This SOP is subject to
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BAY AREA
AIR QUALITY
MANAGEMENT
DISTRICT

TECHNICAL SERVICES DIVISION

QUALITY ASSURANCE PROJECT PLAN

MET SOP 506

PRECIPITATION

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STANDARD OPERATING PROCEDURE
BAAQMD TECHNICAL SERVICES DIVISION

PRECIPITATION AUDIT PROCEDURES

AUGUST 29, 2007

TABLE OF CONTENTS

INTRODUCTION 2
GENERAL OPERATING PROCEDURES 2
FIGURE 1: TEXAS ELECTRONICS TR-525USW.....3
FIGURE 2: TEXAS ELECTRONICS TR-6118 (EXPANDED VIEW).....4
FIGURE 3: TRIPOD AND DRIP BOTTLE 4
AUDIT EQUIPMENT.....5
AUDIT PROCEDURES 5
PREVENTATIVE MAINTENANCE 8
CALIBRATION AND CERTIFICATION PROCEDURES.....8
AUTHORS, REVISIONS, AND APPROVALS.....8
REFERENCES 9
APPENDIX A: BAAQMD CALIBRATION RECORD (PIPETTE METHOD) 10
APPENDIX B: BAAQMD CALIBRATION RECORD (DRIP METHOD).....12

INTRODUCTION

Precipitation data, although used in air quality forecasting studies, are also used for consistency checks in data review and validation. The tipping bucket rain gauge is probably the most common type of instrument in use for gathering precipitation data. The rainfall is collected by a cylinder, usually about 8 to 12 inches in diameter, and funneled to one of two small "buckets" on a fulcrum. Each bucket is designed to collect the equivalent of 0.01 inches of precipitation, and then tip to empty its contents and bring the other bucket into position under the funnel. Each tip of the bucket closes an electrical switch which sends a signal to a signal conditioner for analog and/or digital recording. Inaccuracies may result if the gauge is not level, or when precipitation exceeds one inch per hour due to water dripping into a full bucket while it is tipping. Known as *overspill*, the extra water is not measured and is un-accounted for in the data. This condition causes the system to under-report the amount of actual precipitation.

GENERAL OPERATING PROCEDURES

The rain gauge BAAQMD uses is the Texas Electronics TR-6118 Rainfall Sensor (Figure 1 and 2). The sensor consists of a gold anodized 10-5/16-inch diameter aluminum

collector funnel that diverts water to a tipping bucket mechanism. A magnet is attached to the tipping bucket. As the bucket tips, it actuates a mercury wetted reed switch which is directly wired to a digital counter input on a Campbell Scientific CR10 datalogger. With each bucket tip, a momentary switch closure takes place and the CR10 records 0.01 inches of precipitation.

A *pipette test* is typically performed during summer and winter calibrations. A 10 mL pipette is used to fill the buckets with water until they tip and the measured tip volume is recorded after each bucket tip. The procedure is repeated twelve times for each bucket. The expected tip volume for the left or right bucket is 13.6 mL.

A *drip test* is typically performed during spring and fall audits (contracted auditors may perform this test with their own equipment and method in the fall). A bottle with an adjustable nozzle is filled with a pre-measured amount of water (680 mL). The water is allowed to drip into the funnel and the buckets are expected to tip 50 times (13.6 mL x 50 = 680 mL). While the pipette test can accurately test each bucket independently, the drip test is a quicker and more convenient alternative but may be susceptible to overspill. To minimize this effect, the *U.S. EPA Volume IV (Quality Assurance Handbook for Meteorological Measurements)* specifies a drip rate of less than 1 inch per hour (approximately 3 drips per second) for auditing rain gauges.

The *U.S. EPA Volume IV (Quality Assurance Handbook for Meteorological Measurements)* recommends re-calibration of rain gauges if the volumetric error exceeds 10%. BAAQMD tolerances for both the pipette and drip test are ±10%.

Figure 1:
Texas Electronics TR-525USW Rainfall Sensor
(Similar to Model TR-6118)

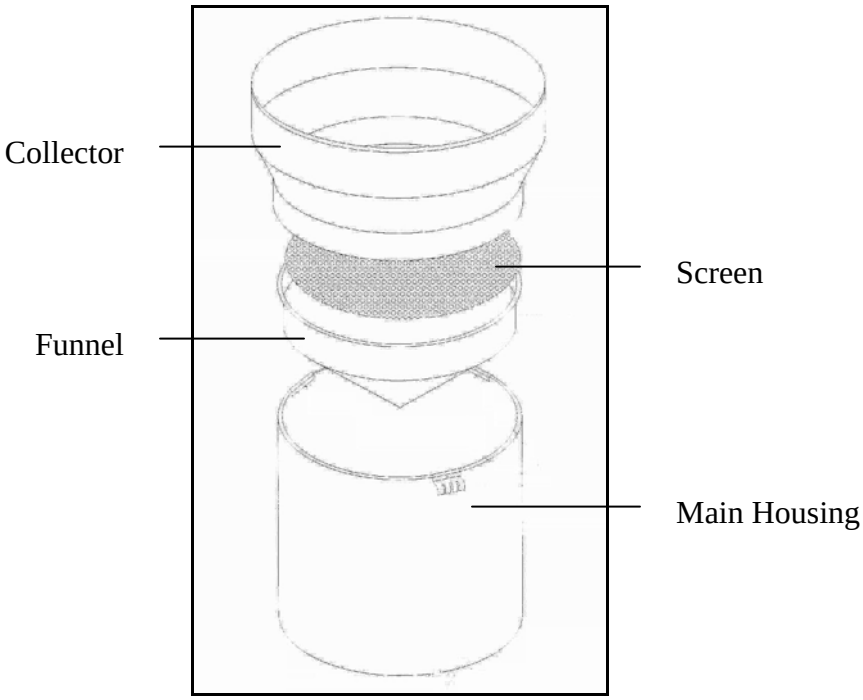

Figure 2:
Texas Electronics TR-6118 Rainfall Sensor
(Expanded View)

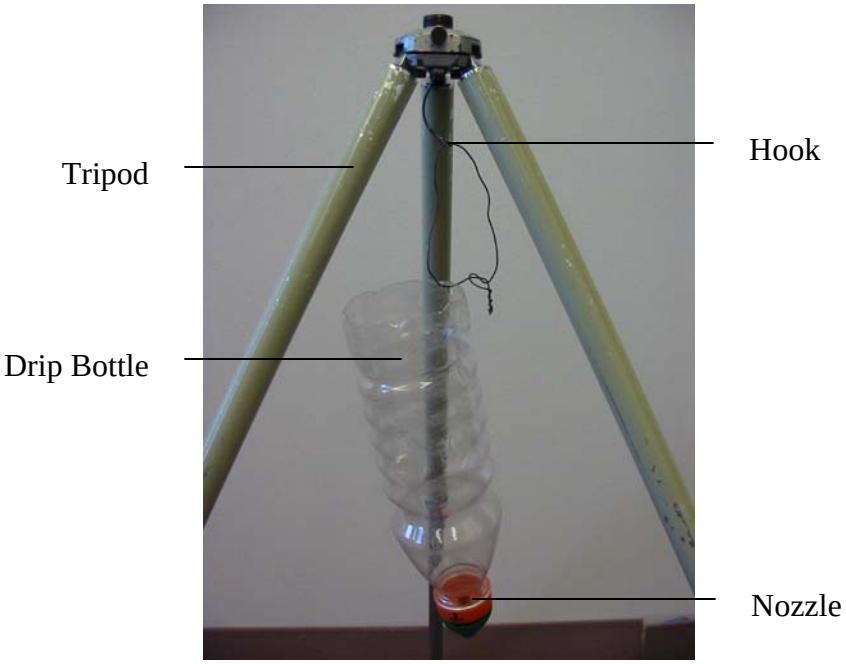

Figure 3:
Tripod and Drip Bottle 1

AUDIT EQUIPMENT

Pipette Test

1. Electronic Level
2. 10 mL Pipette
3. Container filled with water
4. Precipitation Audit Worksheet (Appendix A)

Drip Test

1. Electronic Level
2. Drip bottle with adjustable nozzle (Figure 3)
3. Pre-measured (680 mL) bottle of water
4. Tripod
5. Precipitation Audit Worksheet (Appendix B)

AUDIT PROCEDURES

PREPARATION

1. Using a precision scale in the lab, fill the bottle with 680g of water (680g of liquid is equivalent to 680 mL).

PRE-AUDIT

1. Attach the CR10KD Keyboard Display onto the 9-pin socket on the CR10 wiring panel (a CR10X may also be used).

2. Enter *C1955A on the CR10KD keypad to disable security.

3. Enter *6AD to access the software flags. The first digit from the left represents the state of flag 1, the second from the left – the state of flag 2, etc.

4. Set flag 2 high to disable precipitation data recording to memory. – 0 is *low*, 1 is *high*. Press 2 to toggle it *high*.

5. A *mechanical tip test* verifies that there are no mechanical obstructions (dirt, spider webs, etc.) and that the buckets tip when filled with water. Pour water into the collector. The gauge passes this test if both buckets tip (one after the other).

6. Remove the *collector, screen, and funnel* (Figure 2). Power on the electronic level and place it on the *main housing* along and perpendicular to the length of the buckets. Record the larger of the two degree readings onto the worksheet. If the reading is over ±0.2º, level the rain gauge by adjusting the leveling screws.

7. At the CR10KD, setting flag 2 *high* activates the *precipitation counter* in input location 7. When a bucket tips, the counter increments by 0.01 (inches). Display the counter by pressing *6A, and then A repeatedly to input location 7. If the

counter does not display zero, it will need to be cleared (next step). **Note: The precipitation counter resets to *low* after 3 hours.**

8. To reset the precipitation counter, disable security (step 2), display the counter on the CR10KD (step 7), then press C0A to clear the counter.

9. The *manual tip test* checks that the reed switch is functioning and the CR10 is recording data correctly. Manually tip the buckets twenty times by hand. Return to the CR10KD display and verify that the precipitation counter is displaying 0.20 (inches). Record *number of tips* (20), *expected depth* in inches (0.20), the precipitation counter reading, and calculate the *difference* (counter reading – *expected depth)*. The difference must be zero in order for the gauge to pass.

10. Remove the main housing and clean it, the collector, screen, funnel, buckets, and tipping mechanism with a mild detergent.

<u>PIPETTE METHOD</u>

1. Thoroughly wet the buckets by pouring water over them. This will ensure that the first volume measurement of each bucket will be consistent with subsequent measurements.

2. There are markings on the tipping mechanism bracket inside the main housing that identify the left (L) and right (R) bucket. Tip the left bucket up so that it will be the first to collect water from the funnel. Put the screen aside and replace the main housing, funnel and collector.

3. Fill the pipette with 10 mL of water and release all of it into the funnel. Fill the pipette a second time with 10 mL of water and release the water slowly into the funnel. The expected bucket capacity is 13.6 mL. Just before the bucket tips make sure that the drip rate is no more than one per second to minimize overspill. After the tip, record the total bucket volume in the worksheet.

4. Repeat step 13 a total of 24 times (12 times for each bucket).

5. Under TIP VOLUME in the worksheet (Appendix A), the *expected tip volume* is 13.6 mL. For each bucket, calculate and record the *average tip volume*, *difference* (*expected tip volume – average tip volume*), and *percent difference* (*difference/expected tip volume*).

6. Under TOTAL RAINFALL in the worksheet, the *expected volume* is 326.4 mL (13.6 x 24 tips). Calculate and record the *measured volume* (average volume of all 24 tips), *difference* (expected volume – measured volume), and *percent difference* (difference/expected volume). The passing tolerance for each bucket and for the total volume of both buckets is ±10%.

NOTE: A *high* precipitation system measurement (over-estimation) results from *low* bucket capacity. Therefore, the *difference* calculated is actually a *negated* volumetric difference, as opposed to a *positive difference* (measured – expected*)*, which is the more common method.

DRIP METHOD

1. Put the screen aside and replace the funnel and collector.

2. Reset the precipitation counter (PREPARATION step 8).

3. Loosen and extend the legs of the tripod and place it so that the center is positioned over the funnel opening of the rain gauge. Attach the drip bottle to the tripod with the hook (Figure 3) and adjust the tripod legs so that the nozzle is 1 – 2 inches above the funnel opening.

4. Slowly open the nozzle on the drip bottle, allowing water to drip into the funnel at a rate of 2 – 3 drips per second.

5. As the drip bottle is emptied, the weight of the water above the nozzle decreases, thereby slowing the drip rate. Carefully adjust the nozzle as needed throughout the test to maintain a rate of 2 – 3 drips per second.

6. The drip test is complete when the drip bottle is empty. Display the precipitation counter on the CR10KD display (PREPARATION step 7).

7. In the worksheet (Appendix B), if 680 mL of water was used, the *number of tips* is 50. Record *observed tips* (precipitation counter reading x 100), *difference* (number of tips – observed tips), and *percent difference* (difference/number of tips). The passing tolerance is ±10% (See NOTE after PIPETTE METHOD step 6).

POST-AUDIT

1. Refer back to PREPARATION to re-check the level (step 6), then replace the funnel, screen, and collector.

2. Refer back to PREPARATION to clear the precipitation counter (step 8), access software flags (step 3), and press 2 to set flag 2 *low*.

3. If the CR10KD keypad display is no longer needed (e.g. audits are complete), remove it from the CR10 wiring pane and re-attach the modem cable to the wiring panel's 9-pin connector.

FAILURE

Rain gauges found to exceed a ±10% tolerance should be carefully re-tested using the pipette method. If subsequent tests result in failure, remove the rain gauge and send it to the lab or to the manufacturer for re-calibration. **Do not attempt to perform a**

field calibration. An accurate calibration can only be obtained in the lab or manufacturer. The tipping point for the buckets can be adjusted in the lab by turning the adjusting screws located under the lip of each bucket.

PREVENTATIVE MAINTENANCE

10 mL Pipette
Clean and inspect the 10 mL pipette for cracks and debris before each season of audits. Replace if damaged or dirty. The pipette should be stored in the calibration case when not in use.

Electronic Level
Be careful not to drop the electronic level or get it wet to prevent damage to the electronics. Store in a secure area inside the field vehicle when not in use.

CALIBRATION AND CERTIFICATION PROCEDURES

10 mL Pipette
The pipette does not need to be calibrated. Replace if damaged or dirty.

Electronic Level
The electronic level should be calibrated before each season of audits. The calibration procedure is as follows:

1. Power on the level. If necessary, push the *º%IN/FT* button until degrees is displayed.
2. Place the level on a flat, level or nearly level (< 5º) surface with the display facing you.
3. Wait for the reading to stabilize, then press the *calibrate* button. *CAL 1* should be displayed.
4. Wait for the reading to stabilize, then press the *calibrate* button again. When *CAL 2* appears on the display, rotate the level 180º so that the display faces away from you.
5. When the reading stabilizes, press the *calibration* button to complete the calibration.

AUTHORS, REVISIONS, AND APPROVALS

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2. US Environmental Protection Agency. February 2000. *Meteorological Monitoring Guidance for Regulatory Modeling Application*.. EPA-454/R-99-005. http://www.epa.gov/scram001/guidance/met/mmgrma.pdf

APPENDIX A

BAAQMD CALIBRATION RECORD

PRECIPITATION AUDIT WORKSHEET

(PIPETTE METHOD)

BAAQMD RAIN GAUGE AUDIT REPORT

Site Name:

Auditor:

Date: Start Time (pst): Finish Time(pst):

Sensor Mfg :	**Texas Electronics**	Rain gauge level :	º
Model No :	**TR-6118**	Calibration device used :	10 ml Pipette
Serial No :		Last calibration :	
Sensor Ht :		Mechanical Tip Test :	Results: Pass/Fail

Number of tips:	Expected depth (in)	Data logger in.	Difference
20	**.20**		

Results: Pass/Fail

Observed Tip Volume L Bucket				**Observed Tip Volume R Bucket**			
1	_____	**7**	_____	**1**	_____	**7**	_____
2	_____	**8**	_____	**2**	_____	**8**	_____
3	_____	**9**	_____	**3**	_____	**9**	_____
4	_____	**10**	_____	**4**	_____	**10**	_____
5	_____	**11**	_____	**5**	_____	**11**	_____
6	_____	**12**	_____	**6**	_____	**12**	_____

Tip Volume:

Expected tip Volume in ml:	Average tip L bucket:	Diff:	%Diff.	Average tip R bucket:	Diff.	%Diff.

Tolerance: 10% (each bucket) L Bucket Results: Pass/Fail R Bucket Results: Pass/Fail

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Total rainfall:

Number of tips	Expected volume ml.	Measured volume ml.	Diff.	%Diff.
24	**326.4**			

Tolerance : 10% Results: Pass/Fail

Comments:

APPENDIX B

BAAQMD CALIBRATION RECORD

PRECIPITATION AUDIT WORKSHEET

(DRIP METHOD)

BAAQMD RAIN GAUGE DRIP TEST

Site Name: _____

Auditor: _____

Date: _____ Start Time (pst): _____ Finish Time(pst): _____

Sensor Mfg : **Texas Electronics**
Model No : **TR-6118**
Serial No : _____
Sensor Ht : _____

Last Calibration Date: _____
Rain Gauge Level: _____°
Calibration Device Used: 500 ml. drip bottle w/680 ml. of water.

Mechanical Tip Test:

Results: Pass/Fail

Manual Tip Test:

Number of tips:	Expected depth (in)	Data logger in.	% Diff.
20	**.20**	_____	_____**%**

Tolerance: 0%

Results: Pass/Fail

Total Rainfall (Not to exceed 3 drops / min.)

Expected Tip:	Observed Tips:	Diff:	%Diff.
50	_____	_____	_____**%**

Tolerance: 10%

Results: Pass/Fail

Comments: