Assets Planning and Delivery Group
Engineering

Design Guideline DS 200

Flow Measurement for WRRFs

VERSION 1
REVISION 0

MAY 2025

FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of the Western Australia's Work Health and Safety (General) Regulations 2022 to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

Overview of Western Australia’s Work Health and Safety (General) Regulations 2022 (dmirs.wa.gov.au)

Enquiries relating to the technical content of a Design Standard should be directed to the Senior Principal Engineer, Water Resource Recovery, Advisory Section, Engineering. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Head of Engineering

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Users should use and reference the current version of this document.

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Any interpretation of anything in the Standards/Specifications that deviates from specific Water Corporation Project requirements must be referred to, and resolved by, reference to and for determination by the Water Corporation's project manager and/or designer for that particular Project.

REVISION STATUS

The revision status of this standard is shown section by section below:

REVISION STATUS						
SECT.	VER./ REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
1	1/0	07.05.25	All	New Version/Revision	CH/PS	WB
2	1/0	07.05.25	All	New Version/Revision	CH/PS	WB
3	1/0	07.05.25	All	New Version/Revision	CH/PS	WB
4	1/0	07.05.25	All	New Version/Revision	CH/PS	WB
5	1/0	07.05.25	All	New Version/Revision	CH/PS	WB
6	1/0	07.05.25	All	New Version/Revision	CH/PS	WB

DESIGN GUIDELINE DS 200

FLOW MEASUREMENT

CONTENTS

Section *Page*

1 Executive Summary

Flow measurement of used water entering or leaving a treatment plant is necessary for regulatory reporting and is typically specified on the facility license. In addition to inflow and outflow measurement, many internal liquid, chemical and gas process flows are measured to provide feedback to the control system and for the control of mechanical equipment. Further flow measurement assists with leak detection, consumption analysis, process unit loading and process optimisation.

The selection of the most appropriate measurement device will depend on the unit process being measured, physical site conditions, type of fluid being measured and the required accuracy. For example, if treatment plant inflow and outflow volumes are being used for regulatory reporting or license fee calculation, then an accurate, reliable and verifiable magnetic flow meter installed in pipework is preferred. For monthly potable water usage, a standard mechanical water meter read monthly would suffice.

A wide range of mechanical equipment, instrument types and flow measurement device designs are used across Water Corporation sites in WA. Experience has shown that verification of key design criteria with respect to system hydraulics, mechanical configuration and equipment performance is crucial to selection of the most fit-for-purpose device.

Several current Water Corporation Engineering Standards outline the specific requirements of a particular measuring device including recommended physical installation requirements (SPS320 Sect. 3.2.5) and other key features. These include, in order of most pertinence and detail:

- SPS320 – Magnetic Flowmeters
- DS40-09 – Field Instrumentation, Sections 2 and 3.4.
- DS51 Standard Drawings CA01-57-1-1 & CA01-57-2-1
- DS60 Standard Drawing EG20-4-2
- DS30-02 – General Design Criteria – Mechanical, Section 24.
- DS31-02 – Valves and Appurtenances – Mechanical, Section 8.4 & 8.5.
- DS51 – Design and Construction of Wastewater Pumping Stations and Pressure Mains 4 1o 180 Litres per Second Capacity
- DS60 – Water Supply Distribution – Pipelines other than reticulation

It is not the intention of this Guideline to repeat this information, but it is intended to assist in the understanding of the selection of the various types of instruments available given the fluid being measured in the range of the conditions encountered across Water Corporation's WWTP and WRRF sites. A high-level selection guide has been developed to assist in understanding the preferred instrument type for various flow measurement applications.

The details as to the specific measurement principles of each type of instrument are contained in Sections 3 & 4, with examples of instruments installed in Water Corporation sites contained in Section 6.

Flowchart for preferred instrument selection

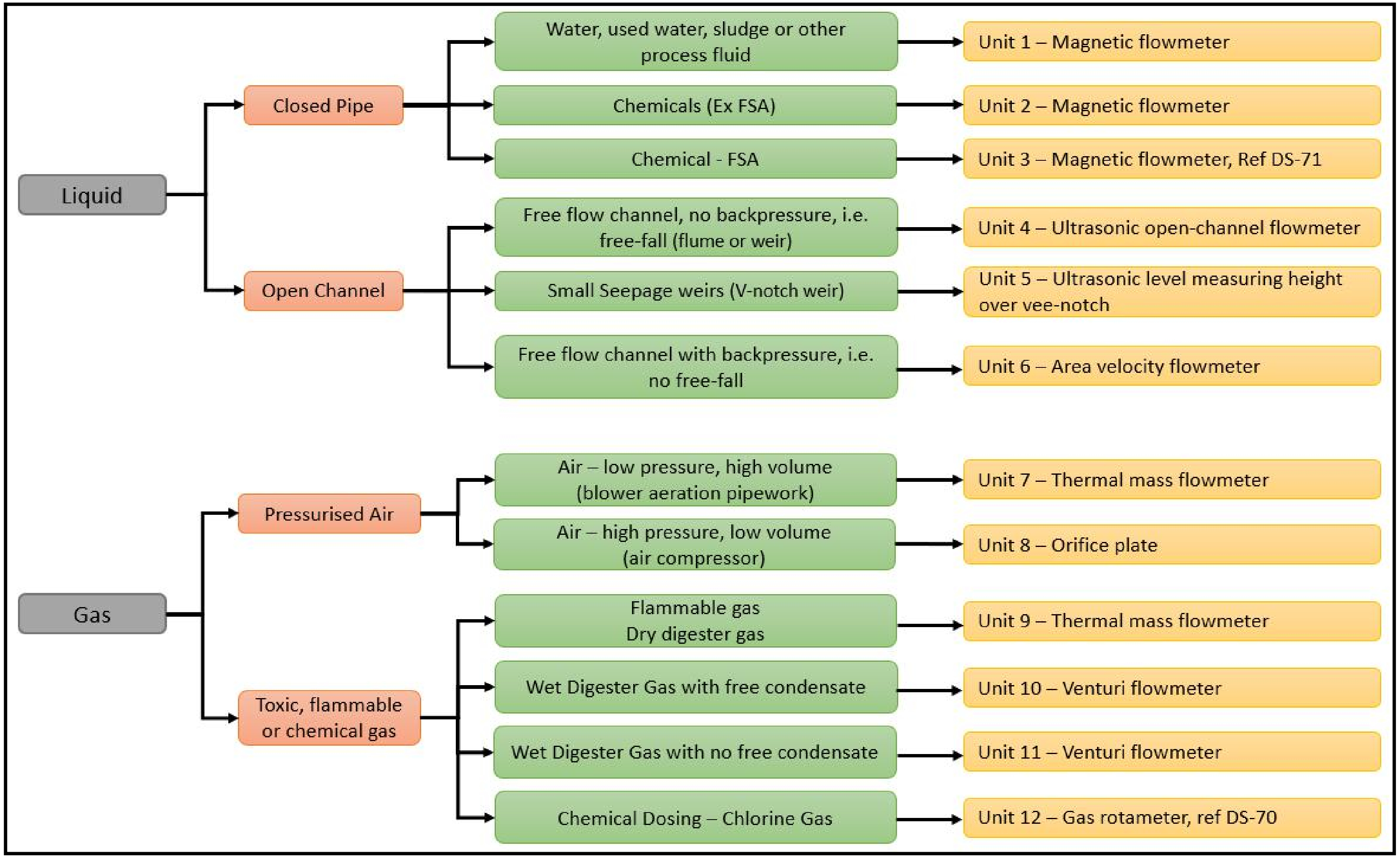

Table of Preferred Instruments

Produced from *DS40-09, Section 3 Table 2*, and the Preferred Suppliers from *SCADA Approved Equipment List.* Please refer to latest versions of these sources for the most up to date advice.

Unit	Application	Preferred instrument types	Alternatives (subject to approval)	Approved Instrument Supplier
1	Water, wastewater or sludge in closed pipes	Magnetic flowmeter	Ultrasonic. DP Transmitter (in combination with DP device eg. Orifice plate, venturi or pitot tube). Turbine. Vortex.	Siemens - MAG5100W & MAG3100 with MAG 6000 transmitter Endress & Hauser - Promag 400, Promag W400 or Promag W500 (Order with Heartbeat© Diagnostics and Verification enabled)
2	Chemical Dosing - liquid	Magnetic flowmeter		Krohne – small bore Optiflux 5000
3	Chemical Dosing - Fluoride	Magnetic flowmeter. Refer to FSA Standards, DS-71		Krohne – Optiflux 4100W IFC 100 W converter. Protection rings #2 Hastelloy C22 Electrodes Platinum Lining: Standard PFA
4	Water or wastewater in open channels (flume or weir)	Ultrasonic open-channel flowmeter	Radar Flowmeter	
5	Small seepage weirs	Ultrasonic level measuring height over the vee-notch (derived flow)		
6	Water or wastewater in open channels with backpressure (no free fall)	Magnetic area velocity flowmeter. Ultrasonic area velocity flowmeter. Radar area velocity flowmeter.		
7	Air in closed pipes, low pressure, high volume	Thermal mass flowmeter	Orifice plate	Endress & Hauser - T-Mass 65I FCI (Fluid Components International) - ST-51
8	Air in closed pipes, high pressure, low volume	Orifice plate	Thermal mass flowmeter	
9	Flammable gas Dry digester gas	Thermal mass flowmeter	Ultrasonic transit-time	See above
10	Wet digester gas with free condensate (should be avoided as measurement is difficult and expensive)	Venturi flow meter with wet gas flow computer		
11	Wet digester gas with no free condensate	Critical applications: Venturi flow meter with wet gas flow computer Non-critical: Thermal mass flow meters (eg. FCI ST80)	Ultrasonic transit-time	
12	Chemical Dosing – Chlorine Gas	Gas rotameter - Refer to Chlorine Standards, DS-70		

2 Scope and General

2.1 Purpose

Water Corporation has developed a suite of Design Standards and Guidelines. Designers shall comply with these Standards and Guidelines for the definition, design and specification of water services assets being acquired by Water Corporation.

The purpose of the Design Standards and Guidelines is to provide:

a) Standards and guidelines applicable in the design of Corporation assets,

b) Explanatory or specific design information, and

c) Information relating to Water Corporation preferences and practices which have evolved from more than 100 years of water industry experience.

2.2 Scope

This Design Guideline provides clear direction on Water Corporation requirements and preferences for the definition and specification of fluid flow measurement systems within used water treatment facilities.

Inflow measurement is a key component of treatment facilities and is typically described as a volumetric inflow per day (kL/d or MLD). The plant volumetric inflow is normally included on the Operating License and must be reported to the Department of Water & Environmental Regulation (DWER) on an annual basis. Some of Water Corporation's low technology regional treatment plants and all advanced treatment plants are equipped with inflow measurement equipment. In cases where plant inflow cannot be or is not measured accurately, treated water volumes leaving the plant are measured for reporting.

Flow measurement of used water and associated fluids being recycled within a treatment plant is necessary for determining the current plant process unit loading and for process optimisation.

A wide range of mechanical equipment, instrument types and flow measurement device designs are used in WA. Experience has shown that verification of key design criteria with respect to system hydraulics, mechanical configuration and equipment performance is crucial to selection of the most fit-for-purpose and lowest Whole-of-Life cost systems.

2.3 Design Process

The design process to be followed by Designers is documented in the Water Corporation Engineering Design Process and applicable Design Standards.

2.4 Standards

All materials and workmanship shall comply with latest revisions of the relevant codes and standards.

Water Corporation Strategic Product Specifications (SPS), or in their absence the latest editions of Australian Standards, or Water Services Association Australia (WSAA) Codes, shall be referenced for design and specification. In the absence of relevant Australian or WSAA Codes, relevant international or industry standards shall be referenced

In the event of conflict between standards or codes, the following hierarchy shall be used:

1. Statutory requirements of Australia and the State of Western Australia.

2. Water Corporation Strategic Product Specifications, design and construction standards.

3.Australian Standards and Codes of Practice, or Water Services Association Australia (WSAA) Codes.

4.Other international standards or codes acceptable to Australian statutory authorities.

5.Alliance preferred alternative international standards or codes acceptable to Australian statutory authorities as described above.

6.Original Equipment Manufacturers (OEM) design standards.

2.5 Referenced Documents

Documents referred to in this Design Guideline are listed in Appendix A of this Guideline.

For Corporation Standards refer to Section 7 of DS30-01 Glossary – Mechanical.

For Australian and International Standards refer to Section 8 of DS30-01 Glossary - Mechanical.

Section 3.4 of DS40-09 Field Instrumentation is particularly relevant to this Flow Measurement Guideline.

2.6 Mandatory Requirements

The use of the imperative "shall" denotes a mandatory requirement. Use of verbs other than "shall" such as "will", "should", "may" indicates recommended practice.

2.7 Nomenclature

2.7.1 Engineering Definitions and Relationships

Refer to Section 2 of DS30-01 Glossary - Mechanical.

2.7.2 Preferred Terminology

Refer to Section 3 of DS30-01 Glossary – Mechanical and Appendix B of this Guideline.

2.7.3 Abbreviations, Acronyms and Symbols

Refer to Appendix C of this Guideline.

2.7.4 Standard Units and Relationships

Refer to Appendix D of this Guideline.

2.8 Feedback

This Design Guideline is a live document which requires regular review and revision in accordance with changes in associated standards, latest knowledge, operational experience and technology. Users of the Guideline are encouraged to provide feedback on the content to the Senior Principal Engineer - Water Resource Recovery, Advisory Section, Engineering Business Unit.

3 Overview of Flow Measurement

3.1 Definition

Flow measurement is the quantification of liquid or gas phase fluid movement. Both liquid and gas flow can be measured in physical quantities such as volumetric or mass flow rates.

Volumetric flow rates are typically used for process liquid flows such as used water inflow, treated water discharge and plant recycle streams. They are typically reported in litres per second (L/s), kilolitres per hour (kL/hr) or megalitres per day (MLD).

Mass flow rates are more commonly used for chemical dosing applications such as chlorine (kg/hr), or in biosolids movement (T/hr).

3.2 Purpose

The purpose of this document is to provide clear guidelines for the preferred type of flow measurement instruments in WWTPs and WRRFs for different process streams.

Flow measurement of used water entering and/or leaving a treatment plant is necessary for regulatory reporting and is typically specified on the facility license. In addition to reporting functions, flow measurement and monitoring assists with leak detection, consumption analysis and optimising system efficiency.

The purpose of the unit process being measured, as well as physical site conditions, type of fluid being measured and required accuracy will affect the choice of measurement device. For example, if treatment plant inflow and outflow volumes are being used for regulatory reporting and/or license fee calculation, then an accurate, reliable and verifiable magnetic flow meter installed in pipework is preferred.

3.3 Flow Measurement Principals

Flow measurement can be separated into two broad categories - closed pipe flow and open channel flow.

In closed pipe flow there is a pressure difference between different points of a pipe or conduit. The flow rate depends on the difference in pressure between each end of the conduit, the distance and cross-sectional area between each end and other hydraulic properties such as pipe material, roughness, bends and fittings. This is typical of a pumped system, but also applicable to gravity pressure systems.

Open channel flow occurs when the flowing fluid has a free surface open to the atmosphere. Flow occurs as a result of the force of gravity on the fluid. A progressive fall in the water surface elevation occurs as the flow moves downstream. Flows in channels, canals or partially full pipes (i.e. stormwater drains or gravity sewers) are examples of open channel flow.

3.3.1 Closed Pipe

Closed pipe flow is typically calculated by measuring the fluid velocity or pressure drop between two points. Typical measurement devices include:

- Magnetic and Ultrasonic flowmeters measure fluid velocity and convert this to flowrate by multiplication with the known cross-sectional area of the meter. These are the most common type of flowmeter used by the Water Corporation for piped/pump applications.
- A mechanical meter has a paddle or piston which moves with the fluid passing through a pipeline. The flowrate is proportional to the rotational speed of the blades of the paddle or piston.

- An orifice plate flow meter creates a restriction in the pipeline where the pressure either side of the plate can be measured. The pressure drop across the plate is linear and directly proportional to the flowrate of the fluid.
- A rotameter is a meter consisting of a vertical tapered tube with a “float” inside. As flow passes the float, the float to lift from its seat. The upwards buoyant force of the flow counteracts the gravity force on the float and the system reaches an equilibrium, indicating flowrate on a visual, calibrated scale.

3.3.2 Open Channel Flow

Open channel flows measurement typically depends on detection of fluid level flowing either through a channel restriction such as a flume, or over a fixed structure such as a weir. Fluid depth is proportional to the volumetric flow rate through the control point.

A recent development is the combination of a radar/doppler based velocity meter working in tandem with a level sensor (ultrasonic or radar) to gauge the depth and flow velocity of channel flow.

Typical open channel fluid measurement devices include:

- Flumes are fixed hydraulic structure used to measure water flow in an open channel. The flume accelerates flow and reduces water depth by narrowing the sidewalls through which the fluid is flowing. The flow rate can be estimated by taking a depth measurement in the converging section of the flume. Flumes are available in a variety of configurations e.g. Venturi, Parshall, cut-throat.
- Weirs raise the water level upstream of the structure and forcing flow to spill over the weir structure. Flow rate is estimated by measuring the depth of the fluid either upstream or within the structure. A wide variety of weir types are available, including sharp- and broad-crested, rectangular, vee-notch, trapezoidal, composite and crump configurations.
- Advanced channel flow measurement using a combination of radar/doppler velocity and level instrumentation can determine channel flowrates without requiring either a weir or flume. However, the channel cross-section and grade must be accurately known.

3.4 Scope of Operational Supervision and Maintenance

Proper selection, installation, maintenance, and verification of instruments is imperative to ensure the required accuracy of the unit is preserved.

Almost all instruments used in flow measurement applications will be provided with a factory calibration certificate. This calibration information is also typically stored within the instrument or the transmitter.

Operational factors such as internal surface deposits (fats, oils & grease), age, contamination and temperature changes can cause loss of accuracy. Periodic inspection and cleaning is strongly recommended particularly in harsh operating environments.

Regular basic inspections of the instrument and transmitters would include:

- Seal integrity of the process connections, cable entries and cover screws.
- Reliability of power supply, lightening protection and earthing.
- Flange bolts and earthing ring.
- Housekeeping items such as dust/dirt and water ponding.

Mounting brackets for level measurement in tanks, over weirs or through flumes need to also be periodically checked. Brackets and instruments are often exposed to environmental factors such as wind, rain and varying temperatures which can affect the mounting equipment and the instrument itself.

The accuracy of magnetic flowmeters will drift over time, so scheduled verification or re-calibration is required. Most flow meter suppliers provide a verification tool which will test the integrity of the system cables, transmitter, sensor magnetic properties, unit accuracy and provide a verification report for record keeping.

<u>The accuracy of flow instruments used for regulatory compliance must be verified in accordance with the manufacturer’s requirements.</u>

3.5 Guidelines for Flow measurement system selection

Many factors can affect the performance of a measurement system. Some of these are common to almost any flow measurement system, such as

- piped versus open channel flows,
- correct installation of the instrument given the available site conditions,
- appropriate flow conditioning,
- instrument calibration and verification,
- instrument selection suitable for the operating environment of the meter, and
- fluid properties.

However, there can also be factors which are highly application-specific, such as the presence of Fats/Oil/Grease in Primary Sludge or grit/solid particulates that cause mechanical wear or erosion. These need to be understood when selecting the most appropriate instrument for the application.

3.6 Preferred Instrument Types and Suppliers

Water Corporation uses a wide range of flow measurement devices. For pumped/pipe applications where liquid is being transported, the Water Corporation’s preferred instrument is the magnetic flowmeter. These units are very accurate, reliable, and easily verified in-situ. For gas measurement, the Thermal mass flowmeter is the most widely used.

A list of preferred units for various applications can be found in DS40-09 Field Instrumentation, and this list should be used as the initial guide for selecting a flow meter.

Table 1 (below) has been reproduced from DS40-09, Version 1 Revision 2.

Once the initial selection of instrument type is made, equipment vendors will assist with selecting the most appropriate unit from their range for the characteristics of the fluid being measured.

Table 1: DS40-09, Section 3 Table 3. Preferred Instrument Types, Ver 1 Rev 2.

Application	Preferred instrument types	Alternatives (subject to approval)
Water or wastewater in open channels (flume or weir)	Ultrasonic open-channel flowmeter	Radar Flowmeter
Water or wastewater in open channels with backpressure (no free fall)	Magnetic area velocity flowmeter. Ultrasonic area velocity flowmeter. Radar area velocity flowmeter.	
Water, wastewater or sludge in closed pipes	Magnetic flowmeter	Ultrasonic. DP Transmitter (in combination with DP device eg. Orifice plate, venturi or pitot tube). Turbine. Vortex.
Air in closed pipes, low pressure, high volume	Thermal mass flowmeter	Orifice plate
Air in closed pipes, high pressure, low volume	Orifice plate	Thermal mass flowmeter
Flammable gas[1]	Thermal mass flowmeter	Ultrasonic transit-time
Wet digester gas with free condensate[2]		
Wet digester gas with no free condensate	Critical applications: Venturi flow meter with wet gas flow computer Non-critical: Thermal mass flow meters (eg. FCI ST80)	Ultrasonic transit-time
Dry digester gas	Thermal mass flowmeter	
Chemical solution lines	Magnetic flowmeter	
Small seepage weirs	Ultrasonic level measuring height over the vee-notch (derived flow)	

[1] : Must be certified for Class 1 Zone 0.
[2] : Should be avoided as measurement is difficult and expensive.

Operational Technology has developed Guideline for equipment procurement, OT Approved Equipment List (AEL), refer to Nexus: 58653590 for the full list. The following table of flow measurement equipment suppliers has been extracted from that document.

Table 2: Preferred Supplier's as extracted from OT Approved Equipment List.

Instrumentation					
Item	**Supplier**	**Model**	**Notes**	**Rev Date**	**Item No**
Flowmeter (Thermal Mass) for Gas	Endress & Hauser	T-Mass 65I		14/10 2008	I18
	FCI (Fluid Components International)	ST-51			
Flowmeter Magnetic (battery powered)	Siemens	MAG8000	Under review	5/2/2019	I53
Flowmeter Magnetic (Chemical Dosing – not Fluoride)	Krohne (small bore)	Optiflux 5000	Not for Fluoride dosing	9/4/2020	I21
Flowmeter Magnetic (Fluoride Dosing)	Krohne	Optiflux 4100 W	IFC 100 W converter. Protection rings #2 Hastelloy C22 Electrodes Platinum Lining: Standard PFA	9/4/2020	I52
Flowmeter Magnetic – Water and Wastewater. As per panel agreement E&H C2-2000000945/4700007450 Siemens - C2-2000000945/4700007439	Siemens	MAG5100W & MAG3100	MAG 6000 transmitter. MAG 3100 or 5100W sensor.	15/6/2021	I22
	Endress & Hauser	Promag 400	Please order with Heartbeat© Diagnostics and Verification enabled		
		Promag W400 "0 x DN full bore" option			
		Promag W500			

4 Types of Flow Meters

4.1 Liquid Flow Measurement

4.1.1 Magnetic Flowmeter

Magnetic flowmeters are the most common measurement instrument used by Water Corporation for measuring liquid flows.

Magnetic flow meters measure fluid flow by electromagnetic induction. A magnetic field is applied to the metering tube and results in a potential difference proportional to the fluid flow velocity perpendicular to the magnetic flux lines. The fluid being measured must be conductive. Flow rate is determined from the measured pipe velocity multiplied by the cross-sectional area of the meter.

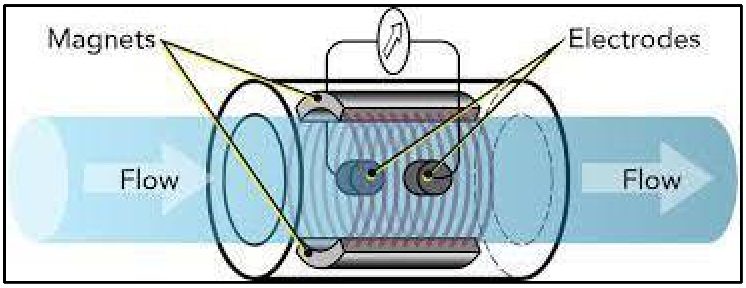

Figure 1: Magnetic flow meter operating principle

Magnetic flowmeters may be installed:

- above ground,
- below ground located in a pit, or
- partially buried.

Fully buried magnetic flowmeters are not preferred and should be avoided wherever possible.

Standard drawings of flowmeter installation for below ground pipework are:

- Water Conveyance: EG20-004-002-01
- Wastewater Conveyance: CA01-057-001-01 & CA01-057-002-01

Magnetic flow meters are typically installed between two flanges on process pipelines, and the sensor must always be completely full of fluid. Meters should be sized so that flow velocities are between 0.6-5m/s, to maintain accuracy to within +0.5%. Meters may be mounted in various arrangements (vertical or horizontal).

Some vendors offer a magnetic flowmeter option for partially full pipes such as the ABB PartiMag. However, installation of one of these units in the SWR resulted in unstable and incorrect readings (up to +/- 50%).

The performance of flowmeters in pipes is critically dependent on location of the meter in the system. System components which create turbulent flow such as bends, tees, valves, reducers or other fittings will affect the accuracy of the instrument.

Water Corporation DS40-09 Field Instrumentation states that magflow meters shall be installed with upstream and downstream straight pipe lengths in accordance with the manufacturer’s recommendations. Common flow meter suppliers are noted below along with their required pipe length requirement.

- Siemens MAG5100W - 5D of pipe upstream, and 3D downstream
- ABB MagMaster - 5D of pipe upstream, and 2D downstream

- Krohne - 5D of pipe upstream, and 2D downstream
- Yokogawa AXF - 5D of pipe upstream, and 2D downstream

DS40-09 also states that in the absence of manufacturers recommendations, at least 5D of pipe upstream, and 3D downstream is required. This is to allow for the flowmeter brands to be changed out in the future.

Where a flowmeter is used for bi-directional flow measurement, such as an MBR permeate pump, then the flowmeter shall have the minimum upstream length (i.e. 5D) on both sides of the meter.

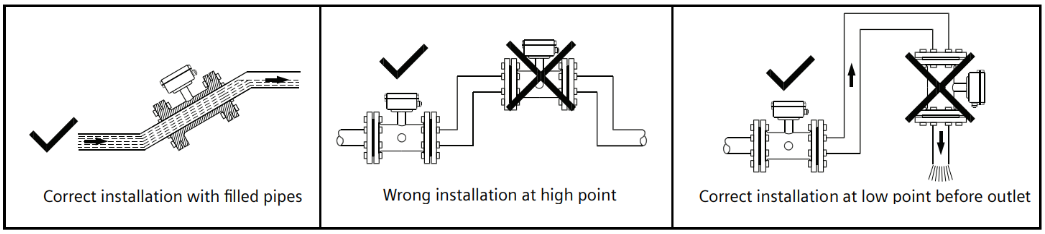

Figure 2: Magflow meter installation guidelines (*Siemens SITRANS FM MAG5100 Operating Instructions*)

4.1.1.1 Internal Materials of Magnetic Flowmeter

Depending on the type of fluid being measured, internal components of a flowmeter can be tailored to improve instrument reliability and durability. The type of fluid needs to be provided to the instrument supplier when selecting a flowmeter to ensure that the most appropriate selection of liner and electrode materials is made.

DS40-09 states that flowmeters to be used in used water pipelines shall be specified with hard rubber (ebonite) linings and 316 Stainless Steel or Hastelloy C electrodes. Flowmeters to be used in water pipelines shall be specified with PTFE (Teflon) or hard rubber (ebonite) linings and 316 Stainless Steel or Hastelloy C electrodes.

Other common flowmeter materials are outlined in Table 3 and

Table 4.

Table 3: Common construction materials for magflow meters.

Material	Description
Liner	
Hard rubber (Ebonite)	Strong abrasion resistance
Teflon/PTFE	More chemical resistant then rubber
NBR	Excellent in general purpose water and wastewater applications
Neoprene	Formerly the most common used liner in water and wastewater applications, other materials becoming more commonly used.
Electrode	
Stainless Steel	The most common electrode used in water and wastewater applications for non-aggressive fluids. Not recommended for salt water or brine.
Hastelloy	Good all-round corrosion resistance, preferred in salt water or brine.
Titanium	Excellent corrosion resistance in oxidising and alkaline chloride environments and also suitable for highly basic fluids.

Table 4: Construction materials and application/resistance table*.

Properties	PFA	PTFE	Neoprene	EPDM	NBR	Linatex	Ebonite
Other names	Perfluoroalkoxy	Polytetraflouroethylene	Polychloroprene	Ethylenepropylenediene	Nitrile Butadiene Rubber	Natural Soft Rubber	Hard Rubber
General Attributes	Excellent chemical resistance, withstands high temperatures without deformation.	Excellent chemical resistance.	Performs well in contact with oils and many chemicals.	Drinking water and many other media than hydrocarbons (oil, tar, graese).	Excellent for water and general purpose applications.	Excellent abrasion performance.	Suitable for wastewater and several chemical applications. Useable for temperatures up to 95 °C and for applications with high pressure.
Wear Resistance	✓	✓	✓✓	✓	✓✓	✓✓✓	✓
Applications							
Drinking Water	✓	✓	✓	✓✓✓	✓		✓✓
Wastewater	✓	✓	✓✓✓	✓	✓✓✓		✓✓
Abrasive Liquids	✓	✓	✓✓	✓	✓	✓✓✓	✓
Chemicals	✓✓✓	✓✓✓	✓	✓✓	✓		✓
Food & Beverage	✓✓✓	✓✓✓		✓✓			✓
Pulp & Paper	✓✓✓	✓✓✓					
Chemical Resistance							
Acid, diluted (<10%)	+	+	0	+	0	0	+
Acid, concentrated	+	+	0	0	–	–	0
Diluted alkalis	+	+	+	+	+	+	+
Concentrated alkalis	+	+	+	+	0	+	+
Aromatic hydrocarbons (benzene)	+	+	–	–	–	–	–
Chlorinated hydrocarbons (trichloroethylene)	+	+	–	–	–	–	–
Ozone	+	+	0	+	–	–	0
Temperatures							
Maximum Temperature	300 °F	356 °F	158 °F	158 °F	158 °F	158 °F	203 °F
	150 °C	180 °C	70 °C	70 °C	70 °C	70 °C	95 °C

	Stainless Steel	Hastelloy C22	Hastelloy C267	Titanium	Tantalum	Platinum
Applications						
Drinking Water	✓✓	✓✓✓	✓✓✓			
Wastewater	✓✓	✓✓✓	✓✓✓			
Abrasive Liquids	✓✓	✓✓✓	✓✓✓	✓		
Chemicals	✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓
Food & Beverage	✓✓	✓✓✓	✓✓✓			✓✓✓
Pulp & Paper	✓	✓✓✓	✓✓		✓✓ (chemical)	
Chemical Resistance						
Reducing acids	–	0	0	–	+ (except flouric acids)	+
Oxidizing acids	0	+	0	+	+	0
Organic acids	+	+	+	0	+	+
Alkalis	+	+	+	+	–	+
Diluted salts	0	0	0	+	+ (except fluor salts)	0

**Sourced from Siemens "Sitrans FM Selection Guide", 2021*

4.1.1.2 Typical uses of magnetic flowmeters

Typical installation uses include

- Used water inflow to a plant
- Treated water discharge
- Internal plant process streams such as, RAS, WAS, sludge flows, reclaimed/washdown water or dilution water.
- Chemical dosing systems such as, polymer solution or odour control chemical dosing (Hypo and Caustic)

Electromagnetic flow meters are not suitable for neat polymer solution as this fluid is non-conductive. A Coriolis meter should be used for this application.

4.1.1.3 Typical Sizes of Magnetic Flowmeters

Magnetic flowmeters are available in a wide range of sizes, DN2 to DN2200. Typical sizes found in used water conveyance and treatment are DN25-DN900. The size of the instrument should be selected so that the flow velocity within the measuring unit is between 0.6-3m/s.

4.1.2 Ultrasonic Flowmeter

Ultrasonic flowmeters measure flow by detecting the action of a fluid flow on an ultrasonic beam or pulse. The meter measures the time between pulses of ultrasound propagating with and against the direction of flow, and determines the average velocity of the fluid based on the time difference between pulses. The flow rate is determined from the measured pipe velocity multiplied by the cross-sectional area of the meter.

Ultrasonic flow meters operate independently of conductivity, viscosity, temperature, density or pressure. Meters are available as either in-line or clamp-on and use either a single path measurement (1-pair of transducers) or multi-path. The multi-path device provides a higher level of robustness for measurement as if one path stops working the remaining path will continue to provide measurement.

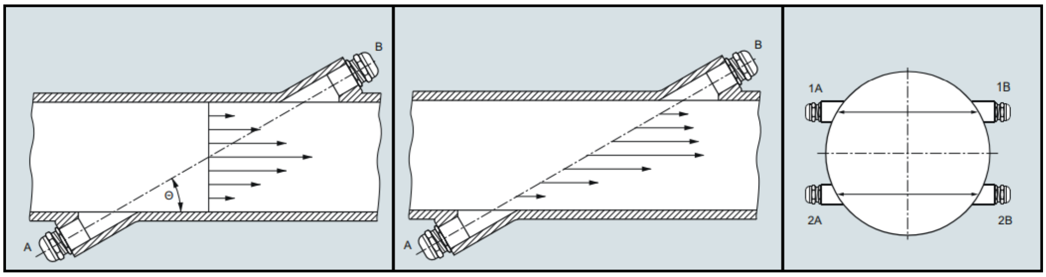

Figure 3: Ultrasonic flowmeter measurement principal

Water Corporation DS40-09 Field Instrumentation states that ultrasonic meters shall be installed with upstream and downstream straight pipe lengths in accordance with the manufacturer's recommendations. Common flow meter suppliers are noted below along with their required pipe length requirement.

- Siemens FS – 2-path - 10D of pipe upstream, and 3D downstream
- Krohne Optisonic 3400 – 3-path - 5D of pipe upstream, and 3D downstream

DS40-09 advises that in the absence of manufacturers recommendations, then at least 20D of pipe upstream and downstream is required for single-beam units, and 10D upstream and downstream for dual-beam units.

4.1.2.1 Typical Uses of Ultrasonic Flowmeter

Water Corporation frequently use clamp-on ultrasonic flow meters for pump performance testing and flow meter verification.

4.1.3 Mechanical Water Meters

A mechanical meter has a paddle, turbine or piston which is moved by fluid passing through a pipeline. The flowrate is proportional to the rotational speed of the blades of the paddle or piston. Mechanical water meters measure the volume of the passing fluid, rather than measuring the flow velocity and calculating a volume.

Mechanical flowmeter are typically used in clean/drinking water applications.

Figure 4: Typical water meters (left) dynamic turbine water meter and (right) digital smart meter.

Mechanical meters are typically read from a local display. However, it is becoming more common to use smart meters or convert the standard meter with the addition of a logging device. Smart meters have the ability to log and transmit data so that water usage may be monitored in almost real-time.

Monitoring of smart meters provides trending data on water usage and provides early warning of water leaks.

Water Corporation has installed smart water meters in selected homes and businesses across WA. The meters collect water use data at regular intervals and transfer the information back to the Corporation. The meters also allow the reading of consumption data without entering a customer's property. Further information is available at smart meters.

4.1.3.1 Typical Uses of Mechanical Water Meters

A positive displacement meter is commonly used to measure drinking water usage at property boundaries.

In treatment plants, these types of meters could be used for monitoring of non-critical water consumption such as wash down hoses, screen wash water or chemical make-up.

If used on re-use water, then a strainer must be provided upstream of the meter to protect the device from solid debris.

4.1.4 Coriolis Mass Flow

Coriolis flowmeters are considered true mass meters as they measure mass flow rates directly while other metering units measure volumetric flow. Fluid passes through an oscillating U-tube with the vibrational force exerted from the mass of the fluid adding to the vibration of the measuring tube. The change in vibration is measured and is proportional to the mass flow rate through the meter.

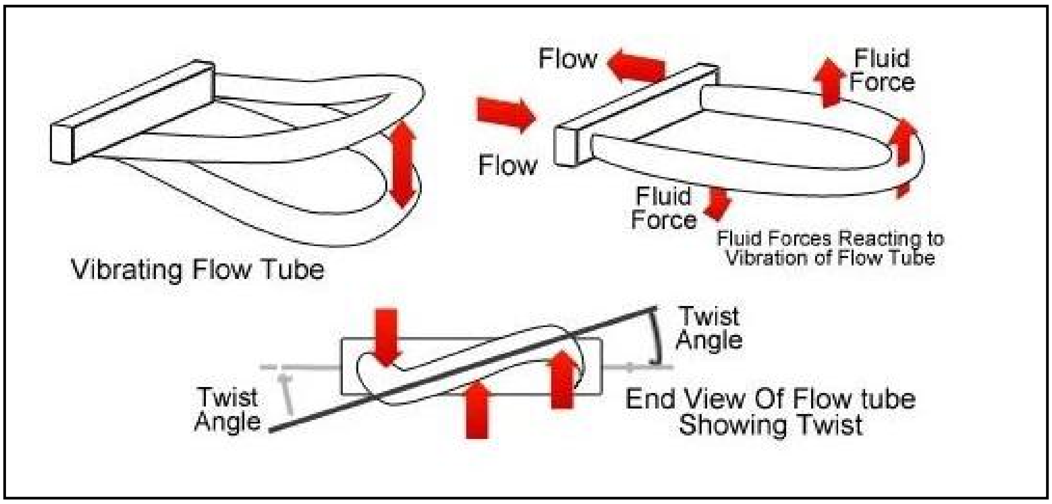

Figure 5: Principal of a Coriolis meter

An advantage of the Coriolis flow meter is the ability to provide direct mass flow measurement without supplementary measurement instruments. The Coriolis meter is capable of measuring mass flow rate, volumetric flow rate, fluid density and temperature all from the one instrument. Operation of the flow meter is independent of flow characteristics such as turbulence therefore upstream and downstream flow conditioning is not required.

4.1.4.1 Typical Uses of Coriolis Mass Flow

Coriolis meters are typically used in the food and beverage, chemical, oil and gas and pharmaceutical industries where accuracy of the flow measured is extremely important.

Coriolis meters are not typically used in pumping conveyance or in normal applications at WRRF's.

They have been used occasionally to measure the flow of neat liquid polymer between a storage tank and the batching system as neat polymer is a non-conductive fluid.

4.1.5 Orifice Plate

An orifice plate is a thin, typically steel plate with a hole in it to allow the fluid to pass through. When the fluid passes through the orifice hole it builds up pressure on the upstream side of the plate as the fluid is forced to converge to pass through the hole. Downstream of the orifice hole, the flow expands and the velocity slows. By measuring the pressure upstream and downstream of the orifice plate the flow rate can be determined from Bernoulli's equation.

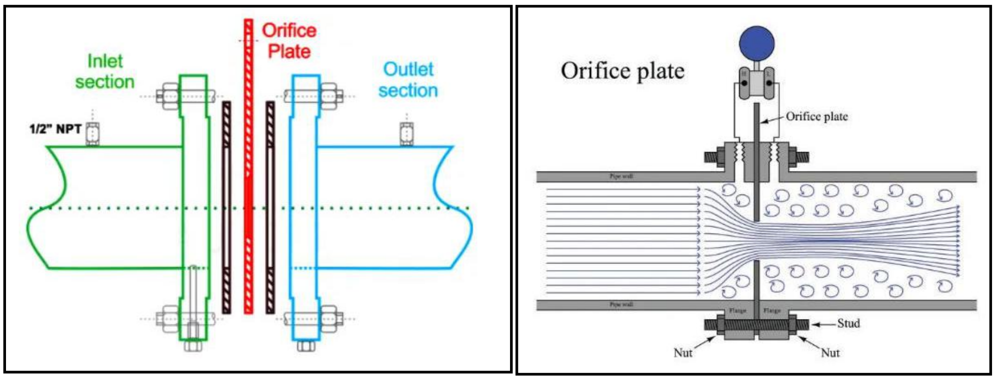

Figure 6: Principal operation of an orifice plate

4.1.5.1 Typical uses of Orifice Plate flow meters

DS40-9 notes that orifice plates in conjunction with a Differential Pressure instrument can be used on water, wastewater and sludge pipelines, but is not preferred. Caution should be taken given the application, particularly in wastewater/sludge applications as there is the potential for the orifice hole to become clogged with rags.

Orifice plates are the preferred measurement instrument for air in closed pipes with high pressure and low volume flows. Refer to

Table 1: DS40-09, Section 3 Table 3. Preferred Instrument Types, Ver 1 Rev 2.

4.1.6 Rotameter (Variable Area Flow Meter)

A rotameter is a meter consisting of a vertical tapered tube with an internal "float". As flow passes vertically into the tube and past the float, the flow causes the float to lift from its seat. The upwards buoyancy of the flow counteracts the gravity force on the float and the system reaches an equilibrium.

The cylinder is marked with a scale from which flowrate can be read. Rotameters are sized for various flow rates and may be used for both liquid and gas applications. An electronic switch may be mounted on the outside of the rotameter to provide indication that flow has reached a certain set-point (i.e. act as a flow switch).

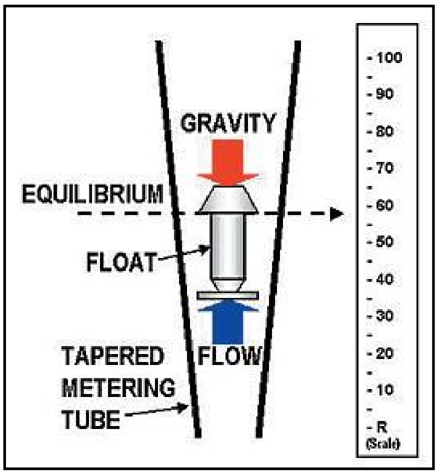

Figure 7: Principal of rotameter operation.

4.1.6.1 Typical uses of a Rotameter (Variable Area Flow Meter)

Rotameters are commonly used by Water Corporation as a means of measuring non-critical process flowrates such as, wash water (to screens or a grit washer) or dilution water to chemical systems such as secondary dilution for polymer.

They are also used on chlorine gas systems to provide indication/feedback of gas flow rate for dosing purposes.

Typical installations would include a needle valve for the fine adjustment of flow through the rotameter.

4.2 Open Channel Fluid Measurement

Open channel fluid flow measurement is based on free discharge of the fluid downstream of the measuring structure, and measurement of liquid level upstream of the structure. This measurement is typically done by an ultrasonic level device which remains above the liquid level.

In the absence of a measuring structure, the wetted area, flow depth, velocity, conduit material roughness and conduit grade are required in order to calculate the flow rate.

4.2.1 Flumes

Flumes are specially shaped structures used to measure the flow of water in open channels. Flumes create a restriction in the channel which increases liquid level upstream of the structure. The measured level is used to estimate flow rate. Flumes consist of three parts; a converging section (1) where the flow is accelerated as it passes into the throat (2), before a widening discharge section (3).

The Parshall flume is the most commonly used flume design, and range of 22 standard sizes have been recognised by the American Society for Testing and Materials (ASTM D1941-21) and International Organisation for Standardisation (ISO 9826:1992). Other types of flume include the Cutthroat, Trapezoidal, Montana and the Palmer-Bowlus (specifically designed for WW conveyance).

Figure 8: Flume measurement, (left) Parshall flume design, (right) fabricated examples

4.2.1.1 Typical uses of flumes

Flumes should be used in gravity flow systems where a conventional magnetic flowmeter might run partially full due to a varying flow pattern. They have been used in measurement of both plant inflow and treated water discharge.

Flumes may also be used to evenly distribute flow between unit processes eg.at Subiaco and Woodman Point WRRF’s, refer to Figure 26 and Figure 27.

4.2.2 Sharp-crested weirs

A weir is a hydraulic structure specifically intended to obstruct flow, and create a stable, measurable water level upstream of the structure. Figure 9 illustrates several different and well-known weir profiles.

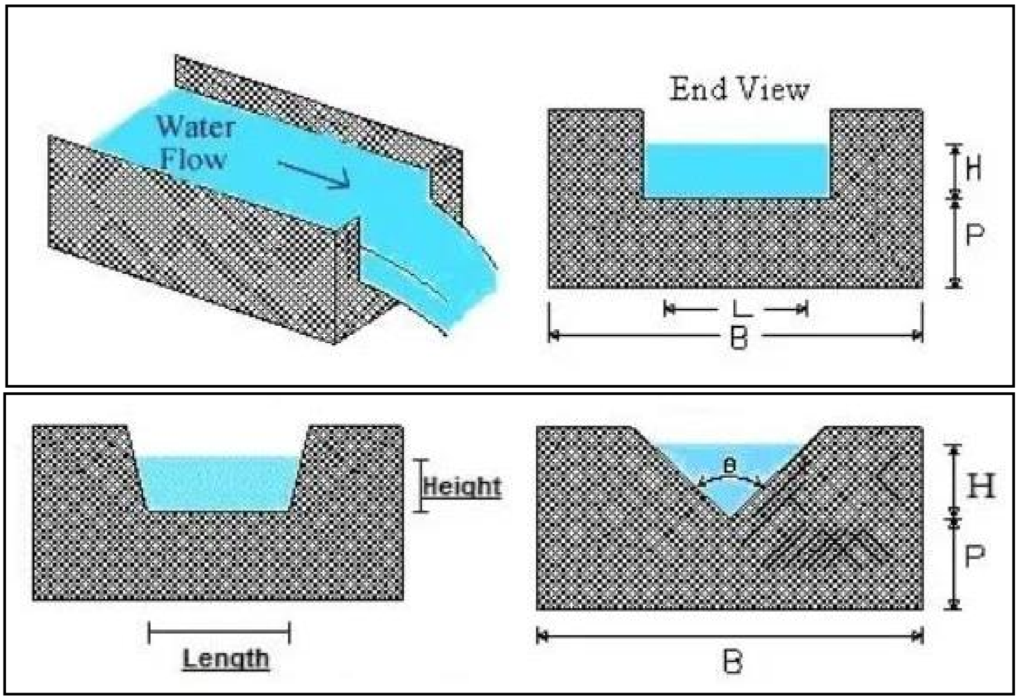

Figure 9: Top – Rectangular, Bottom Left – Trapezoidal, Bottom Right V-notch weir.

Each of the weir profiles illustrated in Figure 8 can be used singly or in combination as a composite weir, to facilitate accurate measurement over a wide flow range. For very low flows, a vee-notch weir is preferred because of high measurement accuracy. The included angle of the vee-notch can be varied to suit flow range requirements, although a 90° vee is most typical. Vee-notch profiles are often added to a trapezoidal profile, so that seasonal flows in a stream or drainage channel can be accurately measured across the full range. Vee-notch weirs are also used in a sawtooth configuration on the outlet launders of secondary settling tanks

Rectangular weirs are commonly used in constructed channels eg. in a WRRF/WWTP, across either part or full channel width. Both cases required consideration of factors which affect discharge coefficient. In the former case, the discharge over the weir will contract whereas in the latter case, wall friction will affect discharge capacity.

The sides of a trapezoidal weir are inclined outwards, typically with a slope of 1:4 (horizontal:vertical). These weirs are less common, but typically used for measurement of large flows.

All sharp-crested weirs operate normally under free-flow conditions, such that the discharge stream breaks free of the downstream face of the weir (the nappe), forming an airgap below. Headloss over the weir cannot therefore be recovered.

4.2.3 Broad-crested weirs

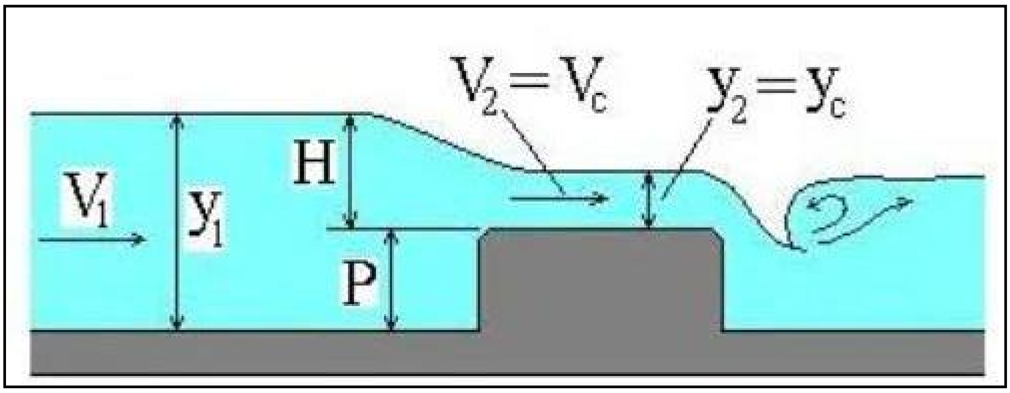

Figure 10: Broad-crested weir

Broad-crested weirs are rarely specifically chosen for flow measurement, although it is possible to calibrate well-defined profiles for this purpose. They are usually constructed in timber, masonry or concrete. Typical examples include low-level river causeways, simple dam spillways or flooded baffle walls within a process reactor.

The broad-crested weir profile generally always operates in a flooded condition. There is a measurable difference between upstream and downstream water levels, but this is much less than for similar capacity sharp-crested weirs. Some hydraulic energy is recovered downstream because of the formation of a hydraulic jump.

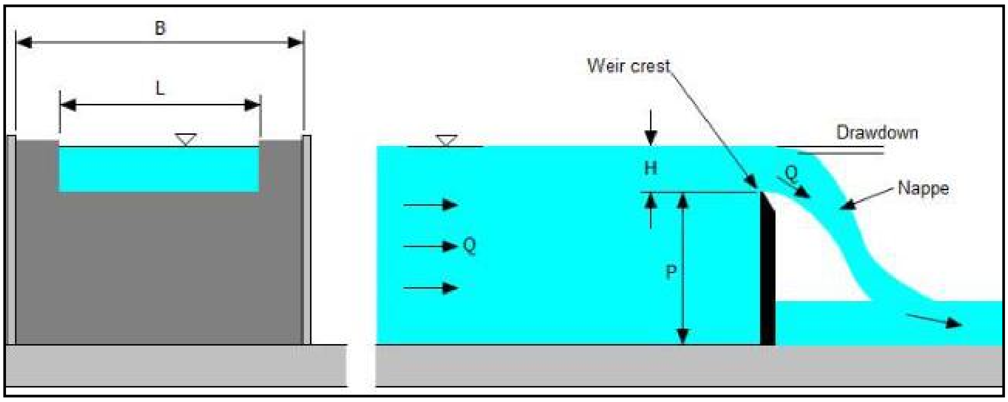

Figure 11: Sharp-crested weir, note the free discharge over the crest.

4.2.4 Transient time flowmeters

Ultrasonic transient time flowmeters measure the difference in speed of pulses sent with and against the direction of flow. A pulse of sound directed diagonally downstream is marginally accelerated by the water velocity, and conversely, a pulse directed diagonally upstream is marginally slowed down by the water velocity. Actual water velocity is then determined by calculating the difference in detection time for pulses being sent upstream and downstream.

A velocity profile may be determined across the depth of a conduit by using multiple pairs of transducers mounted in the conduit at specific elevations. The velocity profile combined with the water level measurement and the cross-sectional area is used to calculate the flowrate within the conduit.

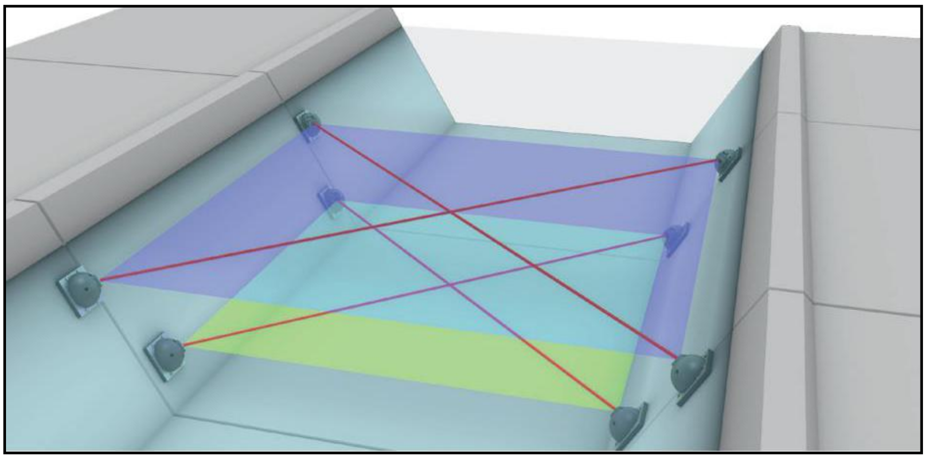

Figure 12: ultrasonic, multi-path channel flow measurement

The main advantage of this type of flow meter in a channel is that it does not rely on constricting the flow path in order to measure the flowrate as is the case with weirs and flumes. It is particularly useful where there is little gravity head available.

This is the case at Subiaco WRRF where this type of measurement device has been installed to measure plant inflows in the gravity channel between the grit tanks and the primary sedimentation inflow distribution chamber.

4.2.5 Doppler/radar

Ultrasonic Doppler flowmeters measure the Doppler shift (change in wave frequency) resulting from reflecting an ultrasonic beam off particles flowing in a fluid, and hence can determine the flow velocity of the liquid surface. A radar level instrument is used to measure the depth of fluid flowing in the channel. With a known channel profile, flow depth and velocity the flow rate can be determined.

As the instrument relies on sound reflection from the liquid surface, some form of surface turbulence is required to ensure accuracy. Refer to the specific vendor manuals for details of the minimum channel speed and wave height for accuracy of the instrument.

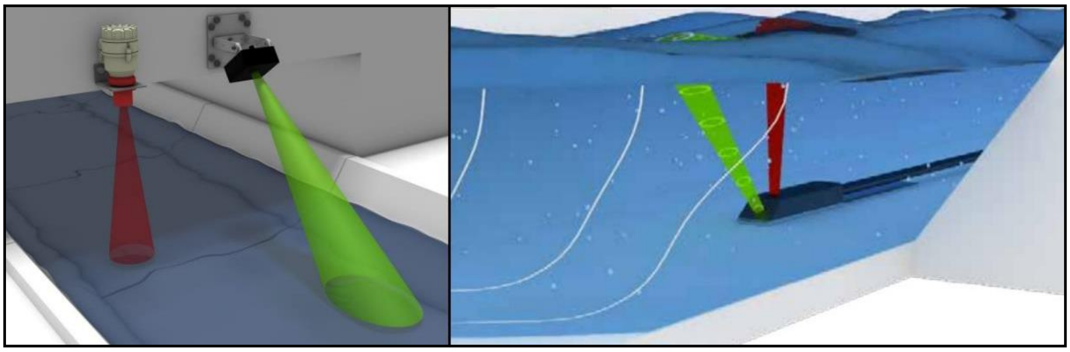

Figure 13: HydroVision non-contact (left) and in-channel (right) doppler/radar velocity profiling instruments.

In 2018 non-contact ultrasonic doppler flowmeters (HydroVision Q-Eye Radar MT) were installed at Subiaco WRRF to measure treated water outflow from each of the twelve secondary sedimentation tanks. During commissioning, instrument accuracy was poor at low flow due to low channel velocity and the laminar surface profile. To overcome this, stainless steel chains were hung in the channel to create some turbulence for the doppler unit to determine the channel velocity.

The instrument supplier subsequently advised that a transient time system described in Section 4.2.4 would have been more appropriate for the application.

4.3 Gas flow measurement

4.3.1 Thermal mass flowmeter

Thermal mass measurement is based on the fact the heat is drawn from a heated body when fluid flows past it. The rate of heat absorption by the fluid is directly proportional to the mass of the flow. Therefore, measurement of the heat transferred enables the mass flow rate to be determined.

As thermal mass flow meters measure mass flow rather than volumetric flow the meter does not need to correct for changes in temperature, pressure, viscosity or density. They are therefore suitable where gas temperature and pressure may fluctuate. Thermal mass flow meters are very accurate and capable of measuring low flowrates. They also don't contain any moving parts.

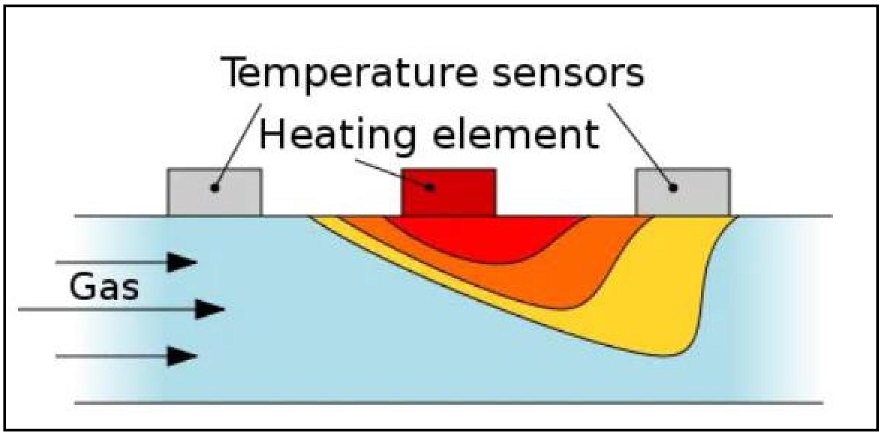

Figure 14: Principles of Thermal Mass Flow measurement.

A limitation of thermal mass flow meters is that he presence of moisture or vapour droplets can lead to measurement inaccuracy. To reduce the impact of moisture, condensation traps and graded pipework can assist.

Thermal mass flow meters are typically used for measurement of process air supply, biogas, foul air collected for odour control and compressed air flow and distribution.

4.3.2 Venturi meter

In a venturi meter, flow accelerates from the main pipe through a restricted throat. Fluid pressure decreases in the throat and the pressure drop may be measured using a differential pressure gauge. Using Bernoulli's equation, pressure drop may be converted to a volumetric flow rate.

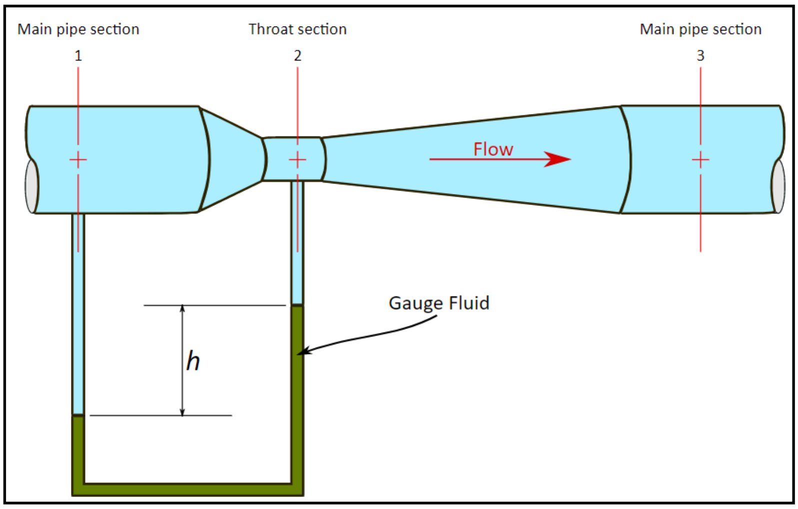

Figure 15: Typical principal of a Venturi meter

From DS40-09, Venturi flow meters are preferred for wet digester gas (biogas) in critical applications. Thermal Mass Flow meters are an acceptable alternative which have been used more widely on Water Corporation assets.

4.3.3 Orifice Plate

For the operational principle refer to Section 4.1.5.

4.3.3.1 Typical uses of Orifice Plate flow meters for gas

Orifice plates are the preferred measurement instrument for air in closed pipes with high pressure and low volume flows such as compressed air systems.

At Subiaco WRRF, an orifice plate flow meter has also been used on the main blower aeration line into each aeration tank. This meter typically ranges between 1,000-4,300m3/hr during the daily flow cycle.

4.4 Liquid chemical flow measurement

In all cases, measurement of liquid chemical flow is integrated with the chemical dosing equipment. Dosing or metering pumps are positive displacement pumps which incorporate an internal means of adjusting capacity to reliably and accurately dose controlled volumes of liquid.

Historically, additional flow measurement instruments and pulsation dampening have been required in chemical dosing systems. However, ongoing development of motors (stepper), variable speed drives and smart controllers have vastly improved the accuracy and reliability of dosing pumps and simplified dosing system design.

4.4.1 DS32 Chemical Dose Pumps

Water Corporation Design Standard DS32 – Pump Stations – Mechanical details the specific requirements for dosing pumps used in various chemical applications. Three types of dose pumps are commonly used by Water Corporation:

1. Solenoid diaphragm pumps are simple and low-cost, and are used mainly for low risk, low flow applications where control is simple, and the chemical being dosed is safe.

2. Mechanical diaphragm pumps include loss-motion (adjustable stroke length) and full-movement (full stroke, adjustable speed) configurations. This pump class includes digital metering pumps. The full-movement design provides greater reliability and longevity then solenoid or loss-motion types.

3. Progressive capacity pumps are used for polyelectrolyte dosing when low sheer is required. Integral metering is not available.

Table 10.3 of DS32 details the dose pumps most applicable for typical chemicals used by Water Corporation.

Digital dosing pumps are widely used in chemical dosing applications as they provide more precise and reliable dosing than mechanical dosing pumps. Varying pump speed rather than pump stroke length results in much greater accuracy.

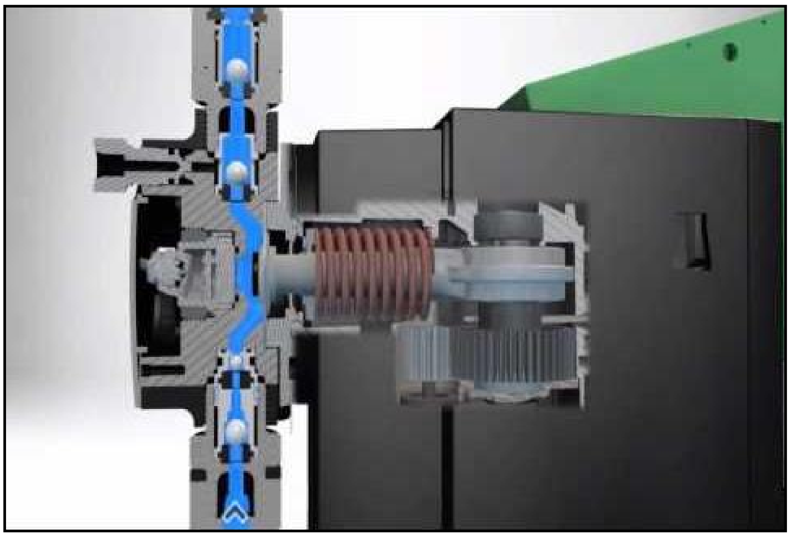

Figure 16: Internal cut-away of a Grundfos Digital dosing pump.

Several other important advantages include superior performance for dosing chemicals prone to off gassing e.g. sodium hypochlorite, and often additional system components such as flowmeters and pulsation dampeners are minimized or eliminated.

Modern digital pumps are equipped with pressure and flow monitoring equipment. The direct feedback facilitates automatic adjustment of pump speed based on the actual volume being delivered and eliminates the need for a separate downstream flowmeter.

4.4.2 Calibration, flow measurement and feedback

Modern digital dosing pumps may be fitted with smart controllers which adjust operational speed to maintain a consistent dose rate. The flow measurement function is based on length of pump stroke multiplied by stroke frequency. Compensation for air bubbles or changes in backpressure are automatically accounted for by adaptable flow monitoring functionality. Field calibration of pumps for a specific chemical duty is performed in-situ using a graduated calibration column.

4.4.3 Dosing pump accuracy

The accuracy of some of the more common pumps are detailed below:

- Grundfos, DDA – metering accuracy of +/- 1%.
- Grundfos, DDE – metering accuracy of +/- 5%.
- Iwaki, AX, IX – metering accuracy of +/- 1%, repeatability of +/- 2%.
- Wallace & Tiernan, Encore 700 - metering accuracy of +/- 2%.

Pump accuracy is very close to that of a magnetic flowmeter which is typically +/- 0.5% when installed correctly. As a pump may be routinely calibrated with a calibration tube, the degree of accuracy means that a stand-alone flowmeter is often not required. This is particularly beneficial where mini magnetic flowmeters, due to their susceptibility to scaling and blockage, can be omitted and the digital doing pump flow signal replied upon instead.

5 Maintenance Of Flow Measurement Instruments

5.1 Operational maintenance and cleaning

Harsh fluid conditions such as fats/oil/grease from sludge tend to line the inside of pipes (including magnetic flowmeters) which can result in the flow reading drifting and not reading accurately. To ensure that flow measurement instrumentation is reading accurately, routine cleaning is often required.

The Operating instructions for both the ABB and Siemens magnetic flowmeters state that their device is "maintenance free", however, both state that periodic inspections should be undertaken. These inspections would include things such as;

- Ambient conditions
- Integrity of seals, flanges, cable entries, cover screws
- Operational and safety checks of the power cables, lightening and earthing protection

Insertion probe type instruments can also accumulate debris under typical conditions which can affect the instrument accuracy.

All flowmeters should be installed with the ability to safely isolate and remove the instrument in order to either replace the unit or remove it for an inspection/clean.

5.2 Compliance maintenance and calibration

As part of an operational license for a treatment plant multiple compliance monitoring points are typically identified where emissions and discharges occur. These tend to be the plant hydraulic inflow and outflow, as well as the discharge of any treated foul gas (odour treatment stack).

Some examples of the compliance conditions from the Subiaco WRRF licence include:

Monitoring – General Monitoring.

14. The licence holder must ensure that all monitoring equipment used on the premises to comply with the conditions of this licence is calibrated in accordance with the manufacturer's specifications.

And

Table 6: Emissions monitoring to air

Volumetric flow rate (m3/s).

Frequency – Quarterly.

Method – Thermal mass flow meters calibrated against USEPA Method 2. and

17. The license holder must maintain a log of all Continuous Emission Monitoring System (CEMS) calibration curve correlations and make this log available on request.

In many installations it is not practical or possible to simply remove a flowmeter and return it to the factory for re-calibration on regular intervals. Proprietary vendor software is typically available to conduct on-line verification of flow measurement instruments. Siemens have available *SITRANS FM Verificator* tool which can test for,

- Insulation test of the FM and cables
- Test of the sensor magnetic properties
- Transmitter gain
- Digital and Analogue output tests.

The verification tool can be connected to a PC, where results of the verification testing can be viewed and saved as a report.

Similarly, Endress & Hauser have developed Heartbeat Technology which consists of diagnostic, verification (to ISO 9001) and monitoring functions.

Water Corporation have developed S461 Maintenance Standard - Water Flow Meters – Non-revenue type in acknowledgement that some of the Corporation's instruments are used for managing and reporting water abstraction, treatment/effluent disposal, leakage and process control. This standard also notes that reporting is done to regulators and statutory stakeholders, and hence the instruments need to be accurate and reliable. S461 describes the formulation of maintenance strategy based on the asset category, business drivers and criticality analysis (loss of service assessment). The result of this standard is the development of preventative maintenance plans based on time or condition monitoring.

For compliance-based flow measurement, it is imperative that the instruments installed in the field are inspected, maintained and verified at regular intervals. The records of these tests should be recorded with the individual maintenance plan to ensure that the test records can be provided to DWER if requested.

6 Examples of Flow Measurement

The following examples are of installation of various flow measurement devices currently in operation at Water Corporation treatment sites.

6.1 Pipe – Magnetic Flowmeter

Figure 17: Magflow meters on RAS pipework at Subiaco WRRF

Figure 18: Flow meter installed with a bypass arrangement to facilitate replacement without interrupting flow.

6.2 Pipe – Ultrasonic Flowmeter

Figure 19: A Strap-on ultrasonic flow meter being used for pump testing

Figure 20: Strap-on ultrasonic flow meter on the feed water line to AWRP.

6.3 Pipe – Water Meter

Figure 21: Mechanical flow meter with smart meter add-on. Installed in a below ground pit.

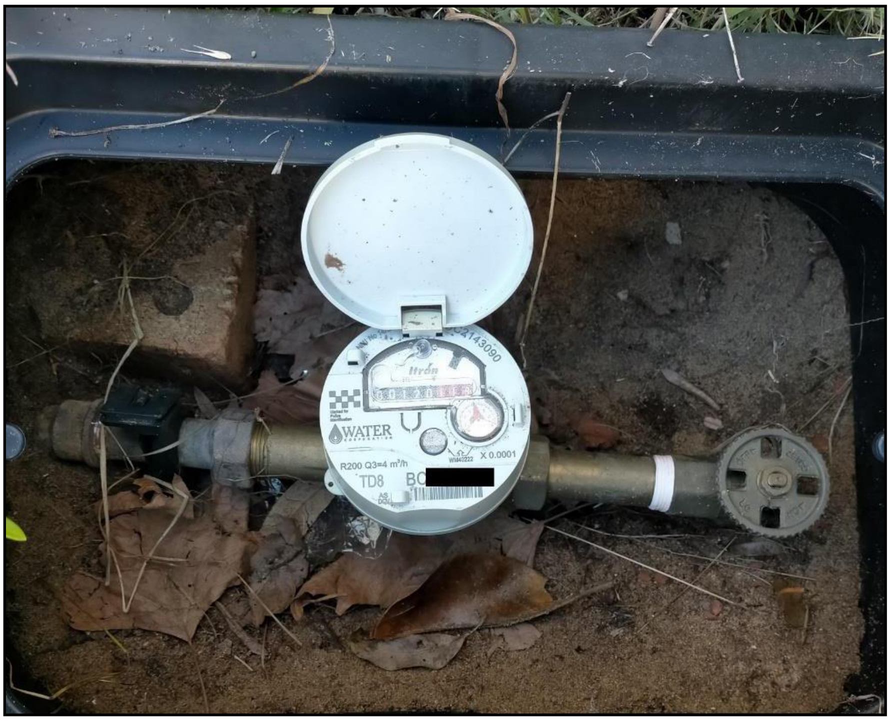

Figure 22: A Smart water meter installed on a residential property supply.

6.4 Pipe – Rotameters

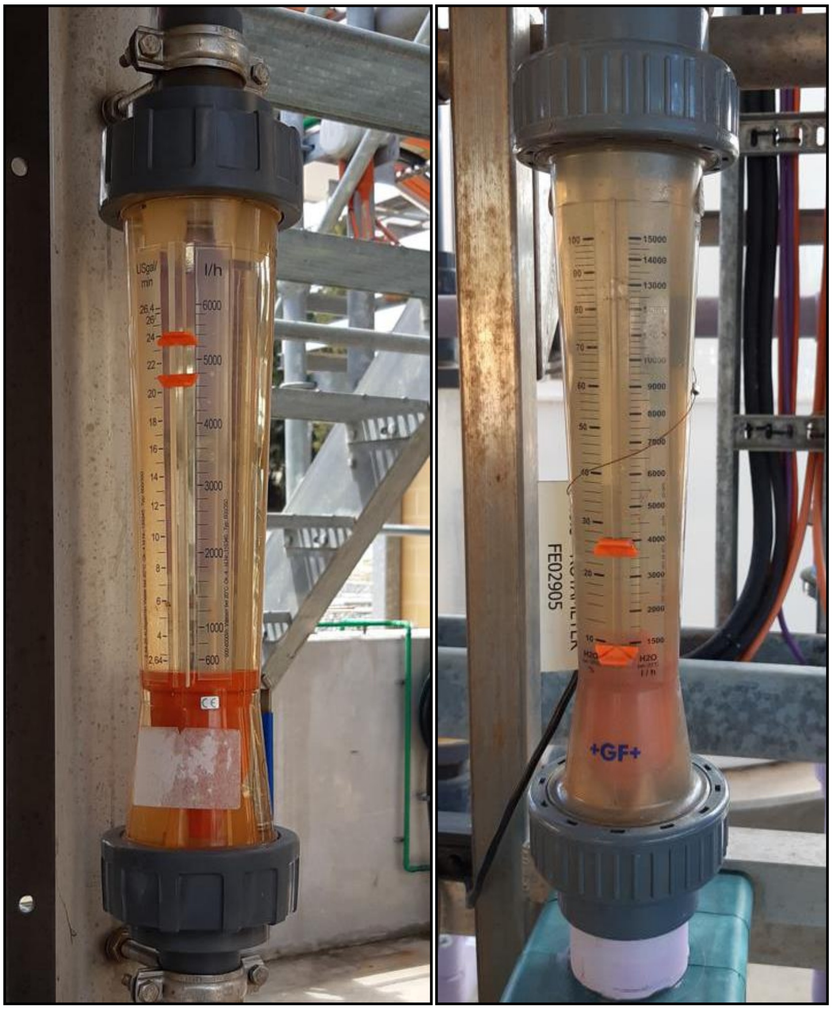

Figure 23: Various rotameters, left – 6,000L/hr, right – 15,000L/hr

6.5 Channel – Flumes

There are numerous examples of flumes being used for either flow measurement or flow distribution across Water Corporation sites. Figure and Figure show flumes being used for flow measurement, where Figure 24 and Figure 25 show flumes being used for flow distribution.

Figure 24: Flumes used to measure final effluent, note the free discharge downstream on the flume.

Figure 25: Flumes: Top - treatment plant inflow at Kojonup, Bottom - treated water from ponds to storage dam at Toodyay.

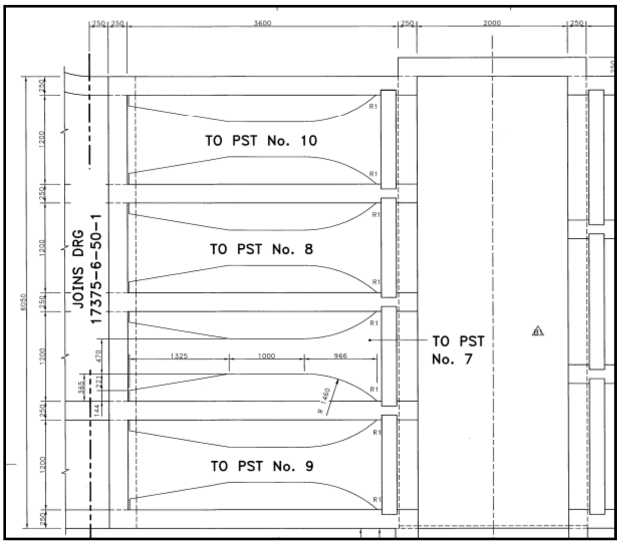

Figure 26: Flumes for flow distribution in to 4 Primary Sedimentation Tanks at Subiaco WRRF.

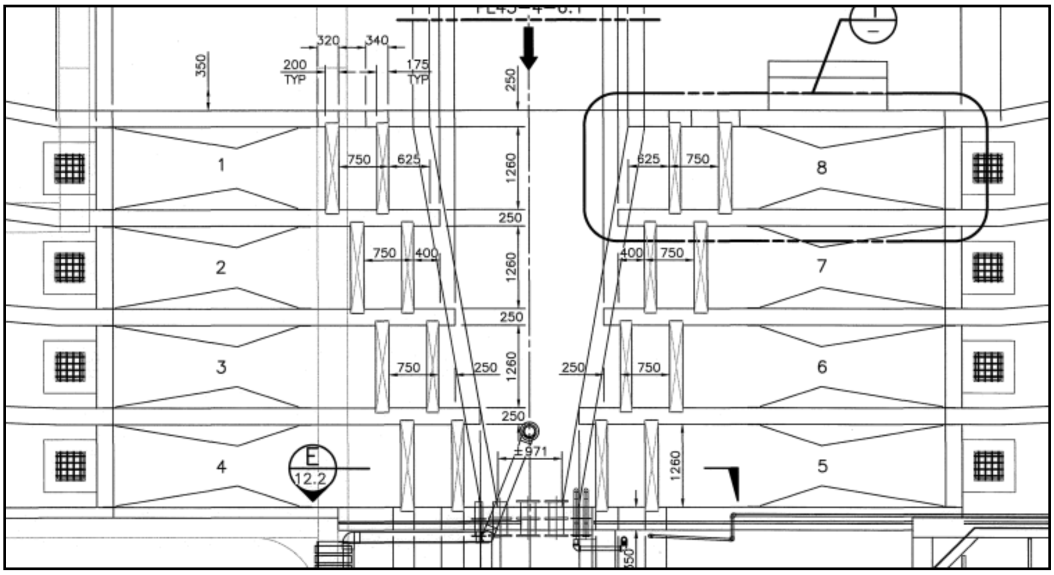

Figure 27: Flumes for flow distribution into 8 Primary Sedimentation Tanks at Woodman Point WRRF.

6.6 Channel - V-notch weir

At Subiaco WRRF, V-notch weirs are used to measure RAS flow into the aeration tanks. RAS flows through a rectangular channel, over a V-notch and into the aeration tank. An ultrasonic level instrument measures level in the channel and calculates flow rate.

Figure 28: V-notch weir and ultrasonic level (under instrument hood) measurement

Figure 29: Example of v-notch weir being used as overflow control from a secondary clarifier, note level/flow is not being measured in this instance.

6.7 Channel – Transient Time

Figure 30: Transient time flow meter installed to measure inflow at the Subiaco WRRF

6.8 Channel – Doppler/Radar

Figure 31: Radar flow meter (velocity and level instruments) installed on the outlet of each of the SST's at Subiaco WRRF.

6.9 Gas – Thermal Mass Flow Meter

Figure 32: Thermal mass flow meters installed on odour collection pipework.

Figure 33: Thermal mass flow meter installed on blower aeration pipework

6.10 Gas – Ultrasonic Flow Meter

Figure 34: Multi-path ultrasonic flow meter on line to biogas burners at Beenyup WRRF

6.11 Gas – Orifice Plate Flow Meter

Figure 35: An Orifice plate flowmeter installed on the blower aeration pipework at Subiaco WRRF

6.12 Gas – Rotameter – Chlorine

Figure 36: Rotameter on a Chlorine gas vacuum system.

APPENDIX A

Referenced Resources and Documents

SPS320 – Magnetic Flowmeters

DS40-09 – Field Instrumentation, Sections 2 and 3.4.

DS51 Standard Drawings CA01-57-1-1 & CA01-57-2-1

DS60 Standard Drawing EG20-4-2

DS30-02 – General Design Criteria – Mechanical, Section 24.

DS31-02 – Valves and Appurtenances – Mechanical, Section 8.4 & 8.5.

DS32 – Pump Stations – Mechanical, Section 10.

DS51 – Design and Construction of Wastewater Pumping Stations and Pressure Mains 4 1o 180 Litres per Second Capacity

DS60 – Water Supply Distribution – Pipelines other than reticulation

S461 Maintenance Standard – Water Flow Meters – Non-revenue type

Reference Case Studies

- Alkimos WRRF inlet flow meter

  Refer RFI documentation on decision to accept re-burial of flowmeter:

  https://nexus.watercorporation.com.au/otcs/cs.exe/app/nodes/177409385

- Margaret River WRRF inlet flow meter

Refer drawing HC05-2-14 showing redesigned above ground flowmeter.

APPENDIX B

Preferred Terminology

The table below contains preferred terms for use by the Designer in Corporation mechanical designs.

Preferred Terminology Units	Non-preferred
Bend	Elbow
Discharge (pump)	Delivery, outlet
Drinking water	Potable water
Ejector	Injector
GRP	FRP
Impeller	Impellor
L/s	l/s
MLD	ML/d, Ml/d
Nominal diameter - DN	ND
Non return valve	Check valve
Pumpset	Pump unit, pumping unit
Pump station	Pumping station
Sewage pump station	Wastewater pump station
Suction (pump)	Inlet, intake

APPENDIX C

Abbreviations, acronyms, and symbols

The table below contains terms and symbols used in this Guideline and more generally in the water industry.

Term	Description
AADF	Average Annual Daily Flow = the total annual flow reaching the WWTP in a calendar year divided by 365. It is useful for understanding annual plant throughput but should not be used as a basis for process design as it includes flows from wet weather events. For process design purposes ADWF and PDWF should be used.
ADWF	Average Dry Weather Flow = the average flow of incoming used water measured in the three driest (non-rainfall) months of the year.
ABS	Acrylonitrile – Butadiene – Styrene (pipe and fittings)
AHD	Australian Height Datum
AISI	American Iron and Steel Institute
ANSI	American national Standards Institute
API	American Petroleum Institute
AS	Australian Standards
ASM	American Society of Metals
ASME	American Society of Mechanical Engineers
ASTM	American Society for testing and Materials
AWS	American Welding Society
BEP	Best Efficiency Point
BFJ	Butt-fusion joint
BJ	Butt joint (plain ends)
BOD	Biochemical oxygen demand
BS	British Standard
BSP	British Standard Pipe
BSI	British Standards Institute
BWL	Bottom Water Level
CI	cast Iron
CIP	Clean-in-place
CML	Cement mortar lined
COD	Chemical oxygen demand
CS	Carbon steel (pipe)
CSA	Canadian Standards Association
©	Copyrighted
Cv	Flow coefficient, flow factor or valve coefficient (imperial)
dBA	Decibel – A weighted scale

Term	Description
DI	Ductile Iron (pipe and fittings)
DICL	Ductile iron cement lined
DIN	Deutsches Institut fur Normung (Germany)
°C	Degrees Celsius
DN	Nominal diameter
EAS	Excess activated sludge
EFJ	Electro-fusion joint
EPDM	Ethylene propylene diene monomer rubber
ESJ	Elastomeric seal joint
FAD	Free air delivered
FBE	Fusion bonded epoxy
FJ	Flange joint (bolted)
FRP	Fibreglass reinforced plastic
g	Acceleration due to gravity – 9.81 m/s^2
GDA	Geocentric datum of Australia
GL	Gigalitres
GRP	Glass reinforced plastic (pipe)
HBW	Brinell hardness number
HDPE	High density polyethylene
HGL	Hydraulic Grade Line
H	Head of water in m
Hz	Hertz (cycles per second)
h	Hour
HRB	Rockwell B (hardness)
HRC	Rockwell C (hardness)
IEC	International Electrotechnical Commission
IFJ	Flush joint
I/O	Input/Output
IRHD	International rubber hardness degree
ISO	International Standards Organisation
JIS	Japanese Industrial Standard
k	Absolute pipe roughness in mm
K	Resistance coefficient
kg	Kilogram
kL	Kilolitre

Term	Description
kN	Kilonewton
kPa	Kilopascal
Kv	Flow coefficient, flow factor or valve coefficient (metric)
kW	Kilowatt
L	Litre
L/s	Litres per second
m	Metre
m^2	Square metres
m^3	Cubic metres
mm	Millimetre
m/s	metres per second
MDPE	Medium density polyethylene
ML	Megalitre
MLD	Megalitres per day
MLSS	Mixed liquor suspended solids
MSCL	Mild steel cement lined (pipe and fittings)
N	Speed in revolutions per minute
NACE	National Association of Corrosion Engineers
NATA	National Association of Testing Authorities
NDT	Non-destructive testing
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	Newton metres
NPSH	Net positive suction head
NPSHa	Net positive suction head
NPSHr	Net positive suction head
NZS	New Zealand Standards
OEM	Original equipment manufacturer
OH&S	Occupational health and safety
O&M	Operations and maintenance
PE	Polyethylene (pipe)
PDWF	Peak Dry Weather Flow applies to the daily diurnal flow pattern. As a factor, it is the ratio of the peak hourly flow (usually late morning) to the ADWF measured in the three driest (non-rainfall) months of the year (Usual range is 1.5 to 2.0).
P&ID	Piping & Instrumentation Diagram

Term	Description
PFD	Process Flow Diagram
pH	Measure of acidity/alkalinity (from German *potenz* = power, and *H*; the symbol for hydrogen). A logarithmic index for the hydrogen ion concentration in an aqueous solution.
PLC	Programmable logic controller
PN	Nominal pressure
ppm	Parts per million
PU	Polyurethane
PVC	Polyvinyl chloride
PWWF	Peak Wet Weather Flow is usually caused by infiltration of water into the collector system during rainfall events. It can be of short (one hour) or long (days) duration. As a design factor it is the ratio of the peak hour flow reaching the plant to the ADWF. (Usual range is 1.9 to 2.2 for Metro plants). To be used for hydraulic design.
Q	Flowrate, capacity or discharge rate
®	Registered
RCD	Residual current joint
Re	Reynolds number
rpm	Revolutions per minute
RPS	Raw primary sludge
RPZD	Reduced pressure zone device
RRJ	Rubber ring joint
s	Second
RST	Rotary screw thickener
SANZ	Standards New Zealand
SCADA	Supervisory control and automated data acquisition
SI	Systems International d' Unites
SLR	Solids loading rate
SPS	Strategic Product Specification
SS	Stainless steel
SSJ	Spherical slip-in welded joint
SWJ	Solvent welded joint
TDH	Total developed head in metres
TEAS	Thickened excess activated sludge (= TWAS)
™	Trademark
TOC	Total organic carbon
TSS	Total suspended solids
TWL	Top Water Level

Term	Description
uPVC	Unplasticized Polyvinyl Chloride (pipe and fittings)
UV	Ultraviolet
V	Volts
VSD	Variable speed drive
VVVF	Variable voltage variable frequency drive (= VSD)
WLL	Working load limit (replaces SWL)
WAS	Waste activated sludge (= EAS)
WSAA	Water Services Association of Australia
WTIA	Welding Technology Institute of Australia
WRRF	Water Resource Recovery Facility
WWTP	Wastewater Treatment Plant

APPENDIX D

The table below contains standard units and relationships used by the Corporation.

Quantity	Unit	Relationship
Flow	L/s	Rate of flow
	MLD	L/s x 86.4
Volume	L	Amount of volume
	kL	L / 10^3
	ML	L / 10^6
	GL	L / 10^9
Length	mm	Linear dimension
	m	mm / 10^3
Area	m^2	Areal measure
	ha	m^2 / 10^4

The table below lists SI unit prefixes and symbols for reference.

Fraction or Multiple	Prefix	Symbol
10^{-1}	Deci	d
10^{-2}	Centi	c
10^{-3}	Milli	m
10^{-6}	Micro	µ
10^{-9}	Nano	n
10^{-12}	Pico	p
10	Deca	da
10^{2}	Hecta	h
10^{3}	Kilo	k
10^{6}	Mega	M
10^{9}	Giga	G
10^{12}	Terra	T

APPENDIX E

The table below lists other Water Resource Recovery Design Guidelines

No.	Title	Revision	Status
DS200	Fluid Flow Measurement		For Review
DS201	Screening		Draft
DS202	Grit Removal		
DS203	Primary phase separation – sedimentation		
DS204	Primary phase separation – filtration		
DS205	Aeration		
DS206	Secondary Treatment systems		
DS207	Secondary phase separation – sedimentation		
DS208	Secondary phase separation – filtration		
DS209	Tertiary treatment systems – denitrification/filtration		
DS210	Mechanical sludge thickening		
DS211	Dissolved Air Flotation Thickening		Draft
DS212	Mechanical sludge dewatering		
DS213	Sludge conditioning with polymers		
DS214	Sludge digestion		
DS216	Sludge handling		
DS217	Thermal Hydrolysis pre-treatment		
DS218	Sludge drying		
DS219	Sludge carbonisation		
DS220	Odour management – collection		
DS221	Odour management – conveyance		
DS222	Odour management – treatment		
DS230	Waste Stabilisation Ponds		Published
DS231	Evaporation Ponds		Draft
DS240	Low risk treated water reuse – filtration		Published
DS241	Low risk treated water reuse – disinfection		

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