Provided By Utah State University, Ecogeomorphology and Topographic Analysis Lab

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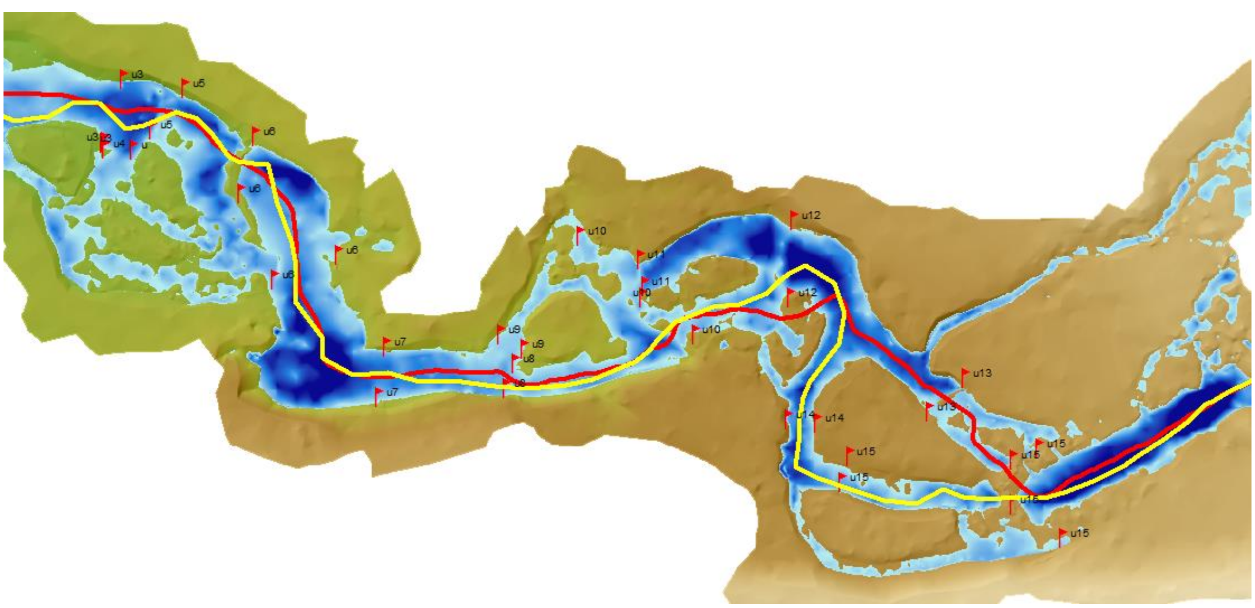
CHaMP Introduction to Topographic Survey Manual

This manual is an introduction to Champ Survey equipment and methodology. The manual is designed to be utilized as a precursor to Champ Camp. The student is expected to read and study all of the material contained herein prior to arrival at Champ Camp. The Champ Camp Topographic training modules will support and supplement this information.

Contents

Topographic Survey Defined

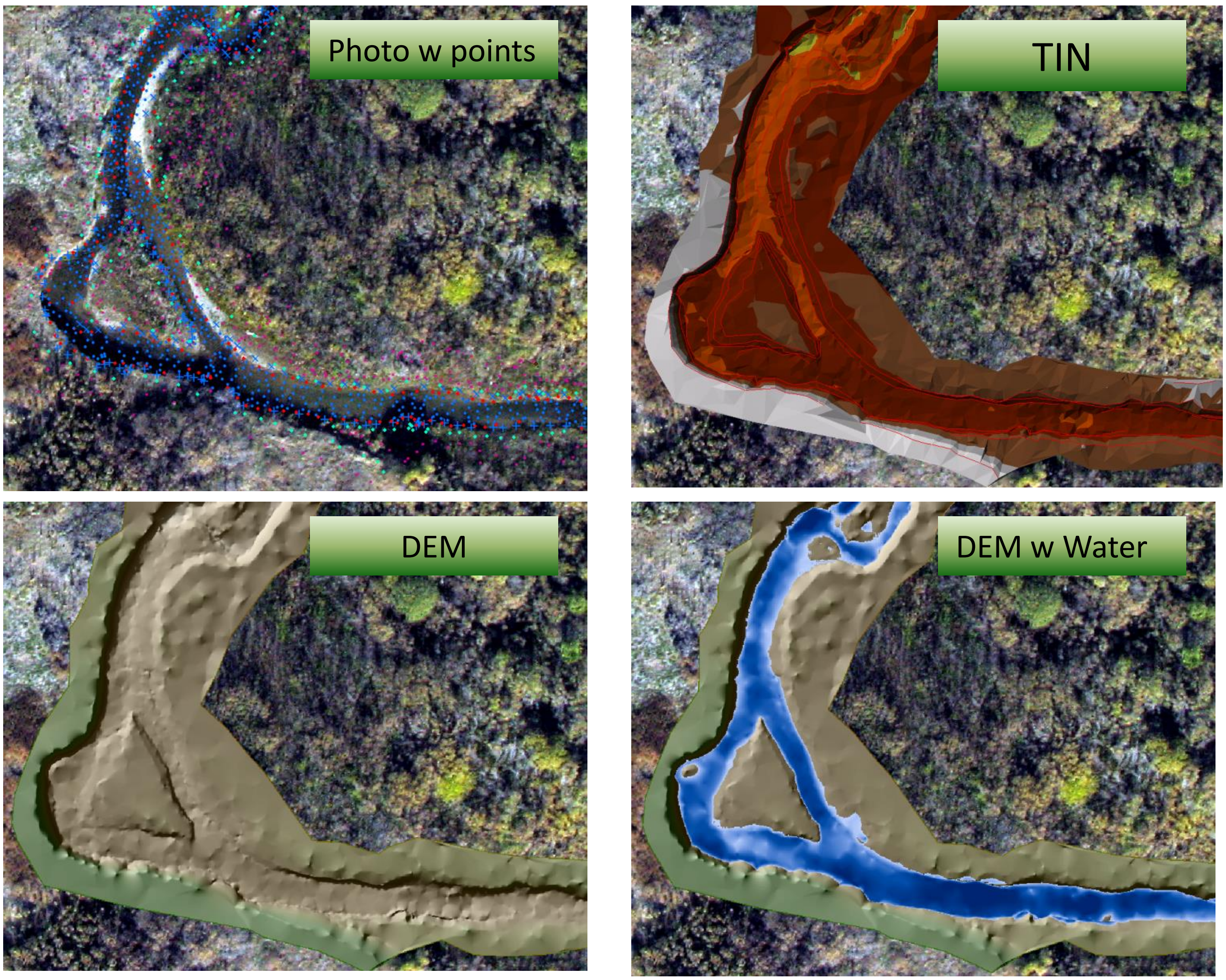
The topographic survey consists of using surveying equipment to collect a series of points and lines that capture topographic features within the stream channel and surrounding floodplain. Each point is attributed with a location (X, Y, and Z coordinates) and a description code. Points with the same description codes can also be connected to make lines. These points and lines are used to construct a Digital Elevation Model (DEM) that represents a continuous gridded surface of the channel topography. During the topographic survey, the responsibility of the person operating the prism rod is to efficiently survey points and lines that accurately represent the channel's topography. The person operating the survey instrument (Total Station) instructs the instrument via a software interface to measure the location of the rod and conduct trigonometric calculations to obtain a coordinate for the location of the ground at the bottom of the rod.



This is a digital eleven model, with water depth, thalweg, centerline and channel unit markers derived by a Champ crew from topographic survey data.

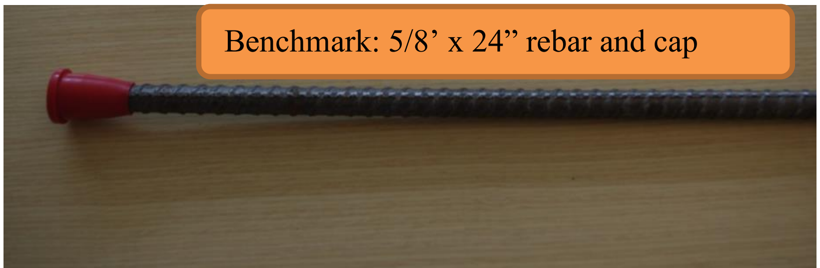
The Big Picture, Why it's important

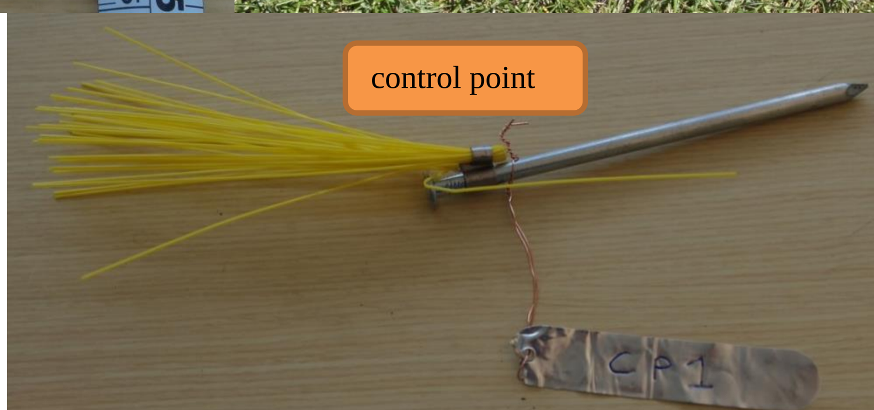
The Topographic Survey is not just a bunch of points, it is the foundation for numerous metrics. The topo describes the physical characteristics of stream habitat utilized by fish during many life stages. The topo data can be correlated to biological characteristics and fish data and be analyzed to improve fish habitat and thus improve fish survival. Below is an example of preliminary metrics Champ crews witness on a daily basis.



Basic Supplies

Benchmark and control point





Flagging

Aluminum Tag

Equipment

Total Station Surveying Instrument

Crew member (rodman) with Survey Rod and prism

The survey is conducted with two people, one person is the instrument operator and another is the rodman. The rodman determines where the data should be collected and holds the rod vertically with the prism visible to the instrument. The instrument operator aims the instrument at the prism and pushes a button which initiates the measuring process. The instrument measures the horizontal angle, vertical angle and distance then performs trigonometric calculations to establish an X, Y, Z coordinate for the location at the bottom of the rod. The equipment and measuring process will be explained in greater detail in the following pages.

The complete set up

The equipment consists of several major components: tripod, rod, prism, bipod, Total Station, tribrach, tape measure, field book and carry case.

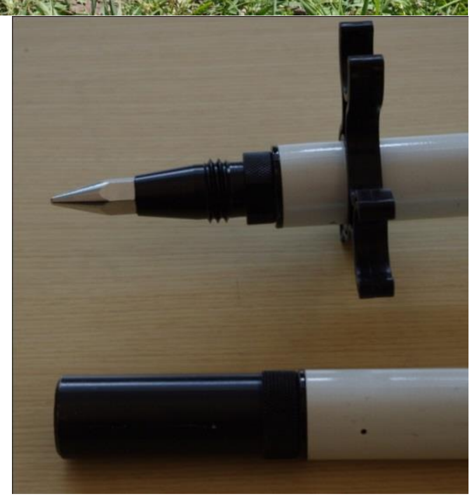
This tutorial will provide information for all of the major components.

Rod Man Equipment

Rod or Prism Pole

Rod can be made of aluminum, fiberglass or plastic. The rod has a knob to adjust to different heights which allows the prism to be seen by the instrument above obstacles such as vegetation. The rod has a level bubble which allows the rodman to hold the rod and prism directly above the point on the ground to be measured. At the top of the rod there is a prism that acts as a reflector to allow the instrument to measure distance.

The bottom of the rod can be configured with two different points. A sharp point is used for high accuracy work such as control points or benchmarks. A larger end cap, or topo point, is used for topographic data collection.

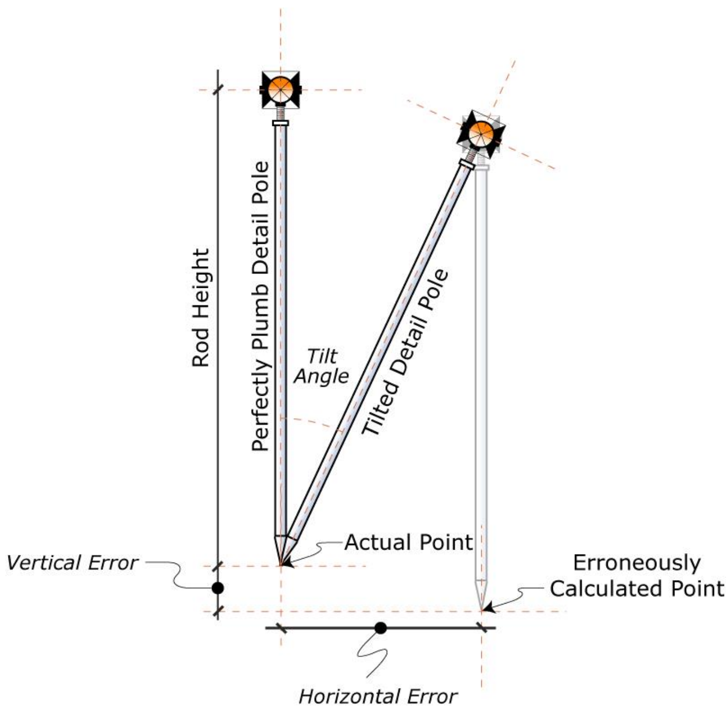


Rod height

To change rod height, use the knob to loosen, then adjust the white section of the rod.

Rod Plumb

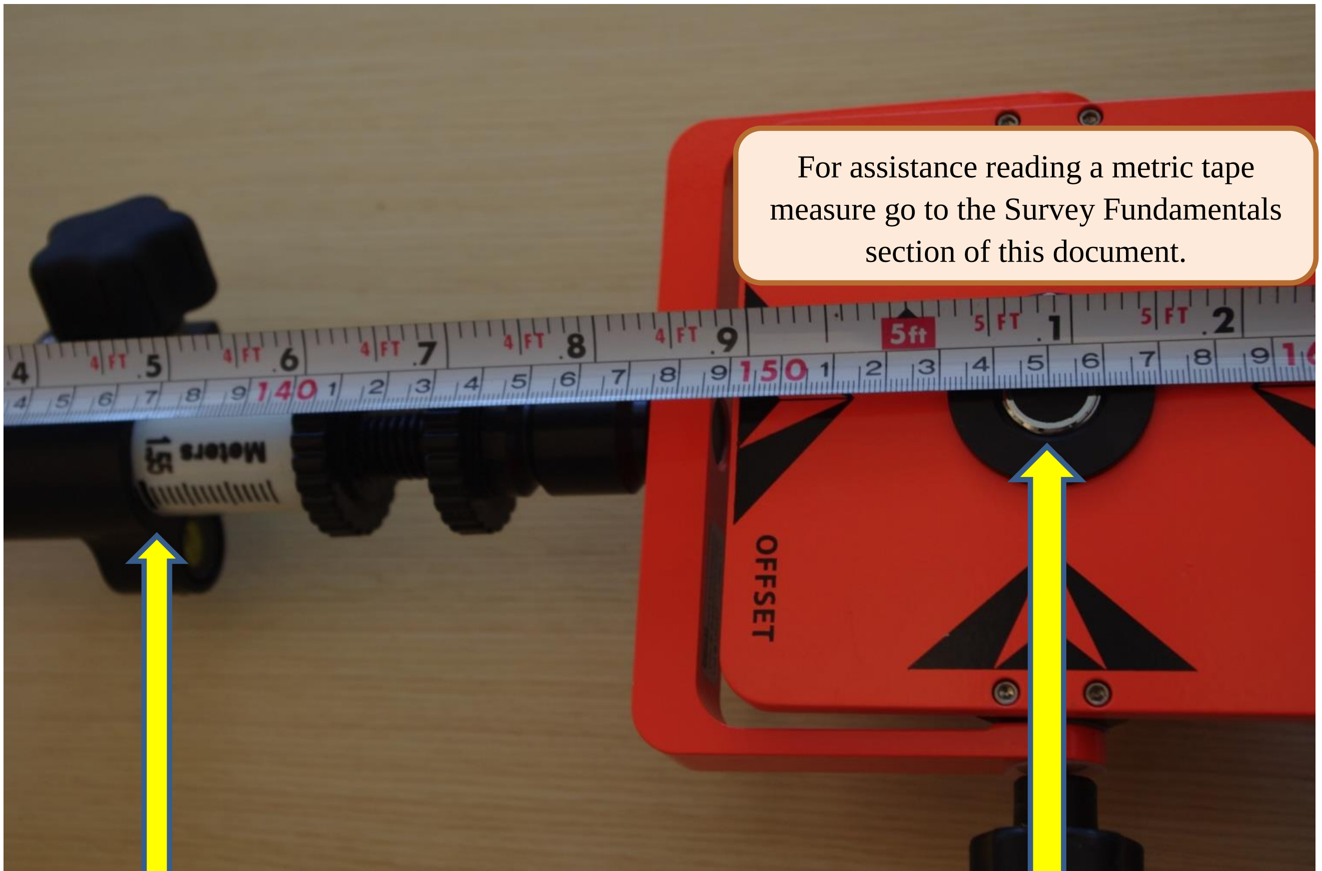
It is very important to plumb the rod when conducting control work. Plumbing the rod positions the prism directly over the center of the control point. If the rod is not plumb a horizontal and vertical error will be incorporated into the measurement.



The rod is plumb by observing the level bubble and tilting the rod until the bubble is in the center of the observation window.

Calibrate Prism

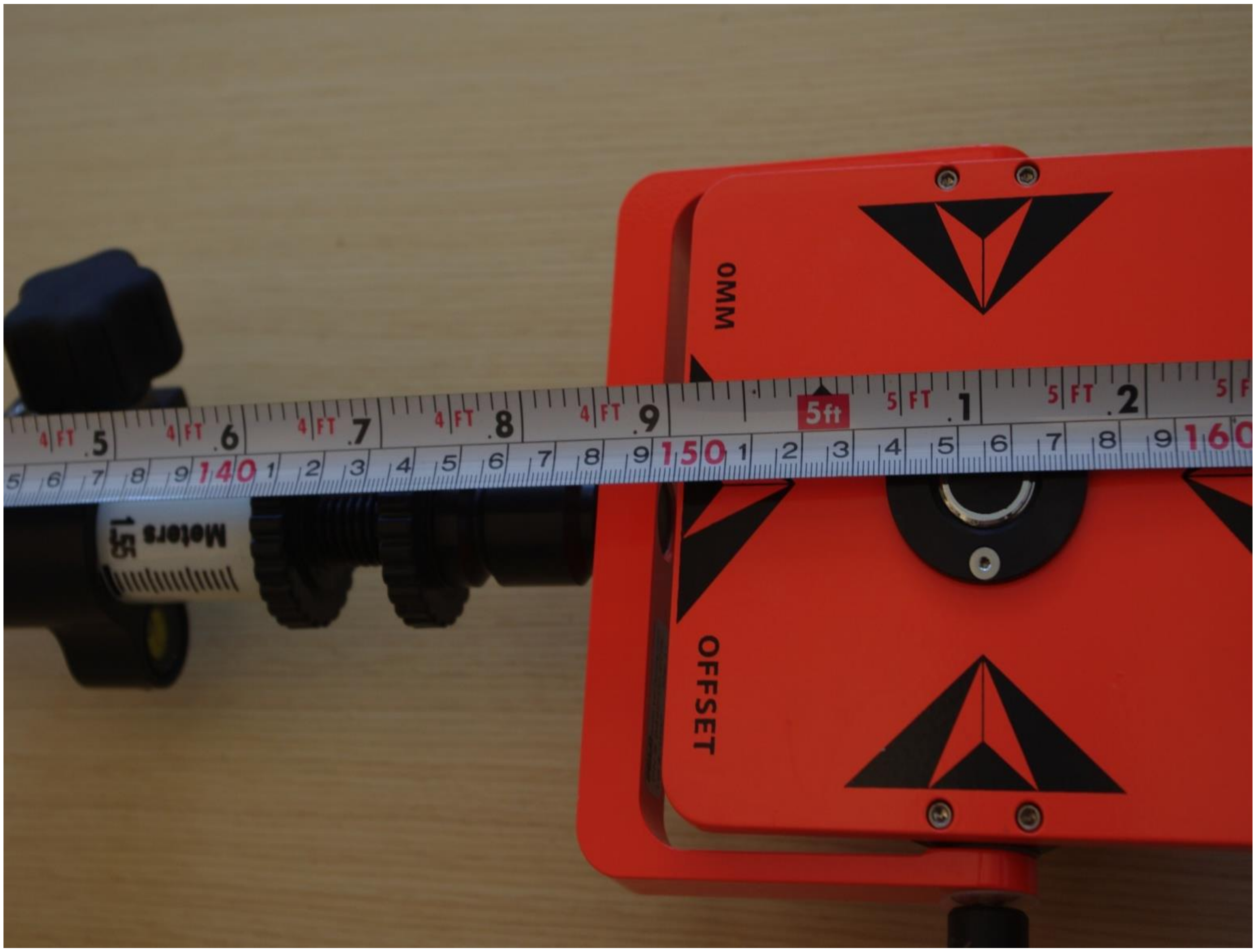
The prism must be calibrated to the rod. The height measured at the center of the prism must be the same as the height indicated on the rod. The prism height can be adjusted.



The height indicated must be the same as the height measured

Use these two knobs to calibrate prism height to rod.

Calibrate Prism



Is this rod height correct?

Prism

The Prism reflects the electromagnetic waves of the total station which enables the instrument to calculate distance. The TS uses the reflected electromagnetic wave to measure distance.

Prisms are made of aluminum plastic and glass.

Handle with care.

Mini prism

Standard prism

Knob for rotational tension

Prism offset

There are different prism offsets that can be used. For Champ the -30 mm offset will be used as in the example on the left.

The Total Station

The Nikon Nivo 5C is a very accurate instrument comprised of mechanical and elelectroinc components and requires a compotent operator. Treat the total station like a carton of eggs; be gentle and keep it clean.

What’s in the case

Case contents:

One Total Station
4 Batteries
Battery Charger
Communications Cable
Carry Strap
Stylus
Calibration Guide

What should not be in the case?

Dirt, your lunch
Vegetation; damages instrument and transportation of non-native species

Transportation

The Total Station (TS) belongs in the case during absolutely all transportation events, short or long distances.

There is **NO** other way to move the instrument.

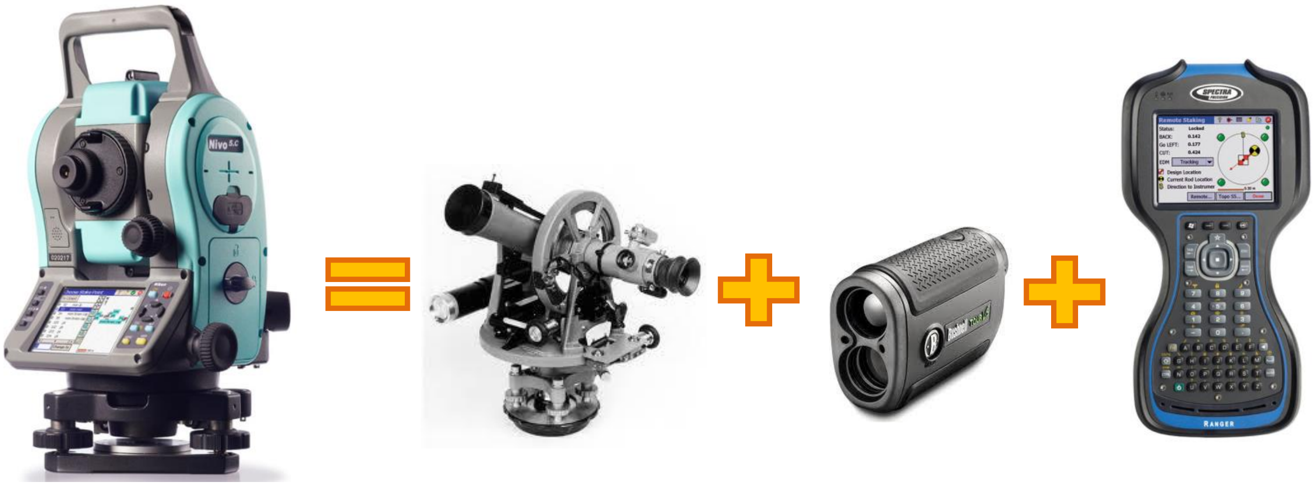
Nikon has invested a tremendous amount of resources (money) on Engineering to develop a beautiful orange, highly efficient, and protective case, specifically for the purpose of transporting the Total Station. Let's use it!

Shoulder Carry

DO NOT SHOULDER CARRY!

When carried horizontally while on the tripod, the instruments weight is an excessive load for the center spindle to bear. This will damage the Total Station.

Nikon Nivo 5c = Theodolite + EDM + Data Collector



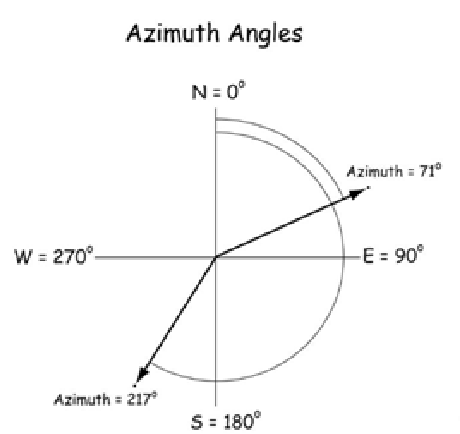
The Nikon Nivo 5c has three major components:

1) Theodolite: Accurately measures horizontal and vertical angles.
2) Electronic Distance Measurement (EDM): Accurately measures distance.
3) Data Collector: Processor performs calculations and stores data.

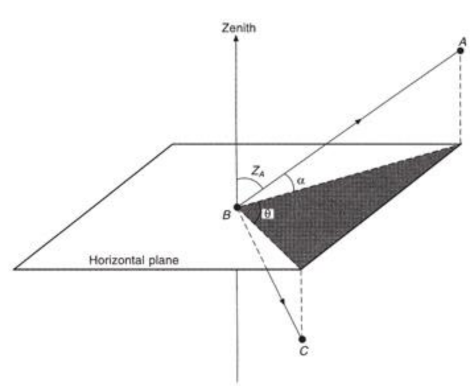
All in one neat little package!

Angular Measurements

Angular measure: Measures horizontal angle from a reference azimuth, known as a backsight.

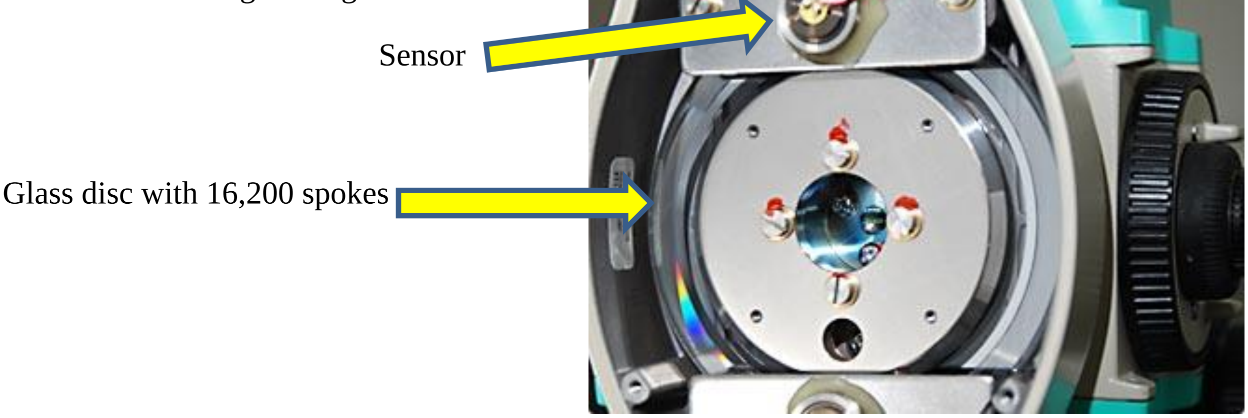


Angular Measure: Measures vertical angle relative to a plane that is established when the instrument is “Leveled”.

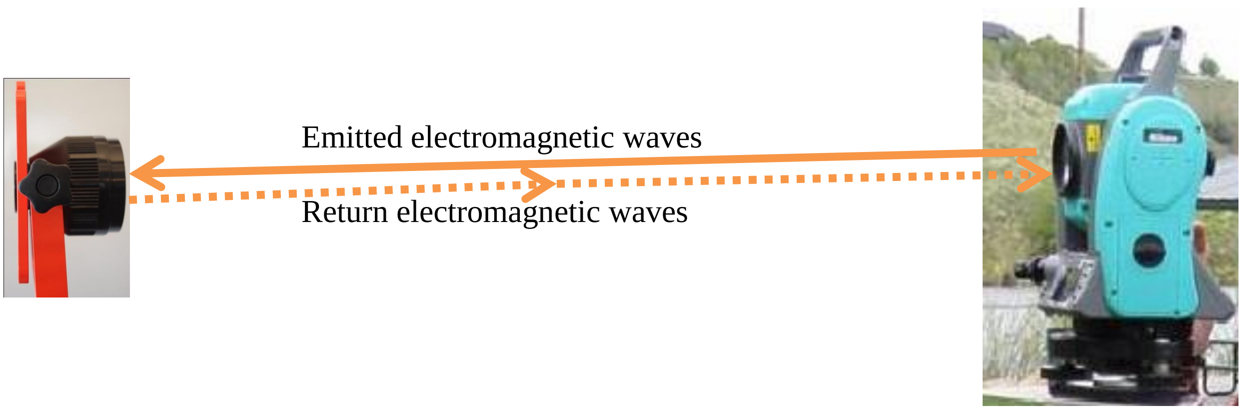


Angle Detection

Angle detection is accomplished using a glass disc with 16,200 spokes. A sensor reads the glass disc to detect change in angle.



Distance measurement



The electronic distance measurement device emits electromagnetic waves, the waves experience a phase change at the prism and are returned to the EDM. The phase change of several frequencies is used to calculate distance.

Compute

The instrument uses the horizontal angle, vertical angle and distance to calculate an x, y, z coordinate using trigonometry.

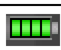
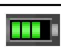
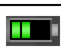
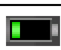
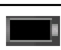
Data storage

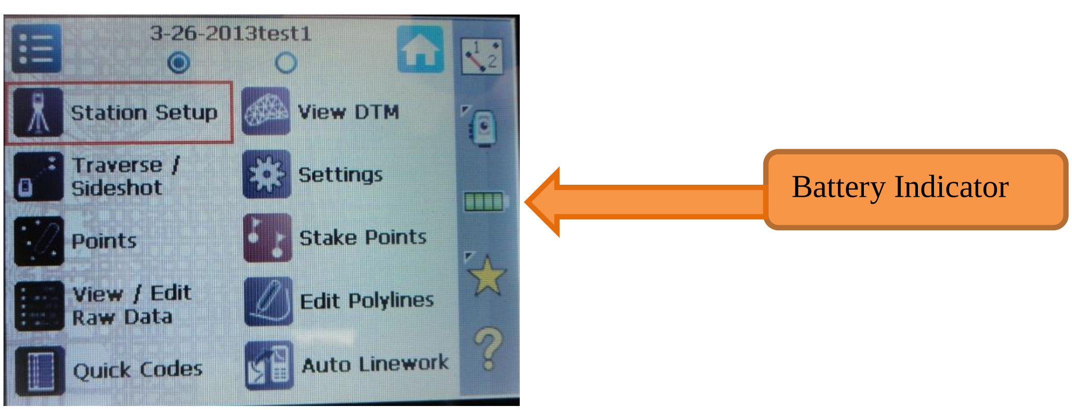
Data can accumulate in memory over time. Occasionally back-up the TS data on the laptop and remove excess files from the TS memory.

Data transfer

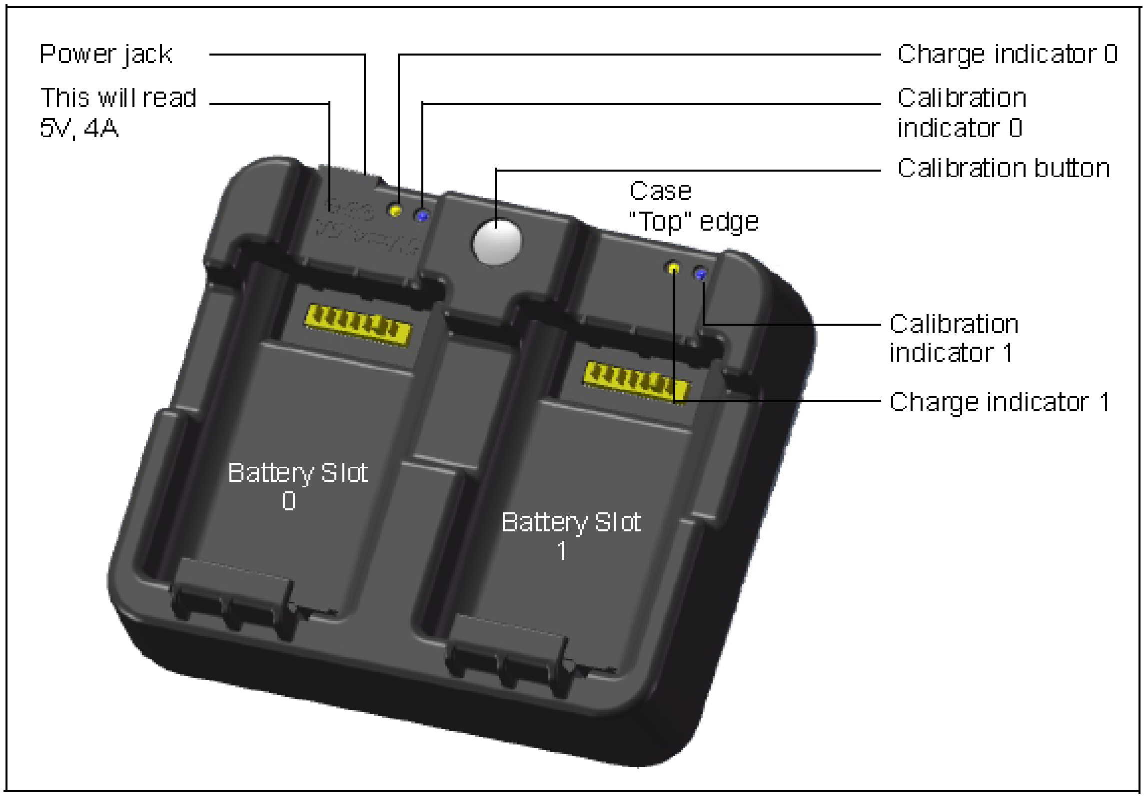
Data is transferred to a Laptop via a com cable.

TS Battery charge indicator

Icon	Meaning
	100% charge remaining
	75% charge remaining
	50% charge remaining
	25% charge remaining
	Less than 5% charge remaining
	Battery charging from AC adaptor



Battery Charging



Applying Power

- Plug in the charger to the supplied AC adapter to turn the unit on. The power input must be 5 V with at least 4 A of current capability. Each battery may take up to 2 A while charging.

Charging a battery

- Simply slide a battery into either battery slot to begin charging. The adjacent charge indicator will illuminate yellow when charging is in progress. The charge indicator will change to green when charging is complete.
- Charger slots are completely independent so a battery may be inserted regardless of the state of the other battery slot.
- Charging may take 2-4 hours if the battery was normally discharged.
- Charging may take up to 5 hours with a completely drained battery which has been stored for several months without use.
- By design Li-Ion batteries should not be charged above 40 °C-45 °C so a blinking charge light may mean the batteries are too hot for charging. Charging will resume after the batteries cool down. The charging time will be longer due to the batteries cool down when charging batteries above 40 °C-45 °C.

Battery calibration

Conditioning / calibrating a battery

- Battery calibration is necessary about once every 6 months or more often if desired. Calibration insures the reported battery charge remaining is accurate.
- Hold down the calibration button on the unit and then insert a battery while holding the calibration button to begin a battery calibration. Only the battery which was inserted while the button was depressed will begin calibration. During a battery calibration the battery will be charged, discharged completely, and then recharged before finishing. Calibration should complete in roughly 17 hours and the charger vents should not be covered during a calibration cycle.
- The blue calibration indicator light(s) will blink slowly (on 1.5 sec, off 2 sec) while a calibration is in progress and the charge light(s) may be on or off during the calibration cycle.
- When a calibration cycle is completed, the calibration light will stop blinking remain on until the corresponding battery is removed.
- The bottom case temperature may continue to climb up to approximately 43 °C before temperature regulation is enabled to keep the case from getting warmer. As the battery voltage drops, the case will cool down and the automatic temperature limiting will no longer be necessary which minimizes the time it takes to discharge a battery.
- If the case temperature continues to get too hot internally even after temperature regulation is enabled, there is a secondary failsafe which will abort the calibration completely. If an abort occurs, the calibration light(s) will blink rapidly and battery charging will be re-enabled.

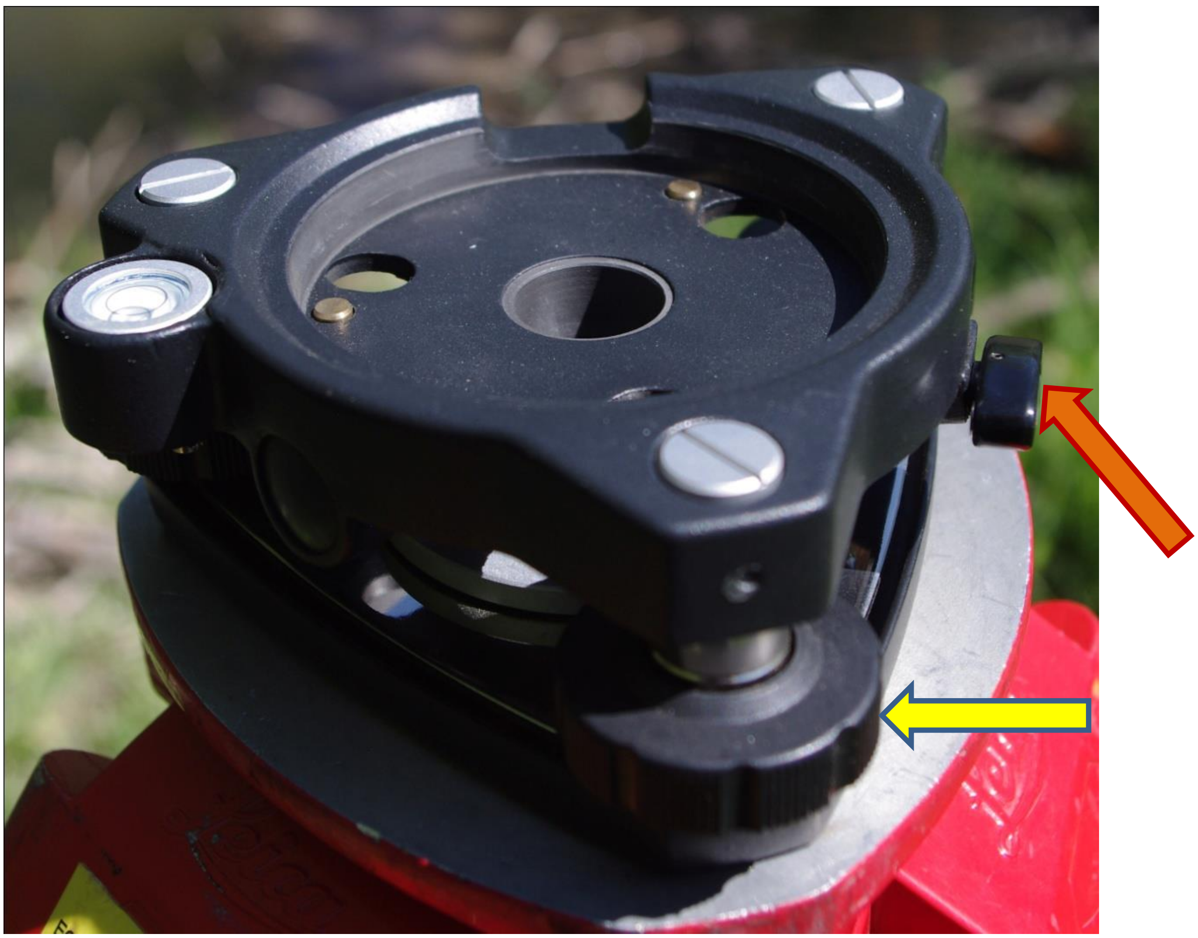
Instrument settings

Instrument setting should be checked prior to conducting a survey. Instrument setting utilized by Champ are available in the Protocol Appendix; "Total Station Defaults and Settings".

Occupation Equipment

Tribrach

The tri-brach attaches the TS to the tripod. It is made of aluminum and is a precision component that should be clean. The tri-brach is secured to the tri-pod via a screw that is attached to the tri-pod. The knob indicated by the orange arrow locks the TS to the tri-brach. There are three screws (yellow arrow) that are used for leveling the TS.



Tri-pod

The tri-pod provides a stable platform for the TS. A tri-pod is made of wood, fiberglass, metal and requires periodic maintenance to continue performing its duties. Be sure to clean the tripod feet between each job-site. The length of each leg is adjusted by loosening the screw indicated by the yellow arrow.

Note the control point in the ground.
See: Set up on What? Page ??

Assembling the TS to the Tripod

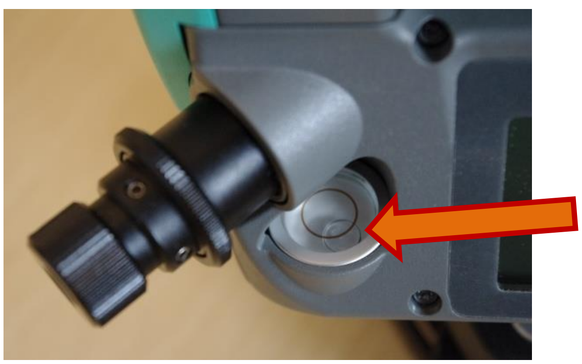
The total station is attached to the tripod via the tribrach as shown in the image below. Make sure the TS is centered on the tripod as indicated by the yellow arrows. To center the TS loosen the mounting screw and slide the tribrach on the tripod.

Leveling the TS

The instrument must be leveled using the three adjustment screws and two level indicators: the coarse level bubble and the fine electronic level.

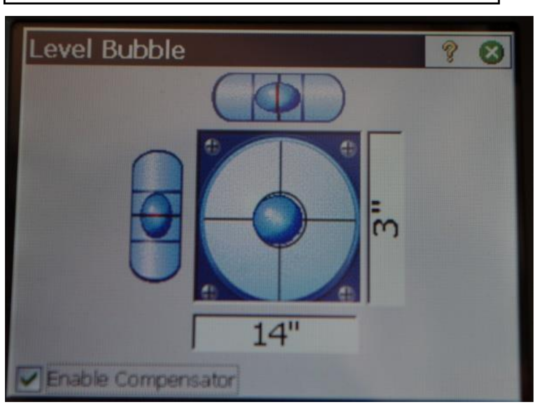
In the image below the arrows indicate two of the black adjustment knobs.

1. In the image below the level bubble is not centered, thus the leveling screws must be adjusted.

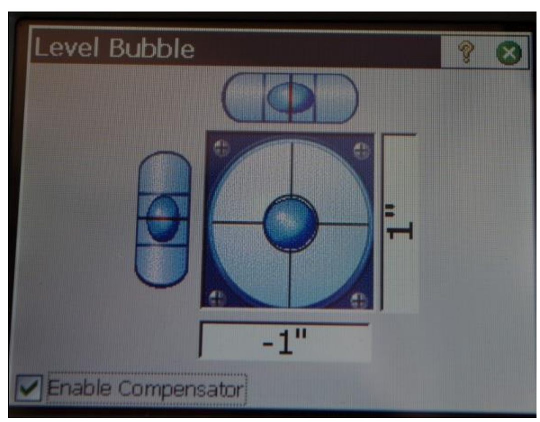


2. In the image below the level bubble is centered. The next step is to use the electronic level bubble.

3. In the image below the level bubble is not centered, thus the leveling screws must be adjusted.

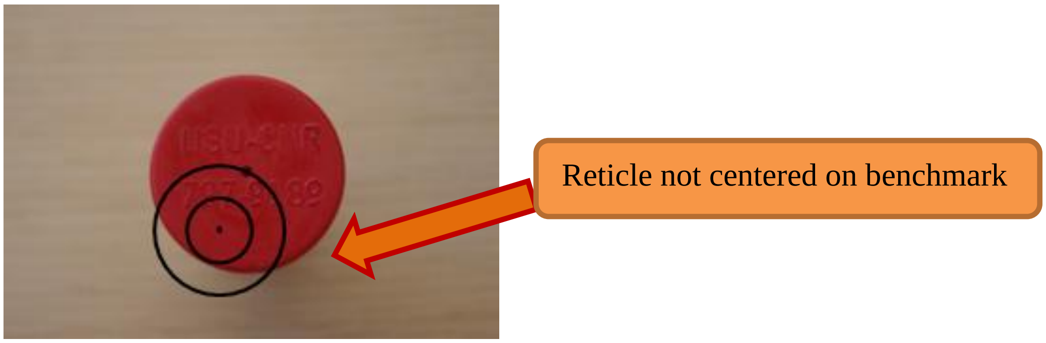


4. In the image below the level bubble is centered.
Try to be within +5” to -5”.

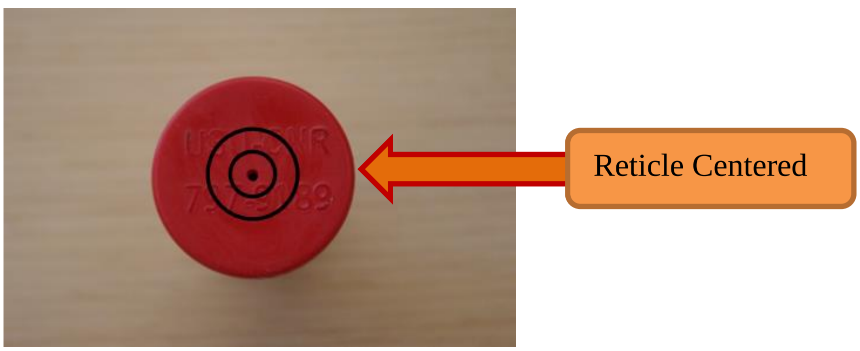


Centering the Instrument

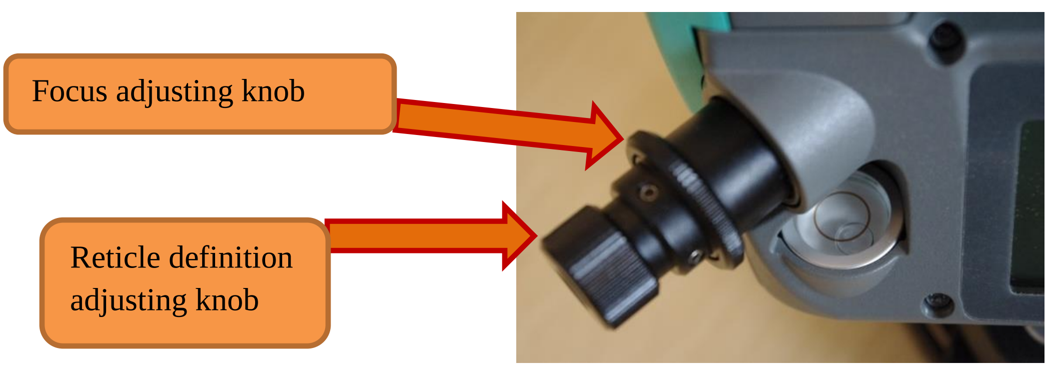
The instrument must be centered directly over the control point or benchmark. To accomplish this task the operator looks thru an optical plummet and centers the reticle. As you look thru the optical plummet you will see the image below. The black circles and dot are the reticle.



The reticle must be moved to the center of the benchmark, as below. There are two means of moving the reticle. The leveling knobs can be adjusted and the tribrach can be slid along the top of the tripod.



The optical plummet has two adjustments:



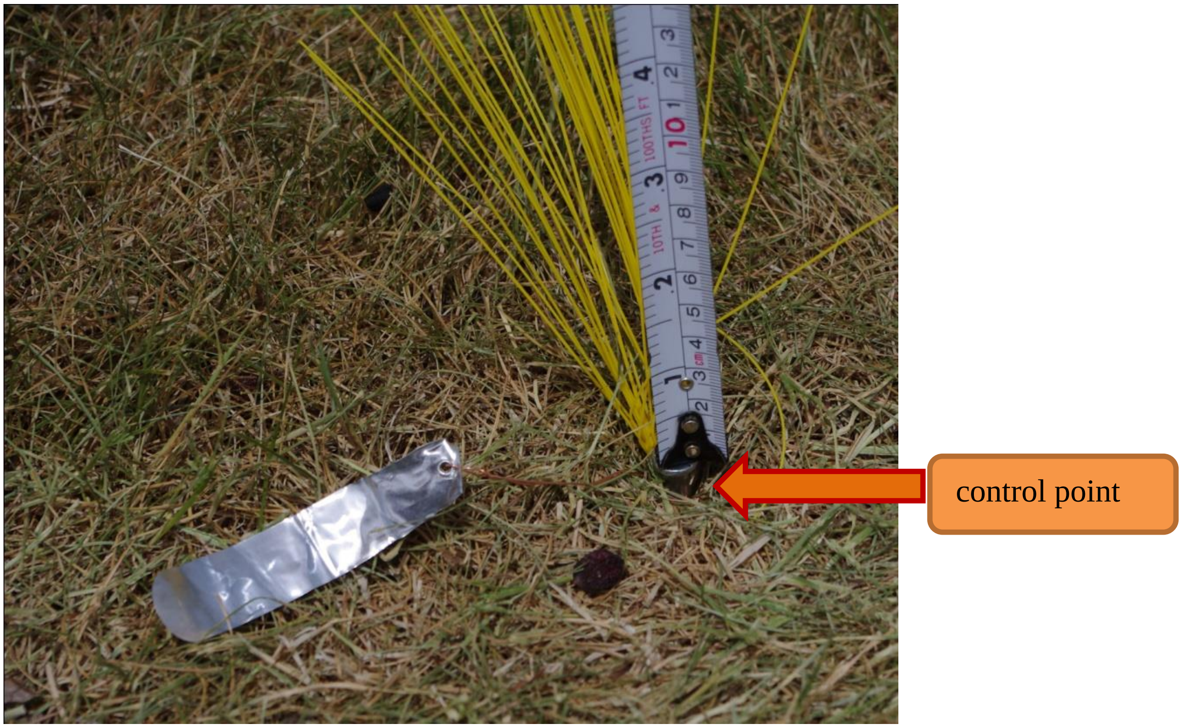
Instrument Height part one

The height of the instrument must be measured and entered into the instrument for use during trigonometric calculations. The height of the instrument is measured at the center of the vertical axis which is the notch in the plastic as indicated by the orange arrow below. What is the height of the instrument (HI) in the image below?

1.490m is correct.

Instrument Height part two

Height measured from top of center of control point or benchmark.



In the image below the tape is on the ground, not on the control point. This is incorrect.

Set up on what?

The total station is set up on a benchmark or control point. Which is preferably either a piece of 5/8 rebar or a big nail that is hammered in the ground in a stable location.

Setting up the Instrument

To use the instrument in a survey it must be setup on a control point or benchmark. The instrument is moved to be positioned perfectly over the benchmark, centered and leveled, and then the height is measured. This skill will be practiced at Champ Camp.

A video demonstrating setting up a total station over a benchmark is available at: https://www.champmonitoring.org/Program/Details/1#documents. In the "How To Guides" look for TS_Setup_KD.mwv.

The Station Setup Principle's

After the instrument is set over a benchmark, leveled and centered the process of conducting a station setup in SurveyPro can begin. SurveyPro is the software that operates the total station. As explained earlier the total station measures angles and distance. A measurement is from somewhere to somewhere else. The station setup is a process whereby the instrument is oriented horizontally and vertically which enables the instrument to measure angles from somewhere to somewhere else. Distance is measured by the electronic distance measurement (EDM) device within the TS. The distance from the total station to the prism is calculated. The protocol appendix contains a document which will guide you through the Station Setup process in SurveyPro and the process will be practiced extensively at Champ Camp.

The TS–rod man Connection

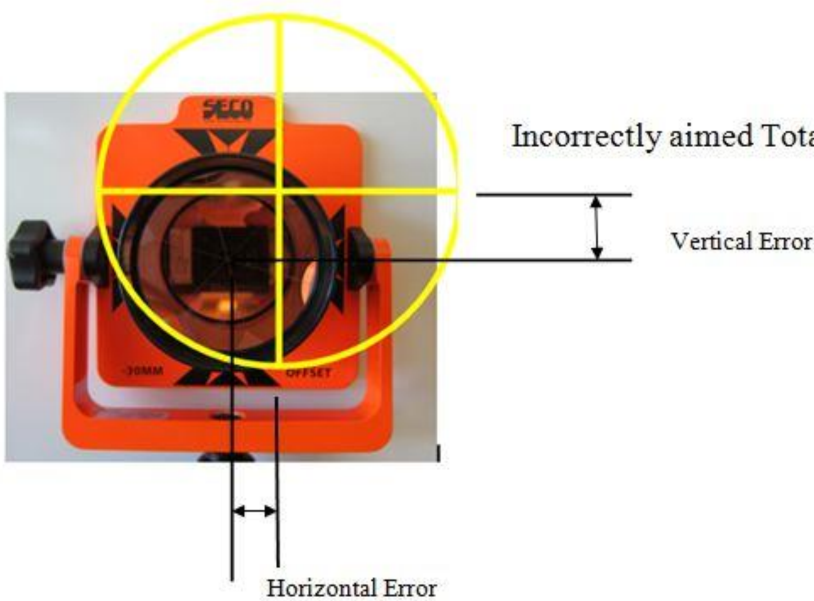
Prism-TS aiming

The total station must be aimed at the prism for the measurement to be performed correctly

Proper aiming of the Total Station to the Prism is vital for surveying control and benchmarks. The Nikon instrument used by CHaMP for surveying does not have a feature to find the center of the prism. The instrument operator is required to center the optical crosshair directly at the center of the glass portion of the prism.

Correctly aimed Total Station

Improper aiming of the TS to the Prism produces errors. The Electronic Distance Measurement (EDM) function measures the distance to a reflective surface. The instrument measures the horizontal angle and the vertical angle of the crosshair and using trigonometry calculates the location of the location of the prism.

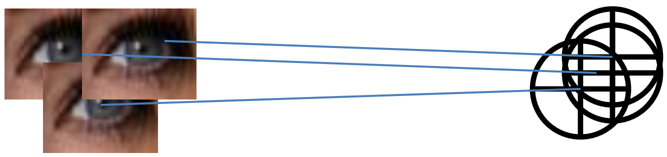


Incorrectly aimed Total Station

Parallax in optics

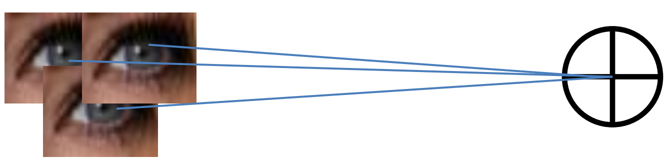
Parallax is the apparent displacement of an object as seen from the eye looking through the scope of the TS. When parallax is present the object will move when viewed through the scope if your eye moves. This means the location of the object viewed is dependent on the position of your eye, which is not good.

Parallax, incorrect optical adjustments.



Parallax can be removed by adjusting the two reticle adjusting knobs on the TS. When done correctly, while viewing an object in the scope and moving your eye the object will not move.

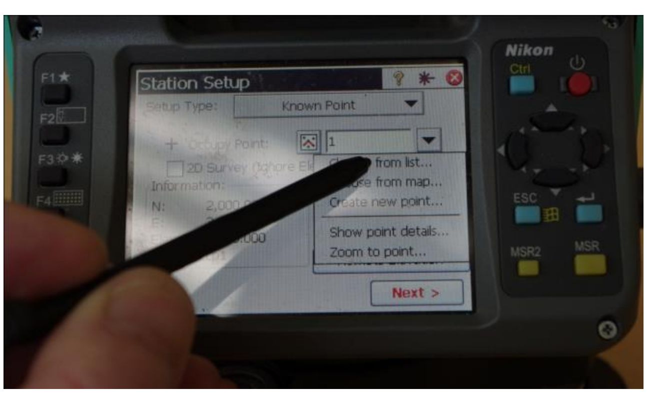
NO Parallax = good optical adjustments.



Communication

The TS- Human interface

The total station requires user input to function. The TS has a stylus to interact with the touch sensitive screen. Please use the stylus and be sure the instrument has a screen protector.



Rod man and instrument man

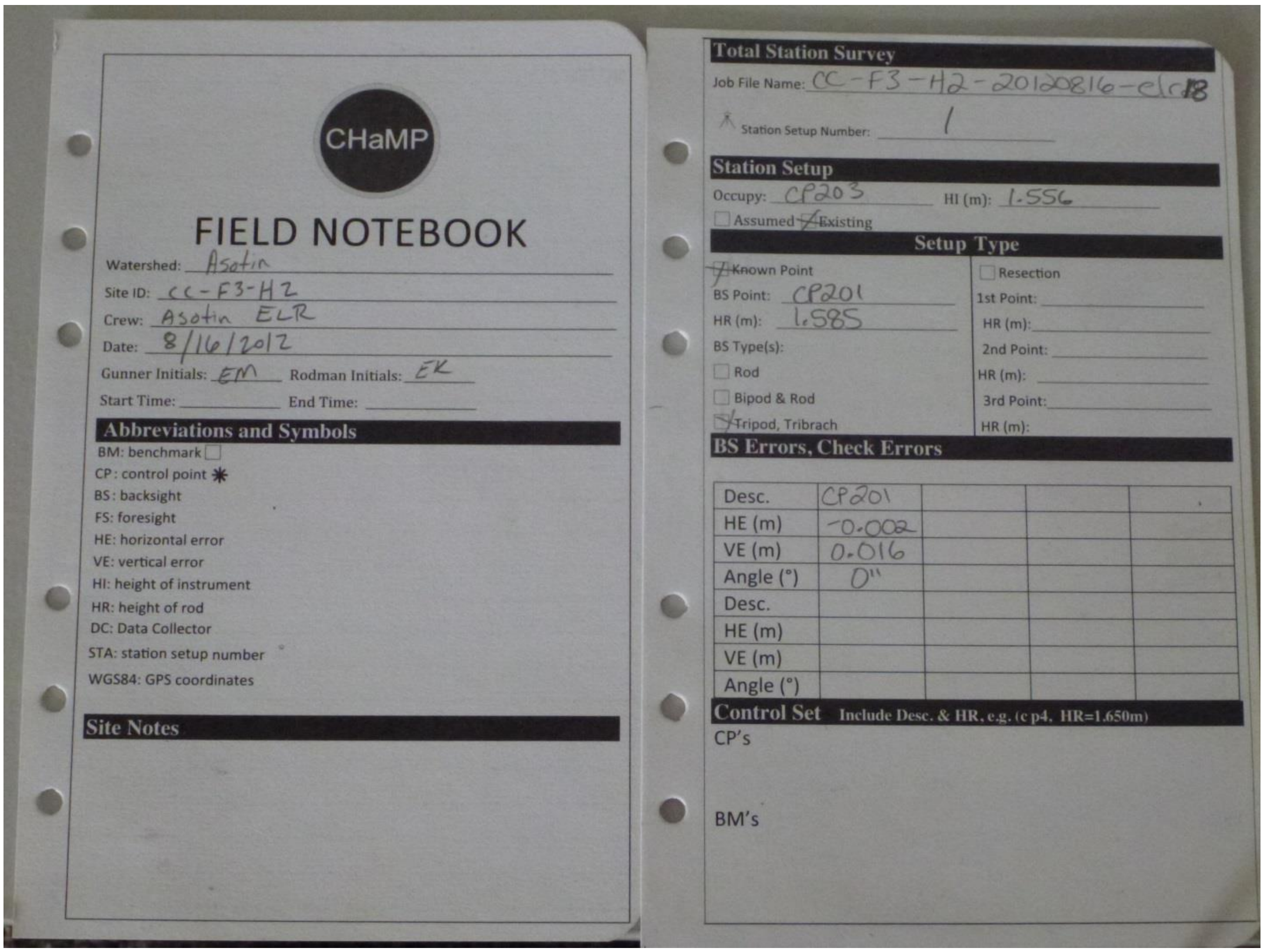
Communication between the instrument operator and the rodman is crucial to surveying. Communication can be accomplished by the use of radios, yelling, or hand signals. Important things to communicate are: point description, linework and rod height change.

Luke: a member of the 2011 Intermountain West Dream Team, utilizes a radio carried high above the water on a necklace made of flagging. Bridge Creek, Oregon

Rod height can be a common problem in surveying. It is the responsibility of crew to manage rod height as a team. The rod-man should communicate rod height change to the instrument operator and the instrument operator should be watching the rod man and looking for changes in rod height to occur.

Field to office, Field Book

The field notebook is used to communicate information from the crew collecting data in the field. The information is useful for GIS processing, and benchmark and control evaluation. More importantly the field book is used to resolve data conflicts of revisit surveys, thus it is crucial to document order of operations, and horizontal and vertical errors experienced in the field. An example of field notes is provided below. Use of the field notebook is explained further on page??.


CHaMP

FIELD NOTEBOOK

Watershed: Asotin

Site ID: CC-F3-H2

Crew: Asotin ELR

Date: 8/16/2012

Gunner Initials: EM Rodman Initials: EK

Start Time: End Time:

Abbreviations and Symbols

BM: benchmark

CP: control point

BS: backsight

FS: foresight

HE: horizontal error

VE: vertical error

HI: height of instrument

HR: height of rod

DC: Data Collector

STA: station setup number

WGS84: GPS coordinates

Site Notes

Total Station Survey

Job File Name: CC-F3-H2-20120816-elc18

Station Setup Number: 1

Station Setup

Occupy: CP203 HI (m): 1.556

Assumed / Existing

Setup Type

Known Point

BS Point: CP201

HR (m): 1.585

BS Type(s):

Rod

Bipod & Rod

Tripod, Tribrach

Resection

1st Point:

HR (m):

2nd Point:

HR (m):

3rd Point:

HR (m):

BS Errors, Check Errors

Desc.	CP201			
HE (m)	-0.002			
VE (m)	0.016			
Angle (°)	0"			
Desc.				
HE (m)				
VE (m)				
Angle (°)				

Control Set Include Desc. & HR, e.g. (cp4, HR=1.650m)

CP's

BM's

Survey Fundamentals

Tape measure

Reading a metric tape measure. The metric system is based on the value of ten. 10 millimeters equals one centimeter. Ten centimeters equals one decimeter. Ten decimeters equal one meter. The equipment and coordinate systems utilized by Champ require metric measurements in meters.

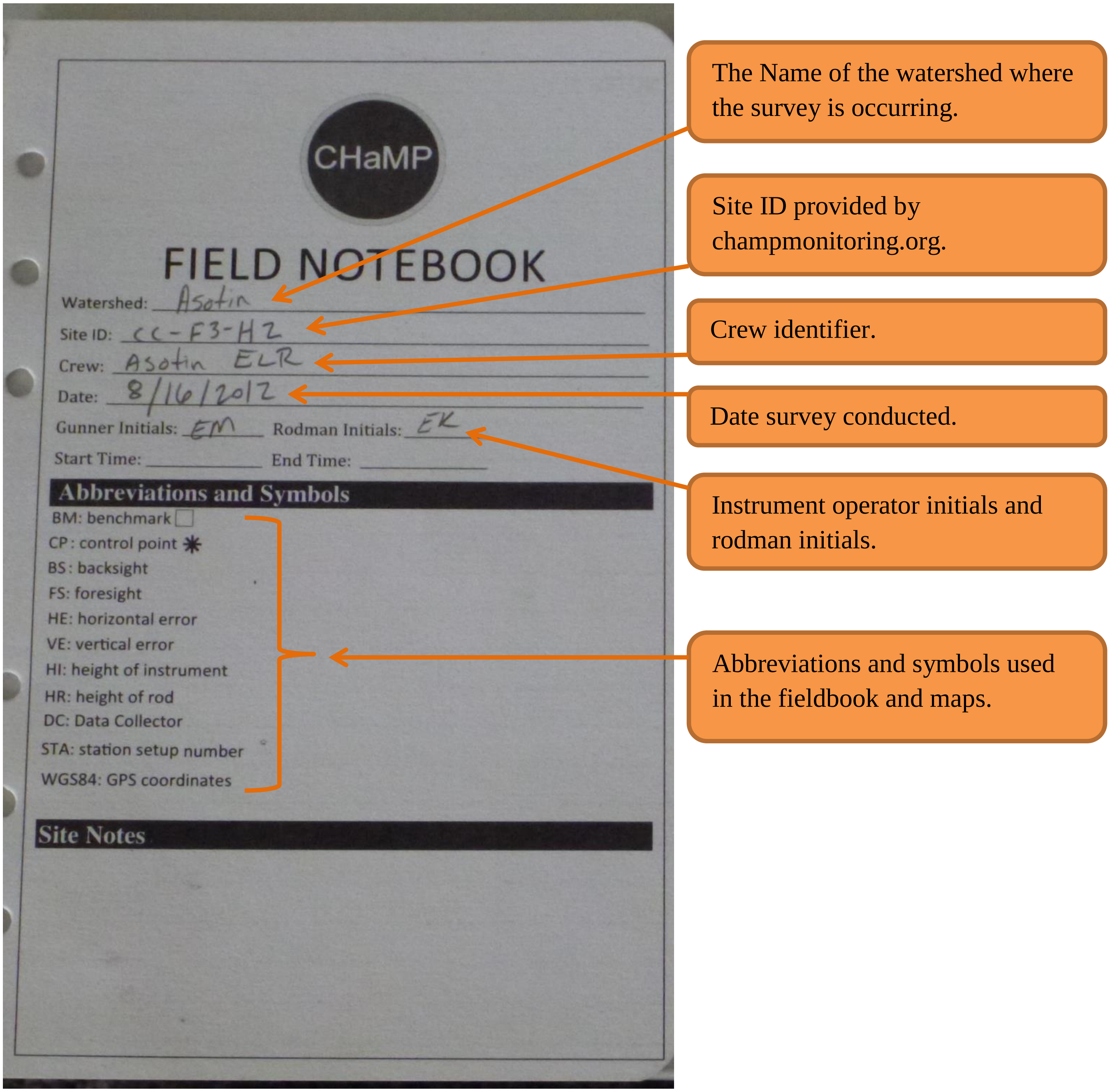
The top portion of this tape is in feet while the bottom portion is metric. Be sure to use the metric portion of the tape. Your crew may use a slightly different metric tape measure; make sure you ask a crew member or Champ Camp instructor for help reading the tape measure.

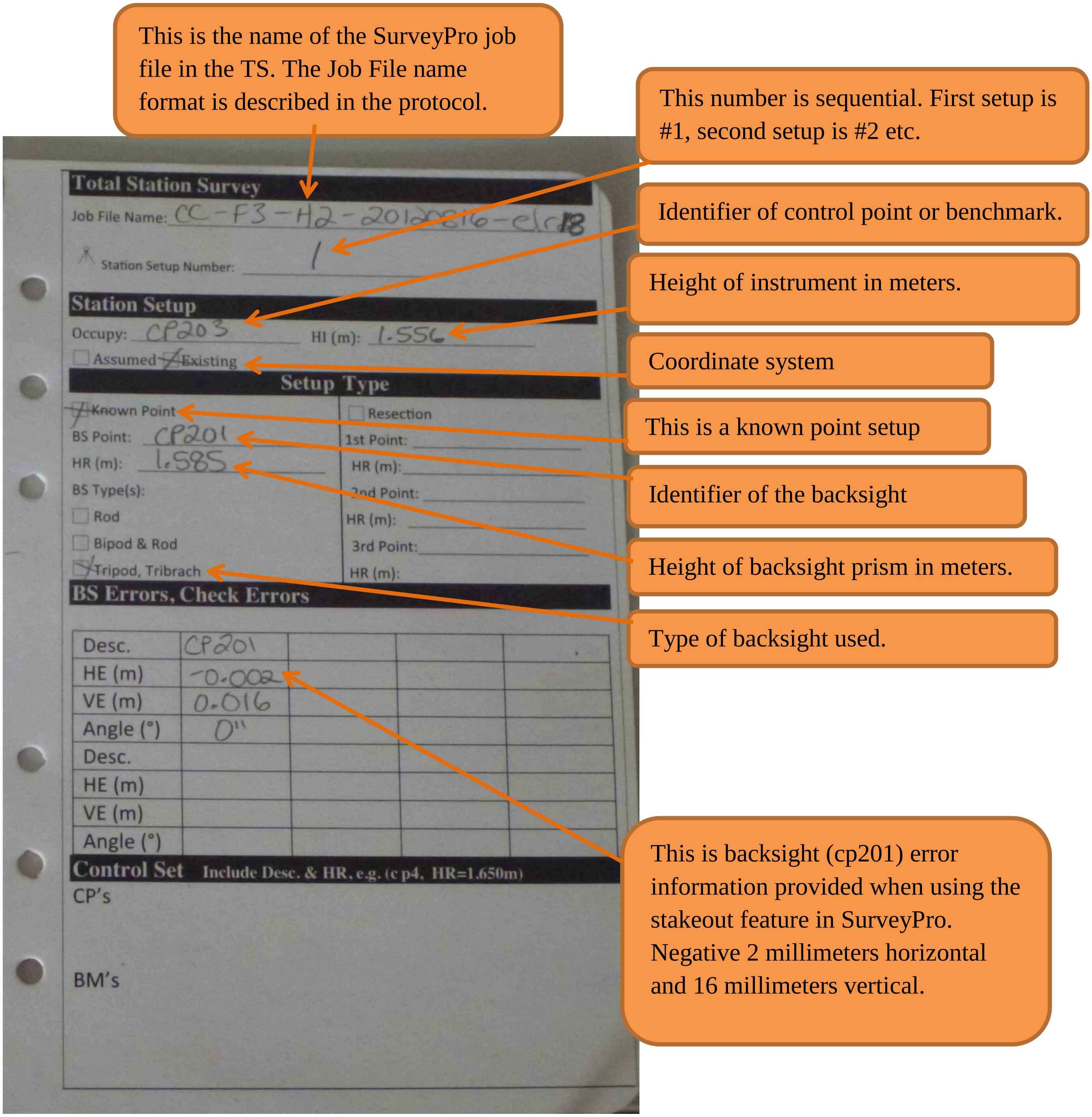
In the image below the arrow is at 71 centimeters, equal to 0.710 meters.

In the image below the arrow is at 124.3 cm, equal to 1.243 meters.

Proper use of the Field book

The proper means of filling in the field book information is demonstrated:




This is the name of the SurveyPro job file in the TS. The Job File name format is described in the protocol.
This number is sequential. First setup is #1, second setup is #2 etc.
Identifier of control point or benchmark.
Height of instrument in meters.
Coordinate system
This is a known point setup
Identifier of the backsight
Height of backsight prism in meters.
Type of backsight used.
This is backsight (cp201) error information provided when using the stakeout feature in SurveyPro. Negative 2 millimeters horizontal and 16 millimeters vertical.
Total Station Survey
Job File Name:
Station Setup Number: 1
Station Setup
Occupy: CP203
HI (m): 1.556
Assumed
Existing
Setup Type
Known Point
Resection
BS Point: CP201
1st Point:
HR (m): 1.585
HR (m):
BS Type(s):
2nd Point:
Rod
HR (m):
Bipod & Rod
3rd Point:
Tripod, Tribrach
HR (m):
BS Errors, Check Errors
Desc. CP201
HE (m) -0.002
VE (m) 0.016
Angle (°) 0"
Desc.
HE (m)
VE (m)
Angle (°)
Control Set
Include Desc. & HR, e.g. (c p4, HR=1.650m)
CP's
BM's

Error sources

Topographic Survey Error Sources

Error for a measurement can be expressed using the equation below:

$$Error_m = \sqrt{a^2 + b^2 + c^2 + d^2 + e^2 + f^2 + g^2 + h^2 + i^2 + j^2 + k^2 + l^2 + m^2 + n^2}$$

a = aiming error

b = reading the tape measure

c = tape measure placement

d = instrument angular error

e = instrument edm error

f = instrument centering error

g = instrument level error

h = rod placement

i = rod calibration

j = rod height

k = prism dirty

l = prism constant

m = environmental Δ

n = parallax

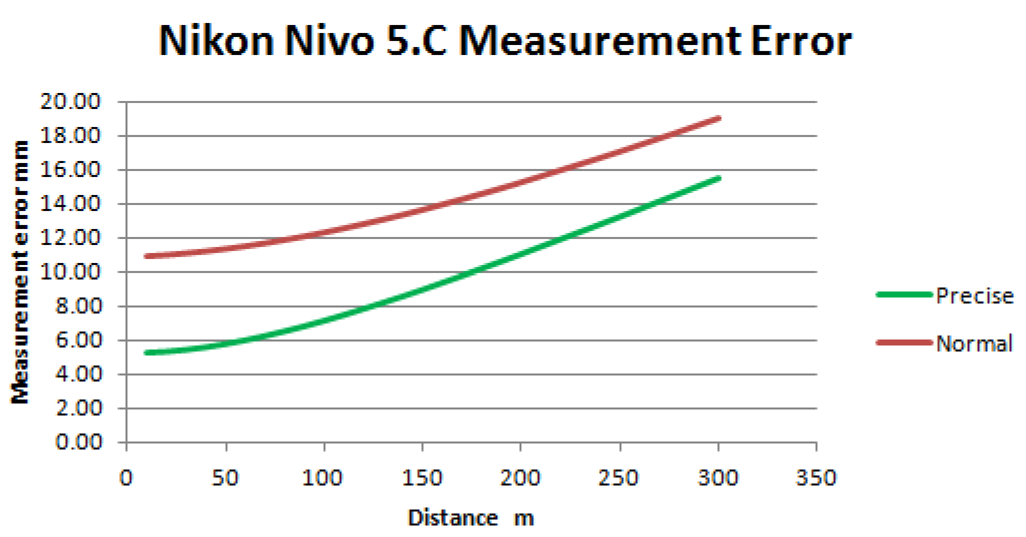
There are many opportunities for errors to occur within a topographic survey. Many of these errors can be minimized thru training. If errors are allowed to accumulate the results of the survey will be unusable for scientific purposes and the fish will suffer the consequences of our inability to properly conduct a survey. These errors are important so learn how to minimize them by studying this manual and make the most of your time at Champ Camp.

Instrument Measurement Error

This chart demonstrates the error between two control points if the crew does everything perfectly.

Significant issues to note;

1) The Nikon Nivo 5.c TS has two EDM modes, precise and normal. In the image below precise EDM is indicated by the green line and generally has about half the error as the normal mode at distances encountered during Champ surveys. This means that while collecting control data the Precise EDM should be used. When collecting topo data the normal EDM is acceptable.



$$Error_m = \sqrt{a^2 + b^2 + c^2 + d^2}$$

a = instrument centering

b = rod centering

c = instrument angular

d = instrument distance

$$error\ for\ distance_N\ \pm (10 + 5\ ppm\ x\ D)$$

$$error\ for\ distance_P\ \pm (3 + 2\ ppm\ x\ D)$$

Error Propagation

Error propagation suggests that error accumulates over the course of a survey and additionally accumulates during subsequent years on revisit surveys. In this example; three, 50 meter segments are used for error evaluation. This calculation only accounts for instrument errors, as you now know there are many other errors.

Significant issues to note;

1) In normal EDM mode error propagates rapidly.
2) In normal EDM mode error propagates rapidly in subsequent years.
3) After two surveys; in normal mode the error of 27.8 mm is much larger than using precise mode with an error of 14.1mm.

Horizontal Error			
Year 1	Normal		
50 m	segments	E series	
	3	19.7	mm
Year 2	Normal		
50 m	segments 3x2		
	6	27.8	mm

Horizontal Error			
Year 1	Precise		
50 m	segments	E series	
	3	10.0	mm
Year 2	Precise		
50 m	segments 3x2		
	6	14.1	mm
Year 2	Normal & Precise		
50 m	segments 3x2		
	6	22.1	mm

$$Error_m = \sqrt{a^2 + b^2 + c^2 + d^2}$$

$$Error_{Series} = \pm E_m \sqrt{n}$$

Use precise EDM mode for control data collection.

Acceptable Error

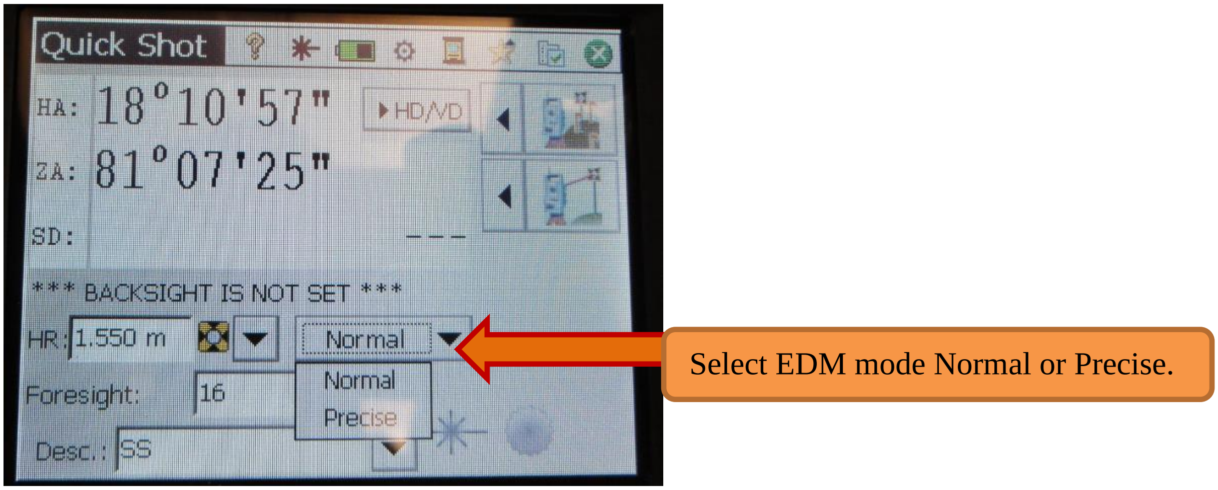
Acceptable errors for Champ Surveys are as follows:

Initial Survey: Horizontal ±.030m, and Vertical ±.015

Revisit Survey: Horizontal ±.050m, and Vertical ±.030

EDM Mode

EDM mode is easily changed by pressing F1 on the total station dashboard which will open the Quick Shot window as in the image below. Use the dropdown to make the selection for normal or precise mode.



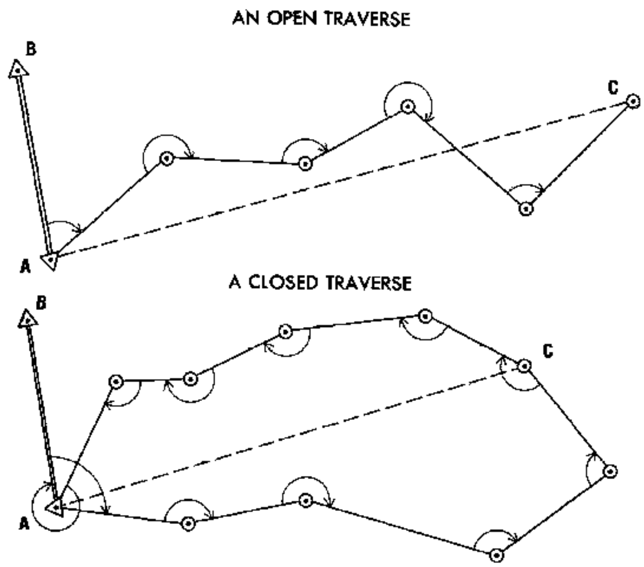
Total Station Calibration

The CHaMP survey equipment endures a significant amount of rough conditions during field use and transport; the total stations are no exception, with their most common affliction being loss of proper calibration. A total station must be calibrated periodically to attain accurate measurements. Thus, it is wise to check that the instrument is operating within acceptable tolerances frequently to avoid collecting unusable data. If a total station undergoes any sort of trauma; such as a particularly rough truck ride, is banged or dropped, it must be calibrated before it is employed to collect data. Additionally, a calibration is advised if a crew encounters unexplainable errors during a survey.

The field calibration sequence can help the surveyor obtain horizontal corrections reasonably well, while vertical correction and EDM correction must be performed by a certified instrument technician. However, unless the instrument has been severely mistreated in some way, the field calibration should be sufficiently effective. The calibration procedure is explained in the protocol appendix and a laminated card is available in the total station case.

Traverse

A traverse is used to connect multiple instrument setups together. There are two types of traverses; an open traverse and a closed traverse. An open traverse is utilized when a survey is conducted in a narrow corridor with limited visibility which is the most likely scenario encountered during Champ surveys. When feasible it is a good idea to close the traverse. The traverse method is explained in the Camp Protocol.



Stake Points

The Stake Points method should be used for checking a backsight and checking to a bm or cp. It is also helpful for finding a lost point. The prerequisite for using the Stake point method is that there must be a pre-existing coordinate for the point you are shooting to in the coordinate file. The stake point method calculates a new measured coordinate verses a coordinate stored in the file (control coordinate) and provides the errors. These errors can come from several sources, including previous survey errors, when a BM or CP has been compromised (moved), or the current survey errors. Deciphering where the error lies can be difficult (see protocol for troubleshooting tips), but knowing there is an error empowers the crew to make good decisions to begin reducing errors. The stake points method is explained in the Camp Protocol.

Resection

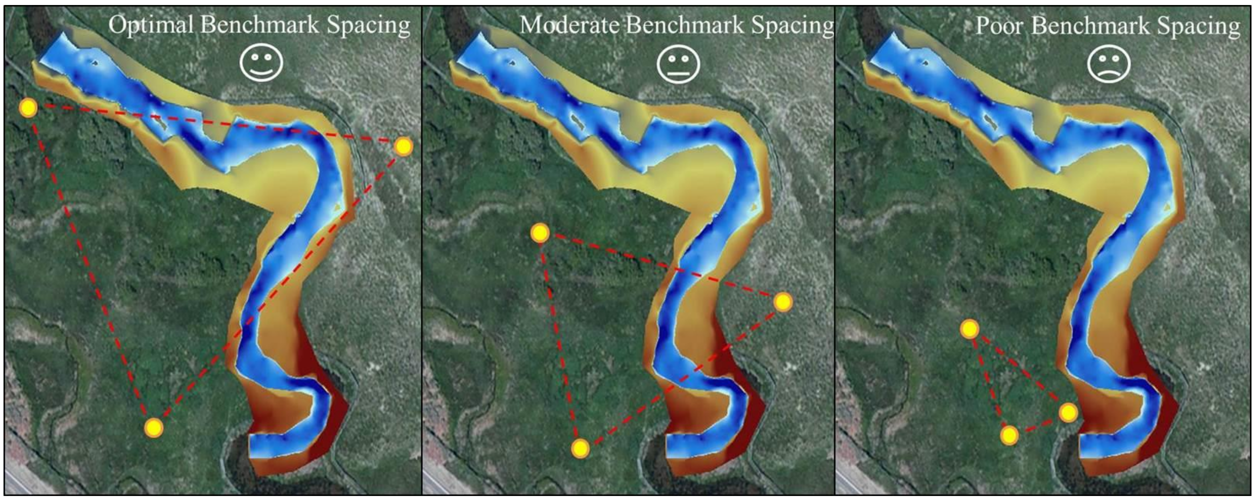
A resection is only performed at revisit surveys when there are no inter-visible benchmarks. It is always preferable to set up the instrument over a known point (benchmark) and backsight to a known point (benchmark) and perform a station setup at revisit sites.

To set up a total station and record points in a given coordinate system, the instrument first needs to be positioned and oriented. Resectioning is a process that allows the instrument to calculate a coordinate for its position based on triangulation between two or more points (benchmarks or control points) with known coordinates. A resection works best when the geometry of the known points relative to the total station are well distributed in space surrounding the instrument (i.e., not clustered in same quadrant), and well distributed over the area you wish to survey. The resection method is explained in the Camp Protocol.

Benchmark Geometry

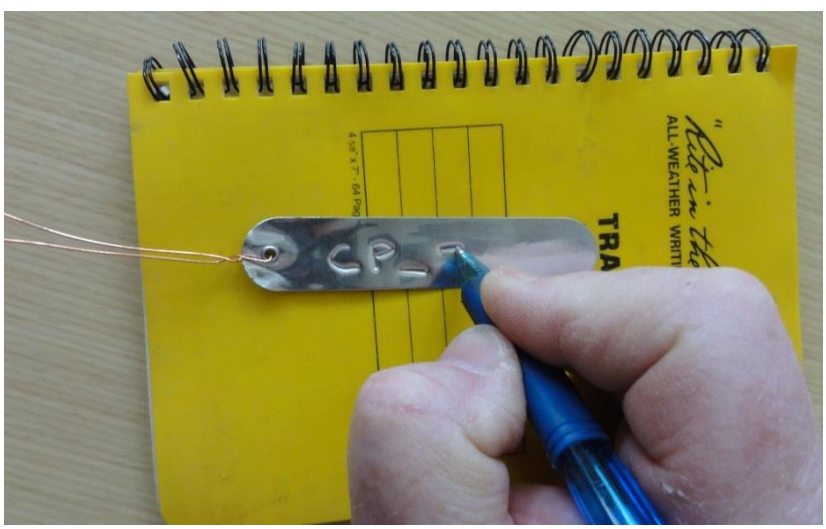
Properly established benchmarks are the key component to survey repeatability. Survey repeatability is a function of establishing benchmarks that can be surveyed repeatedly over many years. New site surveys establish benchmark locations and the coordinate system that will be relied upon for future surveys. Therefore, it is imperative that benchmarks be established with the following criteria: stability, geometry, and inter-visibility.

Stability refers to placing the benchmark in a location that will be unaltered by natural processes or humans. Geometry refers to placing benchmarks in a large equilateral triangle as far apart as possible. Inter-visibility refers to the ability to see each benchmark location from the other two benchmark locations.



Benchmark or Control point marking

A benchmark or control point must be marked for identification to accommodate a revisit survey. Write the description on the aluminum tag with a pen by placing the tag on the fieldbook. Then attach the tag to the BM or CP.



Collect topo Data

Objective: To capture X, Y, and Z coordinates as points and lines that collectively represent a topographic surface of the stream channel and floodplain.

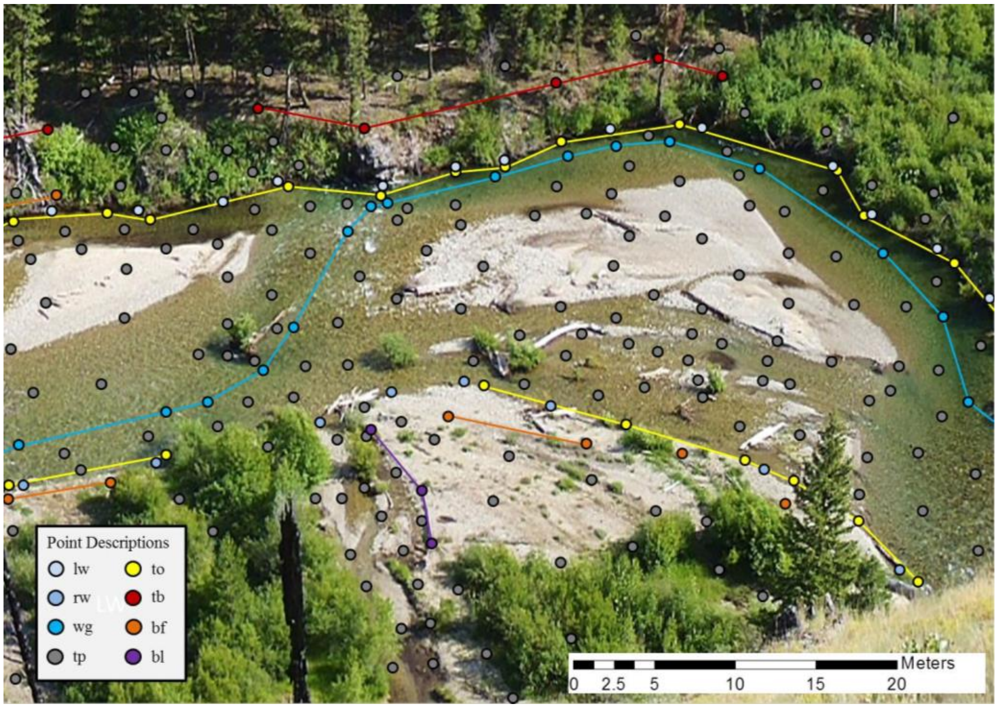
Many topographic surveys are time-limited, thus topographic points and lines must be collected efficiently and strategically to maximize the quality and utility of the DEM. The number of survey points collected is dependent upon the size and complexity of the site. Complex topography should be represented with a higher density of points (approx. 1,000-1,200 points) compared to more simple planar topography (500-600 points). Larger sites may have more points overall but generally have less topographic complexity.

Collect survey points at locations that represent changes in slope (inflection points). When capturing streambed topography, avoid capturing elements of bed roughness and instead, focus effort on capturing the bedform of the channel. Extend survey points far enough into the floodplain so that the areal extent of the survey encompasses all qualifying and non-qualifying side channels in areas where lateral migration may occur.

Use the topographic descriptions on the next page to identify survey points and lines throughout the site.

Points: Points are used to capture changes in topography that are not captured by lines. Use points to capture non-linear features including general topographic features and channel unit boundaries.

Lines: Lines are connections between two or more survey points and are used to efficiently capture visible contours or breaks in the stream channel topography. Lines are best used where there are identifiable linear features such as the edges of water, and tops and toes of banks.



Descriptions for points and Lines

The following table is list of descriptions used to identify unique points and lines in the topographic survey. Note that most descriptions are required for all CHaMP surveys and each crew member should become familiar with the description and definition prior to Champ camp.

Description Code	*Name*	*Feature Type*	*Required*	*Definition*
br	Mid-channel bar	Line or Points	No	Lines or points describing the wetted elevation of mid-channel bars.
out	Outflow point	Point	Yes	Point at the downstream (bottom) end of the site indicating the outflow point of the thalweg.
in	Inflow point	Point	Yes	Point at the upstream (top) end of the site indicating the inflow point of the thalweg.
lw	Left edge of water	Line or Point	Yes, Minimum of 25	Lines or points describing the elevation of the left wetted edge of the channel.
rw	Right edge of water	Line or Point	Yes, Minimum of 25	Lines or points describing the elevation of the right wetted edge of the channel.
ws	Water surface	Point	No	Points describing a mid-channel water surface elevation above the stream bed.
mw	Mid-channel island	Line or Points	No	Lines or points describing the wetted elevation of mid-channel islands.
tp	Topography	Point	Yes	Points describing general channel topography.
tb	Top of bank	Line	Yes	Lines describing the top of bank elevation.
to	Toe of bank	Line	Yes	Lines describing the toe of bank, or the line separating the active stream bed from the bank. Toe locations can be in and out of the water.
wg	Thalweg	Line or Point	Yes, Minimum of 20	Lines or points describing the longitudinal thalweg profile.
bf	Bankfull	Line or Point	Yes, Minimum of 20	Lines or points describing the bankfull elevation.
bl	Breakline	Line	No	Other gradient breaklines as needed.
u#	Channel unit	Point	Yes	Point describing channel unit perimeter within the wetted channel (u1, u2, etc.).
cp#	Control point	Point	Yes	Control points used as station or backsight setup locations (cp301, cp302, etc.).
bm#	Benchmark	Point	Yes, Minimum of 3	Monumented benchmarks (bm301, bm302, etc).

Resources

Protocol

The protocol will be available at Champ camp and is available at champmonitoring.org.

Nikon

Information for the Nikon Nivo 5c total station utilized by Champ is available at: http://nikon-spectra.ru/doc/Nivo%203M-5M%20Manual%20ENG.pdf

SurveyPro

The protocol appendix contains numerous procedural guides for operating the total station software.

CHaMP Camp

Champ Camp signifies an important beginning in your journey to become an effective topographic surveyor. Champ Camp is your best opportunity to learn. Make the most of it by reading this manual before arriving. Come to Champ camp with a list of questions for the instructors and be prepared to consume "tons" of information. The fish in the Columbia River Watershed will appreciate your efforts.

We look forward to seeing you at Champ Camp.

Remember why we are here? It's all about the fish.