

California Spatial Reference Center

**Specifications and Procedures for Second Order, Class II
Geodetic Leveling to Establish Elevations on CORS**

(within 10 km of valid vertical control and using digital/electronic bar-code leveling systems)

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1. **Description:** These specifications and procedures specify the requirements for performing second order, class II geodetic leveling, using electronic digital/bar-code leveling systems, to establish elevations on continuously operating reference stations (CORS). The application of these specifications and procedures is limited to establishing elevations on CORS that are within 10 km of a valid vertical control station.
2. **Requirements:** The leveling work shall conform to the second order, class II specifications and procedures specified in the Federal Geodetic Control Subcommittee (FGCS) document entitled “*FGCS Specifications and Procedures to Incorporate Electronic Digital/Bar-Code Leveling Systems*,” adopted June 14, 1995, and the requirements specified in this document. The referenced FGCS document is referred to as the “FGCS Specifications” hereafter. *This document is available from the National Geodetic Survey (NGS) website at “http://www.ngs.noaa.gov/FGCS/tech_pub/FGCSvert.v40.specs.pdf.”* The FGCS Specifications shall apply unless specifically superseded by the requirements specified below. If there is a conflict between the FGCS Specifications and this document for a given specification or procedure, this document shall take priority.
3. **Network Geometry:**
 - a. **Bench Marks** – Bench marks are not required to be set. However, temporary bench marks that are suitable for the purpose intended shall be set in accordance with the spacing specified for bench marks in the FGCS Specifications. The temporary bench marks divide the leveling line into sections for these specifications and procedures.
 - b. **Bench Mark Ties** – The minimum bench mark tie shall be one valid bench mark (vertical control station) conforming to the specifications below.
 - c. **Valid Bench Mark** – A valid bench mark shall conform to the following:
 - i. Each valid bench mark shall have a NGS-published, second-order, class II (or better) adjusted NAVD88 elevation value. Priority shall be given to those bench marks that are included in the California High Precision Geodetic Network.
 - ii. Each valid bench mark shall have an acceptable “check connection” with an adjacent second-order, class II (or better) bench mark having an adjusted published NAVD88 elevation value. The check connection shall be run either a) from the valid bench mark directly to an adjacent bench mark or b) from the CORS to a bench mark adjacent to the valid bench mark. The allowable tolerance limit for a check connection shall be 8 mm times the square root of the shortest one-way distance of the check connection, in kilometers, ($8\sqrt{L}$). *Note: The FGCS Specifications permit check connections to be single run.*
 - iii. The length of the leveling line from each valid bench mark to the applicable CORS shall be 10 km or less.

- d. Connections to Other Network Control Points – Other than specified above, connections to other network control points are not required.

4. Instrumentation:

- a. Leveling System – An electronic digital/bar-code leveling system shall be used for all leveling work. The leveling system shall be in good condition and shall have been serviced, by an authorized service center, within the last six months.
- b. Instrument Tripod – The instrument tripod shall have non-adjustable legs (fixed-length legs).
- c. Temporary Bench Marks – Temporary bench marks shall be driven steel, turning pins similar to the turning pins utilized by NGS or an acceptable equivalent. A suitable driving cap shall be utilized when driving the pins.
- d. Turning Points – The use of steel turning pins and turtles is not required for turning points but is recommended. Turning points shall be stable points and suitable for the leveling work being performed.
- e. Bipods – The use of bipods to provide stable rod plumbing is recommended but not required.
- f. Umbrella – The use of an umbrella to shade the leveling instrument is not required unless recommended by the instrument manufacturer. In other cases, the use of an umbrella to shade the instrument from a bright sun is recommended.

5. Calibration Procedures:

- a. Collimation Time Interval – The time interval between collimation error determinations shall not be longer than one day for all leveling instruments. This information shall be recorded as part of the leveling raw dataset.

6. Field Procedures:

- a. Minimal Observation Method – The “electronic digital/bar-code” leveling method shall be used for all leveling work.
- b. Section Running – The “double run” leveling procedure shall be used to perform the leveling from the valid bench mark to the CORS.

- 7. Office Procedures:** The paragraph in the FGCS Specifications, under Office Procedures, regarding normalized residuals and least squares adjustments models does not apply to this leveling work, except the superscript footnote “n” for collimation error shall apply.

(end)