Hydrology

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BATTLE MOUNTAIN RESOURCES, INC. M-1988-112

November 25, 2014

RECEIVED
DEC 08 2014
DIVISION OF RECLAMATION
MINING AND SAFETY

Wallace H. Erickson
Division of Reclamation, Mining and Safety
Department of Natural Resources
1313 Sherman St., Room 215
Denver, Colorado 80203

Dear Mr. Erickson:

As you are aware, pursuant to paragraph 26(B) of the decree in Case No. 07CW42, Battle Mountain Resources, Inc. ("BMRI") is required to operate three lysimeters at its San Luis site. As recited in paragraph 26(B) of the 07CW42 decree, pursuant to BMRI's stipulations with Dos Hermanos in Case No. 89CW32, BMRI installed the three lysimeters downgradient from the collection pond and operates the lysimeters pursuant to the manufacturer's specifications once every six months to check for fluid recovery in the sampler. If a sufficient quantity of fluid is obtained for testing, BMRI will have the sample tested for total cyanide, fluoride, cadmium, mercury, chromium, barium, silver, iron, copper, manganese, selenium, lead, zinc, arsenic, and molybdenum. BMRI reports any such sample results to the Mined Land Reclamation Board, Costilla County Conservancy District, and the San Luis Water & Sanitation District. BMRI is required to maintain the lysimeters and replace or repair them as necessary throughout the life of the mine.

Accordingly, BMRI reports on lysimeter operations in its monthly monitoring and site activity reports to DRMS, providing a narrative description of the most recent operation and whether any water was present for sampling and including the three lysimeters, with the two depths measured at each lysimeter, as monitoring sites LS-1, LS-2, LS-3, LD-1, LD-2, and LD-3 in the Ground Water Monitoring Well and Lysimeter Depth to Water Measurements Table.

Additionally, pursuant to the 07CW42 decree, BMRI maintains and replaces or repairs the lysimeters as needed. On June 4th and 5th, 2014, BMRI's consultant, Lytle Water Solutions, replaced three lysimeters, LS-1, LD-1, and LS-2. *See attached*, Lytle Water Solutions, Inc., Lysimeter Replacement Report (October 22, 2014). Consistent with the original lysimeters having never produced water for a sample, Lytle Water Solutions did not find any signs of free water during the replacement installation. *See* Lysimeter Replacement Report, p. 2.

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BMRI will continue to regularly evaluate the lysimeters for maintenance, replacement, and repair purposes. Please contact me if you have any questions.

Best regards,

Julio F. Madrid
Sr. Supervisor Legacy Sites Reclamation and Closure

Encl: Lytle Water Solutions, Inc., Lysimeter Replacement Report (October 22, 2014)
cc: Lawrence Fiske, Battle Mountain Resources, Inc.

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Monoflex Porous Cup Lysimeter System

LYSIMETER SYSTEM ASSEMBLY PROCEDURES (continued)

Assembling the System Components

Assembly of the Monoflex Lysimeter components such as the lysimeter, tubing, and casing should be completed prior to arrival at the installation site. This will allow for pressure and/or vacuum testing and procedures such as tube grooving to be done under clean conditions.

1) Attach the vacuum/pressure and sample recovery tubing to the compression fittings located on the top of the lysimeter. Cut each piece of tubing to the required length, making certain all cuts are clean and straight.

2) Follow the instructions for tubing grooving located on page seven of this manual. Note the vacuum/ pressure outlet at the top of the lysimeter plug is marked with a "V/P", and the sample recovery is marked with an "S". Make certain the other end of each tube is suitably marked or tagged. This will assure each length of tubing is correctly connected to the Monoflex Lysimeter Head Assembly. (See figure four on page nine)

3) Depending on well depth, the lysimeter extension casing should not be threaded together for transport to the job site. This operation is best completed at the job site, as the casing cannot be assembled once the Monoflex Lysimeter Head Assembly is attached to the tubing. After the tubing lines are securely connected to the top of the lysimeter and marked, pass them through the lysimeter casing string.

4) After the lysimeter casing is assembled, insert the ends of the tubing into the corresponding tube fittings located underneath the Monoflex Lysimeter Head Assembly. (See figure five on page nine)

Note: Monoflex Lysimeter casing threads are designed for use ***WITHOUT*** any type of solvents, PTFE tape, or thread compound. Using these items may cause failure to the threads.

Pre-wetting the Porous Ceramic Cup

Finally, before moving the assembled lysimeter system to the installation site, Monoflex recommends the lysimeter body be placed in distilled water and a vacuum of approximately 15" (38 cm) of mercury be applied for one hour. This procedure pre-wets the porous ceramic cup and eliminates air that is trapped in the pores of the cup. The lysimeter should be installed with the body filled with distilled water if no lysimeter casing is used.

Note: An empty, unsupported lysimeter, will float on the wet filter media when placed in the borehole.

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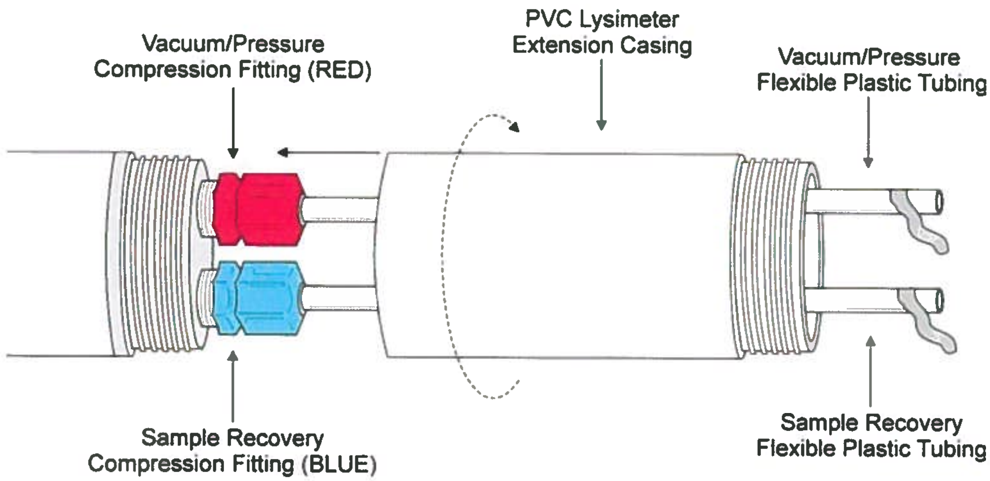
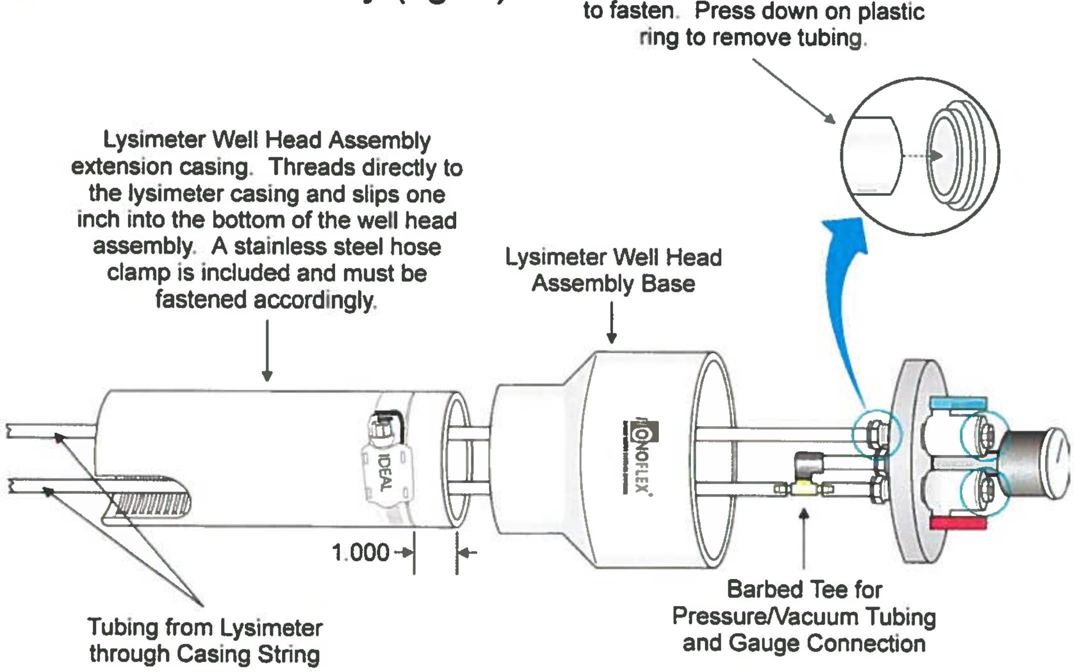
Monoflex Porous Cup Lysimeter System

LYSIMETER SYSTEM ASSEMBLY PROCEDURES (continued)



Monoflex Lysimeter Casing
and Tubing Assembly (fig. 4)

Monoflex Lysimeter
Well Head Assembly (fig. 5)



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M noflex Porous Cup Lysimeter System

LYSIMETER INSTALLATION

The installation of a **Monoflex** Lysimeter System should be in accordance with the following procedures.

Borehole Preparation

The borehole must provide adequate space to allow the lysimeter body to be surrounded by the filter media. For a 1.9" (4.75 cm) O.D. lysimeter, use a 6" (15.2 cm) diameter or larger borehole. The borehole must allow for at least a 1.5" (3.8 cm) thickness of filter media on any side of the porous ceramic cup of the lysimeter. Casing may be used to maintain an open borehole during installation. Immediately after installation of the filter media and lysimeter, pull back the casing and seal the hole with a bentonite grout.

Mixing Silica Flour or Natural Soil for use as Filter Media

Silica flour is mixed with distilled water using a ratio of one part water to three parts silica flour. A fifty pound bag will require about two gallons (7.58ℓ) of distilled water to make the slurry and will be sufficient for a single lysimeter installation in a 6" (15.2 cm) borehole. In a large mixing tub, add the flour slowly to the distilled water with **constant** stirring. (Preparation can be made easier by using an electric drill with a mixing paddle.) The mix must be **completely** blended and free of lumps. Constant stirring is essential as the silica flour is not water soluble and will settle if not agitated.

Note: Wear an appropriate filter mask while handling the dry silica flour. Note the health and safety warning located on the silica flour container and MSDS.

Use approximately the same method for mixing natural soil. The finished mixture should somewhat resemble a smooth concrete slurry.

Placing the Filter Media Slurry

Pour part of the slurry into the borehole to provide a bed beneath the Lysimeter of at least 4" (10.2 cm) in depth. Depending on the borehole diameter, between a quarter and one-third of the total slurry is usually sufficient for the bed.

The Monoflex Lysimeter should now be lowered into the borehole. Make certain that the lysimeter body is centered within the borehole. Monoflex again strongly advises use of the lysimeter casing for accurate depth placement and for the protection of the tubing lines and fittings.

Pour the balance of the slurry into the borehole to completely cover and surround the lysimeter body. Note the lysimeter must have intimate contact with the slurry and the slurry must fill all voids in the bottom of the borehole. The lysimeter should be supported at the ground surface with stakes for at least two hours while the slurry sets. Please see figure six on page eleven of this manual.

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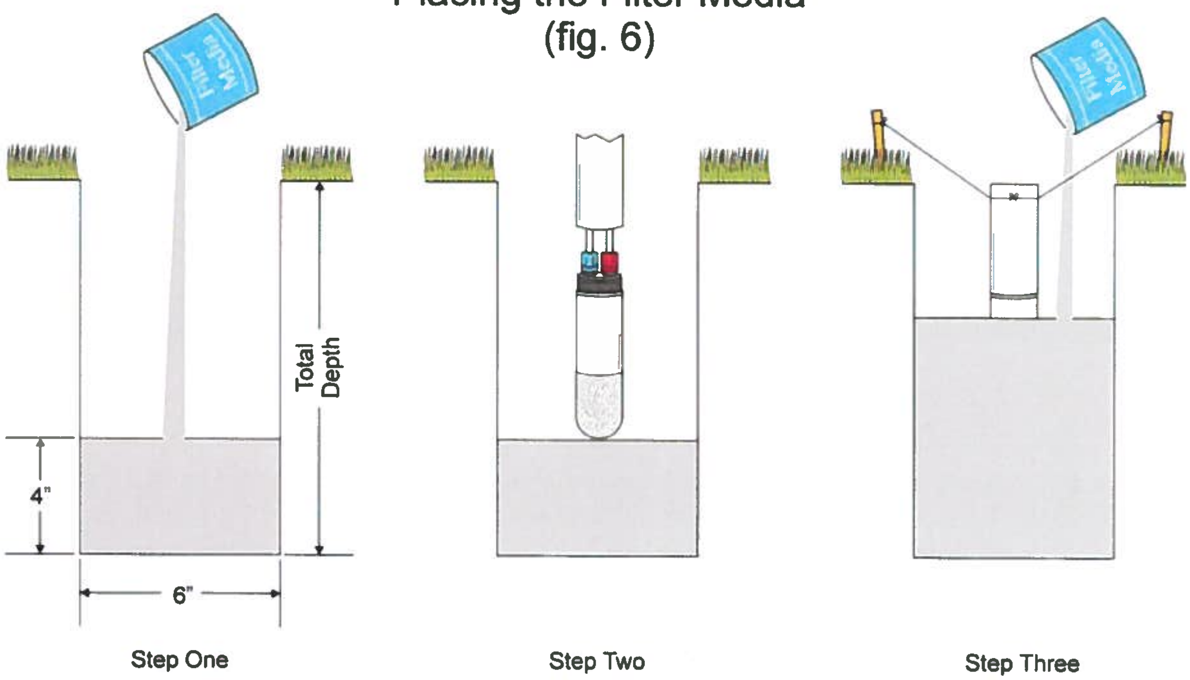
Monoflex Porous Cup Lysimeter System

LYSIMETER INSTALLATION (continued)

Placing the Filter Media
(fig. 6)



Follow the instructions on page nine of this manual for assembling the sample recovery tubing, vacuum /pressure tubing and lysimeter casing. A bentonite seal should be installed above the filter media slurry, followed by tamped backfill. A second bentonite seal is suggested near the surface.

Follow the instructions on page nine of this manual for attaching the Monoflex Lysimeter Head Assembly to the tubing and lysimeter casing. Please note that prior to installation, it must be determined where the lysimeter head assembly will be placed; either flush or above the ground surface. Placing the lysimeter head assembly above the ground is more common, as this provides easier access during sampling. Take into consideration the amount of lysimeter casing you will need to achieve your desired lysimeter head assembly placement.

A steel well protector, set in concrete, provides excellent protection for the lysimeter head assembly. These are available in different sizes. The length is important to remember when deciding the amount of stick up of the lysimeter head assembly, keeping in mind the steel well protector must be buried below grade while set in concrete.

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Monoflex Porous Cup Lysimeter System

LYSIMETER OPERATION

Removing the Distilled Water from the Lysimeter

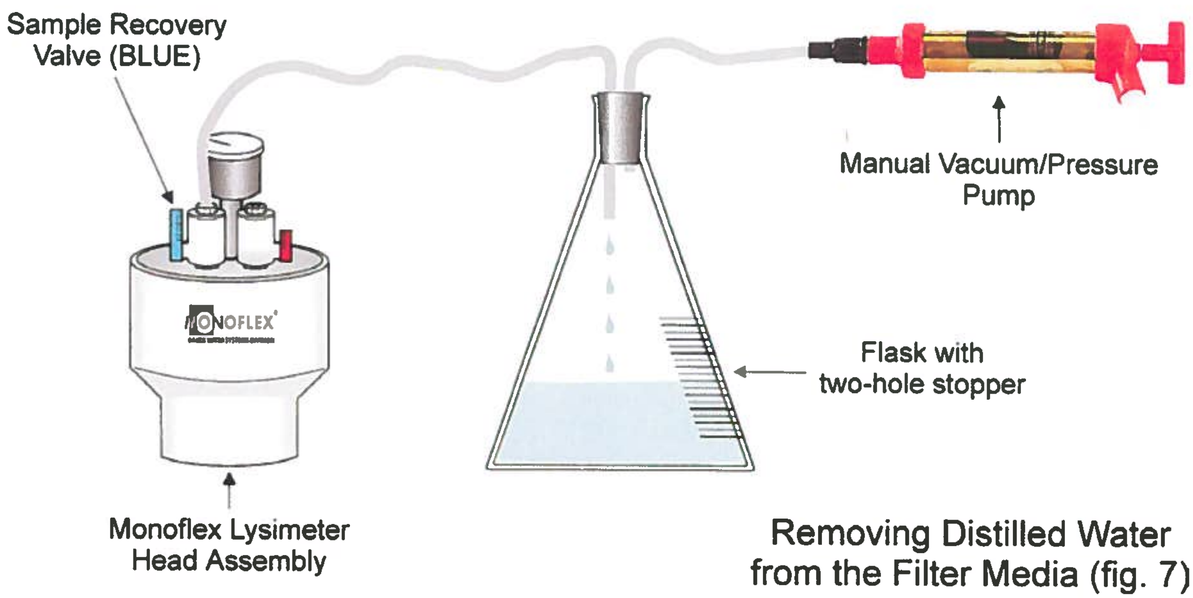
If the lysimeter was filled with distilled water prior to installation, it should be removed at this time. Monoflex recommends the use of a two-port rubber stopper in a collection flask. The size of the flask should be equal to or greater in size than the lysimeter capacity, which is 400 ml. This method is unlikely to disturb the filter media slurry by breaking the seal between it and the ceramic porous cup of the lysimeter. **This would result in a lysimeter system failure**. Please see figure seven on this page.

1) Close the vacuum/pressure valve and open the sample recovery valve on the lysimeter well head assembly.

2) Insert the flexible plastic tubing into the push-to-connect fitting on the sample recovery valve. Insert the other end of the tube into a hole on the rubber stopper on top of the flask. The tube should protrude approximately 1" (2.5cm) below the stopper into the flask.

3) Insert another length of flexible plastic tubing into the other hole on the rubber stopper so the tubing is flush with the bottom of the stopper. Insert the other end of the tubing into the vacuum end of the Monoflex vacuum/pressure hand pump (the end opposite the handle).

4) Apply a **GENTLE** vacuum to the system and the distilled water will flow into the collection flask. Please see figure seven below.



Removing Distilled Water from the Filter Media (fig. 7)

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Monoflex Porous Cup Lysimeter System

LYSIMETER OPERATION (continued)

Activating the Lysimeter

After removing the distilled water from the lysimeter, you may now charge it to obtain a sample. If the charging procedure is started immediately after the installation, it will be necessary to discard the distilled water used to make up the filter media slurry. Remove a water volume equivalent to approximately one-third of that used to make up the slurry.

Example: Using two gallons (7.57ℓ) to mix the slurry would mean the first .6 gallons (2.27ℓ) of distilled water should be discarded. The method described on page 12 for removing the water from within the lysimeter should be used for this procedure.

If the installation is left alone for a few days, the distilled water in the slurry will migrate into the surrounding soil and establish the continuity needed between the porous cup and the surrounding soil. Samples collected in this situation would then be considered representative.

Note: The following activation instructions are to be used for **both** the Monoflex **Shallow** and **Deep** Sampling Lysimeters.

1) Open the vacuum/pressure valve and insert a length of flexible plastic tubing and close the sample recovery valve on the lysimeter head assembly.

2) Apply a **GENTLE** vacuum to the vacuum/pressure line until a reading of 18-21" (46-53.4 cm) of mercury is reached on the vacuum/pressure gauge on the lysimeter head assembly. Quickly close the vacuum/pressure valve.

Sample Recovery from the Lysimeter

Shallow Sampling Lysimeter – Please note a sample may be retrieved from the Monoflex Shallow Lysimeter using the flask activation method described on Page 12. However, this may not be desirable if sampling for volatile compounds **as putting the sample under vacuum could change the quantitative results**.

Deep Sampling Lysimeter – Although the Monoflex Deep Sampling Lysimeter is designed for operation between 20 to 300 feet in depth, it is operated exactly the same as the shallow lysimeter except that pressure **must** be used to recover a sample.

If sampling deeper than 100 feet (30.5 m), the pressure supplied by the hand pump may not be sufficient to bring the sample to the ground surface. A pressure of .45 PSI (.03 bar) is required for each foot (30.5 m) of depth. A portable nitrogen tank or air compressor with a pressure regulator may be used as an alternative pressure source.

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Monoflex Porous Cup Lysimeter System

LYSIMETER OPERATION (continued)

(1) When the vacuum/pressure gauge on the lysimeter well head assembly reads 10" (25.4 cm) of mercury or less, sample recovery should be attempted. Up to 24 hours or more may be needed to collect a sample depending on the amount of soil moisture present.

(2) Open the vacuum/pressure and sample recovery valves on the lysimeter head assembly.

(3) Insert a length of flexible tubing to the push-to-connect fitting on the sample recovery valve.

(4) Apply **GENTLE** pressure to the vacuum/pressure tubing until the sample flows into the sample recovery tubing and into your sample container. It is not necessary to continue pumping once the water flows out of the sample recovery tubing. Simply hold the pump handle in place once this begins.

(5) Close all valves when the sample recovery is completed to protect the system from possible run off contamination.

Note: If using an air compressor or portable nitrogen tank, a pressure regulator must be used.

Note: Any time pressure is introduced to the lysimeter system, always increase the pressure **GENTLY**. **If any excessive pressure is applied to the system instantly, it is possible the filter media would be damaged, resulting in lysimeter system failure.**

Note: Example for calculating pressure requirements for lysimeter sample recovery.

Lysimeter depth at 100 feet:

100 feet x .45 PSI = 45 PSI (30.5 m x .03 bar = 3.03 bar). An additional ten percent of pressure to compensate for any friction loss through the vacuum/pressure or sample recovery tubing may be required.

Lytle Water Solutions, LLC

November 25, 2014

Battle Mountain Resources, Inc.
P.O. Box 310
San Luis, Colorado 81152-0310

Attn: Mr. Julio Madrid
Environmental Coordinator

Subject: Lysimeter Replacement Report, Battle Mountain Resources, Inc., San Luis, Colorado.

Project No. 1006-04

Dear Julio:

Battle Mountain Resources Inc. (BMRI) requested that Lytle Water Solutions, LLC (LWS) replace three existing porous cup lysimeters in the vicinity of the collection pond. These porous cup lysimeters will be used by BMRI to evaluate if there is leakage from either the tailings management facility (TMF) or collection pond and, if there has been leakage determined to be from either of these areas, whether there is sufficient water in the unsaturated soil zones so that water samples can be collected for the purpose of water quality analysis. The placement of the porous cup lysimeters around the collection pond was originally required under the decree in 89CW32. In 2013, it was determined that one lysimeter was not working properly and would have to be replaced. The installation report for the lysimeter that was replaced in 2013 was provided by LWS in a letter dated October 7, 2013. BMRI then decided to preemptively replace three additional lysimeters that were functional, but were showing signs of wear. This installation report has been prepared for the three additional lysimeters that were replaced.

The lysimeters are located directly downgradient of the lined TMF adjacent to the collection pond, at shown in Figure 1. According to the original lysimeter installation report at each of the three sites shown in Figure 1 there are two lysimeters, a shallow lysimeter (approximately 25 feet (ft) deep and a deep lysimeter (approximately 50 ft deep)). For the replacements, one lysimeter is set at 50 ft, at the bottom of the colluvial materials at the interface with the Santa Fe Formation at lysimeter site 1. The other two lysimeters were set at a clay lense found at lysimeter sites 1 and 2, and at 24 ft and 27 ft in depth, respectively. The replacement lysimeters are located approximately 10-15 ft from the corresponding original lysimeters.

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LWS contracted with DrillPro Services (DrillPro) of Denver, Colorado to perform the drilling for the lysimeter installation. LWS and Drillpro mobilized to the site for installations on June 4, 2014. Before the arrival of LWS and DrillPro, BMRI prepared the site for the installation by creating an access way for vehicles and clearing the installation areas of vegetation. LWS and DrillPro arrived on-site at 9:30 AM and began drilling the 27-ft borehole at lysimeter site 2. DrillPro used an 8-inch (in.) hollow-stem auger to drill the borehole to total depth for the lysimeter installation.

During drilling, the cuttings returned on the auger flights were logged. Generally, the cuttings from the borehole were gravel to a gravelly sand. There are minimal fines present in the colluvium. The sand was tan with a reddish hue, and fine- to coarse-grained sub-angular particles. The gravel ranged in size from pebbles to one inch across, and were dark gray in color. The gravelly sand varied minimally over the depth of the borehole. The clay lense encountered in the boring of the original lysimeter was not present in this borehole upon reaching the target depth of 27 ft, indicating that the clay layer is highly localized. The cuttings showed no sign of subsurface water and were dry, individual grains of sand and gravel resisted clumping, and left no moisture on the hands after handling. BMRI staff indicated that the original lysimeter never produced water for a sample, and our findings are consistent with this statement.

After reaching the target depth, the hollow-stem auger was backed out approximately 6 in. to facilitate the placement of the lysimeter. A Monoflex deep lysimeter was chosen by LWS for the installation. The Monoflex deep lysimeter was tested in the LWS offices for leaks with distilled water before being transported to the site, per the manufacturer's recommendations (Appendix A). As a first step in the installation, LWS mixed 200-mesh silica flour with distilled water into a slurry in a clean, five-gallon bucket, and poured this mixture down the hollow-stem auger to create a 6-in. base for the ceramic porous cup of the lysimeter to be lowered into contact with the silica flour. The porous cup of the lysimeter was then hydrated with distilled water before being set downhole, as described in the Monoflex lysimeter installation instructions (Appendix A). The lysimeter was lowered down the center of the hollow-stem auger hole in 5-ft segments, with each segment iteratively threaded and lowered downhole by LWS and Drillpro personnel. Once the lysimeter was lowered to contact the silica flour base and secured, the remainder of the 50-pound (lb) bag of 200-mesh silica flour was mixed into a slurry with distilled water, and then poured downhole to completely surround the porous cup of the lysimeter, and then the augers were lifted an additional 1.5 ft. The silica flour was then left to set around the porous cup for approximately 2 hours (hrs) before the installation resumed.

After the silica flour had set, the auger was backed out 3 ft to allow bentonite chips to be set downhole so as to minimize the risk of locking the auger in place. The depth to the silica flour was tested after the auger was backed out to confirm (a) the depth of the silica flour and (b) that the hole had not collapsed. The end of the measuring device was returned to the surface covered in silica flour slurry, which confirmed that the borehole was intact. One 50-lb bag of untreated bentonite chips was then poured downhole to seal the silica flour from vertical infiltration. Then one 50-lb bag of sand was poured downhole on top of the dry bentonite chips to keep the bentonite chips isolated from native material. Finally, 2.5 gallons of distilled water were poured downhole to hydrate the bentonite chips and create the needed seal.

The auger flights were then pulled out of the borehole without disturbing the PVC lysimeter casing. The depth to the sand in the borehole was measured at that point to estimate if there had been any hole collapse. Approximately 2 ft above the sand was covered with native materials, making the open borehole depth from ground surface to approximately 19 ft. The drill cuttings were then shoveled back into the borehole around the lysimeter casing to a depth of 6 ft below ground surface (BGS). A second 50-lb bag of bentonite was poured downhole and hydrated to form a seal, and also to keep surface water from using the borehole as a preferential pathway into the subsurface. The lysimeter head was then attached to the end of the PVC casing, and a 4-in. x 4-in. x 5-ft lockable steel stickup was installed over the lysimeter head. The stickup was then driven into the backfill and cemented into place. The completed lysimeter was tested, functioned properly, and had no loss of vacuum. The drill rig was then moved to site 1 to install the remaining lysimeters. A schematic of the completed site 1 shallow lysimeter is presented in Figure 2.

As a final test, LWS applied a vacuum of 16 in. of mercury to the 27-ft lysimeter at site 2 at approximately noon. Later, at 4:00 PM, the pressure gage on the lysimeter had dropped from 16 in. of mercury to 14 in. of mercury. This drop in vacuum pressure was expected, as water from the installation process was available to be drawn into the porous cup. LWS staff did not have a pump sufficient to produce the required pressure to push the collected water to the surface. Instead, a vacuum of 18 in. of mercury was applied, and the lysimeter cover was locked.

Drilling operations continued at site 1 on June 4th. The 50-ft deep site 1 lysimeter replacement was completed in the same manner as the site 1 shallow lysimeter. Testing was performed following installation, and the lysimeter performed as expected. The completion details for this lysimeter are shown in Figure 3.

On the morning of June 5th, the 24-ft deep lysimeter was installed at site 1 using the same methodology as was described for site 2. The lysimeter was pressure-tested before the installation and performed well. However, after installation the lysimeter was quickly losing vacuum. The head of the lysimeter at the surface was replaced, but the problem persisted, indicating that the problem was with the porous cup assembly. It is likely that the porous cup was damaged while being lowered down the auger flights, causing a crack in the cup. It was determined that there was no way to fix the damaged lysimeter in the field and that LWS would have to return to the site at a later date to drill and install another lysimeter to replace the damaged unit.

LWS returned to the site on September 10th, 2014 to replace the 24-ft deep lysimeter at site 1 that had been damaged during its initial installation. For this mobilization, LWS contracted with Elite Drilling of Denver, Colorado. Elite Drilling arrived on site at 8:00 AM and began drilling shortly thereafter. The lysimeter was tested multiple times during the installation process, and performed as designed at all times. The construction details of this lysimeter are consistent with the previous lysimeter installations, and are shown in Figure 4. For a final test, the lysimeter was put under a vacuum of 18 in. of mercury and left to sit for 6 hrs. After 6 hrs, the vacuum had dropped to 16 in. of mercury, due to water being pulled into the porous cup. The porous cup was emptied and left at zero vacuum at the end of testing.

The faulty 24-ft lysimeter at site 1 from the June 5th installation was also removed and abandoned. The locking well cover was lifted off the lysimeter and the lysimeter casing was then unscrewed so that the top of the casing was roughly 1-ft BGS. The lysimeter hoses were then cut at the top of the casing and bentonite crumbles poured into the casing, filling it to the surface. The bentonite was then hydrated, fully sealing off and abandoning the damaged lysimeter. It should be noted that while LWS abandoned the lysimeter with bentonite, the lysimeter does not penetrate the water table, and so will not be able to pump or transmit water via the former borehole due to the lack of gravel pack.

We understand that BMRI personnel have a pump capable of applying a vacuum to the lysimeters and extracting water from the lysimeters. As such, LWS recommends that BMRI return to the lysimeter with your pump to extract the distilled water used in the installation process. The distilled water does not need to be tested, as there was no native water present during installation. However, once the distilled water is removed from the silica flour, testing should be performed if, and when, there is sufficient native water to sample.

LWS personnel installed D 1600 locks on all the locking lysimeter covers, which is the same lock type used on the previous lysimeter installations and so will not require additional keys.

If there are any questions regarding the installation procedures used for these lysimeter installations, please do not hesitate to call the undersigned.

Christopher M.D. Fehn
Staff Engineer

Bruce A. Lytle, P.E.
President

attachments
/pk

1cc: Mr. Larry Fiske
Newmont Mining Corporation
6363 S. Fiddler's Green Cir., Ste 800
Greenwood Village, CO 80111

LYTLE WATER SOLUTIONS, LLC

LEGEND

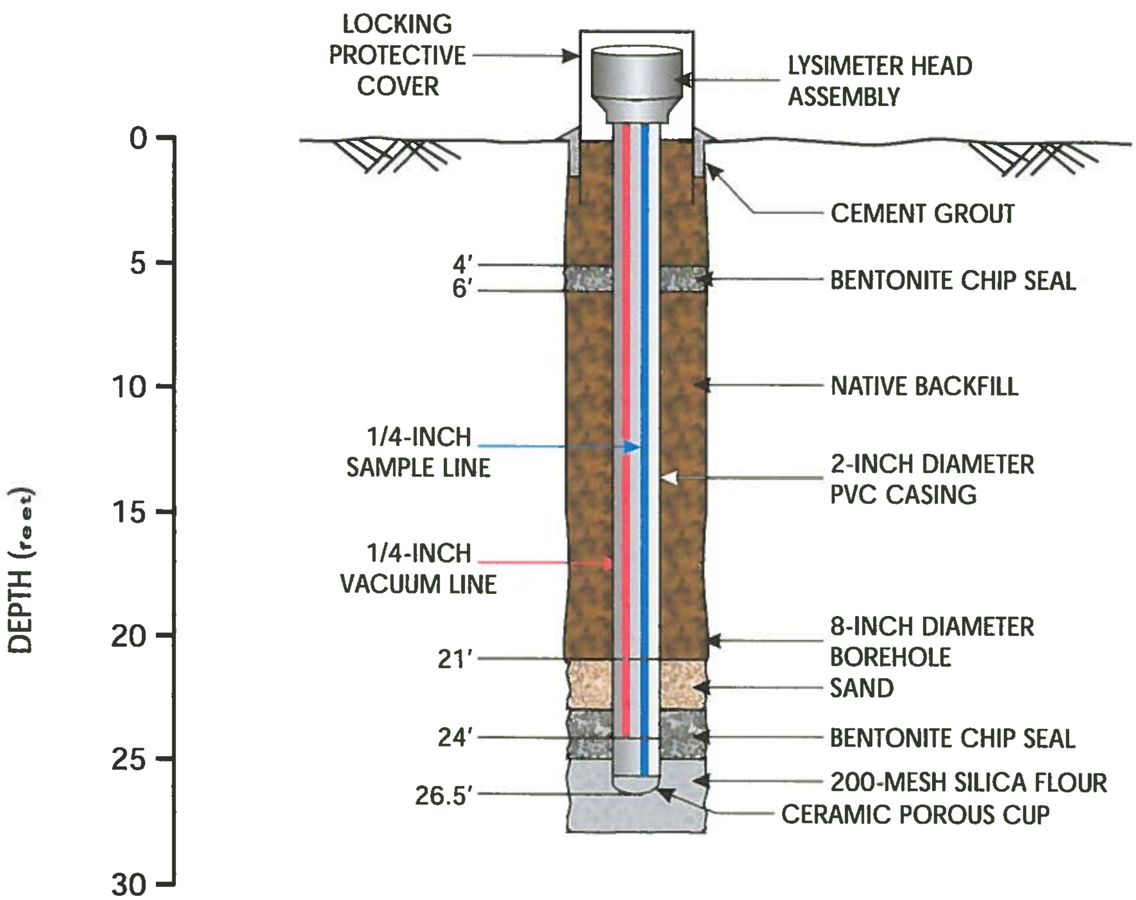
LYSIMETER LOCATIONS

Note:
At each lysimeter location there is a shallow lysimeter (~25 ft deep) and a deep lysimeter (~50 ft deep).

0 .05 mi

N

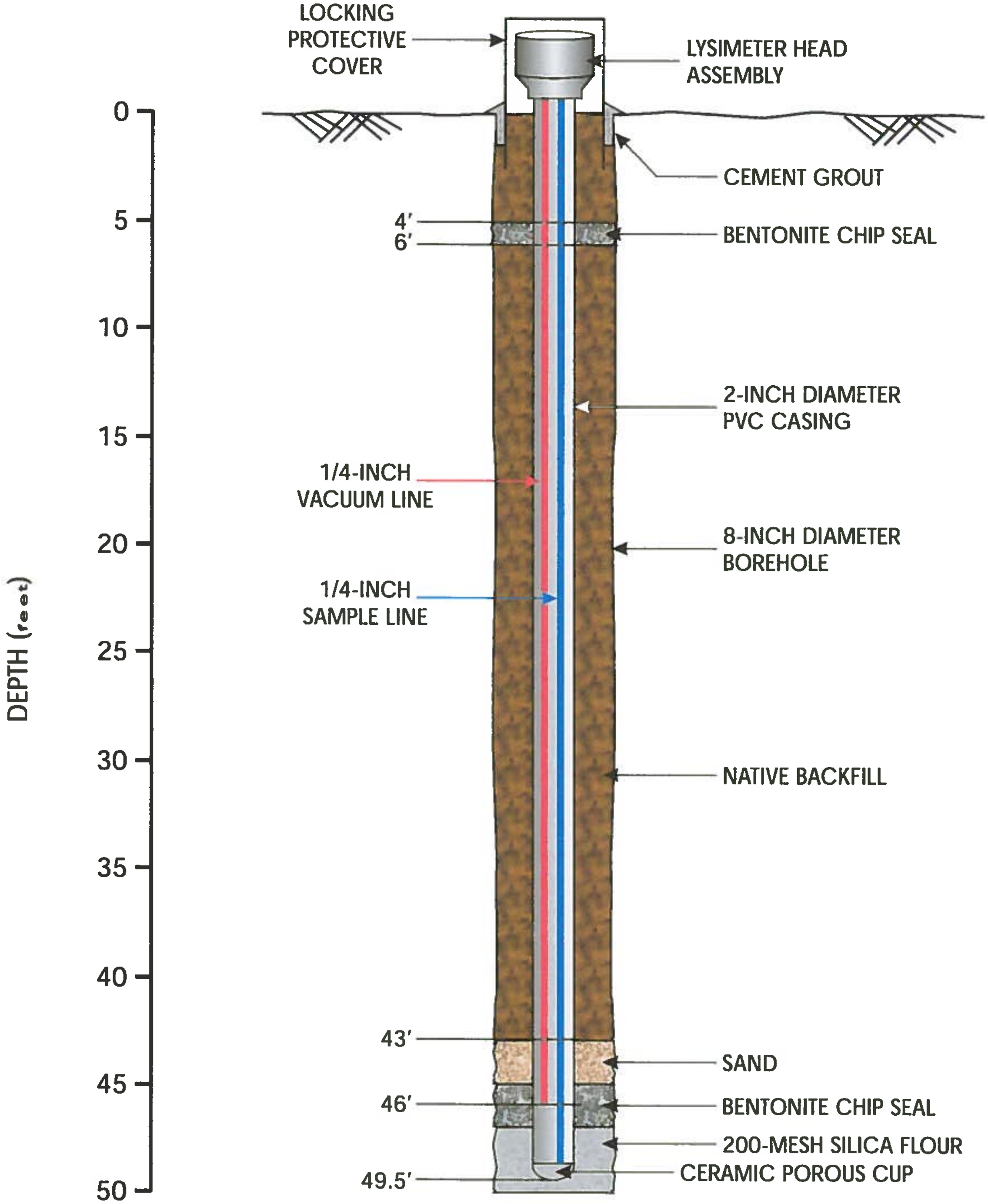
BATTLE MOUNTAIN RESOURCES, INC.		
LYSIMETER LOCATIONS		
File Name: LysimeterLocMap.cdr		Date: 12/01/2014
Project No.: 1006-04	Drawn By: VAL	Fig. No.: 1



Notes:
1) Lysimeter replaced on June 4, 2014.
2) Borehole drilled by DrillPro, using a hollow-stem auger.

BATTLE MOUNTAIN RESOURCES, INC.		
REPLACEMENT LYSIMETER CONSTRUCTION DETAILS SITE 2 SHALLOW		
File Name: LysimeterDetails-1shallow.cdr		Date: 10/20/2014
Project No.: 1006-04	Drawn By: VAL	Fig. No.: 2

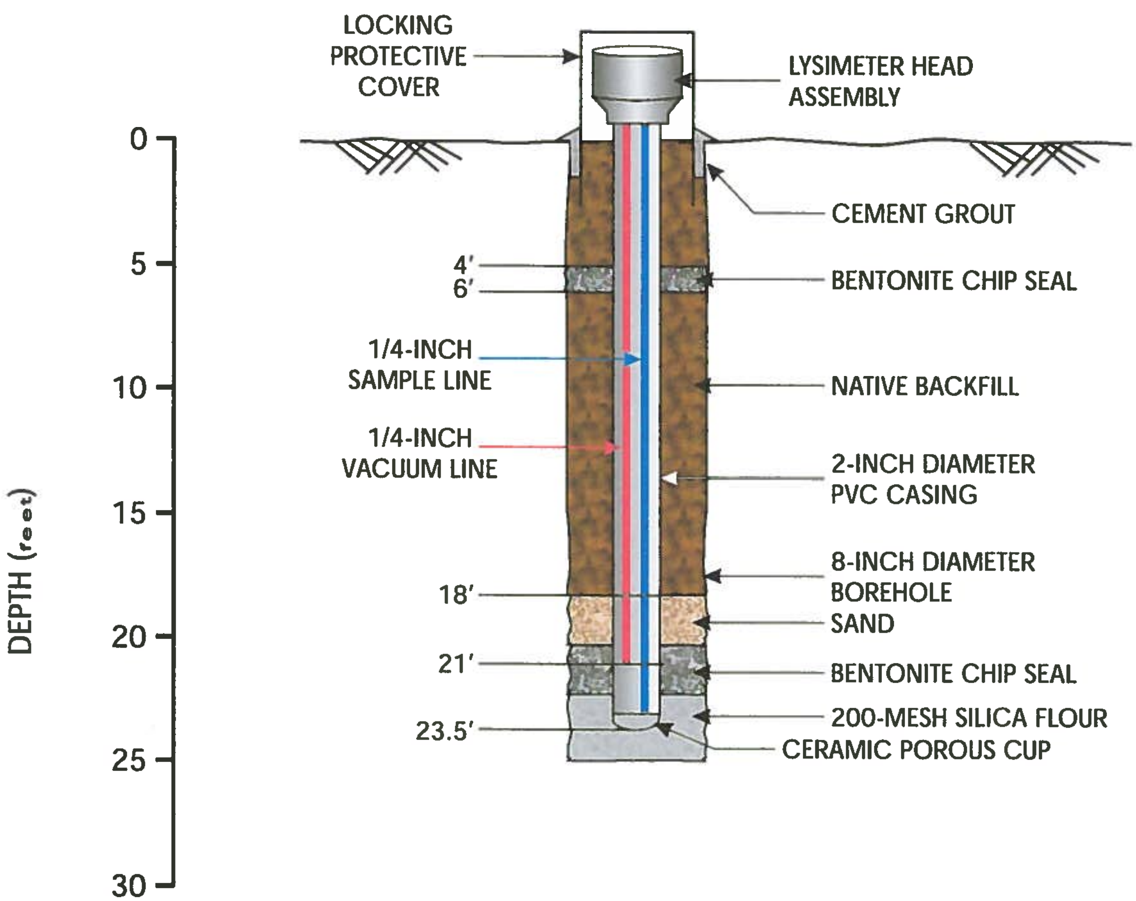
Lytle Water Solutions, LLC



Notes:
1) Lysimeter replaced on June 4, 2014.
2) Borehole drilled by DrillPro, using a hollow-stem auger.

BATTLE MOUNTAIN RESOURCES, INC.	
REPLACEMENT LYSIMETER CONSTRUCTION DETAILS SITE 1 DEEP	
File Name: LysimeterDetails-2deep.cdr	Date: 10/20/2014
Project No.: 1006-04 Drawn By: VAL	Fig. No.: 3

Lytle Water Solutions, LLC



Notes:
1) Lysimeter replaced on September 10, 2014.
2) Borehole drilled by Elite Drilling, using a hollow-stem auger.

BATTLE MOUNTAIN RESOURCES, INC.		
REPLACEMENT LYSIMETER CONSTRUCTION DETAILS SITE 1 SHALLOW		
File Name: LysimeterDetails-2shallow.cdr		Date: 10/20/2014
Project No.: 1006-04	Drawn By: VAL	Fig. No.: 4

APPENDIX A
LYSIMETER INSTRUCTION MANUAL

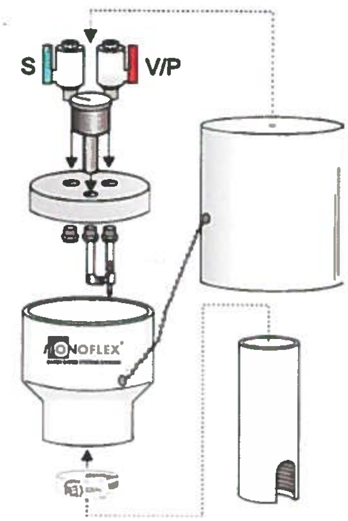
BAKER WATER SYSTEMS DIVISION

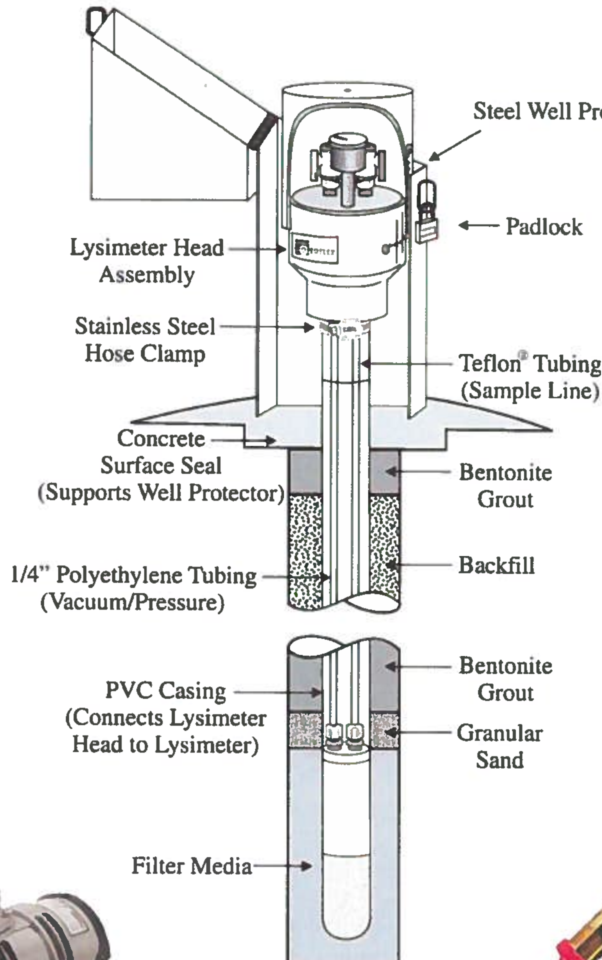
Quality Ground Water Monitoring Products Since 1973

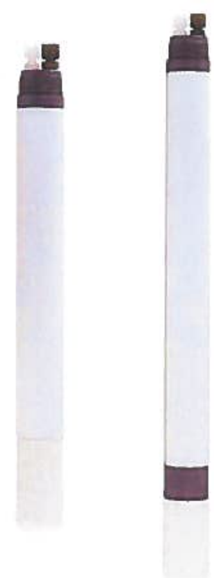
POROUS CUP LYSIMETERS

Instruction Manual

Complete instructions for installation and operation of Monoflex Lysimeters and accessories.







Baker Water Systems Division - Monoflex

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TABLE OF CONTENTS

<u>Note:</u> Drawings featured here-in are representative of Monoflex products; actual products may differ in appearance. Performance and product specifications are correct at the time of publication.

Version 4 – 09/12

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Monoflex Porous Cup Lysimeter System

INTRODUCTION

Investigation of the vadose (unsaturated) zone is an essential part of many environmental monitoring programs. The ability to detect groundwater pollutants as they travel towards the water table is possible with the use of Monoflex Lysimeters. Early detection, by removing samples of soil pore water, may result in less expensive remedial measures.

Monoflex Lysimeters are soil pore water collection devices, designed for permanent installation beneath the ground surface. They are closed tubular devices with a porous ceramic filter element at one end. Monoflex Lysimeters are provided with two ports; one to allow application of a vacuum or pressure, the other to allow delivery of collected water samples to the surface.

They operate by establishing continuity between the soil pores and those on the porous element of the lysimeter. Surrounding the lysimeter with a filter media will ensure intimate contact with the surrounding soil and effectively increase the operating range. An equilibrium will be established between the water in the soil pores, the filter media and the porous ceramic cup. Application of a vacuum to the inside of the Monoflex Lysimeter will cause the pore water to flow from the soil pores through the filter media, the porous cup into the lysimeter body. The soil pore water may then be transferred to the ground surface via the sample recovery line, by pressurizing the vacuum/pressure line.

Sampling Characteristics of Ceramic Material

As stated above, Monoflex Lysimeters feature a threaded porous ceramic cup as the filter. The other materials used in Monoflex Lysimeters are virgin, NSF listed PVC pipe and bar stock, nylon compression fittings, polyethylene tubing and Viton O-rings. **No solvents, glues or adhesives are used in the manufacture or assembly processes**. Please see the following notes regarding use of ceramic materials for ground water sampling.

- The ceramic material absorbs or interferes with NO_3 –N and P, especially when the sorptive capacity of the soil is less than that of the ceramic. Sorption or a combination of factors has been found to reducer levels of Ni, Cu Pb, Zn, Fe, Mn and Mg approximately 10% following percolation through ceramic cups. Percolation through the ceramic also reduced concentrations of the chlorinated hydrocarbons ppDDD, ppDDE, and ppDDT by 90%, 70% and 94% respectively.

- Analysis of extracts from porous ceramic also reveals that Ca, Na, K, Mg, bicarbonate and silica are leached from the ceramic material.

- Researchers have concluded that ceramic does not yield valid water samples for fecal coliform analysis.

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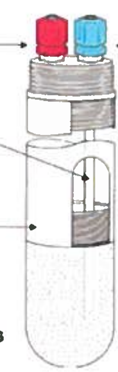
Monoflex Porous Cup Lysimeter System

OVERVIEW OF LYSIMETER OPERATION

* Monoflex Porous Cup Lysimeters are designed for permanent installation beneath the ground surface. Their purpose is to collect water from the vadose (unsaturated) zone. The system is designed for long term use in one location.

* Monoflex Lysimeters consist of a threaded porous ceramic cup, a PVC body in which the sample is collected, and a threaded top plug with two tubing fittings installed. The tubing fittings are sized for ¼" O.D. (6.35 mm) tubing, one for the vacuum/pressure operation and one for sample recovery. The tubing connects to the corresponding tubing fittings between the lysimeter and the lysimeter head assembly. The lysimeter is threaded directly to the PVC flush threaded casing, and the lysimeter head assembly slips onto the casing at ground level. The PVC flush thread lysimeter casing enables placement of the lysimeter at the desired depth while protecting the lysimeter tubing.



Monoflex Porous Cup Lysimeter Components (shallow type)

* The Monoflex Lysimeter is placed in a 6" (15.24 cm) diameter borehole with a filter media placed around the porous ceramic cup. A bentonite seal (grout), backfill, and concrete seal are placed above the filter media to protect the installation from contamination from ground surface run-off (see illustration on page four of this manual).

* To activate the lysimeter, close the sample recovery valve on the well head assembly, attach a hand operated or 12-volt electric vacuum pump to the open vacuum/pressure valve, generating a vacuum of approximately 24 in. Hg (71.1 cm. Hg). Once a vacuum is generated, water will flow from the soil pores through the filter media, through the porous ceramic cup, and into the lysimeter body. Soil pore size and moisture will affect the time needed to collect a sample.

* Evacuation of the sample is achieved by applying a low-level pressure of approximately 10 PSI (52 cm. Hg) to the opened vacuum/pressure valve and opening the sample valve on the lysimeter head assembly. The capacity of the sample chamber on both types of Monoflex Lysimeters is 400 ml. The Monoflex porous ceramic cup has an average pore size of 0.446 micrometers.

<u>Note</u>: Generally accepted practice for lysimeter systems involves the use of 200 Mesh Silica Flour as the filter media. Due to the hazardous nature of silica flour, it is not stocked at our facilities.

Naturally occurring soil may be used as an alternative to silica flour, provided the soil is free from rocks and pebbles. Mix the soil with distilled water to a consistency of smooth concrete for placement in the borehole.

All reference to "filter media" in this manual refers to either silica flour or naturally occurring soil.

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Monoflex Porous Cup Lysimeter System

INSTALLATION COMPONENTS

The Monoflex **Shallow** Sampling Lysimeter is designed for placement to depths of **20' (6.1 m) or less**. For installations to depths of **21' to 250' (76.2 m)**, a Monoflex **Deep** Sampling Lysimeter is required. Our sales representatives will answer your questions to ensure the appropriate model is selected for your particular application. Call 800-257-5183 or 610-367-5675. You can also e-mail us at: monoflex@campbellmfg.com

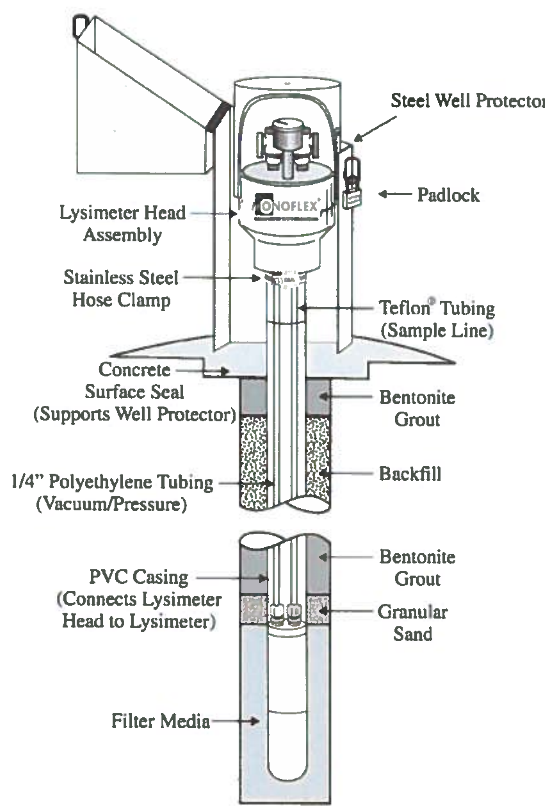
The following items will be required for a typical Monoflex Lysimeter installation:

- Monoflex Shallow or Deep Sampling Lysimeter
- Monoflex Lysimeter Head Assembly* *(one per lysimeter)*
- Filter Media for surrounding the lysimeter *(volume of one five gallon pail)*
- ¼" O.D. PTFE or Polyethylene Tubing *(two lengths per lysimeter)*
- One Tubing Groover for ¼" O.D. tubing
- A Monoflex Vacuum/Pressure Hand Pump or 12V electric vacuum pump
- Monoflex PVC Flush Thread Lysimeter Casing** *(quantity depends on well depth)*
- Steel Well Protector with padlock

Note:
* If a Monoflex Lysimeter Head Assembly is not purchased, a vacuum/pressure gauge, and two ball valves will be needed as well as a method for securing tubing at the surface.

** Lysimeter casing is not absolutely required in all installations. However, Monoflex strongly advises use of casing to protect the tubing lines between the lysimeter and the ground surface. Lysimeter casing also will assist with accurate depth placement. Monoflex Lysimeter flush thread casing **is not** ASTM F-480 compatible.

Note:
Bentonite Grout and concrete **are not** available from Monoflex. These products are typically available through a local drilling equipment wholesale distributor.



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Monoflex Porous Cup Lysimeter System

PRE-TESTING COMPONENTS

The following items will be required for pre-testing Monoflex Lysimeters prior to installation:

- Alconox® or Liquinox® (both available from Monoflex), and distilled water for decontamination.
- Distilled water for pressure testing, de-gassing and pre-filling.
- Protective (latex or nitrile) gloves for handling the system during assembly, cleaning, and installation.
- A latex membrane, such as a condom, for vacuum testing the system.
- Clean plastic bags to wrap the assembled system for transfer to the installation site.
- 2 gal. (7.6ℓ) distilled water per 5 gallon pail of filter media.
- A large, clean container for mixing filter media and distilled water.
- A large, rigid spatula (or drill with mixing paddle) to mix the filter media.
- A clean sample collection container, with a capacity greater than that of the lysimeter, (400 ml).

MONOFLEX LYSIMETER PRE-TESTING PROCEDURES

Note Effective use of the Monoflex Lysimeter System requires that all the fittings and unions must be air tight. Two methods are described to check the assembled system for air leaks. All Monoflex Lysimeters are tested at our facility prior to shipping; fittings may loosen in transit and should be re-checked for tightness. If the optional pre-installation factory testing was purchased, it is not necessary to perform pressure and vacuum testing.

Please see page seven of this manual for assembly procedures. The following pre-testing procedures will reference the Monoflex Lysimeter, tubing and head assembly as one assembled unit.

Pressure Testing

Completely immerse the Monoflex Lysimeter and tubing connections in distilled water. Connect the pressure outlet of the Monoflex vacuum pump to the vacuum/pressure valve (marked "v/p", with red valve handle), on the lysimeter head assembly. Close the sample recovery valve on the head assembly (marked "s", with a blue valve handle), and apply 15 PSI (1 bar) of air pressure, noting the reading on the vacuum/pressure gauge on the head assembly. Observe all connections for evidence of air bubble formation, indicating leakage. The porous ceramic cup should give off small "champagne" type bubbles over the entire surface area. Large bubbles forming at the joint between the cup and lysimeter body indicate a leak. Leaks involving the body components of the lysimeter should be checked for cleanliness, particularly the surfaces that touch the O-rings. Unthread the cup and re-tighten under water. If leaks are observed at the tubing connections, disassemble, check for correct assembly and re-tighten. The threads of the tubing connections on top of the lysimeter are wrapped with PTFE tape at the factory. They may be unscrewed and wrapped with PTFE tape again if needed. See figure one on page six.

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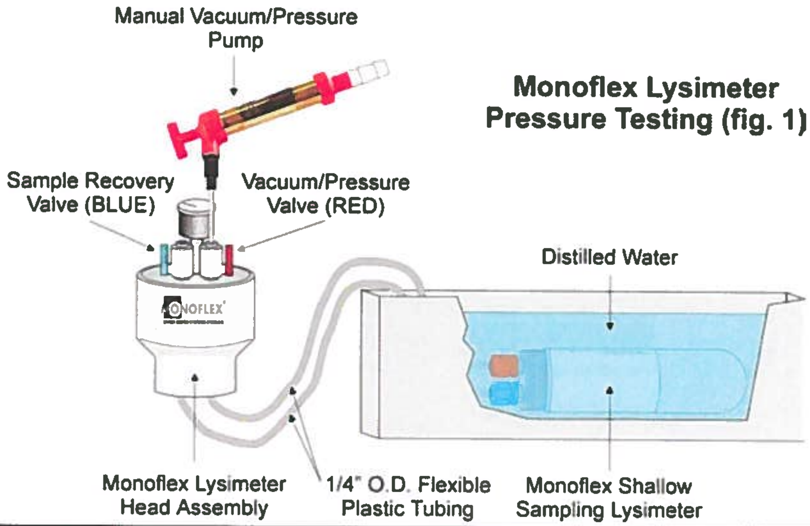
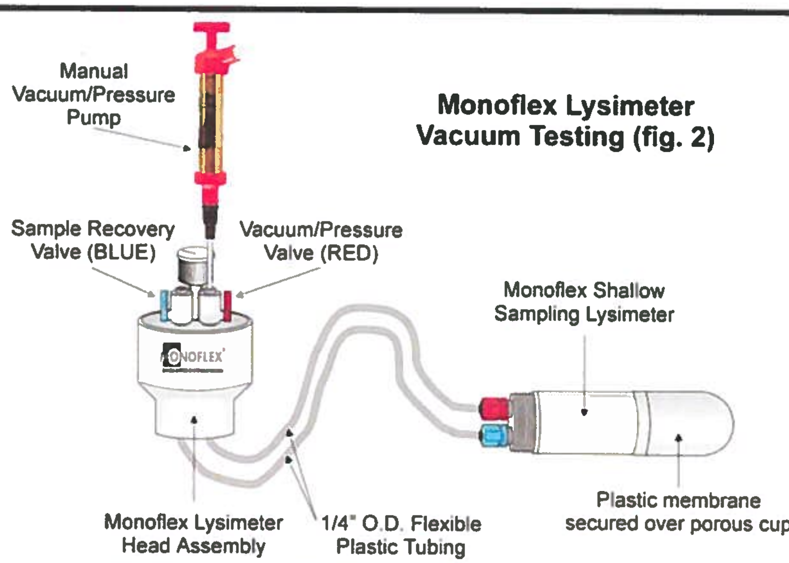
MONOFLEX LYSIMETER PRE-TESTING PROCEDURES (continued)



Monoflex Lysimeter Pressure Testing (fig. 1)

Vacuum Testing

Encase the lower half of the lysimeter body with a latex or flexible plastic membrane, (such as a condom), and secure with rubber bands above the porous cup. After shutting off the sample recovery valve on the head assembly, connect the vacuum inlet of the pump to the vacuum/pressure valve and pull a vacuum in excess of 20" (51 cm) of mercury and close the vacuum/pressure valve. After noting the reading on the head assembly gauge, leave the system for several hours and recheck the gauge reading. A small drop of as much as 3" (7.6 cm) of mercury may be expected. If a large drop is noted, check and re-tighten all connections as described under "Pressure testing" on page five of this manual. See figure two below.



Monoflex Lysimeter Vacuum Testing (fig. 2)

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LYSIMETER SYSTEM ASSEMBLY PROCEDURES

When properly installed, the typical Monoflex Lysimeter system may be expected to produce representative samples for a number of years. It is important that the system be tested thoroughly before taking it to the installation site. Prior to installation, the system should be pressure and/or vacuum tested to ensure it is leak free.

The Monoflex Lysimeter system components are cleaned and packed in plastic bags. The components have not been subjected to the rigorous decontamination procedures required for equipment used to obtain samples for subsequent micro-analysis of trace pollutants. If complete decontamination is required, see the section in this manual titled "DECONTAMINATION PROCEDURES" and/or follow those specified for the project. **Note**: If the lysimeter body is decontaminated, it will be necessary to pass at least two liters of distilled water through the porous ceramic cup to ensure complete removal of liquids used for the decontamination. After this procedure is completed, the components should be bagged. Subsequent handling should be done in a clean area, using sterile gloves.

The system components supplied are manufactured by Monoflex to satisfy the requirements for the order. Mixing these with components from other suppliers may lead to compatibility problems which may result in leakage or failure of the lysimeter system.

Assembly of Tubing to Fittings

Tubing ends should be grooved before attaching a fitting. Failure to do so will allow the tubing to slip out of the fitting and cause leakage. If the installation requires the tubing to be shortened, the new end will need to be grooved, using a special grooving tube available from Monoflex. The tool not only cuts the groove, but also places the groove at the correct distance from the end of the tubing. See figure three below.

Tubing Groover Instructions (fig. 3)