STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES (IDWR)

MINIMUM ACCEPTABLE STANDARDS FOR OPEN CHANNEL AND CLOSED CONDUIT MEASURING DEVICES

The source and means of diversion of water, whether surface or ground water, generally affects the selection of a measuring device. Surface water sources such as streams, springs and waste channels are normally diverted into open channels (ditches or canals), but closed conduits (pipes or culverts) are also used. Ground water is usually diverted into pipes (which may also discharge into open channels).

Measuring devices when required by IDWR are to be installed at or near the point of diversion from the public water source.

I. MEASUREMENTS IN OPEN CHANNELS

The following discussion is applicable only to diversions from surface water sources. Measurement of a ground water diversion with an open channel measuring device must be pre-approved by the IDWR.

A. Standard Open Channel Measuring Devices

All open channel surface water diversions should be measured using one of the following standard open channel flow measuring devices commonly used in Idaho:

- contracted rectangular weir
- suppressed rectangular weir
- Cipolletti weir
- 90 degree V-notch weir
- Parshall flume
- trapezoidal flume
- submerged rectangular orifice
- constant head orifice
- ramped broad crested weir (or ramped flume)
- acoustic Doppler flow meter (ADFM)
- acoustic Doppler current profiler

The installed flow rate accuracy of **open channel measurement devices** must be **+/- 10.0%** as compared to an acceptable open channel current meter or other standard portable measuring devices such as an acoustic Doppler flow meter or acoustic Doppler current profiler.

Construction, installation and operation of these devices should follow published guidelines, such as those published by the United States Bureau of Reclamation[1]

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[1] The Bureau of Reclamation measurement guidelines can be found at; http://www.idwr.idaho.gov/WaterManagement/WaterMeasurement/PDFs/BoR_WMM_%202001revision.pdf

B. Non-standard open channel devices: Rated Structures or Rated Sections

Any weir, flume, or other measuring device that has not been constructed, installed, or maintained correctly and therefore does not measure flow in the standard manner consistent with standard rating tables or curves is considered to be a non-standard device. IDWR may authorize the use of non-standard devices and rated sections provided the device or section is rated or calibrated against a set of flow measurements using an acceptable open channel current meter. Examples of standard portable open channel devices include the acoustic Doppler flow meter, the acoustic Doppler current profiler, or a portable flume. These devices are acceptable provided they are installed and operated according to all relevant manufacturer recommendations. Further information and requirements are available from IDWR upon request.

II. CLOSED CONDUIT MEASURING DEVICES

New installations for closed conduit or pipe line diversions require installation of a full profile magnetic type flow meter that meets or exceeds the specifications in this document. IDWR has published a list of approved full profile magnetic flow meters that have participated in independent third party testing at an NIST[2] traceable lab in Logan Utah. Tests were conducted for both accuracy and repeatability on all submitted models, and a pass/fail rating awarded. A list of these meters may be found at: http://www.idwr.idaho.gov/WaterManagement/WaterMeasurement/PDFs/Approved_flow_meter_list.pdf. Many of the magnetic meters on the market have an accuracy rating which meets IDWR's criteria, but did not participate in the above test. Installation of a non-approved magnetic meter (full profile or insertion) which meets all the specifications below may be permitted through a **Request for Variance** but the water user bears the risk that the meter will perform within the manufacturer's stated accuracy. If a non-approved magnetic meter is installed and does not pass a field check, IDWR may require the water user to replace the meter with an approved meter at the water user's expense. IDWR recommends that water users select a meter from the approved list.

A. Flow Meter Specifications

Currently two types of magnetic flow meters are available.

- **Full profile** magnetic type flow meters are flanged into the piping system and measure across the velocity profile.

- **Insertion** type magnetic meters are installed through a small diameter hole in the piping system to measure an average velocity (determined by pipe diameter) in the flow profile. Insertion magnetic meters can generally be approved for larger diameter pipes (12 inches or greater) if installed according to manufacturer specifications and where range of flow and turbulence conditions do not vary widely.

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[2] National Institute of Standards and Technology (NIST)

Listed below are the flow meter requirements and specifications for full-flowing closed conduits or pipes. Water users may apply to IDWR for a variance to these specifications in accordance with Criteria for Request for Variance of measuring Device Requirements of Section II C. of this document.

Meters shall be full profile magnetic flow meters meeting the following minimum specifications:

1) Flow range of 0.1 to 33 feet per second (fps).
2) Listed manufacturer accuracy of ± 2% of flow rate from 0.1 to 33 feet per second (fps), with a repeatability of ±0.5% of reading.
3) The register or display unit shall:
   a) Have a waterproof and tamperproof seal.
   b) Have an LCD backlit display showing instantaneous flow rate and totalized volume.
   c) Have a minimum of six (6) digits for flow rate.
   d) Have a minimum of eight (8) digits for totalized volume display or a sufficient number of digits so that "rolling over" will not occur within two years operation, based on the maximum rate of flow and annual volume elements of the authorizing water rights. IDWR recommends using Table 1 to aid in selecting appropriate volume totalizing multipliers for the intended use.
   e) Have password or similar protection of all settings and data to protect against unauthorized change or accidental loss of data.
   f) Contain a back up battery (according to manufacturers specifications) to prevent loss of data in the case of primary power failure.
   g) The display unit must contain programmable features that allow the selection of flow units. Available flow units must include gallons per minute (gpm) or cubic feet per second (cfs). The meter flow rate display must also allow decimal display formatting of up to three (3) places when using cubic feet per second units.
   h) The volume totalizer display must contain programmable features that allow the selection of volumetric units and must include either gallons or acre feet. The meter must also allow decimal display formatting of up to four places, and the application of unit multipliers ranging from 0.0001 to 10,000. See Table 1 for examples of appropriate meter multipliers based on expected annual volume use.

4) Signal Output when Data Logger is Required
   Data loggers may be required by specific water right conditions of approval in some locations or circumstances.

   Scaled pulse frequency output (or pulse counting) is required for continuous recording of totalized volume data on data loggers. Output signals must be compatible with data logger inputs. Analog output signal for flow rate (usually 4-20mA) is optional (most magnetic flow meters provide both analog and pulse frequency as standard output signals).

B. Meter Installation and Diversion System Requirements

Meters installed on closed conduit systems shall meet the following installation requirements:

1) The minimum and maximum system operating flows and pressures must be fully within the range of measurable flows and pressures identified in the meter specifications.
2) Pipes must be full flowing.
3) The installed flow rate accuracy of ***magnetic flow meters*** must be ± ***5.0%*** as compared to a second, standard flow meter. ***IDWR, the water district watermaster, or measurement district hydrographer will apply a calibration factor to flow meters whenever the field-test measurement is greater than ±1.0% of the value indicated by the installed meter.***
4) Flow meters must be installed according to the manufacturer's specifications. Most manufacturers recommend that meters be installed a certain distance from turbulence-causing bends and fittings such as discharge heads, single elbows, and valves. Typical industry standards for such distances are listed below, but larger distances may be required if the turbulence is severe.
    a. Full profile magnetic flow meters typically require three (3) pipe diameters upstream of the meter and two (2) pipe diameters downstream.
    b. Insertion magnetic, ultrasonic and mechanical flow meters require (10) pipe diameters upstream of the meter and five (5) pipe diameters downstream. *(Ex. A 12 inch pipe would require a minimum of 120 inches of unobstructed pipe upstream and 60 inches of unobstructed pipe downstream to meet this requirement).* Piping requirements for these meters may be in excess of 15 total diameters in more turbulent flow environments for accurate flow measurement.

Owners or operators who install meters without the minimum manufacturer spacing requirements may need to provide an adequate testing section of straight pipe located somewhere on the diversion system either upstream or downstream of the installed flow meter. This testing section can be excavated pipeline as long as the section of pipe carries all water being measured through the installed flow meter. Water users choosing to expose pipe will be required to excavate the pipe at their expense at the request of the district hydrographer, watermaster and/or IDWR staff.

Table 1: Meter multiplier selection based on water right volume.

Volume Acre Feet (AF)	Multiplier X gallons (gal)	Multiplier X Acre Feet (AF)
0-150	1, 10, 100	.0001, .001
150-1000	10, 100, 1000	.001, .01
>1000	100, 1000	.001, .01

C. Requests for Variance of Closed Conduit Measuring Device Requirements

Owners of closed conduit diversions may request a variance from the standard full profile magnetic flow meter requirements for the following reasons:

a) An operable flow meter is already installed.
b) Installation and maintenance of the standard meter would be burdensome
c) Other conditions of the diversion system preclude the use of a magnetic meter

The following alternate measurement methods may be considered:

- Development of a Power Consumption Coefficient (PCC), which is a ratio of power usage to water withdrawal. Acceptance of the PCC method may be provided *for qualifying irrigation diversions only*;
- Use of an hour meter (time clock) *for qualifying diversions only*;
- Use of an acceptable non-magnetic flow meter that was installed *prior to the date of the measurement order*;
- *For irrigation diversions only,* use of an acceptable non-magnetic flow meter where it can be shown that installation of the standard magnetic flow meter would be burdensome or ineffective.

If a meter is already installed, that meter may be used if the meter is field-tested by IDWR staff, the water district watermaster, or a district hydrographer using a portable certified standard flow meter and upon a determination that the meter is installed properly and accurate to within ±10% of actual rate of flow and volume. The suitability of any pumping station for an hour meter or the PCC method of measurement will be based on criteria found in this document and in the document entitled *IDWR ESPA Water Measurement and Reporting Guidelines*[3].

1. Use of Power Records as an Alternative Measurement Method

An alternative to installing flow meters is the use of power records and other information to estimate the annual diversion from a pump. Estimating total water diversion from power records requires the derivation of a relationship between power demand and flow under normal operating conditions. This relationship, called a power consumption coefficient (PCC), is a ratio of the number of kilowatt-hours needed to pump an acre-foot of water. This number is unique to each well or pumping plant due to the physical attributes of the system and can be applied to the year-end power records to estimate the total acre-feet pumped.

Total power consumption at individual irrigation pumping plants is supplied to the Department by electric utilities. To determine the rate of flow, a portable measuring device, such as a non-invasive ultrasonic flow meter can be used. Simultaneous with the flow measurement, power is measured using the utility's kilowatt-hour meter. A qualified individual with the necessary equipment will be required to perform these measurements.

Some complex systems cannot use the PCC relationship due to the potential for large errors. The PCC method is reliable on simple diversion systems having fairly static pumping levels and must

[3] This document can be found at: http://www.idwr.idaho.gov/WaterManagement/WaterMeasurement/PDFs/IDWRESPA_WaterMeasurement_ReportingGuidlines.pdf

be reviewed for acceptability by the Department on a case by case basis. See the discussion in the following section to see if this method can be used.

Because systems wear and water levels change, it is necessary to occasionally verify the flow to power ratio. Therefore, the PCC must be re-calibrated at least once every three years.

2. Can Power Records be used to Estimate My Diversion?

Only irrigation water users may use power records to estimate their diversion because the utilities will only provide consumption information for irrigation uses. Irrigators wishing to use the PCC method must be able to show that it will yield reliable results. If you are not an irrigation user, but want to use power records, you must propose a method of reporting your power consumption data. The PCC method cannot be used on surface water diversions in most cases because such diversions are typically regulated by water right diversion rates and priority dates.

Owners of **ground water diversions** can either install a totalizing flow meter or ask the Department to use power records to estimate annual withdrawals. The total water diverted can be accurately estimated from the PCC method if the system configuration or operation is not complex. Unfortunately, the PCC or power records will not always yield acceptable results, and it will be necessary to install a flow meter. **Flow meters must be installed if any of the following conditions exist:**

- The well flows (artesian) so that water can be diverted when the pump is off.

- The energy consumption meter that records power used by the pump also records power used by other devices not integral to the irrigation system. For example, if the meter also records power used by a home, shop, cellar, re-lift pumps from surface water sources etc., a flow meter must be installed because power used by the pump cannot be isolated from the other devices. However, if the meter also records power used by center pivots, booster pumps, or other devices which operate as part of the well pumping system, the alternate method may be acceptable.

- The electrical meter records the power used by more than one well pump. If a deep well pump which discharges to an open pond or ditch and a re-lift pump are both connected to the same electrical meter, the discharge from the well pump can be measured, and a time clock can be installed to record the total number of hours of pump operation which can be multiplied by the flow rate to determine the total volume of water diverted.

- Variable frequency drives (VFD) operate the pumping plant. This includes both drives for the well motor and the booster system. Variable frequency drives generally indicate that multiple operating conditions exist in the system where large kilowatt and pressure changes are present.

- The energy supplied to the pump cannot be accurately and reliably measured. For example, most diesel and propane driven pumps do not have provisions to measure the fuel used by the engine.

- The flow rate from the pump varies significantly due to changes in demand or operation. For example, pumps that discharge into a pressurized system some times and then open

discharge at other times, or pumps that supply multiple pivots and/or other discharge points, would likely have flow rates that change considerably. These changes generally alter the flow to power ratio, causing inaccurate estimates of diversions. The alternate method of estimating water withdrawals with power records may only be used if the water user can propose an acceptable method of tracking these changes in operation.

- Changing water levels that cause the flow to vary more than 25% (or pressures to vary more than 15%) over the irrigation season.

2. Use of an Hour Meter as an Alternative Measurement Method

In some cases pumped volume can be estimated by recording the operating hours of the diversion pump with a time clock. This method shall only be used on systems with a known constant discharge such as pumps with open discharge which are not subject to throttling, have minimal water level fluctuations, and where PCC method cannot be used for accurate volume estimation. The time clock shall record operation hours of the diversion pump to at least one-hour precision. An approved examiner using a standard meter shall measure flow rate at least once every three years.

3. Types of Non-magnetic Flow Meters

See table 2 below for information on non-magnetic type flow meters.

Table 2: Types of Alternative Measuring Devices for Closed Conduits

Types	Pipe Sizes	Maintenance Required	Relative Purchase Price
Differential Head • Orifice • Venturi • Annubar	small to large	Low to high. Sand wears on sharp edges, and particles can plug small orifices and tubes.	low to medium
Force Velocity • Turbine • Propeller • Impeller	small to large	Typically moderate to high. Often problematic when exposed to sand, moss or mineralized (hard) water. Some cannot measure low velocities.	low to medium
Ultrasonic or Acoustic Doppler	small to large	Low. Typically non-invasive with no moving parts to wear.	medium to high
Vortex	small to medium (about 12 to 14 inch maximum pipe diameter	Low. Few or no moving parts to wear.	high