Non-Urban Meter Installation - Validation and Facility Maintenance

Resource Handbook

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Version Control

Learning Materials Modification History

Training Package	NWP National Water Package		
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Unit Name	Install and Maintain Meters		
Version	Date of Release	Authorisation	Comments
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16	30/11/2010	Clive Luscombe	Changed to 305B
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18	March 2013	Clive Luscombe	Updated to AS after standards approved

Disclaimer

This Resource Manual has been designed for the installation of meters in a non urban environment. The intention of this Resource Manual is to guide installers in the installation of a range of meter facilities including concrete and pipe work. Installers will validate that the installation has been completed according to manufacturers' guidelines and the local water authority, agency or organisation policies and procedures. It is not intended to guide installers in the verification of flows; this is the responsibility of the meter manufacturer and meter measuring laboratories. This resource manual includes meter installation in channels and pipe systems (including pump systems from streams); it does not cover measurement or meter installation within streams.

Acknowledgements

This Resource Manual and Evidence Workbook have been produced by:

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Murrumbidgee Irrigation
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AWMA Pty Ltd
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Limitations

Water Training Australia and JEB Services have prepared this Resource Manual for use as a training reference document, in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the advice included in this report. It is prepared in accordance with the scope of the work and for the purpose outlined by Irrigation Australia Limited.

Competency Statement

NWP302A Install meters for non-potable, non-urban water supplies

1. **Confirm conditions of the site for meter installation.**
    1.1. Identify the location of the site and establish client information.
    1.2. Identify access to the site and any conditions of access.
    1.3. Test the conditions of the site and analyse impact on installation assets.
    1.4. Complete an environmental impact statement for the site.
    1.5. Carry out a job safety analysis and identify hazards and control measures.

2. **Set out the site.**
    2.1. Locate and install temporary benchmark.
    2.2. Store and secure material and equipment on site.
    2.3. Calculate and mark the site perimeters in relation to the flow of the channel.
    2.4. Ensure that excavations provide sufficient width for movements of installation.

3. **Install meter facilities.**
    3.1. Install sumps and headwalls to ensure correct elevation, orientation and horizontal and vertical levels.
    3.2. Install pipes and meter pits to ensure the correct elevation, fall and orientation.
    3.3. Check pipe fittings and seals and eliminate flow disturbance.
    3.4. Install solar panels and display units according to manufacturers' requirements, check for operation and seal.

4. **Install meters.**
    4.1. Install meters in meter pits according to manufacturers' requirements.
    4.2. Fit meters according to manufacturers' requirements.
    4.3. Align flanges, gaskets and internal pipe walls to eliminated flow disturbance and leaks.
    4.4. Locate and support meters to protect them from traffic and vibration.

5. **Restore site.**
    5.1. Backfill upstream and downstream sumps with suitable material, moisture content and compaction to maximize compaction efficiency.
    5.2. Restore the site to closest to original site conditions.

NWP304A Maintain meters for non-potable, non-urban water supplies

1. **Confirm meter type and location within asset management system.**
   1.1. Obtain organisational maintenance plan and manufacturers guidelines, where available.
   1.2. Locate meter emplacement on a map or by GPS or according to organisational procedures.
   1.3. Confirm that meter type matches maintenance plan or manufacturer's guidelines.
   1.4. Confirm that meter number matches maintenance plan.

2. **Check condition of meters and metering system.**
   2.1. Identify faults using an asset condition checklist.
   2.2. Establish maintenance requirements.
   2.3. Check for hydraulic disturbances.
   2.4. Check condition of battery and charging system.
   2.5. Perform in situ test of meter as applicable.

3. **Maintain meter and meter facilities.**
   3.1. Rectify faults in components, according to organisational guidelines.
   3.2. Identify faults which need to be rectified by a third party, according to organisational guidelines.

4. **Test and recommission.**
   4.1. Ensure meter complies with standards.
   4.2. Perform in situ re-test of meter as applicable.
   4.3. Replace seals and tags.
   4.4. Record faults and meter performance, maintenance and repairs according to organisational procedures and statutory requirements.

Introduction

Accurate measurement of water supplied and accounting for water use against a customer's entitlement is now the focus of the Australian Government under the standards for non-urban metering accuracy.

This Training program will provide participants understanding of the Standard AS (Australian Standard) 4747 which details how meter manufacturers must comply in the design of meters to the standards to be approved, plus procedures and practices for installation of these meters and the required maintenance once installed. Also the National Measurement Institute (NMI) documents M10.2 and M11.2 which details the process of meter manufacturers achieving 'Pattern Approval' for non-urban meters to achieve a level of accuracy within the range of +/-2.5% (known as Class 2.5 Meters).

Water authorities across Australia are responsible for the introduction and compliance of National metering standards as well as improved cyclic maintenance programs.

Key aspects of this training program include:

- *Understanding the new Australian Standards and the pattern approval process*
- *Type of meters used for non-urban (rural) measurement*
- *Meter selection for the location to be metered*
- *Installation of meters*
- *Maintenance of meters*

This **Non-Urban Meter Installation and Maintenance Resource Manual** is intended to be used as a work book in support of assessment requirements for those seeking competency and as a future reference document for meter installation and maintenance activities.

It is not intended as a technical reference document as these are provided by manufacturers in support of their individual meters.

Aims of the Course

To provide people who install and maintain non-urban meters with the skills required to become competent as installers and maintainers of non-urban meters.

Accreditation

Accreditation will be achieved through competency against two current units from the Water Industry Training Package. These units are:

"NWP302A Install meters for non-potable, non-urban water supplies" and "**NWP304A Maintain meters for non-potable, non-urban water supplies"**.

Course Delivery

The course will be presented by training room theory and practical course work and will cover the following topics:

- Details of the competencies to be covered and the process of assessment and recognition of current competency
- The Australian Standards relating to meters for non-urban application – what they mean and how they will be applied.
- 'Pattern Approval' of meters to be used in non-urban metering – why this is important to meter selection, installation and maintenance.
- Meters that will be covered by this course (generically described)
- Installation procedures for these meters
- Meter commissioning – items to be checked and validated
- Maintenance requirements of these meters.

There will be several activities included during the course to reinforce the content and expectations for competency. A field inspection of meter installations will be included where possible to test the validation theory developed during the course.

Assessment

The training is to be assessed against National Water Industry (NWI) Training Package competency standards. As such there are two possible end-points:

- NWP302A Install Meters for Non-Potable, Non-Urban Water Supplies.
- NWP304A Maintain meters for non-potable, non-urban water supplies

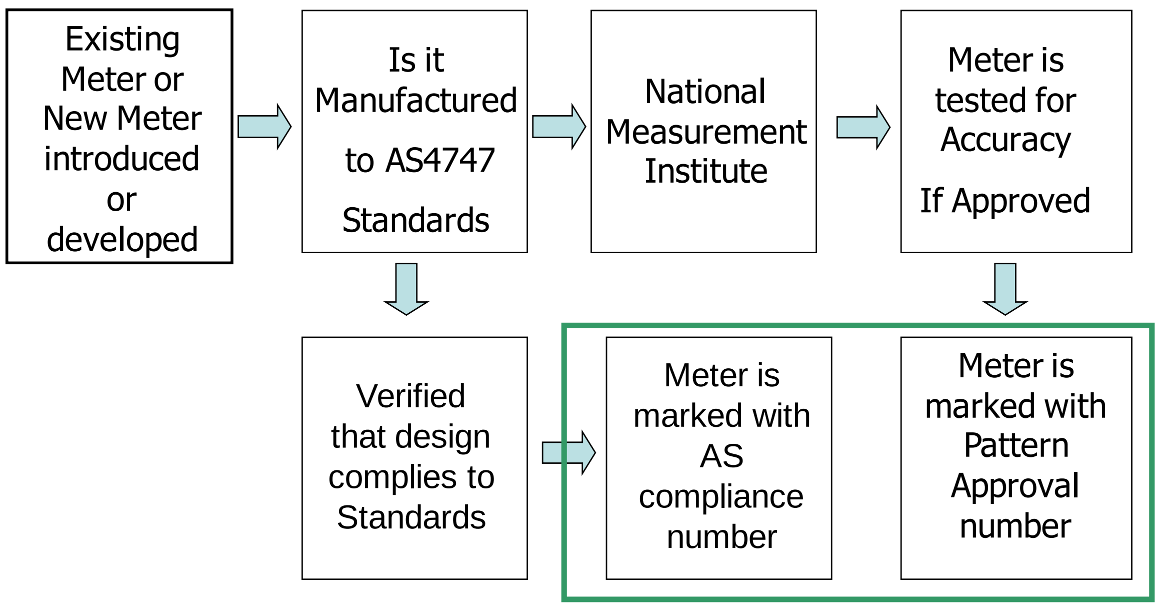
Assessment will be based on:

- Successful completion of the those activities contained in the Assessment Record by the trainee during the formal training sessions
- Successful completion of three workplace assignments, also contained in the Assessment Record, by the trainee at their respective workplace
- Successful completion of the Field Assessment Task 4, located in the Assessment Record to be completed by the trainee and witnessed by a relevant supervisor or workplace expert.

Background

The National Measurement Act provides the basis for the national measurement regulations. Exemptions currently exist for rural irrigation meters. It is the intention of the National Water Initiative to lift exemptions by July 2008 at which time all irrigation meters (non-urban) will need to comply with national metrological requirements for irrigation meters.

The National Measurement Institute (NMI) has developed a metrological control system for utility meters which consists of pattern approval and uniform test procedures for all new meters. Standards Australia have developed standard specifications for both closed conduit and open flow meters. The process required of manufacturers is demonstrated by the following chart:



Existing or new meters developed must first comply with the Standards for design, manufacture and installation guidelines provided with each meter. If approved, each meter must be stamped to show the AS approval number to demonstrate compliance. The accuracy of the meter then must be pattern approved using the test plans detailed in the NMI M10.2 or M11.2 documents. If this is achieved a number must also be stamped on the meter to demonstrate compliance. These markings will be discussed later within the manual.

It is intended that water agencies will demonstrate the field accuracy of meters through the use of a cyclic maintenance and an in-situ auditing process that will show compliance to the national standards. The national accuracy standards adopted by the National Water Initiative effectively means that irrigation meters not meeting the accuracy requirements will not be installed.

Accurate measurement is important for:

- Water trading
- Water accounting
- Dispute resolution
- Security of entitlement
- Resource management
- Community expectation

Legislative Requirements

- Legally traceable measurements
- Ensure fair trade
- National uniformity

Management Requirements

As many of the methods of measuring flow and consumptive volumes to customers will not achieve approval under these new standards, many water agencies must embrace a major investment to install or upgrade existing metering methods to comply with these new standards.

For many water agencies this will mean a significant investment in both resource training and capital cost of the meters and installed sites to meet compliance. Common older types of meters such as the Dethridge wheel will not achieve 'pattern approval' and therefore must be replaced. Other meters may fail as the process continues.

State Implementation Plans

The objective is to have a policy and legislative framework in place in all jurisdictions to enable the delivery of national standards for measuring and metering water taken from natural water resources, including water delivered to and taken by non-urban customers in water supply schemes, consistent with the agreed national Metrological Assurance System.

A national policy framework (Metrological Assurance System) for measuring and metering water taken from natural water resources, including water delivered to and taken by non-urban customers in water supply schemes will be agreed by the Natural Resource Management Ministerial Council. This framework will be implemented in each jurisdiction through State water policies and legislation, supported by national and state trade measurement legislation. This will provide a consistent approach by jurisdictions in their state policy and legislative regime that is relevant to the preferred pathway to the common goal of improved metering standards that deliver equity and fairness to all water users.

Critical to the delivery of the Metrological Assurance System is the introduction of pattern approval for "larger" (>4000 l/hr or 0.09 ML/d) meters under the National Measurement Act; and extension of exemptions for non-reticulated meters under the uniform trade measurement legislation until practical and viable methods of in-situ volumetric verification are available.

Australian Standards

The National Water Initiative Committee is a joint state and Australian Government decision-making group that sits under the Natural Resource Management Ministerial Council and is responsible for overseeing the implementation of the National Water Initiative (NWI). The agreement includes objectives, outcomes and agreed actions to be undertaken by governments across eight inter-related elements of water management, one of which is water resource accounting.

The outcome of water resource accounting is to ensure that adequate measurement, monitoring and reporting systems are in place in all jurisdictions, to support public and investor confidence in the amount of water being traded, extracted for consumptive use, and recovered and managed for environmental and other public benefit outcomes.

Paragraph 88 of the National Water Initiative states:

> "Recognising that information available from metering needs to be practical, credible and reliable, the Parties agree to develop… and apply…:
>
> - *a national meter specification*
> - *national meter standards specifying the installation of meters in conjunction with the meter specification, and*
> - *national standards for ancillary data collection systems associated with meters."*

The Australian Standard 4747 has been prepared by the Standards Australia Committee CE-024, Measurement of Water Flow in Open Channels and Closed Conduits.

The objective of this Australian Standard is to provide manufacturers with requirements for irrigation and non-urban water meters to meet the requirements of the National Water Initiative Clause 88, which provide for an electronic output device (EOD) principally to measure irrigation water. This Australian Standard has been revised to include essential requirements to maintain progress with technology in the water meter industry.

This Australian Standard AS 4747 is made up of parts covering the metering of non-urban water supply, which comprise the following

Part 1:	Glossary of terms (in draft)
Part 2:	Specification of meters for closed conduit fully charged (in draft)
Part 3:	Specification of open channel meters (in draft)
Part 4:	Storage meters (not yet released in draft)
Part 5:	Installation, commissioning and maintenance of meters for closed conduits fully charged (in draft)
Part 6:	Installation and commissioning of open channel meters (in draft)
Part 7:	Output protocols (not yet released in draft)

Part 8: Closed conduit in-service compliance (in draft)

Note: The term open channel includes covered channels or partially filled pipes. The distinction is that the conduit does not usually flow full.

The AS 4747 suite was published in the first instance as Australian Technical Specifications (ATS4747). Following a period of trial and review (normally no more than 2 years but this has been substantially longer) it has now been published as the Australian Standard in early 2013.

The benefits of these standards will be demonstrated through common accuracy and compliance of all meters manufactured and installed in non-urban locations that have met the requirements of these standards.

The key items to be met by manufacturers of meters for use in non-urban water delivery systems are:

- Materials used in manufacture of the meter
- Design, including display of reading, frequency of measurement, storage of data, power supply and sealing methods.
- Performance requirements
- Marking and product documentation
- Other guidelines may include:
  - Purchasing guidelines
  - Means of demonstrating compliance
  - Error of measurement testing
  - Metrology requirements i.e. pressure range, temperature, humidity, etc.
  - Evaluation of a family of water meters

Relevant parts of AS 4747 that will provide good underpinning knowledge for people engaged as meter installers are:-

- Part 2 and 3 for meter design approval requirements
- Part 5 and 6 for meter installation requirements
- Part 8 for codes of practice for in-service compliance

AS 4747 Parts and Section details

Part 2 – Meters for closed conduits fully charged

- Section 2 – materials to be used in the manufacture of the meter body and components
- Section 3 – Elements to be uniform in the design
  - Dimensions and connections
  - Flow Computer
  - Display – separation of digits etc…

  - The display of the water meter shall provide an easily read, reliable and unambiguous visual indication of the metered volume.
  - A secondary display may be provided to indicate flow rate or other parameters
  - The unit ML, kL or m3 shall appear on the display
  - The colour black should be used to indicate Megalitres (cubic metres or kilolitres) and its multiples.
  - The colour red should be used to indicate sub-multiples of a Megalitre (cubic metre or kilolitre).
  - The primary units of measure, its multiples and its submultiples shall be displayed such that there is no ambiguity in distinguishing between the whole and fractional units of measure
- Electronic Storage
- Frequency of measurement – how often must samples be taken and stored
- Power supply – AC or DC
- Electronic sealing devices – passwords etc…
- Environmental requirements

- Section 4 – Performance Requirements
  - Measurement
  - Pressure loss
  - Operating temperature
  - UV light exposure
  - Watertightness
  - Reverse flow
  - Leakage
  - Endurance
  - Performance tests
- Section 5 – Marking and Product Documentation
  - Identification Marks
    - The water meter shall be clearly and indelibly marked with the following information, either grouped or distributed on the casing, the indicating device, an identification plate, or on the meter cover if it is not detachable:
    - Name or trademark of the manufacturer
    - Nominal size
    - Numerical value of Q_3 and the ratio Q_3/Q_1
    - Pattern approval mark as applicable
    - Serial number
    - Direction of flow
    - Maximum operating pressure
    - Letter V or H, if the meter can only be operated in the vertical or horizontal position
    - The unit of measure in ML or kL or m^3
    - Manufacturer may indicate the maximum pressure loss

    - *NOTE: Except for Pattern Approval, Australian Technical Specifications and Watermarks the above information may be provided in the form of a microchip or barcode or other technologies where acceptable to the purchaser*.
    - For meters with electronic components
    - For an external power supply, the voltage and frequency
    - Battery replacement or life details
- Verification Marks
    - A place shall be provided on water meters for affixing the verification mark, which shall be visible without dismantling the water meter.
    - *Manufacturers making a statement of compliance with this Australian Technical Specification on a product, packaging, or promotional material related to that product are advised to ensure that such compliance is capable of being verified.*
- Product Documentation
    - Product documentation provided with the meter shall include the following:
    - Advice on battery life
    - Head loss at Q_3
    - For replaceable battery, the latest date by which the battery is to be replaced.
    - *NOTE: Successive changes are the owner's responsibility*.
    - For a non-replaceable battery, the latest date by which the meter is to be replaced
    - Clauses on sensitivity to irregularities in the velocity field
    - Climatic and mechanical environmental security level
    - Output signals for ancillary devices (type/levels) if any
    - EMC class.
- Installation Instruction
    - The Meter shall be supplied with installation instructions that, if followed will allow the meter to meet the required accuracy. Instructions shall be in accordance with AS 4747.
    - For self contained Meters the installation instructions shall include the method of determining the accuracy or confidence factor in accordance with Clause 7.
- Commissioning Instructions
    - The commissioning instructions shall be supplied with the meter.
- Appendix A – Purchasing Guidelines
- Appendix B – Means for demonstrating compliance
- Appendix F – Metrological requirements

Part 3 – Meters for flow in open channel

- Section 2 – Materials used in construction
- Section 3 – Methodology

- Section 4 – Principles of measurement – Modular Metering Systems
  - Metering of partially filled pipes
  - Modular open channel metering systems
  - Weirs and Flumes
  - Velocity Measurement Devices
  - Flow Computer
  - Velocity Area methods
  - Measurement instruments
- Section 5 – Principles of measurement – Self contained units
- Section 6 – Design
  - Display
    - The display of the water meter shall provide an easily read, reliable and unambiguous visual indication of the metered volume.
    - A secondary display may be provided to indicate flow rate or other parameters
      - The unit ML, kL or m^3 shall appear on the display
    - The colour black should be used to indicate Megalitres (cubic metres or kilolitres) and its multiples.
    - The colour red should be used to indicate sub-multiples of a Megalitre (cubic metre or kilolitre).
    - The primary units of measure, its multiples and its submultiples shall be displayed such that there is no ambiguity in distinguishing between the whole and fractional units of measure
  - Calibration Adjustment Device
  - Output
  - Electronic storage
  - Frequency of Measurement
  - Reverse flow
  - Electronic Sealing Devices
  - Environmental requirements
  - Enclosure
- Section 7 – Performance Requirements
  - Measurement performance
  - Head Loss
  - Operating Temperature
  - UV Exposure
  - Leakage
  - Flooding
  - Endurance
  - Adjustment of Water Meters
  - Performance tests
- Section 8 – Markings
  - Identification Marks
    - The water meter shall be clearly and indelibly marked with the following information, either grouped or distributed on

the casing, the indicating device, an identification plate, or on the meter cover if it is not detachable:
    - Name or trademark of the manufacturer
    - Nominal size
    - Numerical value of Q_3 and the ratio Q_3/Q_1
    - Pattern approval mark as applicable
    - Serial number
    - Direction of flow
    - Maximum operating head
    - Letter V or H, if the meter can only be operated in the vertical or horizontal position
    - The unit of measure in ML or kL or m^3
    - Manufacturer may indicate the maximum pressure loss
    - *NOTE: Except for Pattern Approval, Australian Technical Specifications and Watermarks the above information may be provided in the form of a microchip or barcode or other technologies where acceptable to the purchaser*.
    - For meters with electronic components
    - For an external power supply, the voltage and frequency
    - Battery replacement or life details
- Verification Marks
    - A place shall be provided on water meters for affixing the verification mark, which shall be visible without dismantling the water meter.
    - *Manufacturers making a statement of compliance with this Australian Technical Specification on a product, packaging, or promotional material related to that product are advised to ensure that such compliance is capable of being verified.*
- Product Documentation
    - Product documentation provided with the meter shall include the following:
    - Advice on battery life
    - Head loss at Q_3
    - For replaceable battery, the latest date by which the battery is to be replaced.
    - *NOTE: Successive changes are the owner's responsibility*.
    - For a non-replaceable battery, the latest date by which the meter is to be replaced
    - Classes on sensitivity to irregularities in the velocity field
    - Climatic and mechanical environmental security level
    - Output signals for ancillary devices (type/levels) if any
    - EMC class.
- Installation Instruction
    - The meter shall be supplied with installation instructions that will allow the meter to meet the required accuracy. Instructions shall be in accordance with AS 4747 of this

Australian Technical Specification (Part 5 is currently being developed)..

- Commissioning Instructions
    - The commissioning instructions shall be supplied with the meter.
- Appendix B – Means for demonstrating compliance
- Appendix C – Metrological requirements
- Appendix D – Error of Measurement test

Part 5 – Installation, Commissioning and Maintenance of meters for closed conduits fully charged

- Section 2 – Criteria for the Selection of Water Meter Installations
    - Design
    - Information to be provided by manufacturer
    - Good practice installations
- Section 3 – Particular Installation Requirements
- Section 4 – Particular Hydraulic Requirement
- Section 5 – Commissioning including Validation
- Section 6 - Maintenance

Part 6 – Installation and Commissioning of Open Channel meters

- Section 2 – General requirements for Water Meter installation
- Section 3 – Particular Installation Requirements
- Section 4 – Particular Hydraulic Requirements
- Section 5 – Commissioning including Validation
- Section 6 – Maintenance

Part 8 – Code of Practice for the in-service Metrological Assurance of Non-Urban Water Meters in Full Flowing Pipes (Closed Conduit and Open Channel in-service Compliance)

Pattern Approval

While it is expected that all non-urban metering devices shall comply with the Australian Standards, the requirement placed on meter manufacturers to achieve compliance is by way of achieving ‘pattern approval’, which is detailed in document NMI M10.2 and NMI M 11.2. These documents can be located and downloaded from the following website www.measurement.gov.au/ . Other relevant and useful information may also be found at this location.

Pattern of an Instrument is defined as: *The definitive design of a measuring instrument of which all components affecting its metrological properties are suitably defined*.

The definition of Pattern Approval is: *The process whereby an impartial body examines the pattern of an instrument against a set of national or international metrological specifications. This determines whether an instrument is capable of retaining its calibration over a range of environmental and operating conditions and ensures that the instrument is not capable of facilitating fraud.*

The document NMI M10.2 specifically covers details for meters for closed conduits fully charged and NMI M11.2 specifically covers details for open channel meters – these include meters for use in partially filled pipes or other types of gates that electronically measure and record flow.

- Accuracy in water meters is expressed as the degree to which a meter corresponds with a standard or true value.
- Deviation from the true value is reported in percentages of error - e.g. +/- 2%
- “Pattern Approval” is the process the National Measurement Institute has developed for use to test that the accuracy of manufacturers’ meters are within +/-% under laboratory test conditions.
- Class 2.5 meters are those that are within +/- 2.5% of a true value under laboratory test conditions.

These NMI documents set out details of the test program, principles, equipment and procedures to be used for pattern evaluation and initial verification testing of a meter model. These documents are applicable to the testing of self-contained meters that have defined geometry; they do not cover the pattern evaluation and testing of metering systems, although provision is made for testing of modules that form part of a meter.

The provisions include requirements for testing the complete water meter and for testing the measurement transducer (including flow or volume sensor) and the calculator (including the indicator device) of a water meter as separate units.

To achieve pattern approval, meter manufacturers must be able to demonstrate how specific meters or families of meters measure, record and display flow and the level of accuracy achieved by the meter when installed to specifications. These documents expect meters to achieve accuracy within the range of +/- 2.5 percent under laboratory conditions, thus these meters will be described as Class 2.5 (Non-Urban) Meters.

Workshop Activity

Refer to Activity 1 in your Evidence Workbook

Manufacturers' Installation Guidelines

AS 4747.2 and AS 4747.3 expects that manufacturers will provide work instructions or guidelines for the correct installation of their meters. These guidelines should cover all aspects including specifications, performance analysis and general installation requirements. Some manufacturers provide significant detail including parts lists etc. while others may provide details on the electronics such as the transducers, converters and display units. In some cases manufacturers do not provide a lot of detail about the other components of the metering emplacement.

In essence the manufacturer's installation guidelines should be consistent with the AS 4747 and pattern approval requirements, where approval has been given. Installers must check to ensure the DN (nominal diameter) requirements of the meter meet either the AS 4747 standard or the pattern approval requirements which includes the situation within which the meter is being installed. For example if a meter is pattern approved, the installer needs to check the DN requirements supplied by the manufacturer as stated in the certificate of approval. These may state the DN requirements as less or greater than the AS4747 but under certain operating conditions, such as when the meter is installed in a gravity fed situation, may not be acceptable where a pump is involved.

If the DN requirement is less than 10 and 5 and the meter is not pattern approved the installer should use the standard requirement of 10 and 5. However if the manufacturer recommends a DN greater than 10 and 5 use the greater dimension.

Workshop Activity

Refer to Activity 2 in your Evidence Workbook

Organisation Policies and Procedures

Given the importance of water and the accurate measurement of its use water authorities have a legal and social obligation to ensure that meter readings and the subsequent billing for water use is accurate. The accuracy of meters can be attributed to a range of features however once pattern approved the accuracy of the meter is most likely to be influenced by installation of the meter and operation and maintenance of the delivery system.

As a consequence of this, water authorities need to ensure meter readings reflect the actual use of the water. It will be a high risk to an authority if meter readings are inaccurate from financial, social and political aspects. It is usual for organisations to develop policies and procedures to ensure high risk activities or functions are carried out so that they mitigate or eliminate the risk. In the case of meters, most organisations will have developed policies and procedures to address items such as:

1. Ownership and responsibilities
2. Installation and maintenance
3. Collecting and recording data
4. Grievances relating to meter accuracy

Installers of meters, particularly if they are sub contracting, should be aware of the policies and procedures for the responsible water authority. In particular the installer may install meters for a number of different authorities; therefore it will be necessary to ensure these policies and procedures are understood and considered during the installation and maintenance phase.

Workshop Activity

Refer to Activity 3 in your Evidence Workbook

Types of Meters

As this course only relates to 'pattern approved' meters those meters that are in current use but are unlikely to achieve this status have not been included.

The types of meters that are likely to be approved and used for irrigation measurement can be broadly divided into 4 types:

- Mechanical meters – which includes propeller actuated and turbine meters.
- Electromagnetic meters
- Ultrasonic meters
- Electronic automatic weir structures.

Mechanical Meters

Mechanical meters measure water through the operation of a propeller, turbine or paddle wheel. These devices are located within a pipe and as water passes them they rotate turning a shaft that in-turn operates a number of gears that have been calibrated to measure volume in relation to the rotation of the propeller, turbine or paddle. These meters can become inaccurate when debris enters the pipe and fouls the rotating propeller, turbine or paddle.

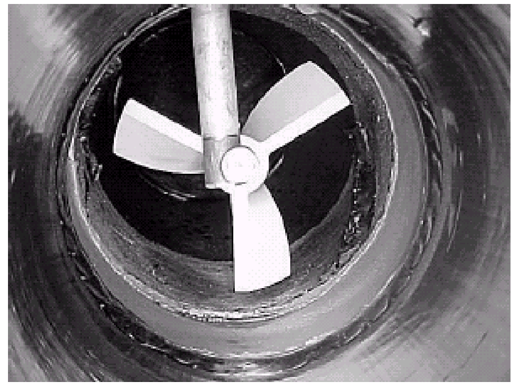
Mechanical meters are subject to wear in bushes and shafts and as a result the rotation and turning of gears can be out of synchronisation with the design calibration of the meter. Cavitation and turbulent water can cause the propeller, turbine or paddle to spin with an irregular pattern and as a result may result in loss of flow synchronisation with the meter

Types of Mechanical Meters

Propeller Actuated (PA) Meter

A helical shaped rotor is located on the centre of the conduit. The design of the rotor influences flow performance of the meter and the amount of unobstructed flow between the blades. This provides the opportunity for foreign objects or small aquatic life to pass through the meter. Generally the performance of the meter is sacrificed to provide less obstruction of flow.

The PA meter is used extensively by river-pumpers and horticulturalists with pressurised irrigation systems.



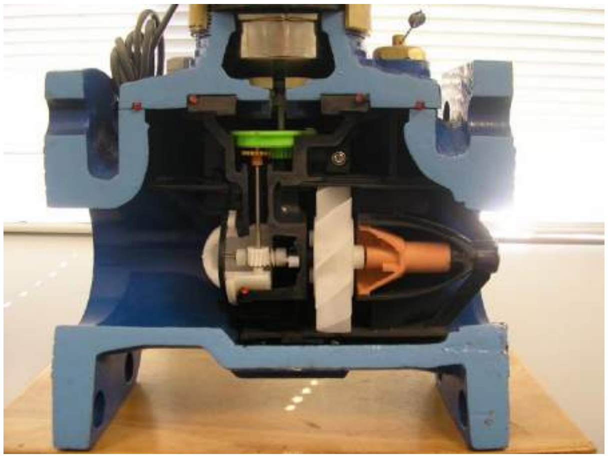
100mm Elster PA 2000

150mm Davies Shephard PA meter

Turbine Meters

The main feature of the turbine meter is the size, shape and number of blades of the impeller. The impeller takes up almost all of the water way and allows it to measure flow at a far greater accuracy than the PA meter.

Turbine meters consist of a bladed turbine rotor installed in a flow tube. The rotor is suspended on its axis in the direction of the flow through the tube. Turbine meters are similar to PA meters in that the movement of flowing water causes the turbine to spin, however Turbine meters are generally more accurate than PA meters at both high and low flows. They will not cope well with floating obstructions and are best used in situations where the water is first filtered.



Example of Turbine meters

Paddle Wheel Meter

Paddle wheel meters generally have a small paddle wheel that extends beyond the surface of the meter body into the waterway and rotates perpendicular to the direction of the flow. The advantage of the meter is that the water way is relatively unobstructed.

Electromagnetic Meters

The electromagnetic meter, as it suggests, involves a magnetic field. The meter has a magnetic field that surrounds the internal wall of the meter housing. The water flows through the magnetic field and generates an electrical current. This electrical current is measured and converted to flow and volume outputs. As the flow increases, the electrical current increases, therefore the meter recognises increases in flow rate and volume. When the flows through the magnetic field reduce the electrical charge decreases therefore the meter records a lower flow rate and volume.

These meters are vulnerable to flow disturbances. Disturbances to flow patterns through the meter cause increases and decreases in the generation of electrical currents due to differences in velocity. Non disturbed flows provide constant even electric current

measurement. Disturbed flows, on the other hand, provide varied electric current measurement and therefore incorrect flow rate and volume outputs.

This type of meter is produced in a range of standard sizes and flow capacities. Electromagnetic meters have been used in the urban water industry for many years and are now becoming more common in the rural water industry.

ABB & Siemens magnetic flow meters

Ultrasonic Meters

These are sometimes referred to as Acoustic meters. Ultrasonic water meters are used widely for urban and industrial applications. The existing technology uses transducers or sensors to measure water velocity in full pipes with known cross-sectional area to calculate flow rate.

Transducers can be fixed on the outside of the pipe. These are "non-wetted" types. They can also be inserted into the pipe and are known as "wetted" types.

Different brands of meter use different numbers of transducers. Some use only one or one set of transducers to give a reading on a single path. Others use multiple transducers to read on more than one path. Generally, multiple paths will provide greater accuracy.

Two methods used to calculate water velocity:

a. Transit time meter and
b. Doppler meter.

a. Transit Time Meter

The Transit Time method calculates velocity from differences in time for an impulse to pass between two transducers located on opposite sides of the pipe and positioned along the pipe at an angle to flow direction. It uses the velocity of sound pulses travelling in the direction of flow compared to the velocity of sound pulses travelling against the direction of flow to determine the velocity of water and calculates the flow rate.

There are normally no obstructions or moving parts to impede the flow and the transducers can be wet or dry. These meters are usually designed for use in full flowing pipe situations and are produced in a range of standard sizes and flow capacities.

The ultrasonic principle can be extended to measure flow in partially filled pipes or open channels. This is more complex and requires additional numbers of transducers and sound paths, combined with a method to measure water depth. The technology shows good potential for developing new types of meters.

Siemens transit time ultrasonic meter

b. Doppler Meter

The Doppler method calculates the velocity by bouncing sound pulses out into the water mass and reading the pulses that are returned after reflecting from moving particles within the water mass such as air bubbles. This is similar to how speed radar works.

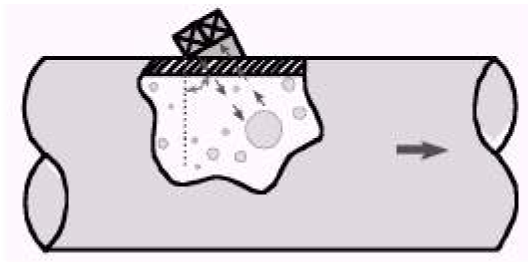
MACE Agriflow (Doppler Ultrasonic) meter

The method generally uses a “wet” sensor that is installed within an existing pipe or structure. There are various ways to mount the sensors depending on the application. Some may be installed through 25mm or 50mm ‘BSP’ fittings welded or clamped onto the external face of the pipe and others by strapping them inside a pipe or structure.

Ultrasonic Doppler meters can be used in a wide range of situations. For situations with Open Channel flow, an additional sensor can be installed to also measure the depth of flow. With known velocity and depth of flow, the flow rate can be calculated.

Depth transducers may be ultrasonic, pressure or bubbler type. The type most commonly used with ultrasonic Doppler meters is the pressure transducer, due to its high reliability.

Unlike other acoustic meters, Doppler meter performance is very dependent on the water's physical properties, such as sonic conductivity, particle density, and flow profile. This can reduce the reliability of this type of meter.



Schematic diagram of a Doppler Ultrasonic meter - showing the reflected path from a non-wetted transducer (MACE).

Automatic Electronic Weir Structures

A recent development in automatic weir structures with incorporated metering capability is the Rubicon **FlumeGate™** which uses ultrasonic sensors to measure the upstream and downstream water level and the door position calculates the depth of water passing over an overshot weir. An algorithm (computer formula) is used to calculate the volume of water flowing over the weir. This volume is recorded on the local display as well as being transferred by SCADA (supervisory control and data acquisition) back to a central database. These units can be set into automatic control mode where the gate will self adjust to keep either a constant water level or flow rate. They can also be used in local manual mode.

Other companies are developing similar technologies for both overshot and undershot weirs. Automatic structures are utilised in irrigation systems with Rubicon's Total Channel Control (TCC™) or alternative automated channel control methods where various systems are utilised.

Rubicon FlumeGate™ M Standard and - Large Irrigation Outlets.

Modular Units

The unit to the right is an example of a Modular Meter whereby, in this case, the meter measures the flow and the gate (Rubicon SlipGate M) adjusts the flow to maintain a constant rate of flow through the facility.

Meter Selection – Advantages and Disadvantages

Advantages and Benefits – PA Meter	Disadvantages
- Reasonably accurate means of measurement provided the meter is correctly installed and maintained. - Can be installed to suit many different irrigation layouts. - Operates satisfactorily in turbid water. - Clear flow passages allow flushing of suspended solids. - Tolerant of moderate levels of sand and silt. - Can be installed in horizontal or inclined pipelines without loss of accuracy.	- Very difficult to detect malfunction or unauthorised interference to meter while operating. - Propeller can be fouled or stopped by floating debris, weeds or other obstruction. - Older type propellers were susceptible to abrasion or mineral build up.

Advantages - Turbine Meters	Disadvantages
- High accuracy and flow range	- Prone to blockages

Advantages Paddle Wheel Meters	Disadvantages
- May pass small debris	- May be prone to high wear on drive axle - Restricted operating range for accuracy

Advantages and Benefits - Electro Magnetic Flow Meters	Disadvantages
- Capable of high degree of accuracy (<±0.5%) and consistent over full flow range when calibrated correctly. - Wide flow range. - No obstructions to flow. - Robust with only minimal routine maintenance. - No moving parts. - Can be buried.	- Relatively high cost. (Indicative costs for meter and sensor range from $2,500 to $7,000 for 3.5 to 20 ML/d units. Power and installation costs could double these amounts). - Power supply required (solar panels with battery back up suitable if mains power not available). - Electronic components vulnerable to moisture/ UV and lightning damage. - Repairs require skilled technician and specialised equipment.

Advantages and Benefits - Ultrasonic Meters	Disadvantages
- Capable of high degree of accuracy (<±1%) and consistent over full flow range when installed and calibrated properly. - Robust with only minimal routine maintenance required. - Capable of measuring bi-directional flow. - Simple to install. - Same meter can be used in a wide range of pipe sizes.	- Repairs require skilled technician and specialised equipment. - Power supply required (solar panel with battery back up) - Electronic components vulnerable to moisture and insect ingress.

Advantages and Benefits - Automatic Electronic Weirs	Disadvantages
- Provides automatic control of channel systems - Accepts larger flows - Measurement is not affected by water quality - Contain a self analysing maintenance log	- Impairs the access tracks for channel operators - Highly reliant on quality radio networks for communication

Workshop Activity

Refer to Activity 4 in your Evidence Workbook

Technical Concepts

It will be important for the installer to have a basic understanding of the key hydraulic concepts associated with the operation of the meter. There are two key areas, units of measurement and flow characteristics.

Units of Measurement

Q - Is a technical symbol used to express flow.
Q_{max} – Maximum Flow
Q_1 – Minimum Flow Rate the lowest flow rate at which the meter is required to operate with +/- 2.5% accuracy
Q_3 – The highest flow rate within the rated operating conditions of the meter
DN – Nominal diameter of the pipe
ML/D – Megalitres per day
kL/s – Kilolitres per second
m^3/s – Cubic meters per second

Terminology

Head – Is the vertical difference between two water levels. In the case of a meter it is the difference between the upstream water level and the downstream water level at the discharge point.

Pressure – Is the amount of force exerted on a particular point(s)

Gravity – open flow - For flow to occur in channels and pipelines there must be a difference in height or head between the two ends. Head is the difference in the vertical height of the two ends. Head, in metres (m) can be used as a measure of pressure. Pressure increases as the head increases between two points. Water will flow from high head to low head and from high pressure to low pressure. Higher head / Pressure differences will increase the velocity of flow.

Elevation - Australian Height Datum (AHD) is the height above sea level and is used by surveyors to set the elevation of structures. Most water authorities use AHD to set the level of regulators within channel systems

Flow Velocity - The speed of water passing a point at a given time

Flow rate – Can be measured or calculated as or the cross-sectional area of the channel/pipe multiplied by the average velocity of the water

Volume - Amount or volume of water passed in a given time can be calculated by multiplying the flow rate by the time.

Flow Characteristics in Channels

Supply Level
Supply level is the minimum level at which the supply channel is designed to supply water. Meter outlets are installed so that there is a specific supply depth in front of the outlet when the channel is running at supply level.

The supply level limits the height of land that can be irrigated from the meter outlet. This allows for head loss through the outlet and flow on the irrigation bay.

If land is to be watered by gravity, then the source of the water must be higher than the land. In gravity irrigation situations this height should give sufficient head loss to allow the meter to receive full head of water and allow the metered water to flow onto the irrigation bay. Water authorities across Australia will have their own policies on supply levels.

As an installer you must be fully aware of the supply level, in particular if you have been requested to install the meter by a landowner. There are many examples where channel systems have been operated above the designed supply level so water can flow onto farm land. This practice has occurred over many years and in some instances the over supply has become the accepted supply level.

Given the focus on irrigation system infrastructure and its efficiency there is a trend to operate supply systems within their design envelope and adjust farm infrastructure to meet the supply design levels.

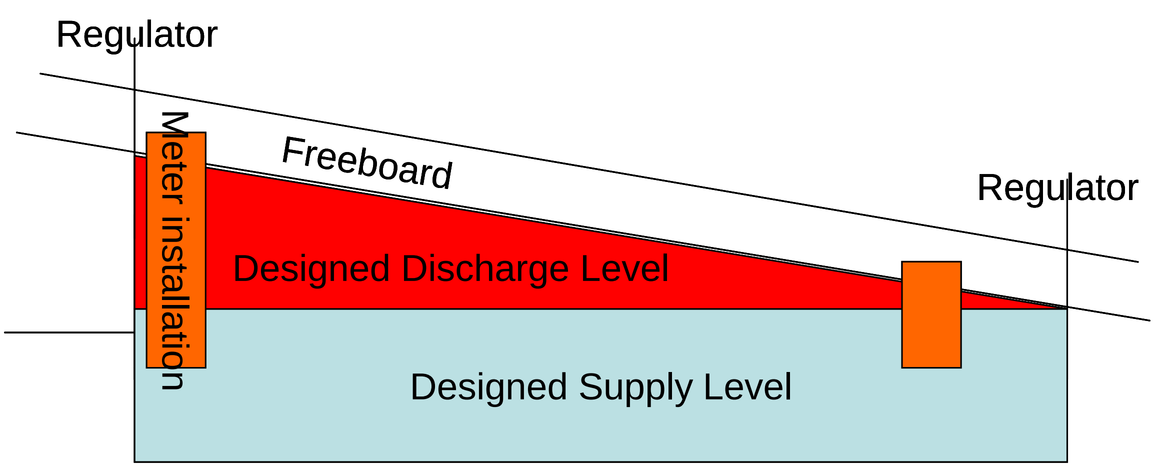


Diagram describing terminology in channel design.

It will be critical as an installer to ensure you have obtained the correct design supply level. There are cases where landowners have laser levelled irrigation land and used the ‘over’ supply level as the bench mark for the laser levelling only to find the water authority has reinforced the operation of supply channels at design supply.

Before installing any meter on an open channel system, be sure you have contacted the appropriate water authority and established the true supply level of the channel.

DDL is the designed discharge level determined from the maximum design flow wedge above the designed supply level.

Freeboard is the height of the bank above the designed discharge level.

Workshop Activity

Refer to Activity 5 in your Evidence Workbook

Flow Characteristics in Closed Conduits

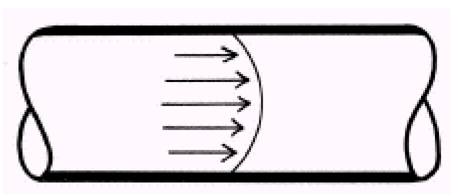
Closed conduit flow

Also known as full pipe flow, where water completely fills the pipe. Many types of meters can operate accurately only in full pipe conditions. In recent years the amount of irrigation water delivered to customers through full or pressurised pipes has increased.

A partially full pipe is classed as open channel flow.

Closed Conduit (or Full Pipe) Flow and meter accuracy

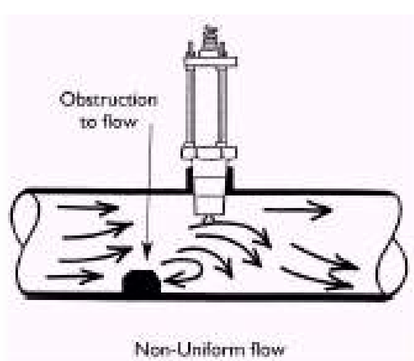
Our earlier flow calculations assume that water flow is uniform across the entire cross-section of flow, but this is rarely the case. Normally, water near the pipe walls travels slightly slower, due to the effects of friction. The water travels in parallel layers. Flow meters are usually designed to measure accurately under laminar (non-turbulent) flow conditions.



Velocity profile of water flow in a horizontal pipe.

Only a few types of meters are able to average the flow velocities across the entire cross-sectional area of a pipe. The most common alternative is to measure the flow in the centre of the pipe, away from the pipe wall. Turbulence in closed conduit flow caused by bends, protrusions and obstructions in a full pipe will break up parallel flow and cause turbulence or swirls in the flowing water. Meters will generally not measure accurately under these conditions.

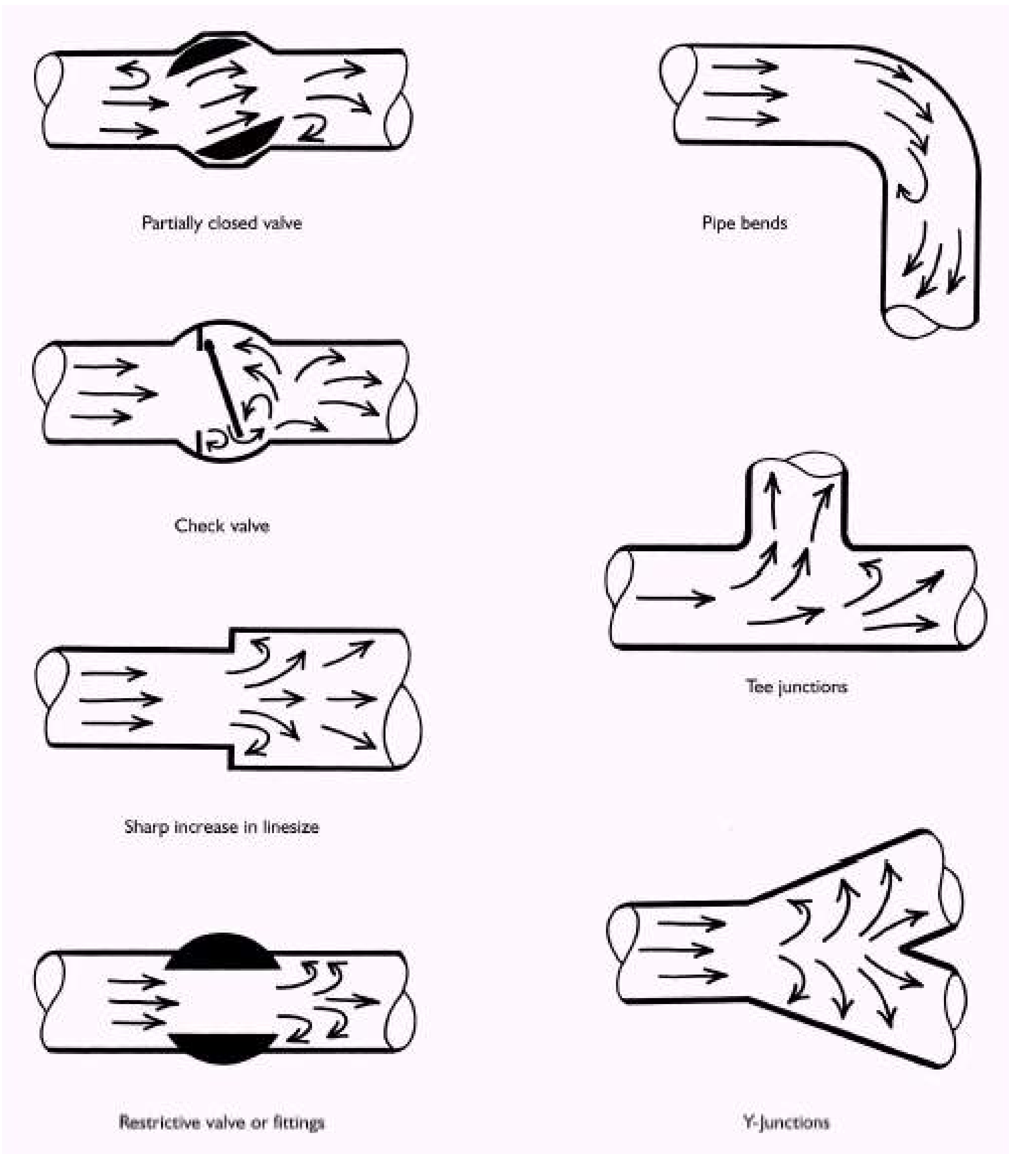
Turbulence could be caused by pipe fittings, valves, weeds, mineral build-up, etc.



Hydraulic Disturbance

Part 5, Section 4 of AS 4747 details particular hydraulic requirements to ensure hydraulic disturbances do not interfere with meter accuracy.

Many types of meters are sensitive to upstream flow disturbances which cause large errors and premature wear. There are likewise, although to a lesser extent, downstream disturbances. As a consequence of this the standard states "the meter shall be designed in accordance with AS 4747 and installed in accordance with installation limitations specified in the pattern approval certificate".



Turbulence due to bends, valves and changes in pipe size.

Methods of Eliminating Disturbances

The primary means of eliminating disturbances is to surround the meter with straight lengths of pipe. Preference should be given to installation of a longer straight section of pipe upstream of the meter.

AS 4747 details the sources of disturbance installers need to be aware of; in particular the specification states as a note:

1. Any device (e.g. a check valve, orifice, flow or pressure regulator, etc) may create a flow profile disturbance that will exist well after a length of 10 x DN (nominal diameter). Wherever practicable, such devices should be installed downstream of the water meter, at the far end of the straight section.

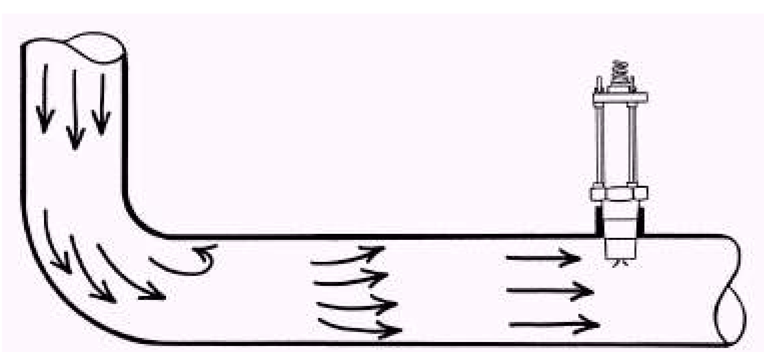
2. Minimum industry practice lengths in the absence of manufacturers' recommendations are 10 x DN upstream and 5 x DN downstream of the water meter. In the case of pumps, the upstream length shall be 20 x DN to correct the disturbance created by the pump.

For example:
For a meter with an internal bore of 100mm, 1m of straight pipe is required upstream of the meter and 0.5m of straight pipe is required downstream of the meter.

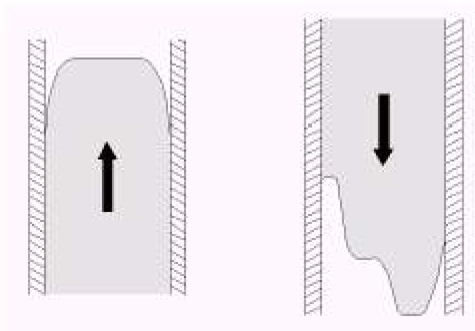
It is imperative that velocity flow profiles be regular for meters to be accurate. Velocity profile distortion can be eliminated by careful application of installation procedures.

Established flow - After turbulence has distorted the velocity profile it takes a length of straight pipe before the profile becomes established again and water again travels hydraulically smooth.

Positioning closed conduit meters for accurate measurement - The distance from an obstruction or bend to allow a confident prediction that established flow is present depends on the pipe diameter.



Distance to the bend should be 10 times the internal diameter at the meter.



Downward flow in a pipe will have a more uneven velocity profile and it is better to position meters in pipes with water flowing upwards against gravity.

Workshop Activity

Refer to Activity 6 in your Evidence Workbook

Installation of Meters

The Australian Standard AS 4747 Part 5, Section 4.3 states that velocity-profile distortion can be eliminated by careful application of installation procedures. Pattern approved meters require established flows that are regular with no flow disturbances.

There are a number of steps involved in the installation of rural water meters in particular installation into open and closed systems.

Installing in an Open System (Channel or partially filled Pipe)

An open system can be defined as a gravity-fed channel system which relies on the head difference between the channel and the farm land to generate flows. Installation in this instance requires some type of structure to bring the water from the channel to the farm infrastructure; normally consisting of an upstream sump or headwall, a connecting pipe and a downstream sump or headwall with the meter installed within the connecting pipe. Alternatively if an electronic automatic weir is being used it will consist of a concrete emplacement and manufactured regulating components.

Sump/headwall and pipe installation

Electronic automated weir (FlumeGate™)

Site Investigation

Locating the Site

The first phase of installing the meter and its infrastructure in an open channel situation is to establish the location of the site.

Section 3 of AS 4747 states:

"Every water meter, single or in a group, shall be easily accessible for reading (without, for example the use of a mirror or ladder). Provision should be made to allow maintenance, removal of the meter and in situ dismantling of the installation so that inspection of all components can be carried out to ensure ongoing compliance.

Fittings shall be readily accessible.

In all cases, contamination shall be avoided, especially when the meter is installed in a pit, by mounting the water meter and the fittings at a sufficient height above the floor. If necessary, the pit shall be provided with a sump or drain for water removal.

In this situation plans will have been developed that have considered the standard requirements for the location of the meter.

The installer must ensure that the meter location has been identified accurately. This will require confirmation with the water authority that the meter location captures the following:

1. The name of the landowner
2. The GPS coordinates if possible
3. The identification, either name or number, of the supply channel
4. The identification of existing meter or outlet
5. The running distance from a known and validated point along the channel
6. On farm discharge point
7. Verify that the site is valid within modernisation or reconfiguration guidelines

Accessing the Site and Location of the Meter Installation

Once the site location has been established the next phase is to ensure that access to the meter is available. The access will allow water authority operators, landowners and meter maintenance people safe and easy access to the meter facilities. In many cases this will be across landowner property; it is expected work vehicles will be able to access the site. Unless stated in any contractual arrangements the installer is not responsible for the development or upgrading of access tracks. However it is expected the installation will take the best advantage of existing access.

In a green-field site the actual location of the meter will need to be negotiated with the landowner and the water authority. The water authority will have an interest in the intake of the meter to ensure that it does not interfere with supply flows or levels. The landowner will be interested in the discharge point to ensure that it links efficiently and effectively with existing or planned on-farm infrastructure.

In an existing site the meter emplacement is usually placed in the same location.

Soil Sampling and Testing

A key aspect of installing any water control, metering or regulating device is to ensure that it is carried out according to contemporary design requirements. Where the emplacement will be placed within an existing channel bank there will be two assets to consider, the channel bank and the meter and its emplacement.

When installing into ground conditions particularly where water is involved it is essential that the installer consider the quality of the soil you will be working with. Placing a meter infrastructure within a channel bank will require the installer to ensure the soil’s permeability is sufficient to eliminate leakage and seepage.

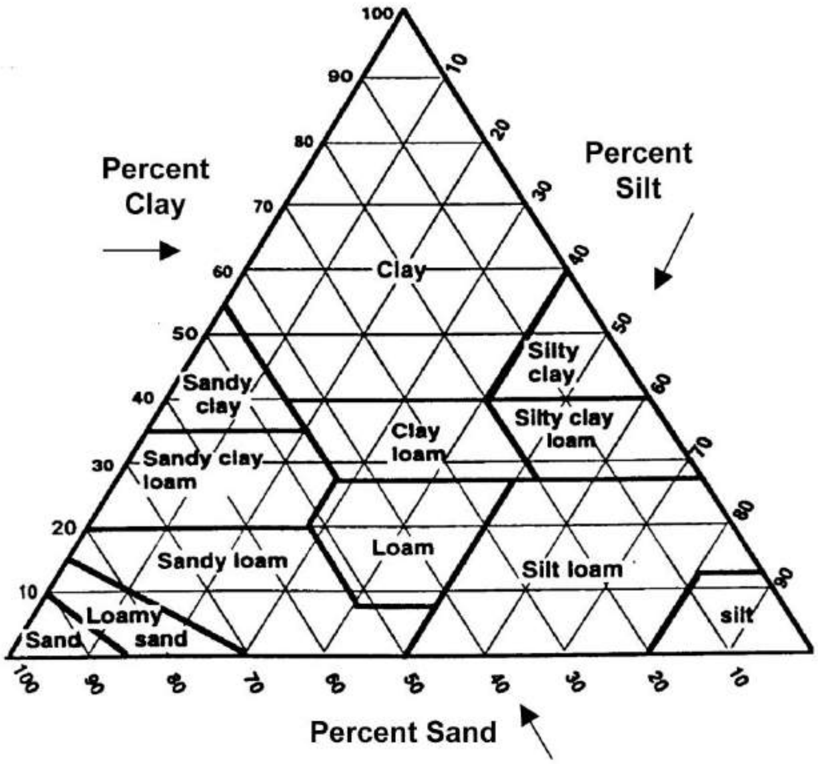
Ideally the soil that is used to compact the upstream and downstream sump or headwall should be of good quality clay. For effective installation, that is the structure is built to reach its economic and functional life, the installer needs to know the condition of the soil you will be installing in and using to backfill the structure.

It is highly recommended that the installer undertake simple sampling tests to establish the condition of the existing soil. If the soil has little clay composition, it will require some type of soil conditioning by the addition of additives such as bentonite.

Alternatively if the soils on site are unsuitable, the installer may need to identify and bring to the site new material for the compaction process.

Note: If the head differential between the supply level in the channel and the discharge point of the meter is high then the potential for seepage and leakage is proportionally high. Therefore the rule of thumb is the higher the head the more rigorous the soil analysis.

The soils used for compaction should have sufficient clay type characteristics to the permeability requirements. A simple test is to take a small handful of the soil and roll it around to form a ball. If this can be done the soil is most likely to be appropriate for the situation.



Soil triangle showing proportions of clay, silt and sand in various soil types.

Soil texture may be assessed in the field by the behaviour of a sample of moist soil when worked between the finger and thumb. This field test is called the ribbon test; soil is pressed against the middle joint of the index finger by the thumb to produce a ribbon about 2 mm thick. The length of the ribbon produced indicates the soil type.

The soil must be moist (near field capacity) and pliable. How it feels and behaves as you moisten and knead it will help to identify the texture.

Soil texture	***Ribbon length***	***% clay***	***How the soil behaves and feels***
Sands (S)	nil	Less than 5%	Coherence nil to very slight, cannot be moulded; sand grains adhere to fingers.
Sandy loam (SL)	15 – 25 mm	10 – 20%	Coherent bolus (ball) but very sandy to the touch; dominant sand grains are of medium size and readily visible.
Loam (L)	About 25mm	About 25%	Loams can be rolled into a thick ribbon. Soil ball is easy to manipulate and has smooth spongy feel with no obvious sandiness. Greasy to touch if organic matter present.
Clay loam (CL)	40 – 50 mm	30 – 35%	Coherent and plastic bolus (ball), smooth to manipulate.
Light clay (LC)	50 – 75 mm	35 – 40%	Plastic behaviour evident, smooth feel easily worked, moulded and rolled into rod. Rod forms a ring without cracking
Medium clay (MC)	Greater than 75mm	45 – 55%	Smooth plastic bolus (ball), handles like plasticine, can be moulded into rods without cracking resistant to shearing
Heavy clay (HC)	Greater than 75mm	Over 50%	Smooth very plastic bolus (ball); resistant to shearing; will mould into rods. Handles like stiff plasticine. Very sticky and strongly coherent. Rods will form a ring without cracking.

The main purpose of the soil test is to ensure the installation is protected from excessive leakage and seepage which could cause failure.

Most water authorities will require the installer to compact the soils within 98% of their original compaction state. Part of the installer's project planning will be to estimate the time it will take to backfill and compact to these standards. Poor soils will take longer and may not even reach the standard compaction.

If a design plan of the meter infrastructure has been provided it will have considered the soil types and made allowances by recommending either an additive be used or appropriate materials be bought in.

Water Infiltration

Water can infiltrate the site from a number of sources;

1. Supply channel
2. Groundwater
3. Storm surface water
4. On-farm infrastructure such as header or recycle dams and/or channels

In addition to soil condition the installer will need to consider any infiltration. In the instance where the installer is using a design plan developed by a water authority it is expected the designer will have taken infiltration into account. As part of the planning process the installer will need to examine the plan as it may have included infiltration protection such as filter zones, cut off walls, drainage systems etc.

Infiltration can cause the infrastructure site to become saturated and influence the levels of sumps and connecting pipes which could cause misalignment and therefore potential for flow disturbance. It may cause the channel embankment soil to become saturated as well as creating slumps and failures.

If the installer suspects water infiltration the appropriate water authority should be contacted before the installation phase begins or continues.

The installation process may differ from State to State, and these differences can vary on who designs and installs the meter infrastructure. Most water authorities or those responsible for the accounting of the water use will have standard plans for the installation. However each site will be different so the installer will need to ensure that infiltration is not an issue.

Infiltration can be checked through inspection of the surface, toes or the lower elevations of the land surrounding the site or by undertaking test bores.

Infiltration can cause significant water logging when the installer is backfilling the structure; it is best to know the likelihood of this occurring so contingencies can be included and control measures developed.

If infiltration has been identified there are a number of ways to control it:

1. Move the metering site to a position where infiltration does not occur.
2. Install temporary drainage system and sump to control the infiltration by either draining or pumping infiltrated water off site.
3. During the draining place quality clay around the sumps to ensure minimal or zero permeability
4. Place gravel in temporary drains to filter and drain infiltration away from the infrastructure in particular the clay zones
5. Consult with a design engineer and redesign the infrastructure to avoid the infiltration.

Assessment of Hydraulic Head and Flows

As stated earlier the important aspect of installation is to ensure there is sufficient head and flow to maintain a full pipe and create an established flow for meter accuracy.

The installer will need to know the minimum head requirements for the meter to be installed. The meter manufacturer and/or water authority will have established this. In some cases 450mm above the inlet sump sill level has been determined as minimum head. In particular for pattern approved meters there will be specifications for minimum head and flow requirements.

Installers should check with the appropriate water authority and establish the flow regime for the supply channel including the design supply level. If the installer is installing the meter emplacement without being provided with a temporary bench mark (TBM) there will be a need to establish the true supply level so the available head can be calculated.

It is expected when the installer is engaged to install the meter the meter has been selected according to the supply flows, head and on-farm requirements. As a consequence of this the installer can assume there is sufficient flow within the supply channel.

However a cursory check should be taken to validate there is sufficient head to maintain a full pipe flow.

This can be done by taking a level from the supply level in the channel off a structure within the system. The level should be transferred to a TBM near the site but far enough away to make sure the TBM will be safe from interference during installation. A check should then be made to establish the sill level of the upstream sump within the channel and then calculating the difference between the sill and SL. This calculation will provide the head difference and therefore validate whether there is sufficient depth to place the sump to obtain the required minimum head.

In the case where a TBM has been provided the installer should still validate there is sufficient head as it has been known that TBM’s have been installed at the incorrect level.

Identification of Communication and Power Supplies

Most modern meters are operated using a DC or AC power supply and can be linked to radio or microwave communication systems. In fact most modern meters are powered by a DC battery recharged through solar panels and have the ability to be connected to communication systems. However in South Australia most of the meters are connected to AC power as the meters are normally located at pump stations where AC power is readily available

Given the emphasis on water accounting it is imperative a regulator knows who is using the water and exactly how much. The users of the water are geographically spread wide apart and in many varying topographical situations. The people accounting for the water need to have water usage calculations on hand readily so there is emphasis on collecting the data quickly and accurately. SCADA is a method used to monitor systems remotely and one could see eventually that all meters will be remotely monitored to establish when they started and when they finished and how much water was used. The National Water Initiative requires new meter installations to have the facility were they will be able to record water usage that can be connected to a database. As a consequence water authorities will be required to eventually provide stakeholders including government detailed accounts of their water supply and usage.

In the investigation phase the water authorities will need to investigate the ongoing communication requirements of the meter.

The installer will need to check with the design plan and/or the water authority if there will be a communication requirement immediately or in the near future. If it is immediately the design will have considered the communication links either by radio, microwave, landline or satellite given the location of the meter. Therefore the installer will need to locate any existing communication lines and/or allow in the site set up for auxiliary components such as radio towers, satellite and/or microwave dishes.

In addition there may be a requirement for AC power; AC power can be used if the meter emplacement energy requirements are far greater than DC is able to provide.

In most instances the meter emplacement will have no communication links and will be powered by a DC battery.

Again the installer will need to establish the power requirements and if there is a need to connect to existing sources the installer will have to locate the source and make arrangements with the power supply company or electrical contractor to connect.

Solar Orientation

As stated before in most instances the meter emplacement will be powered by a DC battery and recharged through a solar panel system. Most sites will be along channel banks that do not have large vegetation growth such as tall bushy trees.

To recharge the DC batteries the solar panel will need to be exposed to the direct sun for significant parts of the day.

The installer will need to check and ensure that sunlight is available on the site for sufficient times during the day to recharge the DC batteries. The location of the solar panel will need to maximize the use of available sunlight.

Environmental Impacts

It is in everyone's mind at the moment and will be for a long time to come the environment is an essential part of life and we need to manage this; every activity that is undertaken in the world can have an impact on the environment. Installing meters can impact on the environment in some way.

As an installer it is expected that you will undertake an environmental impact study to ensure that each activity that is undertaken does not compromise the environmental integrity of the site.

The installer will need to consider the impact on the:

1. Water
2. Air
3. Soil
4. Vegetation
5. Fauna
6. Cultural heritage

Most water authorities will require installers to undertake an environmental impact study. It is recommended that the water authority be contacted to establish the environmental expectations.

Occupational Health and Safety

In addition to the environment there will also be a focus on occupational health and safety. Regardless of which state in Australia the meters will be installed there is a strong safety requirement from all state governments.

The installer will need to undertake a risk assessment associated with the site and activities involved in the installation process. Many organisations have policies and procedures relating to site safety. The installer will be ultimately responsible for the site and therefore all those who enter the site, including landowners.

Installers should check with the responsible water authority and establish the occupational health and safety requirements which should include:

1. All equipment being used is appropriate and complies with relevant regulations.
2. All personnel are competent in the activities they will be undertaking including the appropriate licences
3. The site shall be protected or barricaded to limit access
4. All personnel will be inducted to the site including visitors
5. A safety risk assessment is undertaken and all team members have been involved and understand their responsibilities

Workshop Activity

Refer to Activity 7 in your Evidence Workbook

Installing the Meter Emplacement

Setting up the Site

At the conclusion of the investigation the installer is in a position to begin the installation process; the first part of this is to set the site up. In some instances the materials for the installation may be taken to site. If this is the case the materials could include sumps, meter pit boxes, pipes, sand and quality backfill. The materials should be stowed away from any access tracks and pipes secured to prevent rolling. Barricades should be erected to ensure vehicle, pedestrian and stock cannot be damaged or injured. Control of visitors to the site is of paramount importance to site safety.

Taking the Survey Point

One of the most crucial elements of the installation process is establishing the sump sill levels. On most plans there will be two levels for the installer to use: the sump sill and the foundation or the base of the sump. The level at the base of the sump is used for excavation purposes.

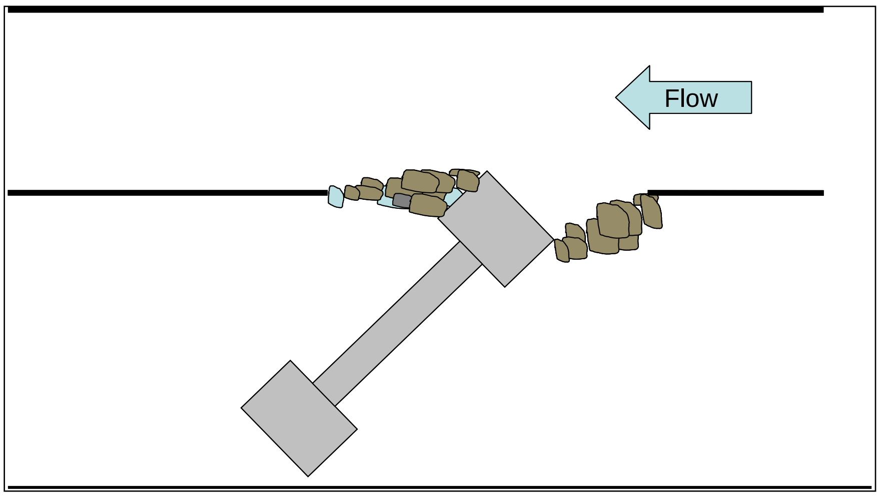
It will be critical to establish the correct levels; this is usually done by taking SL and transferring it as a temporary bench mark (TBM). From the TBM the installer will need to calculate the foundation depth and then confirm the sill level.

The level should be set up within the site so the installer is able to take measurements from the one location. It will be important to validate the levels once excavation has been carried out to ensure that the sumps will be placed at the correct height and there is sufficient head of water at the upstream sump. This is the reason it is a prerequisite to have the knowledge for reducing levels on site from plan.

Temporary bench mark (TBM)

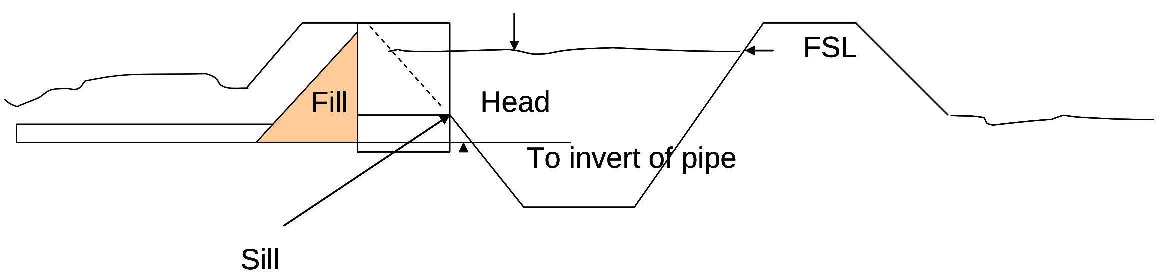
Orientating the Meter Site and Marking it out on the Ground

The meter emplacement should be installed to ensure there are sufficient straight lengths of pipe upstream and downstream of the meter. In most cases the meter emplacement should be located on the water authority's easement or reserve and at right angles to the stream wherever possible. However, to have the emplacement fully contained on the reserve or easement may require installing the emplacement at an angle as shown below.



If it is possible to locate at a 90° angle to the stream, to establish the orientation it is suggested that a string-line be used and placed parallel to the channel flow. This will have to be done by eye and it is best if there are two people to validate the accuracy of the string line. The string line should be extended so that it goes beyond the design scope of the installation and pegged at or near the junction of the access track and the top of the channel batter.

Note: *There are other methods of establishing the orientation, some sophisticated others basic, however it is not essential that the structure be placed absolutely at right angles to the flow but it is however expected that it will be close; 5 ^{o} tolerance will be acceptable.*



Note: The upstream sump should be installed so the sill aligns with the channel batter.

The next step is to install an additional string line that will be 90^{o} from the first string line and the centre of the sumps and connecting pipes. Once again the string line should extend beyond the design scope of the installation. When both string lines have been

installed, a marker spray can be used to establish the orientation clearly for site barriers to be installed, materials to be stowed and excavation points and spoil dumps located.

Carry out Excavations and Establish Foundation Level

Once the site has been orientated and marked on the ground the next phase is to excavate the site.

Shielding the Excavation

When placing the upstream sump in; if the supply channel is operational, the installer will need to utilise a shield placed into the channel to protect the site from flooding

The excavation should be undertaken to provide sufficient room for the installers to level the sumps, fit pipes and use compacting equipment in the backfilling process. In some instances the excavation can be quite deep; anything over 1.5m will require benching or protective shoring to eliminate trench collapse.

Excavated spoil should be placed to ensure it does not fall back into the trench but close enough for the excavation equipment to effectively backfill.

The excavation should be dug as close to the design depth as possible. It is preferred that the sumps are placed on natural ground rather than compacted material. As a consequence it will be important to take a number of levels as the excavation gets closer to the foundation level.

The excavation can be done in two ways: a complete excavation of the site from the upstream sump through to the downstream sump; or partially by excavating the upstream or downstream sumps, installing the sump and then completing the excavation.

The installer should ensure that the excavation has sufficient depth to protect the pipe from traffic vibration and damage from stock.

Install Sumps or Headwalls

Once the excavation has been undertaken and the foundation level validated the downstream or upstream sump or headwalls can be installed. The initial sump or headwall to be installed will depend on a few factors:

1. Is there any existing on-farm works the sump needs to align with? If so the downstream sump should be installed. In this instance the installer will need to factor in the alignment of the upstream sump or headwall sill with the batter of the channel. This may require additional pipes to be installed.
2. Can the on-farm infrastructure be easily aligned with the downstream sump? If so the upstream sump or headwall should be installed.

Note: It is preferred that the upstream sump or headwall be installed first so the sill and the channel batter are aligned.

In the event that the upstream sump or headwall is to be installed first the installer must align the batter and sill and establish the sill height from the TBM. If the sump is low good quality clay backfill must be used to raise the height to the required level.

The sump must also be aligned so the pipes will be 90^{o} to the channel flow. This is usually done by eye but it is proper to do a check with a string line just to be sure.

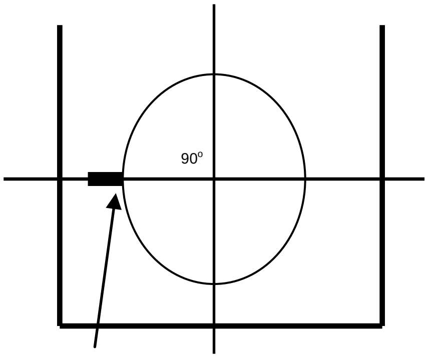
Upstream Sump

Downstream Sump

Install Pipelines and Orientating the Transducers

Ultrasonic Doppler

Once the sump has been placed in the excavation the connecting pipes can be fitted. In the case of an ultrasonic Doppler meter the transducer hole will need to be orientated so it is 90^{o} to the vertical centre of the pipe and have at least 10 x DN of straight pipe upstream and 5 x DN of straight pipe downstream.



Ultrasonic Transit Time

The transducers for the transit time ultrasonic meter are normally housed in a meter pit box and the pipes are connected to the meter pit box. In this instance it is essential that the transducers on either side are 90^{o} to the vertical centre of the pipe and at least 10 x DN of straight pipe upstream and 5 x DN of straight pipe downstream. (or according to the manufacturer's meter pattern approved guidelines in some instances the length of pipe upstream is 3 x DN and downstream is 2 x DN). The installer will need to check to establish the length of straight pipe required upstream and downstream of the meter. However the standards do state the requirements are 10 x DN upstream and 5 x DN downstream; when in doubt default to the standards.

Electromagnetic Meters (Mag Meters)

The electromagnetic meters are very similar to ultrasonic transit time meters and should be installed in the same manner. If flanges are used the meters must be fitted so there is no misalignment between the internal surface of the transducer housing and the pipe; this includes protruding gaskets.

In all cases the transducers are key and must be placed according to the manufacturers' requirements or at least to the standard set in AS 4747.

When installing the pipework and pits it will be necessary to keep checking levels to ensure the pipe inverts are at the required elevation in relation to the supply channel's supply level.

When the pipework has been installed the final component is the sump or headwall. The installer will need to ensure the sill level of the sump or headwall is placed according to the elevation on the plan. There may be a need to pack the sump or headwall to establish the correct elevation.

At this point in the installation the hydraulic components should be fitted within the excavation.

Backfill the Trench

On of the key elements in ensuring the meter emplacement operates to its full economical life is the backfilling of the components. Many installations have failed immediately after the completion of the installation. The reason is poor soils and compaction.

In the investigation process the installer will have established the soil quality and quantity on site and developed a plan for the backfill material. Backfill material must be able to be compacted and provide a strong impermeable barrier.

The installer must either have decided by analysis that site materials are good enough to use, additional material has been brought in or additives have been added to improve the quality of the soil

Install the Solar Panel and Display Unit

The solar panel is a key aspect of the meter's function as it continually recharges the DC battery. The solar panel must be orientated so that it maximizes the availability of sunlight at the site.

The solar panel is attached to a pole, usually 50mm galvanised pipe. The pipe should be concreted at least 450mm into the ground. The pole should not interfere with traffic or be damaged by stock. The solar panel should be attached at a height that reduces the chances of vandalism and in a way that secures it from theft.

The display unit should be attached to the solar panel support pole at a height that allows the meter reader easy access for it to be read. The display must be 1.2 m above ground level and the installer must ensure there is a sufficient cable to allow this to occur

In most instances the meters will not require calibration as they are set up to plug in and start. Once the display unit has been placed on the pole, seals must be attached to ensure there is no tampering with the meter read-out.

Installation of the Electronic Automatic Weir

Installation of electronic automatic weirs will vary. The example used here is the Rubicon FlumeGate™ M which is solely used for flow control and measurement to customers irrigated farms. The installation of these gates involves 3 steps. These are:

Step 1 – excavate the bank of the channel following similar work practices as described for the piped meters. Install the concrete emplacement in the channel bank as per plans provided for the individual gate being fitted ensuring the supply level has been determined, TBM has been provided and excavation foundation is at the correct level.

Step 2 – fit the external gate frame into the emplacement as per the manufacturer's instructions. Comprehensive work instructions are provided by the manufacturer.

Step 3 – install the FlumeGate™ into the external frame. Comprehensive work instructions are provided by the manufacturer for this task as well.

Installing Meters in a Closed Conduit

A closed conduit is defined as a pressurised or gravity pipe. In this instance the meters are normally installed in the discharge pipe which may be connected directly to a pump or a tank. Where these types of installations occur the installer must ensure the following:

1. The investigation phase of the meter installation will need to include:
    a. Locating and confirming the site
    b. Assessing the condition of any existing pipes to ensure the meter flanges can be installed as per the specifications to suit the type of pipe.
    c. Safety and environmental risk assessment
2. The meter has a minimum of 10xDN upstream and 5xDN downstream of straight pipe. In the case where the meter is installed downstream of a pump the straight pipe shall be a minimum of 20xDN between the pump and the meter and 5xDN downstream of the meter unless otherwise stated by the manufacturer's pattern approved installation guidelines.
3. The pipe must be self-supported so it does not place loading on the flowmeter. The flowmeter must not become a focus for pipeline stresses.
4. Pipes may need to be cut and fitted with flanges to allow the meter to be retro-fitted to an existing site. Ensure that all cuts are cleaned and are smooth before mounting the flange brackets.
5. All welds are cleaned and any exposed materials are protected
6. The flanges must align, in particular to the internal walls of the pipe
7. Flange gaskets must not protrude into the pipe
8. Flange bolts must be the correct size. Small diameter bolts can cause the meter and the internal walls of the pipe to misalign.
9. Flange bolts must be tightened to the appropriate torque provided by the manufacture. In some cases bolts may require protection from corrosive environments.
10. If the pipe is located above the ground the meter and the pipe must be supported to ensure there is no misalignment

11. If the pipe is located above the ground the transducers and meter display unit must be protected from any vibration through pump operation and vehicle traffic.
12. If the pipe and meter are above ground they must be protected from potential damage from vehicles, pedestrians and/or stock.
13. If the meter is located in the ground it must be protected by a meter box complete with lid.
14. Install the tamper proof seals

Manufacturer's installation guidelines should include details of torque to be applied to bolts securing flanges and the preferred tightening sequence to avoid misaligned tension on these bolts and fittings.

Installation into an Existing Pipeline

Required straight length of pipe
An accessible straight length of pipe must be provided to enable installation of the meter. This pipe must be:

- a minimum length of ten (10) pipe diameters upstream of the meter and five (5) pipe diameters downstream, plus 400mm to accommodate the average meter body.
- free of any fittings including control valves, bends, tees, fertigation attachments, etc
- free from scale, tuberculation and have a smooth internal bore free from internal corrugations
- straight and have a uniform circular cross-section with a maximum difference in diameter of 3.5% when measured in two directions perpendicular to one another.

Acceptable pipe materials for required straight lengths
The suitability of pipe materials to meet the uniform circular cross-section and smooth internal bore requirements should be determined through compliance with the relevant Australian Standard. A number of pipes are manufactured with push-fit spigot/socket flexible joints with elastomeric sealing rings. This type of joint can accommodate limited longitudinal displacement and angular deflection; but cannot transmit longitudinal forces. Consequently unrestrained spigot and socket joints will fail if subjected to longitudinal forces.

Within each pipe type, pressure ratings are generally a function of the pipe wall thickness. For most meter installations the lower range of pressure classes should be sufficient. However, the pressure class selected for a particular application needs to be based on the maximum operating pressure, any relevant de-rating for water temperature effects (where applicable), fluctuations of surges, required mechanical properties (eg increased wall thickness may be required for attaching flanges). The compatibility of pipe and meter internal diameters also needs to be addressed.

Environmental exposure conditions are a significant consideration when selecting a suitable pipe material. For example, plastic pipe materials are generally not resistant to fire. However, since fire is also likely to damage the water meter, the meter installation should be protected from exposure to fire - rather than choosing pipe work to be fire resistant. Protection from fire may be achieved simply by ensuring a suitable fire break is maintained (i.e. no fuel build-up at, or in the area) around the meter installation. Likewise the risk of inundation and flood debris impacts/loads can be an issue. Here again the meter installation should be located to minimise this risk rather than relying on the resistance of the pipe work.

Pipe jointing and flanges
All flanged pieces must be flanged to either AS2129 Table D or AS4087 Class PN16 and be compatible with the meter selected for installation. Note that AS 4087 requires boltholes on flanges to be equally spaced either side of top centre of pipe. Pipe jointing must allow for assembly/disassembly requirements and the transmission on lateral and longitudinal forces generated by operating and environmental conditions as required.

Restore the Site

The final part of the installation process is to ensure the completed site has been restored so that it is safe for people and stock. The site must also be restored so that any vegetation that has been removed or damaged during the construction phase is replaced.

The site must be clean of any construction materials and where necessary gravel or substantive road material placed to provide easy access.

Commission the Meter

AS 4747 states commissioning is required to ensure the accuracy of a meter installation. This process shall be conducted by a certified officer, delegate or installer. Steps in the commissioning process shall consist of, but not be limited to, those listed below.

The commissioning process shall be as follows:

(i) Check that the meters or measurement instruments have been pattern approved or hold other certification acceptable to the water service provider.
(ii) Check that the instruments have been installed in accordance with the requirements specified in the approval certificate and the manufacturer's installation instructions (see AS 4747)
(iii) Check that the installation complies with the meter design. Where the installation has been carried out by an unqualified installer, commissioning shall also include an internal check of the meter body by a certified officer.
(iv) Where applicable check that the flow computer has been programmed with any revised parameters
(v) Were applicable, check the correct version of the software has been installed.
    a. Check installations of seals to ensure the integrity of the meter
    b. The materials and lining of the pipe shall be checked to ensure that it is in accordance with requirements of pattern approval
    c. The installation shall be checked for leaks

In addition to the above requirements of the standard the commissioning should also validate that the sill levels and head requirements meet the installation design requirements, the site is safe and all environmental requirements have been dealt with.

Record Keeping

Water authorities will require records of the meter installation. The installer will need to check with the appropriate water authority the range of data they will require which may include:

- The serial number of the meter
- The location of the meter including the GPS coordinates
- The date of installation
- The date of commissioning
- An official sign-off of the validation document to state the meter has been installed to standards and seals placed

Workshop Activity

Refer to Activity 8 in your Evidence Workbook

Meter Maintenance

AS 4747 Section 6 states the following in relation to meter maintenance.

Maintenance under certain circumstances may invalidate the compliance with the Australian Technical Specifications and/or the pattern approval certification for the meter device. Examples are:

(a) where changes are made to components that effect the metrology of the meter. Those changes that can be affected without effecting metrology are to be specified in the pattern approval certificate.
(b) Where the maintenance is carried out by unqualified persons; and
(c) Where sealing devices to the meter or meter installation have been broken by unauthorised persons.

If there have been any changes that impact on the metrology of the meter they will have to be recertified. However the standard states that routine maintenance such as cleaning that does not affect the metrology or that require breaks of seals does not require recertification.

In general terms the meter itself does not require any maintenance; they are usually throw away items that are replaced with new ones. However the meter emplacement will require some basic maintenance to ensure that flows are straight and sufficient to provide a full pipe.

Meter maintenance people need to consider the following when maintaining the meter emplacement:

1. Growth of aquatic vegetation near or around the sumps or headwalls.
    a. Vegetation should be removed physically or chemically
2. Seepage along pipe that could create a channel bank failure (called piping failure)
    a. Earth along the pipe should be removed and repacked or replaced with quality clay material
    b. Alternatively filter zones and cut off walls can be installed
3. Misalignment of pipes
    a. Pipes should be realigned and repacked with sand and then backfilled with quality clay like material
    b. Flanges may need to be tightened or gaskets replaced
4. Build up of silt in sumps or headwalls
    a. Silt should be removed
5. Cleaning of probes or transducers – use a broom placed in the pipe to remove silt and debris from around the measuring components
6. DC batteries not charging
    a. Clean the solar panel
    b. Change battery
7. Corroded fittings and pipe
    a. Remove corrosion, treat surface and apply a protective coating

8. Exposed cabling
    a. Relocate cabling to electrical and communication standards
9. Infestation of insects within the display unit
    a. Remove the display cover and gently remove insects and their habitat i.e. mud from wasps or ants, webs from spiders etc. If this requires breaking the meter seals it may only be performed by a certified maintainer/validator. The seals must be replaced immediately after cleaning the meter, and the activity reported appropriately.

In addition to this general maintenance the emplacement should also be checked for damage either by humans or stock. Any damage should be reported to the appropriate authority immediately so action can be taken for repair and records noted to record the damage.

Workshop Activity

Refer to Activity 9 in your Evidence Workbook

Definitions and Terminology

Metering Terminology

Accuracy	Qualitative expression for closeness of a measured value to the true value. NOTE – The quantitative expression of accuracy should be in terms of uncertainty. Good accuracy implies small random and systematic errors
Canal or Channel	Man-made channel, usually of regular cross-sectional shape
Closed conduit flow.	Flow in a closed conduit of any shape. If the conduit is not flowing full then the flow is open channel flow. Flow in pipes flowing full is usually referred to as pipe flow.
Discharge	Volume of liquid flowing through a cross-section in a unit time
Electromagnetic current meter	Current meter which creates a magnetic field perpendicular to the flow direction, this enabling the velocity to be deduced from the induced electromotive force produced by the motion of a conducting liquid in the magnetic field
Electromagnetic flowmeter	Flowmeter which created a magnetic field perpendicular to the flow so enabling the flow rate to be deduced from the induced electromotive force (e.m.f) produced by the motion of conducting fluid in the magnetic field. The electromagnetic flowmeter consists of a primary device and one or more secondary devices.
Established flow.	Established flow, in a pipe, is flow with the characteristics regular velocity distribution across the pipe diameter. A straight length of pipe up to a hundred pipe diameters long may be required for a stable velocity profile to develop after a major disturbance to flow, such as several pipe bends or a partially opened valve. I open channel flow established flow is uniform flow with a stable velocity profile.
Field Accuracy	The accuracy of a meter, as determined *in situ* in the field, taking into account the site conditions and wear and tear on the meter. A field accuracy assessment may include an inspection for compliance with the installation specifications, an inspection to determine whether the meter is operating within acceptable accuracy tolerances and an *in-situ* field accuracy test using an independent test meter

Flow conditioner (straightener)	Device inserted in a conduit to reduce the straight length needed to obtain a regular velocity distribution.
Flow profile:	Graphic representation of the velocity distribution.
Flow rate	quotient of the quantity of fluid passing through the cross-section of a conduit and the time taken for this quantity to pass through this section.
Flowmeter	Flow measuring device which indicated the measured flow rate.
Invert	Lowest part of the cross-section of a natural or artificial channel
Laboratory test	A test of meter characteristics, in particular the meter accuracy, carried out under specified and controlled conditions in a laboratory approved by the Water Authority
Laminar flow	This requires extremely slow velocities or highly viscous liquids and is rare in irrigation. In laminar flow viscous forces are strong compared to inertial forces. Water particles appear to move in smooth paths or streamlines and infinitely small this layers seem to slide over adjacent layers. Water adjacent to the bed of a channel or wall of a pipe is stationary with velocities increasing the greater distance from the perimeter.
Left bank	Bank to the left of an observer looking downstream
Measurement	The assessment of the volume of water supplied to, or taken by, a customer by direct metering, indirect metering or deemed use
Meter	A mechanical or electronic device for measuring the volume of water passed and/ or the rate of flow in a pipe or channel. The meter includes the physical device, the meter emplacement and any supporting equipment, such as the signal converter and readout device. The meter does not include any private works connected to the meter necessary for accurate operation of the meter
Open channel	Longitudinal boundary surface consisting of the bed and banks or sides within which the liquid flows with a free surface
Open channel flow	Flow with a free surface subject to atmospheric pressure. The position of the free surface can change with respect to both time and space. Channel cross-sections can vary from regular to natural stream sections. The channel bed can vary from a smooth artificial bed to a rough irregular river bed and the channel roughness may vary with the depth of flow. The discharge in the channel, depth of flow, slope of the channel bottom and the slope of the free surface are interdependent.

Pipe flow	Flow in a closed conduit flowing full. Flow is in contact with the entire pipe perimeter and the flow cross-section is fixed by the pipe geometry. The flow is subject to hydraulic pressure only and discharge and average velocity stay the same unless the pipe branches or pipe dimensions change. The range of surface roughness in pipes is less extreme than channels.
Right bank	Bank to the right of observer looking downstream
River	Stream of water in a natural open channel
Steady flow.	Time is the criterion. In open channel flow the conditions at a location, particularly depth of flow, do not change over the time interval considered. In pipe flow the discharge at a location in the pipe does not change over the time interval.
Stream	Water flowing in an open channel
Swirling flow	Flow which has axial and circumferential velocity components.
Time-of-flight ultrasonic meter; transit time meter	Ultrasonic flowmeter where the time difference between an ultrasonic signal travelling upstream and one travelling downstream is used to calculate the flow rate. Such flowmeters are most commonly of the diagonal-beam type but can be of the longitudinal-beam type if the pipework associated with the flowmeter incorporates a change in direction of flow at each end of the flowmeter.
Transverse flow	Flow horizontally perpendicular to the main direction of flow parallel to the axis of the open channel (s).
Turbulent flow.	This is the normal flow state in irrigation. Viscous forces are weak compared to inertial forces and water particles move along irregular paths that are neither smooth nor fixed but in aggregate move forward.
Ultrasonic (acoustic) velocity meter	System that uses the difference in travel time of ultrasonic (acoustic) pulses between transducers in a stream to determine the mean velocity on the signal path
Ultrasonic flowmeter	Flowmeter which generates ultrasound signals and receives then again after they have been influenced by the flow in such a way that the observed result can be used again as a measure of the flow rate. An ultrasonic flowmeter normally consists of one or more ultrasonic transducers and equipment which derives the flow rate measurement from the generated and received ultrasonic signals and converts it to a standard output signal proportional to the flow rate.

Uniform flow.	Space is the criterion. In a channel, when the channel cross-section, average velocity and depth of flow are the same along the channel. In pipe flow, when the cross-section and average velocity is the same along the pipe.
Unsteady flow.	Time is the criterion. In an open channel flow conditions at a location, particularly depth of flow, vary over the time interval considered. In pipe flow discharge at a location in the pipe changes over the time interval.
Varied flow.	Space is the criterion. In a channel, when the channel cross-section and/or depth of flow changes along the channel. In pipe flow, when the cross-section and average velocity change along the pipe. Flow can rapidly or gradually varied flow, depending on whether the change takes place over a short or long distance.
Weir	Overflow structure that may be used for controlling upstream surface level or for measuring discharge or for both

Note: ***These definitions and terminologies are not exhaustive and must be read in conjunction with AS 4747 part 1***

Appendices

The following documents have been included as reference material used in the course delivery and should be referred to in that context.

Siemens SITRANS F M document x 3….

Rubicon FlumeGate ™ External Frame Installation Procedures + FlumeGate™ Installation Manual

Copy of the full AS 4747 document Parts 1 to 8

Copy of NMI 10.2 and 11.2 covering Pattern Approval test plans.