Chapter 6

The Data Collection Process

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6. The Data Collection Process

A. Project Control

P&S will conduct GPS observations for every project control network to establish horizontal control. Differential leveling will be performed between all survey monuments and flight line targets to establish vertical control. After the GPS and level data has been collected, the coordinate values for every project control point will be computed. The project control coordinates will then be distributed to the field office. These coordinates will serve as the basis for future survey activities, including but not limited to:

- Extendible and temporary monuments.
- Photo control surveys.
- Locating monuments for right-of-way retracement.
- Topography and utility surveys.
- Slope staking, blue topping and other construction related activities.
- Final quantity surveys.

1. Arbitrary Coordinates

A GPS collected survey is not easily translated and rotated from an arbitrary coordinate system to the true coordinate system once it is established. Also, the accuracy of the manipulated GPS survey cannot be verified. Since every survey should be based on the P&S published coordinates, arbitrary coordinate surveys will no longer be accepted.

2. Data Collector File

After the coordinates for the project control network have been computed, a data collector file is generated. This file (*.dc) is saved on the Falcon Data Management System where it is available for the field office. After the file has been successfully downloaded onto the TSC2, verify that the project control information is correct. This information includes the project name and section, project number, state plane zone, and datum adjustment factor (DAF).

A field check should also be performed by setting up on a control monument and checking the backsight distances and angles to adjacent monuments. Identify any differences between coordinate distances and field measurements larger than the allowable tolerances. Check the tolerances listed in Section VIII, Survey Standards, of the WYDOT Survey Manual. These differences should be reported to the State Photogrammetry & Surveys Engineer.

3. Extendible Control

Refer to Sections IV and V in the WYDOT Survey Manual for a guide on extending the project control network or replacing control points which have been damaged or destroyed.

B. Data Collector Settings

When collecting survey data, it is important to verify that the settings discussed in Chapter 3 of this manual are entered correctly. These settings should always be checked at the start of a new job.

After a power outage, some settings in the TSC2 may default to the last entry. Other settings may default to the values defined in the survey style. Before collecting new measurements, settings such as instrument height, rod height, reflector type and offset, units, and PPM correction should be verified.

1. Date and Time

Set the date and time as accurately as possible. Refer to Chapter 3 of this manual for instructions.

2. Survey Units

The units on the data collector must be consistent with the control file and with the project criterion. Except for the rare metric project, most jobs utilize the U.S. Survey Foot.

3. File Name

Use the following standard format when naming a job file. Typical file names consist of a project number followed by a specific survey type and then a file extension.

a. Survey Type

- SRV - Project control survey.
- DTM - Ground measurements used for earthwork computation and TIN files.
- UTL - Utility survey.
- TOP - Combination of planimetric and DTM data.
- PRO - Profile survey.
- CNTL - A project control file created by P&S for the data collector.
- GEO - Geology survey.

b. File Extension

- .dc - A raw measurement file that has been downloaded from the data collector in a Trimble file format.
- .job - A raw data file in a binary format. This file is created when the *.dc file is downloaded.
- .bak - A backup file created when the *.dc file is opened with the Trimble DC editor.
- .edt - A copy of the original *.dc file that has been edited.
- .cor - A coordinate file in a specific file format. The typical format is point number, northing, easting, elevation, feature code, and attribute. Refer to Chapters 8 and 10 in this manual for coordinate file requirements.

c. Example

N345088UTL2.edt is the second utility survey collected on project N345088. This file is an edited copy of the original Trimble, N345088UTL2.dc file.

4. Feature Code List

Select the appropriate WYDOT feature code list at the start of a job. Refer to Chapter 4 of this manual for the current feature code list.

5. Control File

Coordinate values for the project control network are included in the control file created by P&S. This file is loaded onto the data collector and any project control point can be selected from the control file list as an instrument setup or backsight. When a control point is selected, the data collector displays the coordinate values (see Figure 6-6) for the setup. When creating a new job, link to a project control file as illustrated in Chapter 3 of this manual. Project control coordinates should not be manually entered to avoid key-in errors.

Occasionally, the instrument setup may need to be setup in a location that is not part of the project control network. In these situations, data collector rounds or resection procedures are used to establish the position of a new point. The Trimble data collector software uses a least-squares adjustment method to compute the coordinates.

6. Required Measurements

There are many conventional surveying methods used during the preliminary data collection process. It may be necessary to establish coordinates for an extendible control point or temporary control point prior to data collection. Performing multiple sets of observations from two or more known points are required to determine coordinates for these control points. For each measurement, the vertical angle, horizontal angle, and slope distance will be recorded by the data collector. The data collector compares the first set of measurements to subsequent sets to improve the accuracy of the extendible control points coordinates. Unlike control points, the collection of topographic features only require a single measurement from a known point.

The TSC2 term “rounds” refers to multiple measurements from an instrument setup to two or more survey points. The purpose of this procedure is to determine coordinates for an unknown point by making observations to known backsight points. Resection and sub-traverse procedures are forms of rounds. A resection establishes the coordinates of a point from an unknown instrument point to two or more known backsight points. A sub-traverse also establishes the coordinates of a point using measurements from a known instrument point and a known backsight point.

In Table 6-1, the required number of measurements per instrument setup for specific survey modes are listed below.

Survey Mode	Required Measurements	Point Description	Point Numbers
Rounds	6	Project control points	0000-0299
	6	Extendible project control points	0000-0299
	6	Replacement project control points	0000-0299
	6	Traverse points	0000-0299
	6	Sub-traverse points	0000-0299
	2	Photo control flight line targets	0300-0399
	2	Photo control wing points	0400-0499
Resection	2	Auxiliary control points (i.e. rebar or railroad spike)	0000-0299
	2	Temporary control points (i.e. hub & tack)	0000-0299
	2	Bridge structure ties	1000-8999
Topography	1	Topography/DTM points	1000-8999
	1	Utilities	1000-8999
Editing	0	Renumbering or duplicating point(s) during office editing	9000-9999

Table 6-1. Required measurements.

7. Point Numbering

In the TSC2 data collector, each control point must have a unique point number within a job. This is necessary to avoid duplication and overwriting of points by Geopak. During general topography collection, auto-incrementing minimizes the chance of point number duplication. Table 6-1 illustrates specific point numbers for the observation of certain categories of points. Keep track of the point numbers used in a field book.

When manually numbering special category points and a point number is duplicated, the data collector alerts the instrument person. A verbal announcement "Out of tolerance" will be heard. Typically, the point is renamed with a unique point name to resolve the conflict.

C. Data Collection

1. Rounds

As previously mentioned, rounds are a conventional method of multiple observations to multiple points. At the survey controller main menu, tap on the *Survey* icon. Select *Station setup* from the *Survey* menu.

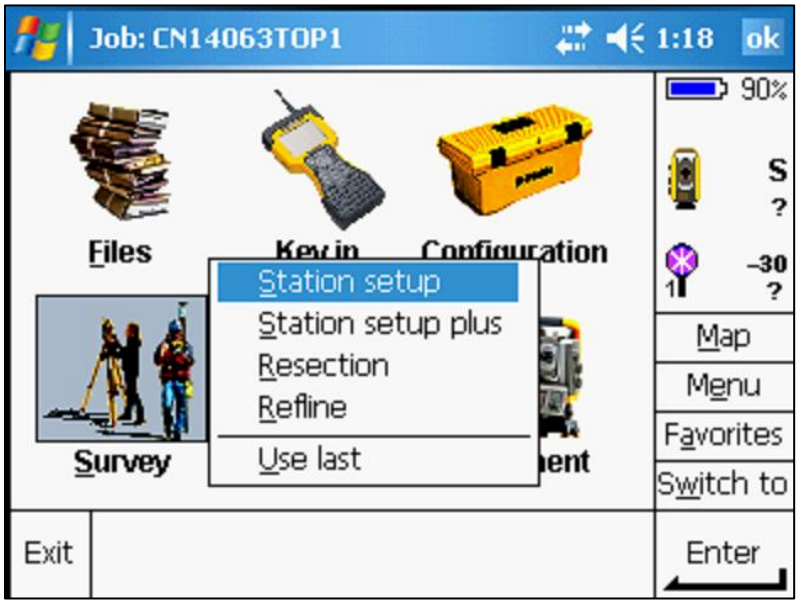

Figure 6-1. Station setup.

Set the *Pressure* and *Temperature* values and then tap *Enter*. Refer to Chapter 3 in this manual for more information on temperature and pressure settings. Tap the *Accept* button as indicated by the red oval to set the values.

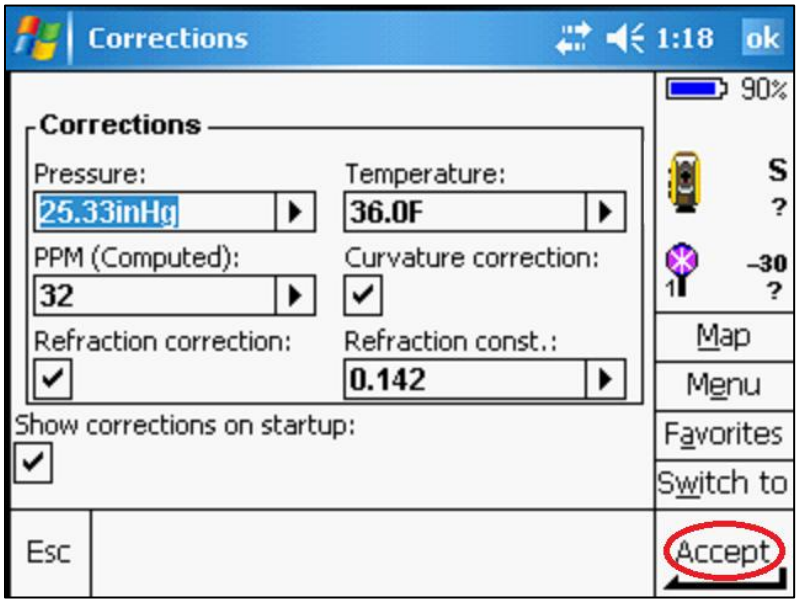

Figure 6-2. Set atmospheric conditions.

At the *Station setup* screen, enter a point name in the *Instrument point name* field. A point name can also be selected from a pre-loaded project control file.

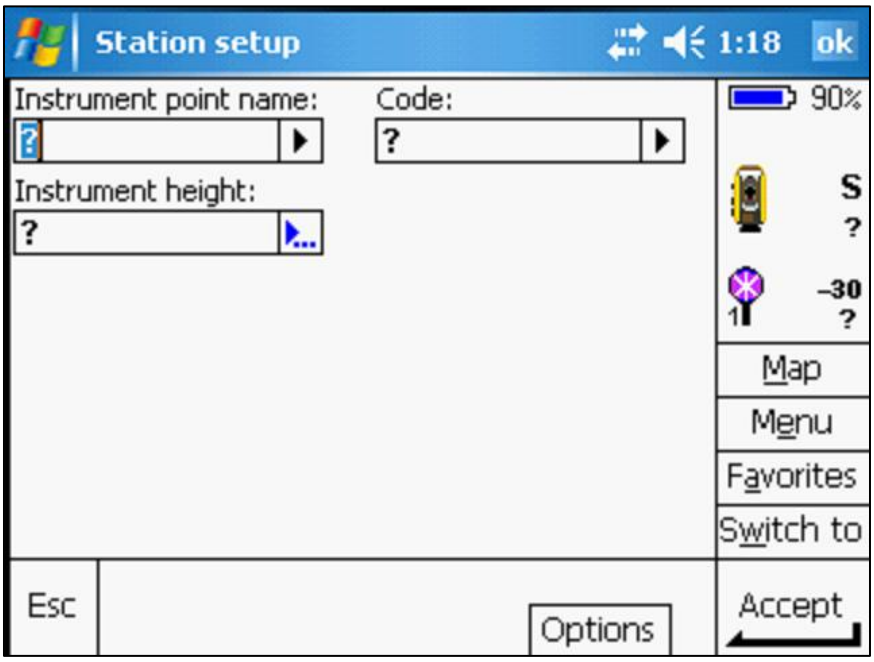

Figure 6-3. Instrument point settings.

Tap the arrow next to the *Instrument point name* field and select *List*.

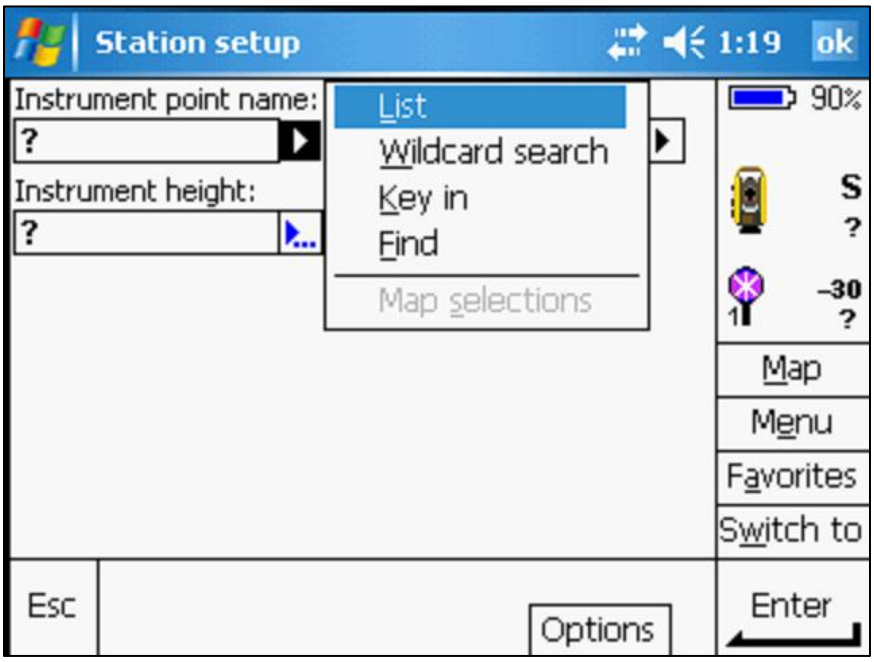

Figure 6-4. Select List.

Highlight the appropriate control point from the menu and tap *Accept*.

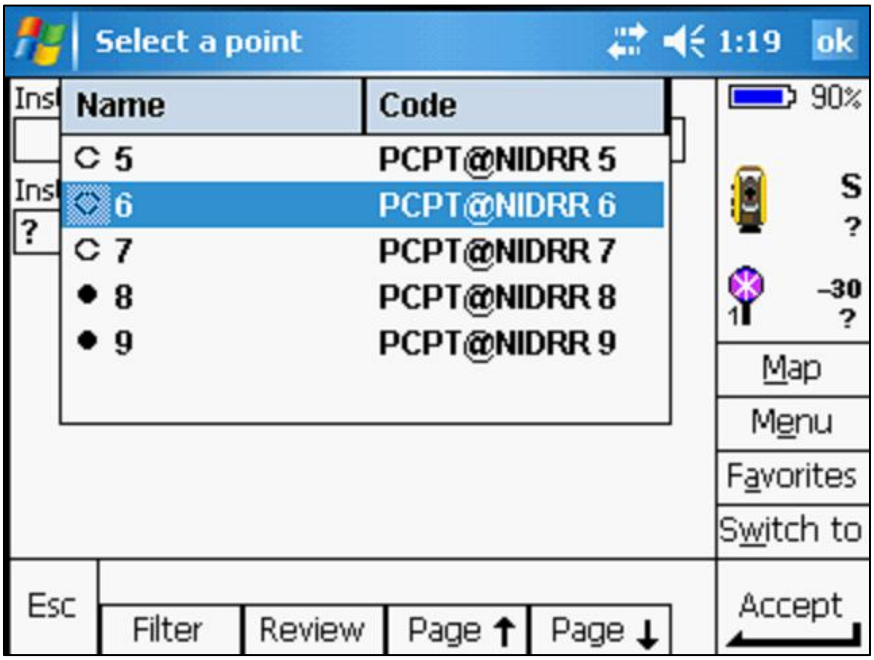

Figure 6-5. Control point list.

Enter a measured value in the *Instrument height* field, and tap *Enter* as indicated by the red oval.

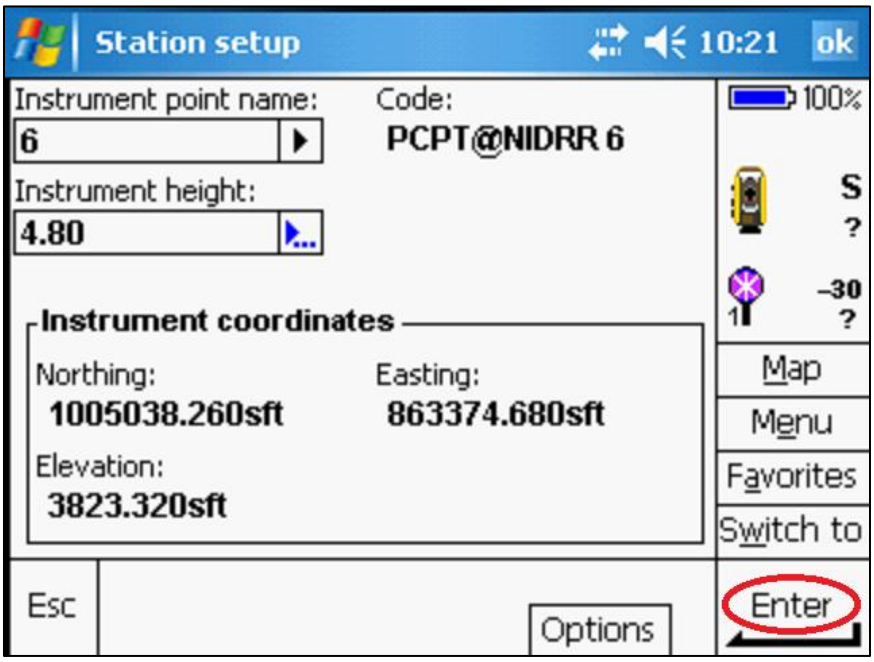

Figure 6-6. Instrument settings.

Tap the *Accept* button to set the instrument setup values.

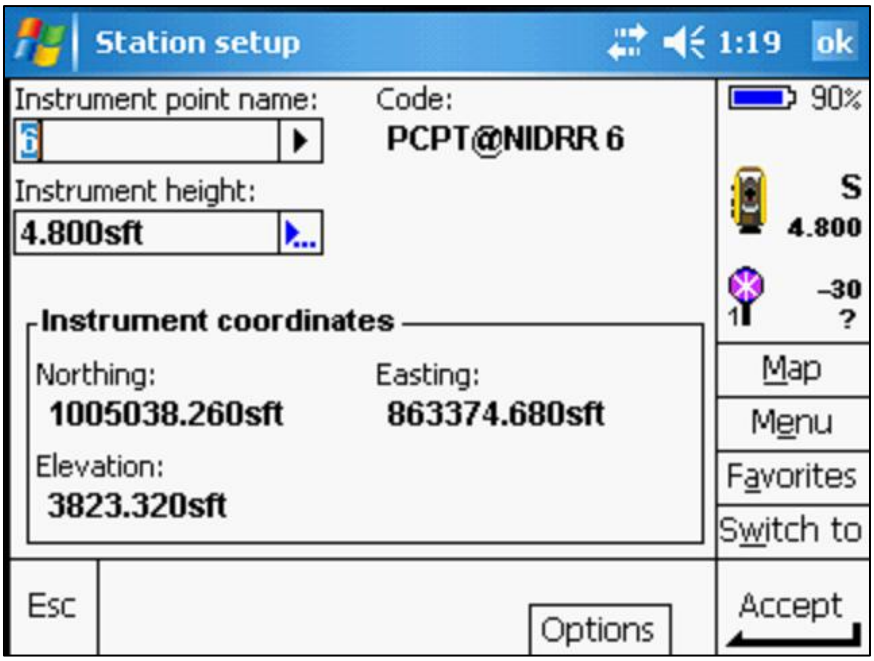

Figure 6-7. Completed instrument setup.

Enter a point name in the *Backsight point name* field. The point may be selected from a pre-loaded project control file. Tap the arrow next to the *Backsight point name* field and select *List*. Next, enter a measured value in the *Backsight height* field and tap *Enter*.

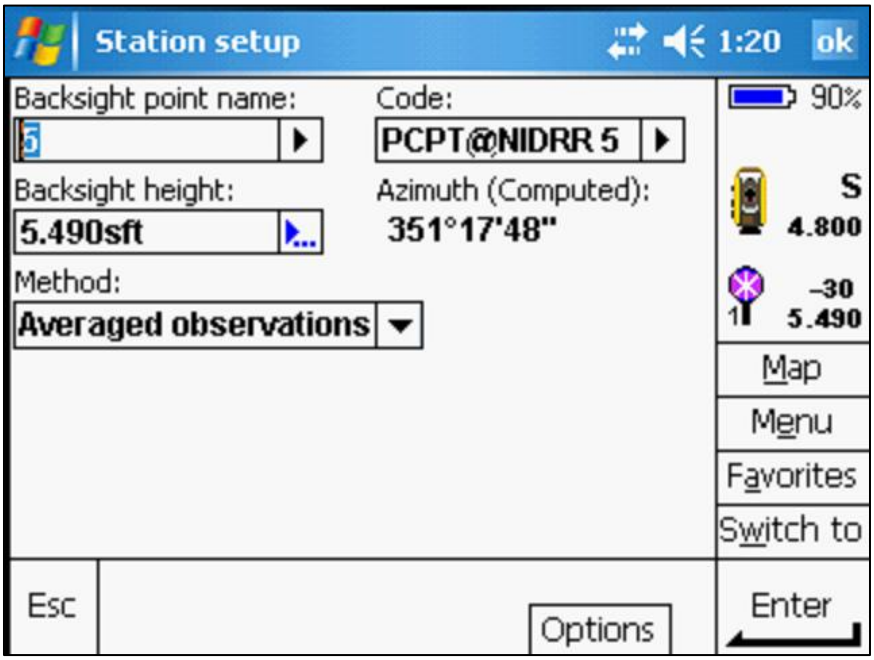

Figure 6-8. Backsight settings.

When the backsight settings have been completed, aim the instrument at the backsight target and tap the *Measure* button as indicated by the red oval when ready. The horizontal angle, vertical angle, and slope distance to the backsight will be measured.

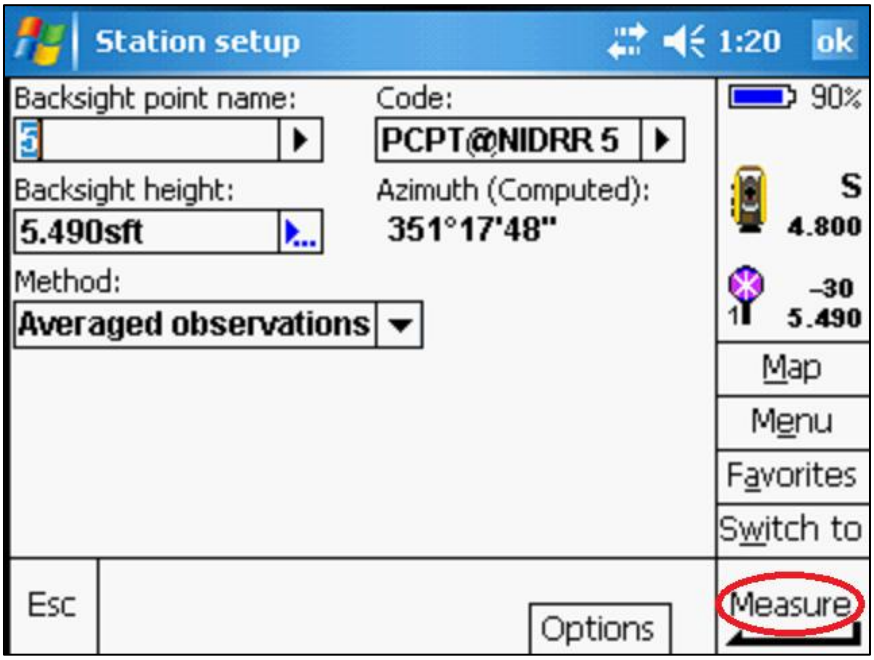

Figure 6-9. Backsight measurement.

Review the measurement data and tap on the *Store* button as indicated by the red oval.

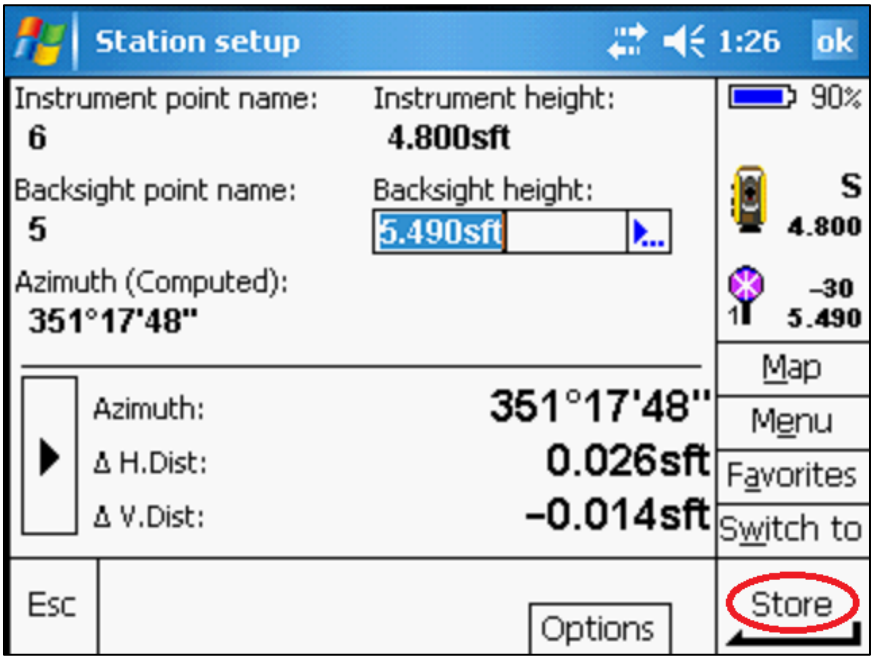

Figure 6-10. Store the measurement.

After the backsight measurement has been stored, the TSC2 announces "Station setup completed." The instrument is now ready to start the rounds procedure, select *Measure rounds* from the *Survey* menu.

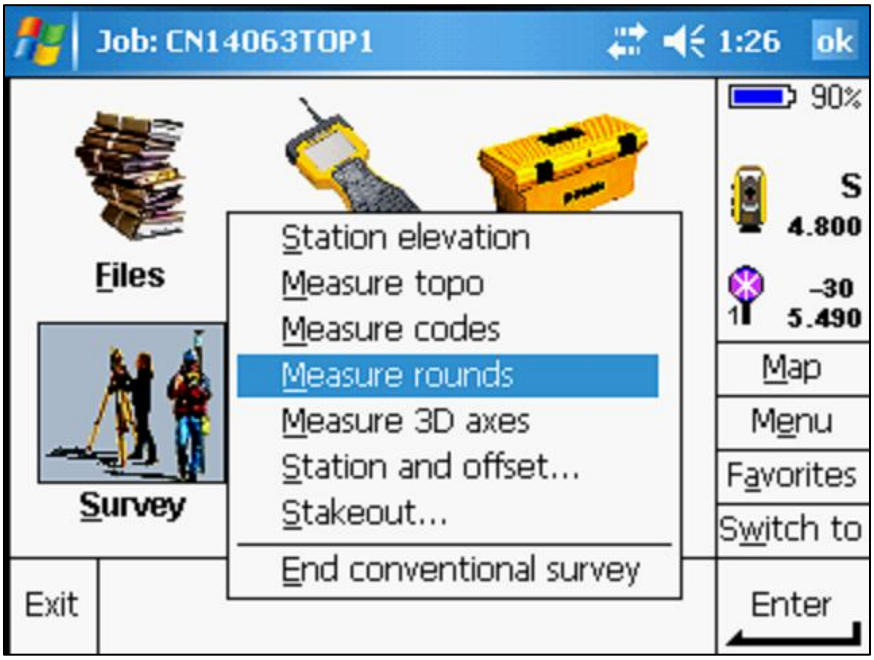

Figure 6-11. Measure rounds.

When the correct backsight information is displayed, tap *Accept* to use it as the first point in the round.

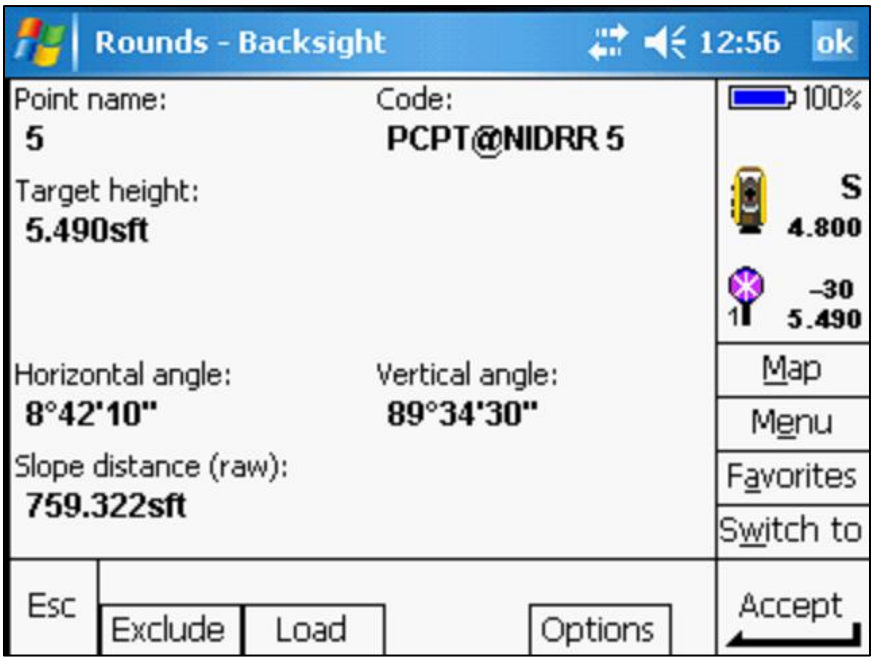

Figure 6-12. First point in the round.

When the *Rounds Face 1* screen is displayed, tap the *Options* button as indicated by the red arrow.

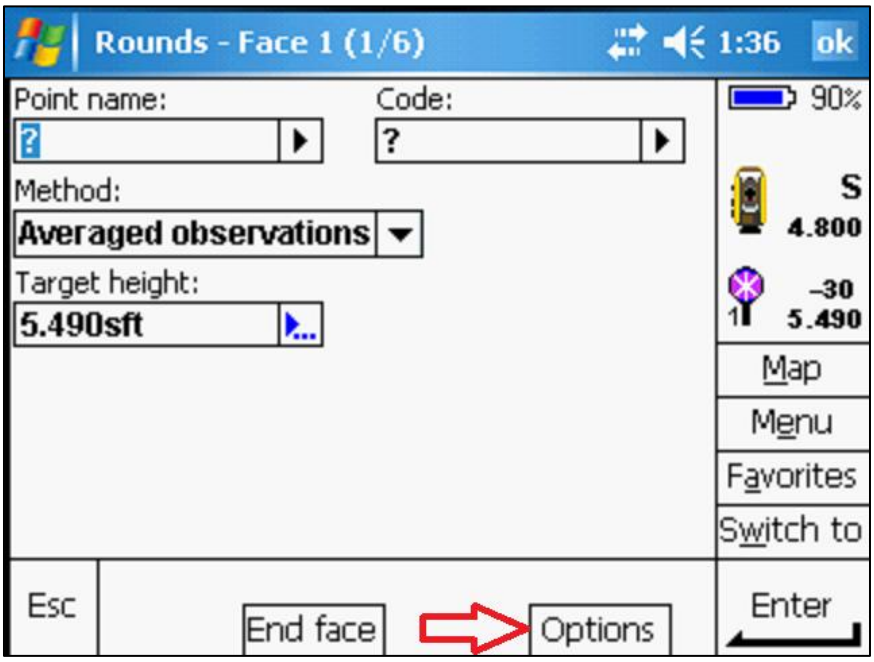

Figure 6-13. Select Options.

Key-in the appropriate number of rounds (red arrow) from Table 6-1 then tap *Enter*. Tap on the *Accept* button to set the value.

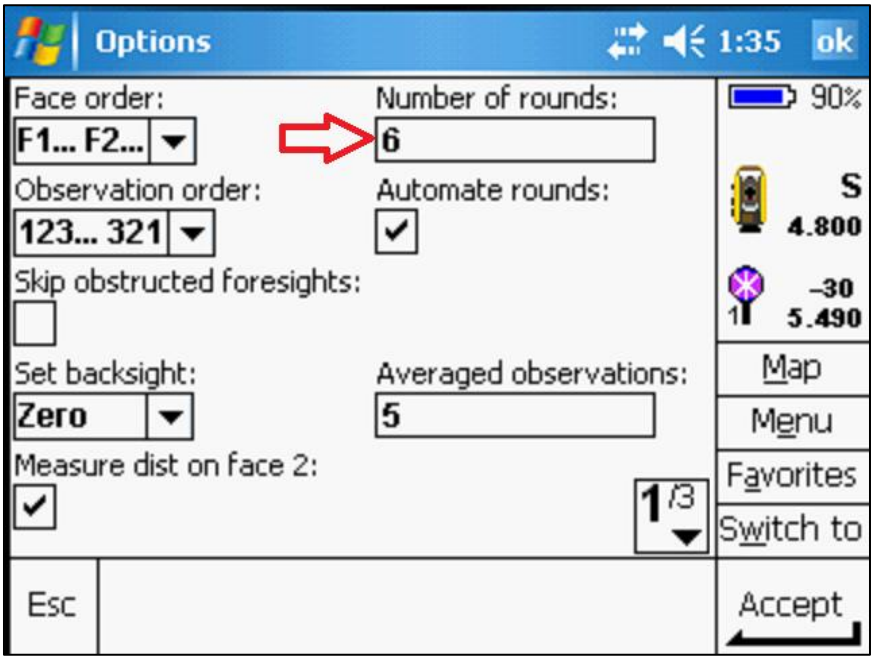

Figure 6-14. Number of rounds.

When the *Rounds Face 1* screen is displayed again, key-in a point name for the supplemental or temporary control point, feature code, and target height then tap *Enter*. Verify that the target offset is correct. Aim the instrument at the desired target and tap the *Measure* button when ready.

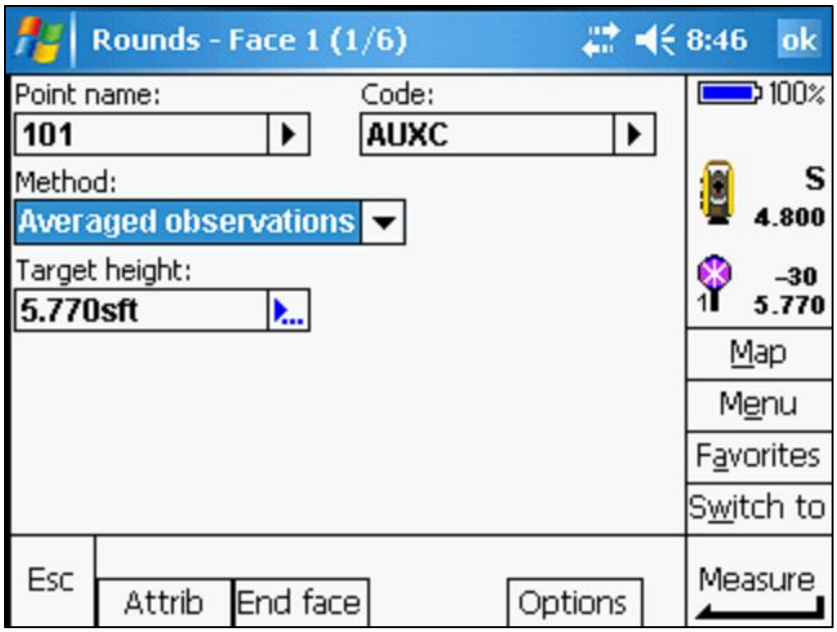

Figure 6-15. Completed point information.

After the measurement is taken, the TSC2 announces "Observation stored." Tap *End face* as indicated by the red arrow when the points in the round have been observed once. The TSC2 announces "First face completed."

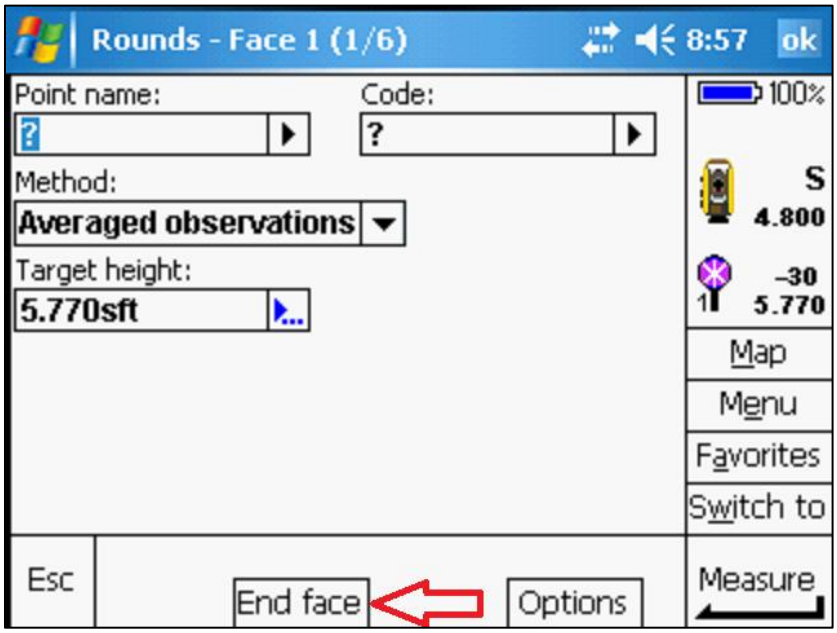

Figure 6-16. End face.

The total station begins the Face 2 measurements by turning to the first target. The TSC2 prompts the operator to "Aim to target." Refine the aiming if necessary and then tap *Measure* when ready.

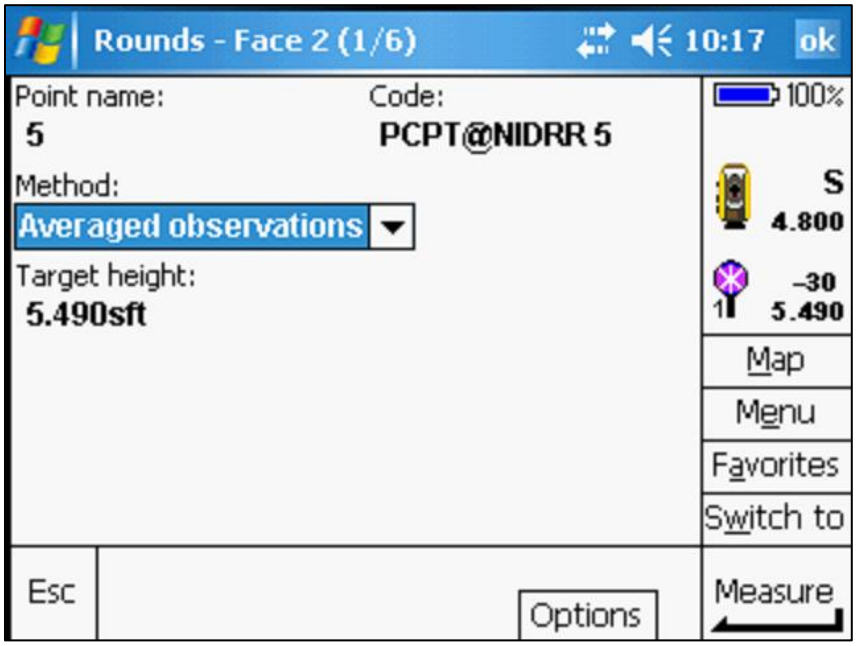

Figure 6-17. Face 2 measurements.

After the Face 2 measurements have been stored, the TSC2 announces "Round completed." After each round, the TSC2 displays the horizontal, vertical, and slope distance residuals. Tap the + *Round* button as indicated by the red arrow to begin collecting the next round.

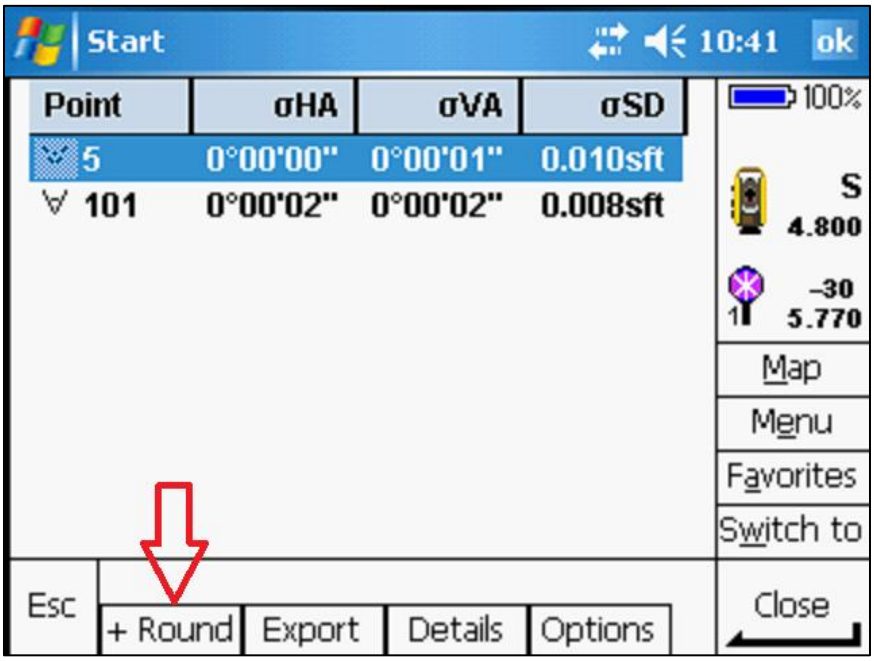

Figure 6-18. End of round.

When the desired number of observations have been stored, the TSC2 displays the horizontal, vertical, and slope distance residuals. Tap *Close* as indicated by the red oval if these residuals are within the allowable tolerance. Refer to the WYDOT Survey Manual, Section VIII, Survey Standards.

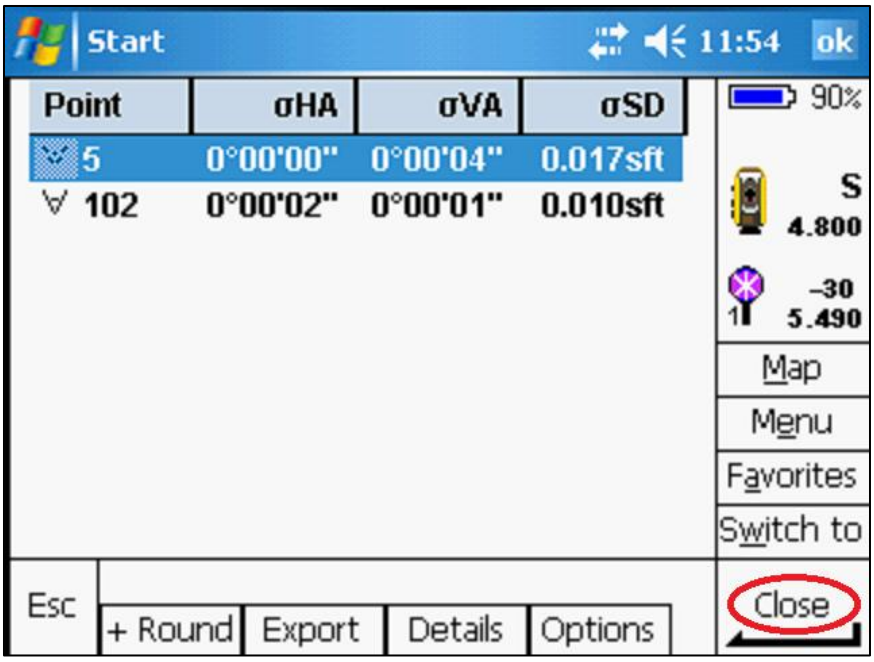

Figure 6-19. Close the round.

Tap *Yes* to save and exit the round.

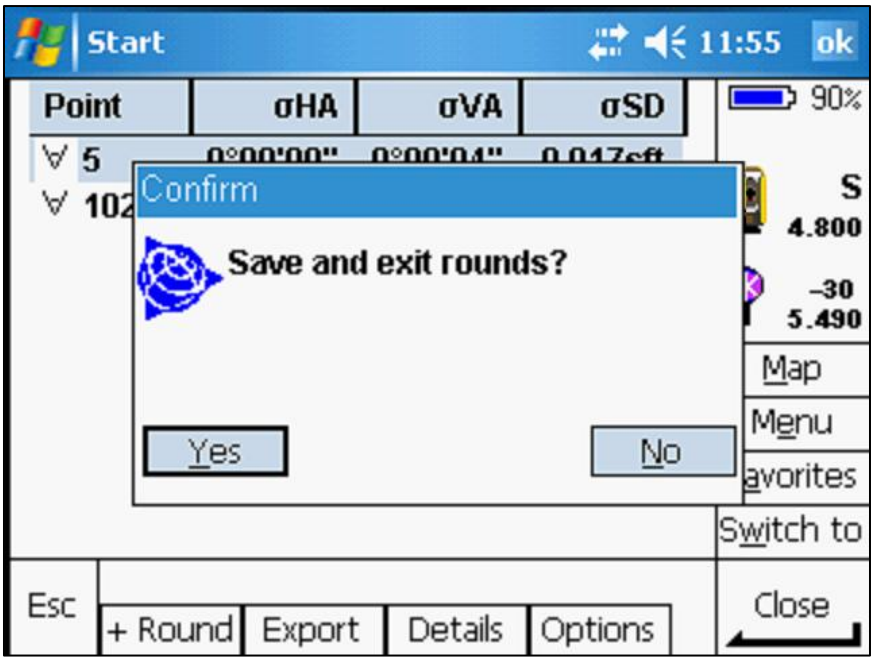

Figure 6-20. Save and exit.

The TSC2 has now calculated and stored a position for the unknown point. Tap the *Survey* icon and select *End conventional survey*.

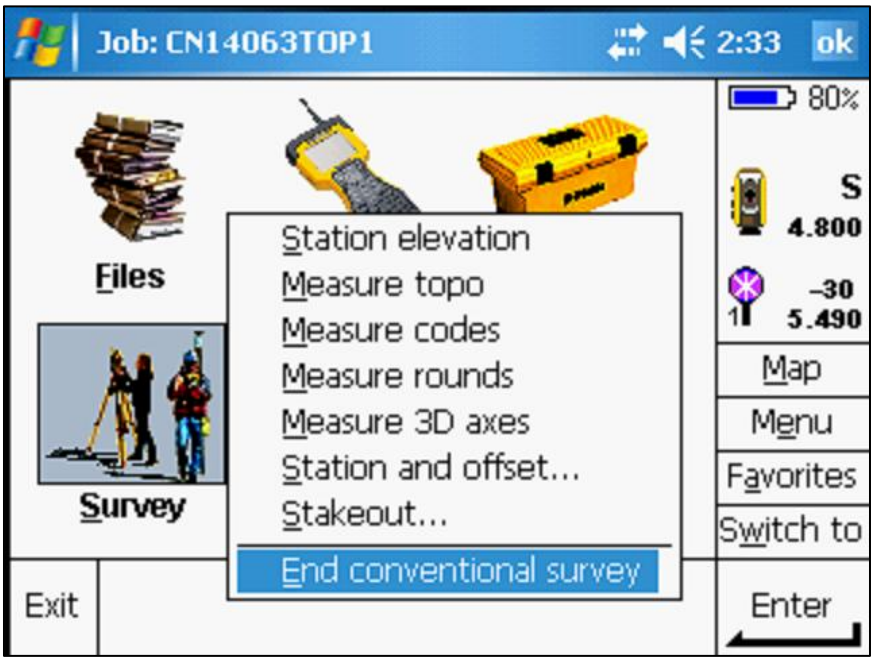

Figure 6-21. End conventional survey.

If topography is to be collected before moving the instrument, tap the Survey icon and select *Use last*. The total station will then use the last instrument setup for the survey. If topography collection is not needed at this instrument setup, move the total station to another location and select *Station setup*.

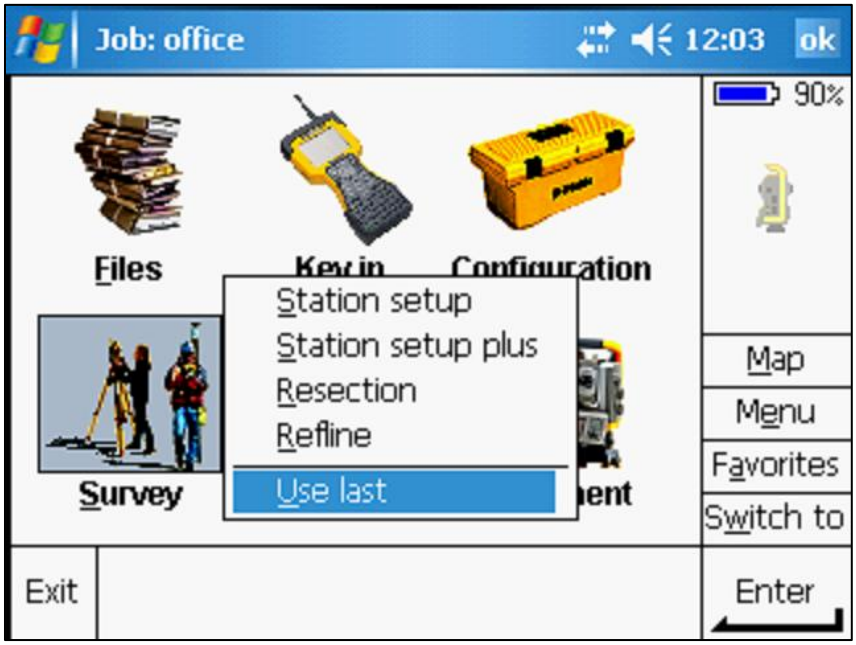

Figure 6-22. Use last.

2. Resection

The collection of a resection is a similar to the collection of a round. The difference being the instrument is set up on an unknown point and the backsight measurements are taken to two or more known points. Review Section V, Control Surveys, of the WYDOT Survey Manual for general procedures detailing the resection of extendible control. The resection should be performed in a separate job reserved for the establishment of project control points.

At the survey controller main menu, tap on the *Survey* icon. Select *Resection* from the *Survey* menu.

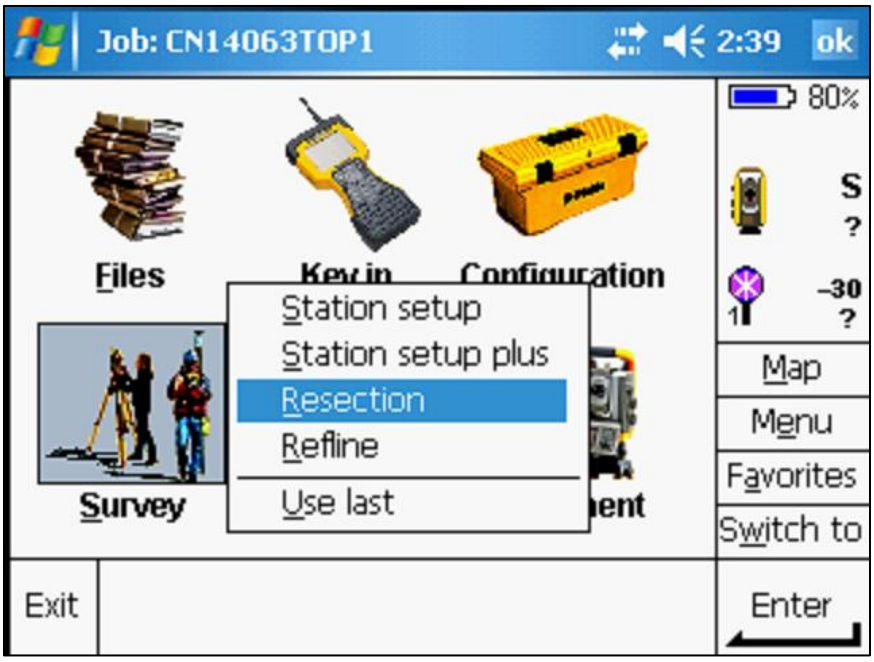

Figure 6-23. Resection.

Set the *Pressure* and *Temperature* values and then tap *Enter* (see Figure 6-2). Tap the *Accept* button to set the values.

Key-in the instrument point name, feature code, and height and tap the *Enter* button when complete. Verify that the target offset is correct. Select *Options* for further settings.

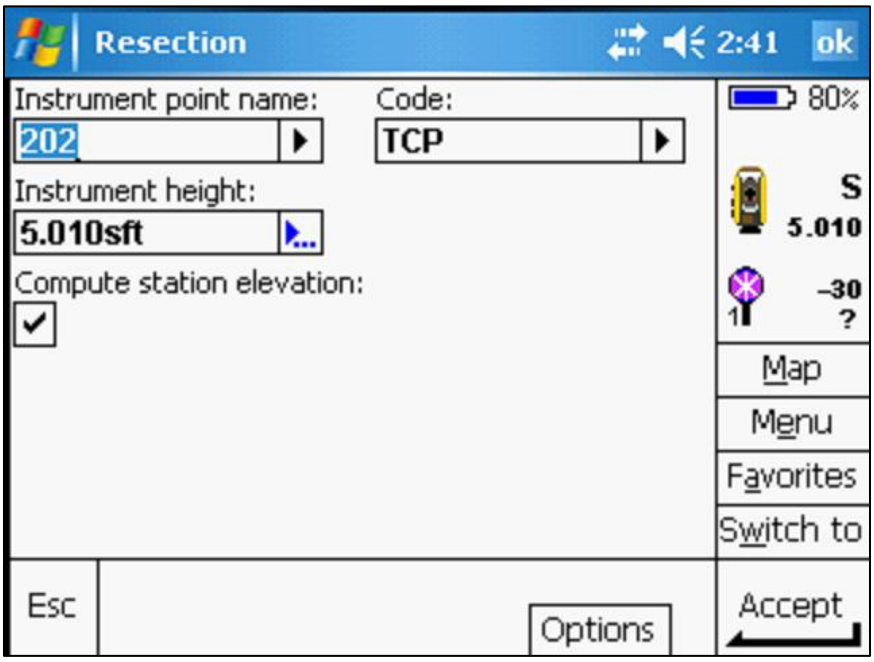

Figure 6-24. Instrument setup.

Set the number of required measurements (red arrow) from Table 6-1, then tap the *Accept* button. When the data collector returns to the *Resection* screen, tap on the *Accept* button (see Figure 6-24).

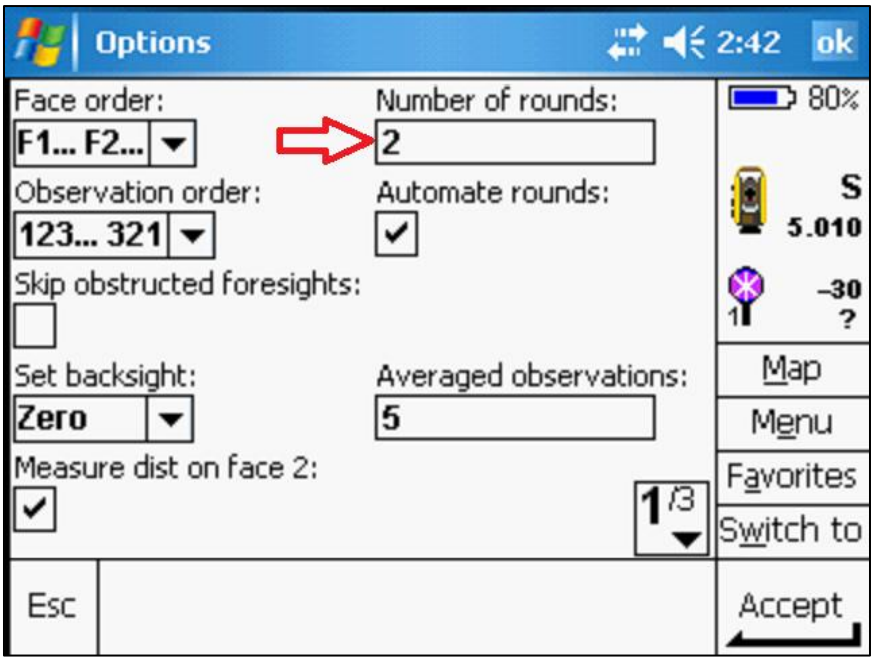

Figure 6-25. Number of rounds.

Enter the point name, feature code, and target height for the first known point. Aim the instrument at the backsight and tap the *Measure* button when ready. After the measurement is taken, the TSC2 announces "Observation stored."

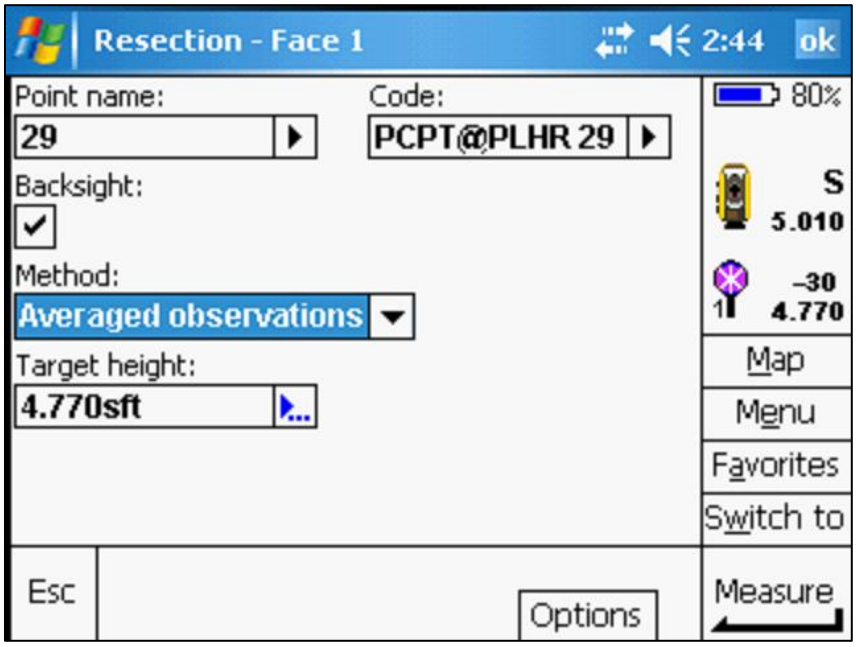

Figure 6-26. First resection backsight.

Enter the point name, feature code, and target height for the second known point. Aim the instrument at the foresight and tap the *Measure* button when ready. After the measurement is taken, the TSC2 announces "Observation stored."

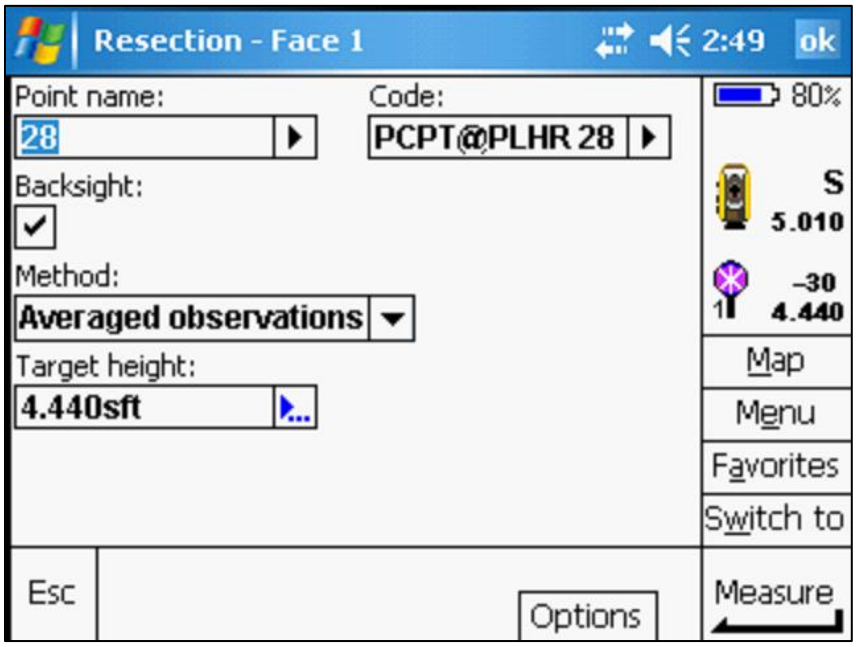

Figure 6-27. Second resection backsight.

The TSC2 displays the horizontal, vertical, and slope distance residuals. Tap on the + *Point* button as indicated by the red arrow to include additional measurements (if needed) to another known point for the resection. Tap *End face* when all points have been observed once. The TSC2 announces "First face completed."

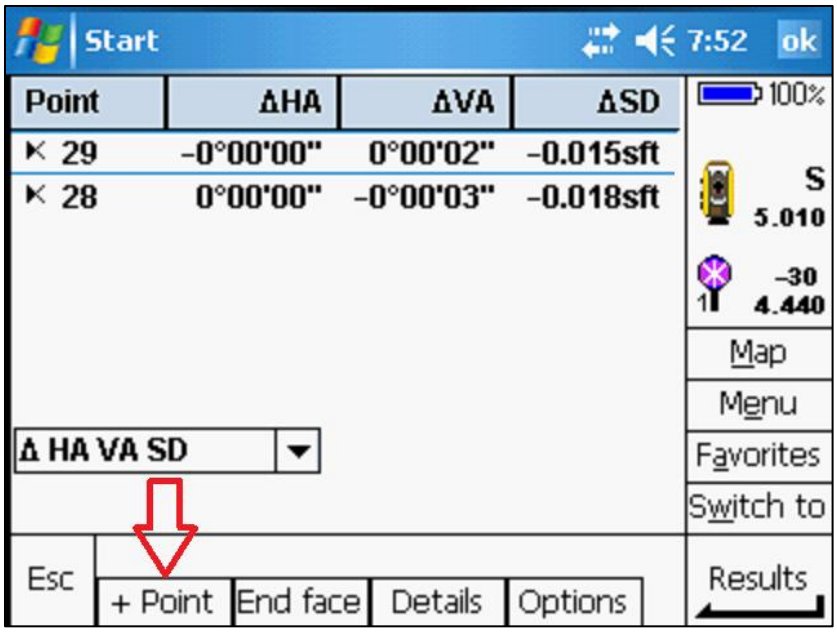

Figure 6-28. Add point or end face.

The total station begins the Face 2 measurements by turning to the first target. The TSC2 prompts the operator to "Aim to target." Refine the aiming if necessary and then tap *Measure* when ready.

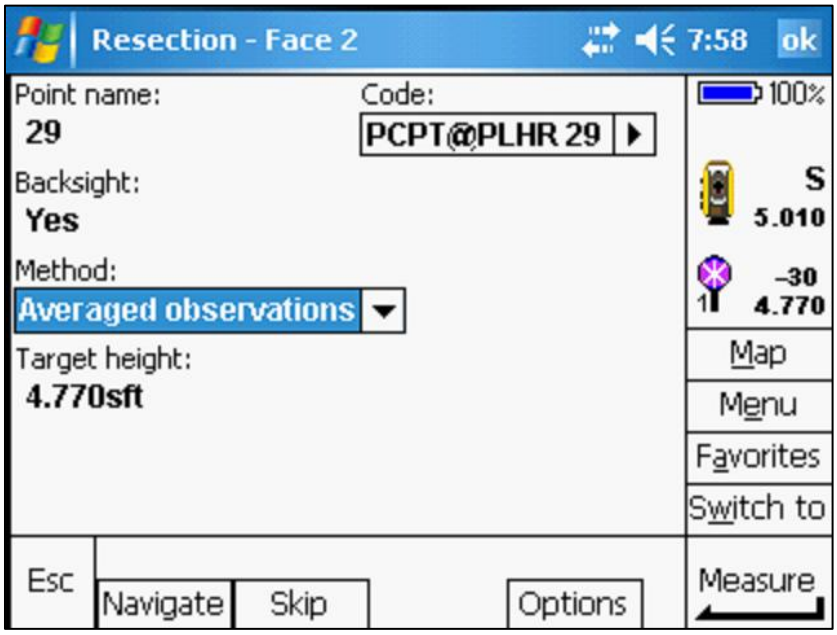

Figure 6-29. Face 2 measurements.

After the second measurement in each round has been stored, the TSC2 announces "Round completed." The TSC2 will then display the horizontal, vertical, and slope distance residuals. Tap the + *Round* button to begin collecting the next round in the resection process. When the desired number of observations have been stored, Tap the *Results* button (red oval) to review the horizontal, vertical, and slope distance residuals. If the residuals are within the allowable tolerances as shown in the WYDOT Survey Manual, Section VIII, Survey Standards, then continue.

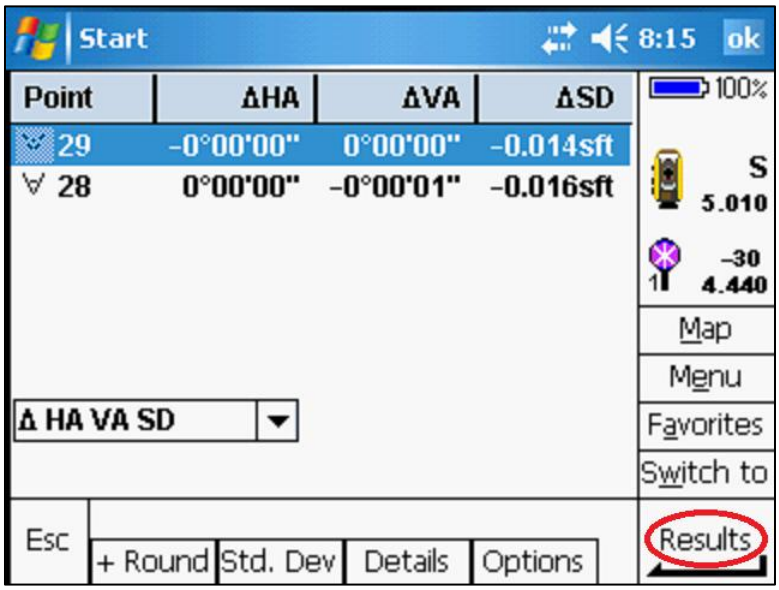

Figure 6-30. End of round.

The TSC2 has now calculated positional coordinates for the point in the resection. Tap on the ***1/2*** button as indicated by the red arrow to view the results on page 2.

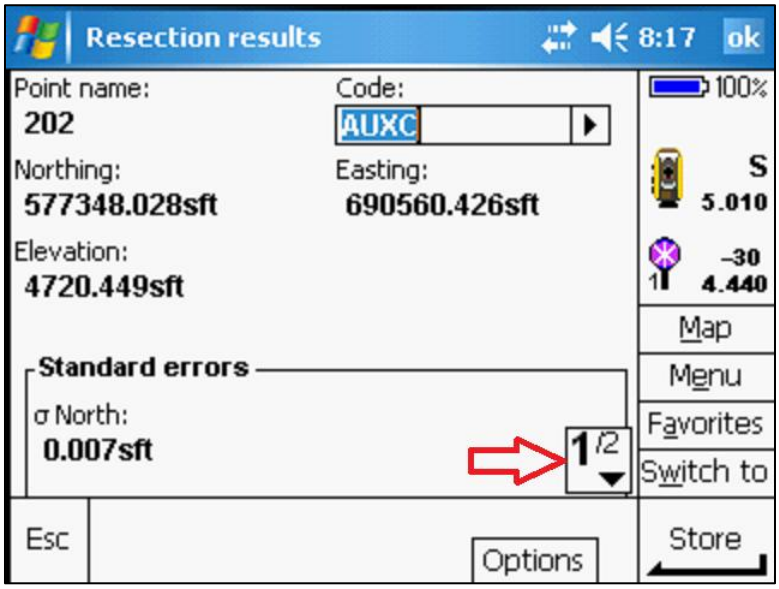

Figure 6-31. Resection results, page 1.

Tap the *Store* button to save the point and its coordinates.

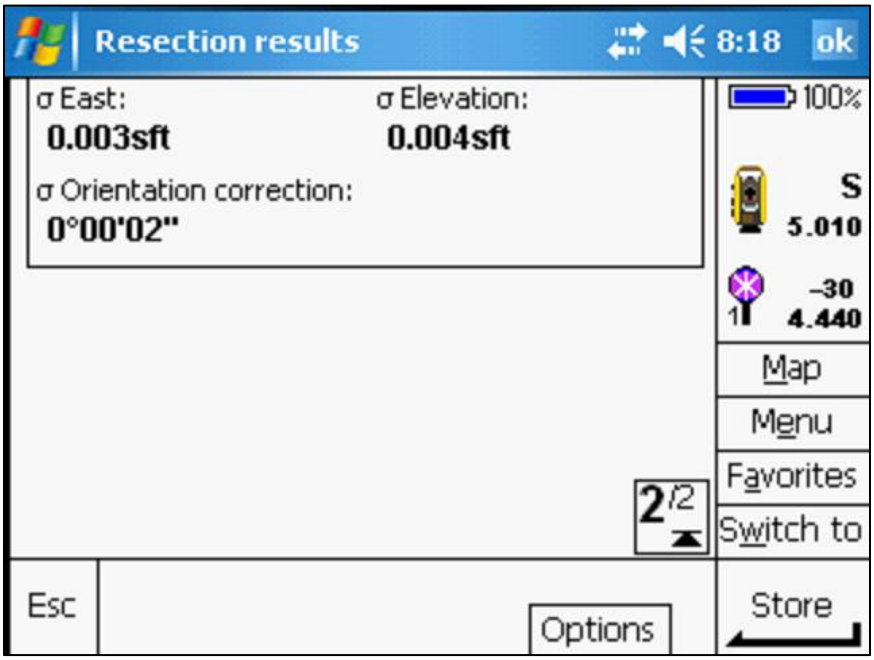

Figure 6-32. Resection results, page 2.

Tap the *Survey* icon and select *End conventional survey*.

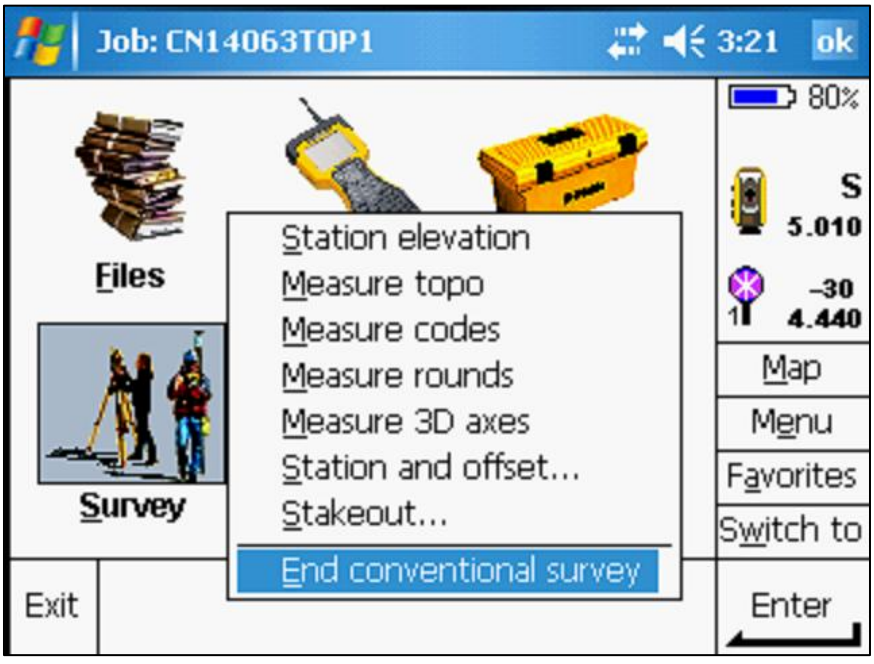

Figure 6-33. End conventional survey.

A resection performed on a newly monumented control point is referred to as an auxiliary point (AUXC) and is typically intended to become part of the project control network. Resections are also used to determine coordinates for temporary control points (TCP) such as a hub & tack for short term collection or stake out purposes.

Before auxiliary points become a permanent part of the control network, they are imported into MicroStation using Geopak Survey. The Geopak Survey program uses the least-squares method of adjustment and may calculate slightly different coordinates than the TSC2 derived coordinates. For P&S mapping purposes, the coordinates calculated from the Geopak Survey adjustment will be used for any auxiliary points. The new point and its coordinates are added to the project control (*.dc) file.

3. Topography

At the survey controller main menu, tap on the *Survey* icon and select *Station setup* from the *Survey* menu (see Figure 6-1). Tap the *Survey* icon again and select the *Measure topo* function.

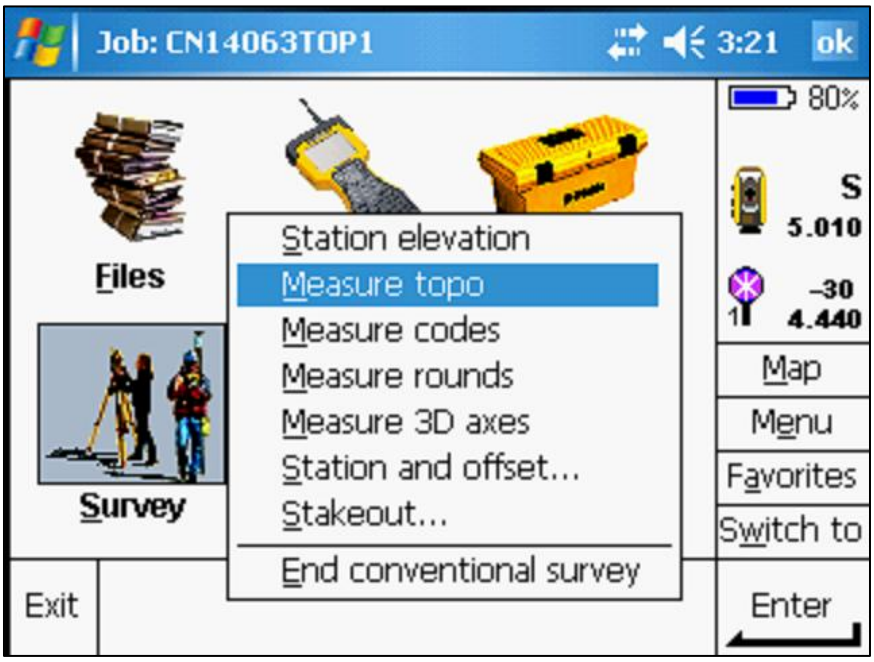

Figure 6-34. Measure topo.

At the *Measure topo* screen, the number for the topo measurement in the *Point name* field will typically start at 1000. The *Code* setting defaults to the previous measurement and may need to be changed. The *Target height* setting also defaults to the previous measurement. Tap on the target icon as indicated by the red arrow to select a backsight target.

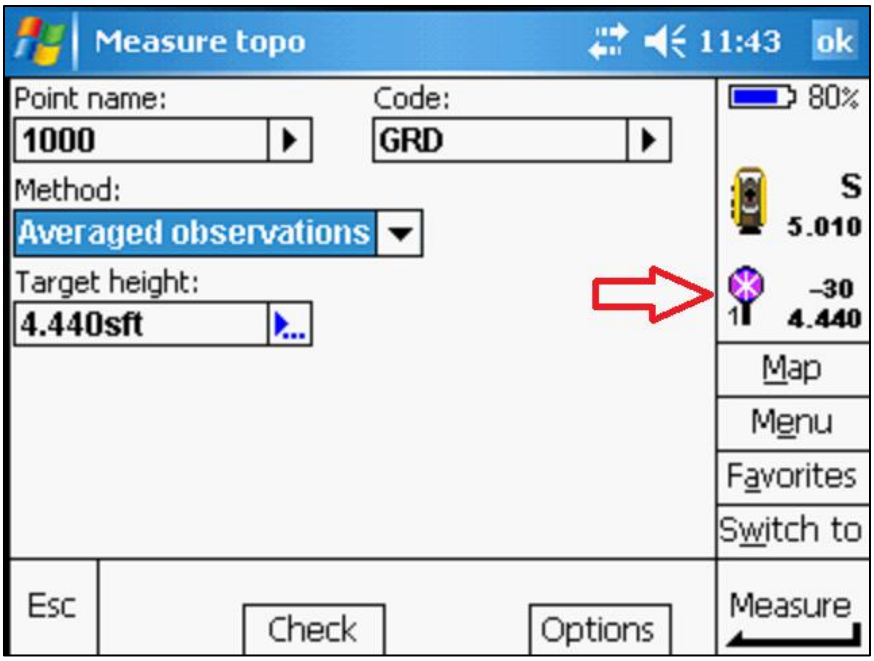

Figure 6-35. Measure topo.

Use the stylus to select the appropriate target, height, and prism offset.

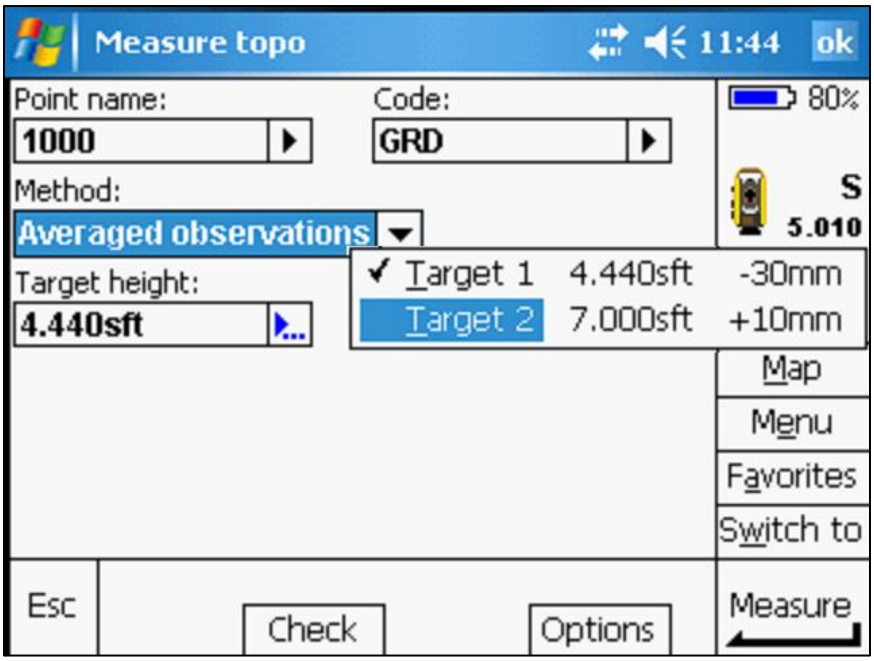

Figure 6-36. Select backsight target.

Once the measure topo settings have been edited, tap the *Options* button to view additional settings.

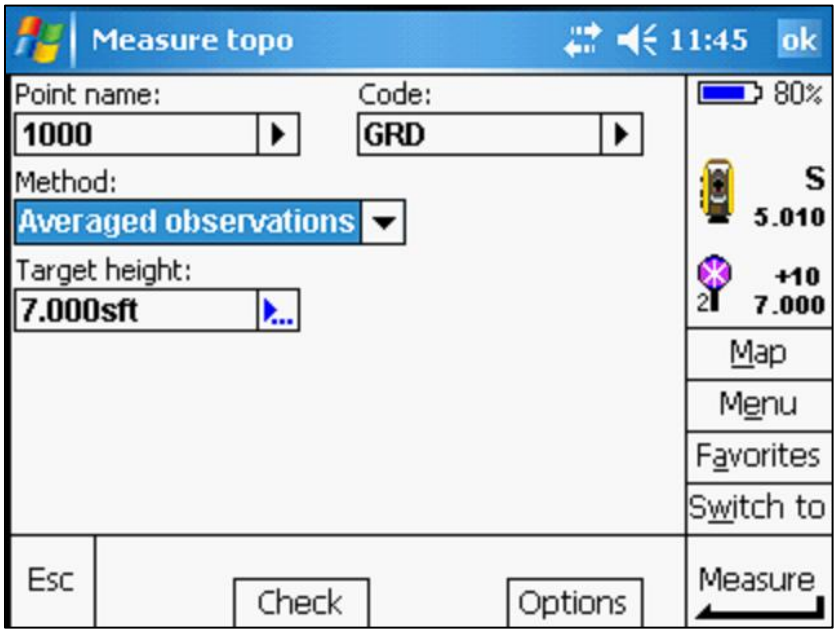

Figure 6-37. Measure topo settings.

Review the additional settings at the *Options* screen. The *Auto point step size* setting is typically set to "1." This setting helps manage point numbers and avoid duplication. If the *View before storage* box is checked, the operator is able to review each measurement and change incorrect settings (e.g. incorrect rod height or feature code) before it is stored. When the *Prompt for attributes* box is checked, the data collector will prompt the operator for attributes associated with the selected code. When it is not checked, the prompts are not displayed.

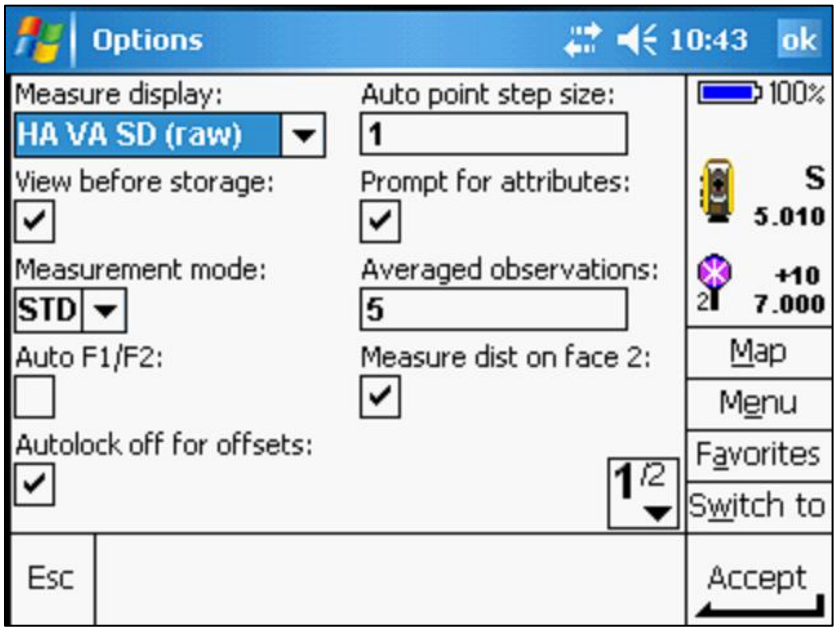

Figure 6-38. Options settings.

Review and edit (if necessary) the code and target height.

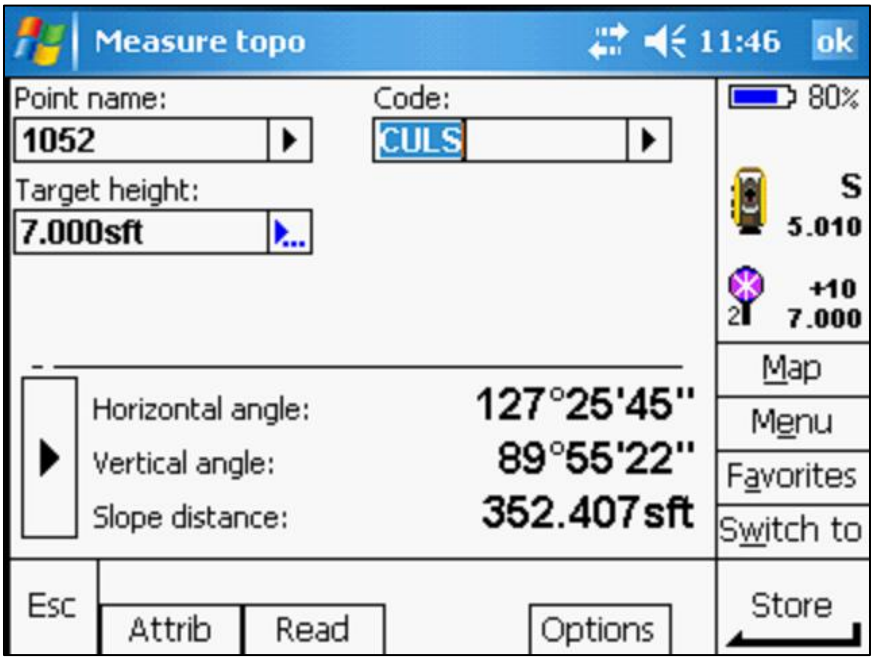

Figure 6-39. Review measurement.

Key-in the feature code attributes, tap on the *Enter* button, then the *Accept* button. Tap on the *Store* button at the *Measure topo* screen (see Figure 6-39). After the measurement is stored, the TSC2 announces "Observation stored."

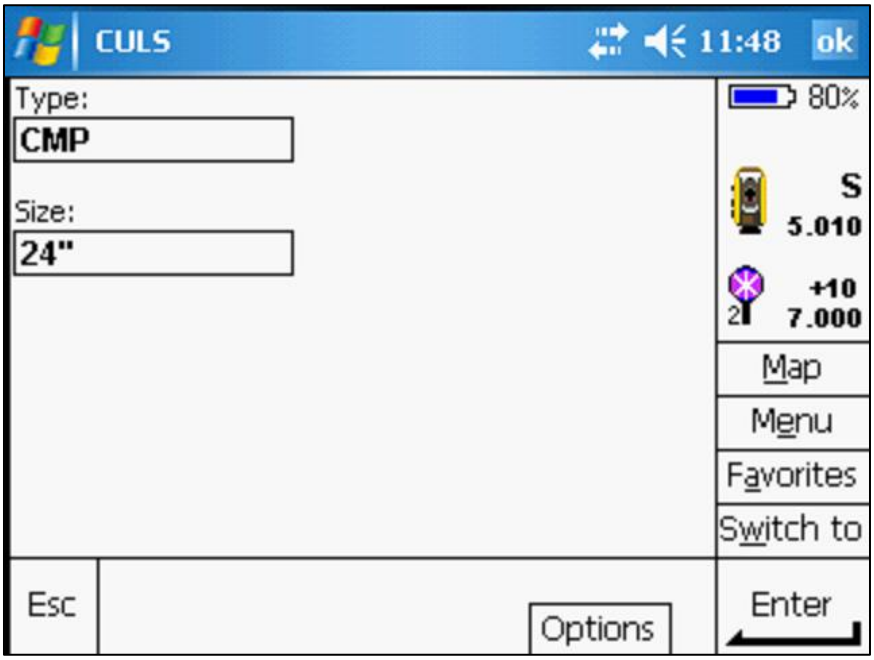

Figure 6-40. Feature attributes.

D. Check Shots

1. Backsight

During the topo collection process, a backsight check shot is recommended. It should be done at least hourly or more frequently when conditions make the setup stability suspect. At the completion of any topo measurement, tap the *Check* button as indicated by the red arrow.

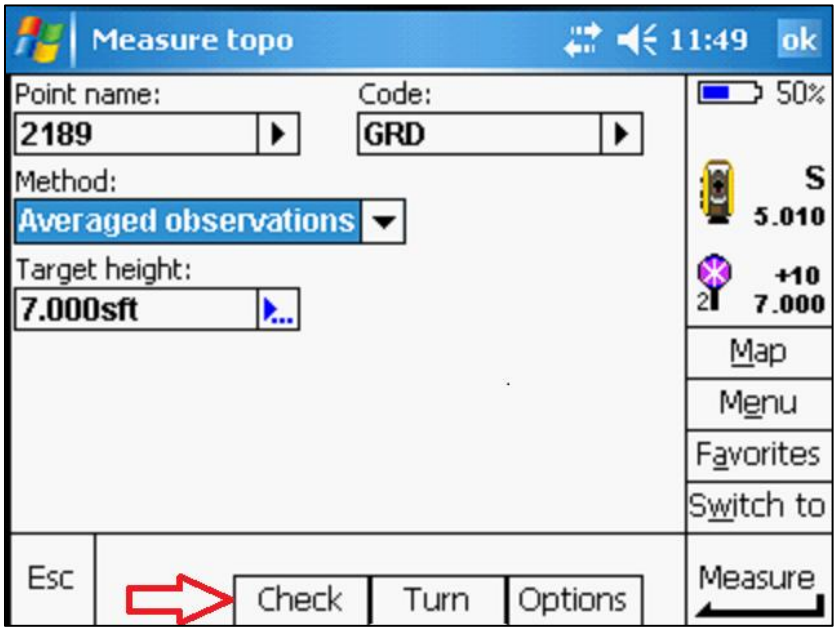

Figure 6-41. Backsight check.

At the *Check shot* screen, tap on the *Chk BS* button as indicated by the red arrow.

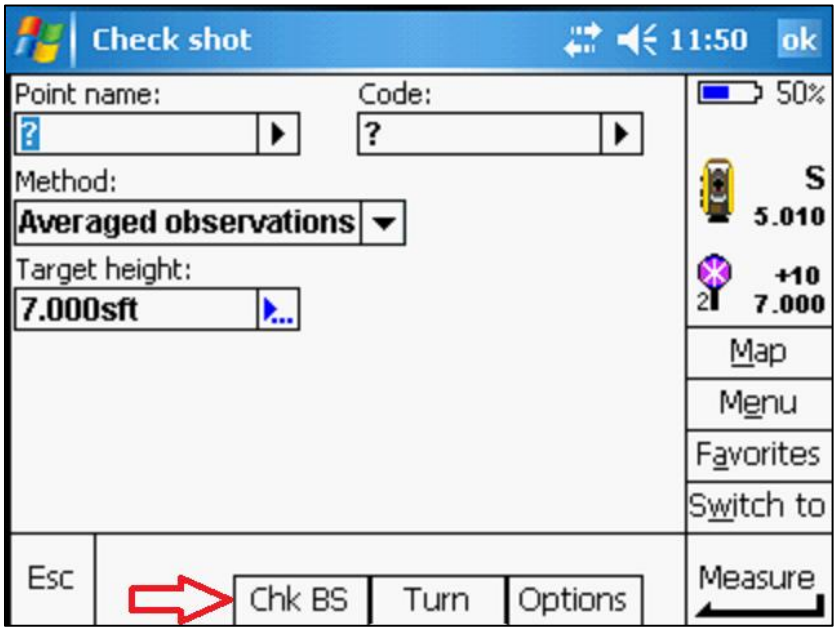

Figure 6-42. Check shot.

The instrument turns back to the current backsight and is ready for the measurement.

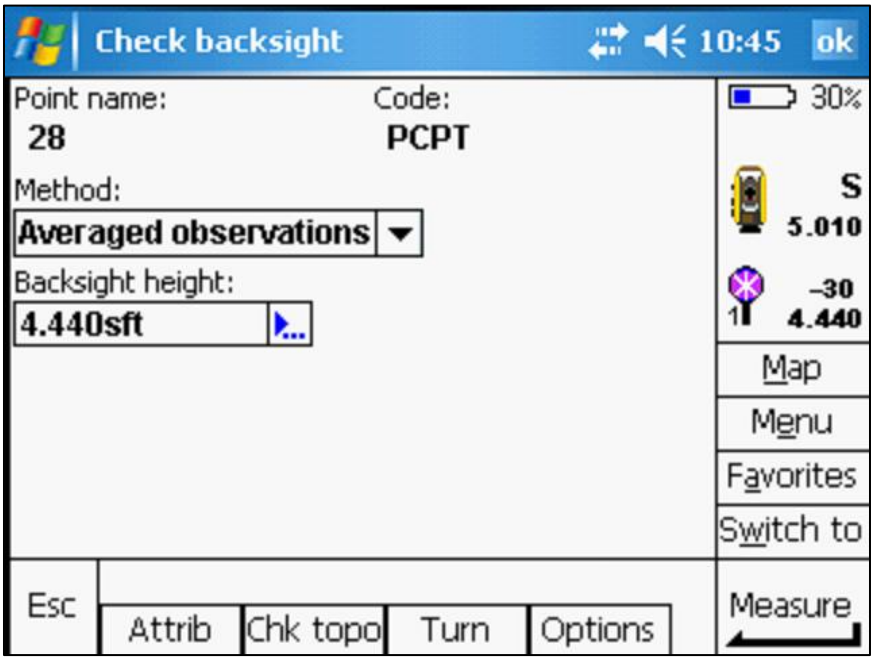

Figure 6-43. Backsight measurement.

a. Small Residuals

Once the measurement has been taken, the *Check backsight* screen displays the residuals (misclosures) between the check measurement and the original backsight measurement. The main residual values, Δ*H Dist.* and Δ*V Dist.*, are within the red box.

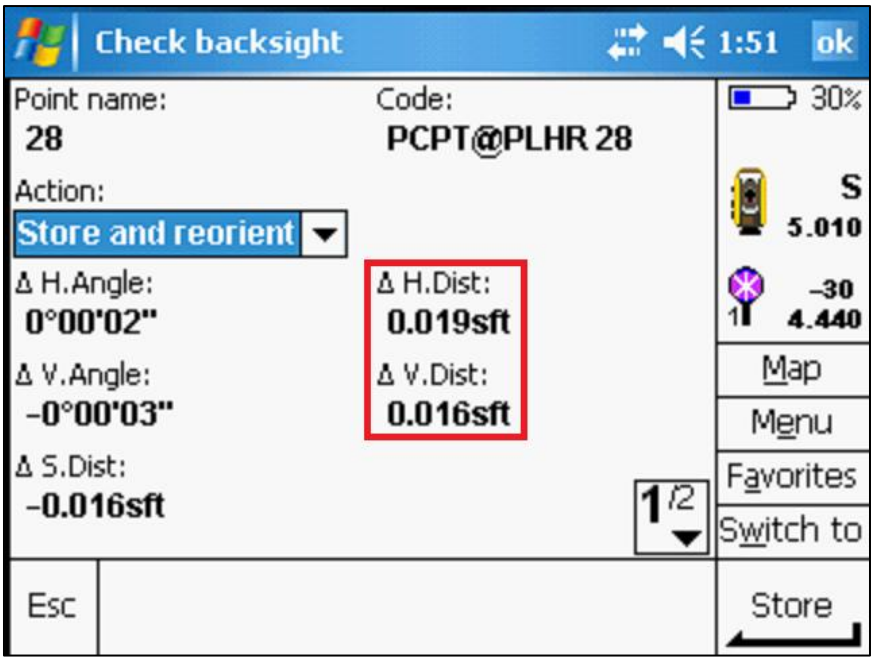

Figure 6-44. Backsight check residuals.

After reviewing the residual values tap on the down arrow to view a list of possible actions. For small residual values, select the *Store as check* option. If the residual values are larger than expected, check the instrument and backsight setups. Ultimately, it is up to the operator to determine if the check shot is acceptable before continuing with the survey.

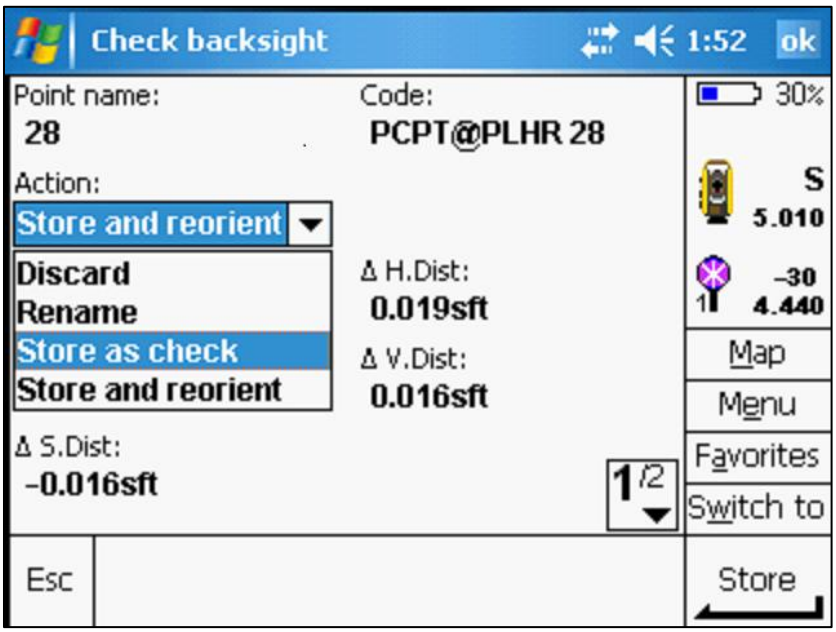

Figure 6-45. Store as check.

Tap on the *Store* button at the *Check backsight* screen. After the measurement is stored, the TSC2 announces "Observation stored."

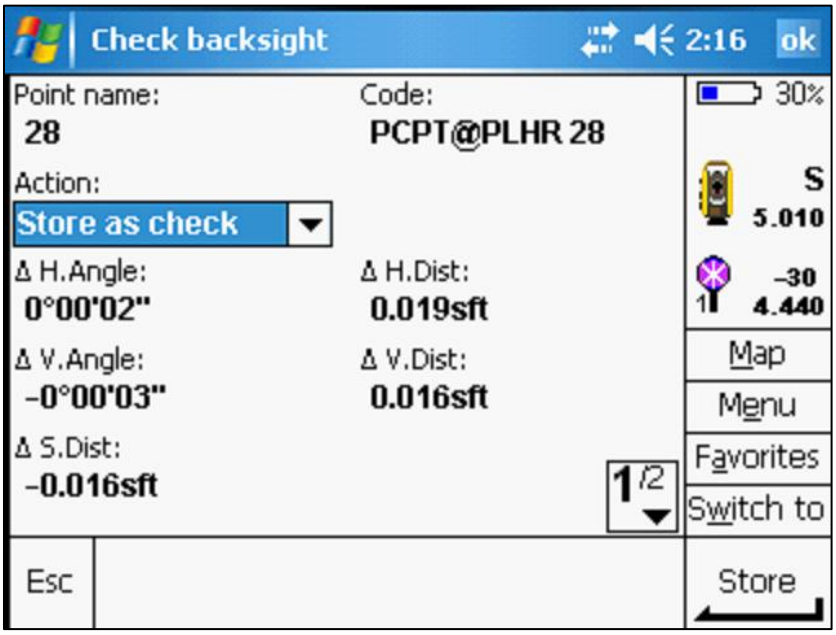

Figure 6-46. Store backsight check.

b. Large Residuals

Occasionally, very large horizontal or vertical residuals are encountered. These residuals are an indication of a potential setup problem. In these situations, the error source is typically linked to movement of the instrument or backsight during the topo collection. This movement may have been gradual or may have been caused by a bump to the tripod.

When a very large residual is discovered, it is important to check the measurements of previously collected topography. These checks will determine the extent of the instrument movement on the entire collection. It may be necessary to abandon the collected data that has occurred since the last backsight check with small residual values.

Tap on the down arrow and select *Discard* from the drop down menu.

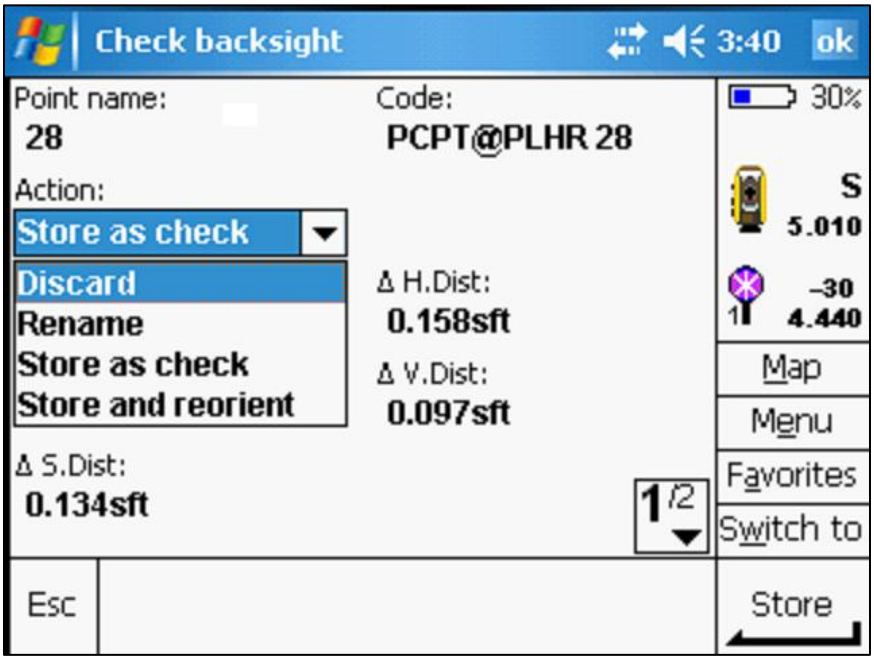

Figure 6-47. Discard.

Tap on the *Esc* button as indicated by the red circle. The backsight measurement may be retaken to check the residuals once more. If the residuals are still questionable, it is up to the operator to determine how to resolve the issue.

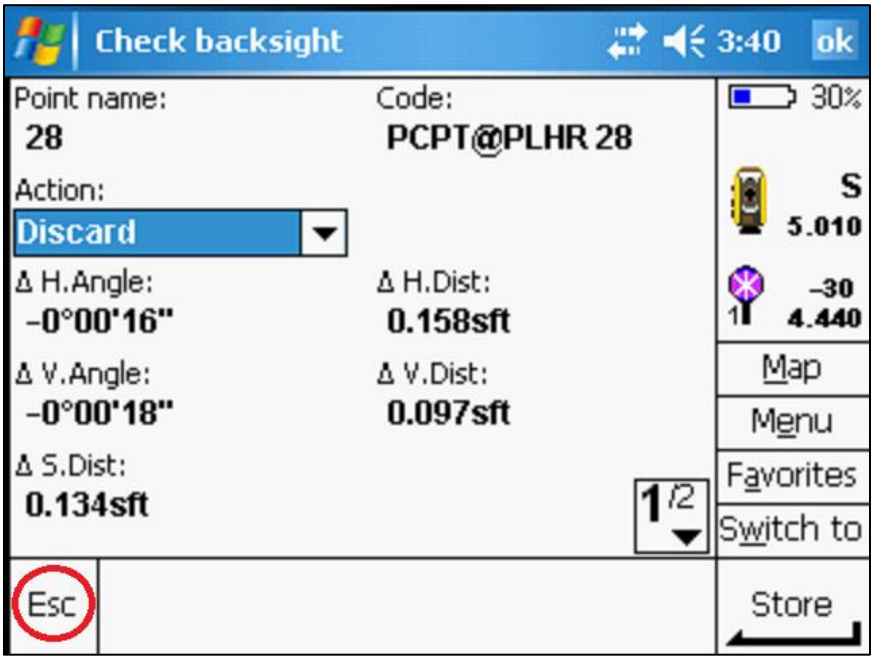

Figure 6-48. Retake measement.

The operator may tap the *Chk topo* button as indicated by the red arrow to check previously stored topography shots.

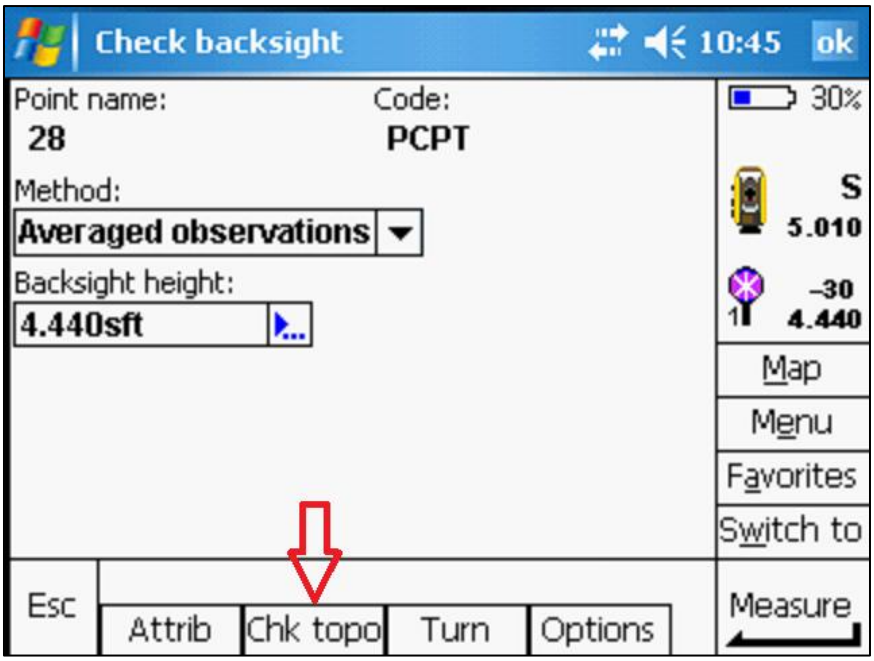

Figure 6-49. Chk topo.

2. Topography

At the *Check shot* screen, enter the point number of a previously stored topography measurement in the *Point name* field. A field diary will be useful to find an easily identifiable feature. Take a new measurement to that point. Review and edit (if necessary) the target, target height, and prism offset. Any topo check measurements out of tolerance should be replaced with the new measurements based upon a corrected orientation.

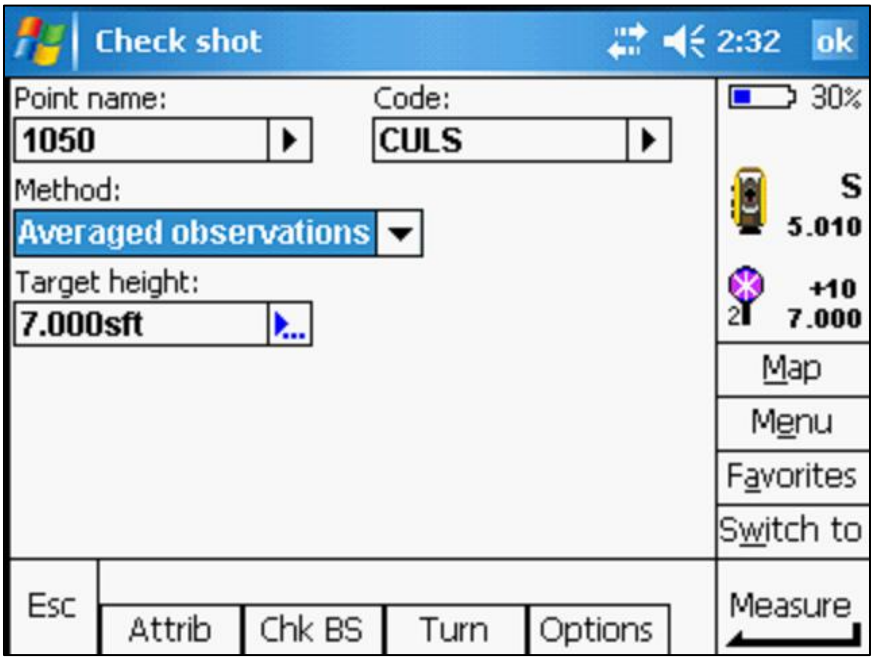

Figure 6-50. Check topo.

E. Collection Guidelines

1. Safety

Safety should be the primary objective during the planning and execution of WYDOT surveys. Areas which should cause special concern include but are not limited to:

- High traffic areas.
- Overhead electrical lines or other electrical devices that could come into contact with the surveyor or the surveying equipment.
- Bodies of water including lakes, rivers, and steams.
- Bridges, cliffs, or steep embankments where falls could occur.

2. Instrument/Backsight Setup

During the instrument setup process, one of the adjacent monuments is typically used for a backsight target. To minimize misclosures in the horizontal or vertical angles, choose the monument furthest from the instrument. For example, a 0.05 ft. sighting error (half the width of a target range pole) at 500 ft. is equal to a horizontal angle offset of 21 seconds. While a 0.05 ft. sighting error at 800 ft. is equal to an angle offset of 13 seconds. However,

extremely long sighting distances (i.e. greater than 1500 ft.) may degrade the surveyor's ability to accurately sight on the target.

3. Topography Collection

When collecting topographic surveys, measurement distances should not exceed 800 ft. The shot interval between topographic measurements along a feature (e.g. EPS, EP, FLC, or TBC) should not exceed 25 ft. Also, when collecting DTM shots the grid distance should not exceed 25 ft. Avoid measurements when obstacles interfere with the line of sight from the instrument to the target. Examples of obstacles are vehicles, signs, highway delineators, buildings, vegetation, and terrain.