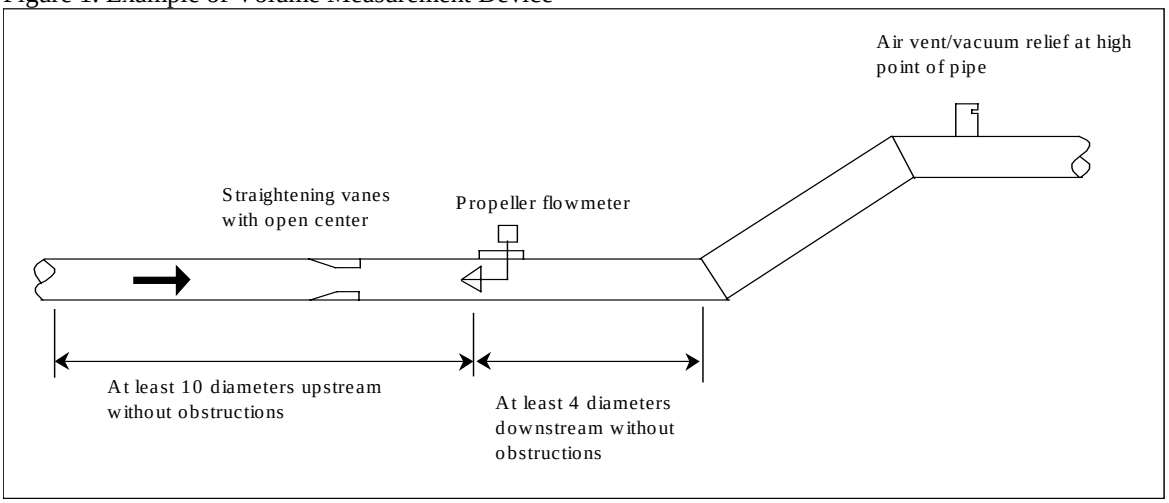
Appendix B. Calibration & Measurement

Figure 1. Example of Volume Measurement Device



- *Propeller Meters;*
- *Venturi Meters;*
- *Magnetic Meters; and,*
- *Acoustic Meters.*

These have a high level of accuracy with proper installation and periodic maintenance and calibration.

Meters	**Installation**	**Maintenance**	**Calibration**
Propeller Flow Meters	When ordering a meter, it is very important to know the exact wall thickness and ID of the pipe (see Figure 2) in which it is to be placed (i.e. 11.9" vs 12"). The meter must be exactly centered in the pipelines in order to be accurate. Units are typically not accurate at low velocities. Meters should be operated at greater than 1 foot/sec.	When propeller meters are placed in locations with large amounts of algae and trash, remove the trash before it gets to the meter or frequently clean the propellers. Also, sand and normal wear can cause the propeller to not spin freely, as it should. The problem may show up as a more erratic needle movement.	Calibration is typically done by sending the unit back to the manufacturer on a regular maintenance cycle and having it checked. Field checks of meters can be done using a portable acoustic meter (transit time type).
Venturi Meters	Manufacturers of the Venturi Meters should be requested to furnish the rating tables for the unit purchased. Venturi Meters are susceptible to turbulence in the pipe.	The tubes used to measure the pressure can become easily plugged so they must checked periodically.	Field calibration can be done using an insert pitot tube or done using a portable acoustic meter (transit time type).
Magnetic Meters	Spool type magnetic (See Figure 3) meters can be very accurate even with turbulence in the pipeline. Insert mag meters should follow propeller meter installation guidelines	Low maintenance on spool meters. Insert meter sensors must be periodically cleaned.	Field checks of meters can be done using a portable acoustic meter (transit time type).

Meters	Installation	Maintenance	Calibration
Acoustic meters	Acoustic meters can be used in both pipelines and channels. Acoustic meters should follow propeller meter installation guidelines.	Transducers (See Figure 4) must be periodically cleaned. It is important to avoid multipath interference and signal bending from solar heating.	Calibration by current-meter measurement or theoretical computation, it is essential to place device in a cross section that will not change significantly. If the transducers are placed out in the channel, the triangular side areas not measured must be accounted for in the calibration.

Figure 2. Inside Diameter (ID) of the Pipe

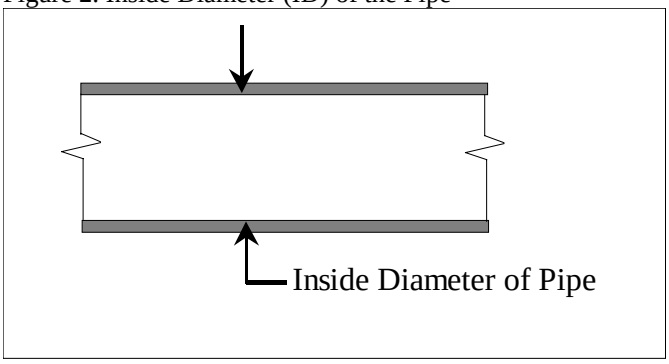


Figure 3. Magnetic Meters (spool type)

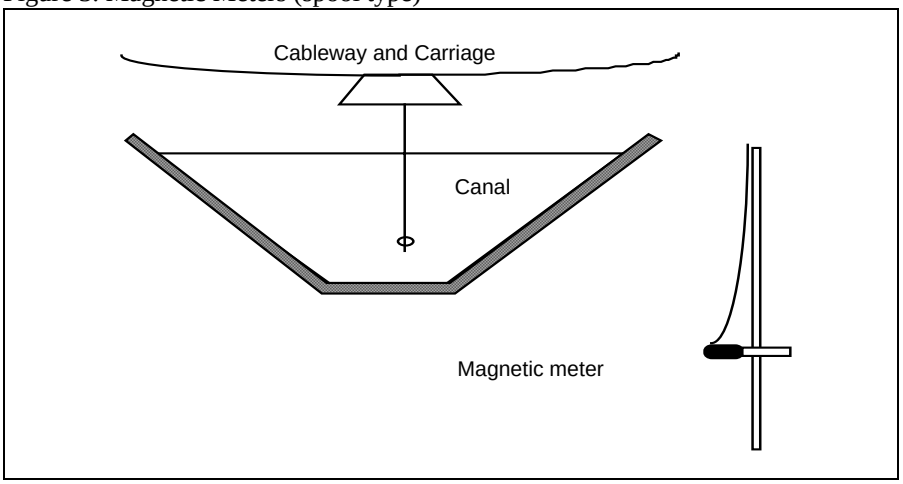
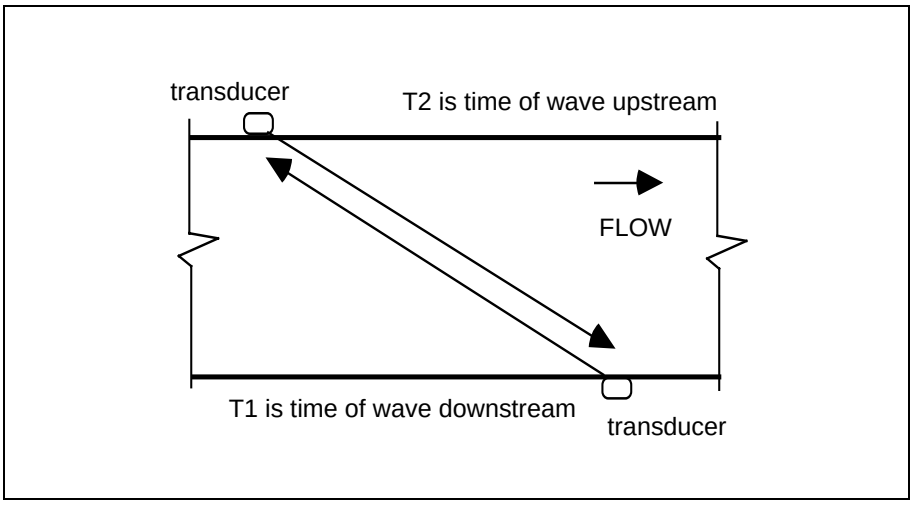


Figure 4. Acoustic Meter



The second category includes standard flow measurement devices that measure flow rate and also require accurate measurements of delivery time to determine volumes:

- *Replogle and Parshall flumes;*
- *Rectangular, Trapezoidal (Cipolletti) and V-Notch weirs; and,*
- *Canal meter gates.*

These devices require proper installation, regular recording of flow rates and delivery times, adjustments for approach velocity in some cases, and regular maintenance and calibration for good accuracy.

Flumes, Weirs and Gates	**Installation**	**Maintenance**	**Calibration**
Replogle and Parshall flumes	It is essential that the entrance of the control section of the flume be level in the direction of the flow. Water must be moving "straight" toward the flume. The flume should be located about 10 times the average channel width downstream of checks, gates or bends in the channel. Staff gauges set too high will underestimate the actual flow rate.	It is important to keep the stilling wells (See Figure 5) from being plugged or partially plugged. The surfaces of the flume must be kept relatively clear of moss and sediment build-up. Limits of submergence should be checked at high and low flow rates.	Can be calibrated with errors of less than 2%. The rating curve used for the flume can be field checked using a current meter.
Rectangular and trapezoidal weirs	It is important that the weir crest is horizontal or level and for the sides of the rectangular weir to be vertical, because the actual flow area of the water will not be correct. The water must be moving straight into the weir, and the face of the weir must be vertical.	It is important to keep the stilling wells from being plugged or partially plugged. Flow into and out of the weir should be as smooth as possible. Sediment accumulation below the weir crest should be removed.	Rating tables must be adjusted to account for the velocity of approach for calibration. Rating tables must be checked for the correct weir (i.e. contracted weir vs. suppressed weir). Rating tables must be adjusted for submergence or slanted conditions.
(Cipolletti), and V-Notch weir	Is important to determine which size of notch (how many degrees) is being used so that the correct flow rate table can be used. It is also important to determine if there are any errors in the	Same as the rectangular and trapezoidal weirs above.	Same as the rectangular and trapezoidal weirs above.

Flumes, Weirs and Gates	Installation	Maintenance	Calibration
	construction of the notch. The water must be moving straight into the weir, and the face of the weir must be vertical.		
Canal meter gates	1. "Zero" height (See figure 6) of the stem is when the flow starts to leak through the gate. 2. Always pull up on shaft (by turning wheel) before taking measurement. 3. Keep the bottom of the gate entrance clean. 4. A change in pipe material several diameters downstream of the gate will not affect the accuracy. 5. A water level in the downstream pool is not the same as a water level measured in a whistle pipe(See Figure 7). 6. Eddies at the gate entrance will generally cause an overestimation of the flow rate. 7. The accuracy is poor if the gate is more than 70% open.	Flow toward and into the structure should be as smooth and quiet as possible. Obstructions should be removed to improve the entrance conditions. Remove severe accumulations of sediment, because they may reduce the actual area of orifice. Debris, such as weeds, should also be remove, because it can get caught in the gate opening.	Manufacturer's specifications must be followed precisely in order to obtain accurate flow rate measurements.

Figure 5. Stilling Well

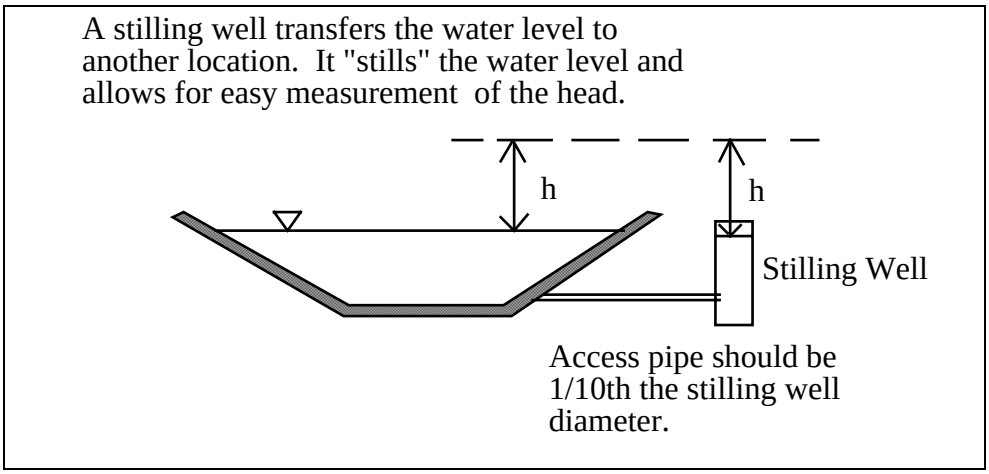


Figure 6. "Zero" Reference

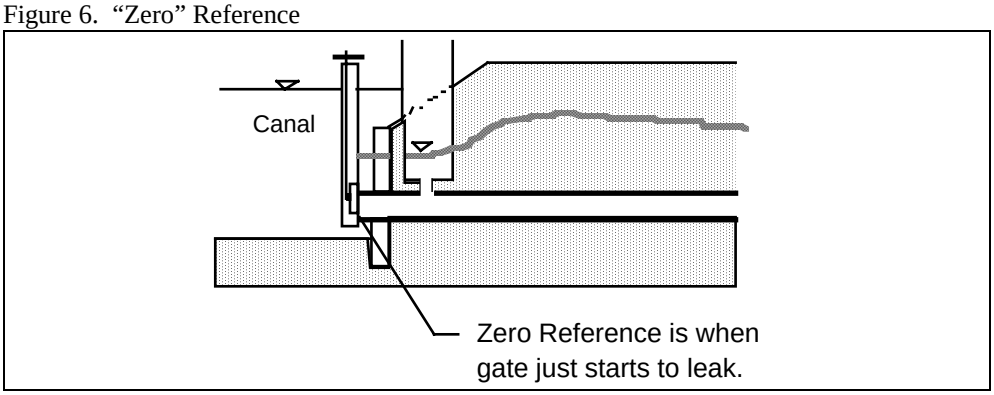
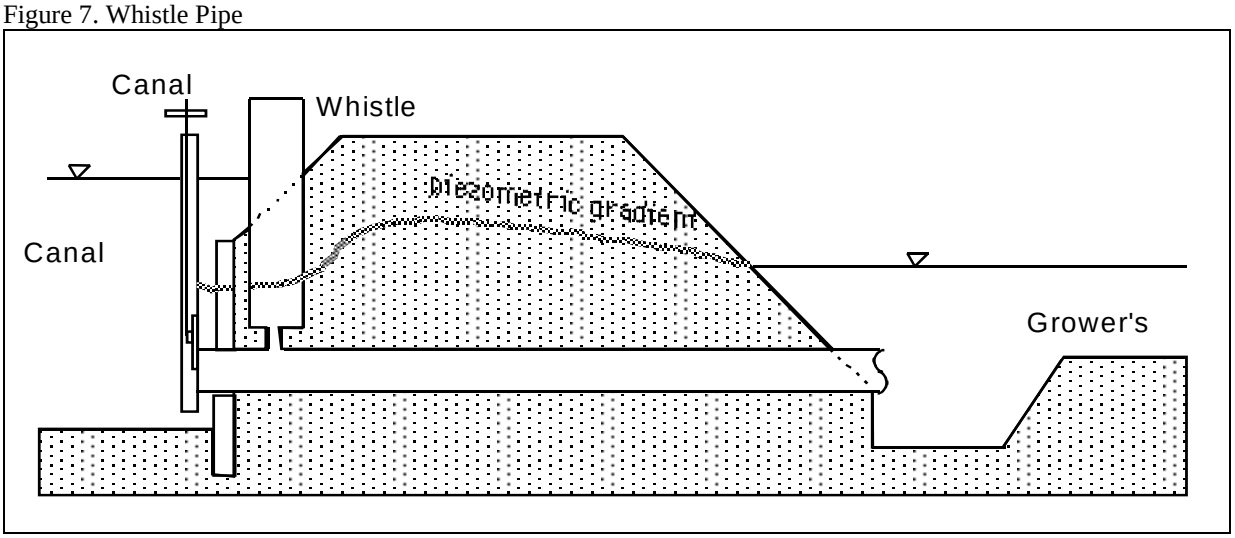


Figure 7. Whistle Pipe



The third category includes non-standard, calibrated flow measurement devices. This category includes special measurement devices developed by a District. Typically, there are no published standard dimensions or flow tables for such devices. Consistent dimensions and installations; accurate determination of delivery time; local calibration and a verification of accuracy, based on a representative sample number of devices measured over time; and a proposed schedule for maintenance and calibration would be necessary for

acceptability. The following steps can be used to calibrate a non-standard structure:

1. Use a current meter to calibrate the non-standard structures. The individuals who will perform the current metering need to demonstrate proficiency in the required skills to perform the measurements.
2. The individuals will need to use an established site such as a calibrated Replogle flume to verify their proficiency in making good current meter readings.
3. Non-standard structure have certain requirements that must be met in order to be calibrated. If these conditions cannot be met, it is useless to spend time calibrating the structure. These required conditions include:

- Good entrance conditions with a low velocity.
- If the device to be calibrated is located right next to a supply canal (within 10 feet or so), the supply canal must have a fairly constant velocity.
- The staff gauge must be "zeroed".
- There must be no moss buildup. That is, the conditions must not change with time.

4. The recommended calibration procedure for a non-standard site that meets the above conditions is as follows:

- A wide spread in the measured flow rate is required. At least a 2:1 ratio in the flow rates should be used to create the table.
- A minimum of 10 values should be measured across the flow rate range.
- Data should be plotted on a log-log scale graph. See the following figure. Such a graph is a standard option in programs such as EXCEL.

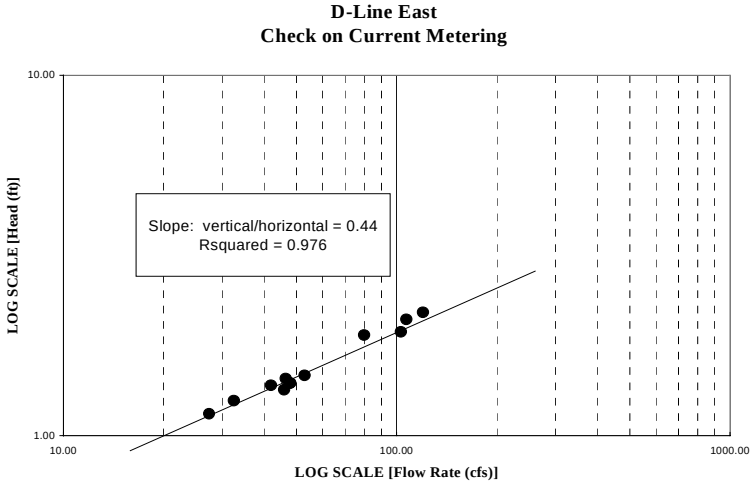


Figure 1. Log-Log plot of the current meter data.

- The data should plot out as a line (not a curve) with a slope between 0.4 and 0.67. A program such as EXCEL can be used to determine the equation, and the equation should be of the form:

$$H = KQ^x$$

where "x" is a value between 0.4 and 0.67

- The regression coefficient (r^2) must be better than **0.97** to assure confidence in the results.

A forth category is using rough estimates of flow rate or volume, such as flow rate estimates at check structures or the sum of siphon tubes (or other methods of measurement not specified here). These approaches are **NOT** acceptable since they do not provide a documented reasonable degree of accuracy.

For more information and support on measurement and calibration, please contact the Cal Poly Irrigation Training and Research Center at (805) 756-2434.

References:

USBR Water Measurement Manual - 3rd Edition

Cal Poly Irrigation Training and Research Center – Flow Measurement (Fall 1999)