A. General

Field notes, also known as measurement documentation, are a written record of a field survey. Measurements are recorded and because they are subject to errors, information about the three error sources is also documented:

- *Natural* - conditions under which the measurements are made.
- *Instrumental* - equipment used to make the measurements.
- *Personal* - who had what role in the measurement process.

Depending on the field operation, additional information may be included such as sketches, explanatory notes, closure checks, etc.

Why manual field notes when most contemporary data collection is done digitally? There are some reasons field notes should still be part of the surveying process.

- For a beginning technician writing down measurements reinforces the field process and provides visualization of the data and running results.
- Some data or information are more easily and effectively documented in a field book than a data collector.
  - Descriptive information, sketches, etc.
  - In a boundary resurvey, the surveyor might record physical evidence descriptions and witness statements (yes, you can record parol statements and have them signed).
- Field notes offer greater flexibility for non-standard measurement situations
  - Digital data collection may lock you into specific measurement procedures.
- Field notes are a tangible physical and permanent measurement record
  - As long as they are protected from the elements, field notes will last forever.
  - Data is more difficult to remove or conceal; alterations are more obvious.
- They are the original measurements and conditions.
  - It is easier to “follow in the footsteps” from field notes since they depict the process as well as the measurements and their quality.
- There are no software compatibility issues.

Field notes do not replace digital data collection but can augment it. Efficient and effective surveying operations can benefit from a hybrid approach, combining the strengths of both platforms.

B. Requirements

Documentation should include enough information for a user to understand the measurements, collection procedure, and assess their quality. It should be stand-alone requiring minimal explanation on the part of the responsible surveyor - data might be used by a third party (such as a CAD technician, design engineer, etc) or long after the original surveyor is gone. To that end, field notes must be:

- Complete - All measurement and support information is recorded.
- Accurate - Field notes should be a true and complete record of the field work performed.
- Understandable - A knowledgeable user should be able to understand the notes and interpret the data.

- Unaltered - While recording mistakes are possible, original data must not be purposely obscured or unjustifiably modified.

C. Physical format

1. Field books

Individual project field notes are generally subsets of a larger series of survey operations and contained in field books. Three main field book types are defined by their method of holding pages together, Figure 1.

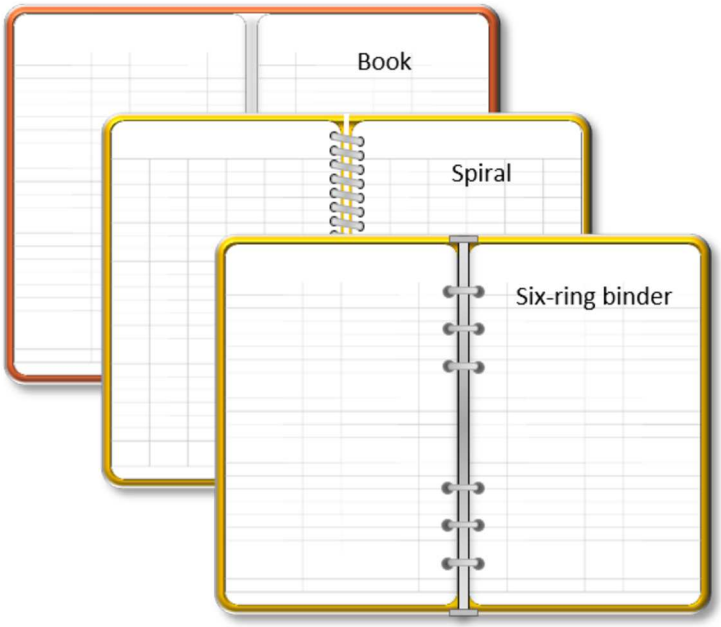


Figure 1
Field Book Styles

Primary characteristics:

- Book - Uses a sewn or glued binding; hard- or soft-cover.
- Spiral bound - Pages are held together with a spiral or comb metal binding which allows the book to be folded back on itself for easier note taking.
- Binder - Loose-leaf pages are held together with two sets of three-ring clips. Its advantage is that the pages can be removed for filing after project completion and can reused with additional paper.

2. Page and Plate

Unlike a traditional book where each side of each sheet is a page, a field book page is the combined left and right sides when the book is laid out flat. Left of the binding is the left plate, on the right is the right plate, Figure 2.

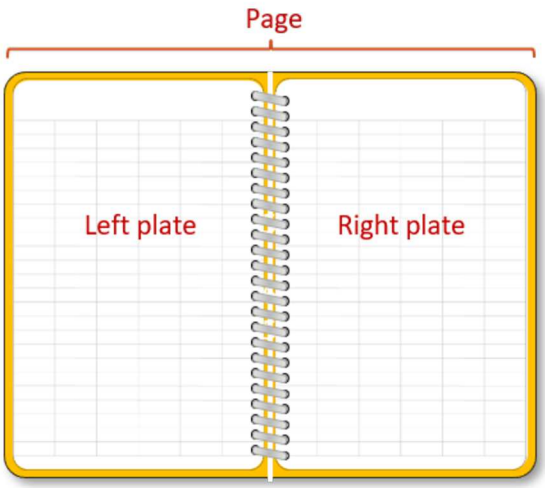
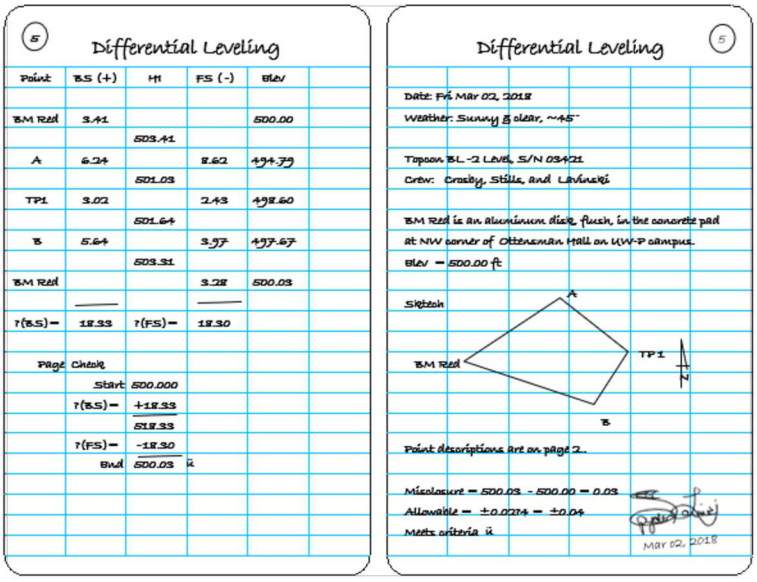


Figure 2
Page and Plates

The left plate is used primarily to record field measurements and preform necessary running calculations. On the right plate is recorded support information: weather, equipment, personnel, sketches, etc. These two plates compliment each other so together are referred to as a page.

Figure 3 shows a page of Differential Leveling field notes.
The left plate contains measurements and running calculations.
Support information on the right plate identifies the weather conditions, equipment, personnel & responsibilities, bench mark description, sketch, and closure computations.
The circled "5" at top left and top right is the page number.



5 Differential Leveling

Point	BS (+)	HI	FS (-)	Elev
BM Rzd	3.41			500.00
		503.41		
A	6.24		8.62	494.79
		501.03		
TP1	3.02		2.43	498.60
		501.64		
B	5.64		3.97	497.67
		503.31		
BM Rzd			3.28	500.03
	———		———	
Σ(BS)=	18.33	Σ(FS)=	18.30	

Page Check
Start 500.000
Σ(BS)= +18.33
518.33
Σ(FS)= -18.30
End 500.03 ü

Differential Leveling 5

Date: Fri Mar 02, 2018
Weather: Sunny & clear, ~45°
Topcon BL-2 Level, S/N 03421
Crew: Crosby, Stills, and Lavinski
BM Rzd is an Aluminum disk, flush, in the concrete pad at NW corner of Ottenman Hall on UW-P campus.
Elev = 500.00 ft
Sketch
A
BM Rzd
TP1
B
Point descriptions are on page 2.
Misclosure = 500.03 - 500.00 = 0.03
Allowable = ±0.02√4 = ±0.04
Meets criteria ü
Mar 02, 2018

Figure 3
General Page Format

3. Plate Styles

There are many different ways to organize field book pages based on survey operation. The Differential Level notes in Figure 3 is one way collection can be structured, there are others which we'll look at in a bit.

To provide field note organization flexibility, a number of different plate styles are available, Figure 4. These differ primarily in the number of printed columns on each plate. Figure shows three common styles.

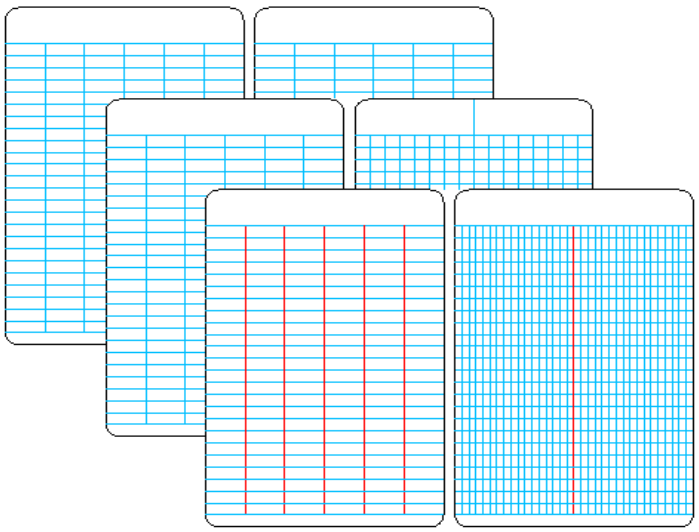


Figure 4
Plate Styles

Because the right plate for one page is the back of the left plate for the next page, the front and back of a sheet will not necessarily be the same style.

A bound field book (sewn/glued and spiral) has a single sheet style throughout; a binder field book can be configured with any style, even mixed.

D. Best Practices

1. Field book Setup

Just as individual field notes must be organized, so must the field book itself. Data in the book should be easy to find and contact information provided should questions come up.

a. Title Page: Project or Job

Use the right plate inside the front cover, Figure 5, for field book identification. A project-based field book should include project information (name, ID, etc), company, crew chief, and appropriate contact information. Figure 6 is a title page from a set of USPLS township subdivision field notes.

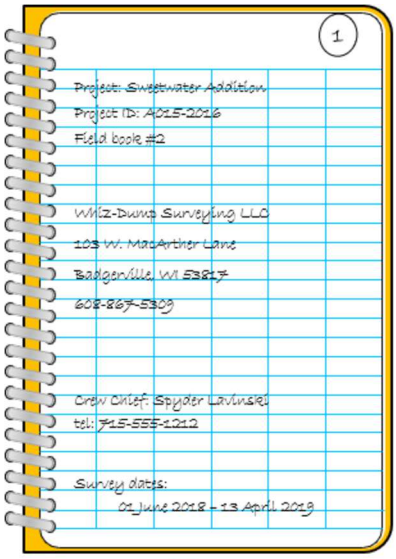


Figure 5
Title Page

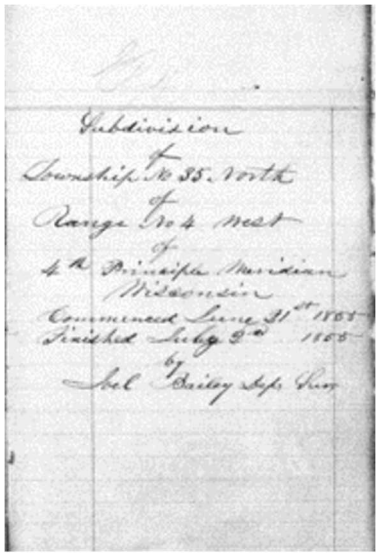


Figure 6
USPLS Title Page

b. Table of Contents

A Table of Contents (ToC) is begun on the left plate of page 1, Figure 7. Projects are identified by page title and are added to the ToC as they are completed.

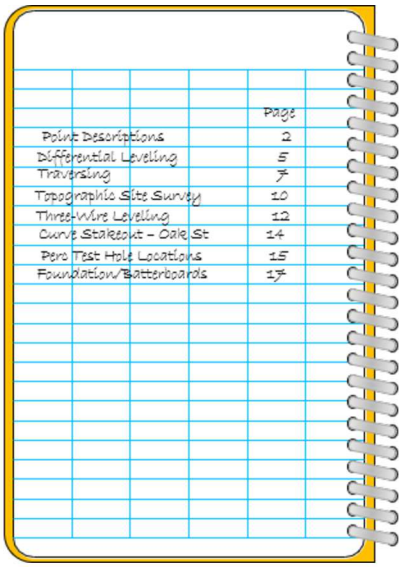


Figure 7
Table of Contents

c. Use consistent page format

Surveying field operations are numerous and varied, consequently there are no specific rigid field note formats. Most Surveying textbooks show example note formats for different surveying processes which can be adopted or modified according to specific needs. Whatever format is used for a particular operation, it should allow for accurate data capture and be used consistently throughout the field book.

d. Do not remove pages or plates

Recording mistakes will happen and appropriate ways to deal with them are discussed in the next section. If an entire plate or page is riddled with errors, it is very tempting to remove it, especially when using a binder field book because page removal is easy. Pages are relatively easy to remove from a spiral bound field book also, while it is harder to do it cleanly with a sewn/glued book.

Sheets should not be removed because:

- Page removal is alteration of original data.
- The left plate is the back of the previous right plate and vice versa, Figure 8. Removing a sheet

can have unintended consequences.

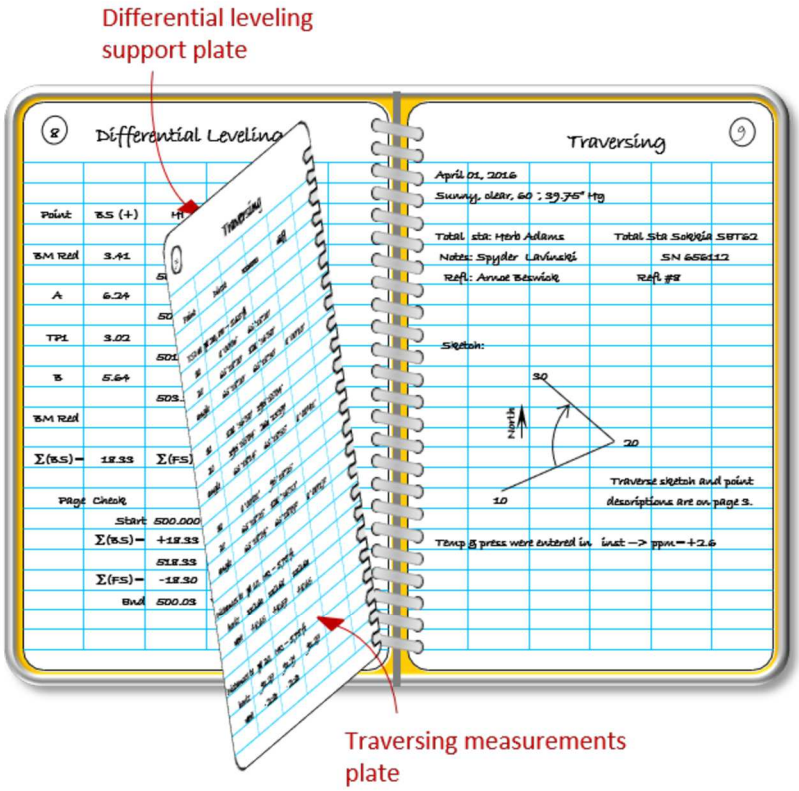


Figure 8
Page Removal Issue

2. Taking notes

Taking notes can be the most frustrating part of surveying because the note taker is subject to the elements and has a very small writing surface on which to work. Added to that are some common writing habits which must be modified.

a. Use a pencil with a hard sharp lead.

Field note paper is typically water resistant (not water proof) with a tighter bond than general writing paper. Ink has a tendency to smear as does regular hardness 2H pencil lead on this field note paper. For field notes, 4H lead is generally hard enough to minimize smearing, even in the presence of misting. Harder lead (6H and up) is too light and requires so much pressure that it indents the paper making recording on both sides problematic.

A simple test can be used to determine if a lead is hard enough: On the last page of the field book, print a line of numbers and letters. With a dry thumb, press down on and rub firmly across the printed line. If there is any smearing, go up one hardness level. Slight smearing with a dry thumb can translate to substantial smearing in humid conditions.

Rather than carry a wooden pencil with a knife or sandpaper for sharpening, a mechanical pencil with a

0.5 mm lead size works well.

b. Legibility

Survey notes are printed, not written in script. Unlike normal writing, note keeping must be done more slowly and deliberately to ensure legibility. Some common problems with hurried writing are 4s that look 9s (and vice versa), disappearing decimal points, and text which is hard to decipher. We are a society used to texting and writing notes legibly in longhand is fast becoming a lost art.

c. Page and plate titles

A title allows the reader to recognize the type of survey data on the page. It also serves as the Table of Contents entry.

d. Record immediately

Measurements are recorded as they are made. They should not be written on scratch paper after which the "best" measurements are copied to the field notes.

e. Use reasonable and consistent accuracy

The measurements should be recorded to the resolution level of the instrumentation used. Most contemporary equipment have digital displays - record the values as displayed. Should analog readings be made, such as a reading a level rod, record to the smallest discrete division.

Keep in mind significant figures. Do not imply accuracy not attainable with the equipment (analog) nor degrade accuracy by leaving off significant zeros (analog or digital). For example, if a Total Station displays a reading of 45°10'00", do not record it as 45°10'; the 00" portion of the angle is significant. If a level rod reading is 4.10 ft, do not record it as 4.1 ft. Written numbers convey both magnitude and accuracy.

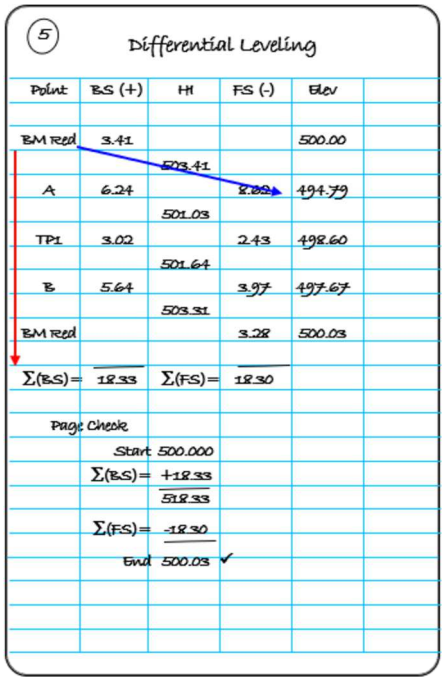
When recording numeric values less than 1, always include the 0 to the left of the decimal point. With a hard lead, a decimal point may be easy to miss so .75 may be misread as 75. Including the 0 serves as a visual notice and does not change the accuracy of the number.

f. Layout reflects measurement order

The layout of survey notes reflects the order in which measurements are made. Data collection generally runs top-down and left-right.

For example, in the Differential Leveling notes of Figure 10, the circuit ran from BM X to A to TP1 to B to BM X (red arrow). The readings (and running calculations) go left to right across the plate between the points (blue arrow).

Figure 9 is a copy of the original notes for running the line north between Sections 20 and 21, T3N, R1W, 4th PM., then east between Sections 16 and 21. Even though the survey took place in 1834, the process and measurements are easy to interpret.



5 Differential Leveling

Point	BS (+)	HI	FS (-)	Elev
BM Red	3.41			500.00
		503.41		
A	6.24		8.62	494.79
		501.03		
TP1	3.02		2.43	498.60
		501.64		
B	5.64		3.97	497.67
		503.31		
BM Red			3.28	500.03
Σ(BS)=	18.33	Σ(FS)=	18.30	

Page Check
Start 500.000
Σ(BS)= +18.33
518.33
Σ(FS)= -18.30
End 500.03 ✓

Figure 10
Measurement Flow

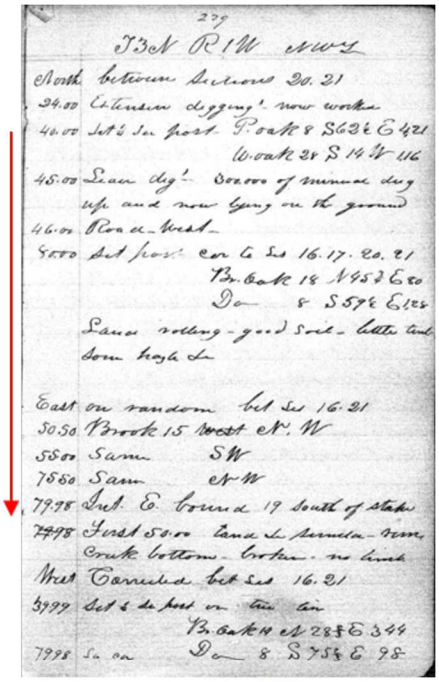


Figure 9
USPLS Section Line Flow

g. Running calculations

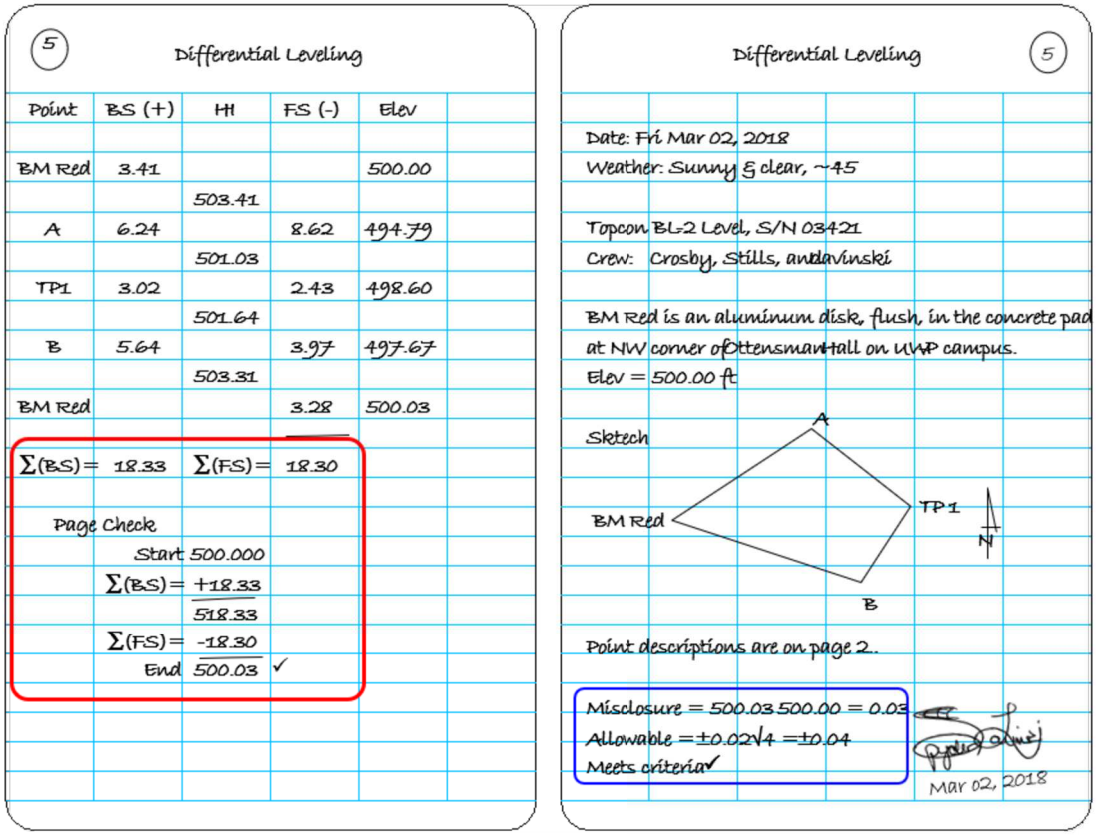
Most field survey operations include some running calculations made using the measurements. This allows the surveyor to check measurement consistency, identify errors, or check if final closure criteria has been met. Running computations should be performed as the survey progresses.

In the Differential Leveling notes of Figure 11, measurements are recorded in the BS and FS columns. After the beginning elevation, everything else is computed as backsight (BS) and foresight (FS) readings are made. When the circuit is completed, the measured closing elevation can be compared against its known value to determine circuit quality.

h. Math Checks

Hand-in-hand with running computations are math checks. These help identify computational errors and potentially isolate measurement errors. Two different math checks are indicated in the Differential Leveling notes in Figure 11:

- Page check, red, which verifies the overall running calculations,
- Closure check, blue, for overall measurement accuracy.



5 Differential Leveling

Point	BS (+)	HI	FS (-)	Elev
BM Red	3.41			500.00
		503.41		
A	6.24		8.62	494.79
		501.03		
TP1	3.02		2.43	498.60
		501.64		
B	5.64		3.97	497.67
		503.31		
BM Red			3.28	500.03
Σ(BS)=	18.33	Σ(FS)=	18.30	

Page Check
Start 500.000
Σ(BS)= +18.33
518.33
Σ(FS)= -18.30
End 500.03 ✓

Differential Leveling 5

Date: Fri Mar 02, 2018
Weather: Sunny & clear, ~45

Topcon BL-2 Level, S/N 03421
Crew: Crosby, Stills, and Lavinski

BM Red is an aluminum disk, flush, in the concrete pad at NW corner of Ottensman Hall on UWP campus.
Elev = 500.00 ft

Sktech

Point descriptions are on page 2.

Misclosure = 500.03 500.00 = 0.03
Allowable = ±0.02√4 = ±0.04
Meets criteria ✓

Mar 02, 2018

Figure 11
Differential Leveling Math Checks

i. Correcting mistakes

If a recording mistake is made, it should be struck out with a single line and the correction written above. For example: 415.57 was recorded instead of 415.75 Figure 12 shows three different ways to "correct" the error. The first two should not be used because they deface the notes. The correct way is to draw a single line through the incorrect number and write the correct number above it.

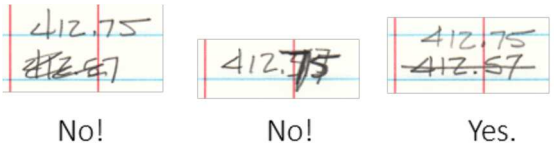


Figure 12
Correcting a Recording Error

Surveying field notes are generally spread out providing sufficient room to make corrections without crowding the notes.

Above all, DO NOT ERASE in field notes, Figure 13. A pencil is used for field notes to minimize smearing, not to allow erasing mistakes. A Surveyor's field notes are one of the few documents recorded in pencil allowed as evidence in court. An erasure is an alteration of original data and could affect credibility of the entire field book.

Erasing is a very tough habit to break, especially since it's common in other aspects of writing and we've done it all our lives - we often do it automatically without giving it a second thought. An effective way to eliminate erasing is to remove the eraser from the pencil used for note keeping.

Figure 13
Do Not Erase!

If there are multiple mistakes on a page (which can easily happen if a reading error is made and subsequent running calculations are affected), making all the corrections could make the data and computations harder to understand, Figure 16.

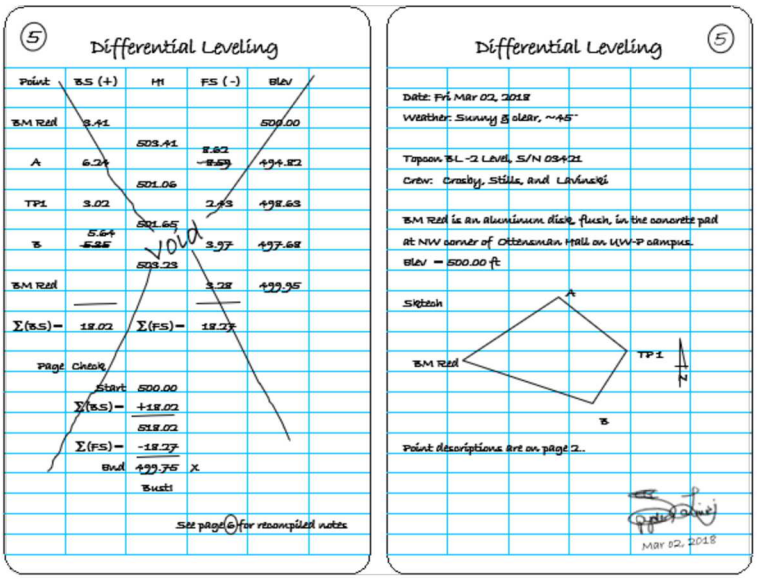
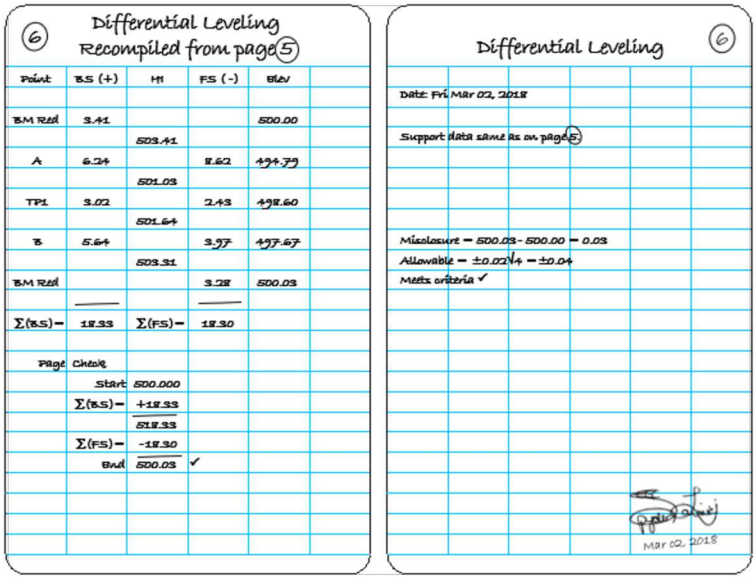


Figure 14
Voided Page

Instead, void the entire page, Figure 17, and measurement data which can salvaged can be copied to a new page and the project completed on the new page, Figure 18.

It's important to connect the two pages:

- The voided page should identify the page number of the recompiled notes.
- The recompiled notes should identify where the data came from.



Differential Leveling
Recompiled from page 5 (6)

Point	BS (+)	HI	FS (-)	Elev
BM Rod	3.41			500.00
		503.41		
A	6.24		8.62	~~494.79~~
		501.03		
TP1	3.02		2.43	~~498.60~~
		501.64		
B	5.64		3.37	~~497.67~~
		503.31		
BM Rod			3.28	500.03
	———		———	
Σ(BS)=	18.33	Σ(FS)=	18.30	

Page Check
Start 500.000
Σ(BS)= +18.33
518.33
Σ(FS)= -18.30
End 500.03 ✓

Differential Leveling (6)

Date: Fri Mar 02, 2018

Support data same as on page 5

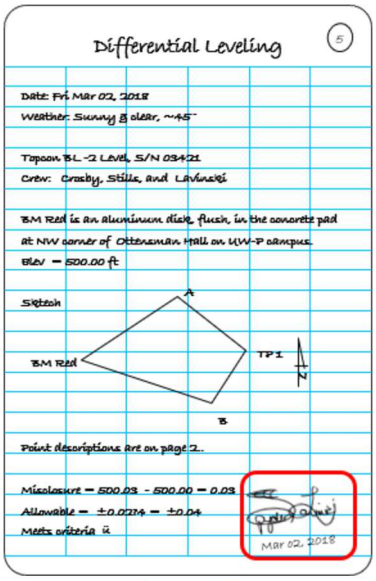
Misclosure = 500.03 - 500.00 = 0.03
Allowable = ±0.02√4 = ±0.04
Meets criteria ✓

Mar 02, 2018

Figure 15
Recompiled Notes

j. Sign and date notes

Upon completion, each field note page should be signed and dated by the note keeper, Figure D-10.



Differential Leveling (5)

Date: Fri Mar 02, 2018
Weather: Sunny & clear, ~45°

Topcon BL-2 Level, S/N 03421
Crew: Crosby, Stills, and Lavinski

BM Rod is an aluminum disk, flush, in the concrete pad at NW corner of Ottesman Hall on UW-P campus.
Elev = 500.00 ft

Sketch

Point descriptions are on page 2.

Misclosure = 500.03 - 500.00 = 0.03
Allowable = ±0.02√4 = ±0.04
Meets criteria ✓

Mar 02, 2018

Figure 16
Signature and Date

E. Digital Data Collection and Field Notes

Figure 17
Combined Collection

An example of using field notes with digital data collection is a topographic survey. Most data collectors make field setup, measurements, and reductions relatively simple. Once the operator sets up and orients the instrument, the rest is generally point, press a button, and enter a feature code. The data collector does the rest, even creating the map.

Two common errors in topographic mapping are using an incorrect feature code and the instrument setup is disturbed.
Depending on the software, editing a feature code may or may not be simple - sometimes it's easier to re-shoot the point.
A disturbed instrument set up, however can be a more difficult problem that may not be apparent until all the data is combined.

Figure 18 shows how manual recorded field notes can be used to deal with these issues.

The point with the incorrect feature code can be recorded along with what its correct feature is.

A backsight check should be made periodically to verify instrument orientation. The point ID when the check is made is recorded. If the instrument is misoriented, the notes make it easier to determine which points are affected and by how much.

Other feature comments (eg, tree species and size) can be recorded and point ID ranges for non-point data (eg, 1020-25 north edge of sidewalk). Some one else may use the data to generate a map or surface and these comments may help interpret the data correctly.

Have you ever:

- included the elevation of a fire hydrant top in a surface model?
- encountered a feature that's not in the code list?

Other comments and descriptions can be recorded as well as support information.

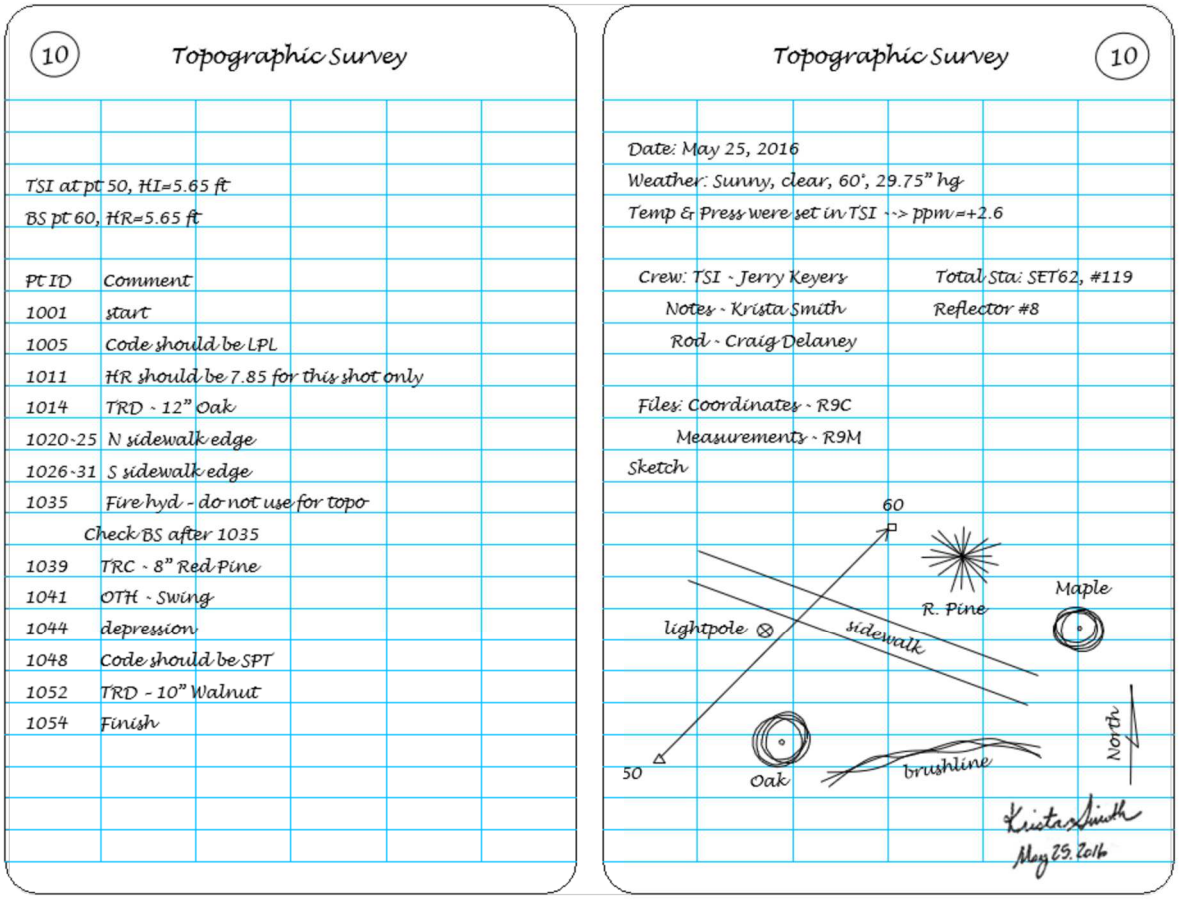
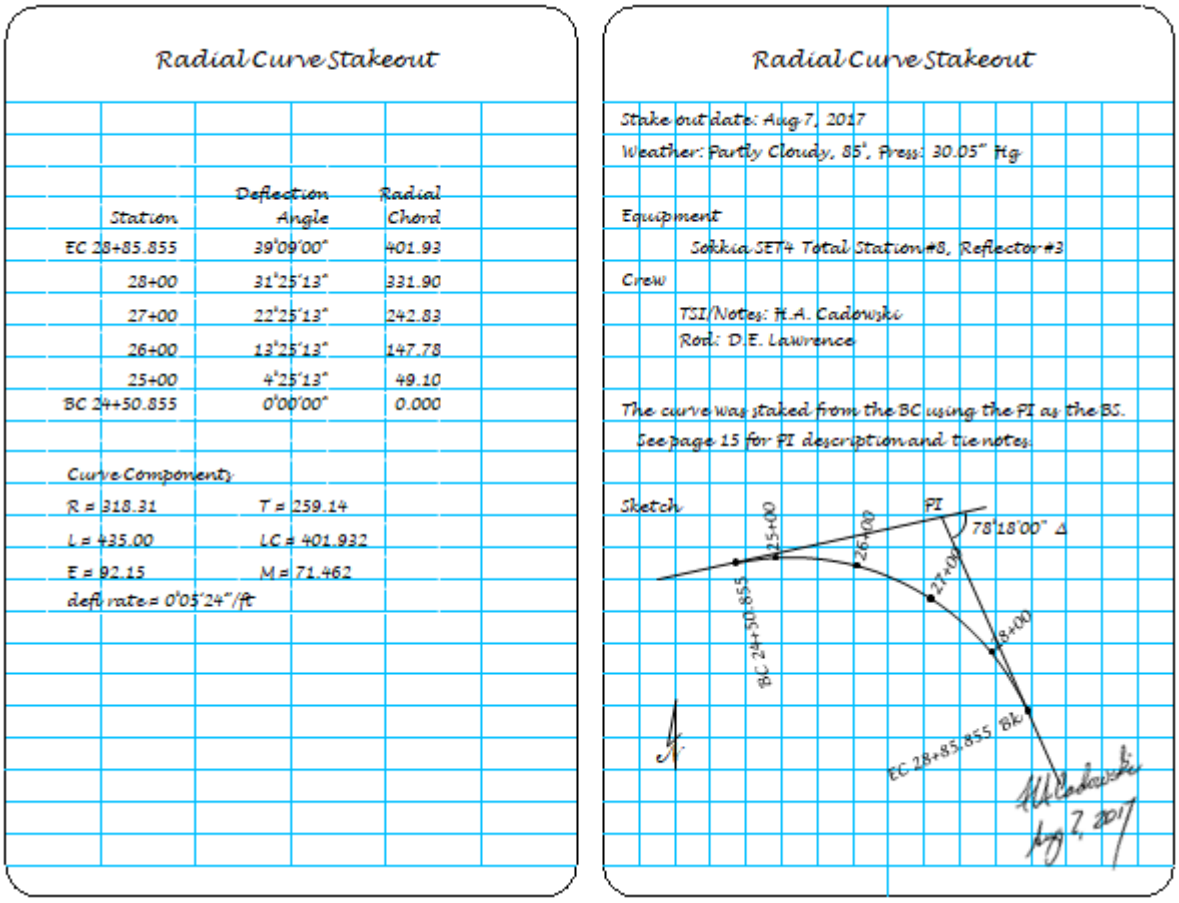


Figure 18
Topographic Field Notes

F. Not Just for Collecting Data

In addition to collecting data, field notes have been traditionally used for infrastructure stake out; alignments, buildings, etc. They are still used extensively in construction applications as they can be included in project documentation.

A common operation was curve stake out. Remember all those horizontal curve tables you computed? Basically those were the curve stake out notes, Figure 19.



Radial Curve Stakeout

Station	Deflection Angle	Radial Chord
EC 28+85.855	39°09'00"	401.93
28+00	31°25'13"	331.90
27+00	22°25'13"	242.83
26+00	13°25'13"	147.78
25+00	4°25'13"	49.10
BC 24+50.855	0°00'00"	0.000

Curve Component:

R = 318.31 T = 259.14

L = 435.00 LC = 401.932

E = 92.15 M = 71.462

defl rate = 0°05'24"/ft

Figure 19
Curve Stakeout Notes

Notice that the curve notes appear upside down with the beginning of the curve (BC) at the bottom of the table. Organized in this fashion, the curve notes visually correspond to curve as seen from the BC.

Another stake out example is sanitary sewer. Prior to field work, the finished pipe invert elevations (Grade Elev) are determined based on the pipe slope., Figure 20.

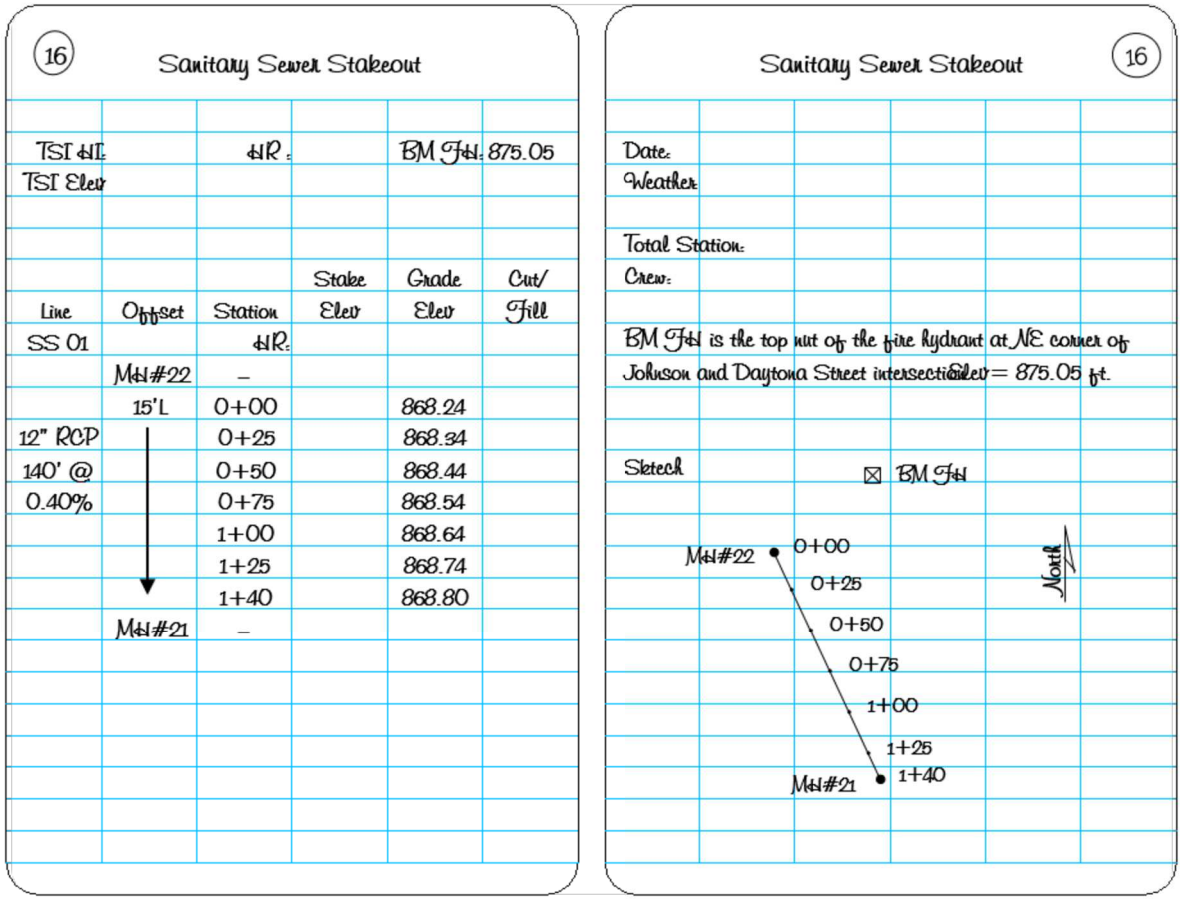


Figure 20
Sanitary Sewer Stakeout Notes

In the field stakes are placed, offset from the pipe center line, and their elevations measured and recorded (*Stake Elev*). From the *Grade* and *Stake* elevations the cut or fill depth (*Cut/Fill*) is determined and entered in the notes and on the respective stake. Part of the field notes are precomputed, part completed in the field.

G. Summary

Although the prevalent data collection and staking technology is digital, there is still a role for field notes. Because they have no single fixed format, they are highly adaptable to different situations. They are compatible with any software, hardware, and instrument platform. Although not the most efficient method for collecting large data amounts, they are good augmentation tools for digital collectors.