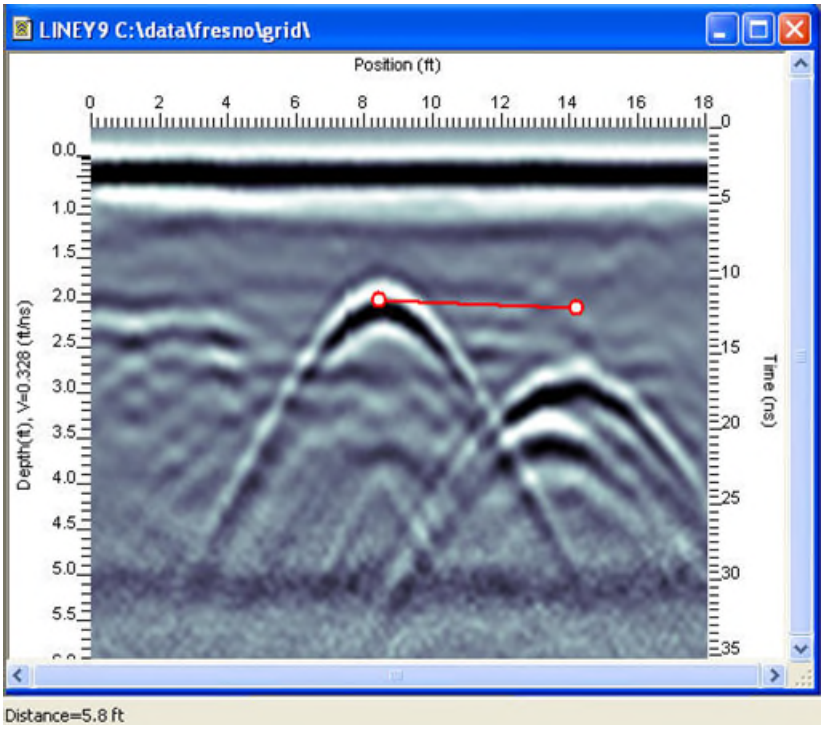
9.3 Measure

The measure tool allows the user to measure the straight-line distance between any two points on a GPR line.

The Measure tool is accessed by selecting Tool > Measure from the menu or by selecting the Toggle Measure Tool button from the Toolbar:



To measure the distance between two points, click the mouse at the start position and drag and drop the mouse cursor at the end position. The distance between the two points (in the current units) will be displayed on the **Status Bar** (2.8) at the bottom of the screen.



It is important to understand that any vertical component of measurements made on GPR lines are based on the velocity so an accurate velocity is critical for an accurate measurement.

To exit from the Measure tool, select Toggle Measure Tool again, either by using the menu or by clicking the button on the **View Toolbar** (2.5).

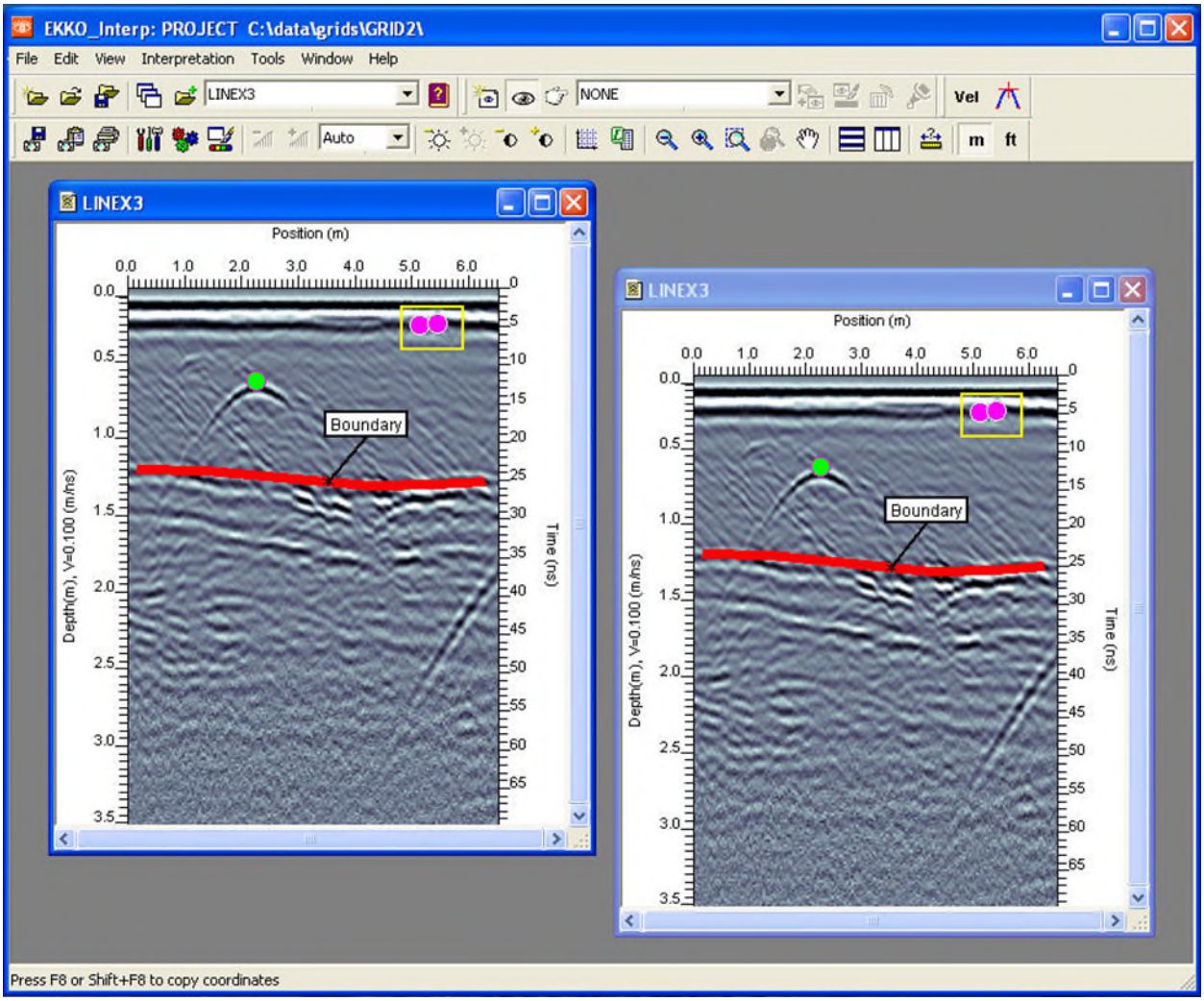
The color of the Measure tool is set under the View > Settings > General Tab > Marker Color (6.7.6).

10 Window

10.1 New

Selecting Window > New opens another GPR line window for the current GPR Line.

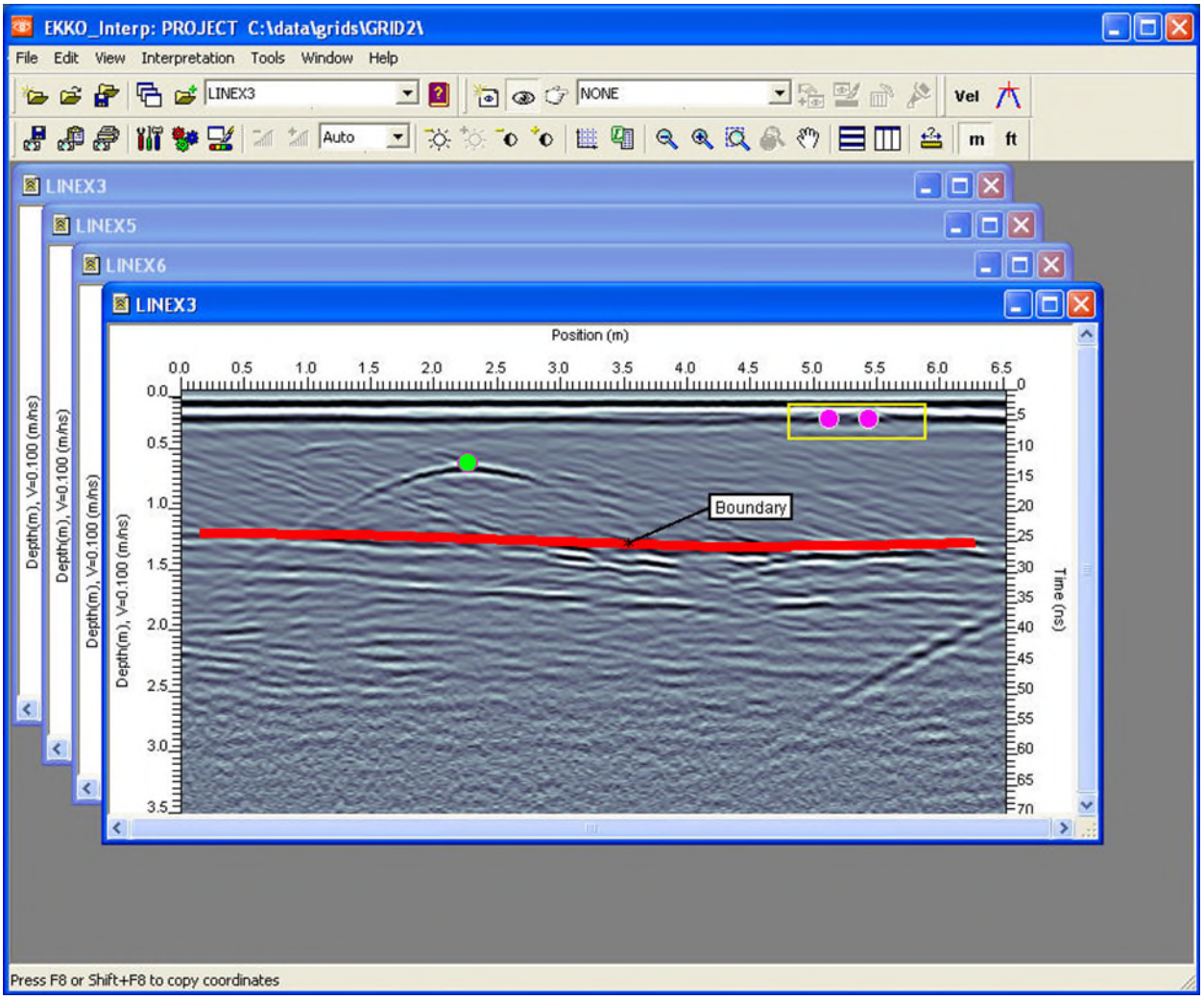
This is especially useful for looking at the same GPR line in different windows with different processing to see differences.



When there are multiple GPR line windows on the screen, only one is active at a time. Changing display settings under the View Settings Menu only applies to the current **Active Window** (2.2.1) unless the **Apply to All** button (6.4) is selected.

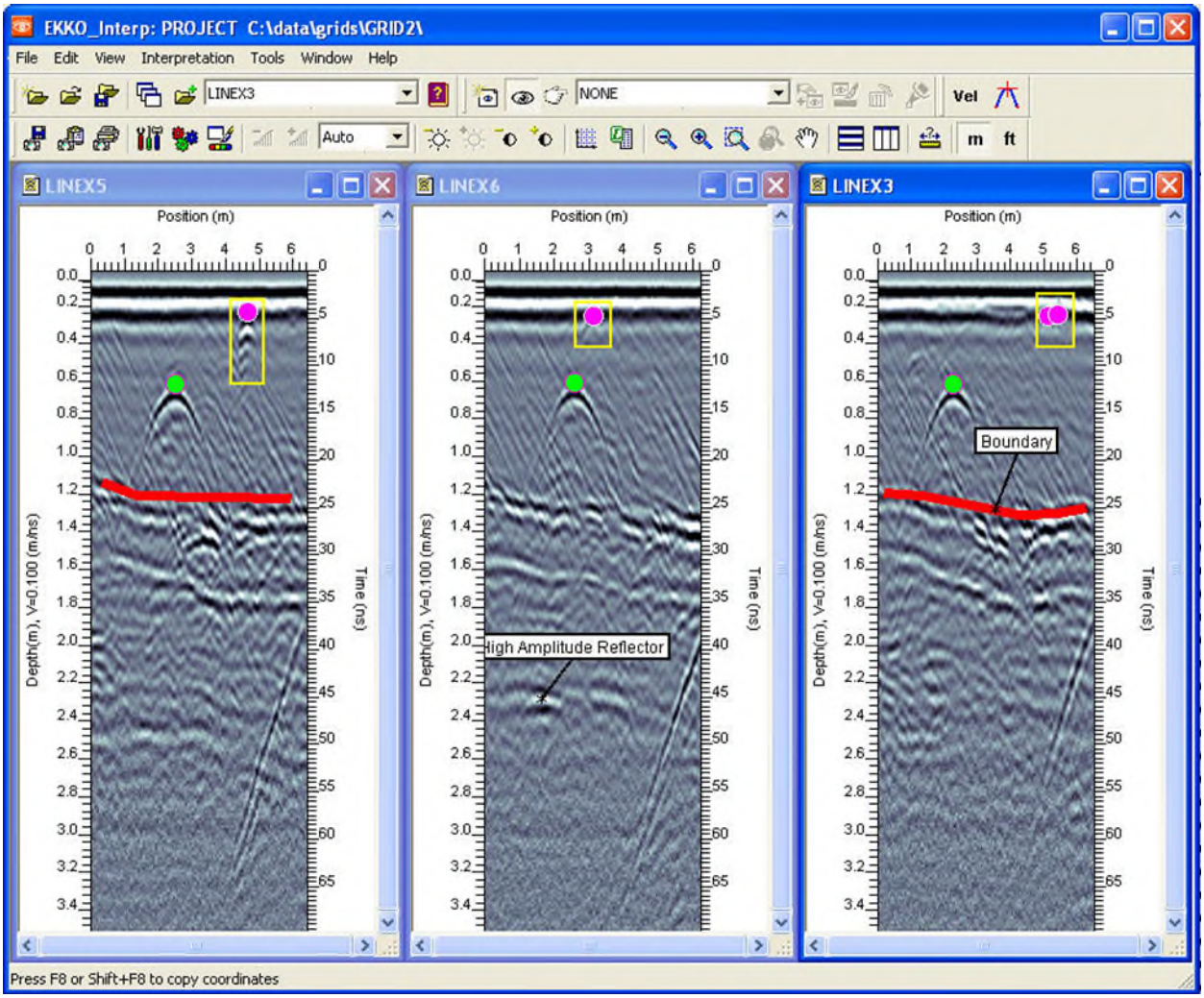
10.2 Cascade

Selecting Window > Cascade will rearrange open windows so they cascade on the screen, that is, the front section is completely visible and accessible.



10.3 Tile Vertically

Selecting Window > Tile Vertically will rearrange all open sections so they are tiled vertically on the screen, that is, all sections are resized so they are all visible and accessible.



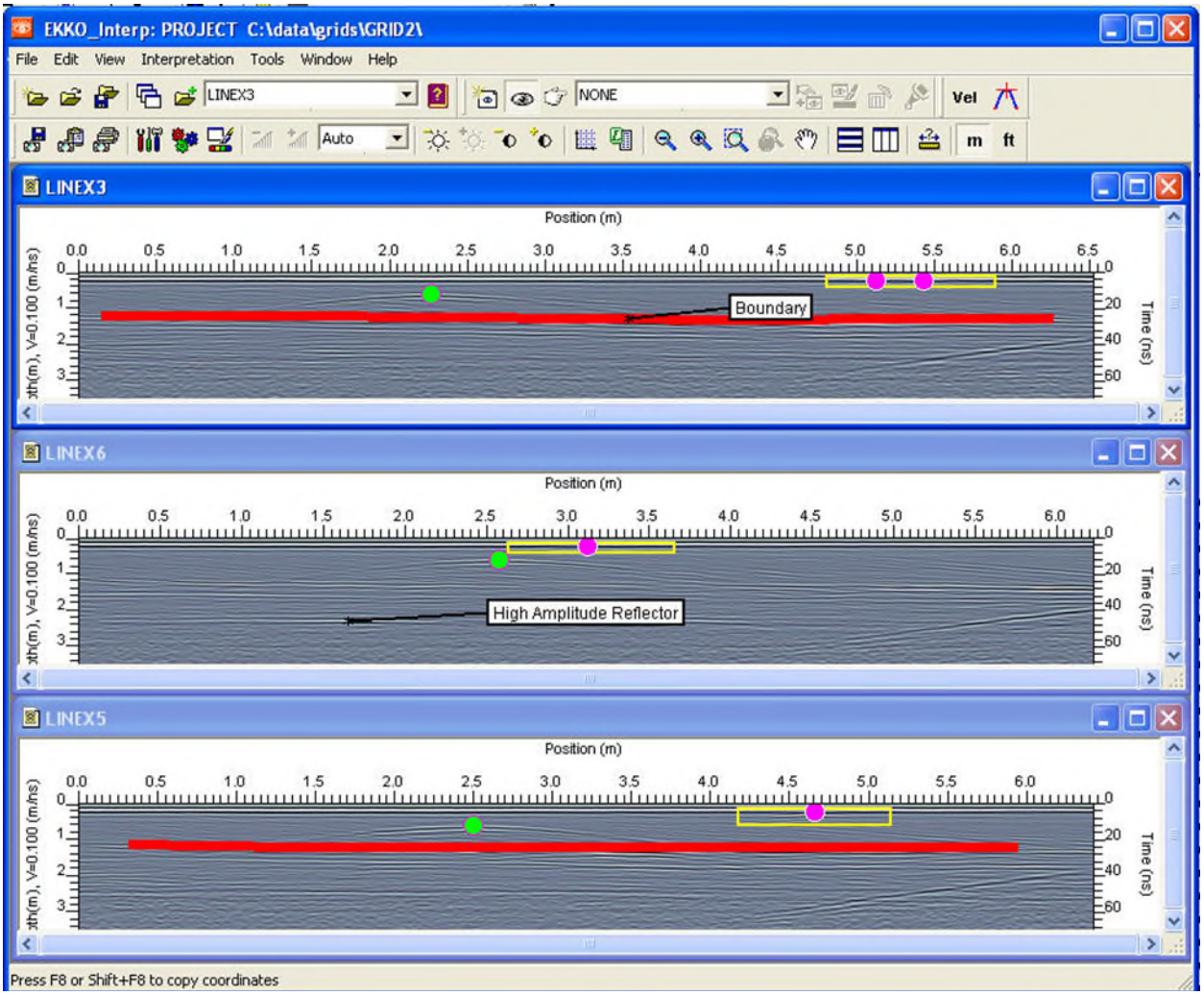
The Tile Vertically option can also be accessed by clicking the following button on the **View Toolbar** (2.5):



If there are many windows, this option may tile them in multiple rows rather than just one row.

10.4 Tile Horizontally

Selecting Window > Tile Horizontally will rearrange all open windows so they are tiled horizontally on the screen, that is, all sections are resized so they are all visible and accessible.



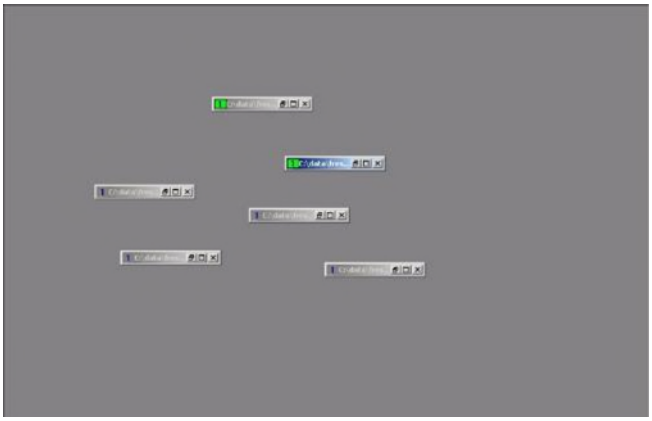
The Tile Horizontally option can also be accessed by clicking the following button on the **View Toolbar** (2.5):

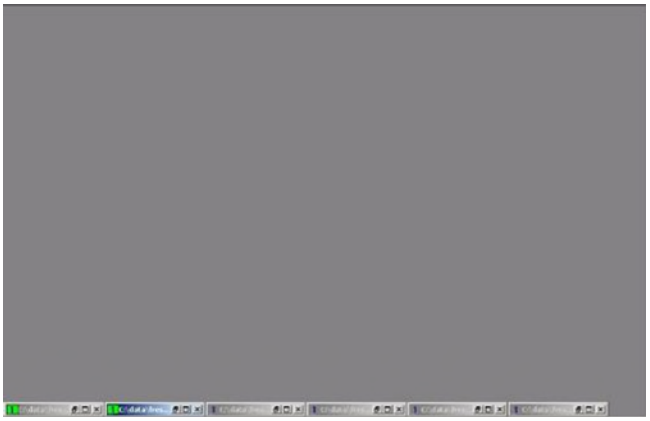


If there are many windows, this option may tile them in multiple columns rather than just one column.

10.5 Arrange Icons

Selecting Window > Arrange Icons will order all the icons (minimized windows).





10.6 Open All GPR Lines

The Open All GPR Lines option opens all the GPR data (DT1) files in the Project (GPZ) file for display; each DT1 file in a separate window.

This provides a quick way of displaying all the GPR lines without having to open them up one at a time.

The File > GPR Line(s) > Open All GPR Lines option can also be accessed by clicking on the **Open All Lines in Project** button on the Project Toolbar:



10.7 Close Current GPR Line

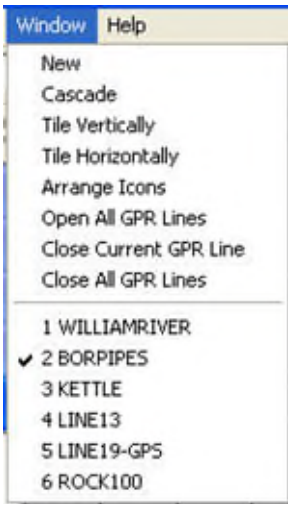
Selecting Window > Close Current GPR Line will close the current **Active Window** (2.2.1).

10.8 Close All GPR Lines

Selecting Window > Close All GPR Lines will close all currently opened windows, whether they have been minimized or not.

10.9 Selecting an Open Window

A list of all the currently open windows is available under the Window menu option. The current **Active Window** (2.2.1) is indicated by a check-mark. The active window can be changed by selecting a different one from the list.



11 Help

11.1 Help Topics

The Contents option opens this document in PDF for viewing.

The Adobe Acrobat Reader program must be installed on the PC to open this document. If not, the user is prompted to download it from the Adobe website.

11.2 Sensors & Software Contact Information

Displays contact information for Sensors & Software including mailing address, email addresses, phone and fax numbers.

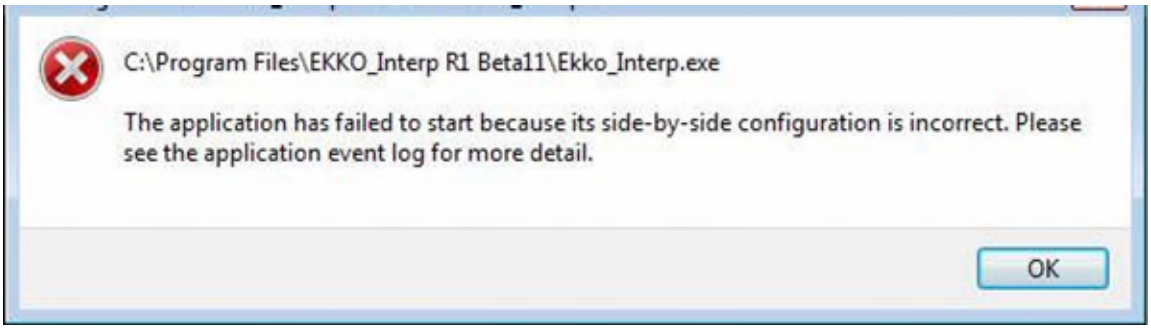
11.3 About LineView & Interpretation module

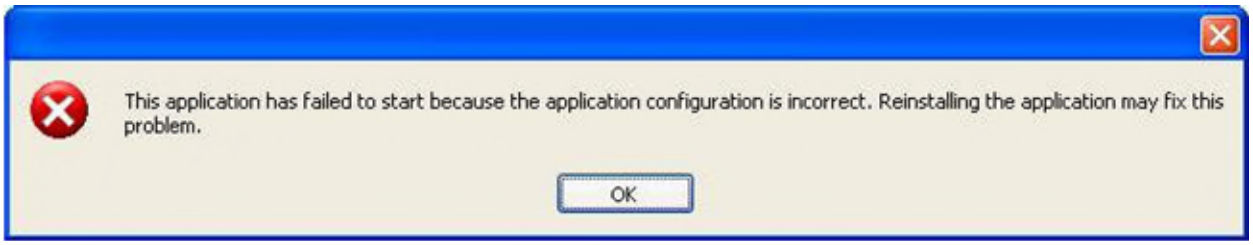
This option displays a description, version number and product number of the LineView program currently in use.

12 Troubleshooting

12.1 Program Fails to Launch

If, when attempting to run LineView, you receive error messages similar to these:

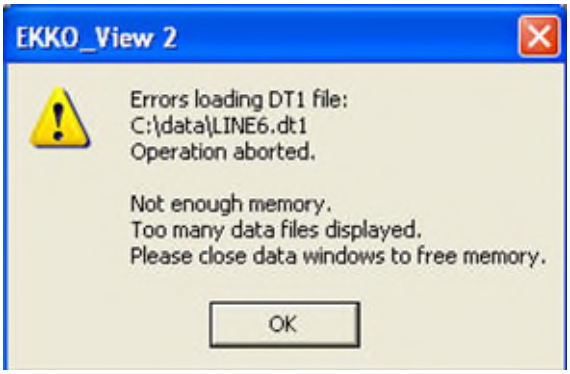




it is necessary to manually run the application “vcredist_x86.exe”. This application is in the EKKO_Project installation folder on the Software installation CD or in the folder downloaded from Sensors & Software. Look for it in the vcredist_x86 sub-folder.

12.2 Out of Memory - Too Many GPR Lines Open

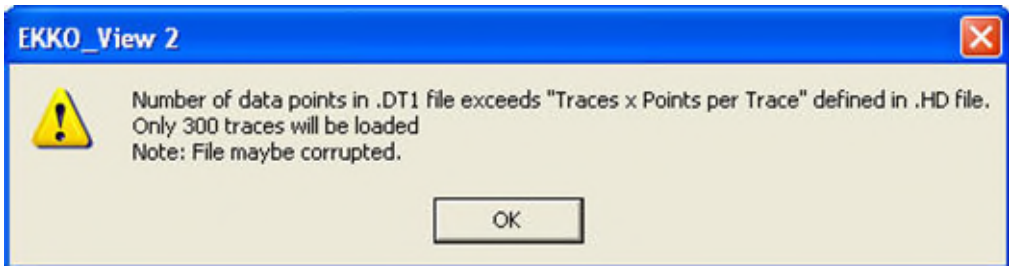
If so many GPR lines have been opened that the computer memory has been exceeded, the user will see the following warning:



Some files need to be closed before others can be opened.

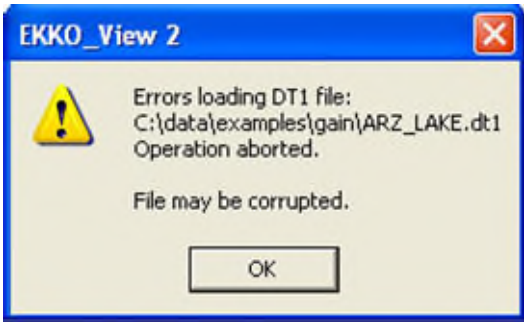
12.3 Opening Corrupted GPR Lines

Sometimes with a corrupted data, the header (.HD) file lists less traces than there are in the data (.DT1) file. LineView will display a warning message that the file is corrupt:



but will plot the number of traces listed in the header file.

If the data (.DT1) or header (.HD) file is corrupted and cannot be displayed, a message will be written to the screen and the plotting aborted.



12.4 Slow Display Response

If the data are stored on an external storage drive, the display response may be irritatingly slow when changes are made to the View Settings. To improve the response time, data files should be copied locally.

13 Glossary

13.1GPR Data View Terms

Line:	is the term used to identify the location of data acquisition. A line is normally straight and data are recorded from the start to the end of the line.
Line Profiling	is the term to describe collecting data along one or more lines for immediate site assessment using cross-section images.
Maximum Depth:	is the term which describes the maximum depth selected for viewing, processing or data acquisition along a line.
Maximum Time:	is the term which describes the maximum time selected for viewing, processing or data acquisition along a line.
Time Window:	same as Maximum Time.
Velocity:	is the term used to characterize the speed at which GPR signals travel. Velocity is a critical parameter when estimating depths of targets since velocity is used to convert travel-time to depth.
Color Palette:	is the term used to refer to the table that converts a data attribute like amplitude into color in the creation of cross-section images.
Line Name/Number:	is the identifier for a line of data saved when surveying along a line. (e.g. XL0010.DT1)
Gain:	when displaying cross sections formed from traces, a display control is often needed to allow strong responses from shallow targets to be viewed at the same time as weaker responses from deep targets. Gain is applied to weak signals to make them larger.
Depth Gain:	is a display gain applied that varies with depth along a trace.
Time Gain:	is a display gain applied that varies with time along a trace.
Cross-Section Image:	the term used when line profiling data are displayed as a computer generated image, showing signal amplitude varying in time or depth versus position along the line. Quite often the term is shortened to cross-section or section.
Depth or Depth-Section	Image: the term used when line profiling data are displayed as a cross-section with the vertical depth scale. Quite often the term is shortened to depth-section or section.
Time or Time-Section Image:	the term used when line profiling data are displayed as cross-section with the vertical time scale. Quite often the term is shortened to time-section or section.

Image Sensitivity	How sensitive the image is to small signal variations. Effectively the Color Palette "widens" around the zero signal level. Given as 0-100%, with default being 100% (most sensitive)
Image Contrast:	How much of image is at extremes of Color Palette. Effectively the Color Palette increases the area of extremes of data signal. Given as 0-100%, with default of 0% (no added contrast)
Hyperbola Velocity Estimate	A point source GPR refection appears as a hyperbola in the Cross Section Image. Hyperbolic fitting enables the media velocity and target depth to be estimated.
Hyperbolic Fitting	Process of fitting a hyperbolic shape to a local GPR response in the space-time domain. The fitting process yields a velocity above target and a depth estimate.

13.2GPR Interpretation Terms

Interpretation (Noun):	A group of observations of a specific type used to categorize and spatially locate a set of buried objects. This allows the user to group buried objects into categories. For example, in a cross-section image of a deck, the observed upper layer of hyperbolic features are interpreted by the user as belonging to the upper rebar mat. The user can then create an interpretation named "Upper Rebar Mat" using the point tool, select this interpretation and then click on the location of the apexes of all the corresponding hyperbolas to assign them to the interpretation "Upper Rebar Mat". Similarly an interpretation consisting of set of polylines define a horizon and a set of boxes can outline a set of similar features.
Interpretation (verb):	Process of marking the location of a feature on a GPR image (cross-section or depth slice) to determine the depth and position of the buried object. As part of this process the user categorizes the feature as belonging to an interpretation type (e.g. rebar, pipe). Note that in LineView we use this as a noun to define a group of like observations.
Drawing Tool or Tool:	The graphic object drawn on the cross-section or depth slice image to interpret and mark the location of a buried object. (e.g. point, line or box). For example, when picking the location of the bottom of an asphalt layer on a cross-section image the polyline drawing tool would be used. To mark the apexes of hyperbolas the point drawing tool would be used.
Point:	A drawing object consisting of a symbol centered on defined x,y,z coordinates.
Polyline:	A drawing object consisting of a set of ordered points with defined x,y,z coordinates.
Box:	A drawing object consisting of 4 points with defined x,y,z coordinates joined by straight segments forming a rectangle.

Annotation:	A rectangle that can be drawn on the cross-section or depth slice image that contains text and has an attached arrow. This uses the Callout type of drawing tool in Word®. This tool creates a text box with an attached arrow. The point on the arrow is at the location the mouse is clicked. The text box can be changed in size and moved around on the cross-section image relative to arrow. The arrow can also be moved but is always attached to the box.
Marker:	The symbol used for the point on the Point drawing tool and the points on Line and Box drawing tools.
Observation:	The member of an interpretation. For example for the point tool this would an individual point, for the polyline tool this would be the set of points that define a polyline and for a box tool this would be the set of points that define the box.
Horizon:	A continuous linear feature in a cross-section image that defines the surface separating two different material types in the subsurface. For example this may be different rock types in a geological section or the interface between asphalt and granular in pavement. A set of horizons provide a stratigraphic interpretation of the subsurface.
Hyperbola:	A characteristic scattering response feature in a cross-section image produced by a buried object. (e.g. utility pipe, boulder). It is shaped like an inverted "V".
Feature:	Characteristic response on a cross-section (e.g. hyperbolic feature)
Object:	The physical buried entity that is causing the observed feature in the cross-section.
Attributes:	The properties of an observation. These would typically include the position, depth, time, amplitude, optional comment and GPS location.
Marking Locates:	Process of drawing a symbol at location of scattering hyperbola features on cross-section. Used for utility locating Interpretation module.
Selected Observations:	The group of observations or line vertices defined by the following processes: clicking on an observation, drawing a box around a group of observations or line vertices and using the 'Select All' item in the right click menu. The user can only select observations from the active interpretations. For example by selecting a group of observations the user can delete them together.
Active Interpretation:	The interpretation on which operations can be performed. These operations include selecting, editing and exporting. Active interpretations are highlighted by small boxes drawn around the points that define the interpretation. In normal use one interpretation will be made active by the user to allow them to delete, add and move observations.
X,Y,Z Coordinates:	The X,Y,Z coordinates described above are the trace, sample number and line position.

13.3General GPR Terms

Alpha	exponential attenuation coefficient - normal units dB/m (see attenuation)
K	relative permittivity or dielectric constant
Sigma	electrical conductivity - normal units mS/m
v	propagation velocity - normal units m/ns
dB/m	decibels/metre, common unit for attenuation,
m/ns	metre/nanosecond, common unit of GPR velocity, v (see nanosecond)
mS/m	milli Siemens/metre, common unit for conductivity,
ns	nanosecond, normal unit of GPR time (see nanosecond)
ps	picosecond = 0.001 ns =10^{-12}s, occasion unit of GPR time
us	microsecond = 1000ns =10^{-6}s, occasion unit of GPR time
COR	common offset reflection (survey type where a constant antenna separation is maintained).
CMP	common mid-point (survey type where a transmitter and receiver antenna separation are changed but the mid point remains constant)
GPR	ground penetrating radar
EM	electromagnetic (common abbreviation)
antenna	Device used to couple electromagnetic energy into the ground. Sometimes called a transducer.
antenna separation	Spacing between transmitting and receiving antennas.
attenuation	A reduction in signal amplitude caused by energy dissipation in the transmitting media (see Alpha).
bandwidth	The range of frequencies over which a given device transmits or detects signals above a specified amplitude or power
center frequency	Middle of the frequency band defined by a device's bandwidth
conductivity	The ability of a material to conduct electrical current. In isotropic materials the reciprocal of resistivity. Sometimes called specific conductance. Units are siemen/m or S/m. (Or occasionally, mhos/m). For GPR, usually expressed as mS/m. Common symbol
cross section	Image that results from side-by-side display of a number of traces which are from adjacent spatial measurement position

gain	Process of amplifying signals to match recording device or display dynamic range
nanosecond	10^{-9}s (One Billionth of a second)
radio wave	Electromagnetic fields that travel through a material as waves and typically have oscillating frequencies in the 1 GHz to 10 GHz range
receiver (Rx)	General term for electronics devices used to detect fields and translate signals into records or displays
resolution	The minimum separation of two objects before their individual responses merge into a single response
sample point	Signal amplitude measured at specific point in time
signal amplitude	A measure of the strength of the radio wave signal
station interval	Spatial distance between observation points along a survey line
step size	See station interval
transmitter(Tx)	General term used for electronics devices used to create propagating electromagnetic fields
transducer	Name used where GPR antenna, electronics, and shield are combined into one physical unit
trace	Sequence of sample points from a single GPR channel that indicate time variation of signal amplitude

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