Using a Surveyor's Level to Generate a Topographical Map

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This application note describes the process of using a surveyor's level for generating a topography (topo) map. The site survey described below uses San Francisco's Yerba Buena Gardens as a site for recording relative elevations over a specific area. With these relative elevations organized into a grid, a topographical map can be created.

***Figure 1**: Surveyor's level*

Equipment: (most available from Tool Lending Library):
Surveyor's Level
- Level Tripod
- Leveling Rod
- Compass
- 100' Tape Measure
- Notebook and Pencil

Procedure:
Step 1: Find a Reference Point (Benchmark Elevation)
Step 2: Set up the Surveyor's Level
Step 3: Reading the Leveling Rod
Step 4: Taking Readings
Step 5: Make a Grid Over the Chosen Plot
Step 6: Making Sense of the Collected Data
Step 7: Drawing Topography Lines

Step 1: Find a Reference Point (Benchmark Elevation)

1. **Establish a reference point, also known as the benchmark elevation.** A list of official benchmark elevations in San Francisco is available from the Bureau of Street Use and Mapping. (located at 875 Stevenson Street, Room 460 /// San Francisco, CA. 94103 /// 415.554.5810). The nearest benchmark to the plot is the intersection of 4th and Mission Street. (***Figure 2***).

CORNER	DESCRIPTION OF BENCHMARK	ELEVATION
LOCATION: 04TH ST & MISSION ST	RECORD NO. 415	
BOX: 3 COMMENTS: none		
DATE: FEBRUARY 1985	SURVEYOR: SCOTT BOOK: 479 PAGE: 56	
NE	.. crow cut outer rim SWI	... 23.062
NE	.. 3 cuts low stop cock fire hydrant	... 25.158
NW	.. crow cut outer rim SWI	... 23.360
NW	.. Letter "O" in "OPEN" top HPFS hydrant	... 26.663
SW	.. + cut top conc wall 4' up	... 27.949
SW	.. + cut SSW conc curb return	... 23.757
SE	.. Letter "O" in "OPEN" top HPFS hydrant	... 26.295

Figure 2: *Benchmark descriptions as printed by the SF Bureau of Street Use and Mapping.*

The benchmark on the list in ***Figure 2*** is a fire hydrant with the word "OPEN" on top. The elevation is 26.295 feet above sea level at the top of the letter "O". For this survey, it will be the reference point (*Benchmark 1*).

Figure 3: Detail of reference point location (Benchmark 1)

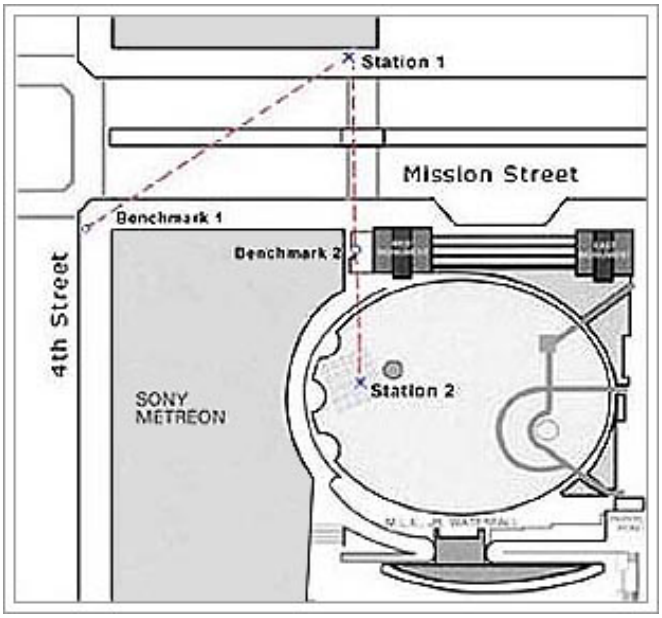


Figure 4: *Plan for projecting the benchmark elevation into the site*

2. **Project official elevation to the target location in the park (*Figure 4*).** Set up the surveyor's level at a convenient and safe location (*Station 1* in ***Figure 4***) where the benchmark and the target plot within the park are visible (see Step 2 below for setup instructions). In this exercise the direct view to the target plot was not available so the elevation from *Benchmark 1* was read at *Station 1*and projected to *Benchmark 2*. *Station 2* is a point near the target plot where the elevation at *Benchmark 2* can be read.

Step 2: Set up the Surveyor's Level

1. **Extend the legs of the tripod and adjust the height by using the levers on the legs for extension.**
   - Place the tripod on stable ground. Since *Station 2* is on a grass surface, each leg should be anchored by stepping on the foot pegs and pushing the end points into the grass.
   - Keep the top of the tripod level.
   - Adjust the top of the tripod so it is above both sight points.

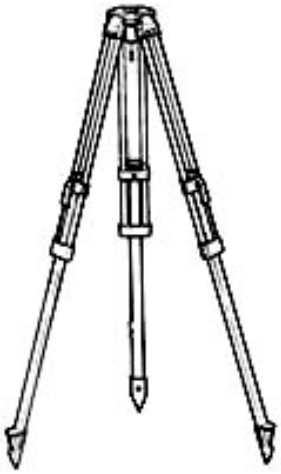


***Figure 5**: Surveyor's tripod*

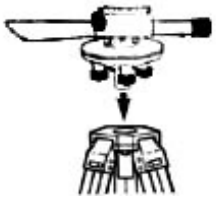


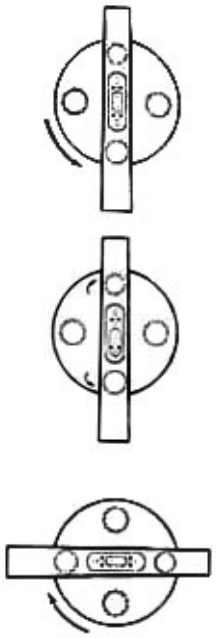
***Figure 6**: Screwing the level onto the tripod.*

2. **Screw the level onto the tripod.** On the underside of the level are four leveling screws. Each screw should be touching the plate at the top of the tripod. If not, extend the leveling screws until they all touch the plate. (***Figure 6***)

1. **Adjust the level by turning the telescopic sight to align with opposite pairs of screws.**

2. **Turn the screws until the bubble on top of the level is centered. (See *Figures 7* & *8*.)**

3. **Turn the telescopic sight to align with the other pair of screws and center the bubble as shown in the step above.**



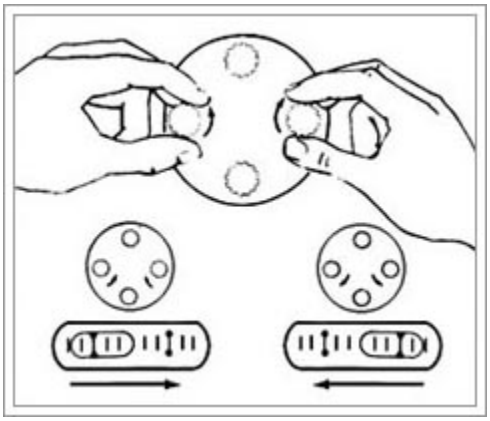


***Figure 7.** "The Golden Rule for quick and simple leveling is THUMBS IN, THUMBS OUT. Turn BOTH screws equally and simultaneously. Practice will help you get the feel of the screws and the movement of the bubble. It will also help to remember that the direction your left thumb moves is the direction the bubble will move." Drawn images shown for Step 2 are from the* David White Owner's Manual #8814-802.

Figure 8: *Bubble centered in vial.*

Step 3: Reading the Leveling Rod by Using Sight Level

1. **Leveling rods are approximately 7-9 feet in length and are extendable to twice their collapsed length.** The face of the rod is usually marked in feet subdivided in eighths of an inch (***Figure 10***). Two people are needed for this step because there are two roles, the rod holder (holder) and the instrument reader (reader).
2. **The holder places the leveling rod on a chosen spot, and turns the numbered side of the rod toward the reader.** The holder slowly rocks the rod back and forth. This assures that the rod is held vertically when reading is taken. In ***Figure 9***, the reading is 4' 10-1/8".
3. **The number is read at the crosshair when it points to the lowest number.** The measurement is in feet, inches, eighths of inches. (***Figure 10***)
4. **The reader looks through the eyepiece and locates the rod in sight (*Figure 11*) and adjusts the focusing knob.** For closer focus, turn the knob clockwise. (***Figure 12***). For farther focusing, turn counterclockwise.

Figure 9. *Reading the leveling rod through the Level.*

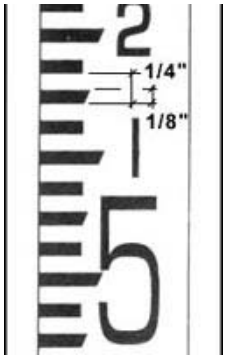


Figure 10: *Leveling rod detail*

Figure 11: *Look through the telescopic sight eyepiece at the measuring rod.*

Figure 12: *Fine-tuning the focus by turning knobs*

Step 4: Taking Readings

1. **The elevation of Benchmark 1 is 26.295'.**
2. **The instrument set up at *Station 1* backsights or plus (+) sights the leveling rod held at BM (Benchmark) 1.**

   Height of Instrument = Elevation + Backsight
   27' 3" (H.I.) = 26' 3.5" + 11.5"
3. **The telescopic sight is revolved to sight the rod at *BM2*. This second reading is called foresight or minus (-) sight.**

   Elevation 2 = H. I. – Foresight
   27' 0.75" *(BM2)* = (H.I.) 27' 3" - 2.25"
4. **Set up instrument again at *Station 2*, near the plot to be surveyed and backsight *BM2*.**

   (H.I. = Elevation 2 + Backsight)
   35' 11.75" = 27' 0.75" + 8'-11"

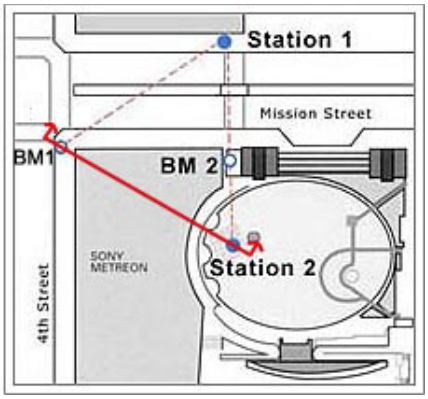


Figure 13: *Benchmark and Station Plan*

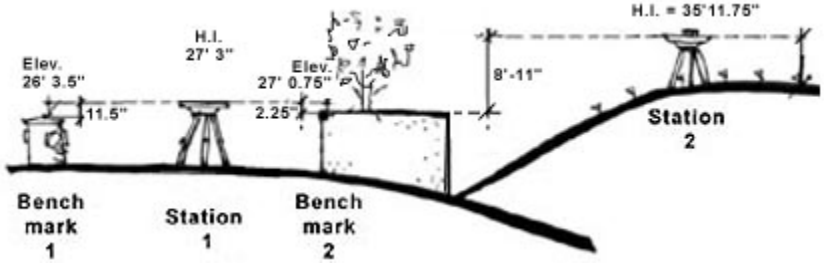


Figure 14: *Benchmark and Station Section Diagram of plan in Fig. 10*

5. **Here are the readings:**

Stations	Backsight	Instrument Height	Foresight	Elevation
Benchmark 1	---	---	---	26' 3.5"
Station 1	11.5"	27'3"	---	---
Benchmark 2	---	---	2.25"	27' 0.75"
Station 2	8' 11"	35' 11.75"	---	---

Figure 15: *Benchmark and Station Readings*

Step 5: Make a Grid Over the Chosen Area

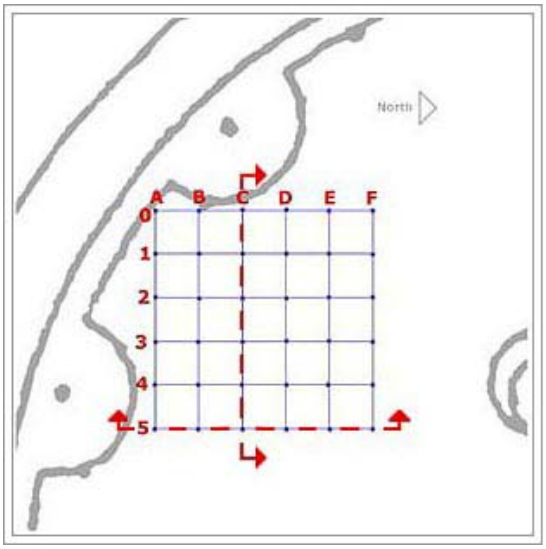


Figure 16: *Grid plotted from which points measurements were taken. Sections along gridlines C and 5 shown in Figure 17 & 18.*

1. **Take measurements with long tape measure every 10'-0" over a 50'-0" x 50'-0" area.**
2. **One person is the anchor for the tape measure and will direct the other person while looking through the compass or surveyor's transit.**
3. **The other person marks the measurement 50'-0" away along the axis.** Stakes are helpful to mark the points of the grid in the grass.
4. **Read and record the elevation of each point as described as in Step 6.**

Step 6: Making Sense of Collected Data

1. **Each grid-point measurement is a foresight reading from the instrument set up at *Station 2*. Elevation of Grid Point = Height of Instrument - Foresight**
   List of Grid Point Measurements and Adjusted Elevations
2. **A cross section of the landscape is plotted from the points that we surveyed.** (***Figs. 17 & 18***)

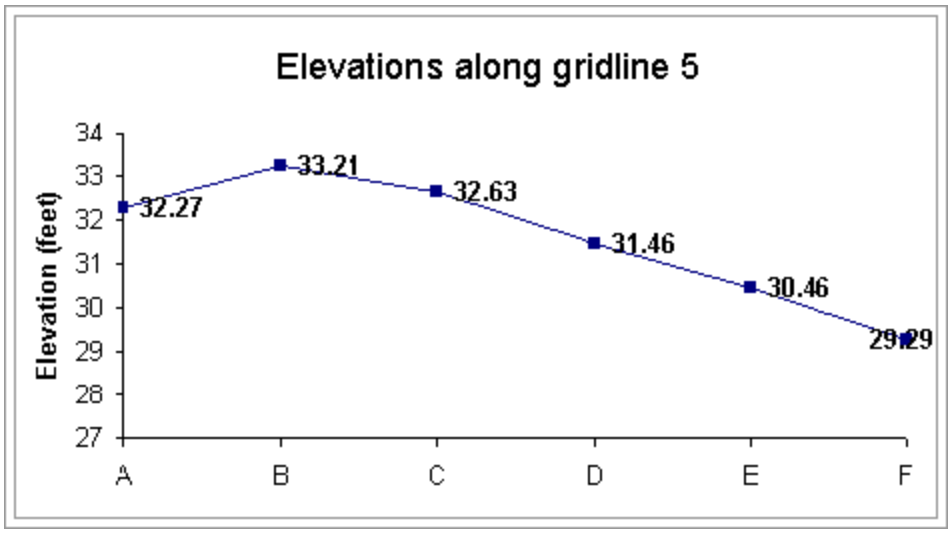


Figure 17: *Section along gridline 5. The distance between each grid line is 10'-0".*

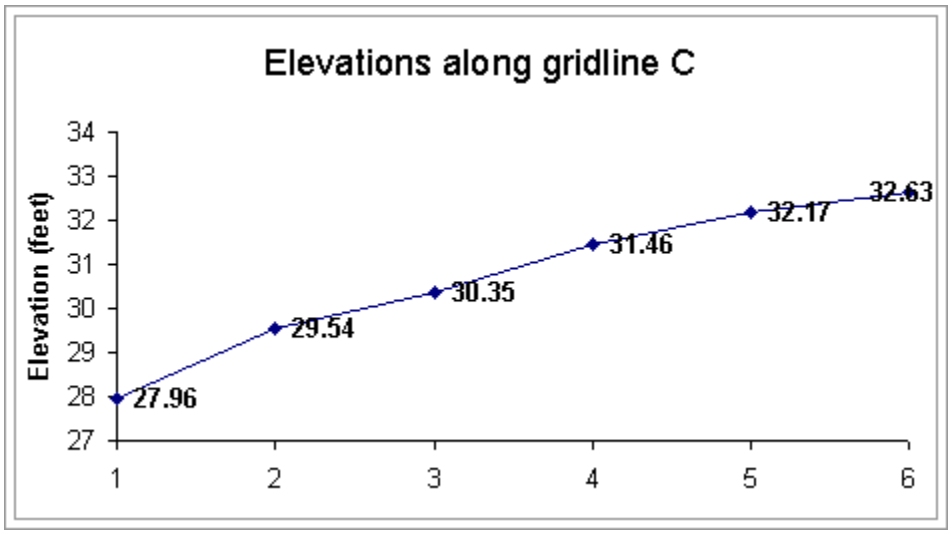


Figure 18: S*ection along gridline C. The distance between each grid line is 10'-0".*

Step 7: Drawing Topography Lines

1. **Plot the elevation at each point on the grid.** Even-foot values occur between the grid points. Approximate and connect the points where even values occur. These lines are the topography (topo) lines. (The location and diameter of all the trees were also determined and plotted in this example, see ***Figure 19***.)

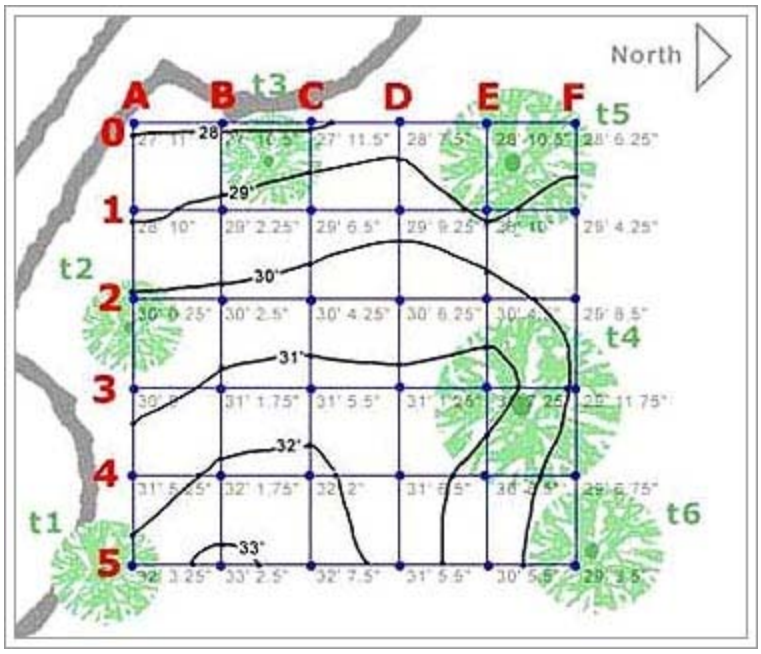


Figure 19: *Topography of a plot in Yerba Buena Gardens, San Francisco*