Slackline Gauging

FLOOD GAUGING

During high discharges a watercourse may carry large amounts of debris at or beneath the water surface. Discharge measurements under these conditions can be both time-consuming and hazardous; equipment can also be lost, damaged or destroyed. Generally there is a significant reduction in the amount of debris being carried downstream shortly after the peak flow has passed; at times the best course of action may be to delay gauging until conditions improve.

The prime consideration must always be the hydrogeophers safety.

In most circumstances, the hydrologist uses current meters for flood flow measurement, but a number of other methods can be used in some situations, to equal or greater advantage, such as with the use of ADCP's – REFER TO THE ADCP – SonTek Gauging SOP found here:
Large floods should also be followed up using Slope-Area Methods. The slope-area technique uses cross-sectional and water surface slope data combined with a channel roughness coefficient to determine flow. It is approximate, and useful for determining peak flow following a flood event. Floats can be used to obtain approximations of mean velocity from measurements of surface velocity. These measurements are carried out by timing the travel of floats over a measured reach.
Obtaining high stage gauging's on small streams can be particularly difficult when peak flows may only last a couple of hours. In this situation stage may change rapidly over the measurement period. Refer to the relevant Information Sheets and Training Notes for slope-area, float and rapidly changing stage methods.

The Problem

When gauging in high velocities, the suspended current meter and weight assembly will tend to be swept downstream before touching the bottom, so that the apparent depths sounded will be too large. Obviously this becomes negatable with the use of modern ADCP equipment.

Figure 1 shows how the measured depth ce has been over-read by the amount cd (the air-line correction), and by the amount which the wetline depth de exceeds the vertical depth dg. The difference (de-dg) is called the wet-line correction. These two corrections (the air-line and the wet-line) therefore need to be applied to depths measured under these conditions.

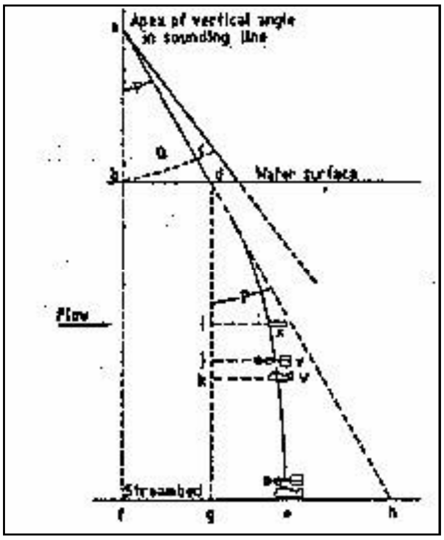
The problem is further compounded because normal depth-setting calculations will, in the presence of vertical angles, result in meter settings that set the meter too high in the water. Given a normal velocity profile this will lead to over-estimated velocities.

Slackline Gauging

Effect on Accuracy

Incorrect soundings are a more important source of error than incorrect positioning of the current meter for velocity measurement. For example, consistent over-estimation of depth by 20% will give a 20% over-estimate of discharge, whereas the error incurred through consistently measuring velocity at 0.5 depth when it was intended to be measured at 0.6 depth will be minor (see velocity profiles in Figure 3-10). Thus correction for sounding are essential.

Vertical Angles on depth measurement and current meter position



Avoidance of Vertical Angles

Correcting for vertical angles is time-consuming, and mistakes made in the field in the meter settings will give erroneous results. Therefore the presence of vertical angles should be minimized by:

- Using the POEM meter if possible
- Using an ADCP as preferred method of gauging
- Avoiding gauging sites where vertical angles will occur.
- Using a weight that is heavy enough not to be deflected downstream. Columbus weights of up to 91 kg (200 lb) are available.
- Giving consideration to the use of backstays where vertical angles are excessive and cannot be avoided. See Training Note Backstays for further information.

Slackline Gauging

Measurement of Vertical Angles

Measure the vertical angle to the nearest 2 degrees. Protractors are fitted to stand-up cable cars, and they are also available for bridge cranes.
The angle measurement on the protractor should be observed during the sounding, and, just at the point when the weight makes its first contact with the bed, the corresponding angle is noted.

With high velocities, the weight will tend to drift further downstream and the angle increase following the first touch on the bottom. The normal sounding technique is to stop the reel upon this first touch, but if the angle is read just after this, it will have increased to a greater value than the relevant one.

Use depths from measured cross-sections taken both before and after the flood for rivers with inherently stable channels. These data will need to be on-hand for the gauging in order to calculate meter settings. Corrections will still be necessary if the vertical angle is significant when the meter has been set to the required depth.

Vertical Angle Correction

When vertical angles exceed 6 degrees two corrections shall be applied to measured depths. These are termed the air-line and wet-line corrections.

Air-line Correction

This takes account of the extra cable above the water, (i.e. the distance *cd).* From the geometry of Figure 3-15

$$cd = ab \{l/\cos P\} - ab.$$

Table 1 gives the air-line correction for combinations of the vertical height in the range 3 m to 25 m, and vertical angle in the range 6
Degrees to 32 degrees. (Corrections for angles greater than this are not reliable, and practical difficulties in feeling the bottom are also likely to occur.)

The correction *cd* is subtracted from the observed depth *ce* to obtain the wet-line depth *de*

Wet-line Correction

This correction takes account of the extra length in the arc of the line below the water surface;
That is, the amount by which the length *de* exceeds the vertical depth *dg* or *bf*:

Subtraction of the wet-line correction from the wet-line depth will give the vertical depth *dg*.

Table 2 gives the wet-line correction for combinations of the wet-line depth *de* in the range 3 to 20 m, and vertical angle *P* in the range 8 degrees to 32 degrees. It has been derived from the principles described by Rantz et al (1982 p
163). It was assumed that drag on the streamlined weight when on the bottom is negligible and that when on the bottom it was entirely supported by the line. The table is general and can be used for any size sounding weight or line designed to offer little resistance to the current.

Slackline Gauging

VERTICAL ANGLE (Degrees) vs VERTICAL HEIGHT (Metres)

	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°
3m	.02	.03	.05	.07	.09	.12	.15	.19	.24	.28	.34	.40	.46	.54
4	.02	.04	.06	.09	.12	.16	.21	.26	.31	.38	.45	.53	.62	.72
5	.03	.05	.08	.11	.15	.20	.26	.32	.39	.47	.56	.66	.77	.90
6	.03	.06	.09	.13	.18	.24	.31	.38	.47	.57	.68	.80	.93	1.07
7	.04	.07	.11	.16	.21	.28	.36	.45	.55	.66	.79	.93	1.08	1.25
8	.04	.08	.12	.18	.24	.32	.41	.51	.63	.76	.90	1.06	1.24	1.43
9	.05	.09	.14	.20	.28	.36	.46	.58	.71	.85	1.01	1.19	1.39	1.61
10	.06	.10	.15	.22	.31	.40	.51	.64	.79	.95	1.13	1.33	1.55	1.79
11	.06	.11	.17	.25	.34	.44	.57	.71	.86	1.04	1.24	1.46	1.70	1.97
12	.07	.12	.19	.27	.37	.48	.62	.77	.94	1.14	1.35	1.59	1.86	2.15
13	.07	.13	.20	.29	.40	.52	.67	.83	1.02	1.23	1.46	1.72	2.01	2.33
14	.08	.14	.22	.31	.43	.56	.72	.90	1.10	1.32	1.58	1.86	2.16	2.51
15	.08	.15	.23	.33	.46	.60	.77	.96	1.18	1.42	1.69	1.99	2.32	2.69
16	.09	.16	.25	.36	.49	.64	.82	1.03	1.26	1.51	1.80	2.12	2.47	2.87
17	.09	.17	.26	.38	.52	.68	.87	1.09	1.33	1.61	1.91	2.25	2.63	3.04
18	.10	.18	.28	.40	.55	.73	.93	1.15	1.41	1.70	2.03	2.39	2.78	3.22
19	.10	.19	.29	.42	.58	.77	.98	1.22	1.49	1.80	2.14	2.52	2.94	3.40
20	.11	.20	.31	.45	.61	.81	1.03	1.28	1.57	1.89	2.25	2.65	3.09	3.58
21	.12	.21	.32	.47	.64	.85	1.08	1.35	1.65	1.99	2.36	2.78	3.25	3.76
22	.12	.22	.34	.49	.67	.89	1.13	1.41	1.73	2.08	2.48	2.92	3.40	3.94
23	.13	.23	.35	.51	.70	.93	1.18	1.48	1.81	2.18	2.59	3.05	3.56	4.12
24	.13	.24	.37	.54	.73	.97	1.23	1.54	1.88	2.27	2.70	3.18	3.71	4.30
25	.14	.25	.39	.56	.77	1.01	1.29	1.60	1.96	2.36	2.81	3.31	3.87	4.48

Slackline Gauging

VERTICAL ANGLE (Degrees) vs WET LINE DEPTH(Metres)													
	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°
3m	.01	.02	.02	.03	.04	.05	.06	.08	.09	.11	.13	.14	.16
4	.01	.02	.03	.04	.05	.07	.08	.10	.11	.14	.16	.18	.21
5	.02	.02	.04	.05	.06	.08	.10	.12	.13	.17	.19	.22	.25
6	.02	.03	.04	.06	.08	.10	.12	.14	.15	.20	.22	.26	.31
7	.02	.04	.05	.07	.09	.12	.14	.16	.17	.23	.25	.30	.36
8	.02	.04	.06	.08	.10	.13	.16	.18	.19	.26	.29	.34	.41
9	.03	.04	.06	.09	.11	.14	.18	.20	.22	.29	.33	.38	.46
10	.03	.05	.07	.10	.13	.16	.20	.22	.25	.32	.37	.42	.51
11	.04	.06	.08	.11	.14	.18	.22	.24	.28	.35	.41	.47	.56
12	.04	.06	.09	.12	.15	.20	.24	.26	.31	.38	.45	.52	.61
13	.04	.07	.09	.13	.17	.22	.26	.29	.34	.41	.49	.57	.66
14	.05	.07	.10	.14	.18	.23	.28	.32	.37	.44	.53	.62	.71
15	.05	.08	.11	.15	.19	.25	.30	.35	.40	.48	.57	.67	.77
16	.05	.08	.12	.16	.21	.27	.32	.38	.44	.52	.62	.72	.83
17	.06	.09	.12	.17	.22	.28	.34	.41	.48	.56	.67	.77	.89
18	.06	.09	.13	.18	.23	.29	.36	.44	.52	.61	.72	.83	.95
19	.06	.10	.14	.19	.24	.31	.38	.47	.56	.66	.77	.89	1.02
20	.06	.10	.15	.20	.25	.33	.41	.50	.60	.71	.82	.95	1.09

Example

Consider a vertical angle of 20 degrees, with a suspension point 10 m above the water surface. The air-line correction table shows that the introduced error is 0.64 m. For the same angle (20 degrees) the wet-line correction table shows that a further correction of 0.06 m must be made for a wet-line depth of 3 m. Thus, if the bottom of the weight is placed on the water surface to zero the counter on the gauging reel, and corrections are not applied, the error in determining the vertical depth will be of the order of 0.70 m, or about 20%.

Meter Setting

Similar adjustments are necessary when setting the meter at the selected depth to measure velocity. It cannot be set simply by calculating the required percentage of the vertical depth as it would be set too high by the airline correction (cd) and by the amount by which the new wet-line exceeded the calculated percentage of the vertical depth. This correction process is referred to as "the initial meter setting correction”.

A final adjustment will be needed if, after setting the meter at the selected depth, the vertical angle P is observed to have changed to Q. If this happens the airline correction will have changed and will have to be corrected for. This is referred to as “the final meter setting correction”.

Adjustments to meter settings for velocity measurements are approximate only, because the drag on the weight and the meter will be significant whereas the wet-line correction table is based on the assumption that the weight and the meter are in the low velocity zone at the streambed, and the only significant drag is that acting on the sounding cable.

Short-cut Correction Techniques

Without a suitable programmable calculator, the proper application of vertical angle corrections is exacting and time-consuming. During a flood, time is a scarce commodity and "short-cut" methods may be more appropriate. Several have been devised with the aim of reducing the amount of work required, and at the same time reducing the sounding error to a level compatible with the overall accuracy normally attainable in flood gauging's.

Zeroing the Meter

From the correction tables it is apparent that the error in the air-line is much greater than that in the wet-line; therefore the simplest form of these short-cut (or quickset) methods is to zero the meter and make the sounding after the air-line error has been taken up.

Zeroing Tag

An alternative method enables the air-line correction to be automatically corrected by zeroing the meter/weight assembly while it is already being dragged downstream. Wet-line corrections are not needed as the meter setting is calculated directly from the wetline depth.

It involves zeroing a tag which has been set some exact distance (say 1.00 m) above either the bottom of the weight or the center-line of the current meter. The option used depends upon the routine method used to set the zero. (Zeroing the bottom of the weight is recommended (see above). Both options will be calculated in the following examples.

- The vertical angle must remain constant throughout the zeroing, sounding and setting procedures; if it changes markedly then the method is not valid.
- The technique does not require the use of air-line or wet-line tables in the field.
- The tag should be of insulation tape with a good sized "tail" so that it can easily be seen.
- Frequent checking should be undertaken to ensure that the tag is not pushed down the sounding cable by flood debris.
- The true vertical depths must still be calculated in the office in order to determine the correct area