# 5. Surveying Basics

A basic field survey establishes the horizontal and/or vertical location of a series of points in relation to a starting point (called a benchmark). If you're familiar with basic surveying techniques, this manual will be a useful review. Specific procedures for the longitudinal profile and cross-section surveys are further detailed in Chapters 6 and 8.

Your survey will record stream dimensions and quantify the relative position of features with the precision needed to document changes. This is vital to support further work at the reference site. Technical considerations include

- fully referencing all benchmarks and measurement points;
- checking regularly for errors and providing suitable closure; and
- following accepted note-taking format and reporting standards.

This type of survey requires at least two persons, and three are best. Minimum equipment (fig. 9) includes

- surveyor's level (with or without stadia hairs);
- leveling rod (English or metric standard);
- 100' tape to match rod (either feet-and-10ths or metric) and another tape for stretching at the cross section;
- field book;
- small sledge and wood survey stakes for stationing and reference; and
- steel rebar (at least 4') and hacksaw, as needed for cross-section endpoints, pins, etc.

A comprehensive list of gear for reference site use appears in Appendix A.

## NOTE-TAKING

As described earlier, a waterproof mining transit book is recommended. For convenience, a belt case holds the notebook, scales, pencils, etc. (fig. 10). Durable cases are made of leather or less costly nylon cases are also available.

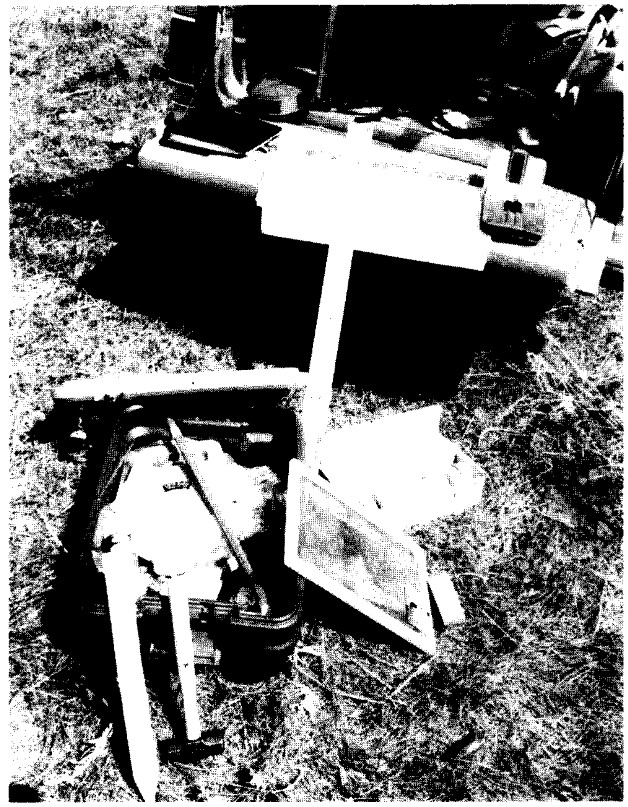


Figure 9. – Survey equipment.

Catalogs for engineering or forestry supplies are sources of suitable cases. Surveyor's or forester's vests also work well.

To help order field notes, prepare an introductory page with name of project, purpose, and other relevant notes such as instrument checks (fig. 11). Prepare notes before starting each day's work or when you start a new site.

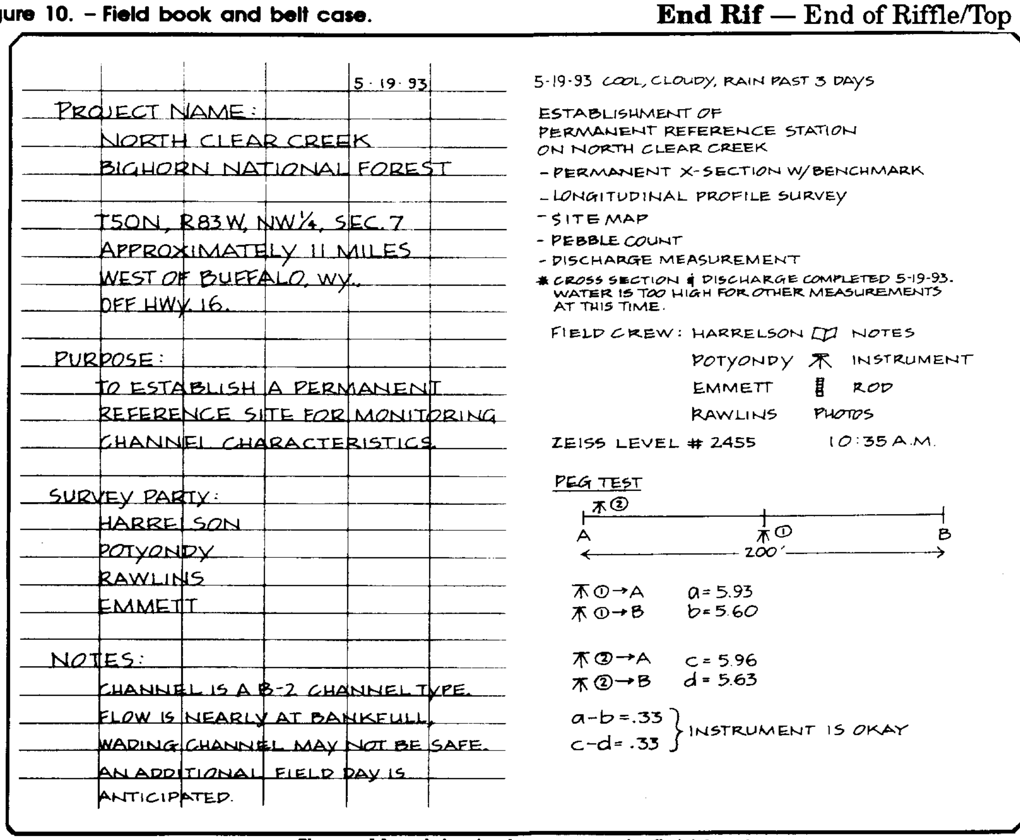
- Always record the date and weather.
- Record the names and tasks of the crew (e.g., W. Emmett, level; C. Rawlins, rod; C. Harrelson, notebook).
- Make a note of instrument manufacturer type and serial number (e.g., Instrument: Zeiss Level #2455).
- Identify supplemental forms used and not included in the field book (e.g., USGS form # 9-207 used for summary of discharge measurements).


Figure 10. – Field book and belt case.

- Use adequate spacing for clarity and concentrate on legibility (e.g., distinguish clearly between 1 and 7, letter O and zero 0, 2 and Z).

These are some standard symbols or labels for recording stream surveys in the field book. Left and right banks are always identified facing downstream.

**BM** — Benchmark
**HI** — Height of Instrument
**FS** — Foresight
**BS** — Backsight
**TP** — Turning Point
**WS** — Water Surface
**FP** — Floodplain
**LT** — Low Terrace
**MT** — Middle Terrace
**HT** — High Terrace
**LB** — Left Bank
**RB** — Right Bank
**LEW** — Left Edge of Water
**REW** — Right Edge of Water
**CL** — Centerline (of channel)
**PB** — Point-Bar
**BKF** — Bankfull Indicator
**SB** — Stream Bed
**Top Rif** — Top of Riffle/End of Pool
**PB** — Point-Bar
**End Rif** — End of Riffle/Top of Pool



5 · 19 · 93

PROJECT NAME:
NORTH CLEAR CREEK
BIGHORN NATIONAL FOREST

T50N, R83W, NW¼, SEC. 7
APPROXIMATELY 11 MILES
WEST OF BUFFALO, WY.
OFF HWY 16.

PURPOSE:
TO ESTABLISH A PERMANENT
REFERENCE SITE FOR MONITORING
CHANNEL CHARACTERISTICS.

SURVEY PARTY:
HARRELSON
POTYONDY
RAWLINS
EMMETT

NOTES:
CHANNEL IS A B-2 CHANNEL TYPE.
FLOW IS NEARLY AT BANKFULL,
WADING CHANNEL MAY NOT BE SAFE.
AN ADDITIONAL FIELD DAY IS
ANTICIPATED.

5-19-93 COOL, CLOUDY, RAIN PAST 3 DAYS

ESTABLISHMENT OF
PERMANENT REFERENCE STATION
ON NORTH CLEAR CREEK
- PERMANENT X-SECTION W/ BENCHMARK
- LONGITUDINAL PROFILE SURVEY
- SITE MAP
- PEBBLE COUNT
- DISCHARGE MEASUREMENT
* CROSS SECTION & DISCHARGE COMPLETED 5-19-93.
WATER IS TOO HIGH FOR OTHER MEASUREMENTS
AT THIS TIME.

FIELD CREW: HARRELSON — NOTES
POTYONDY — INSTRUMENT
EMMETT — ROD
RAWLINS — PHOTOS

ZEISS LEVEL # 2455 10:35 A.M.

PEG TEST



⊼①→A a = 5.93
⊼①→B b = 5.60

⊼②→A c = 5.96
⊼②→B d = 5.63

a−b = .33
c−d = .33
} INSTRUMENT IS OKAY

Figure 11. – Introductory pages in field book.

## BENCHMARKS

The benchmark is the initial reference (or starting) point of the survey. The U. S. Geological Survey typically uses brass monuments set in rock, a concrete pylon, or a pipe driven deeply into the ground. If one of these is within your survey area, use it. Usually, though, you will need to establish a new benchmark. The elevation of this benchmark may be assumed (100 is normally used) or tied into a project datum or mean sea level.

Locate the benchmark outside the channel (and floodplain, if possible) yet near enough to be clearly visible. The best placement is on a permanent natural feature of the site, such as an outcropping of bedrock, or the highest point of a large boulder. A large, embedded boulder on the low stream terrace is ideal. Four recommended methods for establishing a benchmark are

1. Boulder monument—choose a large, embedded boulder with a single high point. To achieve the least visual impact, clearly draw both its profile and location on your site map so that no artificial mark is needed. Otherwise, mark the high point on the boulder with a lightly chiseled X, a spot of slightly-contrasting paint, or a drilled hole with expansion bolt or cemented carriage bolt.
2. Spike monument—drive a 40-80 penny spike into the base of a large, healthy tree so the rod can be set on its head and be visible (no overhanging branches, etc.). Note the assumed elevation on a reference stake. Two stakes can be hinged to identify the site and protect the reading. Select a healthy tree (typically a conifer-like pine or Douglas fir) 14" or larger in diameter, with roots protected from stream erosion, and not subject to windthrow.
3. Cement monument—dig a circular hole 1-2 feet deep, mix concrete, and fill the hole. Then place a 6" plated (not black) carriage bolt into the center, flush. A variation is to cut and place steel or PVC pipe (at least 6' diameter) in the hole as a form, fill it with concrete, and set the bolt.
4. Rebar monument—drive a piece (at least 3-4' long with a 1/2" diameter) vertically to within 1/2" of the ground surface. Cover it with a plastic cap available from survey supply houses, or tag it with an aluminum survey marker tag.

Figures 12 - 15 show various types of benchmarks.

For long-term permanent sites, use two benchmarks. This allows recovery if one is lost and helps detect errors. Tie these benchmarks to a common datum elevation.

Obvious markers such as painted stakes may annoy other visitors and be subject to vandalism. Make permanent marks for the survey in an unobtrusive location, bearing in mind that they must be found in 5 or 10 years from the notes in your field book. Remove temporary flagging, stationing stakes, and other marks when the survey is complete.

Decide on the locations of the benchmark and the monumented cross-section concurrently, before survey measurement begins.

## MONUMENTED CROSS-SECTION

The monumented cross-section lies across the stream (perpendicular to the direction of stream flow). Generally, the cross-section is central to the survey area. Locate a good site for the cross-section before starting survey measurements. Locate the benchmark monument close to this cross-section and mark the endpoints with rebar.

The cross-section is the basis for delineating channel form, for measuring current velocity, and calculating discharge. These measurements are the basis for developing at-a-station hydraulic geometry and for long-term records of stream flow.

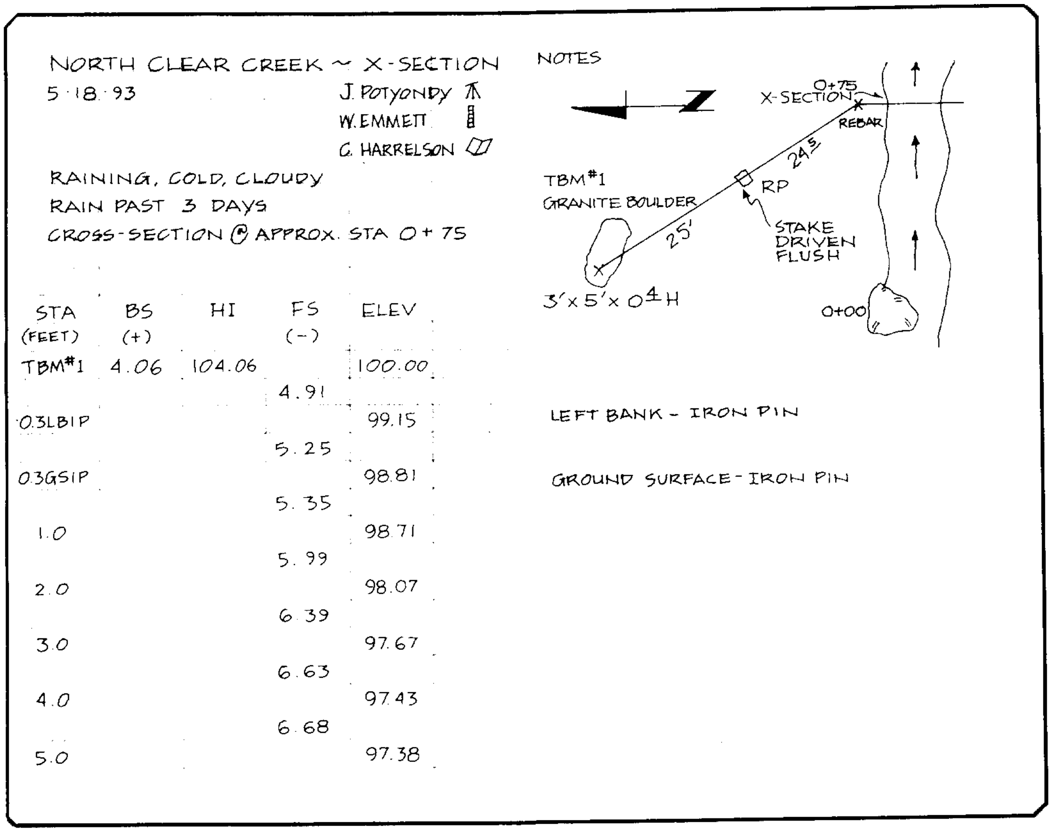
Carefully choose a representative cross-section in the surveyed reach. It should not be located where the character of the channel changes, for instance at a break in channel slope, or where a pool gives way to a riffle or at meander bends (unless you specifically wish to study meander movement). Avoid features such as large boulders, big deadfalls, etc., that have altered the extent and form of the channel. Figure 16 shows sample notes for the cross-section survey.

Figure 12. – Boulder monument.

Figure 13. – Spike monument.

Figure 14. – Cement monument.

Figure 15. – Rebar monument at cross-section (capped rebar on left, next to silver stake).


NORTH CLEAR CREEK ~ X-SECTION
5·18·93
J. POTYONDY
W. EMMETT
G. HARRELSON
RAINING, COLD, CLOUDY
RAIN PAST 3 DAYS
CROSS-SECTION @ APPROX. STA 0+75

| STA (FEET) | BS (+) | HI | FS (−) | ELEV | NOTES |
|---|---|---|---|---|---|
| TBM#1 | 4.06 | 104.06 | | 100.00 | |
| 0.3LBIP | | | 4.91 | 99.15 | LEFT BANK - IRON PIN |
| 03GSIP | | | 5.25 | 98.81 | GROUND SURFACE - IRON PIN |
| 1.0 | | | 5.35 | 98.71 | |
| 2.0 | | | 5.99 | 98.07 | |
| 3.0 | | | 6.39 | 97.67 | |
| 4.0 | | | 6.63 | 97.43 | |
| 5.0 | | | 6.68 | 97.38 | |



**Figure 16. – Sample notes for cross-section survey.**

## LONGITUDINAL PROFILE SURVEY

Conduct the longitudinal profile survey when you conduct the benchmark and monumented cross-section surveys. The cross-section survey measures a single vertical plane across the stream. Using similar methods, the longitudinal profile measures points up and down the stream channel.

The longitudinal profile survey is important for measuring the slope of the water surface, channel bed, floodplain, and terraces. The elevations and positions of various indicators of stream stage and other features are recorded and referenced to the benchmark.

The following sections concentrate on basic techniques, surveying terms, and keeping the field book. Chapter 8 covers the actual process of surveying a longitudinal profile. Figure 17 shows an example of field book setup for surveying the longitudinal profile.

## DISTANCE MEASUREMENTS

Horizontal measurements include: distances between benchmarks and prominent features, cross-sectional distance, distance along the channel centerline and banks, station distances, and slope. Measure distance by stretching a tape or by reading stadia with the level. For most purposes, the tape is simpler, faster, and just as accurate as stadia-measured distances.

### Measuring Tapes

Use a tape of sufficient length (at least 100 feet) to allow measurement without repeated "leapfrogging." Choose a durable, waterproof tape, graduated in feet to 0.1 or meters to 0.01. The tape should be to the same standard (English or metric) as your leveling rod. Obtain tapes from survey and forestry suppliers. Figure 18 shows two common types.

### Use of Stadia

Horizontal, straight-line distances can be measured indirectly with stadia. Many surveying levels have smaller horizontal cross hairs above and below the main horizontal cross hair (fig. 19).

NORTH CLEAR CREEK - LONGITUDINAL PROFILE
9/10/93 - WATER SURFACE L. SCHMIDT
- BANKFULL W. EMMETT
- TERRACES C. HARRELSON
WARM & CLEAR 11:00 AM

NOTES
SURVEY POINT LEGEND
LEW - LEFT EDGE OF WATER
REW - RIGHT EDGE OF WATER
LFP - LEFT FLOODPLAIN
RFP - RIGHT FLOODPLAIN
℄ - CHANNEL BOTTOM
LTERR - LEFT TERRACE
RTERR - RIGHT TERRACE

| STATION (FT) | BS (+) | HI | FS (-) | ELEV (FT) | NOTES |
|---|---|---|---|---|---|
| TBM #1 | 6.25 | 106.25 | | 100.00 | BENCHMARK - GRANITE ROCK |
| | | | 5.60 | | |
| 0+00 | | | | 100.65 | 3' TERRACE / NO FLOODPLAIN EVIDENT |
| | | | 9.20 | | |
| 0+00 | | | | 97.05 | LEW |
| | | | 11.55 | | |
| 0+00 | | | | 94.70 | ℄ |
| | | | 5.81 | | |
| 0+15 | | | | 100.44 | |
| | | | 7.74 | | |
| 0+15 | | | | 98.51 | LFP |
| | | | 9.29 | | |
| 0+15 | | | | 96.96 | LEW |
| | | | 10.66 | | |
| 0+15 | | | | 95.59 | ℄ |
| | | | 9.16 | | |
| 0+15 | | | | 97.09 | REW |

**Figure 17. – Sample notes for longitudinal profile survey.**

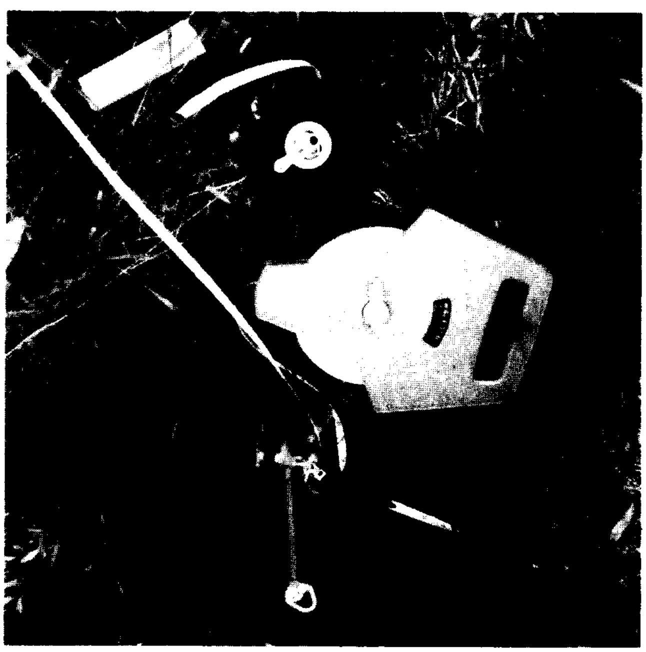


**Figure 18. – Two common measuring tapes.**

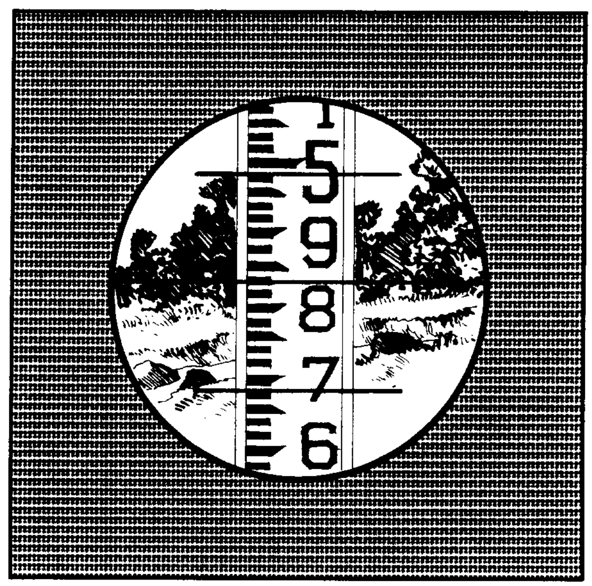



**Figure 19. – View through level showing center and stadia cross-hairs.**

The distance between the level and rod is found by subtracting the rod reading for the lower stadia cross hair from that for the upper stadia cross hair, and multiplying the result by a stadia constant (usually 100). To be accurate, readings must be in a level plane, with the rod exactly vertical. If using a transit (rather than a level), read vertical angles and use correction tables to get an accurate reading.

The accuracy of stadia measurements depends on the individual, the type of instrument and rod used, and atmospheric conditions. Unless you have practical experience using stadia, we suggest that you use the tape and rod.

## ELEVATION MEASUREMENT

For this survey, measure vertical distances with a basic surveyor's level. A self-leveling level is commonly used for surveying river channels (fig. 20). Another instrument that can be used is a laser level. It projects a beam in a circular plane through a rotating prism. It requires use of a special level rod with a detector that is moved up or down until the beam intersects it. Calculate elevation by subtracting the rod reading from the elevation of the laser plane. Measuring elevations with a laser level requires only a single person with laser-leveling rod and field book.

Figure 20. – Self-leveling level.

**Laser Level**

Another instrument that can be used is a laser level. A laser level projects a beam in a circular plane through a rotating prism. It requires use of a special level rod with a detector which is moved up or down until the beam intersects it. Calculate elevation by subtracting the rod reading from the elevation of the laser plane. Measuring elevations with a laser level requires only a single person with laser-leveling rod and field book.

## CARE OF SURVEY INSTRUMENTS

Because malfunctions in survey instruments can cause tremendous losses of time and field data, a few general rules are in order:

- When transporting instruments, protect them from impact and vibration. (When you have the choice of allowing your friend, your dog, or your level to ride on the seat, choose the level. Secure it in place with the seat belt.)
- Place the level on a firm base in a vehicle rather than on top of other equipment.
- Store the lens cap and tripod cap in the level case while the level is in use.
- Keep the case closed while the instrument is in use.
- Don't run while carrying the level, don't drop it, and *never* fall with it. If you do, the level may need repair and recalibration. (See Two-Peg Test, p. 20.)
- Never force screws or parts when adjusting or maintaining your level.
- Use the sunshade to protect the lenses.
- Clean the lenses only with compressed air or special lens cloth, not with fingers, sleeves, kerchiefs, etc.

## SETTING UP THE LEVEL

These procedures apply to a self-leveling level. For other types, refer to the proper manual or instruction sheet.

1. Screw the level snugly to the head of the tripod. "Snug" means finger-tight. Overtightening can cause warping of the tripod plate or instrument, which results in inaccurate measurement.
2. Spread the tripod legs 3 or 4 feet apart, adjust the legs to level the tripod in both directions, and push them firmly into the ground.
3. Move the leveling screws one at a time or in pairs to bring the bubble into the target circle on the vial (fig. 21). Rotate the scope 90° and re-level. Start by leveling across two of the screws and finish with the third screw after making the 90° degree turn.
4. Repeat until the bubble stays level throughout a 360° circuit. With a self-leveling level, this procedure brings the instrument into the range where the leveling pendulum prism can operate.
5. Turn the telescope to bring the rod into the field of vision.

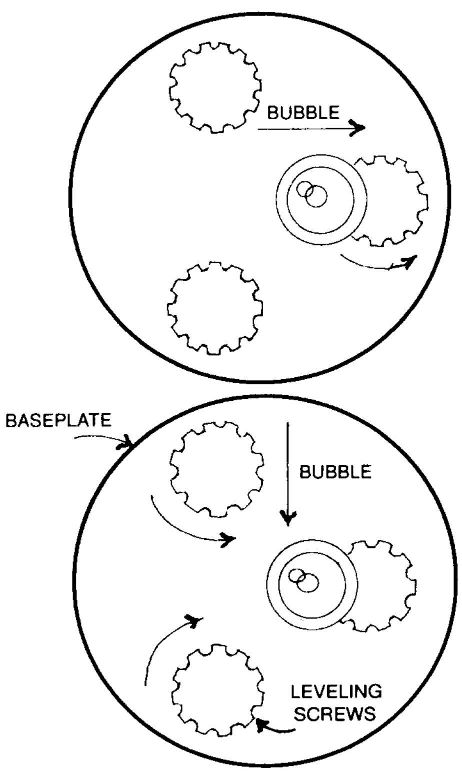



Figure 21. – Centering the bubble.

6. Focus on the cross hairs by adjusting the eyepiece. If the cross hairs appear to travel over the object sighted when the eye shifts slightly in any direction, parallax exists. To eliminate parallax, adjust either the objective lens system or the eyepiece until the cross hair appears to rest on the object site regardless of slight changes in your eye position.
7. Avoid readjusting the leveling screws once the instrument is leveled. If the leveling screws must be adjusted to bring the bubble into the target, reread the benchmark elevation and instrument height.

**TWO-PEG TEST**

Check surveying instruments before field work by doing a two-peg test. Perform a peg test the first time the instrument is used, when damage is suspected, or when custody of the instrument changes.

1) Drive two stakes near ground level 200-300 feet apart with a clear line of sight.
2) Set up the level exactly halfway between the two points. Take a rod reading "a" on stake A and a second reading "b" on stake B. The elevation difference computed, "a - b," is the true difference regardless of instrument error.
3) Set up the level close enough to stake A so that a rod reading can be taken either by sighting through the telescope in reverse or by measuring up to the horizontal axis of the telescope with a steel tape.
4) Take a rod reading "c" on Stake A and a rod reading "d" on Stake B.

If the instrument is in adjustment, (c - d) will equal (a - b).

If the instrument is out of adjustment, compute what the correct rod reading "e" on B should be ( e = b + c - a ) and have the instrument adjusted.

A sample calculation of the peg test follows:

a = 5.93    a - b = .33 instrument is okay
b = 5.60    c - d = .33
c = 5.96
d = 5.63

## READING THE ROD

The rod is marked with a scale, either English or metric. It may be the traditional wood-and-metal type or be made of plastic. Both types have telescoping sections. The rod may be collapsed for transport or field maneuvers, but each section must be fully extended for readings.

The rod person makes or breaks the survey. Knowing what to measure (i.e., where to set the rod) is the most vital part. The rod person sets the pace of the work and often influences or directs the movement of the level.

The numbers on the face of the rod show distance from its lower end. In the English standard, distance is numbered in feet (large number) and tenths (small number). The width of one individual black line is 1/100 (or .01) ft., and the width of a white space between black lines is also 1/100 (or .01) ft. (fig. 22). On the metric rod, distance is numbered with a decimal point, in meters and tenths. The width of black marks and white spaces is 1/100 (or .01) m.

The rod person should hold the rod lightly and let it balance in the vertical position. The level operator watches through the telescope as the rod person rocks or waves the rod forward and backward through the plumb line, noting the minimum rod reading (fig. 23). The minimum reading occurs when the rod is plumb. A common cause of error when sighting is reading the elevation on a stadia hair instead of the central cross hair.

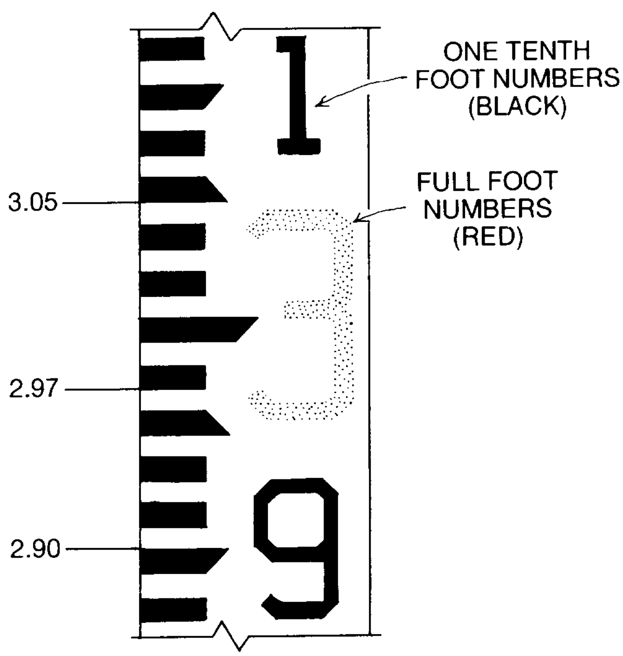



Figure 22. - Leveling rod.

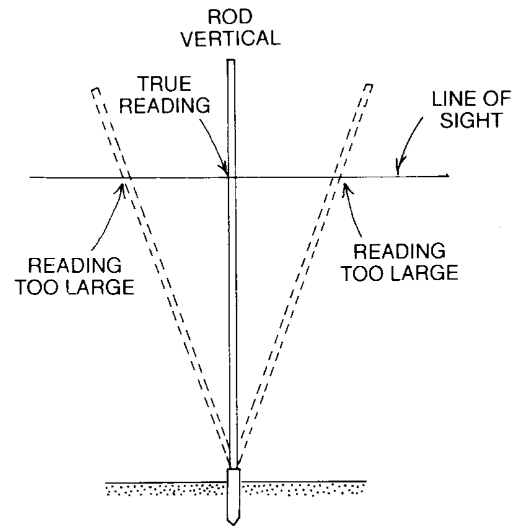



Figure 23. - Rod in three positions.

Use a rod level to ensure an accurate reading. A rod level has a small bull's-eye spirit level, mounted on an L-shaped bracket attached to the rod. A centered bubble indicates the rod is plumb in both directions. Plumb is very important when determining channel characteristics and water surface elevations.

Once you have mastered the basics of setting up the level and reading the rod, check instrument accuracy by using a simple two-peg test.

## LEVELING

Many survey procedures are based on differential leveling, that is, they find the elevation of an unknown point by direct measurement of the difference in elevation between that point and a point of known (or assumed) elevation. Profile leveling determines the elevations of a series of points at intervals along a line.

### Terms Used in Leveling

**Backsight** (**BS**) is a rod reading taken on a point of known elevation. It is the actual vertical distance from the point of known elevation to a horizontal line projected by the instrument. There is only one backsight for each setup of the instrument. (The term "backsight" has nothing to do with the direction in which the instrument is pointed.) The algebraic sign of the backsight is positive (+) because adding this value to the benchmark or turning point elevation gives the height of the instrument.

**Height of Instrument** (**HI**) is the elevation of the line of sight projected by the instrument. Find it by adding the backsight rod reading to the known (or assumed) elevation of the benchmark or the point on which the backsight was taken.

**Foresight** (**FS**) is a rod reading taken on any point to determine its elevation. The algebraic sign for the foresight is negative (-) since the FS is subtracted from the HI to find the ground elevation of the point in question.

**Turning Point** (**TP**) is a reliable point upon which a foresight is taken to establish elevation. A backsight is then made to establish a new HI and to continue a line of levels. The turning point retains the same elevation while the instrument is moved. Set the rod on a turning point and record a foresight. Move the instrument as the rod stays in place. Make a backsight and record it. Large rocks are often used as turning points.

## DIFFERENTIAL LEVELING

Differential leveling measures the relative elevations of points some distance apart. It consists of making a series of instrument setups along a route. From each setup, take a rod reading back to a point of known elevation and a reading forward to a point of unknown elevation.

The points for which elevations are known or determined are called benchmarks or turning points. The benchmark is a permanently established reference point, with its elevation either assumed or accurately measured. A turning point is a temporary reference point, with its elevation determined as a step within a traverse.

For example, the elevation of benchmark 1 (BM1) is known or assumed to be 100.00 feet (figs. 24 and 25).

The elevation of BM2 is found by differential leveling. Set the instrument up first at some point from BM1 along the route to BM2. Hold the rod on BM1 and note the rod reading (5.62) in the field notebook. This reading is a backsight (BS), or a reading taken on a point of known elevation (fig. 26).

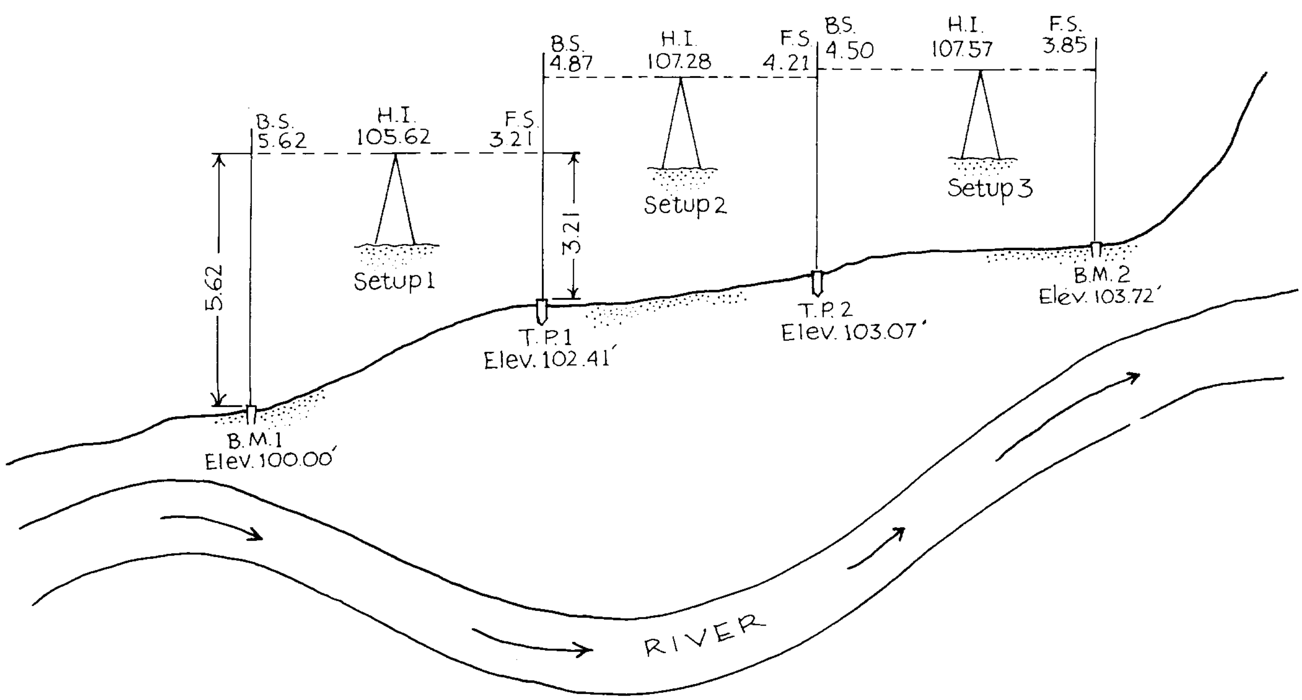
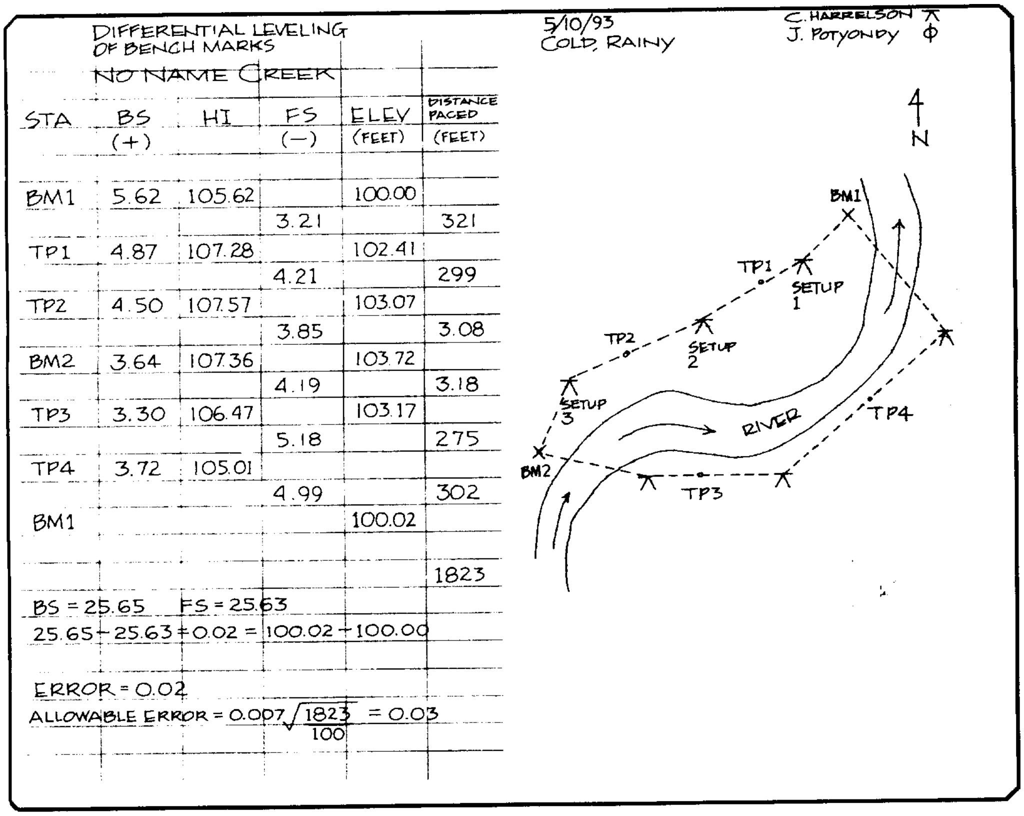



**Figure 24. – Diagram of differential leveling.**




DIFFERENTIAL LEVELING OF BENCH MARKS
NO NAME CREEK

| STA | BS (+) | HI | FS (−) | ELEV (FEET) | DISTANCE PACED (FEET) |
|---|---|---|---|---|---|
| BM1 | 5.62 | 105.62 | | 100.00 | |
| | | | 3.21 | | 321 |
| TP1 | 4.87 | 107.28 | | 102.41 | |
| | | | 4.21 | | 299 |
| TP2 | 4.50 | 107.57 | | 103.07 | |
| | | | 3.85 | | 3.08 |
| BM2 | 3.64 | 107.36 | | 103.72 | |
| | | | 4.19 | | 3.18 |
| TP3 | 3.30 | 106.47 | | 103.17 | |
| | | | 5.18 | | 275 |
| TP4 | 3.72 | 105.01 | | | |
| | | | 4.99 | | 302 |
| BM1 | | | | 100.02 | |
| | | | | | 1823 |

BS = 25.65 FS = 25.63

25.65 − 25.63 = 0.02 = 100.02 − 100.00

ERROR = 0.02

ALLOWABLE ERROR = $0.007\sqrt{\frac{1823}{100}} = 0.03$

**Figure 25. – Field notes for differential leveling.**

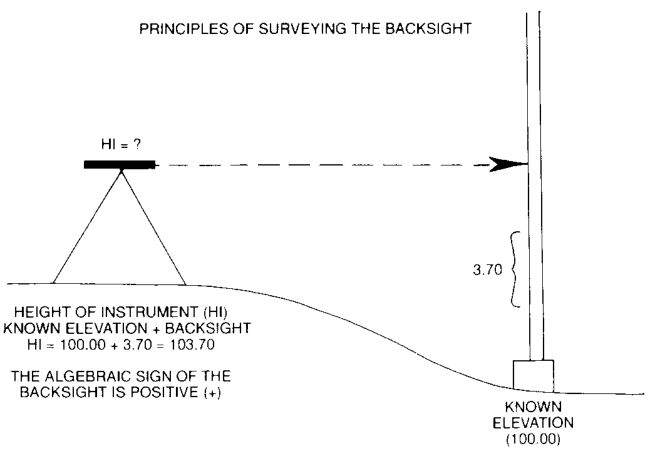



**Figure 26. – Surveying the backsight.**

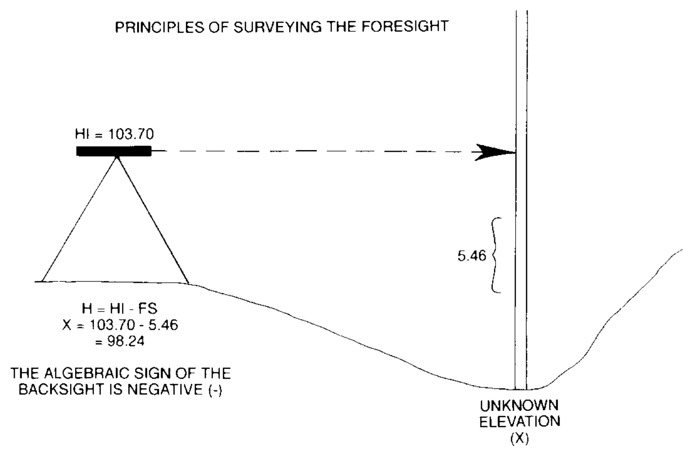



**Figure 27. – Surveying the foresight.**

Add the backsight reading on BM1 to the elevation of BM1 (100.00+5.62=105.62) to give the height of instrument (HI).

Once the backsight on BM1 is recorded, the rod person moves to turning point number 1 (TP1). With the instrument still at setup 1, take a reading on TP1. This reading is a foresight (FS), a reading taken on a point of unknown elevation (fig. 27).

Enter the foresight (3.21) in the field notebook opposite TP1. Compute the elevation of TP1 by subtracting the foresight on TP1 from the instrument height (105.02-3.21=102.41) and enter this elevation on the notes opposite TP1. TP1 now becomes a point of known elevation. Figure 28 shows the principles of turning points.

The rod person remains at TP1 while the instrument is moved to setup 2. From here take

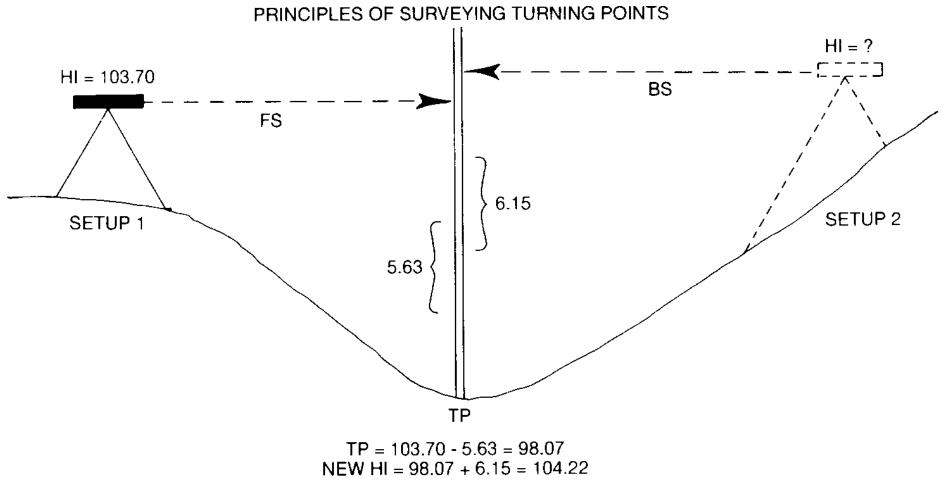



**Figure 28. – Turning points.**

another backsight BS on TP1. Determine the new HI, establish TP2, and determine its elevation. Figures 24 and 25 should make this procedure clear. This same procedure is carried through until reaching BM2.

### Closure of the Survey

To check on the accuracy of the survey, run a line of differential levels from BM2 back to BM1, the original point of known or assumed elevation. No survey is complete until it has been closed within acceptable levels of error. The difference between the original elevation of BM1 and the new or calculated elevation is the error. Very small errors may result from rounding and are acceptable. Acceptable error depends on the intent of the survey. Typically a closure of .02 ft. is acceptable when doing river surveys. One equation to estimate allowable error is:

$$0.007\sqrt{\frac{total\ distance}{100}}$$

A large error may result from mistakes in calculation, so check your arithmetic first. If no arithmetic errors are found, failure to close may be due to errors in reading the rod, or note-taking. In any event, the line of levels must be resurveyed to locate and correct the error.

## PROFILE LEVELING

Essentially, profile leveling is a process of differential leveling with many intermediate foresights between turning points. The longitudinal survey along a stream channel uses profile leveling.

As shown in figures 29 and 30, foresights taken from setup 1 are each subtracted from HI at this setup to determine the elevations of the intermediate points between BM1 and TP1. Find the elevations of points (rod settings on features, indicators, etc.) between TP1 and TP2 in a similar manner. Locate the instrument for the best visibility so that necessary features can be measured without changing the setup.

The next section applies the basic principles learned in this section to the measurement of a channel cross-section. During this process, you will use surveying techniques to establish the elevation and location of the permanent benchmark and then measure elevation and distances along the cross-section across the channel.

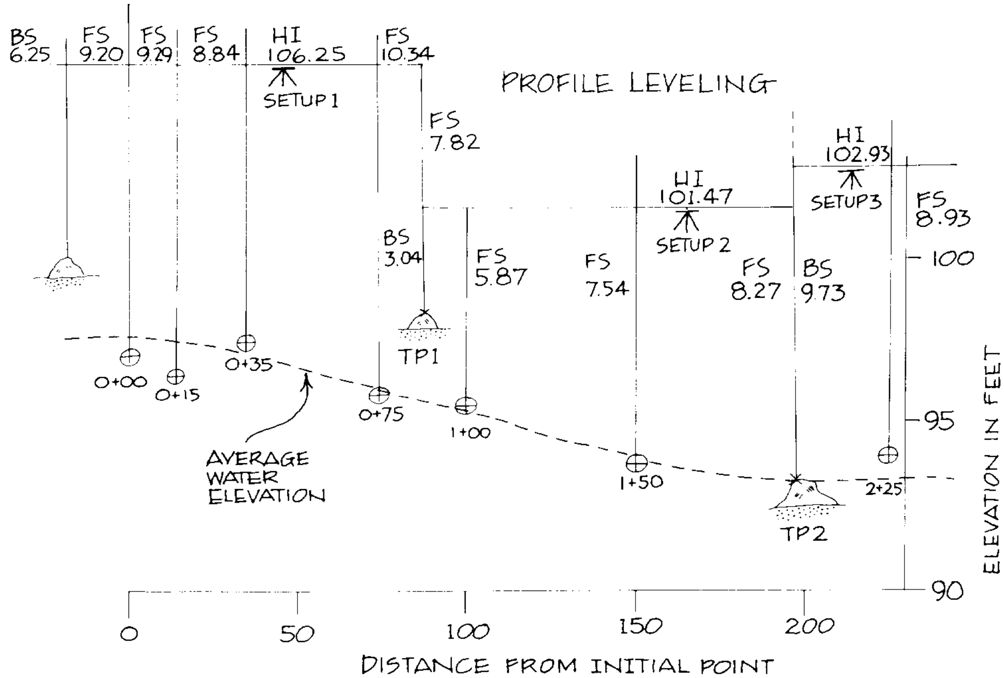



**Figure 29. – Diagram of profile leveling.**

PROFILE LEVELING — N. CLEAR CREEK
WATER EDGE

9/10/93
CLEAR, WARM

C. HARRELSON ⊼
C. RAWLINS ϕ

| STA | BS (+) | HI | FS (−) | ELEV (FEET) | |
|---|---|---|---|---|---|
| TBM#1 | 6.25 | 106.25 | | 100.00 | TOP OF GRANITE BOULDER |
| | | | 9.20 | | |
| 0+00 | | | | 97.05 | LEW |
| | | | 9.29 | | |
| 0+15 | | | | 96.96 | LEW |
| | | | 8.84 | | |
| 0+35 | | | | 97.41 | REW |
| | | | 10.34 | | |
| 0+75 | | | | 95.91 | LEW |
| | | | 7.82 | | |
| TP1 | 3.04 | 101.47 | | 98.43 | LEFT BANK |
| | | | 5.87 | | |
| 1+00 | | | | 95.60 | REW |
| | | | 7.54 | | |
| 1+50 | | | | 93.93 | LEW |
| | | | 8.27 | | |
| TP2 | 9.73 | 102.93 | | 93.20 | RIGHT BANK |
| | | | 8.93 | | |
| 2+25 | | | | 94.00 | LEW |
| | | | 2.93 | | |
| TBM#1 | | | | 100.00 | |

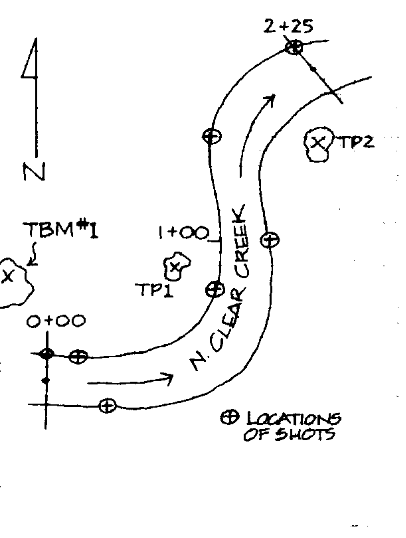



**Figure 30. – Field notes for differential leveling.**

# 6. Measuring Channel Cross-Section

The monumented cross-section is the location for measuring channel form, stream discharge, particle size distribution, and other long-term work. Though more than one cross-section may be needed depending on the objectives of the study, only one is used in this example.

The cross-section survey involves placing endpoints and a benchmark, stretching a tape, taking documentary photos, and measuring elevations with a surveyor's level. At least 20 measurements are recommended to accurately portray most channels, with more needed for broad or structurally complex sites (such as braided channels). Remember to measure all significant breaks of slope that occur across the channel. Outside the channel, measure important features including the active floodplain, bankfull elevations, and stream terraces.

Figure 31 shows a general diagram of the channel cross-section.

The stream must be waded repeatedly to complete the survey. If possible, schedule the work when water levels allow safe wading of the stream, or anchor a safety rope if needed.

Features to look for when locating the permanent cross-section include

- a straight reach between two meander bends;
- clear indicators of the active floodplain or bankfull discharge;
- presence of one or more terraces;
- channel section and form typical of the stream;
- a reasonably clear view of geomorphic features.

Place marked endpoints for the cross-section well above the banks, or at the edge of the low terrace. A tape will be stretched between these points. Once the endpoints have been chosen, mark them with sections of rebar (at least 4' long, driven vertically). The cross-section survey may extend beyond the ends of the tape to delineate not only the present channel and banks but also one or more stream terraces.

Figure 32 shows a suitable site for a channel cross-section.

### CROSS-SECTION SURVEY PROCEDURE

1. ESTABLISH PERMANENT MARKERS FOR ENDPOINTS. Drive a 4' x 1/2" piece of re-bar vertically into each bank to mark endpoints, leaving 1/2" above surface. Attach colored plastic caps, available from survey supply houses, to the top of the rebar for identification. Note their use, and in the case of multiple cross-sections, their color, in the field book. In most instances, drive a second, shorter piece of rebar next to the first, leaving at least 6" above surface, to attach your tape.
2. ESTABLISH THE BENCHMARK. The benchmark establishes elevation and survey controls, and it serves to relocate the cross-section in the future. Methods of locating monuments for a benchmark are covered in Chapter 5, Surveying Basics. Figure 33 shows how to describe the benchmark in the field book.

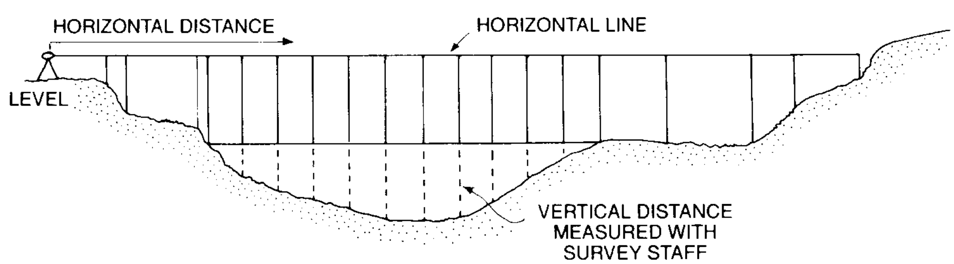



Figure 31. – Diagram of a cross-section survey.

Figure 32. – Suitable site for a cross-section survey.

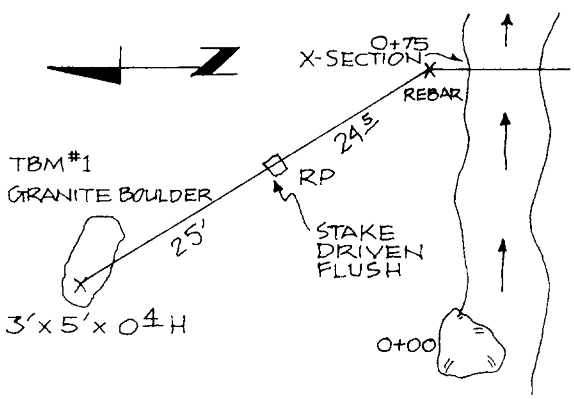



Figure 33. – Description of benchmark in field book.

3. MEASURE AND NOTE ENDPOINT LOCATIONS. With the tape, triangulate between a benchmark, the nearest endpoint, and another permanent feature (an embedded boulder or healthy, long-lived tree away from the water's edge). Measure taped distances to 0.1 of a foot. Record the triangulation or straight line reference point in the field book.
4. SET UP THE TAPE. Attach the zero end of the tape to the left stake. Stretch the tape tight and level above the water from the triangulated endpoint to the opposite endpoint of the cross-section. Use spring-clamps, Silvey stakes, or other means to hold the tape. If the stream is so wide that the tape sags excessively, use a tag line that can be stretched straight. Record the total distance between endpoints in the field book. Leave the tape set up for a discharge measurement.
5. MEASURE ELEVATIONS. Set up the surveyor's level, as covered in Chapter 5. Start with the rod on the benchmark to establish the height of instrument (HI) (fig. 34). Starting with the left endpoint stake as zero, begin your channel cross-section. (Starting from the left side makes for easy plotting of cross-section data.) The plot looks like the cross-section measured in the field. Along the tape, shoot an elevation at each change in each important feature, or at intervals that delineate important features. Set the rod on slope breaks (such as the edge of the low terrace), on indicators of active floodplain boundaries or bankfull discharge, and on other features of interest.

Figure 34. – Shooting the elevation of the benchmark.

Always measure the edge of water. Place the rod firmly on the wetted bottom but don't dig it in. Once in the channel, shoot elevations at a regular interval (basically, either channel width divided by 20, or 1 or 2 foot intervals are commonly used) with additional shots to capture features such as breaks in slope. Avoid the tops of isolated boulders and logs (or shoot at close intervals to accurately record large ones). Continue across the channel to the right endpoint stake. If necessary, go beyond the stake to measure terrace features on the far bank.

Record distance and depth measurements in the field notebook without erasures as shown in figure 35. Line out, correct, and initial any errors.

Measurement standards differ according to purpose. Distances are usually measured to tenths of feet for cross-section and profile surveys. For recording the distance between cross-section elevations, measuring to hundredths may increase the accuracy to a desired standard, if moving the rod a few inches affects the reading dramatically. Elevations are always recorded for hundredths (0.01 ft.) when leveling benchmarks, turning points, height of instrument, or slope.

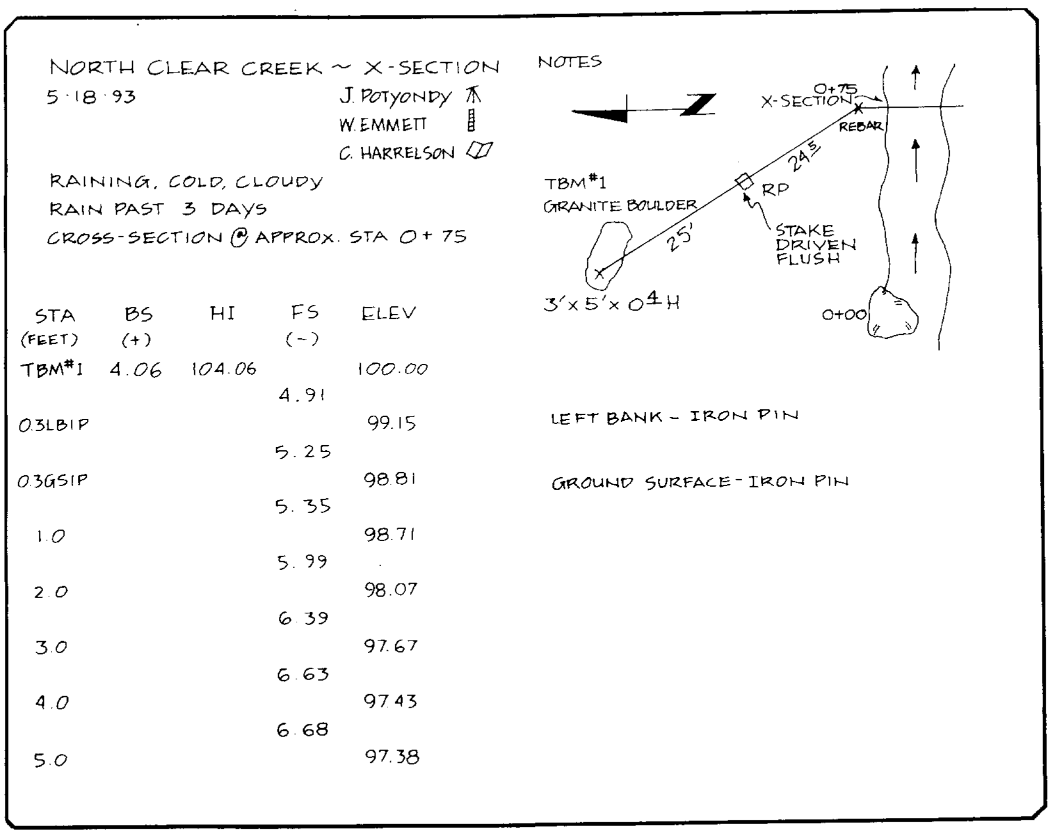



Figure 35. – Survey notes for cross-section.

Many people take all elevations to 0.01. This increases the precision of the survey and may make it easier to close.

6. CLOSE THE SURVEY. Remember to close the survey loop by taking a reading back to the initial benchmark. Doing this properly requires moving the instrument at least once during the course of the survey. Shooting directly back to the benchmark without moving the instrument only detects movement of the level (perhaps by having accidentally knocked one of the legs), not instrument errors. Take a reading on a temporary turning point (transect endpoints are convenient for this purpose), move the instrument across the stream, shoot the endpoint a second time, and follow this with a reading on the initial benchmark. If movement across the stream is difficult or if vegetation obstructs a clear shot, move the instrument the distance of a channel's width along the bank on the same side of the stream and close the survey loop back to the benchmark. Calculate closure in the field before leaving the site and repeat measurements if necessary.
7. PLOT THE DATA IN THE FIELD BOOK. Always plot the data while in the field (fig. 36). This helps to catch errors and gives you a better feel for how your site translates into a notebook record. The purpose of your study will dictate whether to (1) extend the plot to the floodplain or terrace elevations, or (2) plot the channel cross-section alone. For visual emphasis, the vertical scale of the plot may be exaggerated by a factor of 10.

Figure 37 shows a final plot of the field data prepared in the office.

8. MEASURE CHANNEL SLOPE. For the slope measurement, the rod person moves upstream from the cross-section far enough to incorporate one complete pool-riffle or step-pool se-

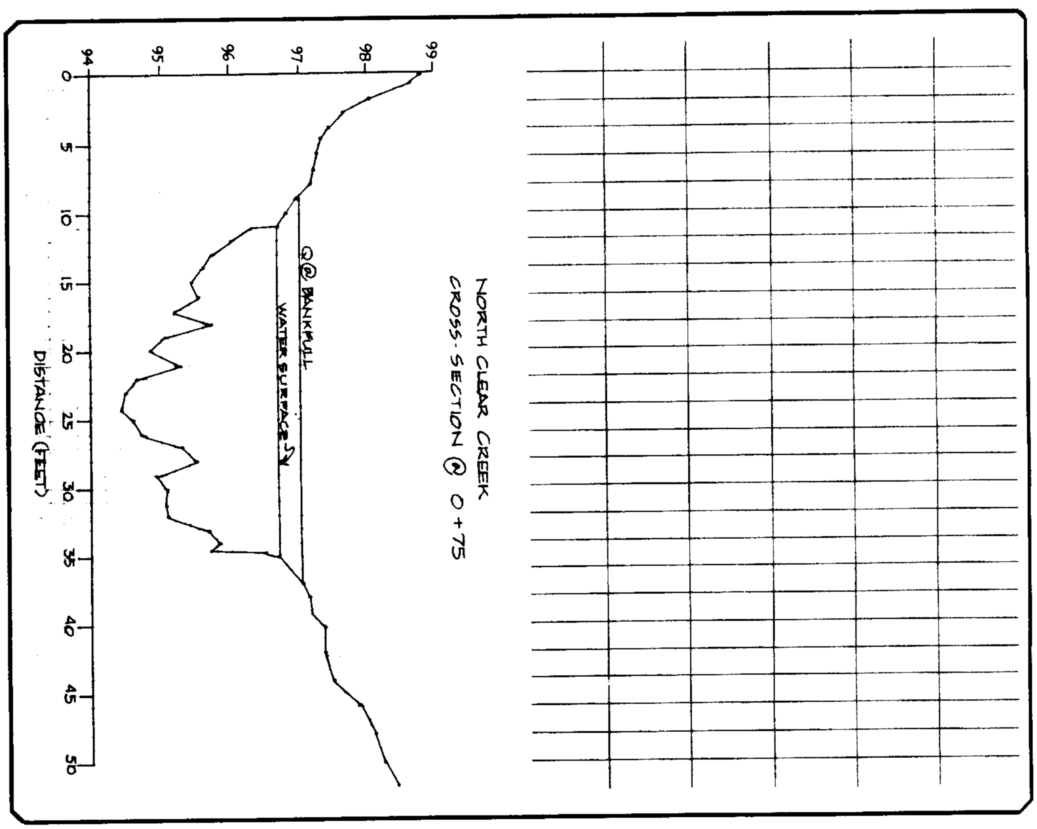



Figure 36. – Field plot of cross-section.

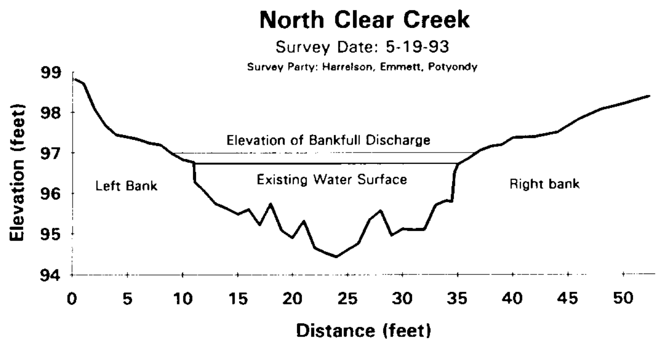



**Figure 37. – Final plot of cross-section.**

quence (if present). Start at a distinct feature (top of riffle, pool, etc.) and measure the distance from the cross-section to each point with a tape to the nearest 0.1 ft. Shoot elevations at water surface and bankfull. (If the survey is done at bankfull stage, that will also be the water surface elevation as was the case on North Clear Creek.)

Repeat the procedure downstream, ending on the same channel feature as at the starting point. For example, if the upstream slope measurement point was the top of a riffle, the lower slope measurement point would also be the top of a riffle (fig. 38). Record the data in the field book and check for potential errors.

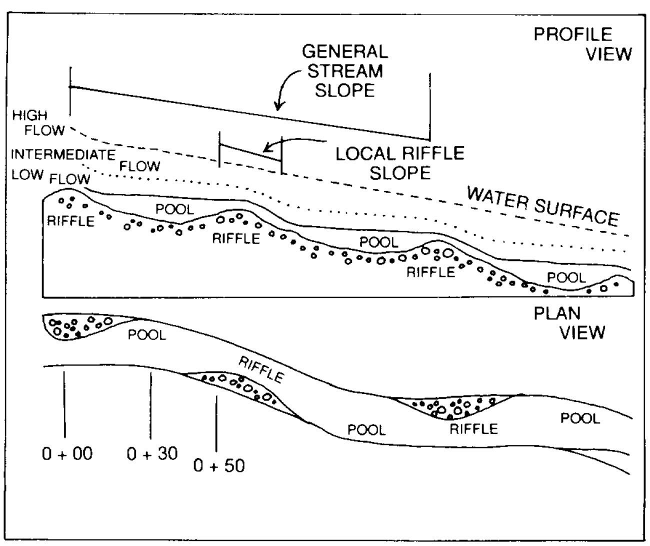



**Figure 38. – Longitudinal profile and plan view of pool riffle sequence.**

For North Clear Creek (at bankfull stage), the observations were

| | | |
|---|---|---|
| Upstream Distance | = | 55.5 ft. |
| Downstream Distance | = | +94.5 ft. |
| Total Distance (run) | = | 150.0 ft. |
| Downstream Water Surface | = | 10.87 |
| Upstream Water Surface | = | - 6.22 |
| Elevation Change (rise) | = | 4.65 |

$$\text{SLOPE (\%)} = \frac{rise}{run} \times 100 = \frac{4.65 ft}{150.0 ft} \times 100 = 0.031 \times 100 = 3.1\%$$

PLOT OF SLOPE

9. ESTABLISH PHOTO POINTS. Record the camera, lens focal length, and film type in the field notebook. A 35mm camera with a fixed-focus normal (50mm) and a wide-angle (28-35mm) lens or setting (focal lengths shorter than 28mm causes distortion) is recommended. Take photos upstream, downstream, and across the channel (figs. 39, 40, and 41). Try to include the entire cross section with both endpoints, and the tape in place, in the frame. Show the benchmark in another photo looking across the site, if possible.

Reference your photo points by triangulating to the endpoint and/or benchmark. To avoid confusion, mark photo points by some means different from endpoint benchmarks. If precision is needed for stereo photos, use a tripod to support the camera rather than driving steel fence posts.

Generally, use color slide film to document field studies. (For this publication, sample cross-section photos were shot with black-and-white film.)

The next section discusses how to identify natural features along the stream. Primary interest centers on identification of the floodplain, bankfull flow indicators, and channel terraces. The process of measuring the elevation of these features and the distance separating them along the length of the channel is called a longitudinal profile. Detailed procedures for doing a longitudinal profile are discussed after the section on identifying these features.

Figure 39. – Cross-section from the left bank looking across.

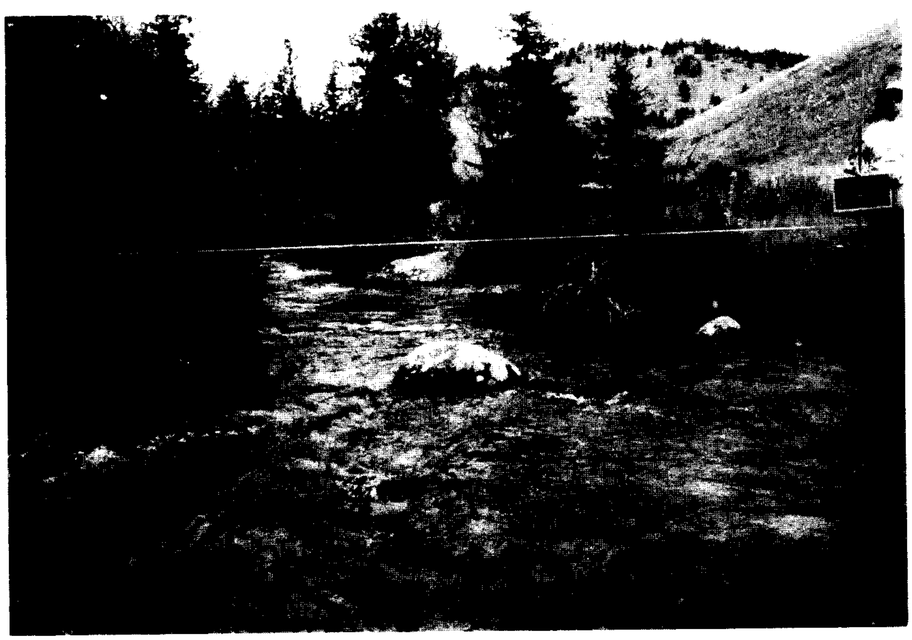


Figure 40. – Cross-section view upstream.

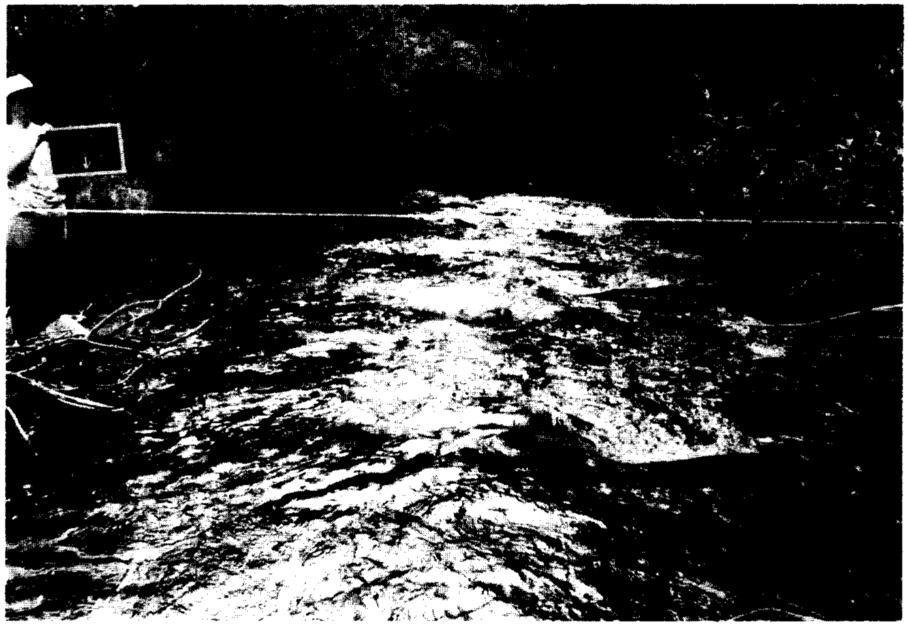


**Figure 41. – Cross-section view downstream.**