1. Scope and Application

1.1 The scope of this SOP is train researchers to measure stream velocity and calculate discharge.

1.2 This standard operating procedure (SOP) outlines the general protocols used by the Los Huertos' lab to measure discharge using flow meters.

1.3 The procedures presented in this SOP have largely been adapted from the protocols established by the United States Geological Survey (Rantz et al., 1982).

1.4 All discharge measurements and estimates must use the described methodology to ensure accurate and uniform results.

1.5 A working knowledge of flow meter operation, as well as the limitations of operation, must be attained prior to the use of this type of equipment. The operation of these meters must follow the instructions provided by the manufacturer in the user manual.

1.6 Water Quality Branch equipment manuals for FlowTracker and FlowTracker2 are located at: TBN and maintenance TBD

2. Summary of Method

In order to measure stream discharge a cross-section of the stream representing the most uniform laminar flow should be located. At this location, a tagline is placed perpendicular to the stream flow and the wetted-width of the stream is determined. This width is divided by the appropriate number of desired vertical measurement stations. At each vertical station along the tagline, the station location and water depth are determined and used to measure mean velocity with a Sontek handheld Acoustic Doppler Velocimeter unit. Upon completion of data collection, these units automatically calculate final discharge (cfs) and an estimate of calculation uncertainty.

3. Definitions

cfs or ft/s3 Cubic feet per second

Discharge volumetric flow rate of water that is transported through a given crosssectional area, measured in cfs.

LEW the left edge of water when facing downstream

PPE Personal Protective Equipment

QA Quality Assurance

QC Quality Control

REW the right edge of water when facing downstream

SNR Signal to Noise Ratio a measure of the strength of the reflected acoustic signal relative to the ambient noise level of the FlowTracker

Velocity the speed at which the water is moving in feet per second

4. Procedures

Preparation

Field Collections

4.1

5. Cautions and Interferences

Specific cautions exist for flow meter equipment. It is important to read the manufacturers user manual and to become familiar with the specific cautions of each piece of equipment prior to its use. The following are general cautions one should be aware of prior to making instream discharge measurements.

5.1 It is not always possible to find a cross section that meets all of the desirable characteristics for measuring discharge. In this case, a cross section should be chosen using best professional judgment.

5.2 An attempt should be made to measure discharge at the same cross-section during each sampling event. However, it may be necessary to change the crosssection location due to instream physical changes.

5.3 The vertical spacing width should never be less than 0.2 feet.

5.4 Velocity readings should be averaged over a time period of 25s 45s, depending on in-stream conditions.

5.5 If multiple channels exist in the cross-section, all islands must be accounted for in the discharge calculation. Island edges should be treated like river edges; however, there should not be velocity data for any area between the edges of the same island.

5.6 Flow meters can be influenced by interference from underwater objects. Reflections can occur from the bottom, the water surface, or from submerged obstacles such as rocks or logs. If the sampling volume is downstream of an underwater object, velocity

data will be altered. When working in very shallow water or when underwater obstacles are 15 cm (6 in) away from the sampling volume, reflections can potentially affect velocity data.

5.7 Pressure can build up inside the FlowTracker unit over time. Vent the unit frequently by loosening the dummy cap on the external communication connector a few turns. Wait a few seconds and then tighten the dummy cap. Leave the dummy cap loose when storing.

5.8 Remove batteries from flow meter units prior to long term storage.

6. Health and Safety

6.1 All field staff should review Worksite Hazard Assessment Guidance Document (DOW, 2017). In addition, each employee will be individually trained by his/her supervisor, or designee, to perform assigned job tasks safely, prior to his/her performing the task.

6.2 Field staff working in and around potentially contaminated surface waters should receive immunization shot for Hepatitis A in accordance with DEP Policy SSE-708. In addition, staff should receive immunization for Hepatitis B and tetanus, to aid in the prevention of contracting those pathogens.

6.3 All field staff should also be trained in with the following SOPs...

6.4 The use of personal protective equipment (PPE) should be used when sampling including, but not limited to: site-appropriate wading boots, personal floatation device, latex or nitrile gloves, and cold weather clothing. Monitoring may include field activities during all stages of the hydrologic cycle, including high discharge/flood stage conditions. It is recommended that field staff use the buddy system and personal floatation devices when collecting samples during high flow conditions. If high discharge conditions are determined unsafe by any Field Activities Staff, do not sample during that time.

Safety and Personnnel Protective Equipment

7. Personnel & Training Responsibilities

7.1 All Field Activities Staff will meet the minimum qualifications TBD... . In addition, field staff will be trained by experienced field personnel in the proper calibration and use of monitoring equipment. Training will continue on-the-job and as formal educational opportunities become available.

Researchers using this SOP should be trained for the following SOPs:

- SOP03 Field Work

- SOP01 Lab Safety
- SOP07
- SOP08
- SOP10

8. Required Materials

SonTek FlowTracker SonTek FlowTracker Handheld ADV

8.1 Instrument #1 (Serial Number 9000-00113)

8.2 Instrument #1 (Serial Number 9000-00XXX) BROKEN

Item 2

9. Estimated Time

9.1 After some practice, and depending on the depth and width of the stream, it can take an hour or more to measure a stream's discharge. However, in many cases, small, relatively shallow streams can be completed in less than 30 minutes.

10. Procedure

Preparing

10.1 Check batteries... ...

Selecting a Cross-Section

10.2 The following site characteristics for cross-section locations are critical for accurate discharge measurements (from Rantz et al., 1982 unless otherwise cited):

- The site lies within a straight reach of stream and flowlines are parallel to each other. Avoid sites directly below sharp bends.
- Flow is relatively uniform and free from eddies, slack water, and excessive turbulence.
- The streambed is free from large obstructions, such as boulders and aquatic vegetation.
- Water velocity is ¿0.5 ft/s.
- Water depths ¿0.5 ft are preferred but a minimum depth of ¿0.1 ft is required.
- The flow is perpendicular to the tagline at all points (SonTek/YSI, Inc., 2007).

10.3 Finding a cross-section that achieves all of the above criteria in the natural environment is difficult.

10.4 Therefore, it may be necessary to engineer the stream by moving rocks, logs, branches, algae mats, rooted aquatic vegetation, debris, and/or other obstructions in order to construct a desirable cross-section free of turbulence.

10.5 Additionally, rocks or other obstructions can be placed in the slack water to create an artificial bank such that no or minimal stream flow goes over or through the obstructions (Rantz et al., 1982).

10.6 If this is necessary, make all adjustments and wait a few minutes for the system to stabilize prior to beginning the stream flow measurements.

Setting the Tagline and Vertical Spacing

10.7 After selecting the best cross-section, set up a tagline by stretching a tape measure across the stream so that it is taut and perpendicular to the stream flow lines.

10.8 The tagline should be directly above the cross-section to be measured and must not touch the water surface.

10.9 Discharge measurements are taken at several verticals, defined as a point along the cross-section where water velocity is measured at a defined depth (or depths).

10.10 Twelve to twenty verticals should be targeted for streams ¡20 feet wide, whereas twenty to thirty verticals should be targeted when stream width is ¿20 feet.

10.11 To calculate the approximate spacing of verticals, determine the width of the stream and divide the stream width by the number of desired verticals.

10.12 Importantly, the average velocity in one vertical should not exceed 10

10.13 Therefore, it may be necessary to space verticals more closely together in areas that are deeper or that have a greater velocity than the majority of the stream. Conversely, the spacing of verticals may be farther apart in areas that are shallower or have lower velocity compared to the majority of the stream. Uniform spacing across the tagline should only be used if the stream is of relative uniform depth and velocity regimes.

10.14 Although vertical spacing can vary, verticals should never be spaced less than 0.2 feet apart. As a result of this minimum spacing, small streams with a flowing width of less than 2.2 feet will have less than 12 verticals and can have as few as one vertical during very low stream flow. If less than 12 verticals are measured, it should be noted in the comments section on the field observation sheet with an explanation.

Measuring Depth

A standard top-setting wading rod should be used to correct for depth when using flow meters. The flow meter probe must be mounted according to the user manual to achieve accurate measurements. The wading rod should be adjusted to the appropriate depth, which is marked in 0.10 foot increments along the rod using hash marks. 0.10 foot increments are denoted by a single groove, whereas 0.5 foot increments are denoted by a double groove, and 1 foot increments are displayed by a triple groove. It is appropriate to further estimate depth to the 0.02 or 0.05 increment level, despite the wading rod not being marked to this level.

Measuring Velocity

A working knowledge of flow meter operation, as well as the limitations of operation, must be attained prior to the use of this type of equipment. The operation of these meters must follow the instructions provided by the manufacturer in the user manual. The number of measurements taken at each vertical depends upon the depth of the stream. Follow these guidelines when determining the number of measurements to make:

Depths of 1.5 feet

When water depth is 1.5 feet, discharge is measured at 0.6 of the depth below the waters surface at each vertical, referred to as the 0.6-depth method (Turnipseed and Sauer, 2010). A standard top-setting wading rod will automatically adjust the probe to the 0.4-depth position up from the streambed.

Depths of 1.5 feet

When water depth is 1.5 feet, discharge is measured at 0.2 and 0.8 of the total depth below the waters surface at each vertical, referred to as the two-point method (Turnipseed and Sauer, 2010). For example, if the stream depth is 3 feet at a particular station, one should take a velocity measurement at 0.6 and another at 2.4. An average of these two readings will be used as the average velocity for the vertical.

A standard top-setting wading rod can be adapted to this method by following these instructions: To set the rod at the 0.2-depth, position the setting rod at twice the water depth. To set the rod at the 0.8-depth, position the setting rod at half the water depth. The wading rod should be set 3 below the tagline with the probe perpendicular to the tag line and the operator facing upstream. The operator should stand at least an arms length distance away from the probe side of the rod so that the operators feet alter the stream flow as little as possible. (Rantz et al., 1982). Rocks, logs, or other obstructions should not be moved during the measurement process as this may cause the stream flow to change in an area of the stream where velocity has already been measured. Once the process of measuring velocity has begun, the stream should not be altered further. Identify the starting edge as either left edge of water (LEW) or right edge of water (REW) when facing downstream. No velocity measurements should be made at the starting or ending edges. Facing upstream, place the wading rod downstream of the tape measure at the first vertical and enter the

location and stream depth. Velocity readings should be averaged over a time period of 25s 45s, depending on in-stream conditions. Once the stream velocity has been measured and recorded at the first vertical, continue measuring water velocity at each vertical, making sure that the appropriate number of measurements are being taken based on water depth (0.6-depth method vs. 0.2/0.8 two point method). Continue until you have reached the end of the cross-section. Record the location and depth of the ending edge. Instruments, such as the SonTek FlowTracker and FlowTracker 2, record depth and velocity information as you progress along the cross-section and then calculate discharge once the ending edge has been reached. If this is the type of instrument being used, be sure to record the final calculated discharge value on a field data sheet.

11. Troubleshooting

A list of warnings, their meaning, and suggested action are listed in Table 2. These warnings will automatically be displayed on the FlowTracker/ FlowTracker2 if a certain parameter exceeds its limits.

12. Data and Records Management

Electronic discharge records, including all related quality control documentation, must be maintained in permanent project files. All records relating to discharge measurements, including hardcopy and electronic files, that are collected by DOW staff or that are collected for the explicit use by DOW must be kept according to DEP record retention policy (KDLA, 2006).

13. Quality Control and Quality Assuarance

The quality control and quality assurance (QA/QC) requirements for various projects must be specified in quality assurance project plans (QAPP). The following sections will outline suggested QA/QC for flow meters and discharge measurements. 11.1 Flow Meter Quality Control and Quality Assurance Types of QA/QC for flow meters may include: Routine maintenance Proper installation and mounting of flow meter probes Field diagnostics Routine in-house beam check Refer to the appropriate user manual for QA/QC requirements and suggestions for specific flow meters. The following table describes the manufacturers suggested QA/QC protocols for flow meters used by DOW. Factory calibration is not required for SonTek FlowTracker ADV units.

14. References

14.1 APHA, AWWA. WEF. (2012) Standard Methods for examination of water and wastewater. 22nd American Public Health Association (Eds.). Washington. 1360 pp. (2014).