EML Environmental Measurements Limited

Rain Gauge Field Verification Kit and Pulse Counter

Figure 1 - The EML Rainfall Intensity Field Verification Kit (P-780-650) with Pulse Counter (P-780-630), The two items, the field verification kit and the pulse counter, are available separately.

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1. General Information

About this Manual

This manual is intended as a general guide for using the Rain Gauge Field Verification Kit and Pulse Counter with different rain gauges. The information contained herein may not cover all aspects of applications. Please refer to associated equipment manuals or consult papers and technical notes on the EML website (www.emltd.net).

Version Information

Table 1 - Document Revisions

EML Document Number:	Description:
Description Rainfall Intensity Field Test Kit_v2.docx	Internal draft version of the User Manual
UM-P-780-650	Version 1.0 - First Release, dated 26/11/2019

Related Manuals

Table 2 - Related Manuals

EML Document Number:	Description:
PN3067 - Testing Report May_2019.docx	Testing report carried out on three field verification kits to determine repeatability and produce a combined uncertainty estimate.

Ordering Information

Table 3 – Ordering information

Product code	Description
P-780-630	Digital Pulse Counter
P-780-650	Rain Gauge Field Verification Kit (No Pulse Counter)

2. Product Description

The EML field verification kit is a simple mechanical device which can be used to simulate five different flow rates. By using three sizes of bottle, the approximate duration of each testing schedule can be planned based on a field engineer's available time. Figure 1 on the first page of this manual shows a picture of the field verification kit (P-780-650) and the pulse counter (P-780-630). The kit can be purchased with or without the pulse counter, which is the square box on the right-hand side of Figure 1. See the Ordering Information on Page 5 for more details. If the pulse counter is included, the full kit is comprised of:

a) Three bottles of different sizes (**147ml, 298ml and 530ml** – when filled to the brim)
b) A funnel with five nozzle attachments, each with a different hole diameter **(0.6, 1.0, 1.2, 1.5 and 2.0mm)**
c) Bubbler device and acetal covering to ensure a constant head during tests
d) Aluminium lined carrying case (shown in Figure 1)
e) A clear Perspex plate to put across the rain gauge orifice (suitable for orifices up to 500cm^2) – shown at the back of the case in Figure 1
f) Pulse counter and cable to record the number of tips – shown as the box on the right hand side of Figure 1 (for tipping bucket gauges or weighing rain gauges with a tipping bucket output)

3. Description of Operation

1) Connect the counter to the rain gauge, if using a tipping bucket rain gauge (TBR) or connect the gauge to a PC or other suitable device, if using a weighing gauge or digital-output TBR.
2) Ensure the gauge is level and place the Perspex plate on top of the gauge orifice.
3) An appropriate brass nozzle and bottle combination is selected from Table 4 (lower left) and described on page 6.
4) Fill the bottle **to the brim** with water and screw the special plastic nozzle cap onto the cutaway bottle cap - shown on top of the medium bottle in the middle of Figure 2.
5) The appropriate brass nozzle is placed on the end of the funnel, like in Figure 2.
6) Place the acetal plastic piece inside the top of the funnel and position so that the brass nozzle is pointing upwards (as shown in Figure 2). Then, place this over the top of the selected bottle. **NB:** in order to prolong the lifespan of the plastic funnel, do not force the brass nozzle on.
7) Take these pieces in hand, and tip them into the hole in the Perspex plate which is sitting on top of the rain gauge. They should fit snuggly, allowing no rainfall to get into the rain gauge if it is raining while the tests are being performed. **To watch a video of this process, click here.**
8) It is good practice to make a note of the time the test starts.
9) Once the water has totally drained from the bottle and the test is completed, note the value shown on the counter or PC.
10) Repeat this procedure for the required number of tests/intensities using different bottle and nozzle combinations.

Figure 2 - Three bottles, five brass nozzles, plastic funnel, acetal ring and special acetal bottle-nozzle, comprising the majority of the field verification kit.

Table 4 (upper) shows the ideal expected tip counts (red) and the equivalent rainfall depths (green) for a range of different rain gauge funnel areas, for each of the three bottle sizes. Note that if partial tips are not taken into account, then it is important to **round down** these values. An example is provided in the line of text underneath this sub-table, marked with an asterisk (*).

Table 4 (lower left-hand side) shows test durations for different combinations of bottle size and nozzle diameter. This should be used to plan the testing schedule. Only the recommended operationally practical tests have been included in this table (green), whereas less practical combinations of bottle and nozzle have been marked with a red X. The recommended minimum test time is 3 minutes for the largest nozzle, in order to try to limit any edge effects at the beginning and end of the tests, such as partial filling of the tipping bucket mechanism. In general, a longer test will provide a more reliable flow rate. This part of the table also displays the average flow rate generated by each nozzle.

The lower right-hand side of Table 4 (on the right of the blue arrows) shows columns of the equivalent rainfall intensity in mm/hr for five rain gauges, with orifice areas marked in cm^2.

Figure 3 and Figure 4 are plots showing the correspondence between flow rate and equivalent rainfall intensity for rain gauges with different orifice areas. They are included for reference. Figure 3 uses standard axes and Figure 4 uses Log axes, which makes the lower intensities easier to read.

Note: Standard tipping bucket rain gauges are calibrated at one intensity, typically between 15 and 50mm/hr. At intensities higher than the calibration intensity, these types of gauges can under-record, and below the calibration intensity they can over-record. The Appendix shows an example of real data from an EML SBS500 rain gauge (calibration intensity = 20mm/hr), broadly representative of the performance a typical pulse output tipping bucket rain gauge with a single-point (static) calibration. See the **Quick Start Guides** for all EML Rain Gauges to find how many tips you need for each test run.

Table 4 - Upper – Showing the ideal tip counts and rainfall depths (mm) for six funnel areas and three bottle sizes, for a 0.2mm per tip rain gauge

***Lower left-hand side of dotted line**: Showing the test durations of different combinations nozzle diameter and bottle size. Also shows the average flow rate for each nozzle diameter.*

***Lower right-hand side of dotted line**: Showing the equivalent rainfall intensities corresponding to each flow rate for rain gauges with different orifice areas, in cm^2*

	Ideal *tip count* / *rainfall depth* for 0.2mm per tip gauges with funnel collecting areas of:					
Bottle Size (ml)	**127cm²**	**200cm²**	**314cm²**	**324cm²**	**400cm²**	**500cm²**
Small (147)	58.1 / 11.62 mm	36.8 / 7.35 mm	23.4 / 4.68 mm	22.7 / 4.54 mm	18.4 / 3.68 mm	14.7 / 2.94mm*
Medium (298)	117.8 / 23.56 mm	74.5 / 14.90 mm	47.5 / 9.49 mm	46.0 / 9.20 mm	37.3 / 7.45 mm	29.8 / 5.96 mm
Large (530)	209.5 / 41.9 mm	132.5 / 26.50 mm	84.4 / 16.88 mm	81.8 / 16.36 mm	66.3 / 13.25 mm	53.0 / 10.6 mm

***Important Note: when not measuring partial tips, all values should be *rounded down* appropriately, either to the nearest full tip, or to the nearest 0.2mm increment e.g. grey highlighted cell would read: 14.0 / 2.8mm**

		Bottle Size (Volume in ml):					Equivalent Rainfall Intensity (mm/hr) for Gauge Area cm2:					
		S (147)	M (298)	L (530)			**127**(Kalyx)	**200**(Pluvio)	**314**(SBS314)	**324**(EA)	**400**(Casella)	**500**(SBS500)
Nozzle diameter (mm):	0.6	12.9	X	X	11	**Flow Rate (ml/min) [Approx. Ave.]:**	52	33	21	20	16	13
	1.0	X	8.8	X	34		161	102	65	63	51	41
	1.2	X	5.8	X	52		246	156	100	96	78	62
	1.5	X	X	5.4	98		464	294	187	182	147	118
	2.0	X	X	3.2	166		786	498	317	308	249	199
		Av. time to empty (mins):										

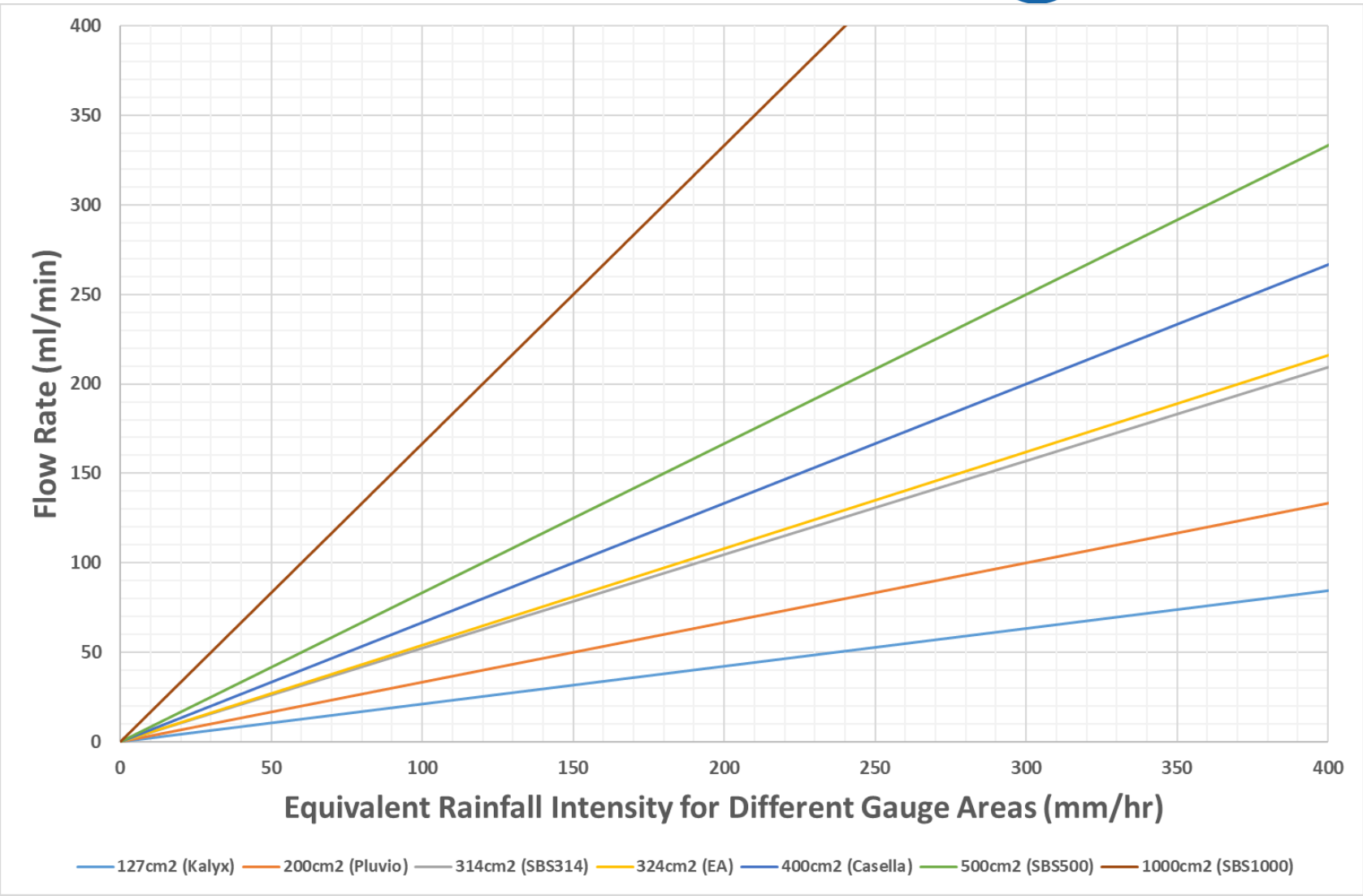

Figure 3 - Flow rates and corresponding equivalent rainfall intensities for rain gauges with different orifice areas

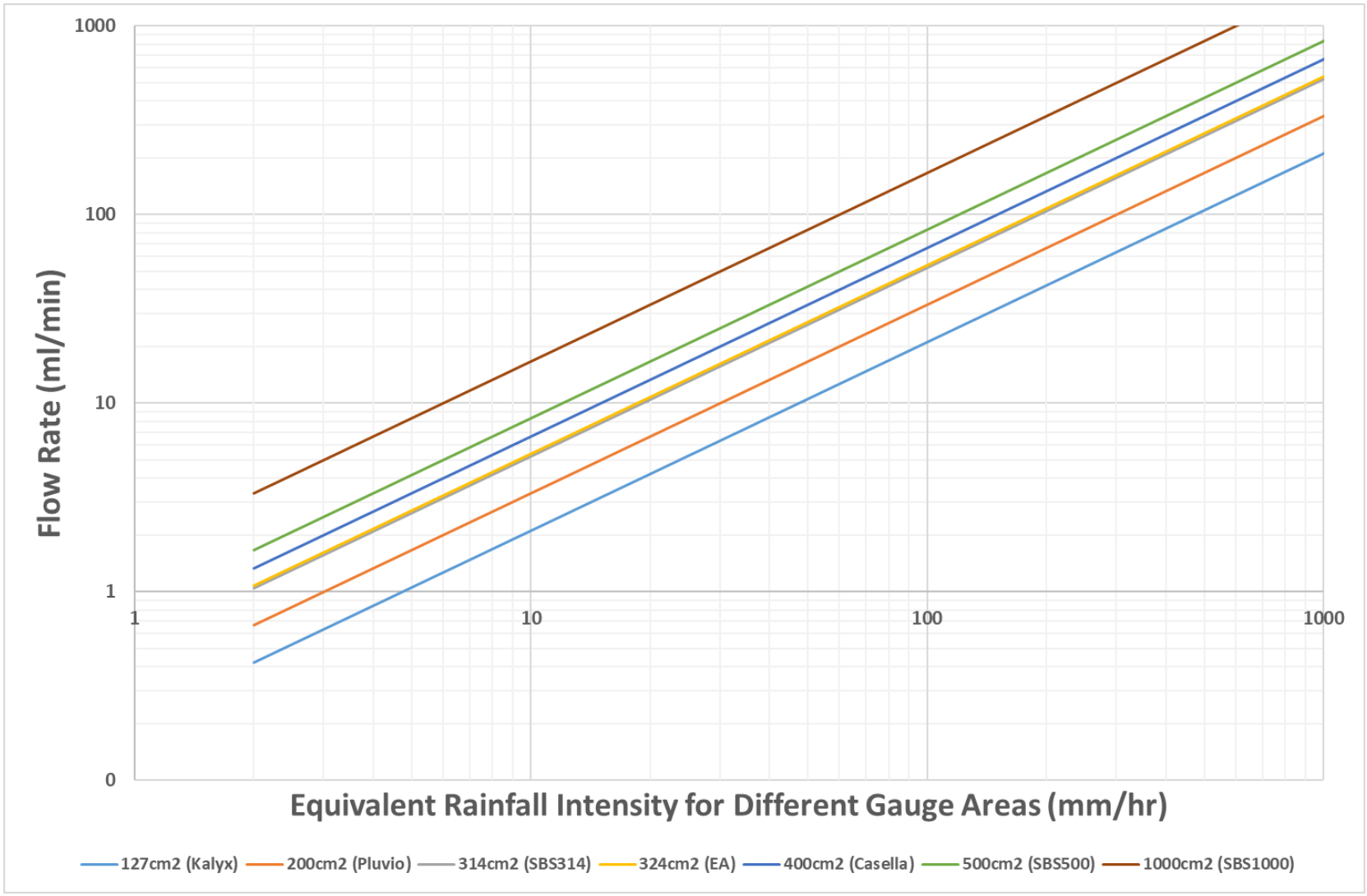

*Figure 4 - Flow rates and corresponding equivalent rainfall intensities for rain gauges with different orifice areas (same as Figure 2 but with **Log axes**)*

4. Maintenance

To ensure good repeatability of the brass nozzles, it is important to keep them free from dust and dirt. This is particularly important for the nozzles with the smallest diameter holes, i.e. the 0.6mm and the 1.0mm, which tend to become blocked or partially blocked more easily, thus affecting the flow rate. To clear dirt and dust from the holes, a total of five drill-bits have been included, one for each nozzle. **NOTE:** Care must be taken not to force a larger drill-bit into a hole which is smaller than the drill-bit itself, otherwise the hole will be damaged, and the flow rates will alter.

5. Statement of Performance in the Laboratory

To test the performance of the field verification kits, a full testing schedule was developed, and a report produced. That report is available on request. To summarise the results of the report, the testing schedule was performed on three field verification kits, with an assessment of the combined uncertainty value produced for each of the five nozzles. The applicability of this user manual hinges on the repeatability of performance between multiple field test kits. More information can be found in the test report, but after a total of 45 repetitions on three field test kits, the results indicated that 87% of the test data were within +/- 5% of the mean value, and 100% was within +/-10%. This is summarised in the following plot, where each boxplot represents one bottle-nozzle combination (shown on the x-axis), and where the y-axis shows the flow rates standardised by the appropriate average flow rate. A summary of the achievable accuracy is supplied in the Table 5 in Section 6 (page 11).

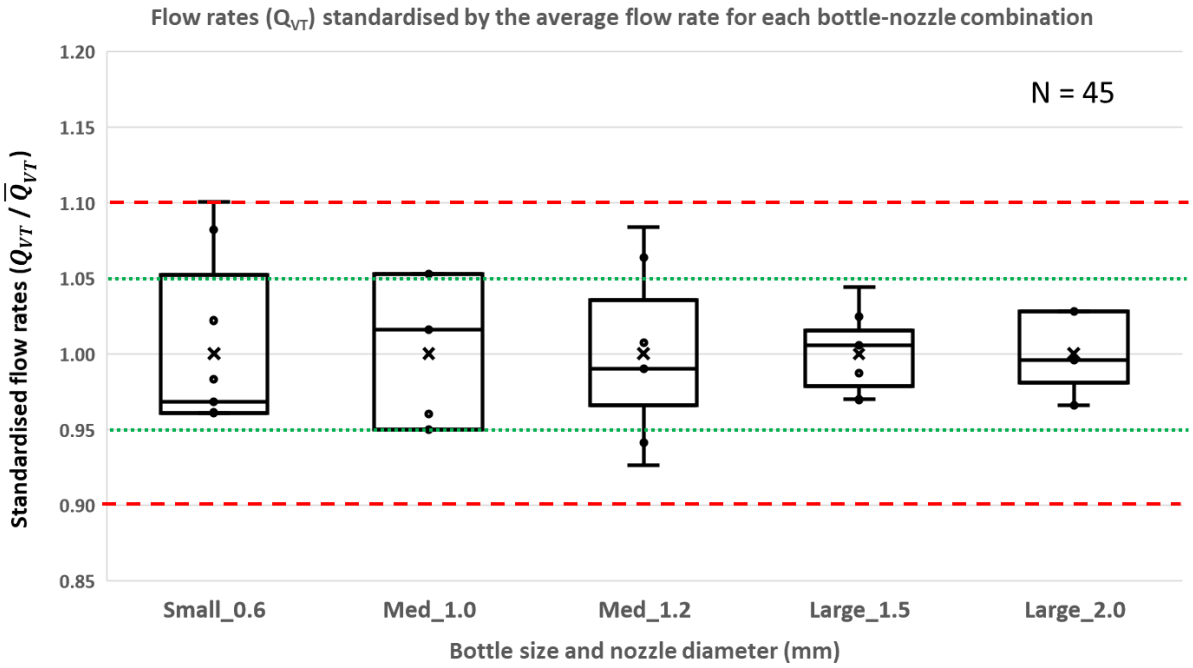

Figure 5 - Standardised flow rates for each bottle nozzle combination, with green and red lines showing the +/-5% and +/-10% limits, respectively. Each boxplot represents nine repetitions (n=9)

6. Specifications

Table 5 – Specifications for Rain Gauge Field Verification Kit

Technical Specifications		
Precision / Repeatability	**Nozzle Diameter**	**Repeatability**
	0.6mm	+/- 10%
	1.0mm	+/- 10%
	1.2mm	+/-10%
	1.5mm	+/- 5%
	2.0mm	+/- 5%
Rainfall Intensity	Five difference flow rates available (See Table 4 for more info)	
Rain Gauge Collecting Areas	$127cm^2 – 500cm^2$	
Operating Temperature	0°C - 60°C	
Weight	3Kg	

Appendix – Conventional Tipping Bucket Rain Gauge Example

In operational practice, a partially full bucket at the end of a test may not be recorded by a user, so the value recorded represents an underestimate. E.g. 14.7 tips would be recorded as 14.0 tips if the user does not measure the water remaining in a bucket which hasn't tipped. In addition to this, conventional tipping bucket rain gauges with a simple pulse output are calibrated at one intensity in the laboratory, this calibration intensity is typically between 15 and 50mm/hr. Therefore, when tested with intensities that are higher than the calibration intensity, such gauges under-record by an amount which is generally repeatable. Table 6 below shows the ideal number of tips and the actual number of tips at rainfall intensities generated by different diameter nozzles for the SBS500. The final two columns of the table show that at the intensities close to the calibration intensity, the performance of the rain gauge is close to ideal. However, at higher intensities the number of tips start to be underestimated. **If your EML rain gauge repeatedly provides values similar to those in the final column, then it is performing how it is supposed to perform.**

Table 6 – Example data from an EML SBS500 0.2mm Rain Gauge with a calibration intensity of approx. 15mm/hr

Nozzle Diameter (Bottle used – S / M / L)	Approx. Rainfall Intensity	"Ideal" No. of Tips	Actual No. of Tips: for an EML SBS500 0.2mm rain gauge (if partial tips not recorded)
0.6mm (Small Bottle)	13 mm/hr	14.7	14 – 15 tips
1.0mm (Medium Bottle)	41 mm/hr	29.8	28 – 29 tips
1.2mm (Medium Bottle)	62 mm/hr	29.8	28 – 29 tips
1.5mm (Large Bottle)	118 mm/hr	53.0	48 – 49 tips
2.0mm (Large Bottle)	199 mm/hr	53.0	47 – 48 tips