Survey Basics

PennState
Center for Dirt and Gravel Road Studies

Pennsylvania SCC
State Conservation Commission

Survey Objectives – DGLVR Program

1. Project Planning – check slopes and elevations
- Slope for cross-pipe installation
- Road fill depths and profile
- Site assessment for stream crossing replacement

2. Construction oversight / inspection
- Check slopes and elevations *during* installation
- ESM / drainage projects
- Stream crossing replacement projects
- Determine adjustments needed to meet planned elevations (up/down)

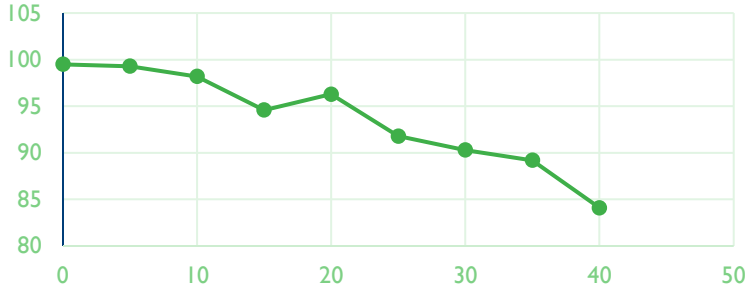
3. Project Completion – verify final slopes and elevations
- As-built survey

Survey Equipment - Instruments

Level

- Laser Level
- Dumpy Level
- Hand Level

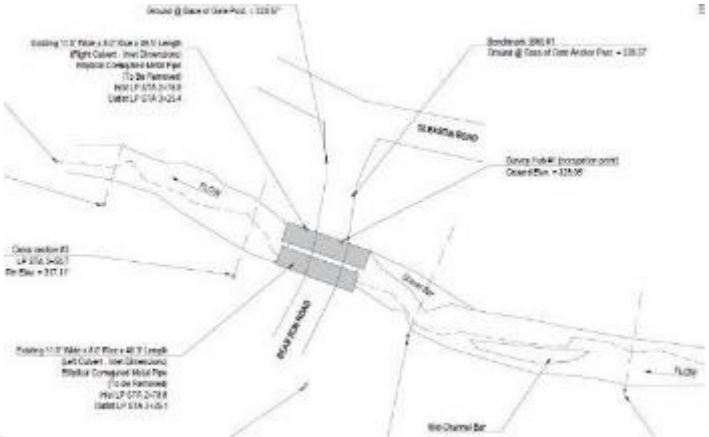
Typically used to generate 2-dimensional *profile* survey (distance and elevation)



Positional

- Total Station
- GPS

Generates 3-dimensional survey in *profile and plan view*
(distance, elevation, and position)



Survey Equipment - Instruments

Laser Level

- Transmitter & Receiver
- Receiver mounts to a survey rod (stadia)
- Most transmitters are self leveling
- Some can do slope
- Can be used by one person
- Needs clear line of site
- Relatively inexpensive ($1,000 - $1,500.00)
- Easy to learn and operate
- Survey team can work close together, away from the instrument (communication)

Survey Equipment - Instruments

Hand Level / Dumpy Level

- Quick and easy to use
- Inexpensive
- Must be leveled manually
- Not as accurate as other instruments
- Need at least 2 People
  - 1 for Rod & 1 for Level
- Instrument must be sighted manually
  - Survey team cannot work close together

Survey Equipment - Instruments

GPS Survey

- Often preferred by Professional Surveyors
- High accuracy
- Elevation, distance and position (3 dimensional)
- Expensive
  - Most cost-effective when frequently used
- Usually operated by 1 person
- Minimal setup in the field makes survey quicker
- Field data can be corrected later in the office

Survey Equipment - Instruments

Total Station

- Most common for professional surveyors
- High accuracy
- Elevation, distance, position (3 dimensional)
- Expensive
  - Most cost-effective when frequently used
- Must be leveled manually
- Somewhat complex to set up in field
- Requires multiple people to operate
- Instrument must be sighted manually
  - Survey team cannot work close together

Survey Basics - Terms

Benchmark (BM) – A point of known or assumed permanent elevation.

- Brass pin, nail in a tree, or cap in concrete
- A lone metal stake

NRCS Part 650 Engineering Field Handbook
Chapter 1 - Surveying

Turning Point (TP) – A point on which the elevation is determined in the process of leveling, but which is no longer needed after necessary readings have been taken.

- Should be located on a firm object such as a stone, fence post, etc.

Survey Basics - Terms

Backsight (BS) - A rod reading taken on a point of known elevation. It is the first reading taken on a Benchmark or Turning Point.

Foresight (FS) – Rod reading taken on any point on which an elevation is to be determined. Only one BS is taken during each setup. All other readings are FS.

Height of Instrument (HI) – The elevation of the line of sight. Determined by adding the BS rod reading to the known elevation of the Benchmark or Turning Point on which the BS was taken.

NRCS Part 650 Engineering Field Handbook
Chapter 1 - Surveying

Survey Basics – Laser Level Setup

Attach the Instrument to the tripod

- Typically mounts with set bolt in top plate of tripod, attaches to bottom of instrument

Choose an Instrument setup location

- Walk through the survey area
- Find (or establish) a benchmark
- Initial setup needs line of sight to benchmark and start of survey
- Solid Ground – No Movement!
- Instrument must be higher than points to be surveyed

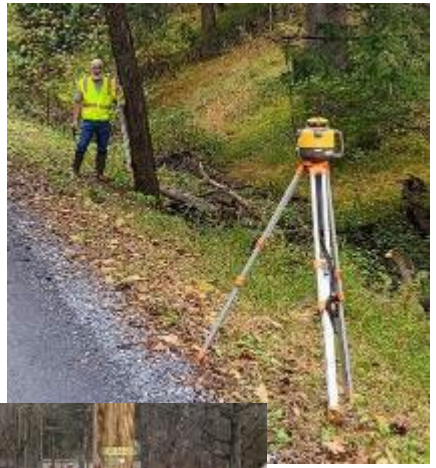
Survey Basics – Benchmarks

<u>The benchmark should be:</u>

- Unlikely to be moved or disturbed
- Accessible (line of sight) to the instrument setup location
- Clearly marked, painted, flagged, etc.
- Easily found again in the future by someone else

<u>Some examples:</u>

- Concrete features, utility poles, plaques or markers
- Set a rebar pin, wood stake, mag nail in tree



Additional Survey Equipment

- Tape Measure
  - Recommend 300 ft. tapes
- Field Books
  - Write everything down in the field.
- Flagging, Stakes, Hammer, Marker, Paint, etc.

- Survey (stadia) rod
  - Marked in either decimal feet or feet/inches
  - Decimal feet is preferred
  - Can be converted to feet/inches (0.1 ft = 1.2 inch)

Survey Basics – Receiver and Survey Rod

Attach the Receiver to the Rod

- Typically mounts with a set screw on the side of mounting bracket
- Best to mount near the top of the upper rod section
- Secure the bracket tightly
- Re-attach the bracket in the same location

Additional Survey Equipment

Survey (stadia) rod

- Decimal feet is preferred
- Can be converted to feet/inches
  (0.1 ft = 1.2 inch)

- Available in multiple lengths
  - 16’ minimum is recommended
  - 25’ is preferred
- Rod must be marked on front & back

Reading the Survey Rod

4.13

Receiver is *not* mounted to top of rod
READ FRONT OF ROD!

Receiver is mounted to top of rod

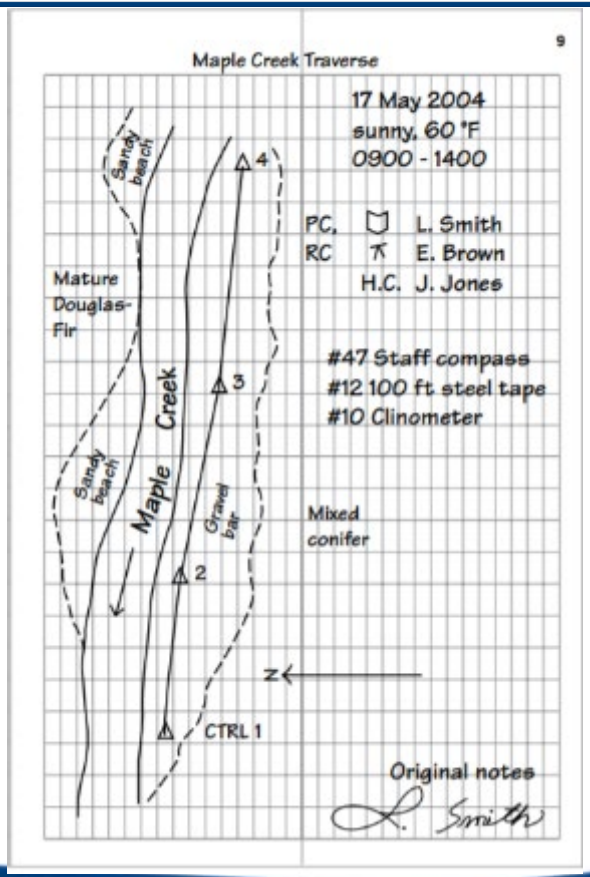
10.47

READ BACK OF ROD!

Survey basics – Notebook Setup

Setting Up Field Notebook

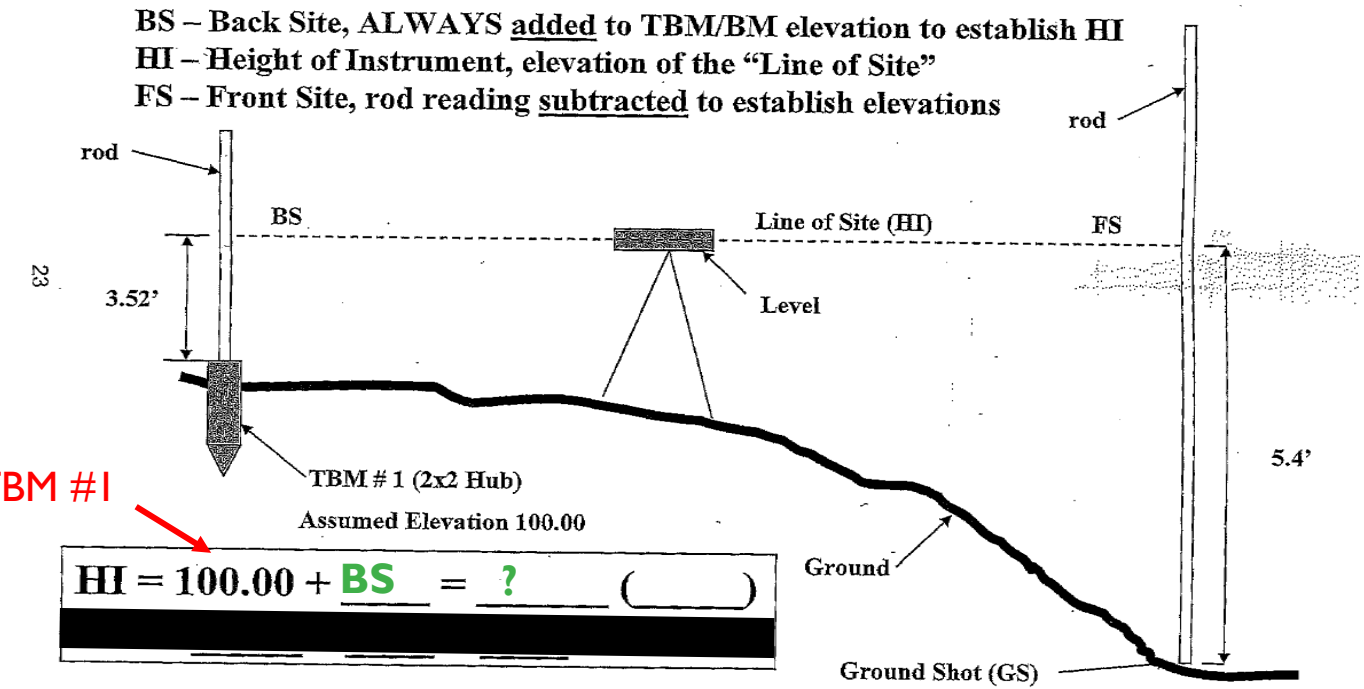
- Record Site Location
- Project Name
- Address
- People Present & Task
- Date
- Field Conditions
- Equipment Used
- North Arrow



Survey basics – Notebook Setup

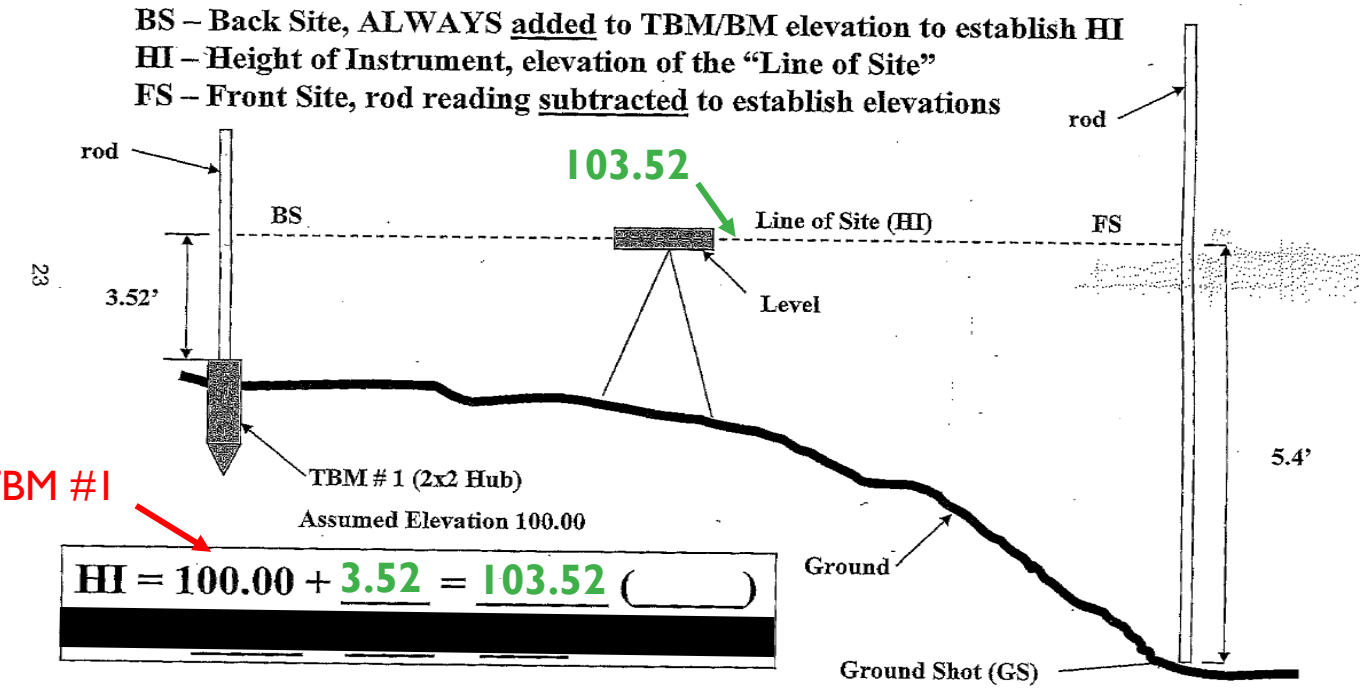
ST	BS	HI	FS	ELEV	NOTE

Setting up - Height of Instrument (HI)



Elevation of TBM #1

Setting up - Height of Instrument (HI)

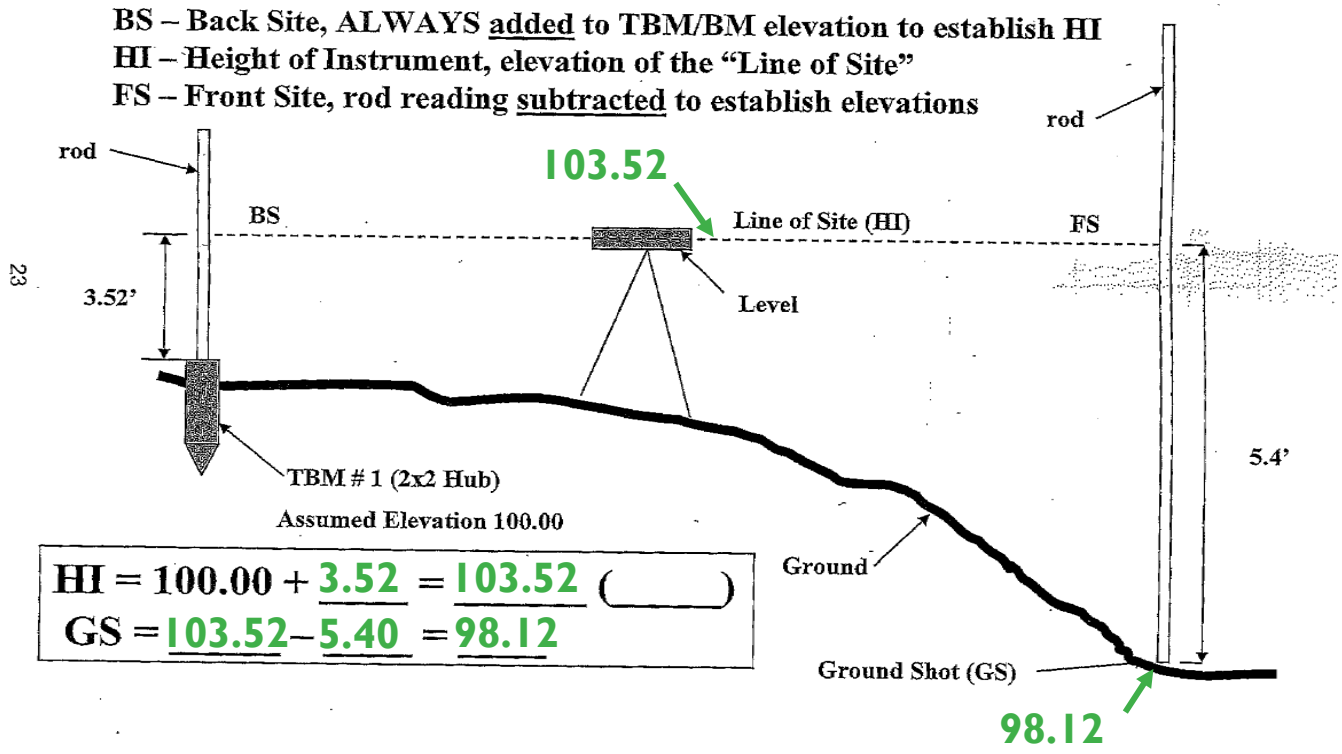


Survey Basics – Notebook Setup

BM#1 Located on top of 2x2 hub along south side of roadway, about 15' west of driveway entrance. Marked with orange paint.

ST	BS	HI	FS	ELEV	NOTE
BM #1	3.52	103.52		100.00	Top of 2x2 Hub

Survey Basics – Foresight & Elevation



Survey Basics – Notebook Setup

Remember:

Always ADD the backsight to an elevation to calculate HI

Always SUBTRACT the foresight from HI to calculate an elevation.

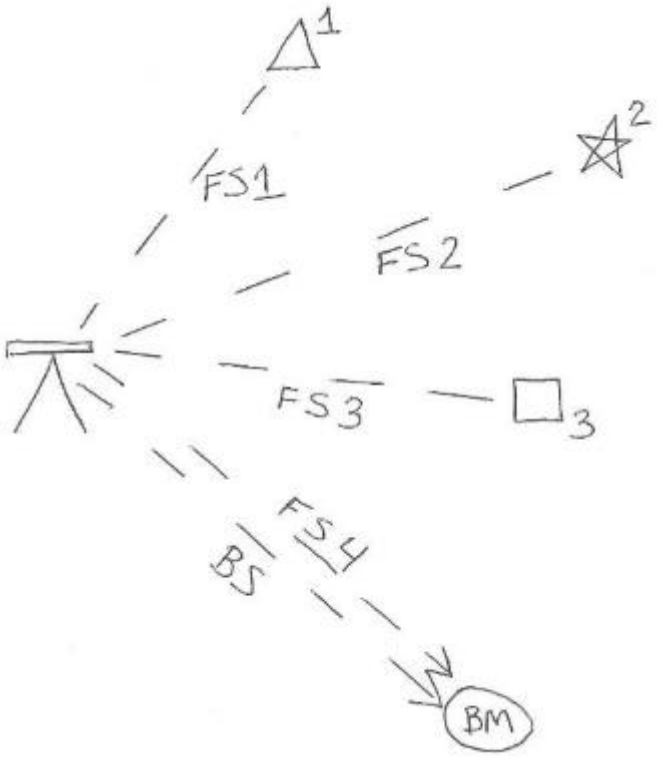
For every survey point collected, must have at least a Station, Foresight (or Backsight), and a Note

ST	BS	HI	FS	ELEV	NOTE
BM #1	3.52	103.52		100.00	Top of 2x2 Hub
GS			**5.40**	**98.12**	Ground at bottom of slope

Survey Basics - Survey Loop

Process:

- Instrument & Notebook setup
- Establish a benchmark
- Collect a backsight on the benchmark to establish HI
- Collect FS at each point of interest
- Calculate ELEV for each point of interest
- To close the survey, collect FS at the original benchmark
- Verify ELEV of benchmark



Survey Basics - Survey Loop

BS to Benchmark to establish HI

BM= 100.00 BS= 4.22 HI= 104.22

BM#1 Located on top of concrete base of light post closest to parking lot

ST	BS	HI	FS	ELEV	NOTE
BM #1	4.22	104.22		100.00	Concrete base of light post

Survey Basics - Survey Loop

FS to Feature #1

FS= 4.64 ELEV= 99.58

BM#1 Located on top of concrete base of light post closest to parking lot

ST	BS	HI	FS	ELEV	NOTE
BM #1	4.22	104.22		100.00	Concrete base of light post
1			**4.64**	**99.58**	**Corner of concrete curb**

Survey Basics - Survey Loop

FS to Feature #2

FS= 4.57 ELEV= 99.65

BM#1 Located on top of concrete base of light post closest to parking lot

ST	BS	HI	FS	ELEV	NOTE
BM #1	4.22	104.22		100.00	Concrete base of light post
1			4.64	99.58	Corner of concrete curb
2			**4.57**	**99.65**	**Base of light by pool**

Survey Basics - Survey Loop

FS to Feature #3

FS= 7.34 ELEV= 96.88

BM#1 Located on top of concrete base of light post closest to parking lot

ST	BS	HI	FS	ELEV	NOTE
BM #1	4.22	104.22		100.00	Concrete base of light post
1			4.64	99.58	Corner of concrete curb
2			4.57	99.65	Base of light by pool
3			**7.34**	**96.88**	**Catch basin grate**

Survey Basics - Survey Loop

Turning Point (TP) #1

FS= 4.34 BS= 4.29 HI= 99.65

BM#1 Located on top of concrete base of light post closest to parking lot

ST	BS	HI	FS	ELEV	NOTE
BM #1	4.22	104.22		100.00	Concrete base of light post
1			4.64	99.58	Corner of concrete curb
2			4.57	99.65	Base of light by pool
3			7.34	96.88	Catch basin grate
TP#1			**4.34**	**99.88**	**Manhole cover**
	4.29	**104.17**			**Manhole cover**

Survey Basics - Survey Loop

Turning Point (TP) #1

FS= 4.34 BS= 4.29 HI= 99.65

ST	BS	HI	FS	ELEV	NOTE
TP#1			4.34	99.88	Manhole cover
	4.29	104.17			Manhole cover

Survey Basics - Survey Loop

FS to Feature #4

FS= 7.23 ELEV= 96. 94

BM#1 Located on top of concrete base of light post closest to parking lot

ST	BS	HI	FS	ELEV	NOTE
BM #1	4.22	104.22		100.00	Concrete base of light post
1			4.64	99.58	Corner of concrete curb
2			4.57	99.65	Base of light by pool
3			7.34	96.88	Catch basin grate
TP#1			4.34	99.88	Manhole cover
	4.29	104.17			Manhole cover
4			**7.23**	**96.94**	**Catch basin near hotel**

Survey Basics - Survey Loop

FS to BM#1 (Closing the loop)

FS= 4.15 ELEV= 96. 94

BM#1 Located on top of concrete base of light post closest to parking lot

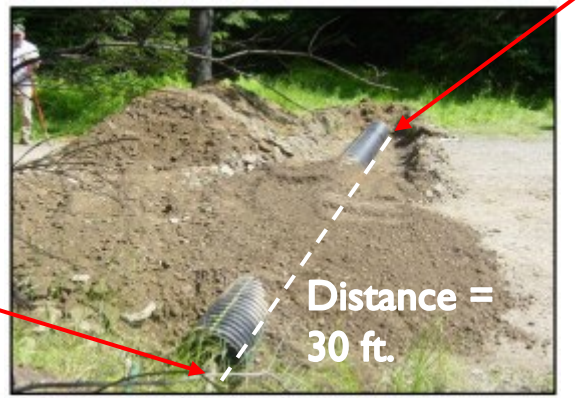
ST	BS	HI	FS	ELEV	NOTE
BM #1	4.22	104.22		100.00	Concrete base of light post
1			4.64	99.58	Corner of concrete curb
2			4.57	99.65	Base of light by pool
3			7.34	96.88	Catch basin grate
TP#1			4.34	99.88	Manhole cover
	4.29	104.17			Manhole cover
4			7.23	96.94	Catch basin near hotel
BM#1			**4.15**	**100.02**	**Close loop @ BM #1**

Survey Basics – Determining Slope

Process:

- Set up and level the instrument
- Measure a FS (or ELEV) at the start point and the end point
  - Basic slope measurement can be performed without a benchmark
- Measure distance between start point and end point (tape measure)
- Calculate slope
  - (Elev. Change / distance) or (rise / run)

Elev. Change = 5.84 – 5.21= **0.63 ft**
Distance = **30 ft**
Slope = 0.63 / 30 = **0.021 (2.1%)**



Survey Basics – Construction Oversight

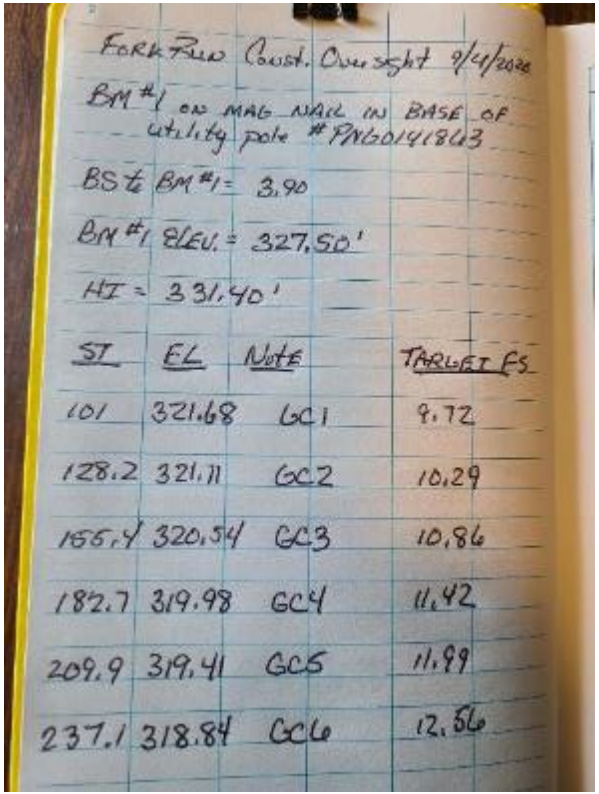
Process:

Translate design elevations to rod readings (FS)

- Create a ST / EL list for points of interest
- Set up the instrument and notebook
- Record BS to a benchmark (known elevation)
- Calculate Height of Instrument

  (HI = BM + BS)
- Create a list of Target FS for points of interest

  (Target FS = HI – EL)



Survey Basics – Construction Oversight

Reading the Rod

- If the rod reads higher than the Target FS, the point of interest is too low
- If the rod reads lower than the Target FS, the point of interest is too high

FS = 9.62 Target FS = 10.30

Point is 0.68 ft too high, and must be lowered

FS = 7.48 Target FS = 6.15

Point is 1.33 ft too low, and must be raised up

Survey Basics

QUESTIONS?