

Watersheds Laboratory	Total G – Pressure Transducer / Weir Measurement	
VU Stormwater Partnership	SOP – VUSP - J	Rev. No.. 1
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Villanova University  
Villanova Urban Stormwater Partnership  
Watersheds Laboratory

## Standard Operating Procedure – VUSP – J

# Depth Measurement and Flow Measurements with Pressure Transducers and V-Notch Weirs

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Note – Reconfigured from VUSP QAQC.

Approved: \_\_\_\_\_  
VUSP Director Robert G. Traver

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**Distribution**

Mary Ellen Dukart – Quality Assurance Officer  
 Laboratory Copy, maintained by Quality Assurance Officer

Revision	Date	Responsible Person	Description of Change
0	30 May 2007	Clay Emerson	Initial
1	March 2008	Robert Traver	Change of SOP #
2			

**The following laboratory staff have read and been trained on this Manual. A copy of this page will be maintained in the Laboratory. Training is good for one year.**

Signature	Name / Position	Date	Trainer
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## 1.0 Scope and Application

The purpose of this SOP is to detail procedures used to measure depth when using pressure transducers and also flow when a pressure transducer is used in conjunction with a weir.

## 2.0 Method Summary

### 2.1 Pressure Transducers

The pressure experienced by a submerged object is the sum of the hydrostatic pressure due to the depth of water and the atmospheric pressure. The Instrumentation Northwest (INW) pressure transducers use a vent tube to account for natural changes in the atmospheric pressure. The hydrostatic pressure readings can then be directly related to an equivalent depth of water through a simple linear calibration. The PS-9800 pressure transducer provides a linear response between 4-20 mA over the specified range of depth. The PS9800 also has an optional temperature reading capabilities which is also implemented with a 4-20 mA signal. INW offers different models of the PS9800 depending on the desired depth range. The smallest range model is the PS9800 5PSIG which can be used to measure depths up to approximately 10 feet. Submerging the transducer in depths greater than this may result in permanent damage to the transducer. The 4-20 mA signal can be read directly with the Analog Input capabilities available on the appropriately equipped American Sigma 950 Flow Meter or 900MAX Sampler. Conversely a precision 100  $\Omega$  shunt resistor can be used to convert the current draw to a voltage signal that can be read by Campbell Scientific data loggers. Calibration is accomplished by submerging the transducer to various known depths of water. The specific procedure differs depending on what type of data logger is used. Once the calibration is complete the depth data can be logged at a specified time interval and stored on the data logger for later retrieval. Note that other manufacturer pressure transducers can be substituted as required.

#### PS9800 User Manual

##### Operating Pressure Specifications

Static Accuracy	$\pm 0.1\%$ FSO (max.) <i>0.1% available on request.</i>	$\pm 0.06\%$ FSO (typ.) B.F.S.L. 25° C
Thermal Error (0-50° C, reference 25° C)	$\pm 2.0\%$ FSO (max.)	$\pm 0.8\%$ FSO (typ.)
Max. Zero Offset at 25° C	$\pm 0.5\%$ FSO	
Max. Temperature Error	$\pm 2.0\%$ FSO	
Over Range Protection	2x (except 300 PSIA)	
Operating Temp. Range	-5° C to 70° C	

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## 2.2 Weirs:

Weirs are used to accurately measure flow by forcing the depth through a hydraulic transition. A pressure transducer can be used to measure the depth upstream of the weir. Since the pressure transducer is generally installed below the weir crest it is necessary to correct the depth measurement to accurately reflect the head on the weir. This SOP focuses on V-Notch weirs which have geometry that make them ideal for accurately measuring both low and high flows. Note that certified manufactured weirs may be substituted.

## 3.0 Definitions

*NA*

## 4.0 Health and Safety Warnings

*See Lab Safety Plan*

## 5.0 Interferences

*None*

## 6.0 Handling and Preservation

*NA*

## 7.0 Equipment and Supplies

Instrument North West (INW)  
Submersible Pressure Transmitter PS9800

Weir  
Manufactured V-Notch Weir of various angles.

## 8.0 Quality Control

The pressure transducers and V-notch weirs are inspected on a monthly basis. The area upstream of the weir must be kept free of debris that may interfere with the weir rating curve. Visual depth observations are compared to recorded data for quality control purposes. The pressure transducer's vent tube has desiccant tube that is located on the data logger end of the cable. The desiccant should be checked frequently. The desiccant should be bright blue; as moisture is absorbed the desiccant becomes lighter in color and will need to be replaced. If viable desiccant is not maintained permanent damage may occur to the transducer. The frequency of the desiccant replacement will vary largely depending on the moisture conditions where the desiccant vent tube is located. The Pressure Transducer should be calibrated at least every 6 months, and more frequently if need be.

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The weir will be calibrated every 12 months by a manual flow rate measurement taken with a graduated cylinder and stopwatch during a storm event. Calibration will be a simple back calculation of the coefficient of discharge from a measured flow rate and head.

## 9.0 Procedures

### 9.1 Pressure Transducer Calibration

The calibration procedure of the PS9800 will differ significantly depending on the type of data logger being used. Therefore this section has been broken into two sections one for American Sigma data loggers and one for Campbell Scientific.

#### 9.1.1 American Sigma

The American Sigma data loggers use simple but limited two-point calibration. The data logger will ask first for the transducer to be placed in a minimum depth of water and then a maximum depth of water. The data logger will use these two points and fit a straight line calibration to relate incoming signal (current draw from PS9800) to depth of water in the chosen units. The data logger will extrapolate for readings outside the calibration range. The minimum depth *should not* be open air as the response of the transducer is not linear at very small (<1 in) depths. Instead the minimum depth should be equal to or close to the depth to the weir crest (depth of the onset of weir flow). The maximum depth should be as close to the maximum depth that is likely to be experienced at the installation location.

#### 9.1.2 Campbell Scientific

The calibration for Campbell Scientific data loggers is slightly more complicated, but much more flexible than that of the American Sigma data loggers. The instruction that converts the voltage reading (produced in conjunction with the 100  $\Omega$  resistor) to a depth is written into the data logger program. The equation will be linear with an 'm' term for slope and a 'b' term for the intercept. If 'm' is set to a value of 1 and 'b' to a value of 0 the data logger will report the actual voltage in Volts that the PS9800 is providing. The transducer can then be placed in multiple (more than two) known depths of water and a calibration curve can be created which related voltage (x-axis) to depth (y-axis). This curve can be fit with a linear regression to determine the true 'm' and 'b' values for depth in the units desired (usually feet or inches). These numbers ('m' and 'b') are then inserted back into the program so that the data logger will log depth in these units.

Comment [S1]: Should this "editorial" comment be included?

### 9.2 Weir Calibration

Calibration of the weirs is a difficult procedure. Proper calibration is necessary to determine the coefficient of discharge for the weir installation. Calibration can be done by either supplying a known flow rate of water or by using a stopwatch and

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capturing and measuring the weir flow. Depending on the size of the weir and specific installation of the weir one or the other may be desired. Neither approach is likely feasible for high flow values. Calibration at high flows may be based on other mass balance approaches over a number of storm events or by other hydraulic measurements (such as velocity). The calibration of the weir should be checked every 12 months or more frequently if changes are made to the weir or the flow approach. Additionally the weir should be checked during periods of high flow to ensure there are no back water effects occurring that could significantly impact the rating curve

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## 10.0 Data Analysis and Calculations

### 10.1 Pressure Transducer

In the case of the American Sigma data loggers the appropriate depth calculations (when using the PS9800 input to the Analog Input channels) are done internally and are not available. As previously mentioned this calculation is a function of the two-point calibration procedure. In the case of the Campbell Scientific data loggers the calculation should be input in the following form.

$$depth = m * voltage + b$$

Where ‘m’ is in units of [L/Volt] with the units of length being consistent with those of the desired measurement, and ‘b’ also in those same units. As previously mentioned these parameters are found based on the calibration procedure.

### 10.2 V-Notch Weir

The geometry of the V-Notch weir makes it ideal for accurately measuring both low and high flows. The weirs currently installed at many sites were machined from a 1/4” 6061 Aluminum plate. This alloy is both easily machined and is resistant to weathering. The weir plates are securely mounted and sealed to frame in the flow path. The design, construction, and discharge coefficient of the weirs are largely based on the guidelines set in the ASTM Standard Test for Open-Channel Flow Measurement of Water with Thin-Plate Weirs (ASTM, 1996). The flow rate calculations are generally done manually (external from the data logger). The general equation for flow over a V Notch is given as follows.

$$Q = \frac{8}{15} * C_d * 2g^{\frac{1}{2}} * \tan\left(\frac{\theta}{2}\right) * H^{\frac{5}{2}}$$

Where:  $Q$  = flow rate (ft<sup>3</sup>/s)  
 $g$  = gravity (ft/s<sup>2</sup>)  
 $C_d$  = is the coefficient of discharge (varies)  
 $\theta$  = angle of V-Notch (varies)  
 $H$  = head on weir (ft)

### 10.3 Data Procedures

The data management goals for both the water quantity and quality aspect of this project are based on the guidelines set in the EPA manual Urban Stormwater BMP

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Performance Monitoring. The database should be one that is easy to “...store, retrieve, and transfer...” (EPA, 2002)

Data is downloaded from the recorder once a week or more often as needed to a computer located in the laboratory. The file name of the data file is the two letter site identifier followed by the date of download in the YYYYMMDD format. For example a data file downloaded on May 30<sup>th</sup> 2007 for the Infiltration Trench would be labeled “IT\_20070530”. The data files are converted into Microsoft Excel (\*.xls) spreadsheets. Copies of both the original data file and the Excel spreadsheet are kept locally on the laboratory computer and backed-up on a weekly basis to the University’s network.

Additional columns may be added to the Excel spreadsheets which convert the height of the water in the chamber to head on the weir. The head can then be converted to a flow rate using the weir equation for flow over a triangular weir as discussed previously.

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## 11.0. Waste Management

NA

## 12.0. References

ASTM (1996). "Standard Test Method for Open-Channel Flow Measurement of Water with Thin-Plate Weirs," *D 5242-92(Reapproved 1996)*, American Society of Testing and Materials, West Conshohocken, PA.

INW (2002). "PS-9805 Submersible Pressure/Temp. Transducer Instruction Manual." Instrumentation Northwest, Kirkland, WA.

U.S. Environmental Protection Agency (USEPA). "Urban Stormwater BMP Performance Monitoring" U.S. Environmental Protection Agency, 2002a.