BISHOP PAIUTE TRIBE
ENVIRONMENTAL MANAGEMENT OFFICE

PRECIPITATION CALIBRATION TESTS

August 12, 2009

This report describes the results of several precipitation calibration tests carried out in July 2009, following audit findings from November 2008 that indicated that one of the Tribe's precipitation gauges was reading low.

The audit carried out by Dave Yoho from T&B Systems showed that the Tribe's precipitation gauge TR-525I, manufactured by Texas Electronics and purchased from Climatronics was reading 18.6% below the audit input, as shown below. The second table shows a correction for two 5-minute intervals of data that were accidentally omitted from the data transmission to the auditor. Either way, the precipitation gauge appears to be out of calibration.

T&B Audit, November 11, 2008 – 9:50 PST TO 11:00 PST

Audit Point	Inches Input	Inches DAS	% Diff. DAS
1	1.06	0.86	-18.6

Audit Criteria: ±10% of input
Comments: The audit results do not meet the audit criteria. A calibration of the precipitation gauge is recommended.

Correction last two 5-minute intervals of data accidentally omitted from data transmission to auditor.

Audit Point	Inches Input	Inches DAS	% Diff. DAS
1	1.06	0.91	-14.2

The original T&B audit was carried out using a Gatorade bottle with an adjustable nozzle that had been modified to be used as a funnel and would yield a relatively low drip rate. Water was obtained from a purchased 500ml bottle of drinking water. The original audit took a little over an hour.

In response to the findings we determined that instrument calibration was appropriate. Initially we attempted to reproduce the results using the manufacturer-specified field calibration kit FC-525 that is specifically designed for the TR-525 gauges. We utilized the brass #65 nozzle that is specified to take 25 minutes and yield 98 counts plus or minus 2 counts. The results are shown below.

First Verification, July 7, 2009

Date **Start Time** **Finish Time**	*7/7/2009* 8:50 PST 9:20 PST	**Site** **Operator(s)**	*Bishop Tribe EMO* *Toni Richards, Walter Hanson*				
Sensor		**Audit Instrument**					
Manufacturer **Model** **Funnel Diameter**	*Climatronics / Texas Electronics* *100505-GO* *6.06*	**Manufacturer** **Model** *inches*	*Texas Electronics* *FC-525 w/ #65 nozzle (brass) per manufacturer's specifications*				
Cal Point	**Audit Instrument**	**Sensor Reading**	**Units**	**% Difference**	**Method**	**ml**	
1	*0.99*	0.97	*inches*	-2.5%	Tex Electronics	470	actual measurement

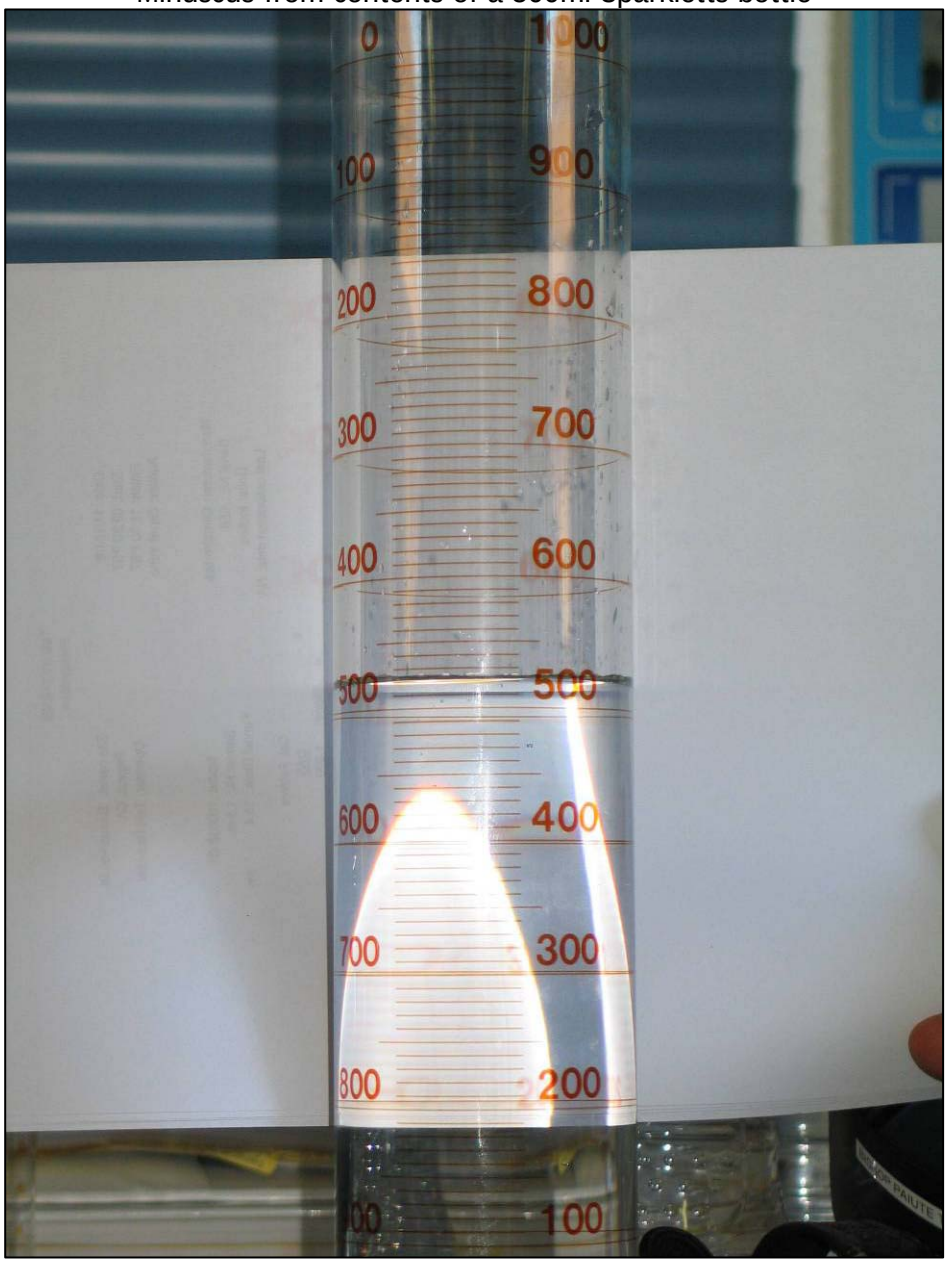
We were pleased with the results but puzzled that they were so different from the audit results. When we discussed these results with Dave Yoho at T&B systems he advised us to try to replicate his method using a Gatorade bottle and a 500ml bottle of drinking water.

As a consequence, we verified the volume of water in the beaker supplied as part of the kit using a glass laboratory beaker. A value of 473 ml had been supplied by Texas Electronics to GBUAPCD and we measured 470 ml, although it is unlikely that we could have detected such a small difference in our large beaker and such a small difference would not significantly alter our results. Even after several try's, the volume was reproducible. See photograph below.

Meniscus on 1000ml beaker after being filled with water from FC-525 kit

We then set up a test replicating the T&B Gatorade bottle / water bottle method. We discovered that Gatorade is no longer supplying that type of bottle in our area and substituted a similar Propel bottle, with the bottom removed so that it could serve as a funnel. For the water, we used 500ml Sparkletts drinking water. To make the test fair, we made sure that both the FC-525 funnel equipped with the brass #65 nozzle and the propel dripped at approximately the same rate. In addition, we measure the volume of a "full" Sparkletts bottle – one where the water was near the rim just below the cap on the bottle. We found this type of bottle typically contained 520ml of water. See the photograph below.

Minuscus from contents of a 500ml Sparkletts bottle



In the process, we noted that there appears to be some variability in the volume of water in Sparkletts bottles. All of the bottles in the next photograph are from the same case purchased from Smart and Final.

Volume of water in Sparkletts bottles

Next we compared the two methods on both the Texas Electronics TR-525I and a Davis Instruments Grow Weather precipitation gauge that is situated on the same platform, with the results shown below. For the water volumes, we used the volumes that we had actually measured.

Method Comparison, July 15, 2009

Date	*7/15/2009*	**Site**	*Bishop Tribe EMO*				
Start Time	7:35 PST	**Operator(s)**	*Toni Richards, Walter Hanson*				
Finish Time	8:35 PST						
Sensor		**Audit Instrument**					
Manufacturer	***Climatronics*** */ Texas Electronics*	**Manufacturer**	*Texas Electronics*				
Model	*100505-GO*	**Model**	*FC-525 w/ #65 nozzle (brass)*				
Funnel Diameter	*6.06*	*inches*	*per manufacturer's specifications*				
Cal Point	**Audit Instrument**	**Sensor Reading**	**Units**	**% Difference**	**Method**	**ml**	
1	*0.99*	0.97	*inches*	-2.5%	Tex Electronics	470	actual measurement
2	*1.10*	1.06	*inches*	-3.7%	500ml water bottle / propel	520	actual measurement
Date	*7/15/2009*	**Site**	*Bishop Tribe EMO*				
Start Time	7:35 PST	**Operator(s)**	*Toni Richards, Walter Hanson*				
Finish Time	8:35 PST						
Sensor		**Audit Instrument**					
Manufacturer	***Davis Instruments***	**Manufacturer**	*Texas Electronics*				
Model	*Grow Weather*	**Model**	*FC-525 w/ #65 nozzle (brass)*				
Funnel Diameter	*6.5*	inches	*per manufacturer's specifications*				
Cal Point	**Audit Instrument**	**Sensor Reading**	**Units**	**% Difference**	**Method**	**ml**	
1	*0.86*	0.88	*inches*	1.8%	Tex Electronics	470	actual measurement
2	*0.96*	0.95	*inches*	-0.7%	500ml water bottle / propel	520	actual measurement

To our relief, both methods yielded similar results for each instrument. In each case, the calibration took approximately 25 minutes.

Further discussion with Bob Baxter at T&B systems lead to the concern that the #65 Texas Electronics drip rate was too rapid and a slower rate would yield more accurate results. We then tested the Texas Electronics using the FC-525 with the #70 nozzle yielding a calibration duration of 45 minutes. We also tested the Propel bottle adjusted for a drip rate lead to a calibration duration of 45 minutes and one that led to a calibration duration of at least 1 hour, to match the original audit time.

Third Verification, 45 minutes, July 23, 2009

Date	*7/23/2009*	**Site**	*Bishop Tribe EMO*				
Start Time	9:00 PST	**Operator(s)**	*Toni Richards*				
Finish Time	9:45 PST	**Auditor**					
Sensor		**Audit Instrument**					
Manufacturer	*Climatronics*	**Manufacturer**	*Texas Electronics*				
Model	*100505-GO*	**Model**	*FC-525 w/ #70 nozzle (aluminum)*				
Funnel Diameter	*6.06*	*inches*	*per manufacturer's specifications*				
Cal Point	**Audit Instrument**	**Sensor Reading**	**Units**	**% Difference**	**Method**	**ml**	
1	*0.99*	0.99	*inches*	-0.4%	Tex Electronics	470	actual measurement

Fourth Verification, August 4, 2009

Date	*8/4/2009*	**Site**	*Bishop Tribe EMO*				
Start Time		**Operator(s)**	*Toni Richards, Walter Hanson*				
Finish Time		**Auditor**					
Sensor		**Audit Instrument**					
Manufacturer	*Climatronics*	**Manufacturer**	*n/a*				
Model	*100505-GO*	**Model**	*n/a*				
Funnel Diameter	*6.06*	*inches*	*per manufacturer's specifications*				
Cal Point	**Audit Instrument**	**Sensor Reading**	**Units**	**% Difference**	**Method**	**ml**	
1 -- 45 minutes	*1.10*	1.06	*inches*	-3.7%	500 ml water bottle / propel	520	actual measurement
2 -- 75 minutes	*1.10*	1.12	*inches*	1.8%	500 ml water bottle / propel	520	actual measurement

Even after multiple tests using multiple methods, we are unable to replicated the audit results and our verification efforts suggest that the Climatronics precipitation gauge is within specification.

To better understand the EPA guidance on matters of calibration and verification, we consulted with Chris Lanane from GBUAPCD who provided the following information.

> The reference is EPA Volume IV: Meteorological Measurements, of the Quality Assurance Handbook for Air Pollution Measurement Systems, EPA-454/B-08-002, March 2008, Section 4.3, **Calibration**, which states, "For rate-sensitive systems such as the tipping bucket, the rate of simulated

> precipitation should be kept constant to achieve 1 tip every 15 seconds." That is 2.4 inches per hour for calibration, however, in Section 4.5, **Auditing**, the document states that, "For tipping bucket gauges, a rate of less than one inch per hour should be used and an amount which will result in a minimum of 10 tips." By inference, the indication is that the precip gauge should work anywhere between those two inputs, from 1 to 2.4 inches per hour. *(Emphasis added.)*

We calculated that if we use the #65 FC-525 nozzle, the rate would be 2.4 inches per hour and the #70 FC-525 nozzle would yield a rate of 1.33 inches per hour. Both seem to be within EPA Guidance for calibration. However, both rates exceed the guidance for audits.

Finally, we consulted the manufacturer, Texas Electronics who indicated that the instrument was sensitive to changes in the flow rate and that variability was to be expected from any verification method that did not have a constant flow rate, such as the two we considered. We searched for other methods of verification, including a model made by HydroLynx that has a constant flow. However, this gauge is better suited for shorter high flow tests than the low rates specified by the EPA auditing guidance and by our auditor.

CONCLUSIONS

After discussions with both Bob Baxter at T&B Systems and Chris Lanane at GBUAPCD, and our own experience, we conclude that several things, either singly or in combination could have led to the discrepancies between our findings and the audit results. There had been no rain in October and only a fraction of an inch in November prior to the audit, so the gauge was dry and potentially dusty. Chris Lanane recommended wetting the tipping buckets prior to starting an audit. We have noted variability in the volume of water in the Sparkletts brand of drinking water and it is possible that the volume in the bottle used by our auditor was also low. Of course, both types of problems may have occurred.