APPENDIX K

Evaporation Gauge SOP

Standard Operating Procedure
for an Evaporation Station

1.0 INTRODUCTION

This procedure applies to an evaporation station composed of the NovaLynx model 255-200 Class A evaporation pan and the NovaLynx model 255-100 analog evaporation gauge. The evaporation pan is a standard National Weather Service Class A evaporation pan. The evaporation pan and evaporation gauge will be used to monitor evaporation in the vicinity of the proposed Energy Fuels Resources Corporation (EFR) Uranium Mill. The selection and location of the site is described in the Energy Fuels Resources Corporation Uranium Mill Licensing Support Ambient Air Monitoring Plan for the Piñon Ridge Mill Site prepared by Kleinfelder West, Inc.

Evaporation data will be collected at the air monitoring site located on the northern boundary of the proposed Energy Fuels Piñon Ridge Uranium Mill site in order to obtain a representative set of data for assessment. Data will be collected during construction and when the mill becomes operational.

2.0 INSTRUMENT INSTALLATION

2.1 Instrument Assembly

The evaporation pan will be assembled and prepared for operation with assistance from Inter-Mountain Laboratories (IML) according to the procedure in the manufacturer's operating manual. IML will also carryout the initial calibration of the instrument.

The evaporation pan will be installed on a wooden platform set on the ground. The pan is filled with water and exposed to represent an open body of water. The pan is filled to within 2.5 inches of the pan top.

The evaporation rate will be measured by an analog output evaporation gauge, NovaLynx model 255-100. The evaporation gauge will be installed on a wooden platform set on the ground next to the evaporation pan.

3.0 OPERATING PROCEDURE

Please enter date, time, technician name, name of any visitors, and purpose of visit in Site Notebook for any visit to the site.

3.1 Necessary Equipment

Meteorological Equipment Checklist
Timepiece
Water Supply
Hose and Pump
Measuring Stick or Tape Measure
Site Notebook
Writing Instrument

3.2 Evaporation Pan Operation

Record necessary information on Meteorological Equipment Checklist (Figure 1). Evaporation measurements will be collected from April 1 to October 31 each year. During this time the evaporation pan and gauge should undergo routine daily (Section 4.2), weekly (Section 4.3), and monthly checks (Section 4.4).

Meteorological Equipment Checklist

Daily Instrument Checks

Date							
Time							
Technician Name							
Visible damage to any meteorological instrument(s)?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If Yes, list instrument(s) with damage in the notes section along with the date and type of damage.							
Will damage affect operation?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If Yes, damage will affect operation, contact appropriate personnel, see contact list.							
Check Rain Gauge debris screens and collection funnel for debris							
Was debris removed?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If Yes, debris was removed, list the date, time and type of debris removed in the notes section.							
Check Evaporation Pan for debris							
Was debris removed?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
If Yes, debris was removed, list the date, time and type of debris removed in the notes section.							

Observe movement of wind vane	
Observe movement of wind speed propeller	
Observe movement of vertical wind speed propellers	
Listen for air movement through ground level temperature shields	

Notes:

Weekly Instrument Checks

Date: Time: Technician Name:

Add or Remove water to bring water level in Evaporation Pan to designated level	Add	Remove	Initial Water Level (in):
Time water addition/removal started:	Time water addition/removal completed:		Final Water Level {in}:

Check radiation shields of ground level temperature sensors for debris														
Was debris removed?	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
If Yes, debris was removed, list the date, time and type of debris removed in the notes section.														

Notes:

Monthly Instrument Checks

Date: Time: Technician Name:

Clean Rain Gauge collection funnel		Check drain hole on Solar Radiation Sensor for debris	
Check that the Rain Gauge is level		Inspect and Clean Solar Radiation Sensor	
Check Evaporation Pan for sediment and algae		Verify that Solar Radiation Sensor is level	
Clean the Evaporation Pan if sediment or algae are present		Visually inspect cable connection on the Barometric Pressure Sensor to ensure it is clean & dry	
Check Evaporation Pan & Pipe for leaks		Visually inspect the Barometric Pressure Sensor for damage	
Note any leaks and call appropriate personnel for next steps		Check the pneumatic connection and pipe on the Barometric Pressure Sensor	

Information to be filled in if Evaporation Pan is Emptied.

Start Time for Emptying Pan:	Evaporation Gauge Calibration Start Time:
Reason for Emptying Pan:	Evaporation Gauge Calibration End Time:
End Time for Refilling Pan:	Final Water Level {in}:

Notes:

Figure 1: Example Meteorological Checklist

3.3 Procedure for Adding/Removing Water to the Evaporation Pan

1. Check the evaporation pan for debris and note in Site Notebook. If debris was removed note the date and time of removal and type of debris removed.

2. Clean the pan as frequently as necessary to keep it free from sediment, algae, and oil films. Any of these contaminants will materially affect the rate of evaporation. Cleaning should be performed if half or more than half of the bottom of the pan has sediment, or if any algae are present. If algae are present follow instructions in Section 3.5 to inhibit growth of the algae.

   Prior to emptying the pan note the start time in the Site Notebook and on the Meteorological Equipment Checklist. When it is necessary to empty the pan, follow the Draining the Evaporation Pan procedures (Section 3.6).

3. If the water level is noticeably low, use the provided water source to fill the evaporation pan until the water level is approximately eight inches from the bottom of the pan. Use a measuring stick or tape measure with 0.1 inches accuracy to measure the water level after adding water. It is important to allow the water to settle before taking the measurement. Please note the time and date when water addition was started and completed and the amount of water added on the Meteorological Equipment Checklist and in the Site Notebook.

4. If the water level is noticeably high, remove water from the evaporation pan until the water level is approximately eight inches from the bottom of the pan. Please note the time and date when water removal was started and completed on the Meteorological Equipment Checklist and in the Site Notebook.

3.4 Evaporation Gauge Operation

The evaporation gauge potentiometer exhibits a varying resistance in response to the motion of the float.

Applying a voltage across the potentiometer allows monitoring of the gauge by a data logger or any other electronic voltage sensing instrument.

The output signal of the potentiometer can be configured to give an increasing or a decreasing voltage with regards to the changing level of the water.

The signal is configured so that a decrease in the water level is represented by a decrease in the gauge voltage.

The gauge will never read below approximately 1.4". When there is 1.4” of water or less in the pan, the float physically hits the bottom of the gauge.

The normal range is typically is 3" to 8.5". If the water is above 8.5", wind could blow water over the edges; if it is below 3", the low level of water absorbs more heat from the sun and bottom pan reflections, causing increased evaporation.

3.5 Seasonal Instructions

If the water in the evaporation pan freezes, note the date ice was observed in the notes section of the Meteorological Equipment Checklist and in the Site Notebook. Do not disturb the ice.

If icing becomes a problem, the operation schedule of the pan may need to be adjusted. The water in the pan should not be allowed to completely freeze as this would change the characteristics of the pan and alter measurements. Call appropriate personnel if freezing becomes a problem.

During months when freezing is expected (November through March) the evaporation pan and evaporation gauge should be drained and stored in the Conex container at the site.

If algae become a problem:

The growth of algae can be discouraged by adding a small amount (5 to 10 mg/liter) of copper sulfate to the water. A standard Class A pan filled to 8 inches would require about 1/2 teaspoon of copper sulfate crystals.

If algae are already present, they must be removed first by thoroughly cleaning the pan. Also check the evaporation gauge to ensure algae are not present in the gauge.

If copper sulfate is used to control algae, prior to emptying the pan for cleaning or maintenance, remove excess copper sulfate by placing 1-3 iron penny nails in the pan overnight. Nails should not be coated or plated. The nails should be suspended on strings or placed on a plastic sheet on the bottom not directly touching the sides or the bottom of the pan. The nails can only be used once. During the removal of excess copper sulfate, the color of the water will change from blue, to orange, to clear with a muddy brown precipitate. Decant the water (siphon or dip out) and rinse down a sink. **Do not pour on the ground.** Place precipitate in the trash.

3.6 Draining the Evaporation Pan

If the evaporation pan needs to be cleaned or drained for the season the pan should be emptied by siphoning or dipping the water out.

Under no circumstances should the pan be lifted and emptied if any significant amount of liquid remains in the pan.

Anytime the evaporation pan is drained for cleaning, or otherwise, the date, time and reason for draining should be noted on the Meteorological Equipment Checklist and in the Site Notebook.

For cleaning, drain the pan and use water to remove any sediment from the pan. Avoid warping the pan by using too much pressure while cleaning and return the pan to a level position on the wooden platform before filling.

Follow the Calibration Procedures After Cleaning Evaporation Pan (Section 7.2) while refilling the Evaporation Pan.

On November 1st of each year the evaporation gauge should be taken offline and the evaporation pan should be drained and stored in the Conex container. During the last week of March each year the evaporation gauge should be removed from storage and placed in its previous location following installation and calibration procedures. The evaporation station should be operational on April 1st of each year.

4.0 DAILY/WEEKLY INSTRUMENT CHECKS

Routine Maintenance of both the evaporation pan and evaporation gauge is covered by following the daily, weekly and monthly checks.

4.1 Necessary Equipment

Timepiece
Meteorological Equipment Checklist
Measuring Stick or Tape Measure
Site Notebook
Writing Instrument

4.2 Daily Check Procedure

1. Record all information requested on the Meteorological Equipment Checklist (Figure 1).

2. Perform a visual inspection of the evaporation pan, the evaporation gauge, and the connecting pipe and note any damages that may affect operation. If needed, contact appropriate personnel for next steps.

3. Check the evaporation pan for debris. If debris was removed, note the date and time of removal and type of debris removed.

4.3 Weekly Check Procedure

1. Perform the Daily Check Procedure (Section 4.2).

2. If water is below or near 3.5” from the bottom of the pan, or above or near 8.5”, add or remove water (Procedure for Adding/Removing Water to the Evaporation Pan, Section 3.3) as necessary to reach designated water level (8” from the bottom of the pan).

3. Prior to adding or removing water, record the reason for disturbing the evaporation station in the notes section on the Meteorological Equipment Checklist and in the Site Notebook (for example: water level low, addition of water needed). Notes should include date and time of water level measurement, time water addition/removal began, time water addition/removal ended and the initial and final water levels.

4. Before measuring the final water level allow water to become calm. Take measurement at the pan outlet to the gauge.

5. Record all information requested on the Meteorological Equipment Checklist (Figure 1).

4.4 Monthly Instrument Checks

1. Perform Daily/Weekly Check Procedures (Sections 4.2 and 4.3).

2. Record all information requested on the Meteorological Equipment Checklist.

3. Perform a visual inspection of both the evaporation pan and the evaporation gauge, and note any damages that may affect sampler operation. If needed, contact appropriate personnel for next steps.

4. Check the evaporation pan for debris, sediment and algae and note on Meteorological Equipment Checklist and in Site Notebook. If debris was removed, note the date and time of removal and type of debris removed.

   Clean the pan (Section 3.6) as frequently as necessary to keep it free from sediment, algae, and oil films. Any of these contaminants will materially affect the rate of evaporation.

5. Check the evaporation pan and pipe for leaks. Note any leaks in the Site Notebook, and on the Meteorological Equipment Checklist.

   Note: If any leaks are found, notify appropriate personnel.

5.0 NON-ROUTINE MAINTENANCE: EVAPORATION GAUGE

Maintenance should only be performed by trained and qualified personnel.

5.1 Necessary Equipment

Timepiece
Digital Multimeter
Site Notebook
Writing Instrument

5.2 Non-routine Maintenance Procedure

Record any non-routine maintenance in the Site Notebook.
Troubleshoot the gauge immediately whenever any of the following conditions are observed:

- severe weather has recently occurred

- the gauge does not appear to operate normally or exhibits a marked change in performance

- the data are missing or appear to be incorrect

- the gauge has been dropped or damaged

- water has damaged the wiring or electronic components
- water has completely dried out in the evaporation pan.

6.0 TROUBLESHOOTING THE EVAPORATION GAUGE

If the evaporation gauge does not register correctly:

6.1 Cables

- Check the sensor cable connections both at the gauge and at the data logger; cable shorts can cause loss of data.
- If a connection is found to be loose, reattach the wire and check to see if the problem has been corrected.
- Check for damage to the cable insulation.
- Replace the cable if it appears that the jacket has been worn or cut open.

6.2 Float

- Inspect the float and chain to make certain that they have not become entangled.
- Whenever the evaporation pan has been allowed to empty or dry out completely, the float may tip sideways at the bottom of the gauge and the chain may become kinked at the mechanical connector.
- Test the motion of the float to ensure that it moves smoothly and freely.

6.3 Natural Influences

A number of naturally occurring events can influence the evaporation gauge reading and will appear as errors or as a gauge malfunction.

These natural events include:

- Animals drinking the water
- birds bathing in the water
- leaves and debris falling into the pan
- high winds
- hail
- thermal expansion of the water and metal parts

7.0 CALIBRATION PROCEDURE: EVAPORATION GAUGE

7.1 Necessary Equipment

Timepiece
Measuring Stick or Tape Measure
Site Notebook
Writing instrument

7.2 Calibration Procedure after Cleaning Evaporation Pan

Note date and time of calibration in the Site Notebook.

1. Use the provided Evaporation Gauge Calibration sheet (Figure 2) and follow these instructions. On the Campbell Scientific CR3000, navigate to the Public data. Record the current values for EvapSlope and EvapOffset as the starting values (starting slope and starting offset) at top of provided sheet.

2. Set EvapSlope to 1 and EvapOffset to 0. The value can be edited by selecting the value to change, then pressing Enter on the keypad. Key in the new value and press Enter again.

3. With evaporation pan empty, record the EvapLevel from the CR3000 as the Empty Pan Logger Reading.

4. Start filling the evaporation pan. Watch for the EvapLevel reading on the CR3000 to change. As soon as the value starts to increase, record the water depth in inches (at the pan outlet to the gauge) and the EvapLevel on the CR3000 as Calibration Point 1.

5. Add water to the pan until the depth at the outlet to the gauge is approximately 2 inches. Record both the measuring stick or tape measure reading and the reading from the CR3000 as Calibration Point 2. Be sure to allow the reading on the CR3000 to stabilize before taking the measurements.

6. Repeat Step 5 adding approximately 2 inches of water for calibration points 3, 4, and 5.

7. Once all five calibration points have been completed, enter the EvapSpan and the EvapOffset from this sheet into the EvapSpan and EvapOffset location on the CR3000. The EvapLevel from the CR3000 should now be the same as the water depth in the evaporation pan in inches.

   In Figure 2, example values are entered in order to show how the spreadsheet will appear following calibration.

Evaporation Pan Calibration Sheet

Values to be entered in this sheet during the calibration appear in BOLD.

The EvapSpan, EvapOffset, and Correlation will be calculated using intrinsic Excel functions and the calibration numbers entered.

Starting Slope:	**9.14**
Starting Offset:	**1.25**

Empty Pan Logger Reading:	**0.00048**

Yardstick Reading - taken at the pan outlet to the gauge

Calibration Point	Yardstick Reading (in)	Logger Reading
1	**1.25**	**0.00050**
2	**1.75**	**0.05471**
3	**4**	**0.30416**
4	**6.5**	**0.57440**
5	**8.25**	**0.76915**

EvapSpan	9.11661
EvapOffset	1.24504
Correlation	0.99999
The correlation should be greater than .9900	

Figure 2: Example Evaporation Calibration Sheet

7.3 Calibration Procedure

This Calibration Procedure should only be performed by trained and qualified personnel.

Write the date and time of calibration in the site notebook.

The Evaporation Gauge will be calibrated at least every six months by qualified personnel.

Calibration of the gauge is required upon initial installation of the gauge and whenever the gauge is removed from its platform or from inside the evaporation pan.

However, it is also necessary to calibrate the evaporation gauge when the evaporation pan is drained for maintenance or cleaning, or when the evaporation gauge is taken offline for any other reason. For Calibration procedures in this case see Section 7.2.

Proper calibration of the evaporation gauge is critical to the accuracy of the data and the correct operation of the gauge.

The evaporation gauge must be calibrated in order to set the operating range of the potentiometer and to determine the zero point of the float motion.

For data logging systems, the slope and intercept data will be measured or calculated from the calibration of the gauge.

After the gauge has been calibrated, the operator needs only to keep track of the amount of water added back into the evaporation pan. With the gauge calibrated, the gauge may be used to measure the amount of water added into the pan each week.

The following procedure is used to properly calibrate the evaporation gauge. Record the calibration values in the Site Notebook in order to check the gauge calibration.

1. Upon completion of the gauge and pan installation, fill the evaporation pan with approximately eight inches of water. Check the evaporation gauge to ensure that the water has filled the stillwell to the correct height inside the gauge.

2. Disconnect the signal cable from the evaporation gauge. Use a digital ohmmeter to measure the resistance of the pot across terminal block pins (2) middle (+) and (3) bottom (-). Rotate the sprocket and you will notice the resistance value changes from 0 to 1000 ohms. Rotate the sprocket slowly until the reading reads 0. This is the deadband; it has a mechanical range of about 20º. Some pots may have an upper end resistance of exactly 1K ohm, but most will vary by ± 15 ohms. There is a white line marked on the back side of the sprocket. When this line is vertical the pot should be in the 20° gap area.

3. Check to make certain that the float is hanging down near the center of the evaporation gauge. As viewed from the front of the gauge, looking toward the face of the sprocket wheel, the float should hang from the right side of the sprocket wheel with the counter-weight to the left side of the wheel. A white line is painted on the back of the sprocket; when viewed from the back side the line should be at the 1 o'clock or 30° when the float is resting on the bottom of the gauge.

4. Move the float by hand down toward the bottom of the gauge. As soon as the float contacts the bottom surface of the gauge, hold the float in position and check to see that the chain is straight and tight. The chain must not be moving nor pulled downward other than by the tension exerted by the float.

5. Measure the resistance of the potentiometer.

6. The potentiometer should be at its point of low resistance for the range of motion of the pot. The resistance should be above zero ohms but may be as high as 150 ohms. If the value appears to be floating or within the deadband of the potentiometer the sprocket wheel must be adjusted with relation to the chain. The potentiometer must not cross into or go beyond the deadband as the float approaches and touches the bottom of the gauge. To adjust the sprocket, allow the float to return to the top of the water.

7. Lift the chain off the sprocket and rotate the sprocket counter-clock-wise, one or two gear tooth positions.

   Remember a 90° Rotation on the sprocket should indicate a change of 2.50 inches on your reporting/recording device; 180° would be a 5.00 inch change.

8. Replace the chain and repeat Step 4.

9. Repeat Step 5 until the chain is properly positioned on the sprocket.

10. Observe the ohmmeter to detect any crossover of the deadband as the float is moved downward.

11. Record the resistance of this bottom or “ZERO” position of the float. If the gauge is connected into the monitoring equipment and power has been applied, measure the voltage at this position as well as the resistance.

    For gauges mounted outside the pan, measure the water level inside the gauge to the center of the float. Usually, the center of the float is aligned with the center of the threaded pipe fitting on the housing when the float touches the bottom of the gauge.

12. Move the float back to the top of the water and let go of the float. The center of the float should now be even with the surface of the water. Measure the resistance and voltage of the potentiometer at this position.

13. Measure the water level at this point with respect to the bottom of the pan.

    The resistance of the potentiometer should be high at this point and approaching the 1000 ohm end of the pot. If the chain and sprocket have been properly set, the potentiometer should not move past the 1000 ohm end of the element and into the deadband.

    If it appears that the pot is in its deadband at the top of the water level, then either the sprocket or chain must be adjusted further or else there is too much water in the pan and some water must be drained. Typically this setting should be offset slightly to avoid going into the Gap Area. When the pan is full to the brim, the resistance should be between 950 and 995 ohms. When the pan is empty or less than 1.25” deep, the resistance should be between 20 to 90 ohms.

14. At this point the slope and intercept information can be generated and the operating curve of the instrument can be calculated. The operating curve can then be verified by setting the float to several points of water level and by comparing the actual output voltage to the calculated voltage.

    Remember the Gap is 20° therefore 340°/360° = 0.9444. Therefore, with a 5.00 volt excitation applied, a 5 Volt reading on the Wiper means 9.44" Not 10.0".

    The formulas used are:

    $Y = m*X + b$ $\quad m = (Y2 - Y1) \div (X2 - X1)$ $\quad b = Y1 - mX1$

    where: Y is inches of water
    X is ohms or volts
    m is the slope of the line
    b is the zero offset

    For a range of 10 inches and a potentiometer resistance of 1000 ohms the calculation reveals that b = 0, and m = 0.00944

For a range of 10 inches and a voltage range of 5 Vdc, b = 0 and m = 1.88.

If the float range of motion happens to be 1.5 to 8.0 inches, then the output voltage can be calculated as 0.75 and 3.776 volts, respectively. Use the actual values measured in the preceding steps, 4.2, 4.4, 4.6, and 4.7 Vdc, with the above formulas to determine the operating line of the gauge. The line should be linear, allowing calculation of intermediate outputs for known positions of the float.

References:

1. Model 255-200 Evaporation Pan Instruction Manual, NovaLynx Corporation, 2007.
2. Model 255-100 Analog Output Evaporation Gauge Instruction Manual, NovaLynx Corporation, 2002.
3. National Weather Service Manual 10-1315, Operations and Services: Surface Observing Program (Land), NDSPD 10-13, 2007.
4. Energy Fuels Resources Corporation Uranium Mill Licensing Support Ambient Air Monitoring Plan Piñon Ridge Mill Site, 2008.