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1.0. INTRODUCTION

The Belfort recording rain gage is a device which converts the weight of precipitation (collected by an internal catch bucket) into an up-and-down motion of a recording pen on a paper chart. This instrument is widely used by national and state-level monitoring networks because of its ability to provide good resolution of precipitation timing and amount during a recording period, and its ability to provide hard copy of that data.

This guide is intended to address troubleshooting and checking of the instrument as pertinent to NADP/NTN monitoring program. It does not provide detailed information on calibration or other related mechanical systems within the rain gage.

For purposes of brevity the Belfort 5-780 will hence forth be referenced by the words GAGE or RAIN GAGE and the Aerochem Metrics Wet/Dry Precipitation Collector will be referenced as ACM.

IF YOU EXPERIENCE A RAIN GAGE MALFUNCTION PLEASE INFORM THE CAL:

(1) call the CAL at 800-952-7353

(2) briefly describe the malfunction and indicate its occurrence on the Field Observer Report Form for that sample. Continue to do this for each sample affected until the malfunction is eliminated. If you use auxiliary precipitation information please remark on the field form the type of rain gage substituted and its approximate distance from the wet-dry precipitation collector.

Example: Rain gage clock stopped on Thursday. Took precipitation from 8" stick gage, measured daily at 0800, 25' away.
2.0.  **PARTS REFERENCE LIST**

This list identifies parts by name and assigns part numbers that are used in conjunction with the “Pictorial Guide to Parts” section which follows. Also, all part numbers are cross-referenced to a corresponding photo number.

Some part numbers are referenced in the “Trouble Shooting” section of this text. Individual part numbers are signified by parenthesis throughout the text (e.g. (1)==Catch Bucket).

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<td>Top Lever</td>
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<td>15</td>
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</table>
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RAIN GAGE DETAILED VIEW
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<tbody>
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<td>18</td>
<td>Funnel</td>
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<tr>
<td>19</td>
<td>Event Recorder Solenoid</td>
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<td>20</td>
<td>Event Recorder Pen and Arm</td>
</tr>
<tr>
<td>21</td>
<td>Event Recorder Pivot Point</td>
</tr>
<tr>
<td>22</td>
<td>Event Recorder L-Bracket</td>
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</table>
PHOTO #3
TOP CAP AND FUNNEL ASSEMBLY

PHOTO #4
EVENT RECORDER GENERAL VIEW
Components on Facing Page

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>Clock Body</td>
</tr>
<tr>
<td>24</td>
<td>Output Shaft</td>
</tr>
<tr>
<td>25</td>
<td>Clock Gear</td>
</tr>
</tbody>
</table>
PHOTO #5
CLOCK TOP VIEW (WITH GEAR IN PLACE)
4.0. TROUBLESHOOTING

For the purposes of this manual the weighing and writing mechanisms of the rain gage and the event recorder mechanism (which is shared between the rain gage and the ACM) will be presented as two distinct subsections within Troubleshooting. Most of the parts and systems discussed are visible from the door of the rain gage.

4.1. Event Recorder Unit - “What It Does.”

The event recorder takes a 12-volt DC power signal produced by the motor box of the ACM and converts it into an up-and-down record on the rain gage chart. The purpose of the event recorder is to allow site and laboratory personnel to evaluate the open/close cycles of the precipitation collector in relation to the incidence of precipitation.

As DC power energizes the event recorder solenoid (19) the solenoid activates the event recorder L-bracket (22) and thus the event recorder pen and arm (20). This means that the wet-side bucket of the precipitation collector is exposed. After an event subsides and the ACM closes the solenoid is de-energized and the mechanism drops down in response to gravity.

4.2. Event Recorder Unit - “What Goes Wrong.”

Malfunctions of the event recorder are often traced to a source external to the rain gage itself. Typically these are the ACM or the cable connecting it to the gage. CAUTION: - Thoroughly check those external systems prior to spending lots of time on the event recorder (reference Appendix C, Aerochem Metrics Maintenance Manual).

When the event recorder itself does break, the malfunctions typically fall into two categories: 1) Failure to rise upon power supply; and 2) Failure to drop upon power reduction (see Flow Chart #1).
FLOW CHART #1

EVENT RECORDER TRACE DOES NOT COINCIDE WITH THE OCCURRENCE OF PRECIPITATION

Check Terminal on Event Recorder in Raingage

If power is present

Visually Check the Activity of the Event Recorder Solenoid

If solenoid is not moving

Replace Event Recorder
Call the CAL

If solenoid is moving

Lubricate Event Recorder Mechanism or Call the CAL

If power is present

Measure for DC Power at Event Recorder Terminal of Wet/Dry Collector

If power is not present

Event Recorder Power Cable Defective. Replace

Reference ACM Maintenance Manual
Motor Box is bad
FLOW CHART #2

RAINGAGE WEIGHING MECHANISM NOT CORRECTLY RESPONDING TO THE ADDITION OF PRECIPITATION TO THE CATCH BUCKET

Make Two 825 gram Weights (Water Filled Bottles, etc.). Place Weights in Raingage Bucket One at a Time, Noting the Response

If

Gage Response is too Little for the First Weight and about Normal for the Second.

Then

Zero Offset Error Indicated. See Section 4.4. Limit Screws are out of Adjustment.

If

Gage Response is Abnormal for Both Weights.

Then

Gage Calibration Problem is Evident. Call CAL Prior to any Onsite Attempts to Recalibrate the Gage. Document the Extent of the Error.

Calibration Looks OK

Then

Call CAL for Further Assistance
4.2.1. Failure to Rise

Generally problems with the rising of the event recorder pen will not be due to the mechanical linkage but to a malfunction in the event recorder solenoid. To confirm this, examine the event recorder solenoid (19) for motion when it receives power. If a malfunction exists within the solenoid the event recorder must be replaced.

If power and motion have been confirmed at the event recorder terminal (15), the mechanical function of the event recorder pen and arm (20) and event recorder L-bracket (22) should be checked.

Simply move the pen arm up-and-down with your fingers, checking for freeness of the mechanism and the condition of the event recorder pivot point (21). If the mechanical linkage appears to be binding and thereby reducing the motion of the pen, lubricate the pivot point (21) in order to achieve the motion required. NOTE: Only Silicon or Teflon based aerosol lubricants should be used. By using the tube which comes with these types of aerosols you can irrigate (clean) and lubricate the pivot point at the same time.

4.2.2. Dropping of the Event Recorder Pen

As opposed to the powered function of its rising, the dropping of the event recorder depends entirely on the force of gravity. The weight of the pen and pen arm (20) and the L-bracket (22) on the pivot point cause the pen to move down.

If the dropping function is impeded, lubricate the pivot point (21) and attempt to work the mechanism free. If this does not solve the problem additional weight must to be added to the event recorder mechanism. Call the CAL for advice.

4.3. Rain Gage Weighing and Writing Mechanism - “What It Does”

Precipitation falling through the top section and into the catch bucket mounted on its support shaft causes the linkage at the rear of the instrument to rotate the shaft upon which the rain gage pen and arm are mounted. In this manner a series of levers and shafts, herein called the fine linkage, translates approximately 825 grams of precipitation into 1" of deflection at the pen. This deflection is marked on the chart by the pen tip which is filled with ink.

DO NOT ATTEMPT MODIFICATION OF THE CURRENT FINE LINKAGE SETTINGS. INCORRECT SERVICING CAN CAUSE SEVERE DAMAGE TO THE MECHANISM.

4.4. Rain Gage Weighing and Writing Mechanism - “What Goes Wrong”

The functions of the gage have been divided into two general categories:

1) weighing functions - generally pertaining to the physical transfer of the precipitation weight to a pen motion; and
2) writing functions - which consist of the pen accurately and dependably writing on the chart.
4.4.1. **Weighing Functions**

As previously mentioned the mechanism in the fine linkage of the rain gage is not to be modified. There are, however, several areas on the rain gage which may be checked in order to identify the area of malfunction. These areas include: the zero adjustment screws (2), limit screws (3), and the catch bucket (1).

When the weighing mechanism is faulty some of the following symptoms may be observed:

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>See Section</th>
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<tbody>
<tr>
<td>Rain gage pen marking erratically.</td>
<td>A and B (see Figures D-1 and D-2)</td>
</tr>
<tr>
<td>No response to weight addition into catch bucket or improper response</td>
<td>B, C, or D (see Figures D-2 and D-4)</td>
</tr>
<tr>
<td>Poor collection efficiency (defined as wet/dry versus rain gage collection volume).</td>
<td>C or D (see Figure D-4 and D-5 and Flow Chart #2)</td>
</tr>
</tbody>
</table>

**A. Wind Shake** - (see Figure D-1).

This phenomenon is often caused by looseness of case or rain gage mounting bolts. Make certain all screws around the bottom of the “milk can” and mounting bolts are secure.

Check the level and quality of the dashpot (12) fluid. The dashpot serves as a “shock absorber” in the rain gage linkage system. If the fluid level is insufficient it cannot dampen the motion of the bucket support shaft (16). In order to offer adequate performance the fluid in the dashpot must be above the level of the floating piston at its highest level. The dashpot fluid is available from the Belfort Instrument Company. For temporary emergency use automotive antifreeze can be substituted.
Figure D-1. Wind Shake

NOTE THE WIDE AND SPIKED NATURE OF THE TRACE IN THESE TWO INSTANCES
CHECK DASHPOT FLUID AND THE TIGHTNESS OF THE CASE
AND MOUNTING BOLTS

DASHPOT DETAIL SHOWING PISTON
AND APPROPRIATE LEVEL OF DAMPENING FLUID
B. Dashpot Freezing

The wild up-and-down markings (as illustrated on Figure D-2) are indicative of frozen water within the dashpot mechanism. As temperatures drop any accumulated water (from blown-in snow or condensation) freezes and ice forms in the dashpot. The fine linkage is then subject to sudden and extreme motion. This situation should be resolved as soon as possible to prevent ruining the dashpot and invalidating precipitation data.

TO REPLACE DASHPOT FLUID

1. Open the sliding door of the rain gage.
2. Spin off the gage clock by turning it counterclockwise.
3. Remove the thumbscrew holding the dashpot (12) on the mechanism base (6).
4. Gently pull the dashpot body toward the door allowing the piston to gently pull up and out of the dashpot. See Dashpot detail in Figure D-1.
5. Empty the dashpot and wipe clean with a cloth, refill and replace.

Figure D-2. Rain Gage Dashpot Freezing

NOTE THE CRAZY WAVE PATTERN WITH SUDDEN PEAKS AND VALLEYS AS ICE PUSHES PEN UP AND DOWN
C. Incorrect or Lack of Response to Precipitation

The calibration mechanism of the rain gage is the most complex portion of the instrument. As previously mentioned, this manual will not discuss how to calibrate the gage. Three areas to evaluate are the catch bucket, limit screws and zero adjustment screws (see Flow Chart #2).

**Catch Bucket.** Difficulties in transferring weight to the rain gage mechanism through the bucket support shaft may be caused by the catch bucket rubbing against the top section (17) or funnel (18) of the rain gage. Check to be certain that the catch bucket bail (handle) and the catch bucket rim are not rubbing against the main housing of the rain gage. This condition will cause the main housing to absorb the weight of the precipitation, therefore not transferring it to the weighing mechanism. If this is the difficulty, a steel gray burnished area - where the contact has occurred - should be readily noticeable on the mechanism. Check to make certain the bucket platform (10) still supports the bucket squarely upon the support shaft, and remove the catch bucket bail if it is bent beyond repair.

**Limit Screws.** The limit screws (3) serve to lock the fine linkage (4) mechanism during shipment and to limit the travel of that linkage during extreme catch bucket loading (i.e., lots of rain). The limit screws can conflict with the top lever (11) when adjusted too far down, thereby preventing the mechanism from registering weight. The bottom of the limit screws should be separated from the top lever, by a minimum of 1/16 inch with the bucket empty. Confirming that "daylight" exists between the top lever and linkage should solve problems associated with the limit screws.

![Figure D-3. Limit Screw Detail](image)

After adjustment firmly tighten the locking nut on the limit screw so that vibration of the case and contraction and expansion from heating and cooling does not cause the limit screws to move down onto the top lever again.

See Figure D-4. This figure illustrates the flat line nature of the rainfall amount pen for a rain gage afflicted by a limit screw defect. Note that the event recorder trace (which means precipitation was falling during a period) exists early in the week, yet no rainfall deflection can be seen.
Zero Adjustment Screws. These screws are often used to set the baseline of the gage pen. When turned, they cause the relationship between the top lever (11) and the limit screws (3) to be changed. CAUTION: When adjusting the zero adjustment screws make certain that; the limit screws maintain the correct distance from the top lever, and that the zero setting bar is approximately parallel to the gage housing. If either of the above factors are in error the gage may appear to undercatch precipitation.

Fine Linkage. At the bottom end of the fine linkage (4) there are two places where an oval shaped slot is cut into the link. These slots have a bolt riding through them. Inspect the area around and inside this slot to see if any worn areas, corroded patches or dirty spots exist. If so, the area will have to be cleaned and lubricated or replaced. Call the CAL for more details.
D. Poor Collection Efficiency

Collection efficiency (C.E.) is defined as the portion of precipitation collected in the ACM (PE) compared to the precipitation measured in the rain gage, or:

\[ \text{C.E.} = \frac{\text{PE}}{\text{RG}} \times 100\% \]

where

\[
\begin{align*}
\text{PE} & = \text{the precipitation equivalent (sample weight in grams x .00058 inches/gram; and} \\
\text{RG} & = \text{the weekly total amount of precipitation as measured on the recording rain gage chart}
\end{align*}
\]

Typically C.E. values for rainfall range between 90% and 110%. Poor C.E.’s do not necessarily mean a malfunction in either mechanism. For example, the ACM is very susceptible to missing light rainfall and blowing snow. In addition, the rain gage is only able to resolve events to approximately 17 grams weight (.01 inch on the chart).

Assuming no problems related to Sections A, B; and C are found, it may be advisable to perform a calibration check upon the weighing bucket mechanism. This is especially true if the C.E. is consistently greater than 100% (ex., ACM - 1.25"; rain gage - 1.00"; in this case a 125% collection). Logic would dictate that the ACM cannot make precipitation. Therefore, the rain gage is under measuring the precipitation.

**Calibration Check.** This procedure can be completed by non-technical personnel as long as accurate means of weighing are available.

As mentioned before, the Belfort mechanism is calibrated to measure 1 inch of water or precipitation equivalent (PE) for the addition of each 825 grams of weight. Any weight added to the rain gage catch bucket can be used to check the response of the mechanism.

The Belfort Instrument Company offers a set of rain gage calibration weights. Contact the CAL for purchase information.

In lieu of a standard calibration weight set any pre-weighed mass can serve for calibration checking procedures. Remembering the 825 to 1 inch rule and using the following steps are all that is necessary.

1. Use your analytical balance to make up a set of weights (five-825 gram bottles for example).
2. After removing the rain gage chart from an ending sample period, install another rain gage chart labeled ‘CALIBRATION CHECK’ onto the drum.
3. Replace the drum upon the clock assembly and mark a base line with the pen assembly in order to define the beginning of your calibration check.
4. Add one rain gage weight to the catch bucket, then twist the chart drum to mark another base line value. The difference between the initial base line and the secondary base line should equal the deflection predicted by the weight (see Figure D-5).
5. Repeat step 4 above until the rain gage reaches approximately 5" of capacity. The effective range of measurement at most sites will be assured in this manner. If a suitable weight cannot be found, remember that one gram of water is equal to one milliliter of water. Therefore a volumetric calibration is possible. Call the CAL for details.
THE STAIR-STEP SHOWN REFLECTS THE ADDITION OF FIVE 1-INCH RAINGAGE WEIGHTS. NOTE THAT THERE IS A SMALL ERROR WITH THE ADDITION OF THE THIRD AND FOURTH WEIGHT. THE ERROR IS ONLY 0.02" HOWEVER. THIS GAGE IS IN ACCEPTABLE CALIBRATION.

If an error in excess of 0.10 inches is identified during the calibration check, contact the CAL. NADP/NTN lacks any 'quick response' mechanism whereby network representatives can come and assist you in the recalibration of the instrument. Local repair is suggested.

Regardless of the maintenance procedure or the amount of error encountered, please notify the CAL. Send along a copy of the Calibration Check rain gage chart. Data screening decisions may be based upon this information.
4.4.2. Writing functions

The writing functions of the recording rain gage break down into two general areas of concern: the rain gage pen (inking) capability and the rain gage clock assembly (which provides the time axis for writing). These two functions are separated in the section which follows.

Pen Function - The pens used on this rain gage fall into two general categories: (1) ink type pens (filled each week out of a reservoir bottle); and (2) felt tip pens. Because most sites use ink pens and because felt tip pens are easily replaced, only ink type pens will be covered in this section.

Typical problems associated with pen function include: 1) dirty or fouled tips due to long-term use and ink evaporation, and 2) lack of pressure upon the chart by the pen arm and pen itself.

Dirty Pens - If the pen appears dirty or clogged, remove it and attempt to service the tip (See Section 5.1.1.).

The pen is held on to the arm by a simple friction fit, carefully pulling it off the arm should remove most pens. If this friction fit does not separate, DO NOT FORCE the mechanism. Apply a liberal amount of deionized water or alcohol to the pen area and attempt to wash off the dried ink which may be causing the pen to stick to the arm.

After removing the pen, immerse it in a small beaker or cup full of deionized water or alcohol. Using a straight pin, single-edged razor blade, etc., attempt to remove any accumulated material from the end of the pen. Scrub the pen with a small brush prior to reinstalling. In an emergency a tightly bound piece of paper can be pulled through the pen nib. This sometimes removes the accumulating material which is causing the clog.

It is suggested that sites consider acquiring one or two extra pens from the manufacturer. Pens sometimes wear out and can be cantankerous. Sometimes the only alternative is to replace them.

Lack of Pressure - In order for the pens to write legibly upon the chart the pen and arm must contact the chart with sufficient pressure.

If the pressure on your pens is not sufficient you may notice that they seem to "float down" onto the chart drum after the pen shifter (8) is pushed back instead of dropping toward it briskly. This is likely to cause the trace to be very faint or erratic during the week.

In order to increase this pressure the pen arm stud (14) must be adjusted. First the screw on the top of the stud must be loosened and the stud rotated counterclockwise (SO AS TO MOVE THE TOP OF THE PEN ARM TOWARD THE CHART). This increases the angle with which the pen arm falls, thus increasing the pressure on the pen tip.

Clock Function - As the pen delivers ink the clock turns the chart drum and chart in a clockwise direction. This creates the X, Y axis marking familiar to us all. There are two general types of clocks available for this rain gage: 1) battery powered, and 2) wind-up clocks. Both the battery powered clocks and wind-up clocks are subject to several problems. Maintenance of the internal mechanism of both designs requires professional assistance. Local clock repair personnel may attempt repairs. Repair at the factory is also available but, generally requires a long time to complete.
Problems break down into three main categories; 1) operator error, 2) dirty or worn gear clusters, and 3) clock drive assembly malfunction.

Operator Error - The clock must be fully wound each Tuesday in order to assure a continuous record. One major benefit of electric clocks is that they don't need winding. It is suggested that winding the clock be the first step taken each time the chart drum is removed. This way it is less likely to be forgotten later.

Dirty or Worn Gear Clusters - The protocol for NADP/NTN state that each rain gage should be equipped to run an 8-day chart. In order for the chart drum to rotate at the correct speed, the drum and clock should be equipped with matching gears (25) marked 192S (see photo 5) matched to the appropriate output shaft (24).

After continuous use the gears may become worn or dirty. Typically the gears have very long lives. If they are visibly worn, then a new gear pair (one for the clock and one for the chart drum) should be ordered. Call the CAL for price and order information.

The gears can be cleaned by simply pulling them off and passing an old toothbrush or a paint brush through the teeth. A light solvent may assist in removing any hardened debris.

Clock Drive Assembly - As mentioned previously, the internal mechanism of the clock IS NOT SERVICEABLE BY SITE PERSONNEL.

The clock can be removed by simply spinning the entire clock body counterclockwise. The clock is mounted on a 1/4-inch threaded shaft.

In normal conditions the clock will run for many years without maintenance; however when it gets dirty it will have to be cleaned and lubricated.

If the clock is subject to low temperatures during winter months a fine powdered graphite or molybdenum disulfide lubricant should be used (see Instruction Book for Universal Recording Rain Gage Cat. No. 5-780, Series/Book No. 8777 by the Belfort Instrument Co.).
5.0. Component Replacement and Routine Servicing

5.1. Component Replacement

5.1.1. Pens

Grasp the pen arm firmly with your right hand and the pen tip with your left. Gently pull the pen nib away from the arm. TRY TO REFRAIN FROM GRABBING THE PEN ON ITS RESERVOIR TIP; rather grab onto the flat section of the pen which attaches directly to the arm.

If you encounter resistance, try applying a little water to the joint between the pen and arm. Let them set for a few minutes and repeat the procedure.

As a last resort a pair of pliers may be needed to remove the pen tip. CAUTION: THE MECHANISM IS FRAGILE AND THE PEN TIP AND ARM CAN EASILY BE BENT OR BROKEN.

5.1.2. Clock

Spin the entire clock counterclockwise. It is mounted on a threaded shaft and will generally come out easily.

IF YOU HAVE AN ELECTRIC CLOCK, exercise caution not to abrade or cut the wires which lead from the clock mechanism to the battery pack.

5.1.3. Funnel

Remove the "milk can" shaped top cap of the raingage. Rotate the funnel on the top section until the slots cut in the funnel clear the tabs in the top section. Simply pull or pry the funnel off the top section (see Photo #3).

5.2. Weekly Servicing

a. When approaching the raingage make certain it is level and well attached to its base. Freezing and thawing over winter, animal activity, or vandalism can cause the gage to tilt. If the gage is significantly off level, measurement problems can arise.

b. Open the door to the gage.

c. Make certain the pen is in roughly the correct position. Move both the pens up and down a little to scribe an "off" tick mark. If the clock indicates a difference of more than 6 hours from the correct time, note this on the chart.

d. Lift the pens off the chart with the pen shifter and remove the drum.

e. IMMEDIATELY WIND THE RAINGAGE CLOCK.

f. Remove the top cap of the raingage and

1. during the summer period dump the raingage catch bucket, or
2. during the winter period service the raingage by replacing or stirring the anti freeze.

g. Reload the chart drum with a new chart and place it back on the clock mechanism. NOTE: It is suggested that sites purchase an extra chart drum (with gear). This will allow the chart to be placed on the drum in the relative calm of a truck cab or office as
opposed to possibly severe conditions at the site.

h. Set the time according to the precipitation pen (NOT THE EVENT RECORDER PEN) and mark the chart with an "on" tick. Make certain the clock is ticking and the ink is flowing.

i. Close the door to the raingage.

5.3. Other Routine Servicing Suggestions

a. Occasionally lubricate the sliding mechanism of the door with a silicon or Teflon based aerosol lubricant.

b. Once each month, after dumping the catch bucket, push the empty bucket down while watching the pens on the raingage. Check to be certain that the event recorder and precipitation pens do not conflict and that the turnover point of the gage is still accurate. (The turnover point is the point at which the raingage amount pen stops its upward motion and begins its downward motion.)

c. Twice each year either have the gage calibrated by a capable technician or, at a minimum, perform a simple weight or volumetric calibration check (reference Section D-4.3).

d. Twice each year check the raingage mounting bolts and the screws attaching the housing to the mechanism base (6) for tightness.

e. An easy calibration check can be performed weekly if you have a standard 8" NWS 'STICK GAGE'. Pour the water from the Belfort catch bucket into the 2" diameter brass tube. Measure this water as normal. This measurement should be equal to the difference between the end of the Belfort gage trace and the original baseline of the trace (i.e., how much water was the Belfort weighing at the end of the week?).

f. Once each year, replace the alkaline power cells in battery powered clocks. NOTE: Sites which experience severely cold winter temperatures may require more than one battery change per year.