Measurement framework

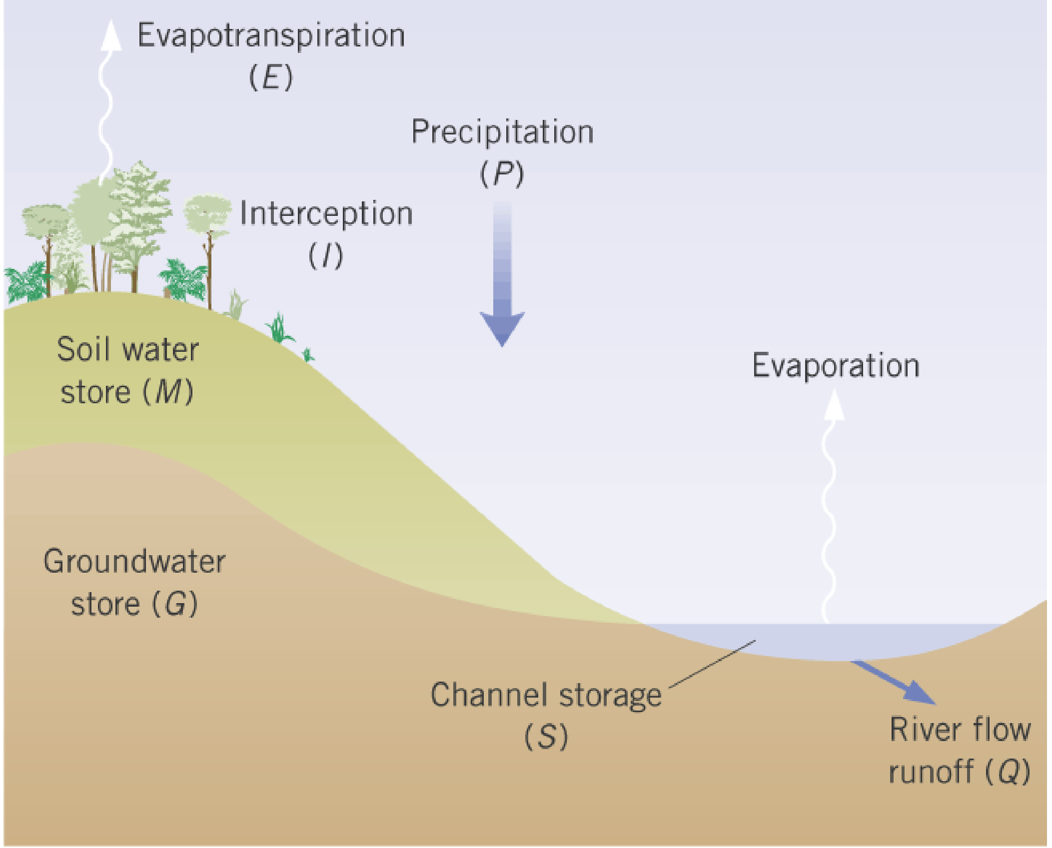
Surface water balance :

Output = input - losses +/- changes in storage

What are the inputs and outputs?

River flow = precipitation – evapotranspiration +/- changes in soil moisture and groundwater storage

+/- changes in other storage by NFM



How would you measure river discharge ?

<u>At one point in time:</u>

Velocity x cross-sectional area

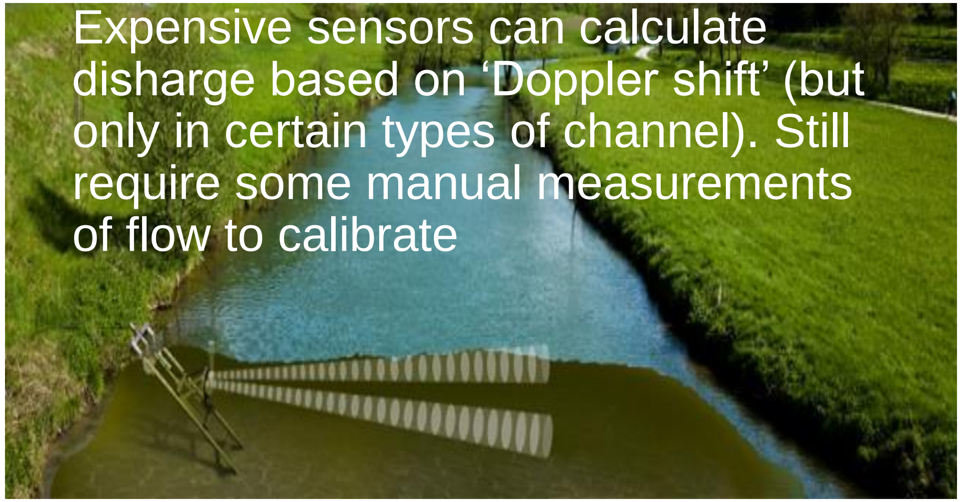
Dilution gauging

<u>If you want time-series data – i.e. how does it change over time:</u>

Automated measurement of velocity and cross sectional area (e.g. Doppler probes)

or

Use water level as a ‘surrogate’ and have an equation that relates each water level to a discharge value



Level/stage – cheap sensors, can be used to calculate flow by creating a rating curve based on manual flow measurements over a range of flow conditions

iCASP

Key questions when setting up a site:

1. Is there a suitable location to measure water level/flow and will a structure be required or can you use an existing structure/confined channel?
2. What do you need to install and what type of sensor will you use?
3. How often do you want to take a measurement?
4. How frequently will you download the data and where will you store it?
5. What regular measurements are required?
6. What maintenance is required?
7. How do you convert water levels to discharge?

Is there a suitable location to measure water level/flow and will a structure be required or can you use an existing structure/confined channel?

Unlikely you can afford to install a significant structure to provide highly accurate water levels over a range of flow conditions

Work with what you have

Are there any existing structures you can use? e.g. walled sections, bridges, culverts

If the channel flows over bedrock can you use any sections that are naturally confined?

iCASP

If the channel is small could you install a v-notch weir?

In other instances try and identify a section of channel that is as confined and stable as possible

Water level sensors

Vented – measures water levels

Pros: automatically compensates for atmospheric pressure

Cons: more expensive, need to prevent water ingress

Absolute – one probe measures A) the pressure under the water and the other measures B) atmospheric pressure. One of B can be used to compensate for lots of A in the area.

Pros: cheaper, robust, long battery life

Cons: requires atmospheric pressure to be measured separately, needs post processing to calculate water level

Water level sensors

Installation requirements

- Installation of a level sensor requires a stilling well as they dampen the effects of waves, surges and turbulence
- A stilling well is basically a section of pipe wide enough for the sensor with holes in drilled in at different depths
- Fix stilling well in place on metalwork driven in to the channel bed and/or the bankside
- Stilling well can be secured to the metalwork using cable ties
- Place level sensor within the stilling well so that the base of the sensor is just above the channel bed
    - For absolute sensor use Kevlar rope or UV stable high breaking strength fishing line
    - For vented sensor use supplied cable
- **Install stage board – can be a steel rule. **THIS IS CRUCIAL****

How often do you want to take a measurement? Depends on catchment size

•If <10km2 in area then perhaps every 5 minutes

•If >10km2 in area then perhaps every 15 minutes

How frequently will you download the data and where will you store it?

Monthly? Store securely and back up. Consider a cloud service so not just stored locally

What regular measurements are required?

Manual level measurement during each visit – use stage board

What maintenance is required

Remove any debris.

Check for undermining of banks

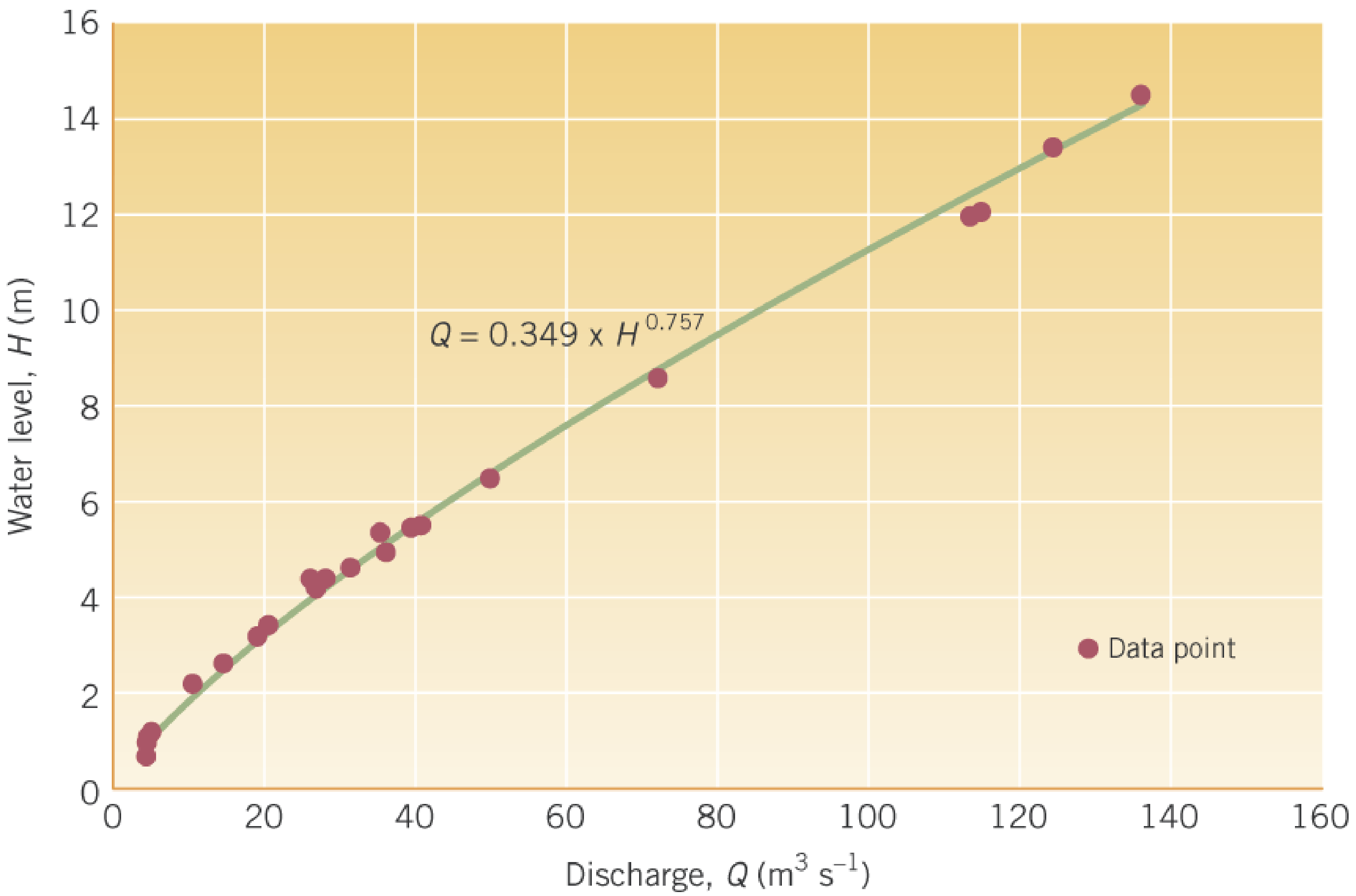
Make sure stilling well is secure

How do you convert water levels to discharge?

Manual discharge measurements over a range of flows to establish a rating curve specific to that location

Can then convert logged or manual level measurements to discharge

Dynamic risk assessment required



Three main methods for discharge gauging:

i) Open channel - velocity-area method

- suitable for clear channels without major obstacles (e.g. large boulder strewn beds or thick vegetation) and is the most commonly used method

ii) Open channel - dilution gauging

- may be used where there is free flow in channels (but can be bouldery)

iii) V-notch weir - validate the 'British Standard' equation for that angle

- Capture flow overtopping the V notch in a collector (bucket/beaker) and measure discharge over a given time period.

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ii) Open c

- may ... bouldery)

THA ... THE

iii) V-notc ... angle

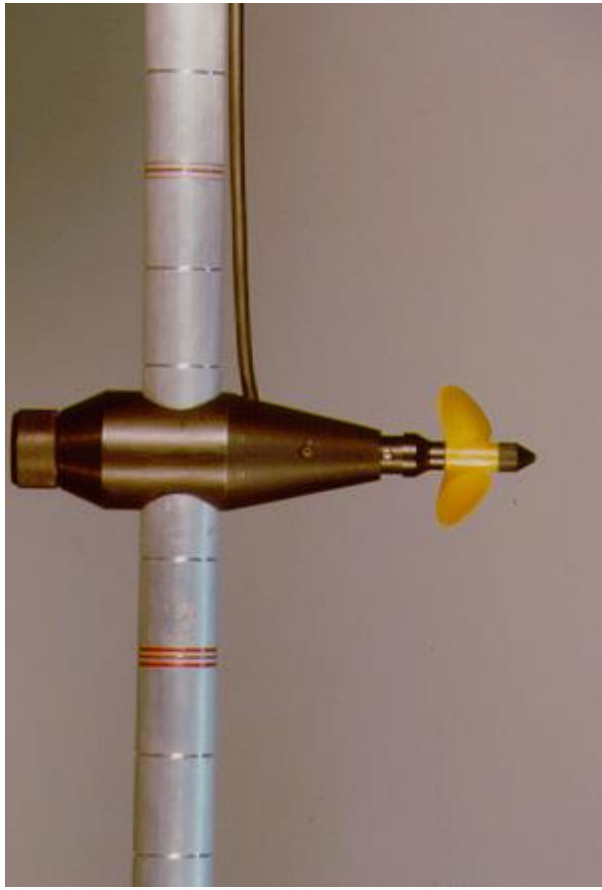
- Capt ... beaker) and mea... [discharge over a given time period.]

REMEMBER TO MEASURE THE WATER LEVEL AT THE STAGE BOARD WHEN YOU DO ANY OF THESE !!!

THAT VALUE IS JUST AS IMPORTANT AS THE DISCHARGE VALUE

Velocity-area gauging

Equipment required: Current meter, tape measure, stopwatch, notebook



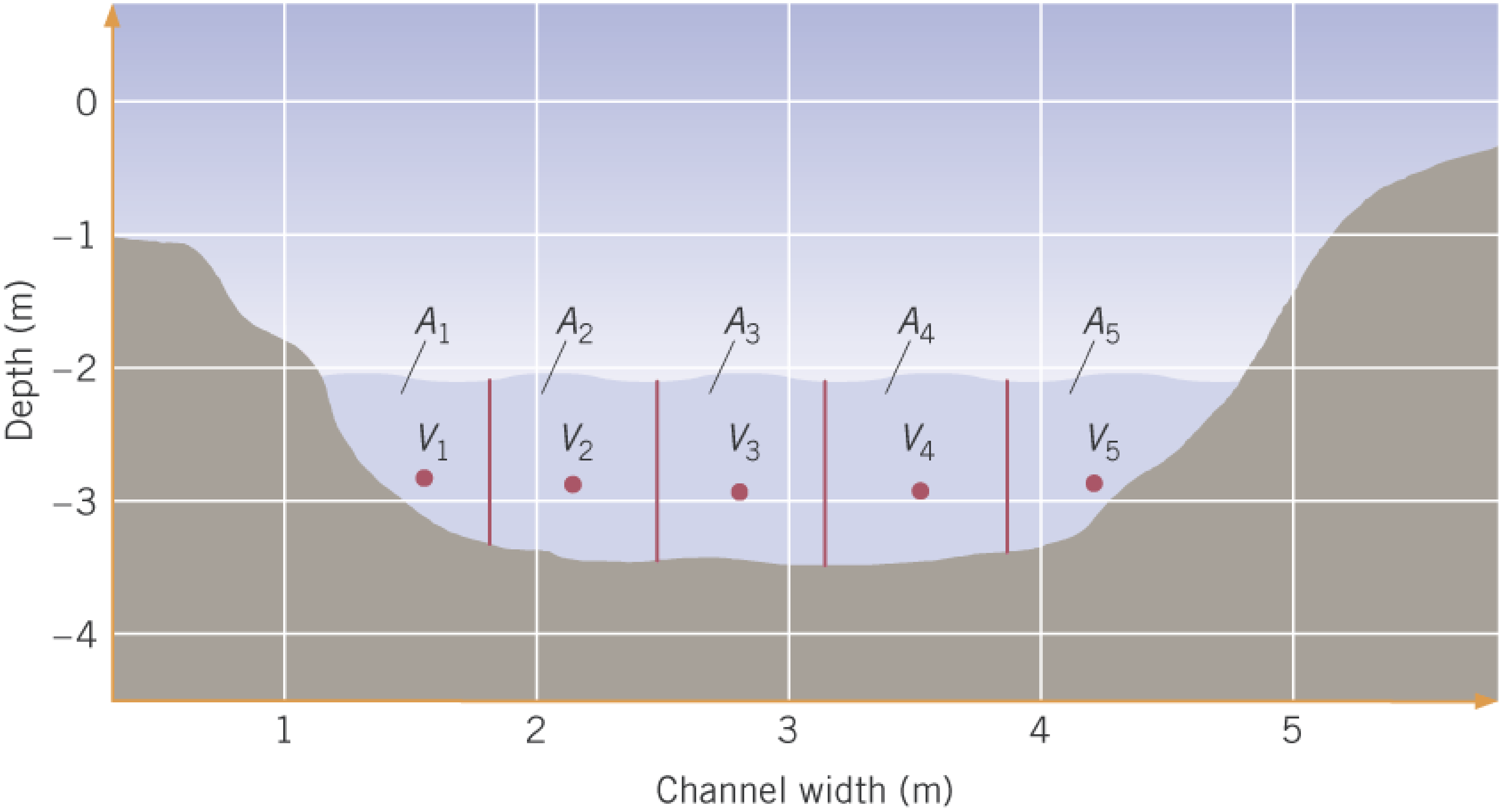
1. Make sure that appropriate risk assessment has been completed. Take any necessary risk avoidance measures throughout the work.
2. Measure the stage as accurately as possible (nearest mm if possible) according to the water level datum used in the automatic water level sensor (if used) for the watercourse. Also enter the time of the gauging. **These are both essential** so we can relate the discharge to the water level in order to produce the stage-discharge relationship for the site.
3. Stretch a tape across the watercourse (approx horizontal) and measure channel width

4. Divide the watercourse into a suitable number of segments – the actual size depends on the channel width

5. At the division between each segment, measure the distance with respect to one bank and the water depth.

6. Work out 0.4 of the water depth above the bed at that segment.

7. Measure velocity with a current meter at 0.4 of the depth above the bed at the division between each segment, for each segment. Use a 60s count period and repeat twice at each segment division.



$$Q = V_1 \times A_1 + V_2 \times A_2 + V_3 \times A_3 + V_4 \times A_4 + V_5 \times A_5$$

Velocity-area gauging

8. Enter data into the spreadsheet provided.

8. The steps above should be repeated for the full range of water levels at the site so that a relationship can be established enabling us to covert water level recorded by the logger to discharge.

About 20 gaugings would be an appropriate level over a project. It is best to do these early on in the project as if the channel form changes in anyway during the study (e.g. big storm causes bank collapse) then a lack of ratings data before that change will render much of the water level record useless for conversion to discharge and hence flux data.

Salt-dilution gauging

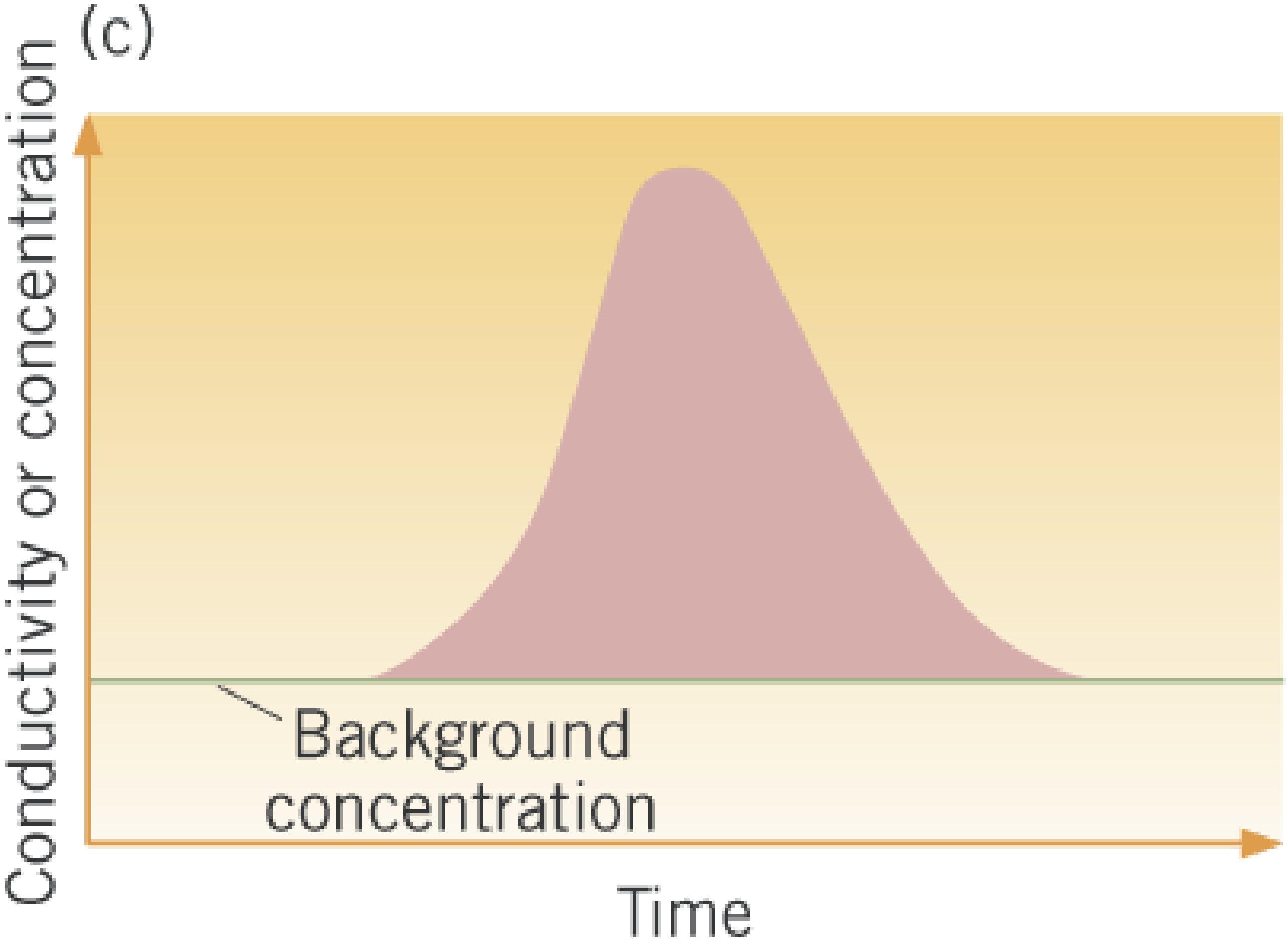
A method based on concentration of tracer (or conductivity)

If you know concentration and volume of water added to stream and you know stream concentration then you only have one unknown in the equation – the stream discharge

Gulp injection

$Q = (Ci\text{-}Cb).V / \int (Cd - Cb)\, \delta t$

Which simplifies to Q = (Ci-Cb).V / area under concentration curve



Salt-dilution gauging

Equipment required - Conductivity probe, salt, bucket, stopwatch, notebook

1. Measure stream water conductivity at half-width and at 0.6 x water depth (measured from bottom of stream).
2. Dissolve a small amount of preweighed salt (e.g. 100g) in a known volume (e.g. 5 litres) of stream water in a bucket. Mix well until all the salt has dissolved. Measure conductivity of solution. Take care to properly record the units from the conductivity probe.
3. Inject the salt solution into the stream water at sufficient distance upstream from the monitoring point to allow for complete mixing of tracer solution and stream water prior to passing the monitoring point. A minimum distance of 25 x stream width is recommended. Rinse bucket to ensure all salt has entered stream.

4. From the time of injection onwards: measure conductivity at monitoring point (at half width and at 0.6 x water depth from bottom of stream) in short time intervals (e.g. 5s) or for low discharges after every change in conductivity. The probe response times will need to be considered when determining a suitable time interval for sampling.

5. Continue the measurement until stream conductivity has fallen to its original background level (approximately for 5-20 min).

6. Measure the stage as accurately as possible (nearest mm if possible) according to the water level datum used in the automatic water level sensor for the watercourse (protocol 8). Also enter the time of the gauging. **These are both essential** so we can relate the discharge to the water level in order to produce the stage-discharge relationship for the site.

Date	14/09/2018		Tracer Volume (L)	10
Time (GMT)	13:57		Salt (g)	1000
Site	SM9		Area	31231.23
Gauge board			Concentration (mg L-1)	10000
			Q (L s-1)	3.20

Tracer volume * concentration / area

Time (sec)	Time change (sec)	Cond (uS)	NaCl (mg L-1)	NaCl change (mg L-1)	Integrated Area
0.00		70.4	37.85	0.00	
10.00	10.00	70.3	37.80	-0.05	-0.27
20.00	10.00	70.3	37.80	-0.05	-0.54
30.00	10.00	70.8	38.06	0.22	0.81
40.00	10.00	72.6	39.03	1.18	6.99
50.00	10.00	74	39.78	1.94	15.59
60.00	10.00	80	43.01	5.16	35.48
70.00	10.00	90.2	48.49	10.65	79.03
80.00	10.00	103.5	55.65	17.80	142.20
90.00	10.00	120.3	64.68	26.83	223.12
100.00	10.00	148.1	79.62	41.77	343.01
110.00	10.00	179.2	96.34	58.49	501.34
120.00	10.00	207.3	111.45	73.60	660.48
130.00	10.00	249	133.87	96.02	848.12
140.00	10.00	283	152.15	114.30	1051.61
150.00	10.00	317	170.43	132.58	1234.41
160.00	10.00	347	186.56	148.71	1406.45
170.00	10.00	358	192.47	154.62	1516.67
180.00	10.00	386	207.53	169.68	1621.51
190.00	10.00	401	215.59	177.74	1737.10
200.00	10.00	409	219.89	182.04	1798.92

Average of last and current tracer change * time change

V-notch weir gauging

Equipment required: bucket or measuring cylinder, tape measure, stopwatch, notebook

1. Simply collect all of the water spilling over the V notch in a bucket or measuring cylinder over a given time (e.g. 20 seconds)
2. Determine the volume of water per second
3. Repeat twice to obtain an average discharge
4. Record the exact date/time of the reading and the height of water above the base of the V and the water height at the stilling well
5. Repeat over the full range of water heights
6. While V notches have standard equations, field calibrated gauging data is best as the standard equations are for very specific environmental set-ups which are difficult to achieve in our studies