Flow Measurement

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Measuring Irrigation Water Flow Rates

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Flow Measurement - Background

- Flow in a pipe:
Flow Measurement - Background

- Flow in a pipe:
- Open channel flow:
Flow Measurement - Background

- Flow in a pipe:
- Open channel flow:
- In almost all cases, it is easier to measure water in a pipe than in an open channel.
Flow Measurement - Background

- Flow in a pipe:
  - Almost all pipeline flow measurement actually measures the flow velocity, then converts that to flow rate using the flow area (e.g. area of pipe).
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- Open channel flow
  - Flow velocity (along with flow area) is also used with some techniques for determining open channel flow rate.
    - Current meters
  - Most methods are calibrated flow rate.
Flow Measurement - Background

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- **Open channel flow**
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    - Current meters
    - Most methods are calibrated flow rate.

- **Turbulence is bad for flow measurement**
  - Prefer lots of straight pipe or straight sections of unchanging channel.
Flow Measurement – Open Channel Flow

- Most commonly see:
  - Weirs:

[Diagram of a sharp-crested weir with labels for Elevation of Weir Crest, 4H, Water Surface, 2H, and Channel Bottom.]

[Diagram of a rectangular-notch weir with end contractions.]
Flow Measurement – Open Channel Flow

- Most commonly see:
  - Weirs: Can be quite accurate but can have a problem with sediment and trash building up behind the weir.
Flow Measurement – Open Channel Flow

- Most commonly see:
  - Weirs:
  - Flumes:
Flow Measurement – Open Channel Flow

- Most commonly see:
  - Weirs:
  - Flumes: Able to pass trash and sediment more easily than does a weir, but flumes are more difficult to construct.
Pipeline Flow Measurement

- Want 6 to 10 pipe diameters of straight pipe upstream and 3 to 5 pipe diameters of straight pipe downstream of meter.
Pipeline Flow Measurement

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- Try to avoid placing a flow meter just downstream of tees, elbows, and especially devices like valves, some check valves, etc.
  - Partially open valves are the worst.
Pipeline Flow Measurement

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- Try to avoid placing a flow meter just downstream of tees, elbows, and especially devices like valves, some check valves, etc.
  - Partially open valves are the worst.
- Most pipeline flow meters require the pipe to be flowing full to be accurate.
Pipeline Flow Measurement

- Propeller flow meters
  - Most common. Often used for measuring pump discharge flow rate.
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  - Difficult to use on large pipes.
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  - Most common. Often used for measuring pump discharge flow rate.
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  - Difficult to use on large pipes.
  - May be used with “flow straighteners” to reduce straight pipe requirements for accuracy.

*The Flow Straightener*
Pipeline Flow Measurement

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- Insertable turbine meters
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  - Only measures flow velocity at a single location so can lead to inaccuracies unless installed just right.
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- Insertable turbine meters
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  - Only measures flow velocity at a single location so can lead to inaccuracies unless installed just right.
  - Can be affected by trash in the water.
Pipeline Flow Measurement

- Propeller flow meters
- Insertable turbine meters
- Electromagnetic flow meters
  - Tube Magmeters

Here’s How It Works...
Induced Voltage = BxDxV

- B = Flux Density (magnetic strength)
- D = Diameter of Conductor
- V = Fluid Mean Velocity
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- Insertable turbine meters
- Electromagnetic flow meters
  - Tube Magmeters
    - Extremely accurate, less sensitive to turbulence, no moving parts, no obstruction in flow path.

![Pipeline flow measurement images](image-url)
Pipeline Flow Measurement

- Propeller flow meters
- Insertable turbine meters
- Electromagnetic flow meters
  - Tube Magmeters
    - Extremely accurate, less sensitive to turbulence, no moving parts, no obstruction in flow path.
    - Limit on pipe size, power is reqd., expensive.
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**Acoustic Meters**
- Work by sending an acoustic signal across the pipe.
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**Acoustic Meters**

- Doppler Meters
  - Measures the velocity of particles in the water. Sends out a signal of known frequency and measures the frequency of the signals reflected back by the moving particles.
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  - Needs some particles in the water, can handle very dirty water, very portable, works on large pipes.
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  - Needs some particles in the water, can handle very dirty water, very portable, works on large pipes.
  - Doesn’t do well with very clean water, needs power, costly.
Pipeline Flow Measurement

- Propeller flow meters
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**Acoustic Meters**
- Doppler Meters
- Transit Time Meters
  - High frequency signal sent out across the pipe. The signal sent upstream takes longer to return than the signal sent downstream, due to the water velocity.
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**Transit Time Meters**

- High frequency signal sent out across the pipe. The signal sent upstream takes longer to return than the signal sent downstream, due to the water velocity.
- Works well on clean and slightly dirty water. Very accurate. Portable. Works well on large pipe.
- Needs power. Expensive. Not good if water is too dirty.
Questions???

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Powerpoint available at: http://ucanr.org/schwankl
Flow Meter Use on Dairies

- How do you measure the flow rates?
  - Manure water – you could use pond drop but a flow meter is the only good choice.
  - Freshwater sources.
    - Wells – could use pump test info. but what if well flow rate is changing?
      - Dropping groundwater table, pump wear, etc.
      - Have to keep track of time of operation.
Flow Meter Use on Dairies

- **Flow Meters:**
  - How are they installed?
  - Where should they be installed?
  - Full Pipe Flow !!!!
  - Avoid installing the meter downstream of a partially open valve, elbow, and anything which disrupts the water flow path.
Flow Meter Use on Dairies

- **Flow Meters:**

- **Other flow measurement situations:**
  - Water is in a channel, ditch, etc. = Open Channel Flow
    - Harder to measure, harder to measure accurately.
  - If can find a spot where the water is in a pipeline, measure there.

**Estimations using Trajectory Method**
Flow Meter Use on Dairies

- Flow Meters:
- Other flow measurement situations:
  - Water is in a channel, ditch, etc. = Open Channel Flow
  - Measuring open channel flow:
    - Flumes – can pass debris, hard to build
    - Weirs – easier to build, traps debris
    - Siphons

![Diagram of siphons and flow measurement](image)

*Figure 40. Measuring the head of siphons. The head is the difference between the elevation of the water surface in the ditch and the water surface in the field.*

![Graph of rate of flow through siphons](image)

*Graph showing rate of flow through small siphons.*