

Staff Range Calibration User Guide

Last updated January 2025

1. Introduction

Digital levelling systems have long been used by the surveying and engineering industry to determine height differences between any two or multiple locations for various applications. In Western Australia, Landgate is responsible for the national standard of measure for length, in this case, defined by the height difference or length measured in the vertical plane. In an effort to provide an accurate and a uniform system of levelling across the State, Landgate established a staff calibration range at Boya in 2002. The range comprises 2 observing pillars and 21 pins set in a granite outcrop. The pins have been placed at optimum distances from the pillars and cater for testing over a 4-metre height difference. The relative height differences between the pins have been accurately determined by repeat observations using precision levels in conjunction with calibrated invar staves.

Regular measurements done by Landgate (every two years from 2002 and on a monthly basis from 2018 to 2020) show fluctuations in height differences between the pins and appear to form a dominant seasonal cycle. This has led us to develop this [calibration application](#) to calculate an average range (values) for each month of the year and then apply the average range (instead of the most recent) for calibrating the barcode staff.

2. Boya Staff Calibration Range

The Landgate barcode staff calibration range is located at the Land Surveyors Licensing Board's examination site at Boya and consists of 2 observing pillars and a series of 21 stainless steel pins set in a solid granite outcrop in a semi-arc rounding the two observing pillars.

The two observing pillars were first constructed beside a large piece of sloping granite which had the required 4 metres of height difference between top and bottom. The highest pillar is set at a comfortable observing height and the lowest a metre lower and closer to the rock and range.

The pins were glued into drilled holes in the granite while the observing pillars were concreted deep into the ground to ensure their stability. With the 3 metre invar staff, it was possible to observe from Pin 1 to 15 from the high pillar and from Pin 7 to Pin 21 from the lower pillar.



Figure 1: Digital level set on Pillar MV 83 (high pillar)

- The low pillar or Pillar B can be seen just below the high pillar.



Figure 3: Stainless steel pins glued in granite rock

- The pins were glued into drilled holes in the granite outcrop in an arc shape with a distance of about 10 metres from the high pillar and 8.8 metres from the low one.



Figure 2: Invar staff set on Pin 2

- Invar staff set up on the pins are levelled and is held firmly by a bipole to maintain stability during the course of reading.



Figure 4: Observing from Pillar MV 83 (high pillar).

- With a 3-metre staff, readings can be done only for the first 15 pins using the high pillar.

3. Boya Access Details and Field Books

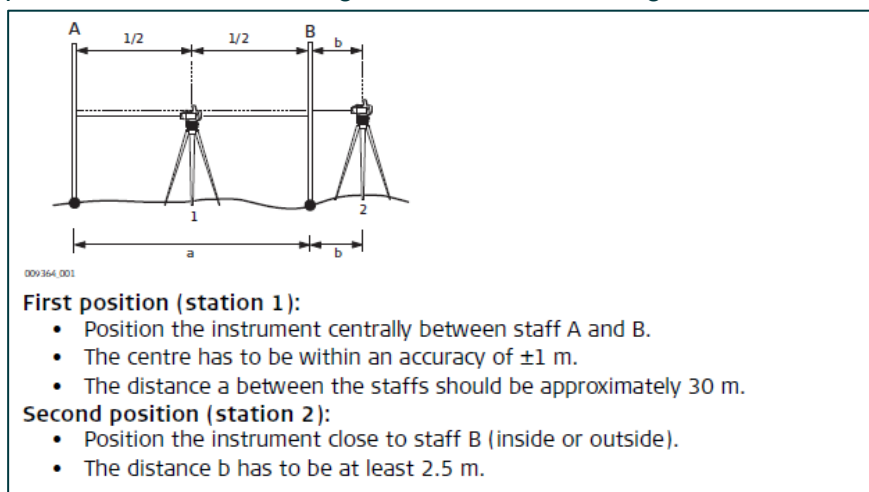
The Boya Barcode Staff Calibration Range is monitored on a regular basis. Landgate provides the [Medjil Instrument Calibration](#) online application to process and generate calibration certificates. The calibration is processed based on more than two years of monitoring data, which is also updated from time-to-time. Please download the following documents before you go to Boya:

- [Access sketch of the Boya Barcode Staff Calibration Range](#)
- [Diagram of the Pin Configuration](#)
- [Barcode Staff Booking Sheet](#)
- [Sample CSV file](#)

4. Field Procedures

The following sets out the field procedures for calibrating the barcoded staff:

- Use the barcode staff booking sheet to record the collimation details and range observations details in the field.
- Check the bubble of the digital level and the staff. Re-adjust them if necessary. The staff needs to be truly vertical for the best results.
- Check **if the Digital Level has an existing staff calibration**. If so, delete it or disconnect it from this calibration session.
- Perform a collimation test on the digital level and use its software to compute and store the constants calculated. For this purpose, four co-linear spikes in concrete 20 m apart have been established adjacent to the range (see the [Access Sketch](#)). The general procedure for the Two-Peg-Test is shown in the figure below.



By following the procedures described in the figure above, the line-of-sight (or the Collimation) error can be determined and automatically adjusted by selecting the **F1 Line of Sight** menu under **Tools** in a Leica LS15 digital level. Other instruments may provide similar capabilities and its best to refer to the instrument User Manual.

- Configure the settings in the digital level to record mean and standard deviation of measurement from multiple readings (at least five), if possible. Otherwise, if the instrument does not allow means from multiple observations, a minimum of three complete sets of observations (see 8 – 10 below) is required for redundancy
- Set the digital level on the high observing pillar (MV 83) and shade it from the sun. Pillar B (low pillar) is utilised by Landgate when calibrating the range.
- Position staff on the highest pin (Pin No 1) and allow at least 5 minutes to settle and adjust to the ambient air temperature. Record the air temperature in the booking sheet with a shaded thermometer.
- A set of observations for a standard four metre staff consist of:
 - Set up on Pillar MV 83
 - backsight to the staff at Pin Number 1

- intermediate sights to the staff at Pin Numbers 2 to 20
- foresight to the staff at Pin Number 21
- i) A set of observations for a standard three metre staff consist of:
 - Setup on Pillar MV83
 - backsight to the staff at Pin Number 1
 - intermediate sights to the staff at Pin Numbers 2 to 14
 - foresight to the staff at Pin Number 15
 - Setup on Pillar B
 - backsight to the staff at Pin Number 7
 - intermediate sights to the staff at Pin Numbers 8 to 20
 - foresight to the staff at Pin Number 21
- j) Record the air temperature in the booking sheet at the end of each survey.
- k) Download the level data and copy it in a csv file in the correct format (see Section 5) without any headers.
- l) Click [here](#) to process your staff readings and print the calibration report in a pdf format.

5. Sample Data

Data should be uploaded in a correctly formatted text or csv file as per the file format. File Format - All fields are separated by a comma (,) and must NOT contain the header line.

- Field 1 = Pin number
- Field 2 = Staff reading
- Field 3 = Number of readings
- Field 4 = Standard deviations

Example of a text/csv file. The file can also be downloaded from [here](#).

| Pin number, | Staff reading, | Number of readings, | Standard deviations |
|-------------|----------------|---------------------|---------------------|
| 1, | 0.07417, | 10, | 0.00009 |
| 2, | 0.16503, | 10, | 0.00007 |
| 3, | 0.32868, | 10, | 0.00002 |
| 4, | 0.47489, | 10, | 0.00009 |
| 5, | 0.68799, | 10, | 0.00007 |
| 6, | 0.87413, | 10, | 0.00004 |
| 9, | 1.52628, | 10, | 0.00003 |
| 7, | 1.07422, | 10, | 0.00003 |
| 8, | 1.27955, | 10, | 0.00005 |
| 10, | 1.79376, | 10, | 0.00004 |
| 11, | 2.12703, | 10, | 0.00008 |
| 12, | 2.39120, | 10, | 0.00005 |
| 13, | 2.51647, | 10, | 0.00011 |
| 14, | 2.64608, | 10, | 0.00005 |
| 15, | 2.87513, | 10, | 0.00012 |
| 16, | 3.05758, | 10, | 0.00006 |
| 17, | 3.20978, | 10, | 0.00004 |

| | | | |
|-----|----------|-----|---------|
| 18, | 3.36207, | 10, | 0.00012 |
| 19, | 3.52057, | 10, | 0.00020 |
| 20, | 3.66920, | 10, | 0.00007 |
| 21, | 3.87885, | 10, | 0.00010 |

Other information required are the staff and observation metadata which is recorded in the booking sheet at the time of observation. Retain a copy of the field booking sheet at least until a new calibration is done for the staff

6. Medjil Procedures

See Medjil Procedures in

7. Conclusion

The Boya Staff Calibration Range and Medjil Instrument Calibration online application is maintained by Landgate to enable surveyors who use digital levels and barcode staves to calibrate their staves in a simple and cost-effective manner for use in geodetic and other high order levelling. Both the calibration of the Range and Staves are based on the methods of least squares estimation, which is considered mathematically more rigorous. Medjil will update the estimated (monthly) average of the Staff Calibration Range whenever a new range measurement is added by Landgate. These (monthly) Range values are then used as a reference to calibrate other staves.