Water Use

Supporting Guidance (WAT-SG-54)

Technical Guide to Flow Measurement

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Update Summary

Version	Description
v1.0	First issue for Water Use reference using approved content from the following documents: Technical Guide to Flow Measurement.doc
v2.0	New base template applied, links to docs revised for new SEPA website, Nov 2008
v3.0	Expired CMS links reviewed and updated.
v4.0	Section 5 added (STW flow monitoring methods), sections 1.1, 1.2, 2.1 details clarified.

Notes

References: Linked references to other documents have been disabled in this web version of the document. See the References section for details of all referenced documents.

Printing the Document: This document is uncontrolled if printed and is only intended to be viewed online.

If you do need to print the document, the best results are achieved using Booklet printing or else double-sided, Duplex (2-on-1) A4 printing (both four pages per A4 sheet).

Always refer to the online document for accurate and up-to-date information.

Table of Contents

Key Points

This document provides technical guidance to site operators who are required to install monitoring equipment to measure flows as required by licence conditions under the Controlled Activities Regulations.

It also provides background information for SEPA staff on the types of flow monitoring that may be used in different situations.

Information on discharge flows and flows at treatment works is given in section 5. Section 1 (Does Flow Pass Through a Pipe?) and section 4 (Does Abstracted Water Flow Through Hydraulic Structure) are also relevant for flow measurement of discharges and at treatment works.

Water Resource Licensing

For water resource licences, this guidance should be read in conjunction with *WAT-SG-51: Water Resource Licence Monitoring Plan Guidance*.

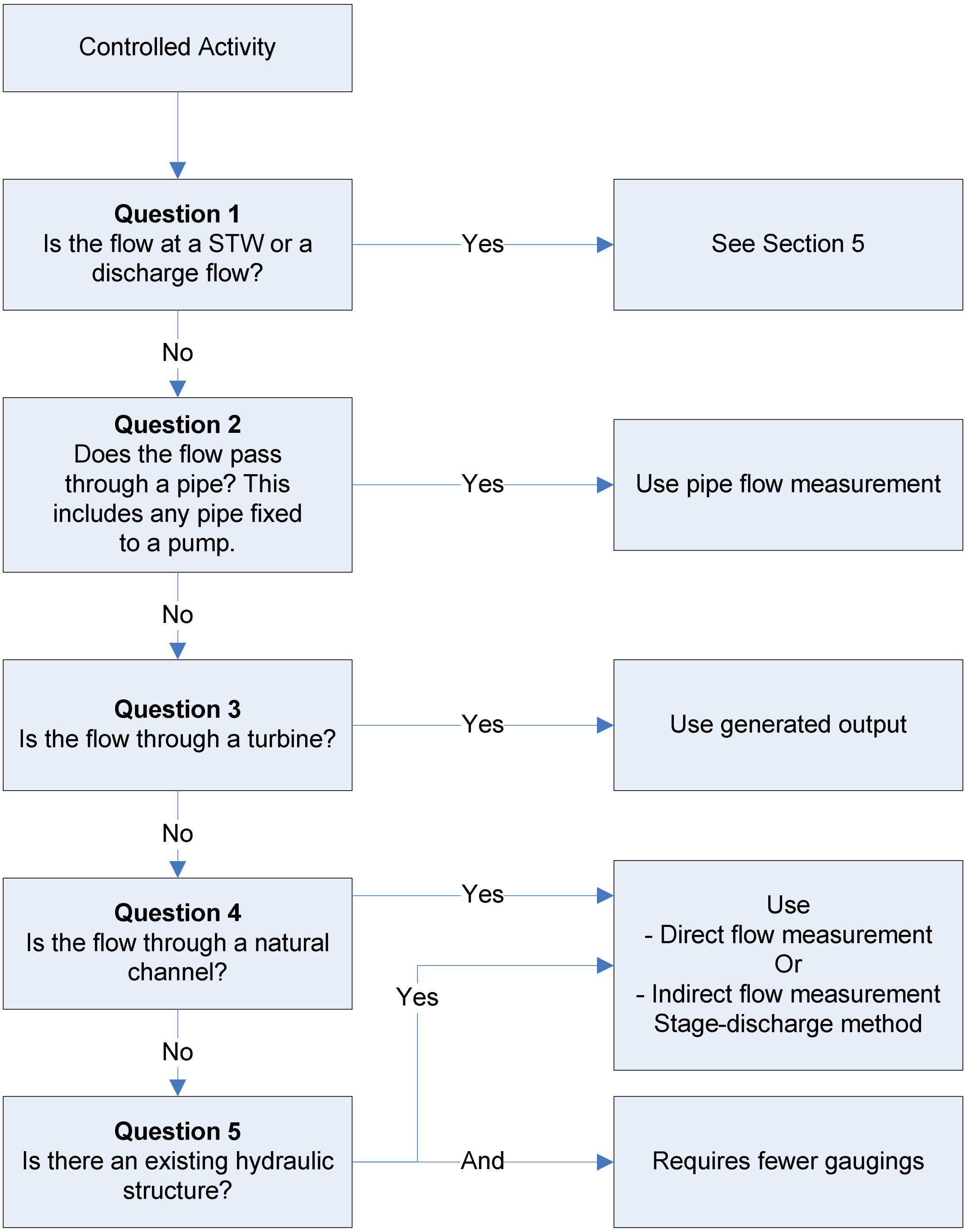
Hydrological Monitoring Decision Tree

In this monitoring guidance document the source of the water can be either surface water or groundwater. The type of monitoring installed in each situation will depend on the shape the water forms as it passes through various containments, either natural or artificial.

Process Flowchart

The following flowchart should be used as an initial guide to the type of flow monitoring that will be required at specific sites. This should cover the majority of situations but for more complex sites you should consult a SEPA hydrologist.

Figure 1 Metering Methods Flowchart



1. Does Flow Pass Through a Pipe?

Question 1: Does the flow pass through a pipe at any point, including any pipe fixed to a pump?

YES	Follow the guidance in this section
NO	Go to *Question 2*

1.1 Pipe Attached to a Fixed-rate Pump

Fixed rate pumps have a known, manufacturers rated, operating capacity. If this capacity is multiplied by the number of hours run, an estimate of the volume abstracted can be calculated. This relies on accurate recording of the number of hours a pump has been operating. The capacity is dependant on a number of factors; including; age and efficiency of the pump, power source for pump, suction and delivery head, length and diameter of hoses. This needs to be documented if total volume is critical. The only way to avoid this is either calibrate the pump (record how long it takes to fill a known volume, e.g. a water bower, or to independently measure the flow using a meter.

1.2 Pipe Attached to a Variable-rate Pump

As variable rate pumps can abstract at different rates, a record of pump hours run can therefore not reliably provide a measurement of the volumes abstracted. The only way to measure volume is either calibrate the pump, as described in 1.1, or to independently measure the flow using a meter.

1.3 Pipe with no Pump

Pipe flow can be true pipe flow or open channel flow (within the pipe). Open channel flow within the pipe must have a free surface, whereas pipe flow has none and the water fills the whole conduit. A free surface is defined as having a surface subject to atmospheric pressure. Open channel flow occurs in pipes provided there is a free surface and gravity flow.

1.4 Measurement of Pipe Flow where there is No Pump

1.4.1 Measuring open channel flow within pipe

If this is the case see section 4 Does Abstracted Water Flow Through Hydraulic Structure.

1.4.2 Measuring true pipe flow using electro-magnetic method

When water flows through an electro-magnetic field a voltage is generated. The mean velocity of the water flowing can be determined from this voltage. The flow can be calculated by multiplying the mean velocity and the known cross sectional area. Such devices are available with data loggers which measure and record pipe flow.

1.4.3 Measuring true pipe flow using ultrasonic method

Measurements are made by sending bursts of signals through a pipe. The measurement of velocity is based on the principle that sound waves travelling in the direction of flow of the fluid require less time than when travelling in the opposite direction. At zero velocity, the transit time or delta T is zero. The difference in transit times of the ultrasonic signals is proportional to the velocity of the fluid. Since ultrasonic signals can also penetrate solid materials, the transducers can be mounted onto the outside of the pipe. The flow can be calculated by multiplying the mean velocity and the known cross sectional area. Such ultrasonic devices are available with data loggers which measure and record pipe flow.

In addition see the Environment Agency guidance in *Abstraction Metering Good Practice Manual* or refer to a suitably experienced consultant.

2. Does Flow Pass Through a Turbine?

Question 2: Does the flow pass through a turbine?

YES	Follow the guidance in this section
NO	Go to *Question 3*

2.1 Monitoring Flow through a Turbine

The power generated by a turbine is a function of its efficiency, the flow of water, and the height difference between the intake and the turbine. Height and efficiency are fixed for most sites therefore provided that a rating curve exists for the turbine; generated output can be used as a measure of flow.

The total efficiency needs to also take into account head losses within the pipework upstream and downstream of the turbine. It may only be possible to do this with an independent calibration of the turbine against flow.

The flow from a turbine is expressed as expressed as:

$$\mathbf{Q = P / (h * c)}$$

Where:

Q = flow (m^3/s)

P = power (Kw)

h = potential energy head above the turbines (m)

c = constant (a function of turbine efficiency and acceleration due to gravity); typically c is approximately 7

3. Does Flow Pass Through A Natural Channel?

Question 3: Does the flow pass through a natural channel?

YES	Follow the guidance in this section
NO	Go to *Question 4*

A natural channel is one where there is no artificial (man-made) hydraulic structure present. A hydraulic structure is a structure installed in a waterway to impound, direct, control or measure the flow of water. Structures include dams, weirs, flumes, overflow spillways and sluice gates.

Figure 2 Natural Channel

Use direct flow measurement or indirect flow measurement of the natural channel. Direct flow measurement is preferable if the channel conditions permit it.

Flow of the natural channel is described by the following equation:

$$Q = V \times A$$

Where:

Q = flow

V = mean velocity

A = cross-sectional area

Where the measuring device measures Q it is known as direct measurement. Where V and A must be measured to derive Q it is known as indirect flow measurement.

3.1.1 Direct Flow Measurement

Direct flow measurement can be accomplished using the following methods.

- Acoustic Doppler velocity / flow meters
  side-looking or upward-looking
- Time of Flight Ultrasonic velocity / flow meters.

Acoustic Doppler Velocity Flow Meters (side- and upward-looking)

These use the principle that the reflection of sound waves from a particle moving within a fluid causes a change in the frequency of the reflected sound wave. This difference in frequency is known as the Doppler Shift. The Acoustic Doppler flow meter uses this Doppler Shift effect to determine velocity in flowing water. The sensor transmits high frequency pulses of sound into the flow. These pulses are reflected back to the sensor by suspended particles, plankton and air bubbles. The sensor measures the difference in frequency as the particles move which determines the velocity. The known cross sectional area is multiplied by the mean velocity to derive flow.

Very clean water can prove difficult for Acoustic Doppler flow meters because of a dearth of reflective particles, as can very turbid water where too many suspended particles can interfere and ‘scatter’ the sound. Water with too many air bubbles is also unsuitable. Acoustic Doppler flow meters generally only sample a portion of the flow in the channel which is related to the mean velocity in the channel. This is called velocity indexing. They are particularly suited to straight, uniform channels with permanent controls.

Two versions of this are available, side looking which is fixed near to the bank and must be submerged to a minimum depth at all times and upward looking which is fixed to the bed looking vertically upwards. Operating principles are the same in both cases.

Time of Flight Ultrasonic flow meters

Time of Flight Ultrasonic flow meters transmit sound pulses at a known angle to the direction of flow which are reflected from a fixed point on the far bank. The transmitter/receiver and reflector are at fixed and known distances. The speed (time of flight) of the pulse differs dependent on the flow, since the speed of the pulse downstream will be enhanced by the flow whereas the upstream speed will be impeded by the flow. This difference in speed is measured electronically and mean velocity along the flight path is calculated from this difference. The product of mean velocity and cross sectional area determines the flow.

Time of Flight Ultrasonic flow meters are usually fixed low down on the banks of the channel with the transducers pointing horizontally at a known angle to the direction of flow. Multi path systems can be used in larger channels with a big stage range. They do not operate successfully in channels with high sediment loads. They must have a clear path between transducers/reflectors.

Both the above methods require a degree of expertise and experience.

Please consult a suitably experienced hydrologist for further advice.

3.1.2 Indirect Flow Measurement

This method is dependent on establishing a unique relationship between stage (water level relative to a known datum) and discharge (flow). The relationship is developed by carrying out flow measurements (gaugings) over, preferably, the complete range of flows for the site. From these gaugings the stage-discharge relationship or rating equation can be determined.

The stage-discharge relationship is described by the following equation:

$$Q = c\ (h - a)\ b$$

Where:

Q= flow (m^3/s)

h= stage (m)

a, b and c are constants

The stage is measured by means of a sensor e.g. shaft encoder, pressure probe etc. and recorded on a data logger at regular (15-minute is recommended) intervals. Flow can then be calculated for each 15- minute reading by applying the rating equation to the stage record.

Site Selection

For accurate flow measurement using the indirect method, site selection is very important.

The ideal site should include the following criteria:

- A control (see *The Control* below)
- A straight and uniform approach channel upstream, at least five times as long as the river width at the cross section (different criteria exists for weirs e.g.10 times the length for thin plate weirs).
- A reasonably straight channel immediately downstream, to avoid bank erosion and to reduce downstream water levels (to avoid 'drowning out' of the control).
- It should be free of weeds. Weeds grow on the control and can affect the stage – discharge relationship. Weeds can also affect the ability to operate flow measurement devices such as current meters.
- Laminar flow is highly desirable for accurate gauging therefore the channel should be free of stones/boulders which create turbulence
- The river bed should be stable and not subject to extensive erosion or deposition

During site selection consideration should also be given to:

- Safe and easy access

- Services e.g. close to mains power (if needed) or telephone lines for telemetry
- Security – the site should be vandal proof
- Fisheries – passage for migratory fish. This is mainly an issue where weirs are used

The Control

The reliability and stability of the stage-discharge relationship is normally controlled by a section of the channel known as “the control”. This is a point in the channel where critical flow occurs i.e. the flow changes from deeper slow flow to shallow fast flow. This is normally identified by a significant fall in water level caused by the shape of the river bed and banks. This fall in water level can be caused by natural or artificial controls. Examples of natural controls are natural waterfalls, rocks or boulders on the riverbed. Examples of artificial controls include weirs, dams and flumes.

Ideally the control should be of such a profile that it does not get ‘drowned out’. This happens at higher flows when the control’s effect is made negligible as it ‘disappears’ under deeper water both upstream and downstream. This is not always possible: an experience hydrologist can advise in these circumstances as it is still possible to derive flow information from “drowned controls”, albeit at lesser accuracy.

Figure 3 Natural Control (1)

Figure 4 Natural Control (2)

Figure 5 Artificial Control: Weir

Figure 6 Artificial Control: Flume

Stability of the control

The control chosen should be stable. A stable control shows very little change in the stage-discharge relationship over time. i.e. for a measured stage, the corresponding flow will not alter significantly over time. An unstable control can be caused by factors such as erosion and deposition of the river bank or bed and weed growth.

Sensitivity of the control

The control should be sensitive i.e. a significant change in stage produces a significant change in discharge. Small errors in stage readings during calibration at a non-sensitive site can result in large errors in the discharge indicated if the stage-discharge relationship isn't sensitive. Sensitivity in natural channels is site dependent. Wide shallow controls tend to be insensitive. Narrow deeper controls tend to be sensitive. Sensitivity can be achieved by installing a compound weir with a 'low flow notch'. A low flow notch is a section of the weir that is at a lower height than the rest of the weir and at low flows all the water flows through the notch and the stage can be accurately measured. Notches can be of various different shapes e.g. rectangular, v- shaped etc.

3.1.3 Determining the Stage-Discharge Relationship using the Velocity Area Method.

Once a suitable site has been established the stage-discharge relationship is developed, usually by carrying out a series of flow measurements known as gaugings.

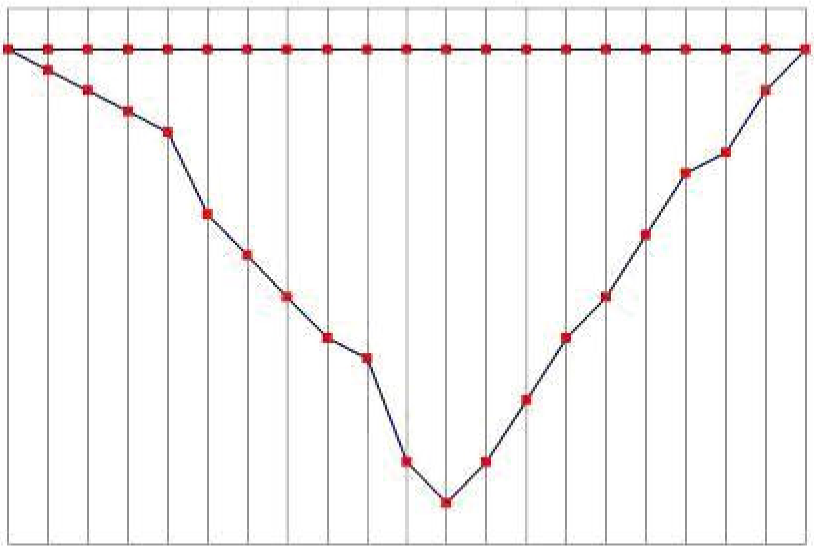
Obtaining Gaugings

It is necessary to carry out gaugings throughout the full range of expected flows. There are several different types of equipment suitable for this, detailed below. They are listed below in descending order of preference.

Rotating element (impellor) current meter

A current meter gauging is carried out by taking a series of water velocity measurements and depths at points (verticals) across a section of the channel. The distances to each of the points are measured by means of a steel tape or tagline stretched across the channel at right angles to the flow. The depths are measured by means of a wading rod graduated in centimetres. The velocity is determined by recording the number of revolutions of the impellor over a known time period and converting to velocity using the impellor calibration (revolutions to velocity in m/s). The impellor is positioned at the point of mean velocity in the vertical which is 0.6 of the depth measured from the surface. The flow in each panel (section between each vertical) can then be calculated by multiplying the area by the mean velocity (m^3/s). The total flow for the section is the sum of the flows in all the panels. Rotating element current meters come in different sizes for use in different depths of water.

Figure 7 Typical channel cross-section with suggested points for verticals



Electromagnetic current meters

These are used like the rotating element current meter. A series of point measurements are taken across a suitable cross section of river. The electromagnetic current meter measures velocity directly at these point measurements. It has the advantage of operating in low and negative velocities, heavily silt laden or weedy conditions and in shallow depths.

Acoustic Doppler current meter (Sontek Flowtracker)

This is a current meter which works using the Doppler shift principle previously discussed. It is used in exactly the same way as the rotating element current meter. Its advantages include its ability to operate in extremely low velocities, shallow depths, being able to account for diagonal flow and having no moving parts.

Acoustic Doppler Velocity Profiler (ADVP)

The ADVP operates using the Doppler Shift principle explained previously. It is mounted on a boat, winch and cableway, or flotation device and it is moved across the measuring cross section or measures at discreet points similar to current meter. It measures the flow directly. They are not suited to narrow shallow streams.

Volumetric method of flow estimation

Provided there is a suitable point where all the flow can be captured, small flows can be measured using a graduated container and a stop watch. The time taken to fill the container to a known volume is recorded. It is advisable to undertake the procedure a number of times and take the average.

Discharge is estimated from:

Discharge (Q) = Volume (l) / Time (s)

Graduated domestic buckets are not scientific instruments and require calibration to ensure the graduated marks on them tally with the correct volume of water.

Dilution Gauging

This measures discharge by adding a chemical tracer of known concentration to the flow then measuring the concentration of the solution downstream where the chemical has completely mixed with the stream water. By measuring the dilution of the tracer it is possible to calculate how much water has been available to dilute the tracer, and hence the discharge in the channel. This method is generally only used if no suitable site exists for alternative methods.

Gauging Method Summary

The most popular, and generally considered as still the standard, method used from those stated above is the rotating element current meter. However the new technologies particularly the acoustic Doppler methods in their various forms are becoming increasingly accepted and are now in widespread use through out the world.

No matter which method is used, it is imperative that the exact river stage at the time of gauging is also recorded. See Staff/Ramp gauge (section 3.1.4 below.

3.1.4 Plotting Gaugings

In order that an accurate stage – discharge relationship be determined it will be necessary to take 10 or 12 gaugings evenly spaced throughout the range of flows, using any of the above methods. The gauging results are generally plotted on log-log axes and the relationship can be defined by applying regression analysis in order to determine the equation.

The stage discharge relationship is normally given by an equation:

$$\mathbf{Q = c\ (h - a)\ b}$$

Where:

Q = flow

h = gauge height or stage

a, b and c are constants

Re-calibration

Few rivers have completely stable characteristics. The stage - discharge relationship can seldom be determined only once. It must be repeated as frequently as required according to its stability. For example a stable rock control may require only an initially intense period of gauging to establish the relationship, and only a few gaugings thereafter to confirm its stability. A gravel control affected by constant scour and deposition must be gauged continuously for accurate results.

Staff/Ramp gauges

A staff gauge is a permanent graduated staff generally fixed vertically to the river bank at a stable point in the river unaffected by turbulence or wave action. A ramp gauge is fixed at an angle. They both have metre graduations marked on them which should extend from the lowest to the highest stage expected. The zero on the gauge can correspond to the crest of the control, but it is more often set at a level which is lower than the lowest water level experienced at the site.

All gauges should be made of durable material, insensitive to temperature changes and kept clean especially in the range of average water levels.

Figure 8 Staff Gauge

Figure 9 Ramp Gauge

3.1.5 Site Visits

It is recommended that the site is checked at least once a month. The logger should be downloaded and the data archived electronically elsewhere. The logger should be checked that its reading corresponds with the staff or ramp gauge. Differences should be adjusted and dates and times noted. The site should be checked for anything unusual e.g. branches/leaves/debris blocking the control, weeds, silt, vandalism.

4. Does Abstracted Water Flow Through Hydraulic Structure?

Question 4: Does the abstracted water flow through an existing hydraulic structure?

YES	Follow the guidance in this section
NO	Refer to SEPA Hydrologist

The same principals are applied for measurement of flow through a hydraulic structure as those for a natural control, using direct or indirect flow measurement.

There are benefits of hydraulic structures over natural channels. If the structure has been specifically designed to measure flow and installed correctly then the stage-discharge relationship can be estimated in accordance with theoretical formulae. Due to the stable nature of the control, the need to undertake frequent current meter gauging will not be necessary. However the accuracy of the theoretical relationship will need checked over the full flow range and confirmed from time to time.

Hydraulic structures include:

- Thin plate weirs
    - Rectangular
    - V-notch

Figure 10 Rectangular Thin Plate Weir

Figure 11 V-notch Thin Plate Weir

- Broad crested weirs
    - Rectangular
    - V-shaped
    - Can also be compound i.e. having a low flow structure.

Figure 12 Broad Crested Weir with a Low Flow Structure (Broad Crested Compound Weir)

Figure 13 Broad Crested Weir with a Low Flow Structure (Broad Crested Compound Weir)

Figure 14 Broad Crested Weir With No Low Flow Structure

- Triangular profile weirs
  - Crump
  - Flat-V
  - Can also be compound.
- Flumes
  - Rectangular
  - Trapezoidal
  - U-throated

Figure 15 Compound Crump Weir

Figure 16 Trapezoidal Flume

Non-purpose built structures

Structures which have not been specifically built for flow measurement can be used to derive flow. If the dimensions of the structure are known flow can be derived from monitoring the stage. Non purpose built structures include:

- Sluice Gates
- Culverts
- Pipes
- Bridges
- Off-takes
- Water Tanks

Figure 17 An Offtake Lade

Figure 18 Artificial Control At Loch Outlet

Consult a suitably qualified hydrologist for further advice.

5. Measurement of Discharge Flows and Flows at Treatment Works

5.1 Why do we need flow monitoring at treatment works?

Treatment works have usually been designed based on flow so it is important to gather accurate information to inform on overloading or underloading.

Flows measurement and reporting is often a requirement in STW and Network licences. See *WAT-RM-07: Regulation of Sewer Overflows* and *WAT-SG-53: Environmental Standards for Discharges to Surface Waters* for more information.

Accurate flow monitoring is also important to inform investment decisions.

5.2 Flow Measurement in an Open Channel

This is the most common type of flow measurement found in sewage treatment works.

There is a relationship between the upstream water level (also called stage or head) and the flow rate. The water level is easily measured by a variety of methods, such as by an ultrasonic detector, and from that, the flow rate can be calculated.

The relationship between head and flow can be affected if there are flow disturbances such as penstocks, screens or bends in the channel upstream of the flow control device.

Compliance with the relevant British Standard and Statement will avoid these disturbances – this may specify for example, minimum distances of straight channel upstream.

5.2.1 Rectangular Flume

This is the most common flow measurement structure at sewage treatment plants and can be used anywhere where there is an open channel. However because they are relatively unaffected by choking with debris, rectangular flumes are particularly suitable for inlet flow measurement where there can be considerable amounts of solids.

Figure 19 Rectangular Flume with upstream ultrasonic sensor

5.2.2 U Shaped Flume

This is a version of the rectangular flume which provides more accurate measurements of low flows because of the U shaped lower section of channel. This is more usually seen at smaller STWs.

5.2.3 Trapezoidal Flume

This is not so common as under certain conditions two measurements are required. Under free flow conditions trapedoidal flumes only require a measurement of the head upstream which is converted to flow via a rating equation. Under submerged flow conditions the downstream depth is great enough that the flow throughout the flume is subcritical and an additional depth reading downstream is required.

5.2.4 V-Notch Weir

These are more prone to blockages and therefore more suitable to measure effluents with low quantities of solids.

V-notch weirs are suitable for measuring very low flows. A narrower ‘V’ angle increases the accuracy at low flows.

See Figure 11 V-notch Thin Plate Weir.

5.2.5 Rectangular Weir

Rectangular weirs are not as suitable as V-notch weirs for measuring very low flows. See Figure 10 Rectangular Thin Plate Weir.

5.2.6 Flow Measurement in a Pipe

The two types commonly used are electromagnetic flow and ultrasonic flow measurement. Please see sections 1.4.2 and 1.4.3 for a more detailed explanation.

As with open channels, flow meter readings in pipes can be affected by nearby structures and compliance with the relevant British Standard will avoid these unwanted disturbances.

Flow measurement in pipes usually takes place where the pipe is full of liquid such as when it is being pumped through a rising main in a sewerage network. In a full pipe flow can be measured by Orifice or Venturi Meters which narrow the diameter of the pipe so that the flow is constricted. Flow is calculated from the pressure differential across the constriction. Excessive entrained air can affect flow readings.

If the pipe is continually partially full then a specialist different type of meter must be selected. Such specialist meters include Electromagnetic flow meters specifically designed to operate in partially full pipes.

There is relatively little to see since most of the equipment is within the pipe.

Figure 20 Electromagnetic Flow Meter

Refer to section 1 for further information on flow measurement in pipes.

Appendix 1: Glossary & Units

Table 1 Glossary

Term	Description
Calibration	The process of checking the scientific accuracy of a relationship e.g. the process of defining a unique relationship between stage and discharge.
Control	A point in the river channel where critical flow occurs i.e. the flow changes from deeper slow flow to shallow fast flow. This is normally identified by a significant fall in water level caused by the shape of the river bed and banks. This fall in water level can be caused by a natural or artificial controls. Examples of natural controls are natural waterfalls, rocks or boulders on the riverbed, examples of artificial controls include weirs, dams and flumes.
Direct flow measurement	A process that measures flow, as opposed to measuring stage and converting it to flow using a rating equation (indirect flow measurement).
Discharge	volume of water per unit of time i.e another word for flow
Drowning out	Occurs when the stage has risen to such a height that a hydraulic structure ceases to provide a unique relationship between stage and discharge.
Groundwater	Water within the earth that supplies wells and springs; it comprises water in the zone of saturation which fills all openings in the rocks and soil, the upper surface of which forms the water table. Once the water emerges onto the earth's surface via a well or a spring it is then termed surface water.
Head	See *Stage* definition.
Hydraulic structure	A structure installed in a waterway to impound, direct, control or measure the flow of water. Structures include dams, weirs, flumes, overflow spillways and sluice gates.
Indirect flow measurement	Obtaining flow by measuring stage and converting it to flow using a stage – discharge relationship also known as a rating equation.
Laminar flow	Fluid flowing in slow moving smooth sheets (laminae).
Measurement Units (see list of *common units*)	Flow is generally reported as mean daily flow (MDF) in cubic metres per second (Cumecs or m^3/s). In the UK the convention is to report MDF from 9am one day until 9am the next day, this is called the water day. In addition for the stage-discharge method consult a suitably qualified hydrologist.
Natural channel	A stretch of river where there is no artificial (man-made) hydraulic structure present.
Ramp gauge	A permanent graduated staff generally fixed at an angle to the river bank at a stable point in the river unaffected by turbulence or wave action.
Rating equation	Numerical form of expressing the unique relationship between stage and discharge at a particular site.
Stable control	A stable control shows little change in the stage-discharge relationship over time. i.e. for a measured stage, the corresponding flow will stay the same, or only alter very gradually.

Stage	Water level relative to a known datum, either a local bench mark or the crest level of the control.
Stage-discharge relationship	Method of expressing the unique relationship between stage and discharge at a particular site.
Staff gauge	A permanent graduated staff generally fixed vertically to the river bank at a stable point in the river unaffected by turbulence or wave action.
Surface water	Water that flows overland in streams, rivers, natural lakes, wetlands, and in reservoirs constructed by humans.
Unstable control	An unstable control will have a rapid change in the stage-discharge relationship over time, i.e. for a measured stage, the corresponding flow will differ due to factors such as weed growth, shifting sand or gravel in the river bed and banks.

Table 2 Common metric measurement units

Measurement	Units
Cubic metres per second	Cumecs or m^3/s
Litres per second	l/s
Mega litres per day	Ml/d
Distance and depth	metres
Area	square metres or m^2
Velocity	metres per second or m/s

Appendix 2: List of ISO/BS Standards

Table 3 List of ISO/BS Standards for Flow Measurement (non-exhaustive)

Title of Standard	ISO/EN Standard	British Standard
Velocity area methods	748:1997	BS EN ISO 748
Establishment & operation of a gauging station	1100/1:1996	3680/3B:1997
Stage discharge relation	1100/2:1998	BS ISO 1100-2
Ultrasonic (acoustic)method	6416:2004	BS EN ISO 6416:2004
Guide for the selection of methods (TR)	8363 :1997	BS ISO/TR 8363
Electromagnetic method	9213:2004	BS ISO 9213
Free surface flow in closed conduits (Methods) (TR)	9824/1:1990	3680/11A
Guide for safe practice in stream gauging	N/A	3680/3Q:2002
Electromagnetic current meters (Methods of use) (TS)	15768:2000	BS ISO/TS
Doppler shift flow meters (TS)	15769:2000	BS ISO/TS
Thin plate weirs	1438/1:1980	3680/4A:1981
Triangular profile weirs	4360:1984	3680/4B:1986
Flumes	4359:1983	3680/4C:1981
Compound gauging structures	14139:2000	BS ISO 14139
Rectangular broad crested weirs	3846:1989	3680/4E:1990
Round nose horizontal crest weirs	4374:1989	3680/4F:1990
Flat V weirs	4377:2002	BS ISO 4377
Guidelines for the selection of structures	8368:1999	BS ISO 8368
V shaped broad crested weirs	8333:1985	3680/41:1986
End depth method	3847:1977	N/A
End depth method (non-rectangular channels)	4371:1984	N/A
Trapezoidal broad crested weirs	4362:1999	N/A
Parshall and SANIRI flumes	9826:1990	N/A
Streamlined triangular profile weirs	9827:1992	N/A
Vertical underflow gates	13550:2002	N/A
Glossary of terms	772:1996	BS EN ISO 772:2001

Dilution methods − general − radioactive tracers − chemical tracers − fluorescent tracers	 9555/1:1994 9555/2:1992 9555/3:1992 9555/4:1992	 3680/2A:1995 3680/2B:1993 3680/2C:1993 3680/2D:1993
Mixing length of a tracer in open channels (TR)	11656:1993	N/A
Water level measuring devices	4373:1995	N/A
Current meters	2537:1988	3680/8A:1989
Current meter calibration	3455:1976	3680/8C:1980
Cableway system	4375:2000	BS EN ISO 4375
Free surface flow in closed conduits (Methods) (TR)	9824/2:1990 ISO/TR 9824-2:1990	3680/11B:1992 BS 3680-11B:1992
Electromagnetic current meters (TR)	11974:1998	BS ISO/TR 11974
Acoustic Doppler profiler (TS)	24154:2005	BS ISO/TS 24154
Propeller type current meters	ENV 14028	Non-BS Title
Guide to hydrometric data management	N/A	BS 7898:1997

For further details on any of the above publications, search on the BSI and/or ISO sites:

- *British Standards Institute* (www.bsigroup.com/)
- *International Standards Organization* (www.iso.org/)

References

NOTE: Linked references to other documents have been disabled in this web version of the document.

See the Water >Guidance pages of the SEPA website for Guidance and other documentation (*www.sepa.org.uk/water/water_regulation/guidance.aspx*).

All references to external documents are listed on this page along with an indicative URL to help locate the document. The full path is not provided as SEPA can not guarantee its future location.

Key Documents

- *WAT-RM-07: Regulation of Sewer Overflows*
- *WAT-SG-51: Water Resource Licence Monitoring Plan Guidance*
- *WAT-SG-53: Environmental Standards for Discharges to Surface Waters*
- *WAT-TEMP-68: Water Resource Monitoring Plan Licence Template*

Other References

- *Abstraction Metering Good Practice Manual* EA (Code: LIT 1532) (www.environment-agency.gov.uk)
- *Flow Measurement of Effluent Discharges above 50m3/day: A guide for EA Inspectors* EA (Code: LIT 2171) (www.environment-agency.gov.uk)
- *Hydrometry. Measurement of liquid flow in open channels using current-meters or floats* BSI (BS EN ISO 748:2007, www.bsigroup.com)
- Shaw, Elizabeth M. (1996). Hydrology in Practice, Third Edition. Chapman & Hall, London

Standards

- *British Standards Institute* (www.bsigroup.com)
- *International Standards Organization* (*www.iso.org/*)

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