Surface Potential Surveys Training Manual – Gx Data-logger Version

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CONTENTS

SECTION I

INTRODUCTION

The "Surface Potential (SP)" pipeline survey method is similar to the DCVG survey method, at least in terms of how the reference electrodes are employed to measure the difference in potential between two points on the surface of the soil above a buried pipeline. SP surveys, however, are typically performed on uncoated, or poorly-coated pipelines, whereas DCVG surveys are usually performed on well-coated pipe that has an impressed current source providing the "signal strength".

Localized current flow can gives rise to potential gradients on the surface of the soil above a buried pipe due, for example, to the presence of corrosion cells (combinations of anodic and cathodic areas) on the pipe, and the goal of an SP survey is to locate such potential gradient fields.

In the case of bare pipe, typically only about 10-15 % of the pipe will be subject to galvanic corrosion and, in addition, typically this small percentage is made up of small, highly-localized, corrosion areas (anodic areas) that are randomly-distributed along the length of the pipe. Thus, an "above-the-ground" survey technique that can accurately locate these isolated areas is invaluable.

The objective of SP surveys is to locate **anodic** areas existing along a segment of pipeline, as evidenced by potential gradient fields having a particular polarity presenting themselves on the surface of the soil directly above the anodic areas. Once any anodic areas have been located, remedial action can be taken, such as the installation of "sacrificial" anodes to suppress current flow from the corroding area, with a view to preventing further external corrosion in that particular area.

SECTION 2

PHYSICAL PRINCIPLES

When current flows onto (or away from) a localized area on a buried-pipeline, a voltage gradient field presents itself on the surface of the soil directly above the localized area.

In the case where current is flowing **onto** a pipeline at some localized area, that localized area is considered a **cathodic** area and the voltage gradient field on the soil above the pipe will have a **negative** polarity. The largest negative potential will exist directly above the anomaly and the negative potential will decrease in magnitude to remote earth potential with distance away from the pipe.

The opposite is true in the case where current is flowing **away** from an isolated (localized) area on a buried-pipeline. In this case, the area is considered an **anodic** area and the voltage gradient field presenting itself on the surface of the soil above the pipe will have a **positive** polarity. The largest positive potential will exist directly above the anodic area and the positive potential will decrease in magnitude to remote earth potential with distance away from the pipe.

Since corrosion occurs on an uncoated buried pipeline via the development of "corrosion cells", both anodic and cathodic areas must exist simultaneously. The current flowing away from the anodic area will be collected by the cathodic area and the return path for the current will be the pipeline itself.

This situation is illustrated schematically in Figure 1 below (top diagram).
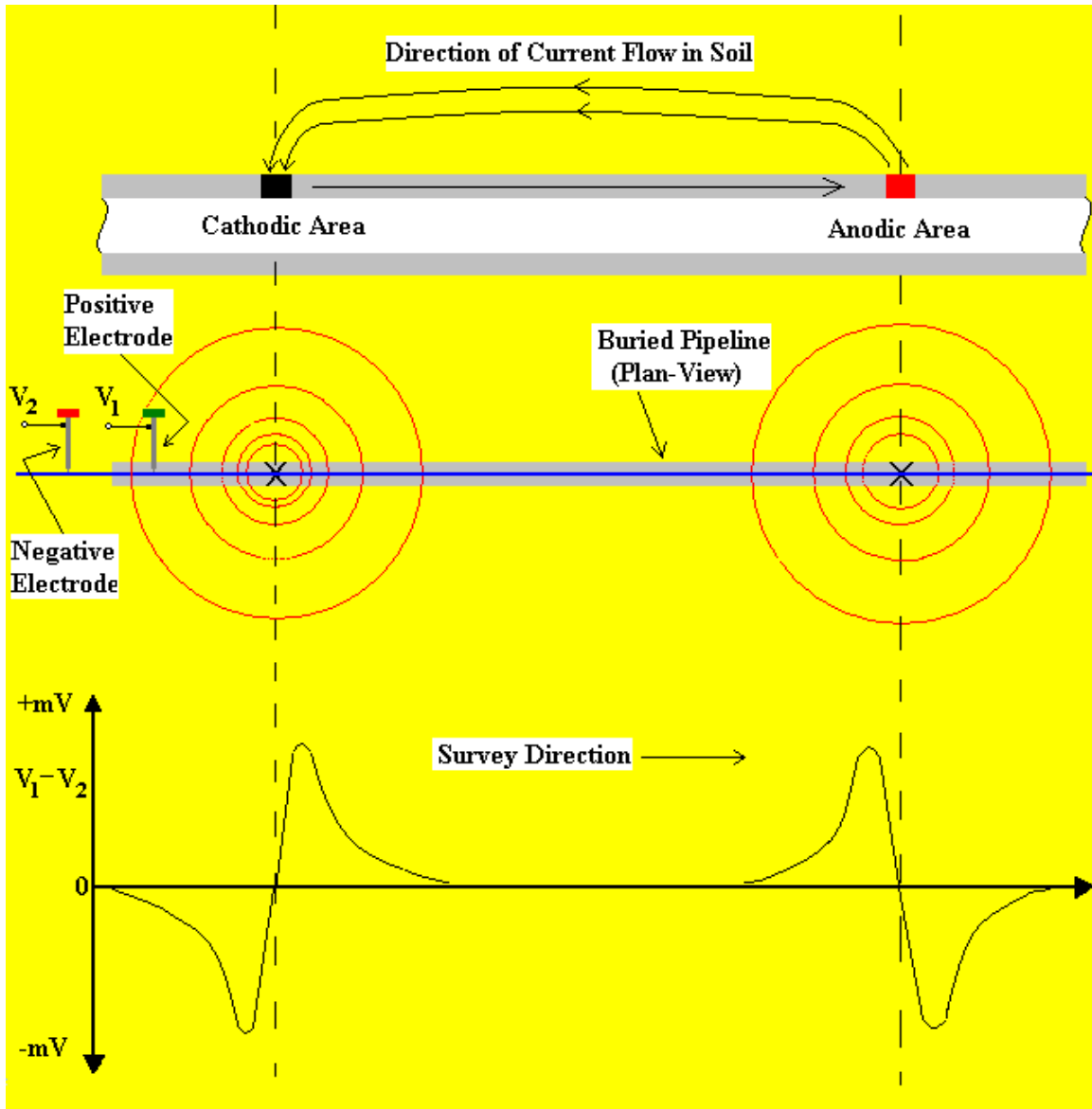
Figure 1: In-Line method of conducting SP surveys. Soil-to-soil potential difference readings are plotted in the bottom diagram against the position along the pipeline of the center point between the reference electrodes
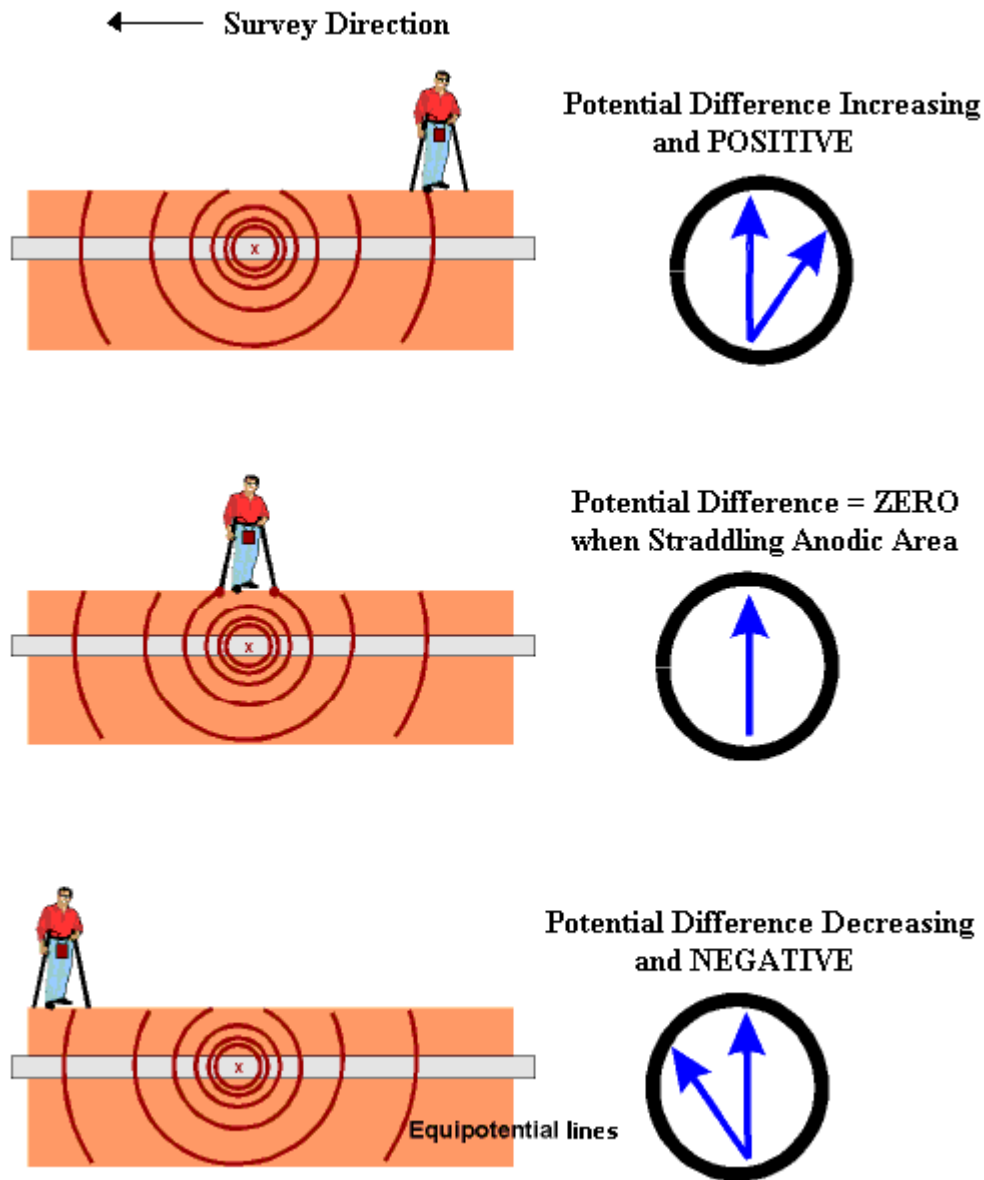
In-Line SP Survey Method

One way to perform a SP pipeline survey is to use the, so-called, "In-Line" method. In this case, the reference electrodes are both positioned over the pipe and their separation is kept fixed as the operator, or operators in the case of large electrode spacings (for example, a 20 feet spacing), walks down the length of the pipeline section. With a view to detecting localized anodic areas and accurately measuring the longitudinal voltage profile, the survey needs to be close-interval in nature.

With the electrodes positioned as illustrated in Figure 1, i.e., with the positive data-probe leading, when cathodic and anodic areas are encountered, the polarity of the longitudinal voltage (V^1 minus V^2) switches from negative to positive, in the case of isolated cathodic areas, while in the case of isolated anodic areas, the polarity switches from positive to negative as the voltage gradient fields are traversed.

The (longitudinal voltage) polarity switching phenomenon is explained with reference to Figure 2 below.

For the case of a localized **anodic** area, the potential gradient on the surface is positive and, so, when the positive data-probe enters the gradient field, a positive potential difference will be measured, relative to the zero potential difference measured with both data-probes positioned outside the gradient field. The potential difference measured between the probes will continue to increase, as the data-probes advance into the gradient field, and will go through a maximum value before dropping through zero (as the data-probes straddle the epicenter of the anodic area) and becoming negative. After going through a maximum negative value, the potential difference measured between the probes will decrease (staying negative) and eventually become zero again with both data-probes positioned on the far side of the potential gradient field. This type of longitudinal voltage profile is illustrated in Figure 1.

It should be noted that the nuances of the profile shown in Figure 1 will only be observed if the survey is close interval in nature (relative to the size of the potential gradient field).

Figure 2:   In-Line SP Survey Method.

Illustration is for the case of transiting a localized ANODIC area with the lead data-probe being the positive probe, in which case the polarity of the longitudinal voltage switches from positive to negative as the operator walks through the voltage gradient field.

Anodic Area "Severity" Factor:

In addition to locating anodic areas, there is interest in determining some sort of "severity factor" for each location.

However, unlike in the case of DCVG surveys which utilize a known "signal strength", i.e., the IR drop in the soil in the vicinity of the anomaly, there is no directly measurable "signal strength" in the case of Surface Potential surveys.

Consequently, some other approach is required to come up with a "severity factor".

At the present time, the specification upon which our software is currently based calls for the generation of a "Corrosion Factor" value for each "marked" anodic location. The calculation is as follows:

Corrosion Factor = [Maximum longitudinal voltage reading logged on either side of the SP anomaly (within 2 reading intervals of the "marking" location)] / [Soil resistivity in the vicinity of the SP anomaly]

Since the magnitude of the current flowing away from an anodic area correlates with the rate of corrosion in that area, factoring in soil resistivity makes sense, if we're trying to get a handle on the rate of corrosion for a given magnitude of voltage gradient. For instance, for a given magnitude of voltage gradient on the surface, the corrosion rate will be higher (current flow away from the pipe will be larger) if the soil resistivity in the area is relatively small. Conversely, for the same magnitude of voltage gradient on the surface, the corrosion rate will be lower (current flowing away from the pipe will be smaller) if the soil resistivity in the area is relatively large.

Another approach regarding Corrosion Factor determination would be to use the sidedrain readings, which are a direct measure of the gradient field magnitude, as the numerator in the Corrosion Factor calculation, as opposed to the "maximum longitudinal voltage" whose value is subject to data-probe placement, relative to the potential gradient field.
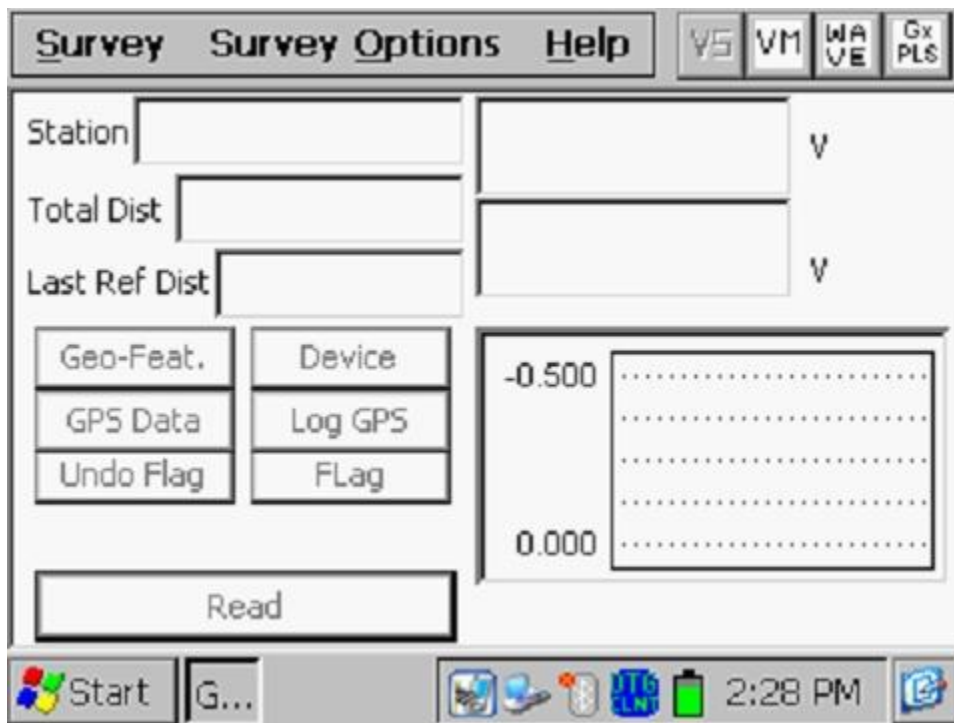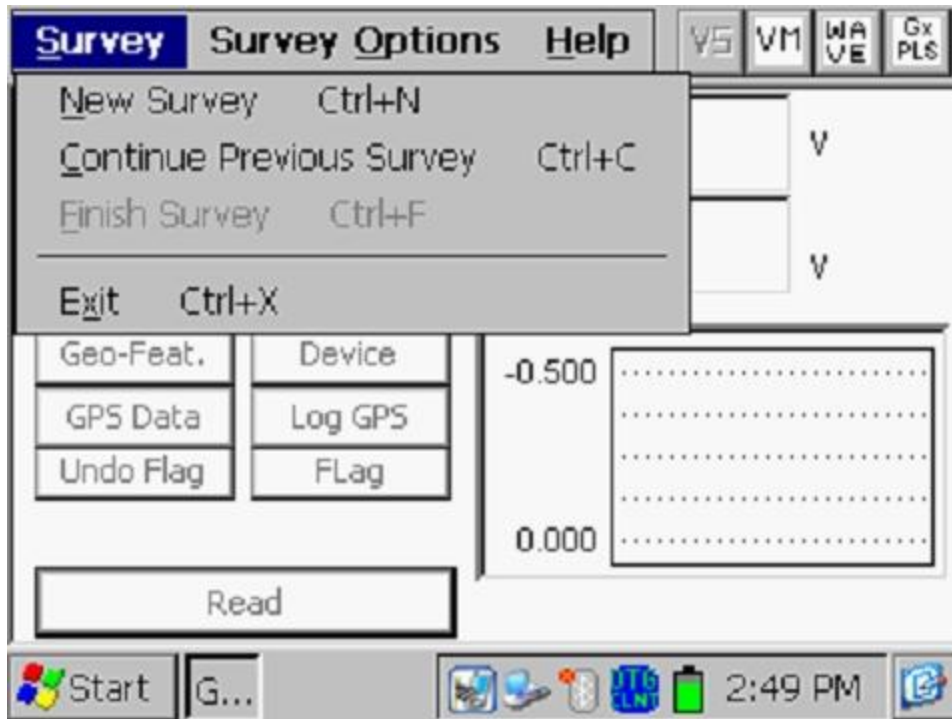
SECTION III

**HOW TO SET UP THE Gx DATA-LOGGER FOR
SURFACE POTENTIAL SURVEYS**

### III.1 Gx Data-logger Setup for Surface Potential Surveys

Step 1: Double-tap on the Gx_PLS icon on the Gx desktop. The screen shown below will be displayed.

Step 2: Tap on the "Survey" button located on the menu bar. The screen shown below will be displayed.

Under "Survey" there are several options. If this is a new survey (not a continuation of a previous survey) tap on "New Survey". The screen shown below will be displayed.
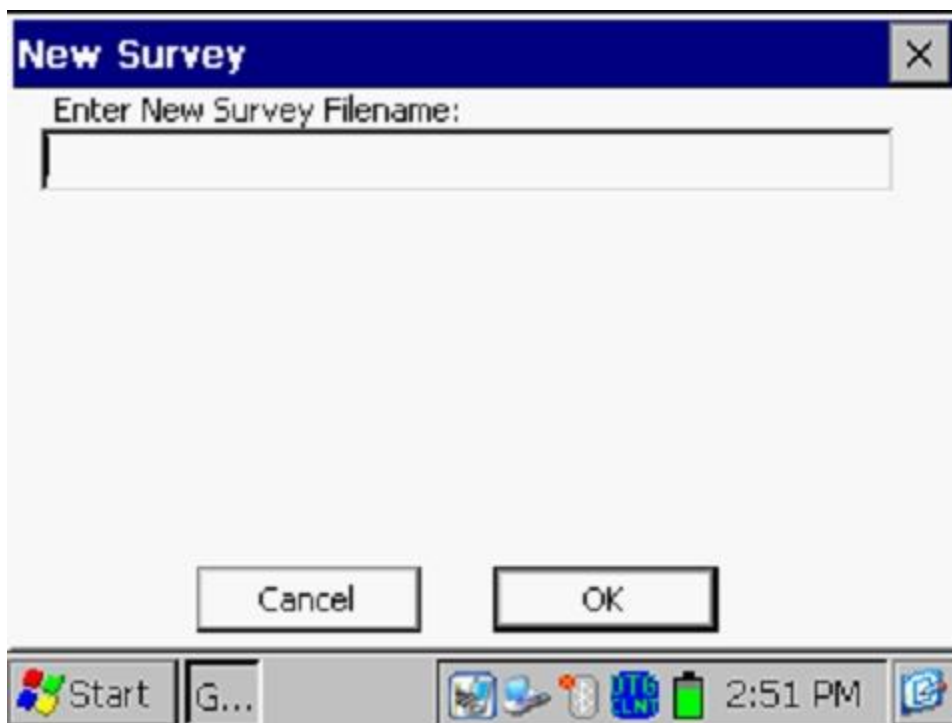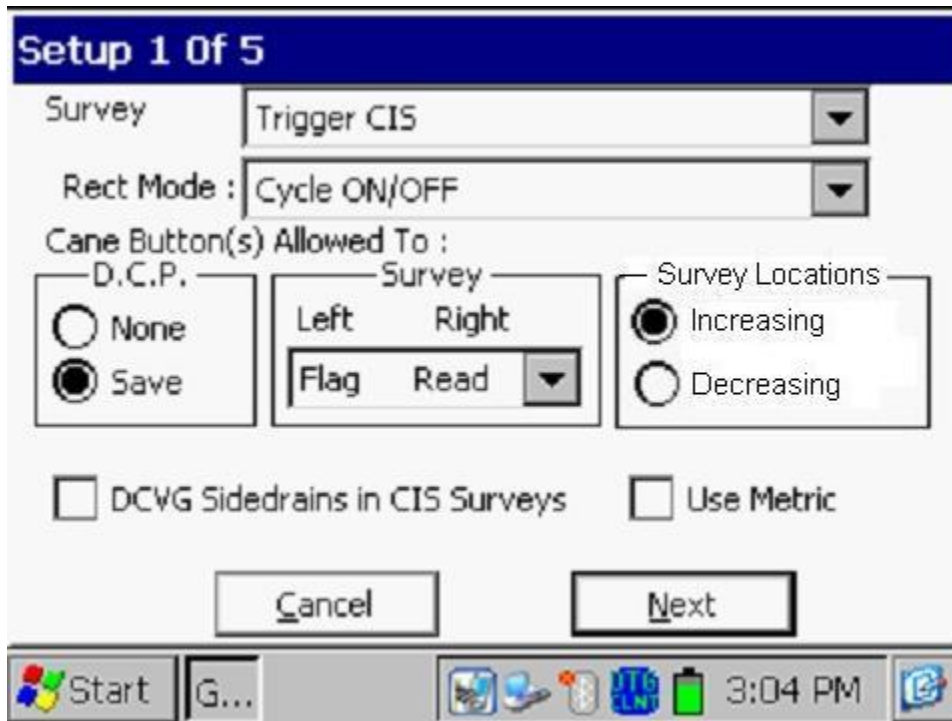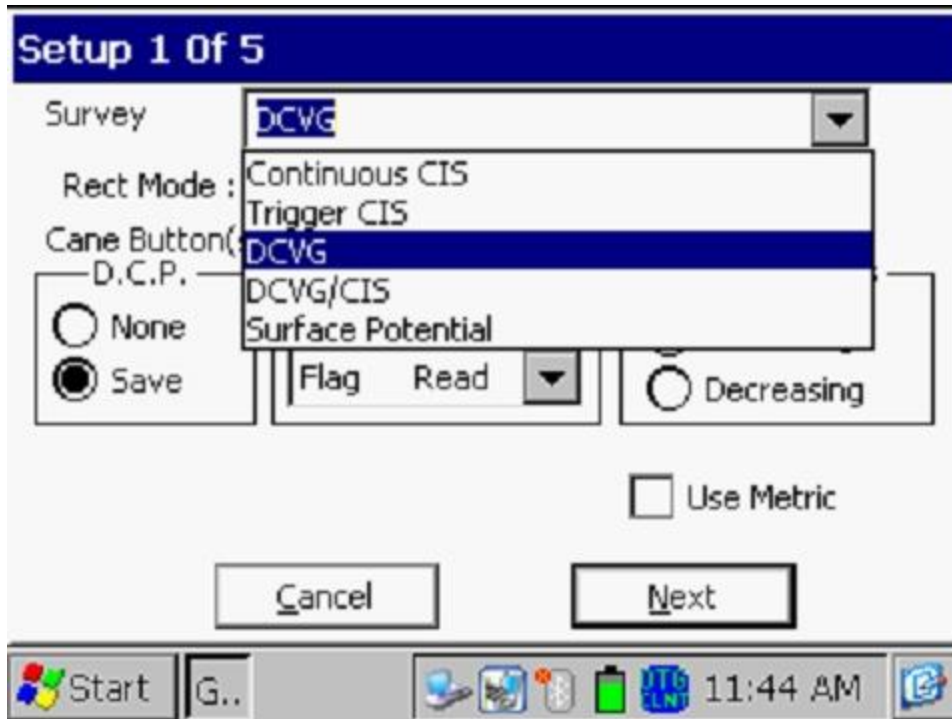
Step 3: Enter a "filename" for the Survey.

This should be a descriptive name that will help you identify the survey at a later stage. Perhaps the name of the section of pipe you are surveying could be part of the filename. "Surface Potential" and the survey date do not have to be part of the filename as these tags are incorporated with the survey on the ProActive side (assuming that you will be downloading the survey data to the ProActive application).

Note: You will not be permitted to use invalid characters, such as slashes(/ or \ ), as part of a filename. You will be alerted if you try to use any invalid characters.
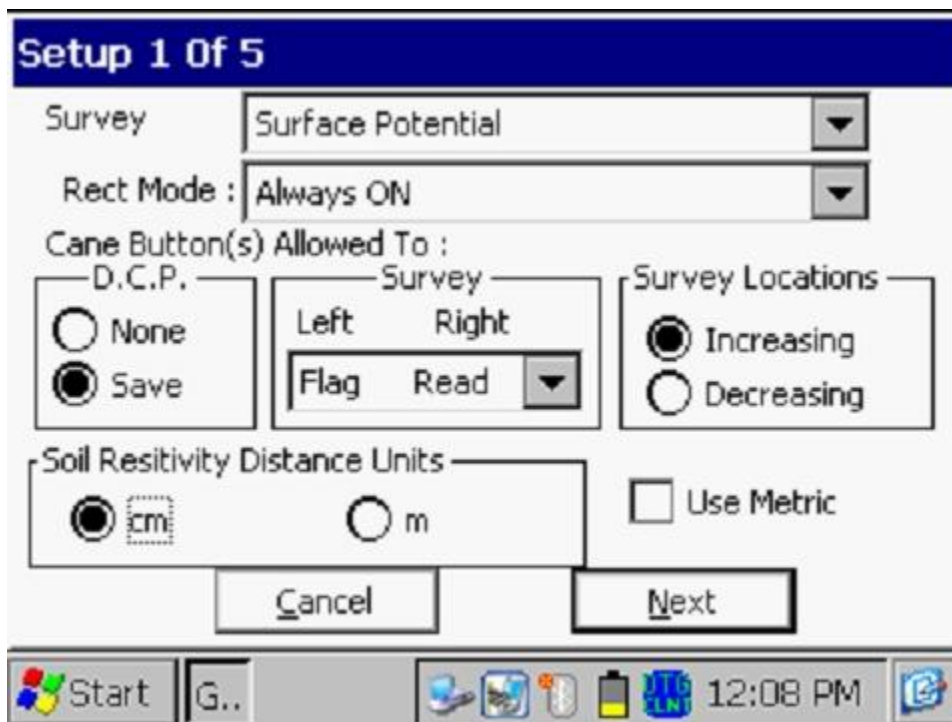
Step 4: Once you have entered a filename, tap the OK button on the above screen. The screen shown below will be displayed. The specific selections indicated on the screen will reflect the selections made for the previous survey.

Step 5: Select the survey type by tapping on the menu button in the "**Survey Type**" field and highlighting the survey type of your choice.

Setup 1 Of 5

Survey: DCVG

Continuous CIS
Trigger CIS
DCVG
DCVG/CIS
Surface Potential

Rect Mode :
Cane Button(

D.C.P.
○ None
● Save

Flag   Read

○ Decreasing

☐ Use Metric

Cancel   Next

Start G...   11:44 AM

By tapping on the "Surface Potential" option, the screen shown below will be displayed, depending on the previous survey selections

Setup 1 Of 5

Survey: Surface Potential

Rect Mode : Always ON

Cane Button(s) Allowed To :

D.C.P.
○ None
● Save

Survey
Left   Right
Flag   Read

Survey Locations
● Increasing
○ Decreasing

Soil Resitivity Distance Units
● cm   ○ m

☐ Use Metric

Cancel   Next

Start G...   12:08 PM

Rectifier Mode
By tapping on the menu button in the "Rect Mode" field, you can select either, "Always On", if the rectifiers influencing the pipe are ON, or, "Always Off", if the pipe is unprotected or is temporarily depolarized. *Note:* The "Cycle On/Off" option is not available for Surface Potential surveys as the process involves cell-to-cell potential difference "single" readings.

Survey
Typically, for Surface Potential surveys, you would "trigger" readings using either the positive (green-handled) data-probe or the negative (red-handled) data-probe. In the case where an "in-line" survey is to be performed by two crew members (one holding the positive data-probe, the other holding the negative data-probe, the choice of which push-button switch to designate as the "trigger" for readings will depend on which data-probe the crew member operating the Gx is holding. If the Gx operator holds the red-handled (negative) data-probe, the selection should be "read flag" in the "Survey" category and, if the Gx operator is holding the green-handled (positive) data-probe, the selection should be "flag read". In either case, the crew member who is not the Gx operator could use his push-button switch to designate the location of survey flags.

D.C. P.
You can also use the push-button switches when recording voltages at D.C.P.'s (data collection points (devices)) to "save" a device reading, as opposed to tapping on the "save" button on the survey screen, if you wish. To do so, you would select the "Save" radio button on the above screen. If the "None" option is selected, the push-button switches will have no functionality at D.C.P.s

Note: When "Marking" SP anomalies (see the Surface Potential Training Manual – Gx Data-logger Version), the push-button switch functionality becomes "accept", regardless of whether "save" or "none" is selected here.

Survey Locations:
Once a value has been entered for the "Distance between Readings" (see the Setup 3 of 5 screen), that distance, for example 5.0 feet, can be added to each successive station number each time a reading is triggered, or, it can be subtracted from each successive station number each time a reading is triggered.

Your selection of "Increasing" or "Decreasing" will depend on your walking direction over the pipe with respect to the pipe's stationing.

You would select "**Increasing**" if the station number will be increasing as you perform the survey and you would select "**Decreasing**" if the station number will be decreasing as you perform the survey.

Use Metric
By checking off the box labeled "**Use Metric**", the reading interval (distance between triggered readings) and the flag internal (survey flag spacing) will be displayed on the Setup 3 of 5 screen in meters, as opposed to feet.

Soil Resistivity Distance Units
As indicated in the Surface Potential Survey Training Manual - Gx version, you have the option to manually enter a value for soil resistivity measured at the location of a "marked" SP anomaly, which will allow the ProActive software to calculate a "Corrosion Factor" value. The units "Ω.cm" or "Ω.m" for soil resistivity that will appear on the SP anomaly "marking" screen, for your manual data entry, will depend on your selection here in the "Soil Resistivity Distance Units" field (cm or m)

Step 6: Tap on the "Next" button on the above screen which will result in the screen shown below being displayed, depending on the settings used on the previous survey.
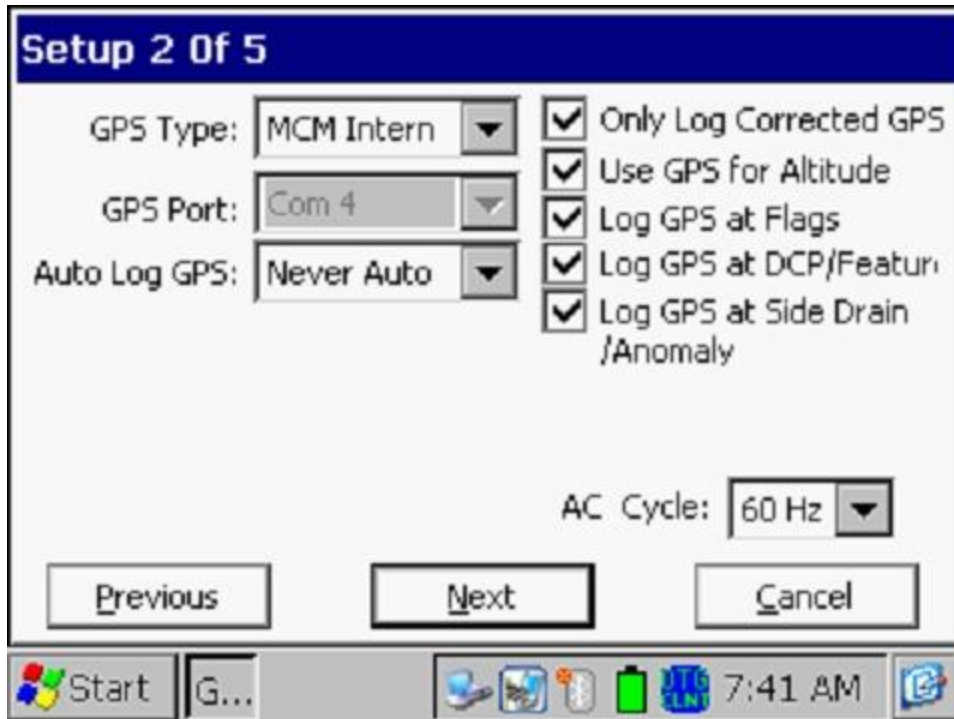
AC Cycle
By tapping on the menu button in the "**AC Cycle**" field on the screen shown above, you will have the choice of 60Hz or 50Hz AC. Select 60Hz for all U.S. applications. This is an important select with regard to the AC filtering system that's applied to all of the DC voltage channels.

GPS Type
By tapping on the menu button in the "**GPS Type**" field on the above screen, the screen shown below will be displayed.
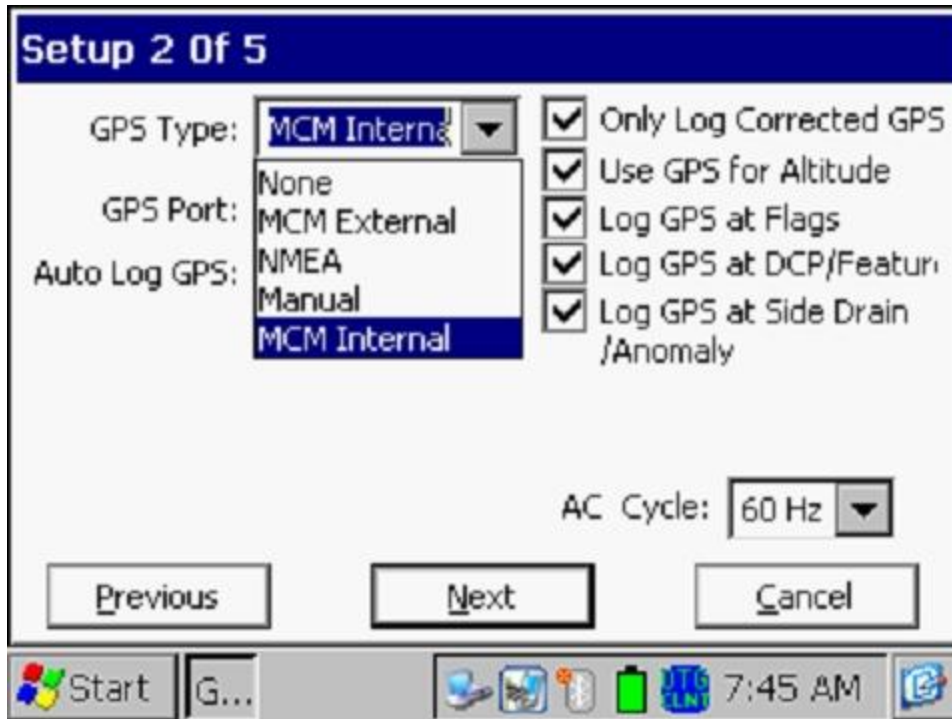
As can be seen from the above screen, there are 5 choices for "GPS Type":

None:	This means that a GPS receiver is not being used
MCM External:	This means that an external MCM GPS Accessory is being used (currently not available)
NMEA:	This means that an external NMEA-compatible GPS receiver is being used (such as a Trimble unit)
Manual:	This means that location data will be entered manually when the GPS button is tapped on the survey screen during a CIS
MCM Internal:	This means that the Gx's internal GPS unit will be used (a u-blox NEO, WAAS-enabled, receiver)

Select the appropriate choice by tapping on your selection.

Com Ports

When using an external GPS unit (NMEA option) connected via a serial cable, select the COM 1 option, which represents the built-in serial port located under the flap on the bottom left-hand side of the Gx data-logger. The COM 4 option will be automatically selected when the MCM Internal GPS receiver option is selected.

Only Log Corrected GPS

This box should be checked if you only want differentially-corrected GPS data to be logged by the Gx data-logger on the survey. Leaving this box un-checked will result in standard GPS data being logged in cases where differentially-corrected data are not available.

Note: If this boxed is checked and the unit is not receiving a differential correction message, no GPS data will be logged.

Use GPS Altitude

If this box is checked, altitude data will be logged, in addition to the Lat/Long data whenever GPS data are logged. *(Note:* Altitude data on some GPS units are not particularly accurate).

Log GPS at Flags

If this box is checked, GPS data will be logged automatically at survey flags when either the flag button is tapped (directly on the Survey screen) or when the push-button switch on the designated "flag cane" is pressed.

Log GPS at DCP/Features

If this box is checked, GPS data will be logged automatically at "Devices" or "Geo-Features" when either the "Device" button is tapped on the Survey screen and a "Device" reading is logged or when the "Geo-Feat." button is tapped on the Survey screen and a geo-feature is registered.

Log GPS at Sidedrain/Anomaly

If this box is checked, GPS data will be logged automatically when SP anomalies are "marked", as described in our DCVG Training Manual – Gx Version.

Auto Log GPS

By tapping on the menu button in the "Auto Log GPS" field, the selections available will be displayed.

By selecting one of these options, you can elect to have GPS data logged automatically at every SP reading, at every second SP reading, at every fifth SP reading, at every tenth SP reading, or not at all (never) at SP readings.

Step 7: Tap on the "Next" button on the above screen which will result in the screen shown below being displayed, depending on the settings used on the previous survey.

Dist Per Reading
By tapping in the field on the above screen labeled, "Dist Per Reading" you can type in the interval distance, in feet (or meters for the metric case), expected between reading. Typically, in Surface Potential work this expected interval distance is 5.0 feet (or 2 meter in the metric case).

Distance Between Flags
By tapping in the field labeled, "Distance Between Flags", you can type in the survey flag interval (distance between survey flags) for the section of pipeline being measured, assuming that survey flags have been laid out. Typically, survey flags are located at 100 feet intervals. In such a case, you would have a new reference (a stationing correction) every 100 feet.

Note: If survey flags are not in use, enter zero in this field. In this case, tapping accidentally on the Flag button will not adversely impact your stationing.

Flag Dist Error Limit %
Select the maximum permissible error between the **actual** number of readings logged between 2 survey flags and the **expected** number of readings.

By tapping in the field labeled, "Flag Dist Error Limit %" you can type in the maximum permissible error. For example, the maximum permissible error is indicated as 20% on the above screen. If the reading interval is expected to be 2.5 feet and the survey flag separation is 100 feet, this means that 40 readings are **expected**. If, however, only 30 readings are **actually** logged between survey flags, an error window will appear on the screen, since there is a 25% difference between the expected and actual number of reading in this example. No error window will appear if the difference is less than 20%. For this example, you could have a minimum of 32 readings and a maximum of 48 readings between survey flags to stay within the 20% (max.) error allowance.

Auto Pacing Mode (optional):
Select whether or not you would like the readings to be uniformly spaced between any two survey flags, regardless of the actual locations of the readings between the two flags.

By checking the box labeled, "Auto Pacing Mode", you will enable the data-logger to automatically adjust the reading locations in order to evenly-space the readings between two survey flags.

Name of P/L (optional)
By tapping in the field labeled, "Name of P/L", you can enter the pipeline name.
Note: This is **not** necessarily the same name as the filename for the SP survey that you used to setup the survey file.

Valve Segment (optional)
By tapping in the field labeled, "Valve Segment", you can enter the name or number of the valve segment to be surveyed, if known.

Starting Location (very important)
Provide the Starting Location for the survey by tapping in the field labeled, "Starting Location" and entering the location.

You can select to have location information displayed on the survey screen as station number, feet or milepost (station number, meters or kilometer post for the metric case).

Whichever selection you make here will determine how you enter your starting location information.

For example, if your pipeline locations are represented by station numbers, you would select "Station Number" from the menu list and you would enter a starting location for the survey in the form of a station number. [If you do not know the station number associated with the beginning your survey, enter 0+0.0].

Step 8: Tap on the **Next** button on the above screen. A version of the screen shown below will be displayed, depending on the current Date & Time and also the filename entered for your survey.

Work Order # (optional)
By tapping in the field labeled, "Work Order #", you can enter the work order number associated with the survey, if known.

Technician Name (optional)
By tapping in the field labeled, "Technician Name", you can enter the name of the surveyor.

Comments/Descriptions
By tapping in the field labeled, "Comments/Descriptions", you can enter any general comments you might have regarding the survey (perhaps weather conditions, soil conditions etc.).

Also shown on the above screen are the survey filename ("Survey Name" field) and the Start Date and Start Time for the survey ("Survey Date" field). *Note:* The survey files are stored in the Gx_Data folder on the Gx datalogger's CompactFlash memory (SystemCF) – a non-volatile memory. *Note:* These data cannot be changed manually.

Step 9: Tap on the "Next" button on the above screen. A version of the screen shown below will be displayed, depending on the settings selected for the previous survey.
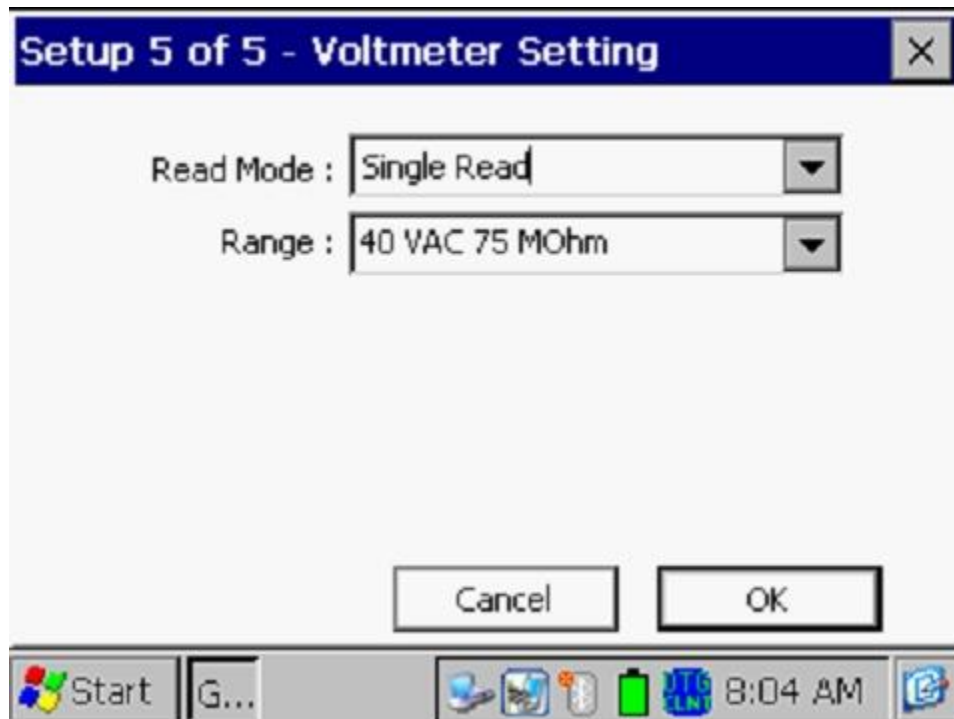
Read Mode:
By tapping on the menu button in the "Read Mode" field, you will see that
there are two options available for selection as follows:

Single Read
This voltmeter reading mode is appropriate for "cell-to-cell" potential
difference single readings, which are the basis of Surface Potential surveys.

Single Read (GPS Timing)
This voltmeter reading mode is similar to the "Single Read" mode except
that in this case the data-logger uses the GPS clock signal to associate
readings with the actual time they were made.

When the "Single Read (GPS Timing)" mode is selected, the screen shown
below will be displayed.
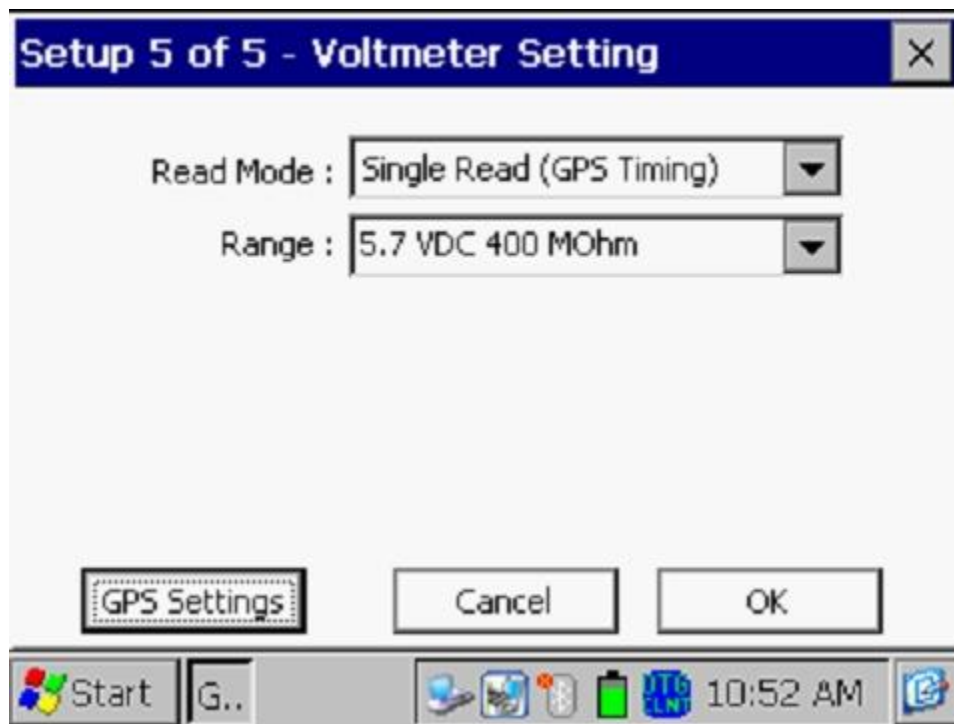
The only addition information that needs to be supplied here is the type of
GPS receiver you will be using, via the "GPS Settings" button.
Note: Currently, only the MCM Internal GPS Receiver can be selected for
this voltmeter reading mode.

<u>Range:</u>
By tapping on the menu button in the "Range" field, you can select the voltmeter range and associated input impedance setting for your application from the full list of available options.
*Note*: Use the scroll bar to view all options.

Note: Since SP survey readings are typically small (either tens of mV or hundreds of mV only), with respect to sensitivity, the most appropriate DC ranges are the 5.7V, 400mV and 40mV ranges, depending on the size of the gradient fields that you encounter. Another issue is the signal-to-noise ratio with respect to being able to "find" and "mark" anomalies. For small signals (small gradient fields), the voltmeter's noise level is the limiting factor. The noise levels associated with the 5.7V, the 400mV and the 40mV ranges are approximately as follows: ±5mV, ±1mV and ±0.5mV, respectively.

Step 10: Tap on the "OK" button on the "Setup 5 of 5" screen.

A version of the screen shown below will be displayed, depending on the start location entered previously and the location type entered previously (station number, feet or milepost (or station number, meters or kilometer post, for the metric option)).
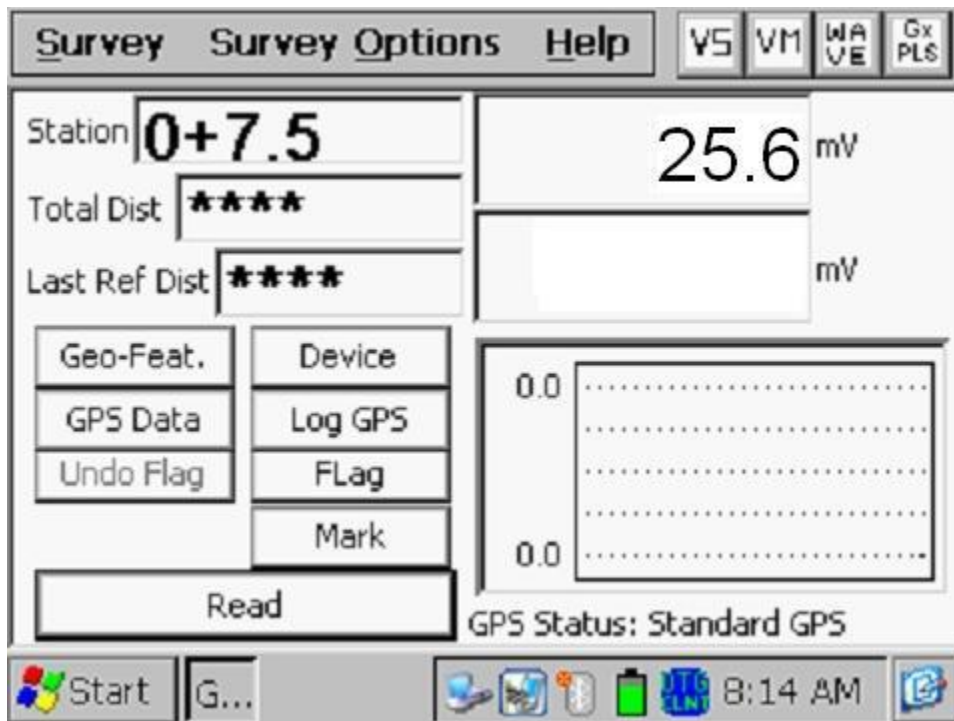
Note: When readings are logged, the latest logged reading (the prior reading) is displayed in the bottom mV field on the above screen and the current reading is displayed in the top mV field (see the screen below for an example).
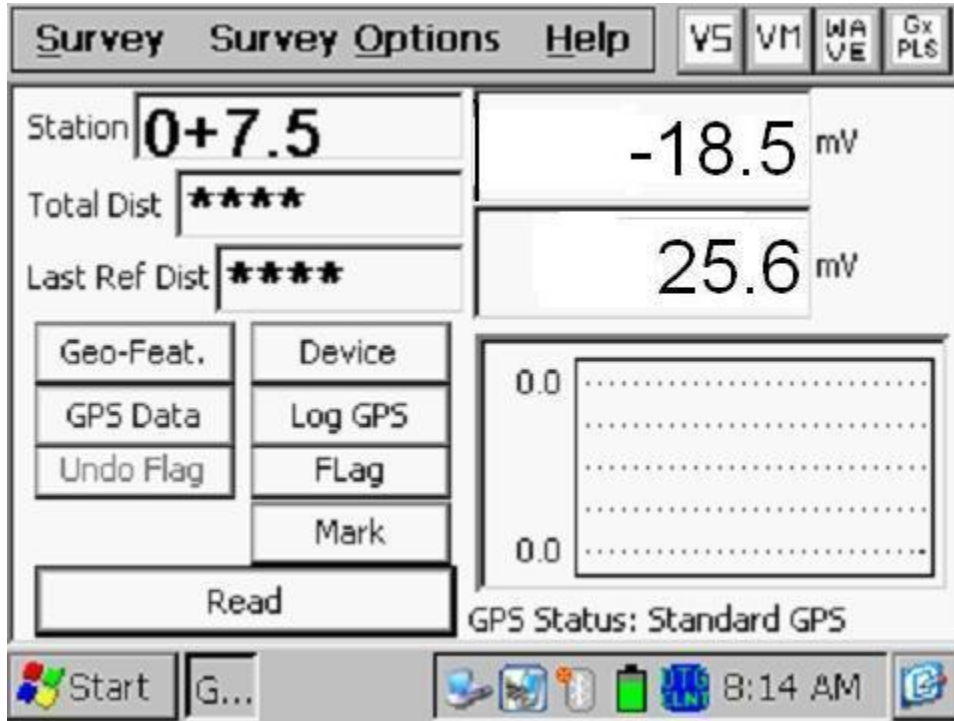

On the above example screen, the prior reading was 25.6mV and the current reading is -18.5mV. In this example, a polarity switch has been detected, which means that a gradient field has been detected.
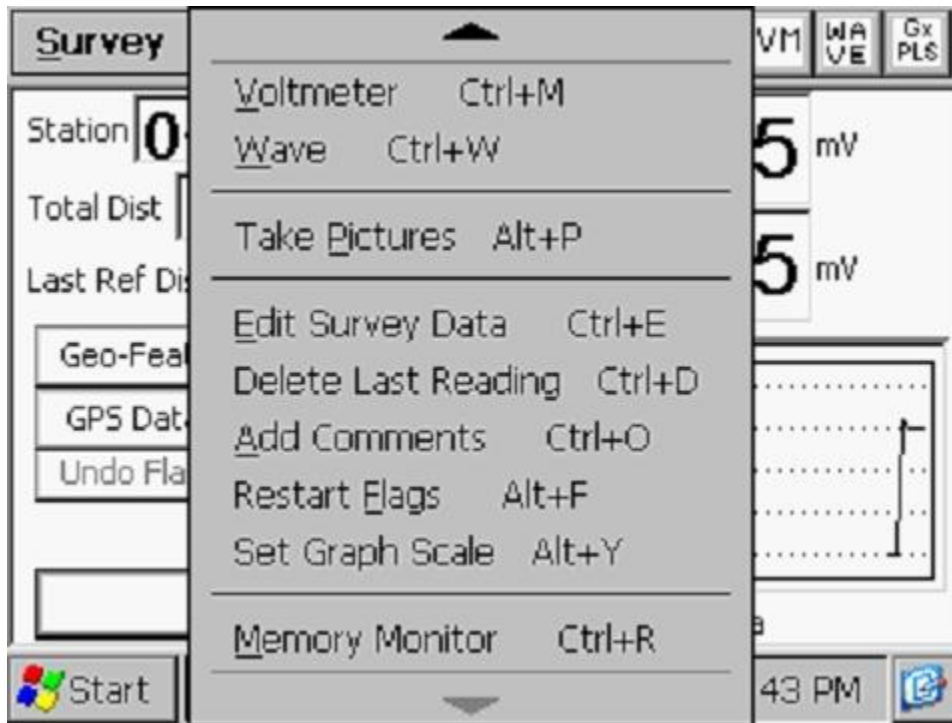
III.2 "Survey Options" Menu including Picture Taking Option and Editing Option

By tapping on the "Survey Options" button on the Survey screen, the Survey Options menu will be displayed as indicated below.
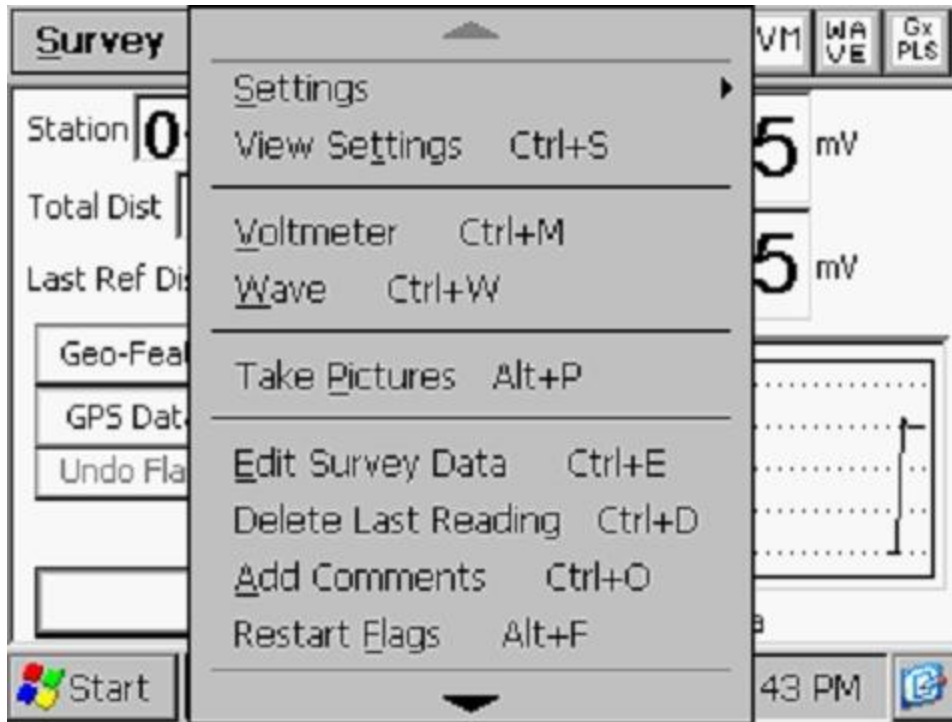
Tapping on the down arrow on the above menu will reveal additional options, as illustrated in the screen shown below.

<u>Settings</u>
Once you've set up the Gx data-logger for a particular pipeline survey, you can make changes to your setup selections with the exception of your "Survey Type" selection and the currently indicated "Station". If you have selected a Surface Potential survey, for example, you cannot change to a DCVG survey, without setting up a new survey.

To change survey settings, tap on "Settings" and tap on "Change Global Settings".

<u>View Settings</u>
To simply view your setup selections, you can tap on "View Settings" on the above menu. Alternatively, you can use the Ctrl and S keys.

<u>Voltmeter</u>
To run the stand-alone voltmeter, either tap on the "Voltmeter" option on the menu or use the Ctrl and M keys. Please see section IV.6 below for more information on running the stand-alone voltmeter.

<u>Wave</u>
To run the stand-alone waveprint generator, either tap on the "Wave" option on the menu or use the Ctrl and W keys.

<u>Take Pictures</u>
You can run the integrated camera program by either tapping on the "Take Pictures" option on the menu or by using the Ctrl and A keys.
Note: Several seconds are required to open and close the camera program.

The "Pictures" screen shown below will be displayed.
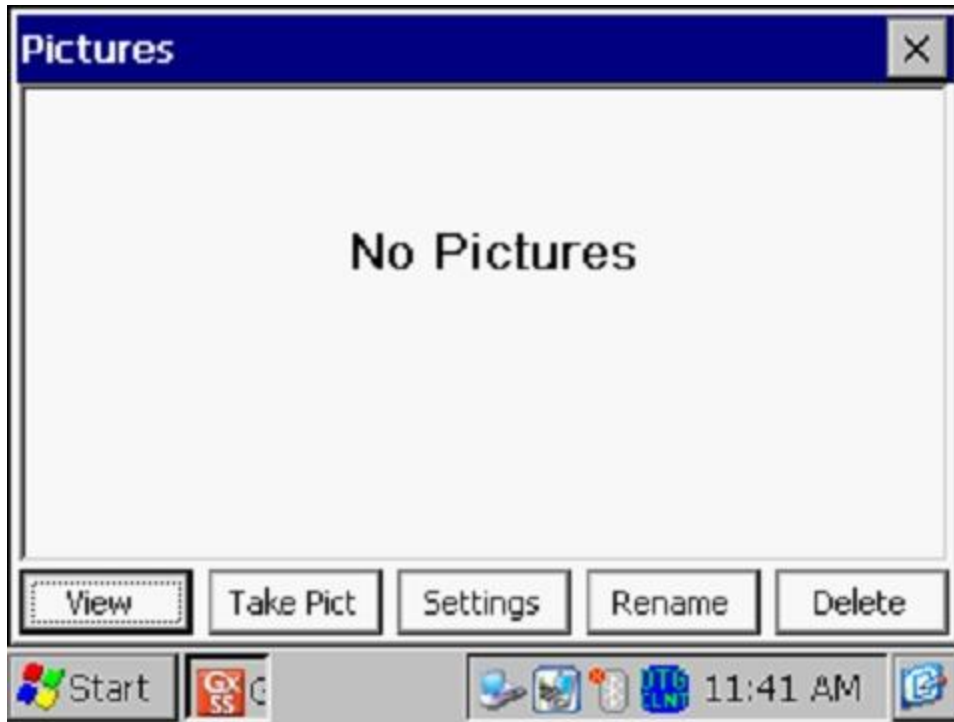
To take a photograph, tap on the "Take Pict" button. The camera will go through a focusing process and you will see a "Ready to Take" indication at the top of the screen when you can take a picture, as indicated below.
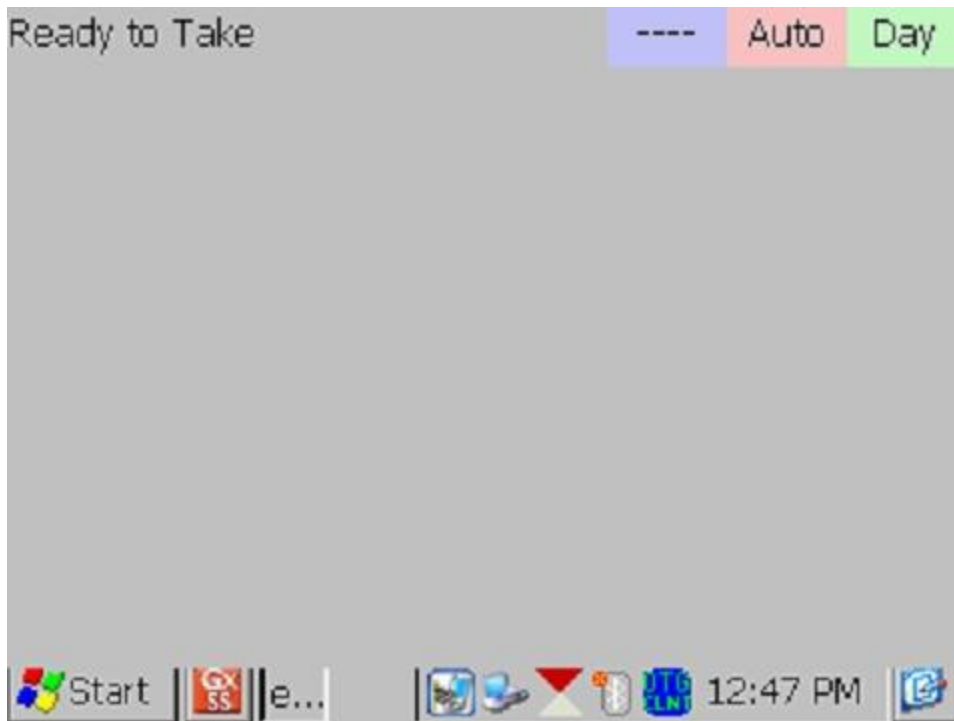
At this point, press (and release) the camera button located at the top right hand corner of the keypad. You will have the choice of saving the picture or deleting it, as indicated by the "4 to Save/1 to Delete" indication on the screen below. To save the picture, press (and release) the #4 key.
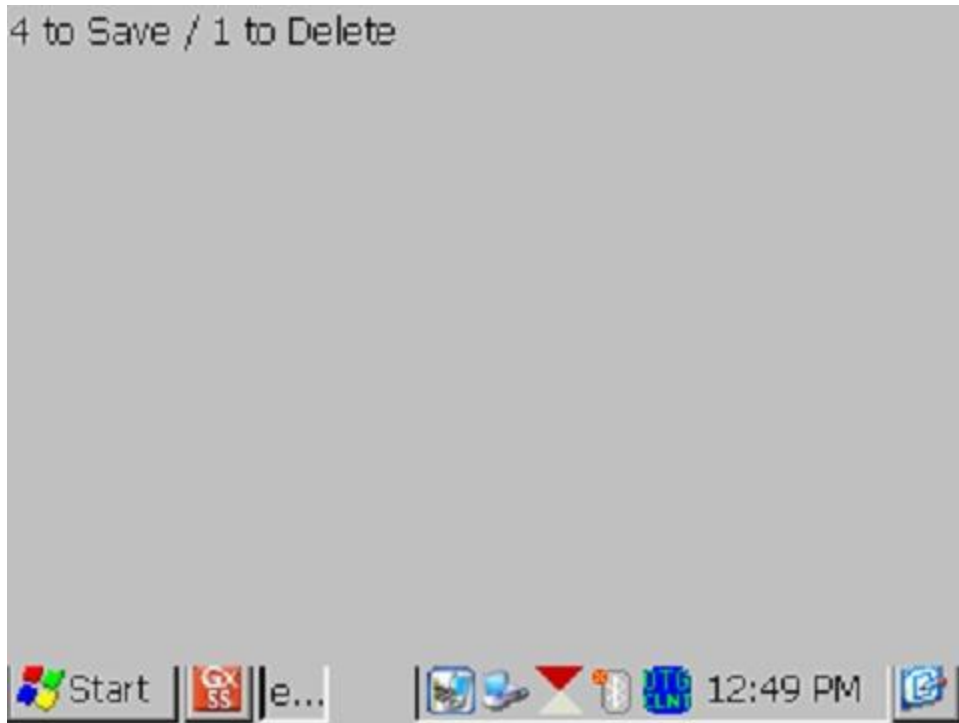
An example of a saved image is shown below on the Picture screen.

As indicated in the above screen, the image is given a filename, by default, which represents the date/time stamp for the image. The above image, for example, was recorded on July 13, 2010 at 8:27am.

You can rename the image, if you prefer, by highlighting the image (tapping on the image) and tapping on the "**Rename**" button. You can then enter a new name for the image. For example, the image above has been renamed, "Office Desk" on the screen shown below.

You can view a larger version of the image by highlighting the image (tapping on the image) and tapping on the "**View**" button.

You can take multiple photographs at a test site by repeating the process outlined above. For example, the Picture screen shown below shows two (renamed) images.

If you would like to adjust the camera settings from their default settings you can do so via the "**Settings**" button on the Pictures screen. For example, you can change the size and resolution of the image to be captured, the lighting conditions under which the image will be captured and the focusing method to be used, for example.

By tapping on the settings button, the screen shown below will be displayed.
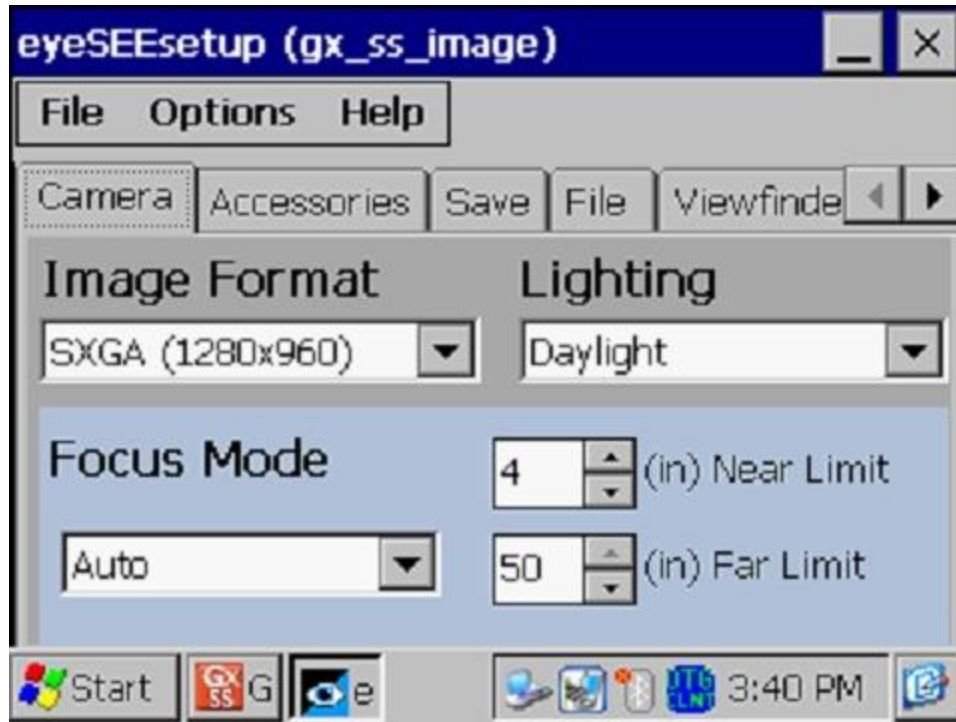
As indicated on the above screen, there are a number of page tabs labeled, "Camera", "Accessories", "Save" etc. For information on the selections available via the various tabs, please see Appendix 3 (Camera Settings) in the Gx Pipeline Survey User's Manual.

Note: For the default picture size (SXGA (1280x960)), the Flash light is <u>not</u> available. However, you can turn on the LED Lamp (which is turned OFF by default), if direct light is required. You can do so via the "Accessories" tab on the above screen. Also, please note that the Flash light is available for the largest picture size (highest resolution) setting (QSXGA 2048x1944).
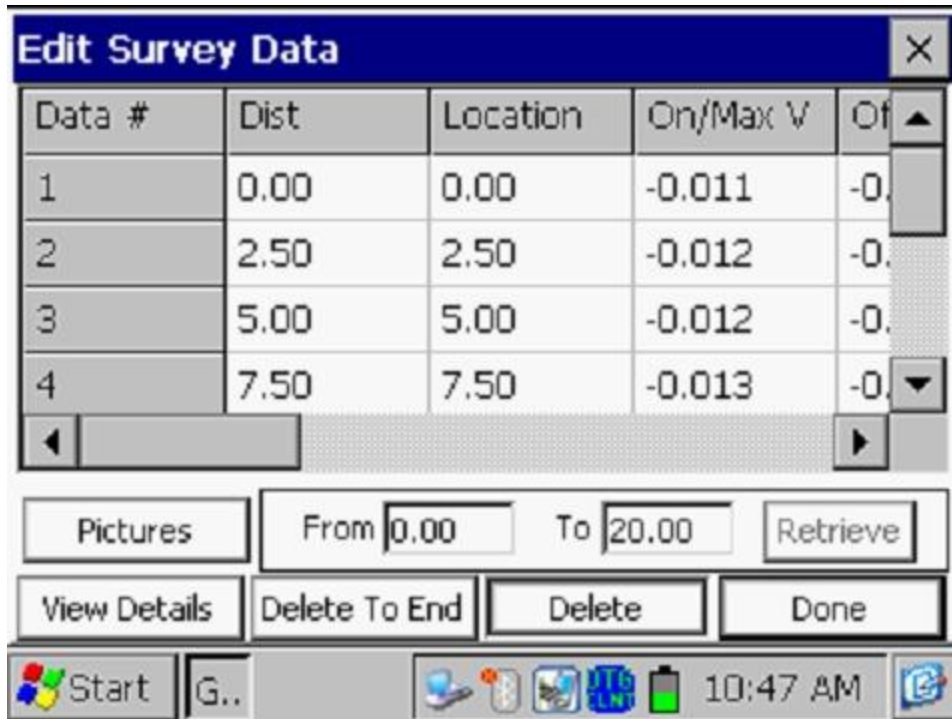
You can return to the "Survey" screen (after the picture taking process) by tapping on the "X" button on the Picture screen.

<u>Edit Survey Data</u>
Collected survey data can be edited by tapping on the "Edit Survey Data" button or by using the Ctrl and E keys.

The screen shown below will be displayed, depending on the readings values and reading interval etc.

Edit Survey Data				
Data #	Dist	Location	On/Max V	Of
1	0.00	0.00	-0.011	-0.
2	2.50	2.50	-0.012	-0.
3	5.00	5.00	-0.012	-0.
4	7.50	7.50	-0.013	-0.

Pictures   From 0.00   To 20.00   Retrieve

View Details   Delete To End   Delete   Done

Start   G..   10:47 AM

The data to be viewed can be selected by entering values in the "From" and "To" fields and tapping on the "**Retrieve**" button. Using the horizontal and vertical scroll bars, you can scroll through the collected data. A row of data can be deleted by highlighting the row and tapping on the "**Delete**" button. Multiple rows can also be deleted at the same time.

Pictures can be viewed and/or deleted by first highlighting the location (see screen below) and tapping on the "Pictures" button.
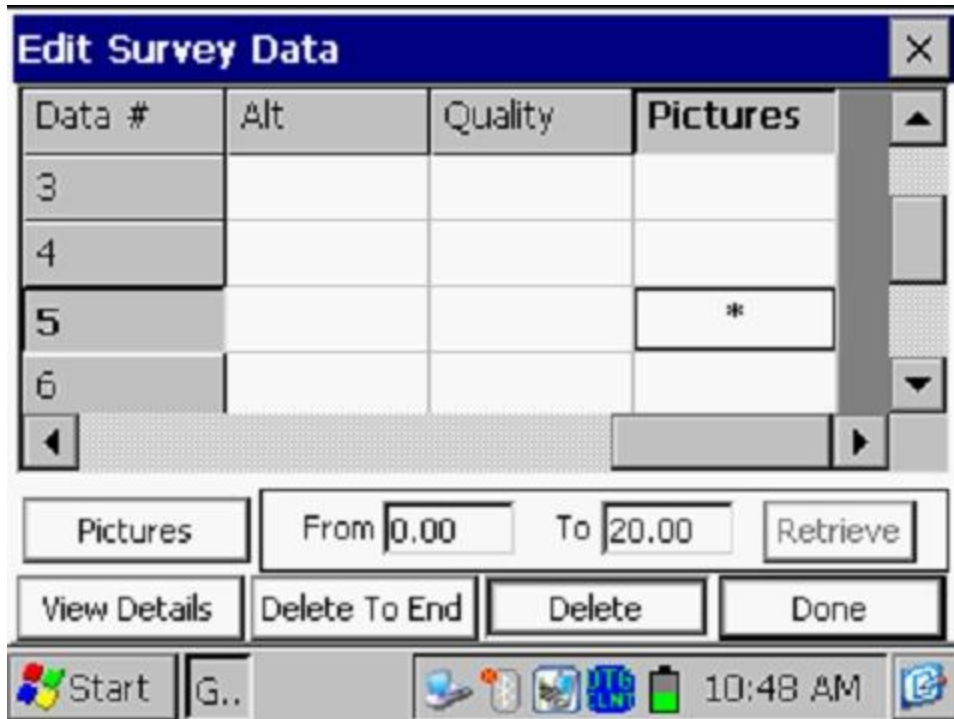
Once highlighted, the picture can be deleted by tapping on the "Delete" button, or viewed by tapping on the "Pictures" button.

Delete Last Reading
By selecting the "**Delete Last Reading**" option from the menu, you can have your last reading deleted, without having to go through the "Edit Survey Data" option. Alternatively, you can use the Ctrl and D keys to access the function.

Add Comments
You can add remarks (comments) at anytime on your survey by selecting the "Add Comments" option and manually entering data on the screen shown below.
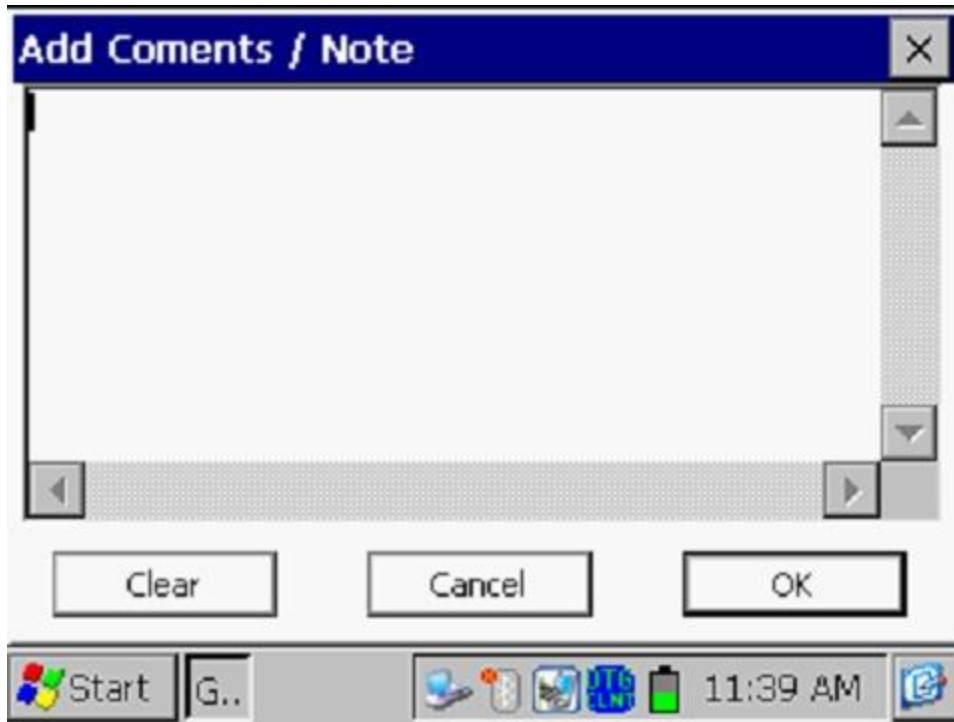
Alternatively, you can use the Ctrl and O keys to access the function.

Tap on the "OK button on the above screen to return to the Survey screen after entering your comments.

Restart Flags
You can reset survey flags by selecting the "Restart Flags" option from the menu. This action will establish your current location as the new zero reference, as far as flagging is concerned, and "zero" should be entered automatically in the "Last Reference Distance" field on the Survey screen.

Set Graph Scale
Rather than having the software auto scale the graph on the Survey screen to accommodate the actual data values logged, you can establish the maximum and minimum values for the graph scale in order to restrict the data values to be displayed on the graph.

To do so, you would un-check the box labeled, "Auto Scale" on the window shown below and enter specific values for "maximum" and "minimum".
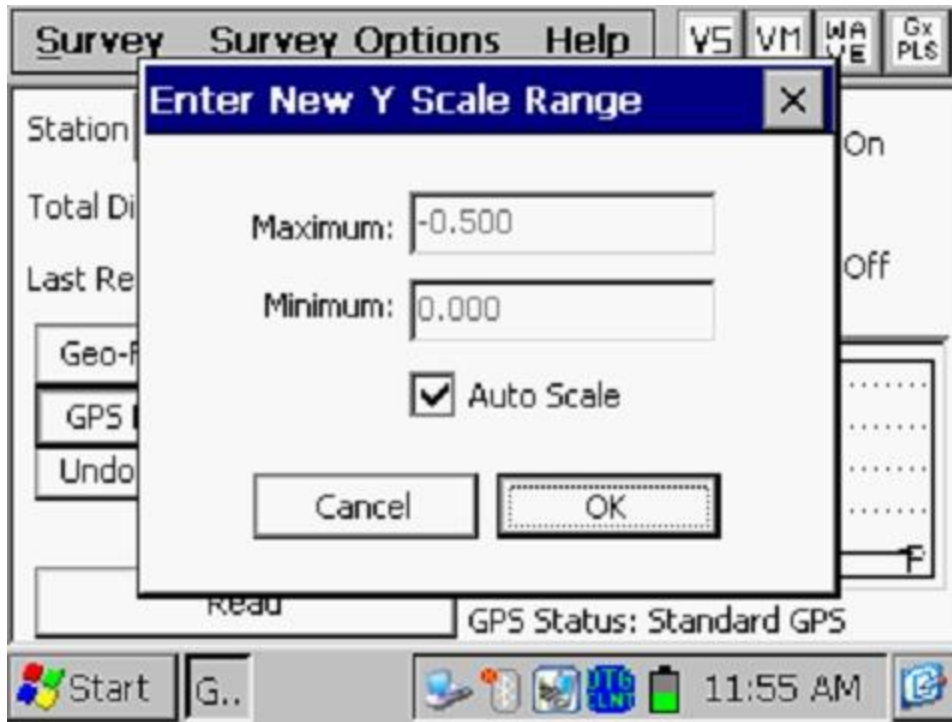
Tapping on the "OK" button will return you to the Survey screen.

SECTION IV

EQUIPMENT HOOK-UPS

The Gx data-logger, data-probe and data-probe cable hook-ups for Surface Potential surveys using M. C. Miller equipment are illustrated in Figure 3 below.

As can be seen from Figure 3, two reference electrode data-probes are illustrated, a RED-handled data-probe and a GREEN-handled data-probe. These data-probes, which will be placed on the soil above the pipeline in either the "Perpendicular" or the "In-Line" configuration (see Section II), have push button switches on top of the handles so that the operator can "trigger" readings at each of the survey measurement locations and can also be used to designate the locations of survey flags (please see Section III.1).

The reference electrode data-probes are connected as shown to the "input" terminals of the dual-probe adapter and the "output" terminal of the adapter is connected to the 5-pin socket on the top side of the Gx data-logger.
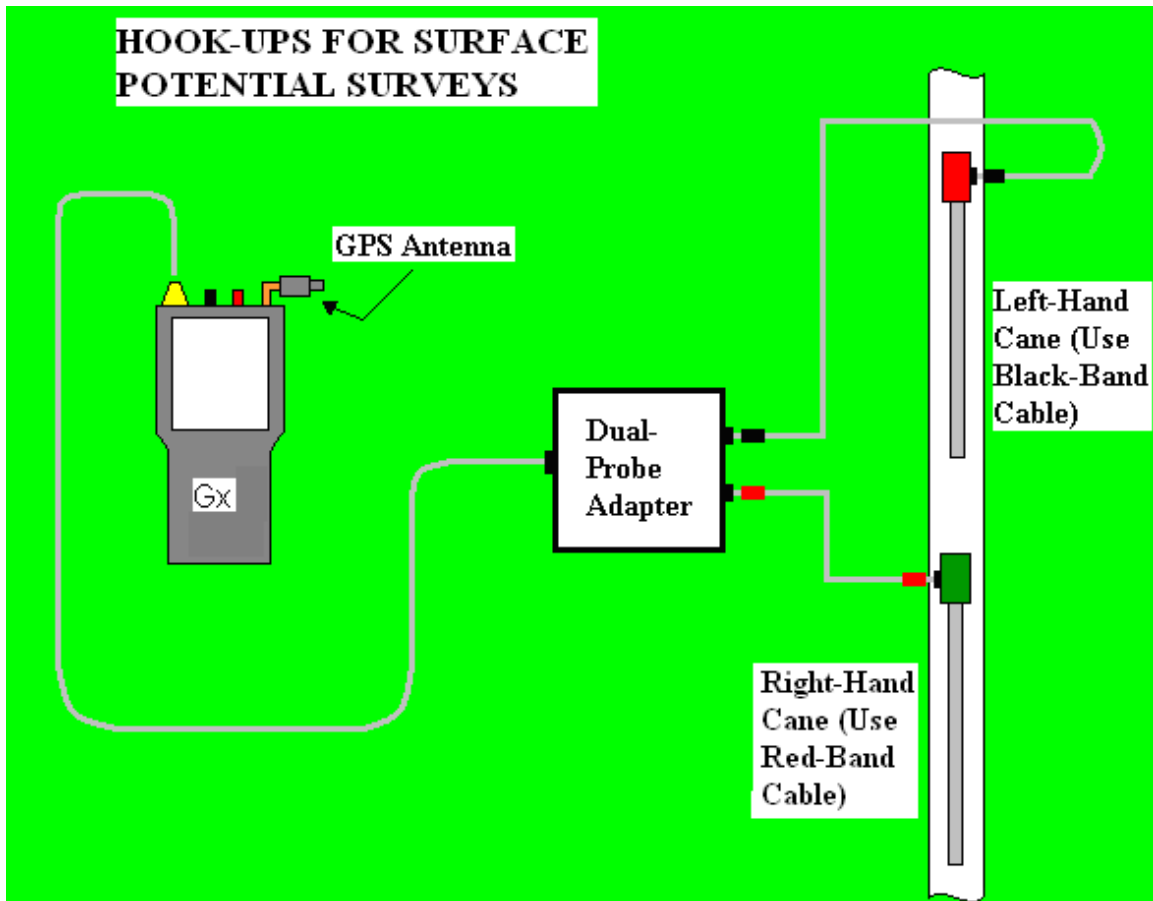
Figure 3

NOTE: The red-handled cane is connected to the dual probe adapter via a "black-band" cable while the green-handled cane is connected to the dual-probe adapter via a "red-band" cable. This results in the reference electrode of the **red-handled** data-probe connecting to the **negative** side of the data logger's voltmeter and the reference electrode of the **green-handled** data-probe connecting to the **positive** side of the voltmeter.

Consequently, the data-logger's voltmeter will measure the soil potential at the location of the green-handled (positive) data-probe minus the soil potential at the location of the red-handled (negative) data-probe.

SECTION V

HOW TO LOCATE AND "MARK" SP ANOMALIES

The objective in SP surveys is to locate **anodic** areas, i.e., areas on the buried pipe where current is "leaving" the pipe. As discussed in Section II, such areas can be located by observing a polarity switch in the recorded "in-line" (or longitudinal) voltage. As also discussed in Section II, the nature of the polarity switch (i.e., positive-to-negative, or negative-to-positive) depends on whether the lead data-probe is the "positive" or the "negative" probe.

For the case where the "positive" data-probe is leading (i.e., leading with the green-handled data-probe), since the potential gradient on the surface is positive over an anodic area, a positive potential difference will be measured, as a gradient field is entered, relative to the zero potential difference measured with both data-probes positioned outside the gradient field. The potential difference measured between the probes will continue to increase, as the data-probes advance into the gradient field, and will go through a maximum value before dropping through zero (as the data-probes straddle the epicenter of the anodic area) and becoming negative. After going through a maximum negative value, the potential difference measured between the probes will decrease (staying negative) and eventually become zero again with both data-probes positioned on the far side of the potential gradient field.

Consequently, in this case, the polarity switch would be positive-to-negative as the anodic area is traversed. The opposite polarity switch would be observed if the lead data-probe was the red-handled (negative) probe.

In order to make the process of determining polarity switches easier, the survey screen displays the prior reading (including its polarity), in addition to displaying the current SP reading, as shown in the screen below.
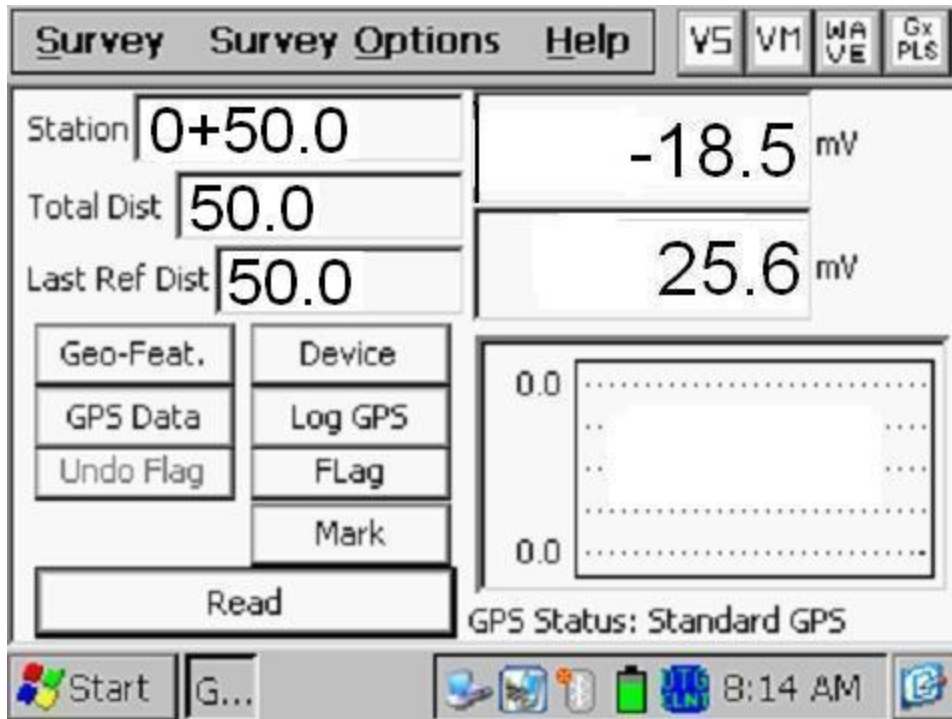
Note: When readings are logged, the latest logged reading (the prior reading) is displayed in the bottom mV field on the above screen and the current reading is displayed in the top mV field.

On the above example screen, the prior reading was 25.6mV and the current reading is -18.5mV. In this example, a "positive-to-negative" polarity switch has been detected (with the lead data-probe being positive), which means that an anodic area has been detected.

By fine-tuning the location of the epicenter of the anomaly, i.e., by straddling the epicenter with the data-probes and reading (close to) zero mV, the anomaly can then be "marked" by taking side drain readings on both sides of the pipe at the epicenter location.

To do so, you would tap on the "Mark" button on the Survey screen which would pull up the "Side Drain" screen.

By placing the negative data-probe over the pipe (at the epicenter spot) and the positive data-probe off to the left-hand side of the pipe, you can "accept" the Side Drain Left (SDL) reading by tapping on the "Accept" button. The screen shown below will be displayed for an example value of -19.0 mV.
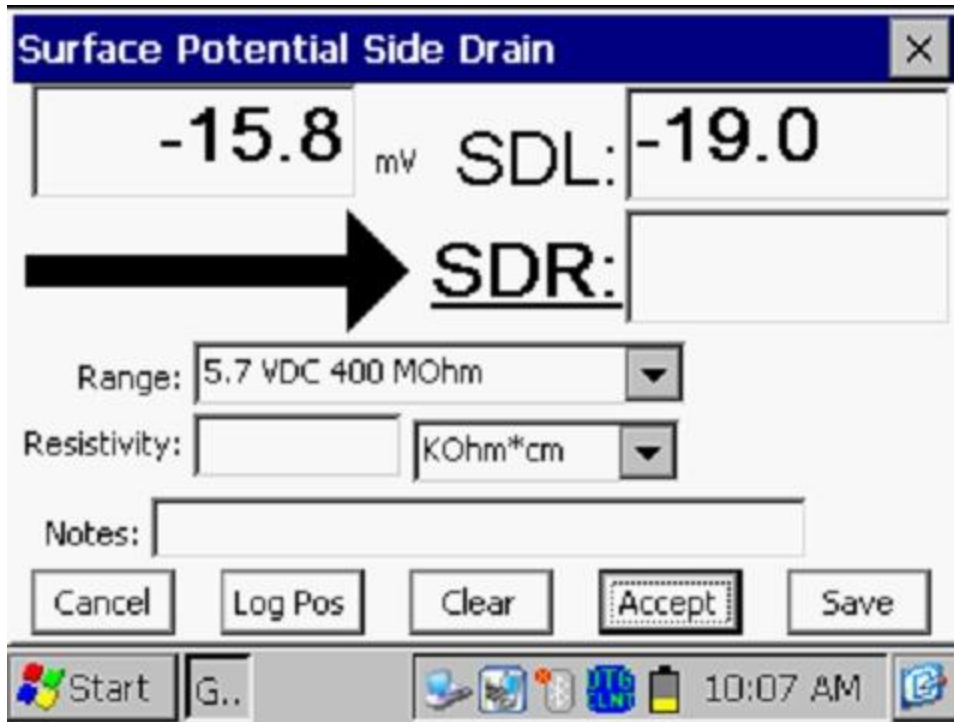
Next, you would keep the negative data-probe over the pipe and you would swing the positive data-probe to the opposite side of the pipe (the right hand side) to take the Side Drain Right (SDR) reading. The screen will be as displayed below after accepting the SDR reading for an example value of -17.0 mV.
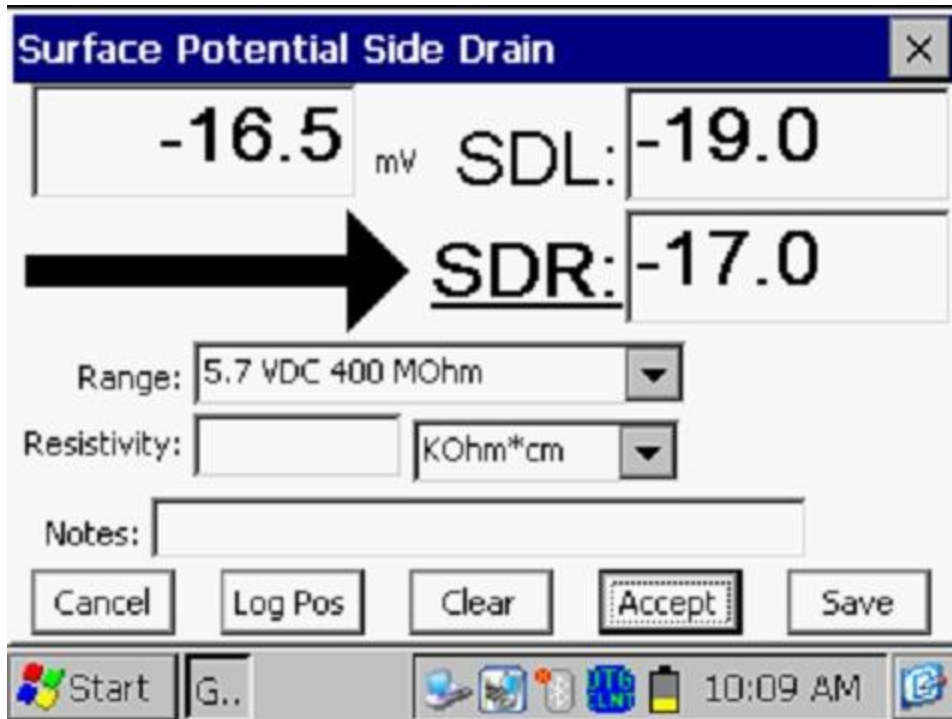
Note: Alternatively to tapping on the "Accept" button on the screen, you could press the push-button switch on either data-probe handle to "accept" the SDL and SDR readings.

Note: The arrow direction on the "Side Drain" screen indicates the direction of current flow in the soil. In the above case, the direction of current flow is **away** from the pipe, which is the case for an anodic area (current is leaving the pipe). [This is different from the arrow shown on a DCVG survey screen which always points back to the pipe].

Next, you can manually enter a value for the soil resistivity measured in the vicinity of the anomaly. As discussed in Section II, the software will use this value in its calculation of the "Corrosion Factor" for the anomaly.

As indicated in the above screen, you can select the units ($M\Omega.m$, $K\Omega.m$ or $\Omega.m$) for your resistivity value [or $M\Omega.cm$, $K\Omega.cm$ or $\Omega.cm$, if the "cm" length unit was selected during the survey setup process].

At this point, you should tap on the "**Save**" button which will save all of the data associated with the anomaly.

When the data are saved, you will be given the opportunity to take a photograph at the "Anomaly" location, as indicated by the question displayed on the screen shown below.
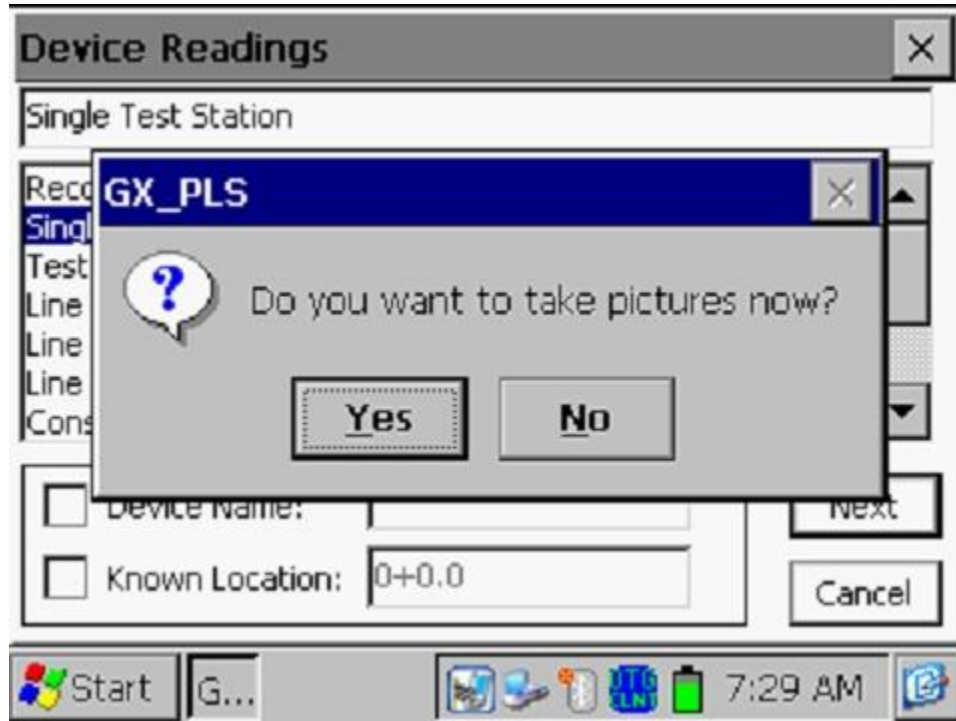
Answering "Yes" on the above screen will take you to the "Pictures" screen, as described in Appendix 3 of the Gx Data-logger Pipeline Survey User's Manual.
Note: Several seconds are required to open the picture program.

How to Position the Camera for a Picture:
Since the camera on the Gx is located on the underside of the handheld unit, it is necessary to remove the unit from its mounting platform by grasping the unit around its mid section and pulling in an upward motion. The unit should snap out of its retaining brackets. You can now position the camera to take your photograph, since the coiled cable connecting the Gx to the dual-probe adapter provides a considerable degree of flexibility. The unit can then be snapped back into position on the platform, after picture taking, by lining up the groove on the bottom orange bumper with the registration post on the platform and pressing in a downward motion.

Note: By tapping on the "X" button on the "Pictures" screen (top right hand corner), after taking a photograph, you will be returned to the Survey screen.

Answering "No" on the above screen will return you directly to the Survey screen.

You would then pick up the survey where you left off and continue triggering readings until you encounter the voltage gradient field associated with another anomaly.

SECTION VI: HOW TO COPY SURVEY FILES FROM THE Gx DATA-LOGGER TO YOUR PC

VI. 1 Introduction

Survey data are stored in independent files (one file for each survey) on the Flash memory card on the Gx data-logger and you can copy survey files to your PC using one of two approaches; manually or via the driver in the ProActive software program.

The ProActive software program represents MCM's CP data management system and this program allows integration of pipeline survey data in a database system and offers extensive reporting (both textual and graphical) capabilities on the survey data.

If you have the ProActive software program installed on your PC, or you can bring your Gx to a PC that has ProActive installed on it, you can use the ProActive program to automatically access survey files on the Gx. If either of these situations applies, you would proceed to Section VI. 3.

Note: The ProActive program is required to actually view the survey data.

If you do not have ProActive installed on your PC and you cannot bring your Gx to a PC that has ProActive installed on it, you can copy survey files manually from your Gx to your PC and you can subsequently send the copied files to a recipient who is a ProActive user. If this situation applies, you would proceed to Section VI. 2.

VI. 2 The Manual Approach

Step 1: Establish a connection between the Gx and your PC.

Gx Data-loggers can be connected to a PC using the USB cable supplied with the unit.

Connection via the USB Cable:

The requirements and procedures with regard to Gx Data-logger/PC connectivity depend on the operating system of the PC.

Case 1: Windows XP (or earlier) PC Operating System

The Microsoft "ActiveSync" communication program is required on the PC. If not currently installed, the application can be installed from the CD provided with the Gx Data-logger. Once installed, make sure that the "Allow USB Connections" option is selected in the "Connection Settings" window of the ActiveSync application.

Next, connect the USB cable from the Gx Data-logger to the PC and switch ON the Gx (via the RED power button). The connection should be automatic and you will be asked if you'd like to set up a partnership or not between the Gx and the PC. Answer NO to this question, as the ability to transfer file data is all that is required, as opposed to a synchronized partnership. You can then exit the Activesync application.

If the connection is not established automatically, make sure that the connection option on the Gx is "USB_Serial", which it should be by default. To do so, tap on the "Start" button on the Gx screen, tap, on "Settings", tap on "Control Panel" and double-tap on "PC Connection". If "USB_Serial" is not indicated, tap on the "Change Connection" button and select "USB_Serial" from the drop down menu. Repeat the connection process.

Case 2: Windows Vista or Newer (such as Windows 7) PC Operating System

The Gx Data-logger connects to these systems via the "Mobile Device Center" which replaces the Activesync program on the PC side.

Make sure that the USB connection option is set up via the Mobile Device Center. Connect the USB cable between the Gx Data-logger and the PC and switch ON the Gx. The connection should be established automatically. If the connection is not established automatically, make sure that the connection option on the Gx is "USB_Serial", which it should be by default. To do so, tap on the "Start" button on the Gx screen, tap, on "Settings", tap on "Control Panel" and double-tap on "PC Connection". If "USB_Serial" is

not indicated, tap on the "Change Connection" button and select "USB_Serial" from the drop down menu. Repeat the connection process.

Step 2:
Follow the procedures detailed below:
*   Double-click on "My Computer" on your PC
*   Double-click on "Mobile Device"
*   Double-click on "SystemCF"
*   Double-click on "Gx_Data"
*   Right-click on the survey file you wish to copy & select "Copy"
*   "Paste" the file into a local folder on your hard-drive
*   Create a compressed (zipped) version of the file

You would now be in a position to send the compressed file via email, for example, to a recipient who has access to the ProActive software program.

Note: Do not rename the survey file prior to sending the file to the recipient, as the survey file must have the same name as the survey itself.

VI. 3   Using the Driver in the ProActive Software Program

Step 1:
Create a folder on your PC's hard-drive (perhaps in your "My Documents" folder) that will be used to "permanently" save files copied from your data-logger. You might choose to name this folder something like, "Surveys".

Step 2: Establish a connection between the Gx and your PC.

Gx Data-loggers can be connected to a PC using the USB cable supplied with the unit.

Connection via the USB Cable:
The requirements and procedures with regard to Gx Data-logger/PC connectivity depend on the operating system of the PC.

Case 1: Windows XP (or earlier) PC Operating System
The Microsoft "ActiveSync" communication program is required on the PC. If not currently installed, the application can be installed from the CD provided with the Gx Data-logger. Once installed, make sure that the

"Allow USB Connections" option is selected in the "Connection Settings" window of the ActiveSync application.

Next, connect the USB cable from the Gx Data-logger to the PC and switch ON the Gx (via the RED power button). The connection should be automatic and you will be asked if you'd like to set up a partnership or not between the Gx and the PC. Answer NO to this question, as the ability to transfer file data is all that is required, as opposed to a synchronized partnership. You can then exit the Activesync application.

If the connection is not established automatically, make sure that the connection option on the Gx is "USB_Serial", which it should be by default. To do so, tap on the "Start" button on the Gx screen, tap, on "Settings", tap on "Control Panel" and double-tap on "PC Connection". If "USB_Serial" is not indicated, tap on the "Change Connection" button and select "USB_Serial" from the drop down menu. Repeat the connection process.

Case 2: Windows Vista or Newer (such as Windows 7) PC Operating
         System
The Gx Data-logger connects to these systems via the "Mobile Device Center" which replaces the Activesync program on the PC side.

Make sure that the USB connection option is set up via the Mobile Device Center. Connect the USB cable between the Gx Data-logger and the PC and switch ON the Gx. The connection should be established automatically.
If the connection is not established automatically, make sure that the connection option on the Gx is "USB_Serial", which it should be by default. To do so, tap on the "Start" button on the Gx screen, tap, on "Settings", tap on "Control Panel" and double-tap on "PC Connection". If "USB_Serial" is not indicated, tap on the "Change Connection" button and select "USB_Serial" from the drop down menu. Repeat the connection process.

Step 3:
Double-click on the "ProActive" icon on your PC's desktop screen.

This will open up ProActive's main menu window. A window labeled "Entire Database" will also be seen here. The suggested organization of your database is discussed in the **ProActive Training Manual**.

Step 4:
Click on the "Surveys" speed button on the main menu bar.

This will open a window labeled "Data Logger: Get Pipeline Survey".

By clicking on the menu button in the "Data Logger" field, you can select the data-logger from which you are copying the survey file. The various data-loggers currently supported by ProActive are offered as choices in the menu list.

Step 5:
Select the Gx Data-logger Option.

Highlight "GX" in the menu list and make the appropriate "Survey Type" selection (CIS in this case). Next, click on the "Go" button. This will open up a window labeled, "Gx Driver (Pipeline Survey)".

Note: It may take a few seconds for the "Driver" Window to appear.

Step 6:
Identify the Survey File to be Copied.

The "Get Pipeline Survey from Gx" field on the "Gx Driver" window will list all of the survey files currently stored on your Gx's Flash memory card.

Highlight the survey file that you would like to be copied to your PC. Also, check-off the box labeled "Copy to Local Folder" and identify the target folder's location on your hard-drive in the field underneath using the "browse" button.

This is the folder that you set up previously (Step 1 above) in which to save all of your survey files copied from your Gx.

Also, if you used the metric system on the data-logger, check off the box labeled, "Use Metric".

Finally, click on the "Go" button on the Gx Driver window.

Step 7:
Examine the Survey Data Prior to Posting the Data to the ProActive Database.

You will have actually completed the process of copying a survey file to a local folder on your PC by this point, using the Driver in ProActive.

However, before exiting the Driver, it is recommended that you examine your survey data prior to posting the data to the ProActive database. The process of posting the pipeline survey data to the ProActive database is detailed in the **ProActive Training Manual** and is beyond the scope of this manual.

To examine the survey data in the Gx Driver, you can click on the various page tabs now appearing on the Gx Driver (Pipeline Survey) window:

Survey Settings
Readings
Device Readings
Graph

By clicking on these page tabs, you can view information on the Survey settings or you can view the actual survey (and "device") data - please see the ProActive Training Manual for details.

APPENDIX 1: How to Delete Survey Files from the Gx

Once you have copied your survey files to your PC (see Section VI), you can (if you wish) delete the files from your Gx's Flash memory card.

Since your survey files are stored on the Flash card, you will have to access this memory (SystemCF) in order to delete selected survey files. The procedure would be as follows:

- Tap on the "Start" button on the Gx
- Tap on "Programs"
- Tap on "Windows Explorer"
- Double-tap on "SystemCF"
- Double-tap on "Gx_Data"
- Tap and hold on the Survey File you wish to delete until a menu pops up
- Tap on the "Delete" option. This will delete the highlighted survey file