



Geopacks

Advanced Flowmeter Operation Manual

ZMFP126-T



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Important Safety information

BE AWARE – BE SAFE

Fieldwork Safety when working in streams or rivers

There are a number of things to consider when carrying out work in streams or rivers.

1. **CHECK THE WEATHER FORECAST** before you go out on fieldwork. In heavy rain rivers can rise quickly and what was a gentle trickle can become a torrent in a short space of time. Fast moving water which is higher than knee-deep can easily take you off your feet, especially if working on an uneven, or rocky river bed.
2. **WEAR THE RIGHT CLOTHING** for the day. If you get wet (see image below) then you will get cold. Cold is unpleasant and uncomfortable at best and life threatening at worst (hypothermia). Always make sure you take enough clothing even in summer. You'll be surprised how quickly you can get cold if you are wet, even on a summers day.
3. **NEVER WORK ALONE** and always let someone else know **WHERE** you are working and your **EXPECTED TIME OF RETURN**.
4. Moving water is powerful, and the banks of rivers may be undercut.
CHECK THE STABILITY OF THE BANKS before you start working on the channel so you don't fall in before you've even started!
5. River beds can be very rough, or have a bed-load of boulders which can easily move underfoot.
CHECK THE CHANNEL IS SAFE before stepping into it. Water can appear deceptively shallow at times.
Check how deep it is before stepping into the channel.



1.0 Key Components



Impeller Stick

Impeller Unit

USB Cable

Electronic Flowmeter

Protective Case for Flowmeter

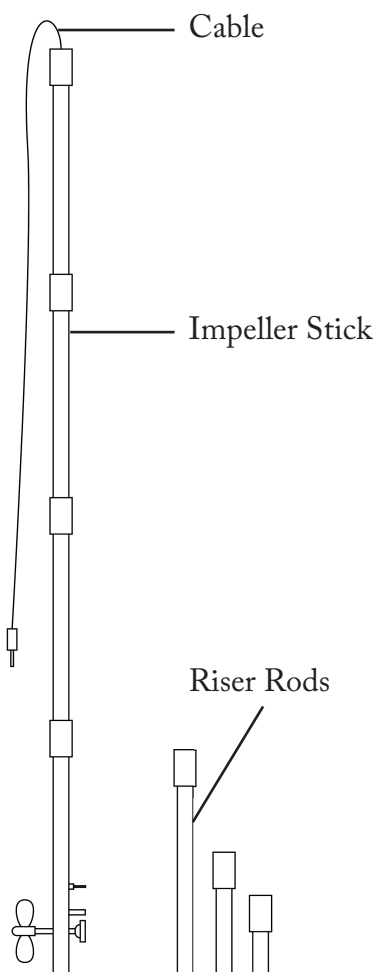
Riser Rods



Impeller Stick


The impeller stick is used for measuring water velocity and consists of:

- An **IMPELLER** and coupled **SENSOR** in which a switch opens and closes as the impeller is rotated by the flow of water and a temperature sensor.
- Four 250 mm long tube sections which slot together to make a 1m stick
- Three “riser rods” which when slotted singly or in combination, allow the impeller to be elevated above the stream bed at fixed heights – 250mm, 125 mm and 75mm or combinations of these up to a maximum of 450mm.
- A 1m long cable which connects to a flowmeter
- A USB cable which connects the flowmeter unit to a laptop or PC to allow data transfer. Data is stored as a CSV(comma-separated-values) file which can be used without modification in Excel, Word etc.



Geopacks Duo-Meter Setup

Before using the meter you need to:

- Assemble the stream flow impeller (see page 4)
- Insert the jack plug from the flow impeller into the socket.
- Set up the meter with the date, time and the units which you wish to use for measuring stream flow and temperature. Although not always necessary this action adds the date and time to your data file so you can track it later.
- Initiate motion of the sensor in the water
- Switch the instrument  - the **ON** button also brings the flowmeter out of sleep mode




How to set up the flowmeter

1. Remove the plastic tag from the battery compartment. The unit will display

| |
|---------------|
| Duo-Meter 1.0 |
| Geopacks 2020 |


2. To start the meter press the  key twice. This will allow you to set the date and/or time for data logging purposes.


3. The meter will show **Set Date**

Use the  or  arrow keys to scroll through the menu options

These are:-

Set Time
Set Units
Set Logging
Finish




The meter defaults to metres/sec as the flow units of measurement and degrees C for temperature so if these units are correct and data logging is not required then pressing the  arrow will display "**Finish**".

Pressing the  button will start the meter running.

Setting the DATE

5. Press the  or  arrow keys until **Set Date** is displayed then press 

The display will now show **Year? 2000**




With the cursor under the tens of years digit use the  or  keys to obtain the correct tens of years and then confirm with 

 will also move the cursor to the next location. Repeat for units of years and confirm.

When the year has been set the display will show **Month? Jan**

Use the  or  keys to select the required month and confirm with 

The display will now show **Day? 01**




With the cursor under the tens of days digit use the  or  keys to obtain the correct tens of days and then confirm with 

The cursor will then move to the days units column.


With the cursor under the days units digit use the  or  keys to obtain the correct units of days and then confirm with 

The display will now revert to **Set Date**.

Setting the TIME

6. Press the  or  arrow keys until Set Time is displayed then press 

The display will now show **00:00:00** and should be set as a 24 hour clock.

With the cursor under the tens of hours digit use the  or  keys to obtain the correct tens of hours and then confirm with 

The cursor will then move to the hours column. Repeat for units of hours, tens and units of minutes then press 

The display reverts to **Set Time** and automatically sets the seconds to zero.

Setting the RECORDING UNITS

7. The meter defaults to metres per second (m/s) on power up.

Press the  or  arrow keys until **Set Units** is displayed then press 

The display will now display the current units -

Use the  or  key to toggle between **m/s** and **mph** and confirm with 

The display will now show the current temperature units




Use the  or  key to toggle between C and F and confirm with 

Setting up LOGGING



About Data Logging

The Duo Meter gives you the opportunity to log your data into an internal flash memory for later use. The data you save will remain in the memory, irrespective of whether a battery is installed or not, until a Clear Data action is performed.

The memory is organised as 1024 sectors each of 4096 bytes. Each new logging session will reside in a new sector and no session can overflow a sector boundary. Hence the total number of records in a session cannot exceed 220.


To set up **LOGGING** press the  or  arrow keys until **Set Logging** is displayed then press 




The display will now show Manual Log?

Use the  or  arrow keys to scroll through the following menu options



Manual Log?
Auto Log?
Logging Off
Clear Data?

How these options work:

- a. **Manual Log** – the meter will store the reading whenever the  button is pressed during normal operation. The reading is stored in a file called Flowdata.csv which is accessible via the USB connection to a laptop or PC.




To set up Manual Logging press the  or  arrow keys until **Manual Log** is selected then press 

The display will now show **New Session?** This is asking if a new Session should be created.




Use the  or  to select between **New Session?** and **Continue?** which appends data to your previous session.

Press  to select and the display will now return to **Set Logging?**


- b. **Auto Log** – the flowmeter will store the reading at a programmed interval set by the user. This interval can be between 1 and 59 minutes. The reading is stored in a file called Flowdata.csv which is accessible via the USB connection to a laptop or PC.




To set up Auto Logging press the  or  arrow keys until **Auto Log?** is selected then press 

The display will now show **Log Interval**
00 mins

The cursor will be under the tens of minutes digit. Use the  or  buttons to select the required tens of minutes. Confirm with 

The cursor will now be under the units of minutes

Repeat to set the units of minutes and confirm with 

You will now be prompted to set up a **New Session?** or **Continue?** as in the Manual Log setup described above. Use the  or  buttons to select then press 

The display will now revert to **Set Logging?**

- c. **Clear Data** – Clear Data deletes **ALL** the data from the Flowdata.csv file and sets the logging 'file pointer' back to zero. Be careful using this option.

To Clear Data press the  or  arrow keys until **Clear Data?** is displayed then press 



The display will now show **Are you sure**

Use the  and  to move between **YES** and **NO**

When sure press  to confirm

The display will now show **Set Logging?**

- d. **Logging Off** – turns off all logging.

To set Logging Off press the  or  arrow keys until **Logging Off** is displayed then press 

The display will now show **Set Logging?**

Note if AutoLog is being used then waking the meter will cancel the AutoLog.

Finish setting up the Duo-Meter


To complete the setup process and start the meter running select **Finish** using the





The display will now show

It+22.5 Et+17.5C
MAN 10:34:01

or something similar.

Press the  key to show **Flow = x.xx m/s**

The  and  keys toggle between the two displays.

Note if AutoLog has been selected the screen will blank at this time as the meter enters its AutoLog sleep mode.

The units displayed (m/s or mph) and (C or F) will reflect those selected. The logging mode will show **MAN** or remain blank if no logging is selected.

Sleep Mode

If the Flowmeter detects no input for a period of 2 minutes the display will go blank and the meter will go to sleep to conserve power as it will if **AUTOLOG** is selected.

Pressing the  button will restore operation and cancel **AUTOLOG** if this is selected.

All other settings and data are retained.


If you wish to continue autologging then go to Set Logging, Auto and select Continue to append data to the current session.

USB Operation

To retrieve the logged data from the Flowmeter plug the micro USB cable (supplied) into the Flowmeter and a suitable PC or Laptop.

The meter will display...

USB Detected Connect?

To start the connection process to the computer press the  button. To disconnect remove the cable.




The meter will display...

Session Most Recent

You may now select which session data you wish to download

Press the  key to download the most recent session use the  or  to select

Previous and press  you will now see the previous session shown in date and time format

Use the  and  keys to scroll to the session you require and press  to download the session you require.

The Duo-Meter appears on the computer as a very small flash drive named **Flowmeter**.

The drive contains a read-only file named Flowdata.csv which contains the data for export to Excel (or any other application capable of using CSV files).

If you are saving data from multiple meters onto a single PC then consider renaming each Flowmeter.CSV file once it is downloaded to the PC before downloading the file from the new meter.

Each meter will use the same file name for its CSV file so be careful not to overwrite one file with another. No attempt should be made to write to, delete, or format the flowmeter from a PC or all functions could be lost.

The Duo-Meter can store 1024 sessions of 220 readings. After this the data needs to be downloaded and the **CLEAR DATA** option used to ready the meter for new logging.

During logging an asterisk flashes on the display next to the MAN indicators to show that data has been recorded. If there is no more space for data then the asterisk will NOT flash indicating no available space.

Battery Condition

The battery is tested at the point of waking up. A flashing “B” on the display indicates a low battery. When connected to a PC via the USB the power to the meter comes from the PC so it can be a convenient way to change the battery without loss of setup information.

2.0 Operating Instructions

Impeller Stick with the Flowmeter



Slot the rods of the **IMPELLER** unit together and point the impeller up into the flow of moving water at the required depth (Figure 1a).

Use one or more of the three “riser” rods to elevate the impeller off the stream bed if necessary (figure 1b).

Figure 1a Impeller Stick in the flow

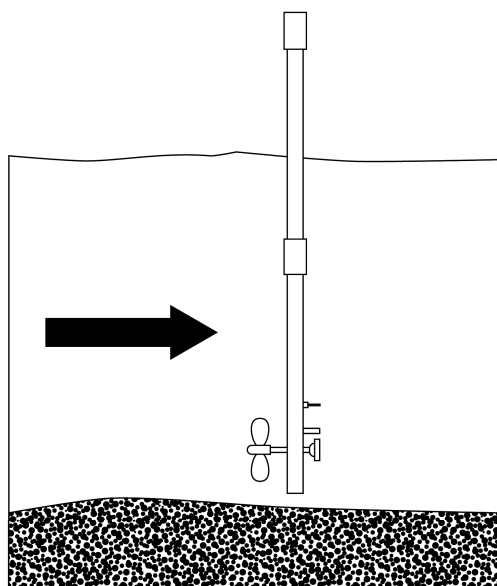
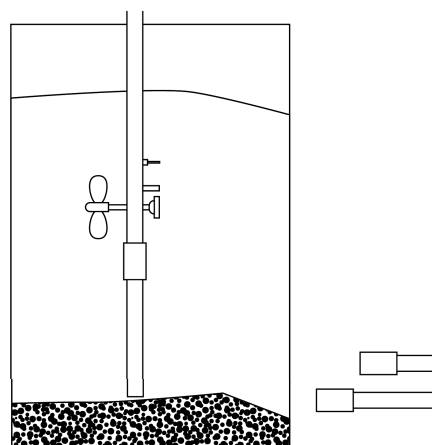


Figure 1b Using Riser Rods







When the impeller is turning at the correct depth (which will depend on the purpose of your measurements), press the **SEL** button.

The Flowmeter will either record the velocity of the water at that point in time if set to **MANUAL**

When Manual logging, a * symbol will appear in the display when the button is pressed to acknowledge that data has been written to the data file.

To ensure that it is clear which record is which if you are logging it to a data file (see above) it may be convenient to select “NewSession” each time you move on to a new recording location. That will ensure that when you download the data you have each location (no matter how many readings) on one line when viewed in the data file.

To set “New Session” press the  button (“Finish” will display) then press  to get to

Set Logging. Use the  button to select “New Session” then  to confirm.

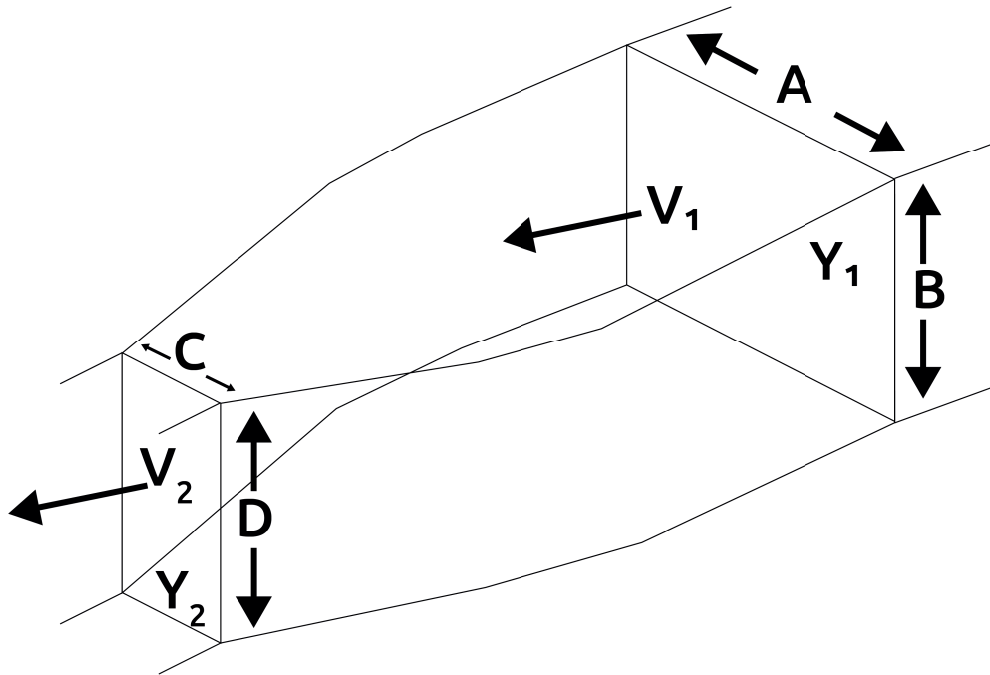
In order to have a clear record of which readings are taken at which location, river depth etc we recommend using the field observation chart included in the Appendix.

3.0 Stream Flow Velocity

Theoretical Background

A moving fluid exhibits certain important features. The flow velocity of a fluid depends upon the cross-sectional area of the flow, the roughness of the surfaces it is passing over (friction) and upon the quantity of fluid, which passes through that area in unit time. This is known as the **DISCHARGE** and illustrates the 'Principle of the Continuity of **MASS**'.

Figure 2: River Cross-sections and Flow Velocity



In the river channel depicted in Figure 2 the volume of water, which passes through section Y1 in a second, is the **DISCHARGE** (Q) and will be given by:

$$Q = a \cdot b \cdot V_1$$

and similarly at section Y2

$$Q = c \cdot d \cdot V_2$$

In these equations, a and c are the widths and b and d are the depths of the channel at the two sections, and V1 and V2 are the flow velocities. Since the same **DISCHARGE** (Q) passes through both of the sections then flow velocity relates to the difference between a . b and c . d (the cross-sectional area) ; i.e. if the channel becomes either narrower or shallower then the flow velocity increases and vice versa.

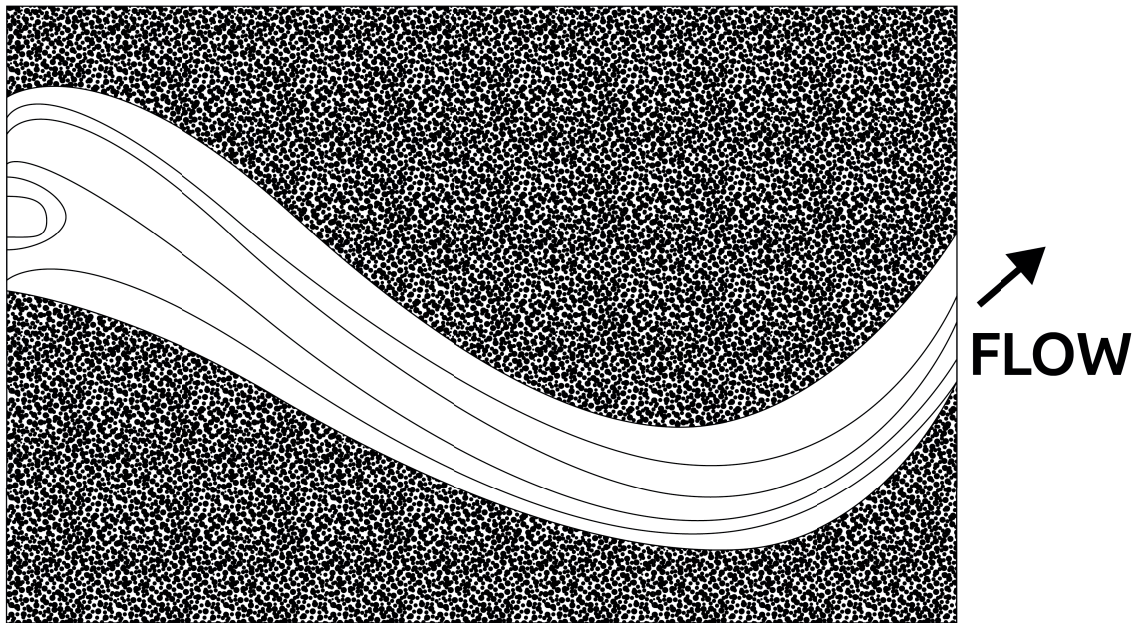
This principle explains many of the variations in the river channel morphology and in flow velocity. It is therefore important that this principle be understood by anyone undertaking serious fieldwork measurements in rivers. This could be demonstrated by measuring channel cross-sectional area discharge at a number of different sections along a short stretch of river.

3.2 Describing Flows

To understand the flow characteristics within streams of moving water it is sometimes helpful to consider the flow in the form of **STREAM LINES** or **VECTOR LINES**.

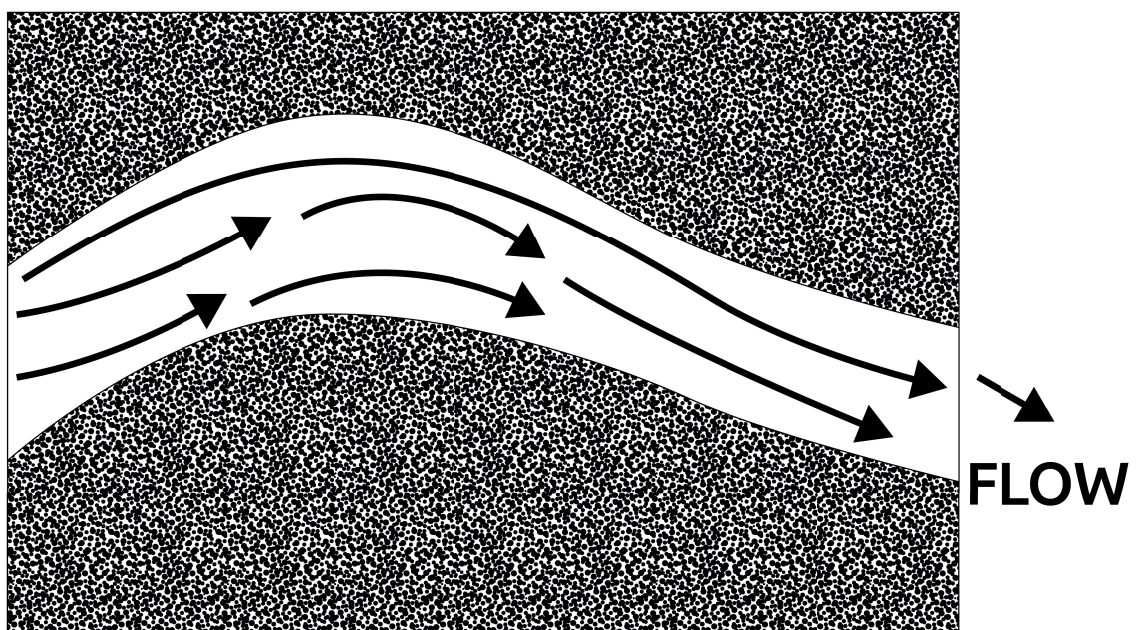
Figure 3 shows how Stream Lines depict possible paths of a single fluid particle.

Figure 3 Stream Lines in a flow around a meander



Vector Lines represent both the flow direction and velocity. The longer and broader the line the greater the flow velocity. Vector lines convey useful information about the stream flow characteristics.

Figure 4 Vector Lines in a flow around meander

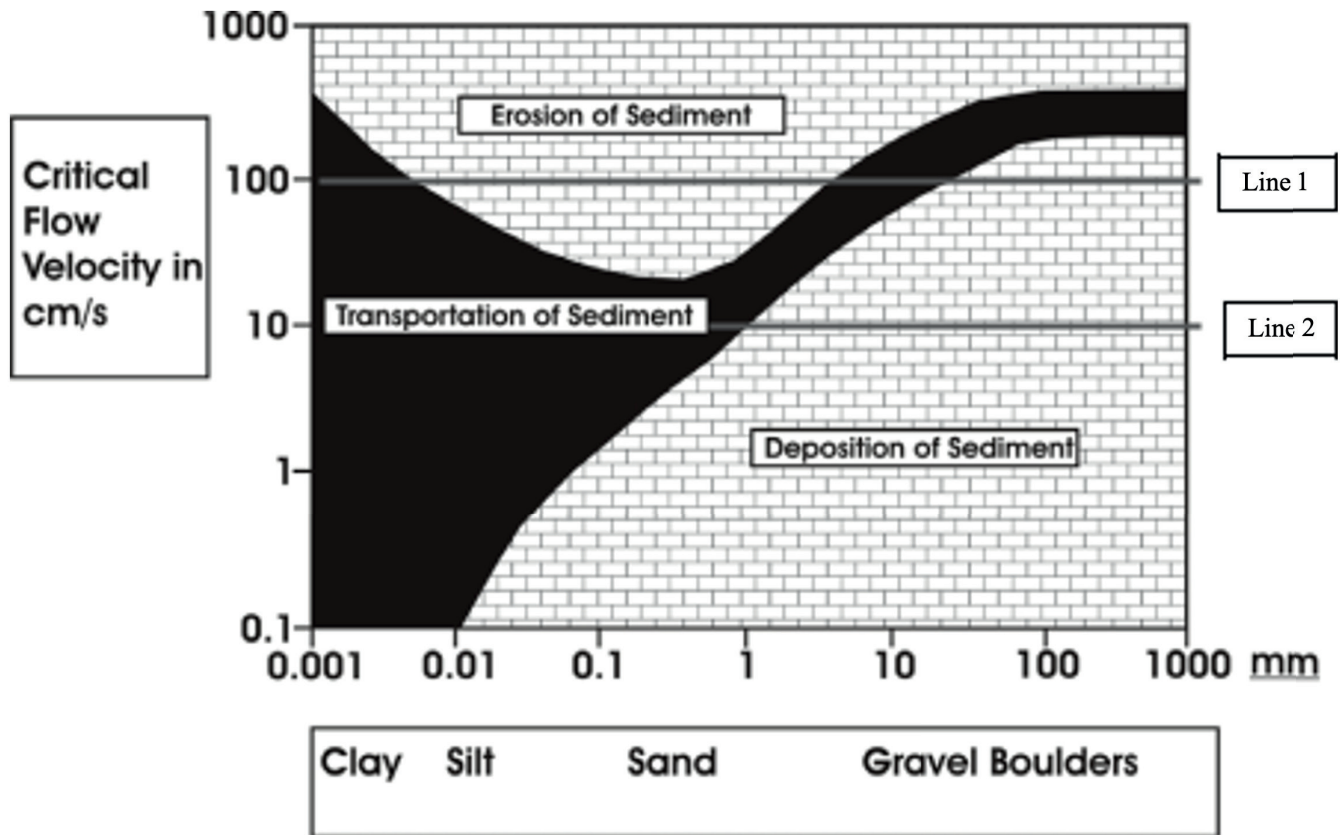


In this diagram the short arrows represent the slower areas of the stream and the long arrows the regions of faster flow.

3.3 Sediment Transport

The amount of sediment and maximum particle size that can be transported by moving water is related to the flow velocity. Therefore, measurements of velocity obtained using the flowmeter can be used to determine the maximum size of sediment particles, which may be transported by the flow (Figure 5).

Figure 5 Erosion Velocities for Water



The chart, which is referred to as the “Hjulstrom Curve”, has been derived from a mass of accumulated observed data, shows that for a given flow velocity there are a range of behavioural possibilities for sediment particles lying on the bed, or entrained within the flow, of a stream. For example, at a measured flow velocity of 100 cm/s (1 m/s) silt and sand (through not compacted clay) will be eroded from the stream bed and transported downstream (see Line 1). At the same velocity, all sediment particles finer than 1mm, which were already in motion, will continue in motion. Where the stream velocity falls below 10 cm/s (0.1 m/s), due to, say, a widening of the channel, sediment particles greater than 1mm diameter will be deposited (see Line 2).

Thus, a stream flowmeter can be a valuable observation tool when used in sediment transportation studies. Observed flow velocities can be traced on the graph and the corresponding maximum particle size which can be transported at the velocity (the competence of the river), can be determined.

4.0 Studying Streams – Some fieldwork suggestions

4.1 Recording Stream Velocity

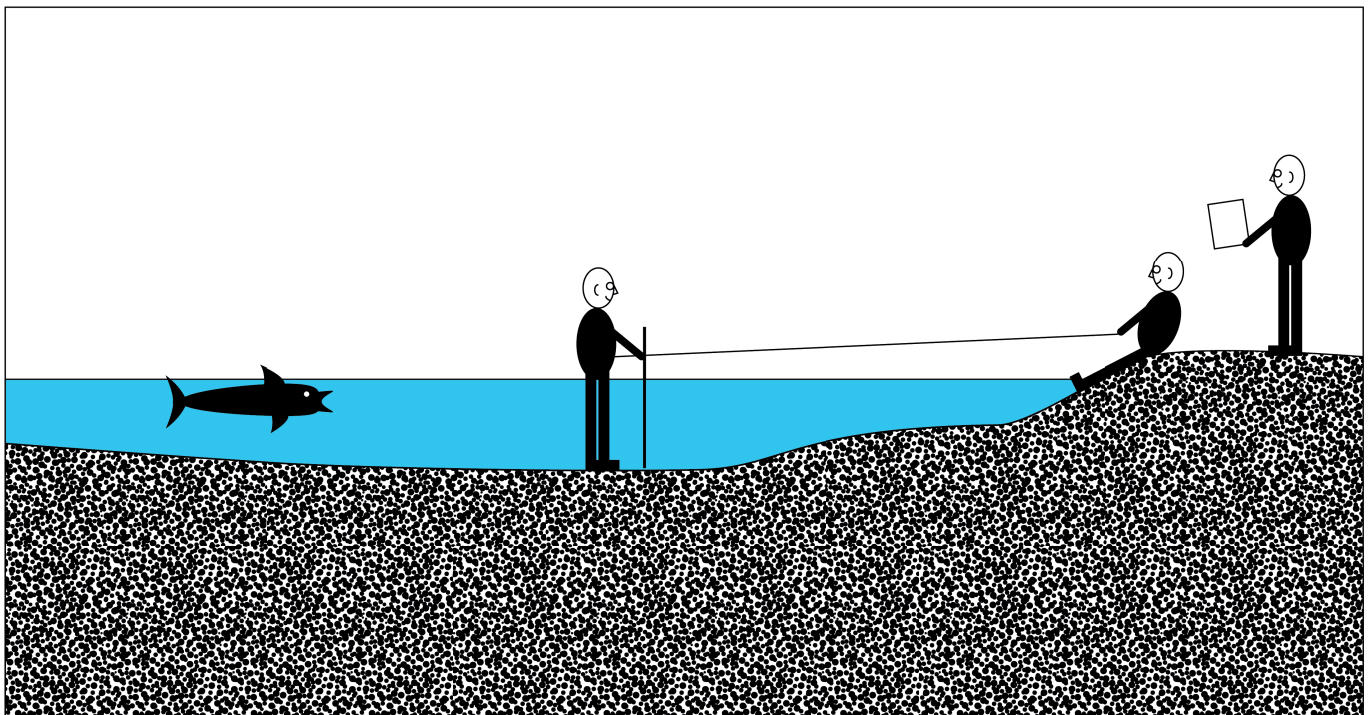
Equipment Needed:

Geopacks Stream Flowmeter
Measuring tape
Ranging pole
Clipboard and pen
Field observation chart
Watch

Working in groups of two or three, students make rapid progress provided they work efficiently, know their objectives and have thoroughly prepared the ground. For example, one student works in, or above the stream with the meter while a second student uses a watch to note the time (and date) of the velocity recording. A third member of the group records the data, such as notes on the site, distance from the bank from which the measurements are being taken, also the depth of reading, recording time, and possibly, as a backup-plan to be on the safe side, the velocity.

Measurements of the distance from the banks and the position of the meter in the stream are vital. For systematic collection of stream velocity data, the position of the meter readings should always be recorded with reference to one bank – **DISTANCE OUT**. For example, in larger channels, where stretching a tape across is impractical, this may be determined by attaching a tape to the waist or belt of the student working in the stream with the meter. By standing on the bank, and holding the tape out horizontally across the channel one person can determine the position of the meter from the bank.

Figure 6 – Measuring “Distance Out” using tape attached to student’s belt



In smaller channels it maybe more convenient to stretch the tape measure across the channel horizontally from the bank to bank. The ends of the tape can be attached to ranging poles on the bank or secured with heavy stones at each end.

Figure 7 Measuring “Distance Out” using tape secured at each end



Depth of measurement (**DISTANCE DOWN**) can easily be measured if the flowmeter tubes are simply calibrated beforehand using tape or water-resistant paint or ink, or more accurately, by taping a meter ruler to them. In estimating water depth please note that each section of the flowmeter stem is 250 mm long. Total water depth from surface to bed (sometimes called the **WET READING**) can be measured with the impeller stick if less than 1M. It is useful to have an elastic band or some other device on the impeller stick which can be moved up and down the stem to the water level. This allows a reasonably accurate estimate of depth to be made visually. Alternatively, if calculating the position of 0.6 of the depth (see section 4.3) for mean water column velocity measurement, the band can be moved to the appropriate position along the stem.

Plotting the Channel Cross-Section

This is essential for meaningful stream velocity recording. A plan or “map” of the stream cross-section at each point where measurements are to be made forms the basis for recording observations.



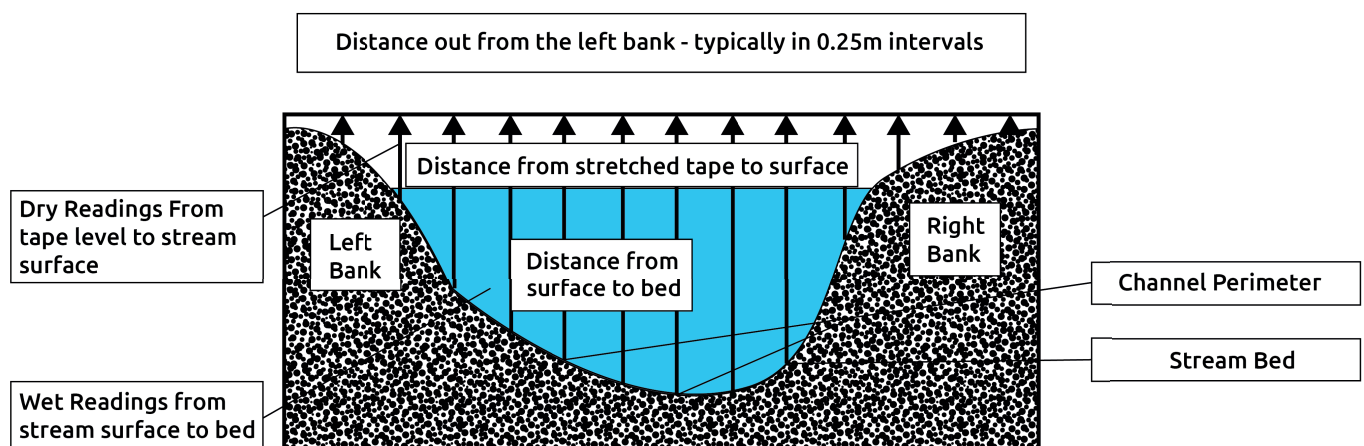
One method of measuring and plotting the channel form is by stretching a tape measure across the channel as described above. Depths can be measured vertically down from the tautly stretched tape to the stream bed.

Measurements of channel widths and depths are then recorded using data sheet provided. At regular intervals along the tape, two measurements should be noted. Firstly, the distance from the tape to the ground or water surface known as the **DRY READING**. Secondly, the **WET READING** should be recorded. This is the depth of the water at each point.

| Distance from Bank | Dry Reading | Wet Reading | Total |
|--------------------|-------------|-------------|-------|
| 0m | 0cm | 0cm | 0cm |
| 0.25m | 14cm | 3cm | 17cm |
| 0.5m | 14cm | 15cm | 29cm |
| 0.75m | 14cm | 22cm | 36cm |
| 1.00m | 14cm | 31cm | 45cm |
| 1.25m | 14cm | 35cm | 49cm |
| 1.50m | 14cm | 38cm | 52cm |
| 1.75m | | | |

This depth can be measured using the calibrated stem of the flowmeter, but more accurately by using a meter rule. The greater the number of measurements taken at each cross-section, the more accurate the representation of the channel, however, the closer the readings are together the longer it will take. In small channels, which are less than say 2 metres wide, a horizontal interval of 10cms would be workable. However, in a larger channel, maybe 5 or 6 metres across an interval of 20 or 25cms would give sufficient accuracy.

Figure 8 – Measuring & Plotting the Channel Cross-Section



Calculating Stream Discharge

In section 3.1 it was demonstrated (Figure 2) that:

DISCHARGE (Q) = Cross-Sectional Area x Flow Velocity

So, if the cross section area of a channel was 1 m² and the rate of flow was measured at 1 m/s, then the Discharge Q would be 1 m³/s (1 cumec). If, after heavy rain the channel area increased to 2 m² and the flow velocity to 1.5 m/s then the discharge (Q) would be 3 m³/s or 3 cumec. Discharge is an important variable, unfortunately, it's not always easy to measure.

Figure 9a Semi-Circular Channel

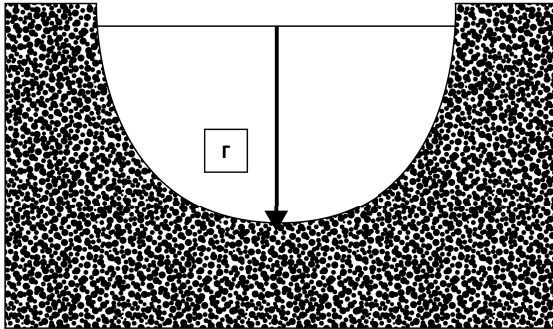
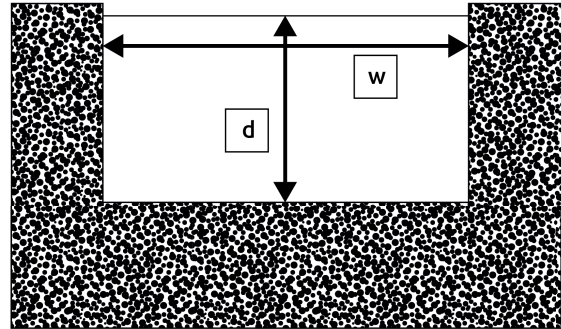


Figure 9b Rectangular Channel



Calculating discharge in the case of either the semi-circular channel (Figure 9a) or the rectangular channel (Figure 9b) is relatively simple. In the semi-circular channel, if we take:

| | | |
|-----------------------------------|---|---|
| Radius of Channel (r) | = | 1 m |
| Cross-sectional area (Δ) | = | $\pi^2 / 2 = 1.57\text{m}^2$ |
| Mean Velocity (V) | = | 1 m/s |
| Discharge (Q) | = | $\Delta \times V = 1.57 \text{ m}^3/\text{s}$ |

Similarly, in the rectangular channel, if the:

| | | |
|-----------------------------------|---|---|
| Depth (d) | = | 1 m |
| Width (w) | = | 1.5 m |
| Cross-sectional area (Δ) | = | 1.5m^2 |
| Mean Velocity (V) | = | 1 m/s |
| Discharge (Q) | = | $\Delta \times V = 1.57 \text{ m}^3/\text{s}$ |

In a real-life situation, however, the channel geometry will be far from regular.

However, there is a “work around” which allows fairly accurate estimates to be made of these channel variables with a minimum of calculation. Try this...

Measured

| | |
|--------------|--|
| Width | = as measured (in metres) |
| Wet Readings | = as measured (use metres – convert from cms if necessary) |
| Velocity | = as measured (metres per second) |

Calculated

| | |
|----------------------|--|
| Mean Depth | = the mean average of all wet readings taken (in metres) |
| Cross Sectional Area | = Width * Mean Depth (metres ²) |
| Wetted Perimeter | = Width + (2 * Mean Depth) |
| Hydraulic Radius | = Cross Sectional Area / Wetted Perimeter (metres) |
| Discharge | = Cross Sectional Area * Velocity (metres ³ per second) |

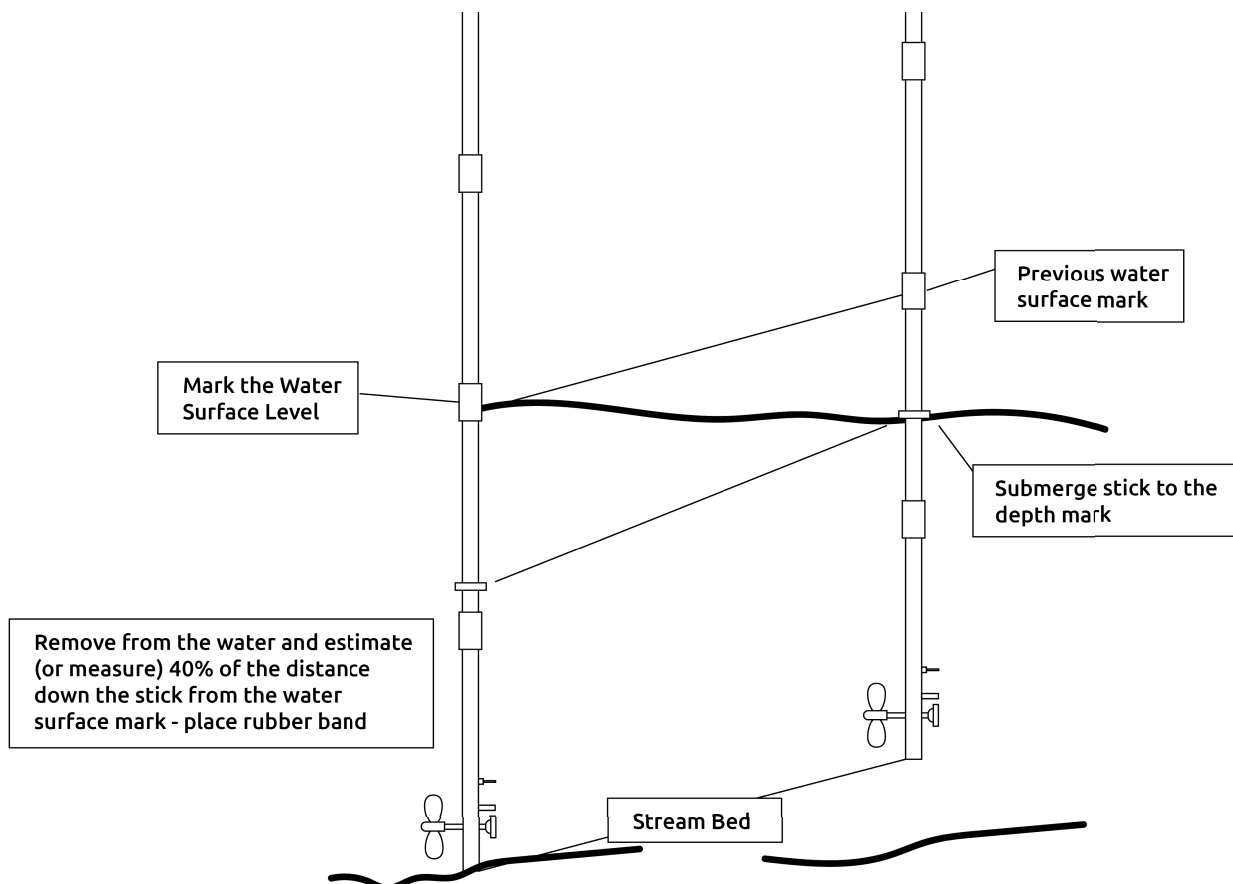
Unfortunately, there remains the problem of measuring the flow velocity in the channel. Because of friction with the bed and banks (the **WETTED PERIMETER**) and because of internal turbulence, stream velocity varies from point to point. Large numbers of observations under controlled conditions suggest that in water depths of less than 0.6m, a reliable average velocity can be recorded at a point, which is **0.6 of the depth of the water below the surface**. At this depth the faster surface flow is averaged out against the slower bed flow and this figure is an acceptable **EMPIRICAL GUIDELINE** (i.e. one derived from observation and experiment under a variety of circumstances).

A quick way of finding 0.6 of the depth requires a special piece of equipment – a rubber band!

Follow this simple procedure:

- Step 1 Rest impeller base on stream bed.
- Step 2 Mark the water surface level with finger and thumb.
- Step 3 Remove stick from the water keeping water surface mark.
- Step 4 Visually estimate (or measure) 0.4 of the distance down the stick between the water surface mark and the base.
- Step 5 Place a mark (e.g. rubber band) at this point.
- Step 6 Submerge the impeller stick to this point on the stem.
- Step 7 The impeller will be approximately at the 0.6 of the depth from the surface down.

Figure 11 Finding 0.6 of the depth



But the problems aren't over yet! In the semi-circular and rectangular channel sections shown in Figures 9a and 9b, an impeller placed in the centre of the channel at 0.6 of the depth, would give a reasonable average flow velocity. In the real-life section shown in figure 10b, the channel geometry is much less regular. Where should the mean velocity be measured? The most likely choice would probably be in the vicinity of the label "A".

Thus, if the flow velocity (V) at this point was recorded as being 1 m/s and with a cross-sectional area of 1.45 m^2 then the **DISCHARGE** (Q) would be $1.45 \text{ m}^3 / \text{s}$

To do the job properly however, it would be necessary to make a series of average flow velocity measurements, and this would require the channel cross-section to be subdivided into a series of columns like those in Figure 12.

Figure 12 Constructing Water Columns in a Stream Cross-Section

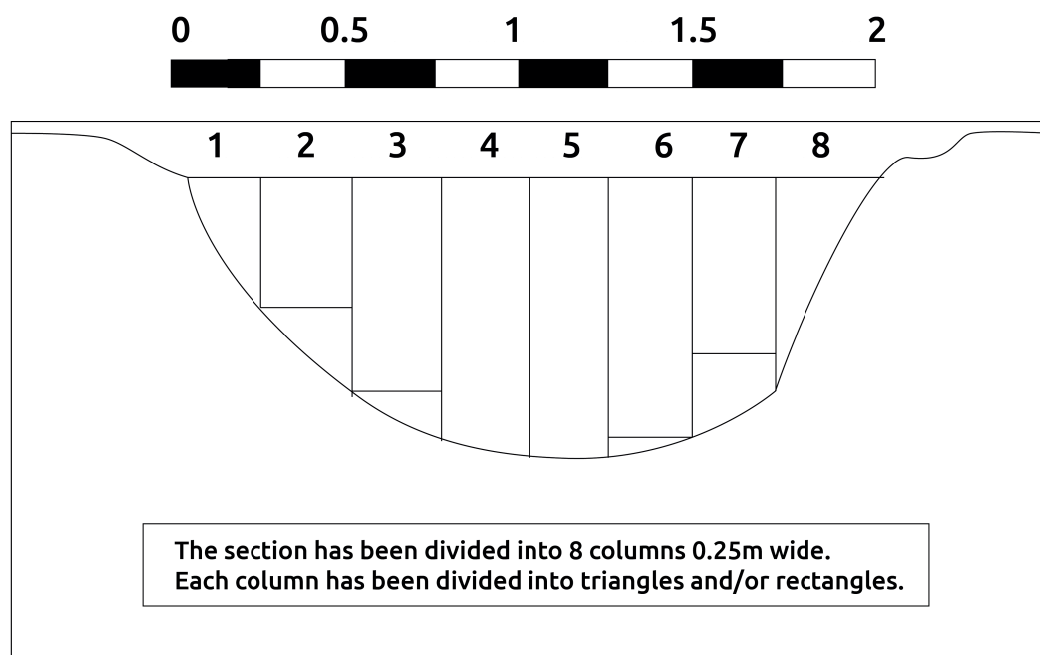


Figure 12 shows a stream cross-section which is 2 m wide. The section has been subdivided into columns (**WATER COLUMNS**) 0.25 m wide. According to the geometry of the channel, each column consists of a triangle and/or a rectangle. The area of each column has been calculated using the techniques described earlier and using the scale provided on the diagram. At an appropriate point within each column, the flow velocity would be measured with an impeller. A set of hypothetical velocities and the area measurements are displayed in Table 1, along with the calculations necessary to determine **DISCHARGE** (Q).

Table 1 Table of Measurements and Calculations for the Cross-Section

| | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 | Cols 1-8 | |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|-------------------------------------|
| Area 1 | 0.00 | 0.07 | 0.12 | 0.22 | 0.23 | 0.19 | 0.13 | 0.00 | 0.96 | |
| Area 2 | 0.07 | 0.06 | 0.03 | 0.00 | 0.00 | 0.02 | 0.02 | 0.11 | 0.31 | |
| Areas 1+2 | 0.07 | 0.13 | 0.15 | 0.22 | 0.23 | 0.21 | 0.15 | 0.11 | 1.27 | Cross-Section area (M^2) |
| V | 0.05 | 0.60 | 0.90 | 1.10 | 1.00 | 0.50 | 0.40 | 0.10 | 0.58 | Mean Velocity (M/S) |
| Q | 0.00 | 0.08 | 0.14 | 0.24 | 0.23 | 0.10 | 0.06 | 0.01 | 0.86 | Discharge (M/S^3) |

In the Table, Area 1 refers to rectangles and Area 2 to triangles

From the table:

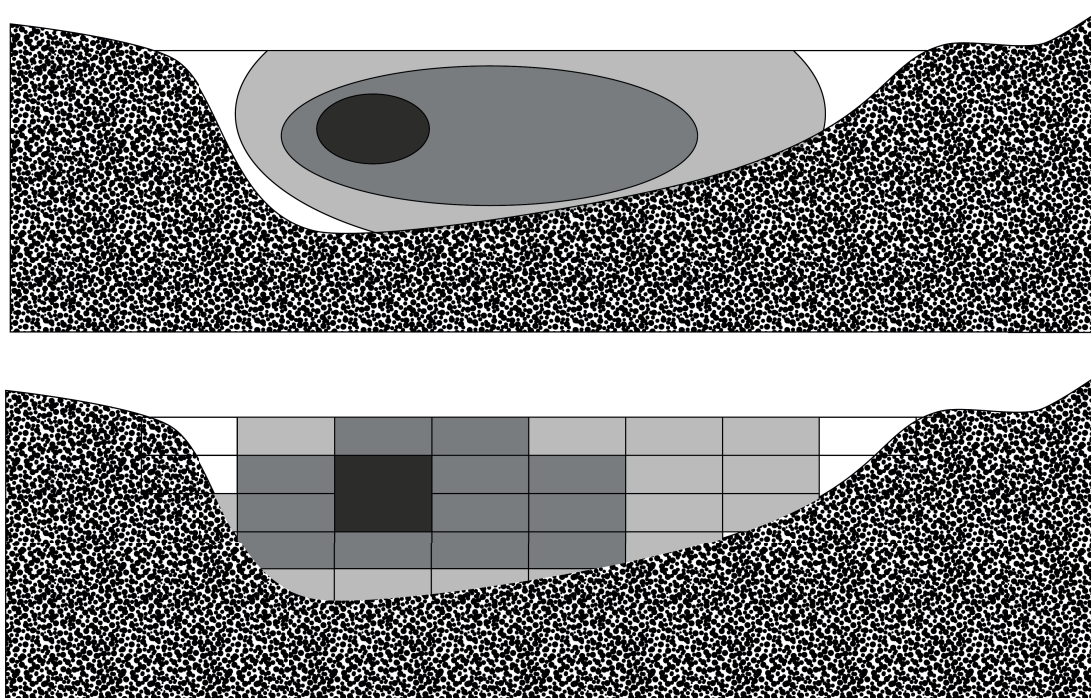
| | |
|---|------------------------|
| The total cross-sectional area has been calculated as | 1.27 m ² |
| The mean flow velocity through the section is | 0.58 m/s |
| The total discharge (Q) through the section is | 0.86 m ³ /s |

These procedures ensure that the best possible results are obtained from fieldwork. Once the hard work of surveying the channel section has been done, the profile can be used repeatedly under varying circumstances (e.g. before and after heavy rain) though adjustments for changes in depth and in-channel geometry due to erosion and deposition must be made. The exact position of the cross-section(s) must be fixed by inserting discrete stakes into the river banks.

4.4 Plotting Flow Patterns within a Stream

Using the cross-section channel profile(s) constructed for discharge measurements (or survey some new sections), it is possible to collect data to illustrate the internal flow characteristics of channelled flow. There are a number of techniques, most common being the construction of **ISOVELS** or **CHOROPLETHS**. Isovels are lines joining points of equal velocity and Choropleths involve shaded areas of like and unlike velocity.

Figure 13 Showing internal flow patterns – Isovels (above) & Choropleths (below)



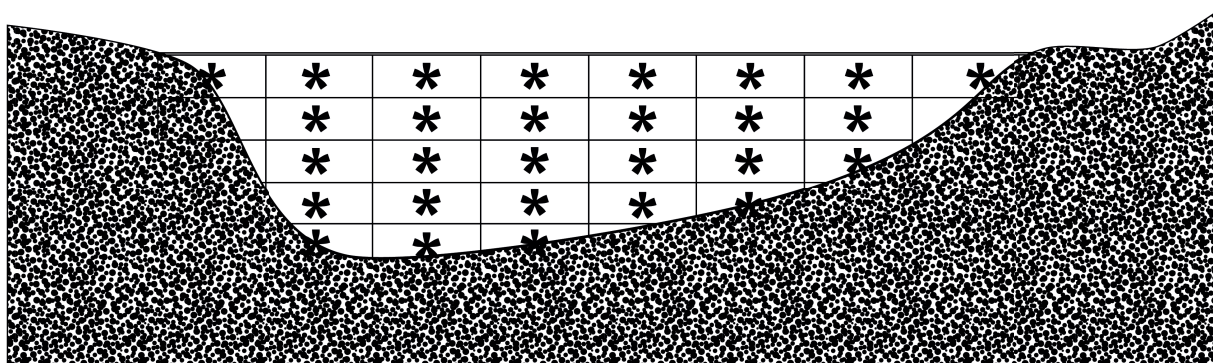
Key: dark shades = high velocity; light shades = low velocity

The isovels and choropleths represent lines and areas of equal velocity respectively. The highest velocity occurs usually in the centre of the channel near to the surface, while it is often lower nearer the bed and banks (Figure 13). However, the pattern displayed by the isovels and choropleths also reflects the shape of the channel i.e. its width, depth and symmetry (Figure 13). The spacing of the isovels and choropleths represents the velocity gradient.

Both methods can be effective in showing internal flow patterns. The degree of refinement depends on the number of readings which are taken – the more the better. Three values must be collected at each point – distance out from one or other bank; depth; and velocity at that point.

The stream cross-section must be surveyed as meticulously as for the calculation of discharge and readings are collected systematically in a transect across the stream channel. Instead of taking just one velocity reading 0.6 of the depth, a number of readings are taken at regular points within the water column.

Figure 14 Data collection grid for Isovel and Choropleth Construction



In Figure 14, the * signs indicate the midpoint of each “cell” in the grid. Typically a grid would consist of cells 0.25 m wide and 0.125 m deep. The size is determined by the size and scale of the channel and degree of accuracy required.

Table 2 Stream Velocity Data collected in Cells

| Stream Velocity in m/s | | | | | | | | |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Depth | Col.1 | Col.2 | Col.3 | Col.4 | Col.5 | Col.6 | Col.7 | Col.8 |
| to 0.125 | 0.00 | 0.06 | 0.12 | 0.11 | 0.07 | 0.05 | 0.05 | 0.00 |
| to 0.25 | 0.00 | 0.09 | 0.17 | 0.10 | 0.10 | 0.05 | 0.06 | |
| to 0.375 | 0.05 | 0.11 | 0.16 | 0.10 | 0.10 | 0.10 | 0.04 | |
| to 0.5 | 0.00 | 0.09 | 0.12 | 0.09 | 0.08 | 0.04 | | |
| to 0.625 | | 0.06 | 0.07 | 0.06 | 0.06 | | | |

Cells are 0.25 wide and 1.25m deep

The data shown in this grid are ideally suited to constructing choropleths. For a representative and refined Isovel construction, at least twice as many velocity readings would be required (typically in a grid with 0.1 by 0.1 m cells).

Geopacks publishes a computer software package called “River Channel Analysis” which not only plots choropleths from fieldwork data but also draws channel cross-sections and calculates discharge among a wide range of other functions. For details see Appendix III.

5.0 Calibration

Before shipment the impeller unit has been carefully calibrated under laboratory conditions. The formulae and graphs from what we call the Calibration Data which was essential for users of the earlier Flowmeters. The latest Flowmeter has the relevant calibration data built into electronics so that direct velocity data is generated in m/s or mph as selected.

Pre –shipment Impeller Stick Calibration

The impeller sticks have been calibrated in a flume where flow velocities can be strictly controlled by combined variations in discharge, gradient and weir height adjustments. Flow rate was monitored by a miniature Nixon electronic flowmeter and an Ott flowmeter. The formula required to convert counts per minute (C) recorded by the Flowmeter to water velocity (V) in m/s is:

$$\text{Water Velocity (V) m/s} = (0.000854C) + 0.05$$

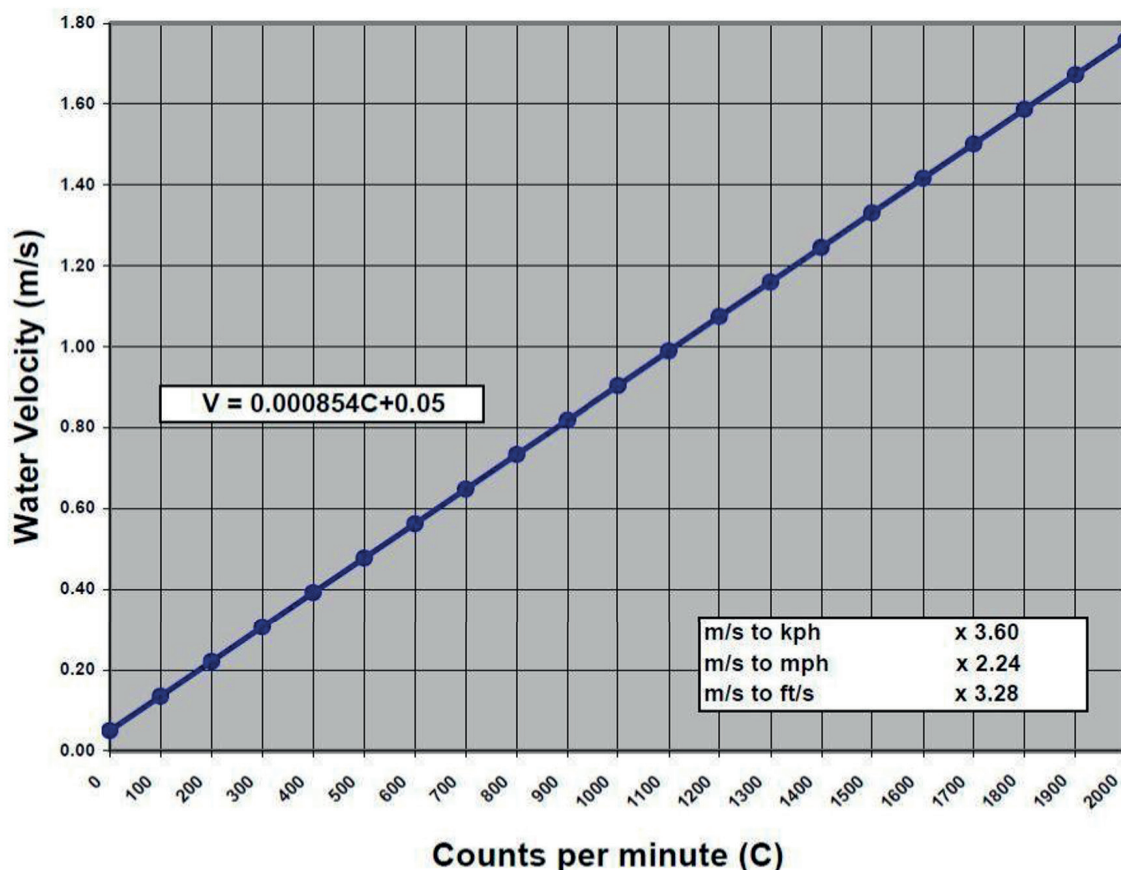
Alternative units can be calculated using the following conversion factors:

| | | |
|-------------|---|------|
| m/s to kph | x | 3.60 |
| m/s to mph | x | 2.24 |
| m/s to ft/s | x | 3.28 |

Values in this manual are given in metres per second (m/s).

The chart below (Figure 15) shows the relationship between revolutions of the impellor and calculated velocity displayed on the meter. This is for information only.

Figure 15 Calibration Chart showing the relationship between revolutions of the impellor and Water Velocity



Appendix I

CARE OF YOUR FLOWMETER

Check your equipment before you start work.

BEFORE leaving for fieldwork check your equipment as follows:

Switch on the meter by plugging the impeller jack-plug into the socket then use the **ON** switch to activate the meter.

If nothing is displayed, check the batteries are correctly fitted. Batteries are accessed in the flowmeter by carefully removing the sliding panel on the back of the unit (take care not to lose the cover). Fit new batteries if necessary: always carry spares (Two by “AA” – average life several months depending on how often the meter is used). The battery is tested at the point of waking up. A flashing “B” on the display indicates a low battery, if you are out in the field and the “B” starts flashing then simply remove the batteries and put them straight back in again which will reset the charge chip and give several hours extra life. However removing the batteries will wipe any saved data unless the meter is connected to a USB device whilst the batteries are removed.

Although your flowmeter has been designed for use by fieldwork parties under a wide range of conditions and is reasonably robust, it can be damaged by rough treatment or immersion in water. Should the meter be immersed in water, **REMOVE** the batteries **IMMEDIATELY**; the flow meter can be left open to dry in a warm room, do not attempt to open the meter compartment. Just remove the batteries, leave the battery panel off and leave it to dry slowly. In case of a serious dunking then, after removing the batteries, wipe dry with a towel and cover the meter entirely with dry rice and leave for 24 hours. The rice will absorb any moisture, discard the rice and replace the batteries.

Should the flowmeter (impeller stick and/or meter) be damaged or otherwise malfunction we can repair/replace damaged parts at a very reasonable cost and will also provide repairs under guarantee where appropriate.

Please telephone Geopacks on 0843 2160 456 and speak to customer services or email us on service@geopacks.com **before** returning the meter to the address below:

GEOPACKS

Unit 4A, Hatherleigh Industrial Estate
Holsworthy Road
Hatherleigh
Devon, EX20 3LP

We can also customise your Flowmeter for any special requirements.

After each field session we recommend that the flowstick and impeller are rinsed in clean water and allowed to dry before being stored back in the carry case. Also, the batteries should be removed if the equipment is not being used for any length of time.

YOUR FLOWMETER IS GUARANTEED AGAINST DEFECTS IN MATERIALS AND WORKMANSHIP FOR 12 MONTHS FROM THE DATE OF PURCHASE.

Appendix II

Field Observation Sheet

Keep a log of your readings by river depth and distance from bank. Use this sheet to keep a track of the different sets of data that your meter will log so that you can use it in conjunction with the .csv file when back in the classroom.

Enclosed – 1 laminated sheet – please photocopy as required.

| Obs number | Location number | Distance from bank | Channel depth | Internal temp | External temp |
|------------|-----------------|--------------------|---------------|---------------|---------------|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
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Field Observation Sheet for use with Geopacks Advanced Flowmeter (users may copy this sheet)

Appendix III

Resources

Geopacks manufacture and distribute a wide range of products associated with the flowmeter discussed in this manual. We have measuring tapes, stop watches, ranging poles, a wide range of other survey equipment as well as the more specialized items described below.

Of particular interest are the following products – but be sure to ask for our full Geopacks catalogue. If you don't already have a copy, our address and telephone number given in Appendix I.

Why buy from Geopacks?

- 30 day money-back guarantee if you are not completely satisfied
- No minimum order value
- Sign up to our Newsletter - Be the first to hear about new products and special offers
- Visit geopacks.com to sign up
- Stocked goods will be dispatched within 24 hours
- If items are out of stock we will inform you
- 30 day credit terms available to all UK educational institutions
- Geopacks branded products are UK designed and manufactured



"Fast, helpful and efficient service as always. Thoroughly recommend the company and its products."



Please tel:
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Mon-Fri, 9am-5pm
if you need help or
product advice



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service@geopacks.com
If you are a school please
email through your
Purchase Order



Cheques:
Payable to Geopacks
Unit 4A Hatherleigh Ind.
Est., Holsworthy Road,
Devon, EX20 3LP

Appendix IV

CSV Formatting

The Duo-Meter records data in a CSV format which can be read by any suitable software. The example below shows the typical data displayed in Microsoft Excel.

The header starts with a capital S this is just the session marker and is used internally to mark the start of a new session.

The date and time is shown in the format yy:mm:dd:hh:mm

The example below shows 09:59 on the 29th April 2021

The next two lines show the recording units and the final line the logging period if auto logging is used.

The data fields are Flowrate in the format x.xx internal meter temperature +/- x.xx and probe tip temperature +/- x.xx

Each session can contain 220 records.

| | A | B | C | D | E | F | G |
|----|---------------------|------|------|---|---|---|---|
| 1 | S21:04:29:09:59 | | | | | | |
| 2 | Flow units = m/s | | | | | | |
| 3 | Temp units = C | | | | | | |
| 4 | Log Period = 03mins | | | | | | |
| 5 | 0 | 23.3 | -0.8 | | | | |
| 6 | 0 | 23.6 | -0.9 | | | | |
| 7 | 1.31 | 23.8 | 13.8 | | | | |
| 8 | 1.32 | 23.8 | 13.8 | | | | |
| 9 | 1.34 | 23.7 | 13.9 | | | | |
| 10 | 1.36 | 23.7 | 13.9 | | | | |
| 11 | 1.36 | 23.6 | 13.8 | | | | |
| 12 | 1.35 | 23.6 | 13.9 | | | | |
| 13 | 1.35 | 23.5 | 13.8 | | | | |
| 14 | 1.31 | 23.5 | 13.8 | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |