Site Levelling Surveys – Dumpy and Laser levels

Performing a levelling run with a Dumpy/Laser level

1. Set up the level on a tripod where you have adequate visibility between the points you are levelling (from this position)
2. Adjust the device so that is it level (using the built in bubble level), rotate it 90 degrees and confirm it is still level
3. Have someone with a survey staff hold the staff upright and level on a survey point you are levelling – your first point should be your most reliable/trusted reference point
4. Measure the height on the staff and record this as a back sight in your level book along with the name of the point e.g. BM1
5. Set the staff upright and level on the next survey point and record the level on a new line:
   a. As an intermediate if you are measuring more points from this location
   b. As a fore sight if there are no **new points from this location**
6. If it was an intermediate, repeat the steps in **5** above until you have completed a foresight
7. Once you have measured a foresight, reset the survey level at a new height, and check it is level (as in step 2)
8. Re-measure the last point you measured (the fore sight), and record the new value in your level book on the **same line**, this time as a Back Sight – This is known as a change point or 'CP'
9. Work your way back through all the survey points previously measured as you work back to your original back sight (from step 4)
10. Once you measure your point of origin again (your initial back sight) record this as a **fore sight** to close your survey

Checking and reducing the survey

This should be completed in the field where possible, at a minimum the checks of rises and falls should be completed in the field to determine the accuracy of the survey.

How to calculate rises and falls

To calculate the rise or fall from a survey, in any **pair of rows**, you subtract the **right column value** of the second row from the **left column value** of the first row. This means subtracting intermediates from back sights, or subtracting fore sights from intermediates or back sights. In some cases, you will have two intermediates, in these instances, subtract the bottom intermediate from the top intermediate (see example below).

Site Levelling Surveys – Dumpy and Laser levels

Back Sight	Intermediate	Fore Sight	Rise	Fall	Reduced Level	Description
1.204						BM 1
	0.996		0.208			Peg 1
	1.086			0.090		Peg 2
		0.454	0.632			BM 2 (CP)

Any positive value is a "Rise", while any negative value is a "fall" these should be recorded in the appropriate column of your level book.

When we have completed the survey and returned back to our origin (BM1 in the example below), we can compare the sum of all rises and falls to quickly determine if our levels are accurate. When these differ significantly, this may indicate an error in the surveying procedure or transcription.

Back Sight	Intermediate	Fore Sight	Rise	Fall	Reduced Level	Description
1.204						BM 1
	0.996		0.208			Peg 1
	1.086			0.090		Peg 2
0.436		0.454	0.632			BM 2 (CP)
	1.067			0.631		Peg 2
	0.978		0.089			Peg 1
		1.186		0.208		BM1
SUM of R/F			**0.929**	**0.929**		

In this example, the sum of the rise and fall columns is equal, so the survey has a 0mm close assuming no gross errors that just happened to balance out (this can happen more easily in larger surveys). We could be confident to use the levels obtained to set up a WL recorder, or as a reference for any of our hydrological purposes once we have reduced the survey to a common datum.

Site Levelling Surveys – Dumpy and Laser levels

Reducing the levels to a known or assumed datum

The next step is to reduce the levels. This involves applying the known (or assumed) RL (reduced level) of the benchmark we used as our origin and using it to calculate the levels of each of our surveyed points.

Back Sight	Intermediate	Fore Sight	Rise	Fall	Reduced Level	Description
1.204					**100.000**	BM 1
	0.996		0.208		100.208	Peg 1
	1.086			0.090	100.118	Peg 2
0.436		0.454	0.632		100.750	BM 2 (CP)
	1.067			0.631	100.119	Peg 2
	0.978		0.089		100.208	Peg 1
		1.186		0.208	**100.000**	BM1
SUM of R/F			**0.929**	**0.929**		

We can see that our origin, BM1, was calculated as the same RL at both the start and finish of the survey. Between each run we can see a 1mm difference in the RL of Peg 2, this isn't uncommon no is it outside of the bounds of what we would accept in a site survey. For direction on the acceptable error level for a survey, see Section 3.4 of the Operations manual: Survey Accuracy

http://tqm.horizons.govt.nz/hydrology/SOPs/cd_om_3.4_Survey%20Accuracy.pdf

Complex Surveys

In some cases, slightly more complex procedures are required in order to survey a site. At first these can be confusing but, with a good understanding of basic survey principles, it can be done with relative ease. The most common challenges for technicians new to surveying would be EPB surveys and invert levelling.

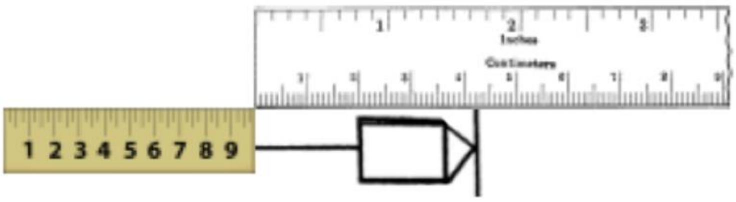
EPB Levelling

There are multiple methods we can use to check the accuracy of an EPB, the simplest requires the technician to Get a level from a benchmark followed by a direct reading of the Tip of the EPB, while the person at the EPB records what the reference mark is reading on the EPB tape at that level. From this, we can determine the RL zero for the EPB reference using this formula:

Site Levelling Surveys – Dumpy and Laser levels

EPB Zero = $RL_{(Benchmark)}$ + Back Sight – EPB Reference reading

We also record the length of the EPB with the survey (measurement from the end of the tape **plus** the distance to the EPB tip).



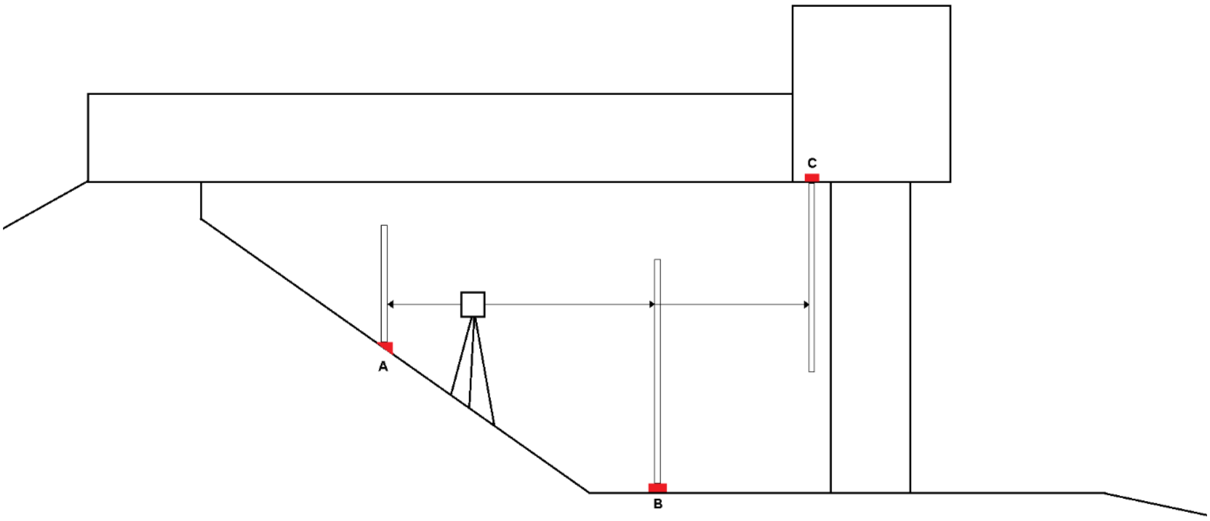
When we reduce the levels of the survey, the EPB Zero should equal our site RL zero, any variance in this may indicate that there is an error in the survey, or that something has changed at the site.

If you are unable to get a direct EPB tip reading, but you are able to read the **EPB Tape** directly, you can record this measurement, and add the difference between your reading and the **EBB length** to the reading from the reference point. Be sure to record all of the details you used on your survey so that someone who looks at it later can understand how you obtained your RL measurements and check your work if necessary.

Invert levelling
Some situations, particularly those with larger vertical changes in levels, require us to do an inverted level, which we would record differently in our level books. In these cases the staff is held upside down, and the base levelled onto an object or reference point above us.

This has been made a lot easier with the introduction of laser levels such as the Leica Sprinter 250m. These units scan barcode staves and automatically detect an inverted staff. The Leica is able to calculate RLs as you survey (if you have started from a known RL and entered it into the unit), so in the case of inverts, all the confusing work can be done for you.

With a traditional dumpy level, or in situations where you need to manually read and record the level from a staff, we read and enter these values as **negatives** in our level book. During calculation, when you subtract the negative value, it will **add** to the RL.



In the above diagram, point C is significantly higher than point B, by doing an invert we are able to measure both from the same point.

Calculating and reducing levels where inverts are present

The following table shows how the survey in the diagram might be entered into a level book and calculated to show the corresponding RLs of the benchmarks when an invert is present.

Back Sight	Intermediate	Fore Sight	Rise	Fall	Reduced Level	Description
0.472					95.000	**A**
	1.986			1.514	93.486	**B**
-1.402		-1.375	3.361		96.847	**C –** Invert, CP
	1.960			3.362	93.485	**B**
		0.445	1.515		95.000	**A**
SUM of R/F			**4.876**	**4.876**		

Site Levelling Surveys – Dumpy and Laser levels

Field Procedure Flow Diagram