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Status of SRNL Radiological Field Lysimeter Experiment – Year 1

Daniel I. Kaplan, Kimberly A. Roberts, and Laura A. Bagwell

October 2013

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REVIEWS AND APPROVALS

EXECUTIVE SUMMARY

The Savannah River National Laboratory (SRNL) Radiological Field Lysimeter Experiment is a one-of-a-kind field facility designed to study radionuclide geochemical processes at a larger spatial scale (from grams to tens of kilograms sediment) and temporal scale (from months to 10 years) than is readily afforded through laboratory studies. The lysimeter facility is intended to capture the natural heterogeneity of moisture and temperature regimes in the vadose zone, the unsaturated subsurface region between the surface soil and the underlying aquifer. The 48 lysimeter columns, which contain various radionuclides (and stable iodine), were opened to rainfall infiltration on July 5, 2012. The objective of this report is to provide a status of the lysimeter facility operations and to compile data collected during FY13, including leachate volume, rainfall, and soil moisture and temperature *in situ* probe data. Radiological leachate data are not presented in this document but will be the subject of a separate document.[1]

Leachate samples were collected quarterly and shipped to Clemson University for radiological analyses. Rainfall, leachate volume, moisture and temperature probe data were collected continuously. During operations of the facility this year, there were four safety or technical concerns that required additional maintenance: 1) radioactivity was detected in one of the overflow bottles (captured water collected from the secondary containment that does not come in contact with the radiological source material); 2) rainwater accumulated within the sample-bottle storage sheds; 3) overflow containers collected more liquid than anticipated; and 4) significant spider infestation occurred in the sample-bottle storage sheds. To address the first three concerns, each of the lysimeter columns was re-plumbed to improve and to minimize the number of joint unions. To address the fourth concern regarding spiders, new sample-bottle water sheds were purchased and a pest control program was established. During this retrofit, the lysimeters were temporarily capped (covered to preclude additional water from entering lysimeter columns) for about two months (except the four Tc-cementitious containing lysimeters, which remain capped).

At a later date, data summarized in this report will be combined with the leachate radionuclide concentration data that are presently being analyzed. Together, these data can be numerically modeled to provide bench-marking information, to test hypotheses regarding hydrogeochemical conceptual models, and to estimate effective transport parameters under field conditions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CSLM	Controlled low-strength material
D_e	Effective diffusion coefficient
DOE	Department of Energy
PA	Performance Assessment
RadFLEx	Radiological Field Lysimeter Experiment
PVC	Polyvinyl chloride
SRNL	Savannah River National Laboratory
SRR	Savannah River Remediation
SRTC	Savannah River Technology Center

1.0 Introduction

1.1 Objectives and Scope of Report

The objective of this report is to provide a status of the SRNL Radiological Field Lysimeter Experiment facility (or RadFLEx) and a summary of the data collected during fiscal year 2013. No radiological leachate concentration data are discussed in this report. Results of leachate concentration data will be presented in a separate report.[1] Modeling and interpretation of the interaction between the radionuclide (and stable iodine) leachate concentration data and the water mass-balance are not presented in this report.

The specific objectives of this report are to provide:

1. a review of the lysimeter retrofit and maintenance,
2. a timeline of each lysimeter,
3. leachate and overflow sample volume data,
4. rainfall data, and
5. temperature and moisture-probe data from control lysimeters and a reference sediment outside the lysimeter facility.

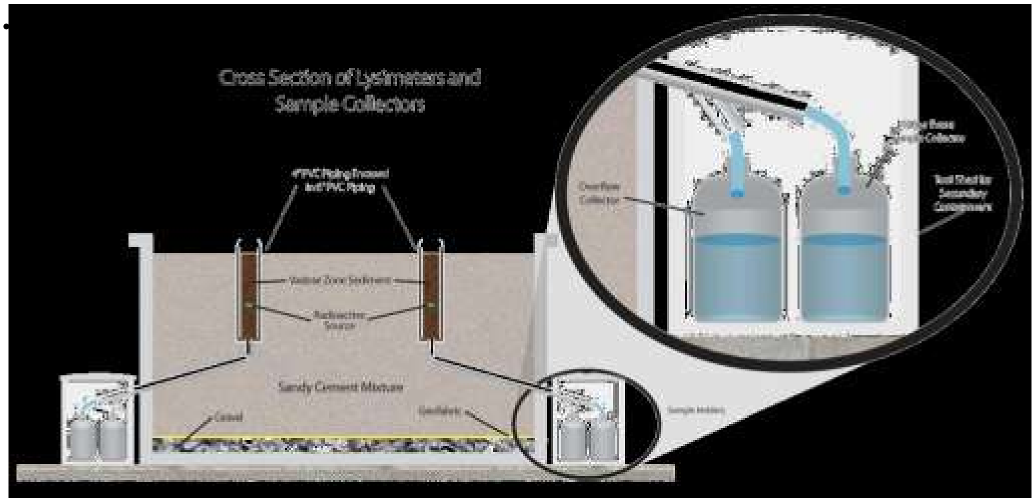
1.2 General Description of the Radiological Field Lysimeter Experiment Facility

A detailed description of the construction, radiological source material preparation, and initial operations between July 5, 2012 and September 30, 2012 is presented by Roberts et al.[2] A brief discussion follows to provide sufficient background to permit understanding the information presented in this document. The basic concept behind these field column experiments that hold radiological source materials within vadose zone sediment is as follows: infiltrating precipitation enters the top, percolated leachate is collected as a function of time from the bottom of the column, and the radionuclide (and stable iodine) concentrations in the leachate are measured (Figure 1-1). At the end of the individual experiments (typically 2, 4, or 10 years), lysimeter sediment cores will be removed and sectioned to provide depth-discrete samples that will be analyzed for radionuclide concentrations. Additionally, the lysimeter source materials will be analyzed to provide information about the release mechanism and to provide a radiological mass balance.

The overall scientific objectives of the lysimeter facility are to:

1) quantify the rate that radionuclides move through the SRS vadose zone sediments for up to 10 years,
2) provide temporally and spatially scale-up from previous tests that were largely limited to beaker-scale experiments involving gram quantities of sediment over a period of weeks to months,
3) capture the effects of natural climatic heterogeneity and dynamic flow conditions that may be expected in the vadose zone, and
4) reduce uncertainty associated with geochemical transport to support performance assessments and composite analyses.

A.



B.

C.

Figure 1-1. (A) Cross-sectional schematic of the lysimeter facility; (B) operating facility; (C) inside the sample bottle storage shed and a saltstone source within lysimeter L20 before it was covered with vadose zone sediment.

The lysimeter facility consists of 48 separate column experiments in which radiological source materials were buried 30-cm below the lysimeter sediment surface in a 60-cm long column

(Figure 1-1). Each lysimeter was fabricated from standard PVC materials purchased from local plumbing and hardware vendors. The lysimeter columns consisted of two pipes; one sediment-containing pipe (60 cm long x 10 cm diameter) was placed within a larger pipe (60 cm long x 15 cm diameter). The outer pipe was designed to provide secondary containment in case the inner pipe with sample becomes saturated and overflows. The bottom of the inner, sediment column was connected to the sample containers with flexible Tygon tubing. The sample containers were located in storage sheds outside the Sea Land shipping containers that hold the columns. The 48 columns were held in place and were insulated within the Sea Land shipping containers with controlled low-strength material (CLSM; about 3 – 6 % dry-weight cement and 94 – 97% local quartz).

The radiological treatments (type of radionuclide, form of source, and sediment treatment) are summarized in Figure 1-2. The sources were either placed in cementitious pucks (1.6 cm radius x 1.2 cm height) or placed directly on filter paper. For the filter applications, the radionuclides were applied as a liquid or suspension to the inside of two filters that were joined to form a "pita bread" configuration. The intent of this filter paper design was to help ensure the safe emplacement of the source in the lysimeter sediment.

There were eight non-radiological control lysimeters: two slag-free cementitious source controls, two saltstone source controls, one grass control, one sediment/filter paper control, and two sediment/filter paper controls with moisture and temperature probes (more information about these probes is presented in Section 7.0) Additionally, there are five empty lysimeters. Identical treatments are generally in groups of three to permit sacrificing a lysimeter column after 2, 4, and 10 years, thereby providing a history of a similar treatment. At the end of a column experiment, depth-discrete sediment sampling will be conducted to evaluate the depth that radioactivity migrated through the column. Ultimately, a radionuclide mass-balance and biogeochemical model will be developed through the use of numerical modeling.

The lysimeters generated two types of liquid samples. The "leachate" sample originates from rain water that passed through the column containing the radiological source material. The "overflow" sample originates from rain water that passed through the annulus between the two columns. Rain water was designed to enter this annulus space, when rain water ponded on the sediment surface passed through "overflow holes" placed a couple centimeters above the sediment surface (Figure 1-1-A). The leachate samples were shipped to Clemson University for radionuclide concentration analyses. The leachate analyses will be presented in a separate report.[1] Leachate and overflow sampling was conducted on a quarterly basis. Leachate sample volumes were determined gravimetrically (assumed ρ_{water} = 1 g/cm^3).

There are three sets of lysimeters containing $Pu^{V}O_2NH_4(CO_3)$ sources placed on filter paper. Lysimeters L41, L42, and L43 are the nominal case to be sacrificed after 2, 4, and 10 years, respectively. Lysimeters L21, L22, and L23 are similar to the previous three lysimeters except a high organic matter sediment was used throughout the lysimeter. Finally L9, L10, and L11 are like the nominal case except that fescue grass was planted in each column. Regarding the fescue grass treatment, on May 9, 2013, the surface of the lysimeter sediment was roughed up by scratching with a spatula; seeds were spread over the surface at a density of approximately one per cm^2 and then covered with about 0.6 cm of lysimeter sediment. The added sediment and seed were moistened with 25 mL of water. For the following three weeks, it rained extensively so only one other 25-mL watering was required for seed germination. A control lysimeter without any $Pu^{V}O_2NH_4(CO_3)$ sources, L12, was also seeded with fescue. During this early period, the lysimeters were seeded a second time to fill in areas of poor germination. Although the fescue germinated and grew well, the growth was hindered when they were covered with caps as part of the facility retrofit (see Section 2.0 for more details). These lysimeters will be reseeded in the fall of 2013.

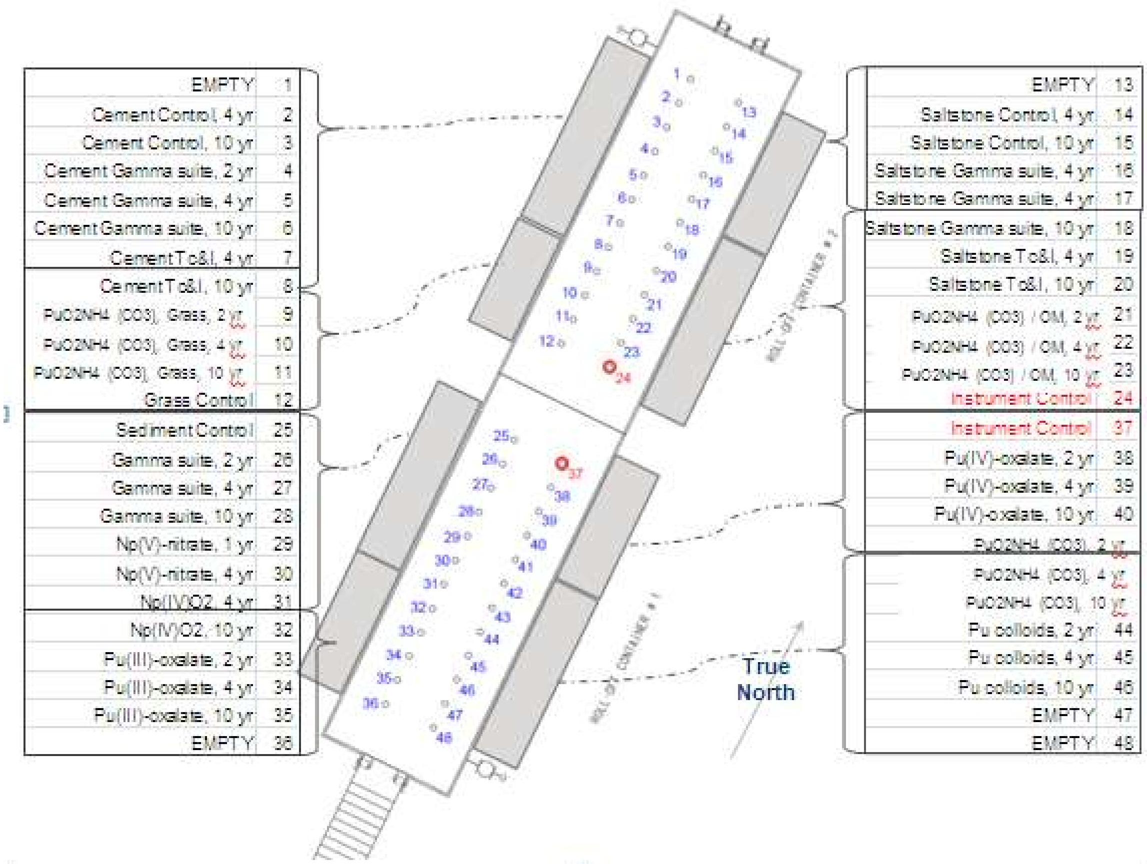


Figure 1-2. Schematic of the radionuclide treatments in the lysimeter facility.

2.0 Review of Lysimeter Retrofit and Maintenance

As part of the routine quarterly sampling during January 2013 four safety or technical concerns were identified.

1. Radioactivity (^{99}Tc) was detected in the overflow bottle for lysimeter L20.
2. Rain water accumulated in pans used as secondary containment for sample bottles within the storage sheds.
3. Overflow bottles contained more liquid than anticipated.
4. Significant spider infestation occurred during the summer in the bottle storage sheds.

Regarding the first concern, once ^{99}Tc was identified in the overflow bottle for L20, the lysimeter was capped by adding an expandable rubber stopper to the top of the lysimeter column to prevent additional rainwater to infiltrate the sediment. No radioactivity was released outside the facility. The unexpected finding was attributed to a poorly secured reducing union between the ½ and ¾ inch tubing used to connect the inner lysimeter column to the leachate sample bottle (Figure 2-1). The poorly secured reducing union was within a two inch PVC pipe located outside the Sea Land container. To repair this likely leak, two hose clamps were added to the union to secure better the two ends of the hose to the plastic, ribbed union.

The second concern was associated with water accumulating in some of the storage sheds. The water came in through holes in the storage shed through which the plumbing from the lysimeter columns connected to the sample bottles. The water did not compromise the experimental results, but precautionary steps were taken to eliminate this concern. To address this concern, sealing gaskets were added and smaller holes were drilled in the storage shed to form better seals around the 2-inch pipes entering the storage shed (Figure 2-1-C).

The third concern was that some of the overflow sample bottles contained more liquid than anticipated (details are presented in Section 4.0). To address this concern, three actions were taken. First, about 1.3 cm of CSLM was removed around the top of the lysimeter facility. Water occasionally collects on the top of the facility. This precaution was designed to reduce the potential for this ponded water to enter through the union of the top PVC fitting and the lysimeter column. The second precaution that was implemented for each individual lysimeter was to replace the multiple PVC plumbing parts outside the facility (Figure 1-1) with a single flexible tubing (Figure 2-1-C). Finally, about 1.3 cm of the lysimeter sediment was removed from each lysimeter to minimize the chance for ponded water to pass through the overflow holes leading to the annulus between the 10-cm and 15-cm PVC tubes. The distance between the overflow holes and the soil surface was increased from about 2.5 cm to 3.8 cm.

The fourth concern was that in June 2013, as these retrofits were underway, it was discovered that there was a major infestation of black widow spiders in some of the storage sheds. SRS pest management services concluded that simple pest control methods would not be adequate because the spiders had infiltrated the double-wall construction of the shed. To address this safety concern, the leachate bottle storage sheds were replaced and a routine insect/spider control program was put in place.

To address the four concerns and stop additional rain water from coming into contact with the radiological source materials, all of the lysimeters were capped between June 13, 2013 and August 8, 2013. The time table differed for the four lysimeters with ^{99}Tc (L7, L8, L19, and L20). Details of these differences are presented in Section 3.0.

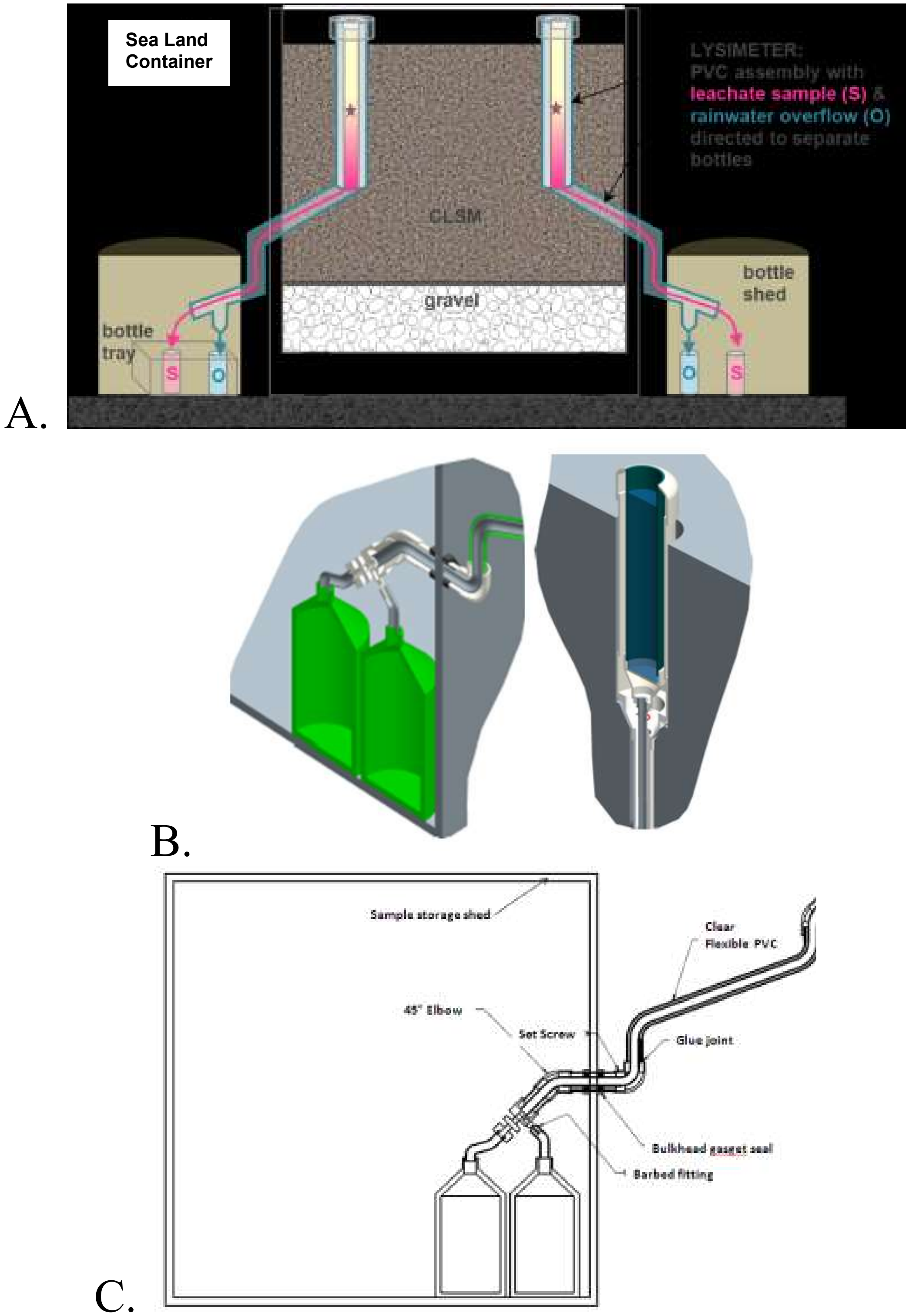


Figure 2-1. (A) Schematic cross-section of a lysimeter column assembly; (B, Left) detail schematic highlighting improved sealed plumbing into shed and single flexible tubing (green) between sample-bottle storage shed and Sea Land container; (B, Right) detailed schematic of lysimeter showing the inner and outer pipes and tubing; (C) Schematic highlighting design changes made during retrofit.

3.0 Timeline of Each Lysimeter

Timelines of the activities at the lysimeter facility are presented in Table 3-1. The lysimeter columns were originally uncapped on July 5, 2012 and rainwater was permitted to infiltrate the sediment columns containing the radiological source materials. Leachate samples were collected October 4, 2012, January 9, 2013, March 7, 2013, and June 13, 2013. Leachate samples from the ^{99}Tc lysimeters (L7, L8, L19, and L20) were also collected on February 12, 2013. To address the various maintenance issues described in Section 2.0, the lysimeters were capped on June 13, 2013 and then all but four were brought back into service on August 8, 2013, after completion of the maintenance. Again, as described in Section 2.0, the cementitious lysimeters containing ^{99}Tc required additional radiological precautions during maintenance and retrofitting, and as a result, their timelines deviated somewhat from those of the other lysimeters as shown in Table 3-2.

.

Table 3-1. Timelines of lysimeter activities.

Lys.	Description	Installed rad source material	Uncapped - start of infiltration	Leachate sampling date I	Leachate sampling date II	Leachate sampling date III	Leachate sampling date IV	Leachate sampling date V	Start expt. interruption (capped)	Ended expt. interruption of expt (un-capped)
1	EMPTY	(a)								
2	Cement Control, 4 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/17/2013	6/13/2013	8/8/2013
3	Cement Control, 10 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/17/2013	6/13/2013	8/8/2013
4	Cement Gamma suite, 2 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
5	Cement Gamma suite, 4 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
6	Cement Gamma suite, 10 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
7	Cement Tc&I, 4 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013	2/12/2013	3/7/2013		3/11/2013	
8	Cement Tc&I, 10 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013	2/12/2013	3/7/2013		3/11/2013	
9	Pu(IV)-oxalate, Grass, 2 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
10	Pu(IV)-oxalate, Grass, 4 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
11	Pu(IV)-oxalate, Grass, 10 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
12	Grass Control	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
13	EMPTY	(a)								
14	Saltstone Control, 4 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/11/2013	6/13/2013	8/8/2013
15	Saltstone Control, 10 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/11/2013	6/13/2013	8/8/2013
16	Saltstone Gamma suite, 2 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/11/2013	6/13/2013	8/8/2013
17	Saltstone Gamma suite, 4 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/11/2013	6/13/2013	8/8/2013
18	Saltstone Gamma suite, 10 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	(b)	6/13/2013	8/8/2013
19	Saltstone Tc&I, 4 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013	2/12/2013	3/7/2013	(b)	3/11/2013	
20	Saltstone Tc&I, 10 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013			(b)	1/15/2013	
21	PuO2NH4 (CO3)/OM, 2 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	(b)	6/13/2013	8/8/2013
22	PuO2NH4 (CO3)/OM, 4 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	(b)	6/13/2013	8/8/2013
23	PuO2NH4 (CO3)/OM, 10 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	(b)	6/13/2013	8/8/2013
24	Instrumented Control	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	(b)	6/13/2013	8/8/2013
25	Sediment Control	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
26	Gamma suite, 2 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
27	Gamma suite, 4 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
28	Gamma suite, 10 yr	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
29	Np(V)-nitrate, 1 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
30	Np(V)-nitrate, 4 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
31	Np(IV)O2, 4 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
32	Np(IV)O2, 10 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013

Lys.	Description	Installed rad source material	Uncapped - start of infiltration	Leachate sampling date I	Leachate sampling date II	Leachate sampling date III	Leachate sampling date IV	Leachate sampling date V	Start expt. interruption (capped)	Ended expt. interruption of expt (un-capped)
33	Pu(III)-oxalate, 2 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
34	Pu(III)-oxalate, 4 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
35	Pu(III)-oxalate, 10 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
36	EMPTY	(a)								
37	Instrumented Control	4/27/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
38	Pu(IV)-oxalate, 2 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
39	Pu(IV)-oxalate, 4 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
40	Pu(IV)-oxalate, 10 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
41	PuO2NH4 (CO3), 2 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	6/13/2013	6/13/2013	8/8/2013
42	PuO2NH4 (CO3), 4 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	5/14/2013	5/14/2013	8/8/2013
43	PuO2NH4 (CO3), 10 yr	6/20/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	5/14/2013	5/14/2013	8/8/2013
44	Pu colloids, 2 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	5/14/2013	5/14/2013	8/8/2013
45	Pu colloids, 4 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	5/14/2013	5/14/2013	8/8/2013
46	Pu colloids, 10 yr	5/11/2012	7/5/2012	10/4/2012	1/9/2013		3/7/2013	5/14/2013	5/14/2013	8/8/2013
47	EMPTY	(a)								
48	EMPTY	(a)								

(a) Empty cells indicated that activity did not take place.
(b) The bottle storage sheds for L17 – L24 were declared a Contamination Area, so it was not possible to sample these lysimeters for the June 11 – 17, 2013 sampling.

Table 3-2. Timeline for lysimeters containing Tc: L7, L8, L19, and L20.

	Date	Task
1	4/22/2012	Made up Tank 50 simulant. Also made two extra sources as archive samples.
2	4/27/2012	Added Tc Saltstone sources to lysimeters, L19 and L20 (45%FA / 45%slag / 10%cement).
3	5/11/2012	Added slag-free cement Tc sources to lysimeters, L7 and L8 (45% flyash / 55% cement).
4	7/5/2012	Started lysimeter study by removing caps from columns
5	10/4/2012	121004 sampling (FY12Q4)
6	1/9/2013	130109 sampling (FY13Q1)
7	1/15/2013	Capped L20 because Tc detected in overflow.
8	2/12/2013	130212 sampling (FY13Q2-1)
9	3/7/2013	130307 sampling (FY13Q2-2)
10	3/11/2013	Capped L7, L8, and L19
11	8/8/2013	Removed caps from all lysimeters, except L7, L8, L19, and L20

4.0 Leachate and Overflow Volume Data

As described in Section 1.2, at the bottom of each lysimeter column, there were two effluent samples, one is the leachate sample that passed through the sediment containing the radiological source material, and the second is the overflow sample that contains water that moved between the annulus of the two tubes comprising each lysimeter column. The volumes of these samples are presented in Table 4-1 and the totals of these volumes for each lysimeter are presented in Appendix A. Two generalizations can be made about these data. First, there is little uniformity among the leachate volumes for a given sampling date. The leachate volumes for all lysimeters should be near identical for a given collection date. This same sort of large variability in the leachate sample volumes were noted in our prototype demonstration conducted at Clemson University prior to building this facility.[2] To reduce the variability, some changes to the Clemson facility design were incorporated in the design of the SRNL facility, including more uniform sediment packing and adding similar masses of sediment to each column. (More uniform packing was achieved by, after every 5-cm lift of sediment added to the column, the sediment column was dropped 10 times from a height of ~30 cm; bulk density measurements are planned in year two of the study.) The second general issue regarding these measured volumes is that much more overflow water was recovered than anticipated. It is expected that the plumbing improvements described in Section 2.0 will help to address this concern. The presence of overflow water does not compromise the leachate samples, but the experiment was designed to minimize this overflow water. In an attempt to identify the source of the overflow water, the pH was measured; with the contention that rain water or groundwater would have a pH of ~5.5, and water that was in contact with CSLM would have an elevated pH, pH >9. On March 7, 2013, as part of the third quarterly sampling, 28 overflow samples had pH values that approached that of rain water, whereas three overflow samples, from L9, L26, and L46, had pH values closer to ~10 (Appendix B). The pH data suggested that in most cases the overflow water originated from rain water or groundwater and was not infiltrating from the CSLM. Additional pH measurements will be conducted to confirm this trend in pH data. Actions to reduce the overflow volumes are presented in Section 2.0. There was only one overflow sample, from L20, that had detectable radioactivity.

A general discussion of water mass-balance will be provided in Section 6.0 and a more detailed discussion will be postponed until additional data are available to reflect improvements introduced through the retrofit.

Table 4-1. Sample and overflow water volumes recovered from lysimeters.

		10/4/12		1/9/13		2/12/13		3/7/13		6/11-17/13	
Lys.	Description	Leachate (mL)	Overflow (mL)	Leachate (mL)	Overflow (mL)	Leachate (mL)	Overflow (mL)	Leachate (mL)	Overflow (mL)	Leachate (mL)	Overflow (mL)
1	EMPTY	(a)		670	57			608	0	452	800
2	Cement Control, 4 yr	427	3	526	122			1777	152	2052	847
3	Cement Control, 10 yr	104	194	302	293			1373	464	2055	1571
4	Cement Gamma suite, 2 yr	325	0	417	15			1454	628	1638	1882
5	Cement Gamma suite, 4 yr	370	81	521	103			1722	224	2053	582
6	Cement Gamma suite, 10 yr	354	59	522	43			1590	308	1260	2032
7	Cement Tc&I, 4 yr	498	10	518	325	725	1236	1087	941	0	1298
8	Cement Tc&I, 10 yr	374	1	612	0	785	1246	956	0	0	0
9	Pu(IV)-oxalate, Grass, 2 yr	240	115	334	2051			1486	2059	1730	2040
10	Pu(IV)-oxalate, Grass, 4 yr	258	170	117	343			1594	579	361	2055
11	Pu(IV)-oxalate, Grass, 10 yr	604	37	462	36			1268	37	1808	2041
12	Grass Control	731	3	568	19			1811	38	2031	1152
13	EMPTY	267	3	936	308			1533	365	885	494
14	Saltstone Control, 4 yr	1	222	27	399			1085	514	2021	888
15	Saltstone Control, 10 yr	444	19	575	258			1521	704	2005	1050
16	Saltstone Gamma suite, 2 yr	356	4	451	245			1360	723	2008	1021
17	Saltstone Gamma suite, 4 yr	418	0	578	19			1678	0	2013	118
18	Saltstone Gamma suite, 10 yr	374	1	527	1			1647	0	(b)	(b)
19	Saltstone Tc&I, 4 yr	375	3	425	1	201	1246	260	1128	(b)	(b)
20	Saltstone Tc&I, 10 yr	294	139	247	456					(b)	(b)
21	PuO2NH4 (CO3)/OM, 2 yr	447	160	337	0			1017	53	(b)	(b)
22	PuO2NH4 (CO3)/OM, 4 yr	100	499	23	1201			60	1402	(b)	(b)
23	PuO2NH4 (CO3)/OM, 10 yr	953	393	829	671			1735	1614	(b)	(b)
24	Instrumented Control	855	1	788	254			1258	684	(b)	(b)
25	Sediment Control	442	83	185	665			299	2055	1420	2058
26	Gamma suite, 2 yr	407	7	331	1			1165	223	1189	9

		10/4/12		1/9/13		2/12/13		3/7/13		6/11-17/13	
Lys.	**Description**	**Leachate (mL)**	**Overflow (mL)**	**Leachate (mL)**	**Overflow (mL)**	**Leachate (mL)**	**Overflow (mL)**	**Leachate (mL)**	**Overflow (mL)**	**Leachate (mL)**	**Overflow (mL)**
27	Gamma suite, 4 yr	401	46	459	44			493	210	2051	488
28	Gamma suite, 10 yr	481	73	516	172			1465	580	2028	916
29	Np(V)-nitrate, 1 yr	491	22	539	34			1745	0	2039	541
30	Np(V)-nitrate, 4 yr	602	61	552	51			1688	168	2042	592
31	Np(IV)O2, 4 yr	663	1	388	371			873	1052	1809	2040
32	Np(IV)O2, 10 yr	521	18	524	1470			1547	2043	1990	2022
33	Pu(III)-oxalate, 2 yr	622	2	556	52			1221	594	2046	667
34	Pu(III)-oxalate, 4 yr	275	22	198	312			439	1161	410	2040
35	Pu(III)-oxalate, 10 yr	629	1	554	1			1469	93	1592	862
36	EMPTY	415	151	694	366			1458	665	2052	1291
37	Instrumented Control	876	0	791	0			1832	0	2006	0
38	Pu(IV)-oxalate, 2 yr	617	1	580	36			1730	454	2011	489
39	Pu(IV)-oxalate, 4 yr	601	19	633	400			1634	121	2012	936
40	Pu(IV)-oxalate, 10 yr	497	0	524	212			1615	114	1983	1440
41	PuO2NH4 (CO3), 2 yr	433	1	578	9			1746	0	1857	1298
42	PuO2NH4 (CO3), 4 yr	272	1	440	148			1163	520	995	55
43	PuO2NH4 (CO3), 10 yr	410	23	174	351			823	828	423	524
44	Pu colloids, 2 yr	681	0	568	5			1526	118	872	87
45	Pu colloids, 4 yr	632	4	492	269			1373	1044	870	276
46	Pu colloids, 10 yr	644	160	514	509			1570	2061	928	2062
47	EMPTY	939	0	406	180			989	1012	980	465
48	EMPTY	885	1	479	1			962	0	65	895

[a] Empty cells indicated that sample was not collected.
[b] Lysimeters were not sampled because they had temporarily been declared a contamination area, thereby restricting access because of radiological issues in the bottle storage shed. L19 and L20 had been capped off, whereas L18, L21, L22, L23, and L24 were not capped off.

5.0 Rainfall Data

The SRS weather station closest to the lysimeter facility is the "SRTC" station, located approximately 1.2 km from the lysimeter facility. The rainfall data during each sampling period are presented in Table 6-1. Rainfall is expressed in Table 6-1 in units of volume, rather than the common unit of height, as reported by the weather stations. Units of volume were selected to facilitate water mass-balance calculations:

$$V = h\pi r^2 \qquad (1)$$

where, h = cumulative rainfall between sampling dates, and r = the radius (5 cm) of the lysimeter column.

6.0 Early Water Mass-Balance Estimates

Early estimates of the average water mass-balance during the 343 days between initiating the study on 7/5/12 and when the lysimeters were capped between 6/13/2013 to 6/17/2013 were calculated for all active lysimeters. Water mass balance for those lysimeters with near identical exposure to rainfall (had similar capping schedules) were included in these calculations (see Table A-2 in Appendix A).[1]

- Total rainfall = 128.2 cm = 10310 mL/343 days (**A** – Table 6-1)
- Average total leachate volume = 4094 mL (**B** – Table A-2)
- Average total overflow volume = 1994 mL (**C**– Table A-2**)**
- Percent leachate volume (**B/A*100**) = 40%
- Percent overflow volume (**C/A*100**) = 19%
- Percent leachate and overflow (**((B+C)/A)*100**) = 59%

As mentioned earlier, we anticipate that the mass-balance may change after the retrofit is completed, especially in regard to the volume of the overflow. With the improved data, the water mass balance will need to be completed with each individual lysimeter to permit reactive transport modeling. *A priori,* it was anticipated that about 33 to 38% of the rainwater would be evaporated from the lysimeter sediments. About 41% of the water was not recovered in the sample or overflow bottles. Additionally, controls in the storage sheds indicated that essentially no liquid was volatilized from the sample bottles in those storage sheds (<5 mL/343 days). This value of 41% would be a rather large evaporation percentage for this region. Again, as the experiment progresses, moisture mass-balance will continue to be monitored.

[1] Lysimeters with near identical schedules and whose data were used in these calculations are L2-L6, L9-12, L14-17, L25-35, L37-L41.

Table 6-1. Rainfall (SRTC Weather Station) volume (mL) between sampling dates.

Lys.	Description	Volume Between Start (7/5/12) and Sampling Date I (10/4/12) [a]	Volume Between Sampling Dates I (10/4/12) and II (1/9/13)	Volume Between Sampling Dates II (1/9/13) and III (2/12/13)	Volume Between Sampling Dates II (1/9/13) or III (2/12/13) and IV (3/7/13)[c]	Volume Between Sampling Dates IV (3/7/13) and V (6/11-17/13)
1	EMPTY	[b]				
2	Cement Control, 4 yr	2719	1607		2367	3617
3	Cement Control, 10 yr	2719	1607		2367	3617
4	Cement Gamma suite, 2 yr	2719	1607		2367	3617
5	Cement Gamma suite, 4 yr	2719	1607		2367	3617
6	Cement Gamma suite, 10 yr	2719	1607		2367	3617
7	Cement Tc&I, 4 yr	2719	1607	1141	1125	
8	Cement Tc&I, 10 yr	2719	1607	1141	1125	
9	Pu(IV)-oxalate, Grass, 2 yr	2719	1607		2367	3617
10	Pu(IV)-oxalate, Grass, 4 yr	2719	1607		2367	3617
11	Pu(IV)-oxalate, Grass, 10 yr	2719	1607		2367	3617
12	Grass Control	2719	1607		2367	3617
13	EMPTY					
14	Saltstone Control, 4 yr	2719	1607		2367	
15	Saltstone Control, 10 yr	2719	1607		2367	3617
16	Saltstone Gamma suite, 2 yr	2719	1607		2367	3617
17	Saltstone Gamma suite, 4 yr	2719	1607		2367	3617
18	Saltstone Gamma suite, 10 yr	2719	1607		2367	3617
19	Saltstone Tc&I, 4 yr	2719	1607	1141	1125	
20	Saltstone Tc&I, 10 yr	2719	1607			
21	PuO2NH4 (CO3)/OM, 2 yr	2719	1607		2367	3617
22	PuO2NH4 (CO3)/OM, 4 yr	2719	1607		2367	3617
23	PuO2NH4 (CO3)/OM, 10 yr	2719	1607		2367	3617
24	Instrumented Control	2719	1607		2367	3617
25	Sediment Control	2719	1607		2367	3617
26	Gamma suite, 2 yr	2719	1607		2367	3617
27	Gamma suite, 4 yr	2719	1607		2367	3617
28	Gamma suite, 10 yr	2719	1607		2367	3617

Lys.	Description	Volume Between Start (7/5/12) and Sampling Date I (10/4/12) [(a)]	Volume Between Sampling Dates I (10/4/12) and II (1/9/13)	Volume Between Sampling Dates II (1/9/13) and III (2/12/13)	Volume Between Sampling Dates II (1/9/13) or III (2/12/13) and IV (3/7/13)[(c)]	Volume Between Sampling Dates IV (3/7/13) and V (6/11-17/13)
29	Np(V)-nitrate, 1 yr	2719	1607		2367	3617
30	Np(V)-nitrate, 4 yr	2719	1607		2367	3617
31	Np(IV)O2, 4 yr	2719	1607		2367	3617
32	Np(IV)O2, 10 yr	2719	1607		2367	3617
33	Pu(III)-oxalate, 2 yr	2719	1607		2367	3617
34	Pu(III)-oxalate, 4 yr	2719	1607		2367	3617
35	Pu(III)-oxalate, 10 yr	2719	1607		2367	3617
36	EMPTY					
37	Instrumented Control	2719	1607		2367	3617
38	Pu(IV)-oxalate, 2 yr	2719	1607		2367	3617
39	Pu(IV)-oxalate, 4 yr	2719	1607		2367	3617
40	Pu(IV)-oxalate, 10 yr	2719	1607		2367	3617
41	PuO2NH4 (CO3), 2 yr	2719	1607		2367	3617
42	PuO2NH4 (CO3), 4 yr	2719	1607		2367	1893[(d)]
43	PuO2NH4 (CO3), 10 yr	2719	1607		2367	1893[(d)]
44	Pu colloids, 2 yr	2719	1607		2367	1893[(d)]
45	Pu colloids, 4 yr	2719	1607		2367	1893[(d)]
46	Pu colloids, 10 yr	2719	1607		2367	1893[(d)]
47	EMPTY					
48	EMPTY					

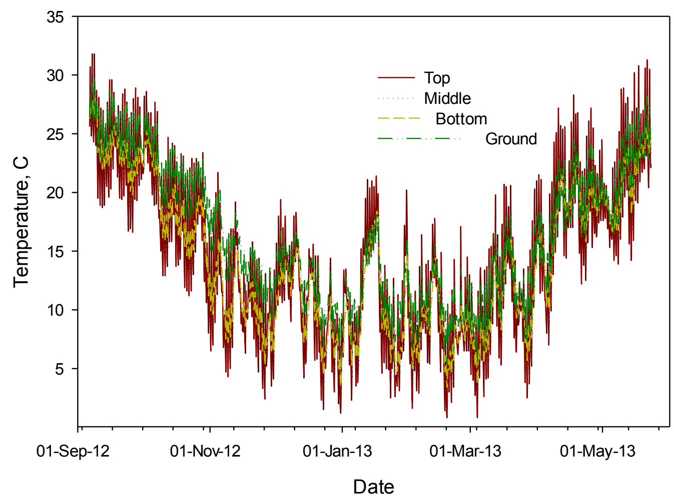
[(a)] Sampling dates are presented in Table 3-1. Rainfall data reported in cm, was calculated in units of volume through the use of the equation $V = h^* \pi r^2$; where h = cumulative rainfall between sampling dates, and r = the radius of the lysimeter column.
[(b)] Empty cells indicate that data are irrelevant because the lysimeters were either capped or otherwise not operating during this period of time.
[(c)] Lysimeters L7, L8, L19, and L20 were sampled separately on 2/12/13. For these lysimeters, rainfall volume reported is between 2/12/13 and 3/7/13. All other lysimeters that were not sampled on 2/12/13, the volumes reported are from 1/9/13 to 3/7/13.
[(d)] Lysimeter L42 – L46, were capped earlier than most of the others to permit conducting a "non-rad" dry-run for the retrofit task. These lysimeters had released no detectable radioactivity, thereby posing less risk of exposure during the retrofit task. The "non-rad" dry-run was in preparation for doing the retrofit with the hotter Tc-containing columns: L7, L8, L19 and L20. See Table 3-1 for dates.

7.0 Temperature- and Moisture-probe Data from the Control Lysimeters and a Soil Reference outside the Lysimeter Facility

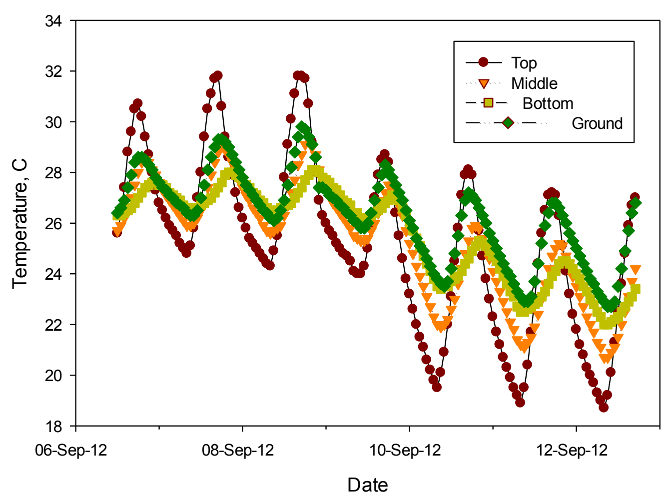
Temperature and moisture sensors were placed at three depths (15, 30, and 45 cm) in two of the control lysimeters, L24 and L37 located in two separate Sea Land containers (Figure 7-1A). Hourly data downloads were initiated on September 6, 2012 and are on-going. For purposes of comparison, an additional set of probes was placed 30-cm below the soil surface outside the lysimeter facility. The data collected from L24 and L37 were nearly identical. Because there is a large amount of data, portions of the dataset will be used to exemplify some key points (Figure 7-1 and Figure 7-2). Looking at the temperature data over a 10-month period (Figure 7-1B), there is a general high temperature of ~27 °C in September and June, and a general low temperature of ~7 °C between January through March. A closer examination of the data over a one week period shows a strong diurnal cycle (Figure 7-1B). The top probe, closest to the air had the greatest diurnal fluctuations. The temperature fluctuations of the middle probe were quite similar to those of the ground probe, although the middle probe reported temperatures that were consistently about half a degree lower than the ground probe. Both probes were placed 30 cm below surface.

The moisture probe data did not show a strong diurnal influence, but did respond quickly and sharply to rain events (Figure 7-2). The major difference between the ground probe and lysimeter probe data was that the former showed greater variability, showing much greater volumetric water content in response to storms and lower volumetric water contents upon periods of drying. This difference could in fact be an experimental artifact resulting from 1) better packing of the lysimeter sediment than the sediment outside the lysimeter facility, which would permit greater moisture contents in the less tightly packed ground, and 2) the PVC would reduce the tendency for the soil to dry out, holding the moisture in place, thereby slowing the rate that the sediment dewatered after a rain event. If differences in packing are in fact an issue, than with time, we should see the differences between these moisture values decrease. At present, it is not clear how these measured probe values differ from field measurements.

A.

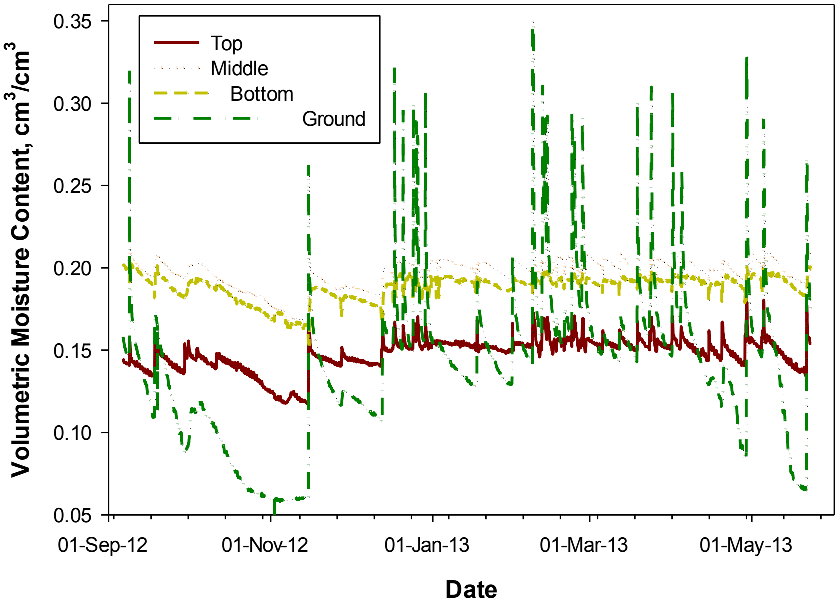


B.

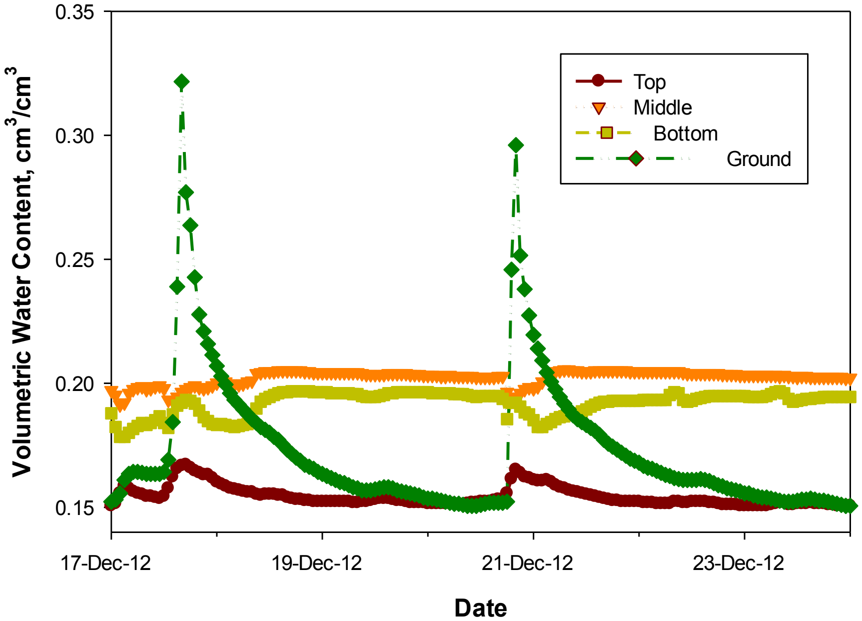


C.

Figure 7-1: (A) Photo of Decagon 5TE moisture and temperature probes place at the top (15-cm depth), middle (30-cm depth) and bottom (45-cm depth) of a control lysimeter, L37; (B) temperature in lysimeter L37 during a 10 month period; (C) temperature in lysimeter L37 over a 1 week period (ground probe place at 30-cm depth).



A.



B.

Figure 7-2. Volumetric water content in lysimeter L37 at 15 cm depth (top) 30-cm depth (middle) and 45-cm depth over: (A) 10 months, and (B) one week (ground probe place 30-cm below surface).

8.0 Conclusions

The lysimeter facility has been in operation for about 13 months. The experiment was interrupted for two months while repairs to the facility were completed. As of 8/8/13, 44 of the lysimeters were uncapped to allow water to enter the sediment columns. Four lysimeters, which contain cementitious sources amended with Tc, remain capped until further programmatic and safety reviews are completed. A separate document is being prepared by Clemson University that will document the radionuclide concentration in the sample leachate.[1] The data from that report and the moisture data from this report can be used in reactive transport modeling to provide hypothesis testing for hydrogeochemical conceptual models and for estimating effective transport parameters under actual field conditions.

9.0 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.[3]

10.0 References

1. Powell, B. A.; Witmer, M. *Determination of radionuclide concentrations in field lysimeter effluents*; SRR Project G-SOW-Z-00007; Clemson University, Clemson, SC: 2013.
2. Roberts, K. A.; Powell, B. A.; Bagwell, L. A.; Almond, P.; Emerson, H.; Hixon, A.; Jablonski, J.; Buchannan, C.; Waterhouse, T. *SRNL Radionuclide Field Lysimeter Experiment: baseline construction and implementation*; SRNL-STI-2012-00603; Savannah River National Laboratory, Aiken, SC: 2012.
3. Butcher, B. *Savannah River National Laboratory technical report design check guidelines*; WSRC-IM-2002-00011, Rev. 2; Savannah River National Laboratory, Aiken, SC: 2002.

Appendix A. Total Overflow and Leachate Volumes between 7/5/2012 and 6/17/2013 for from Each Lysimeter Column

Table A-1: Total volume of leachate and overflow samples between 7/5/2012 (the start of the experiment) and 6/13/2013.

		7/5/12 through 6/17/13[a]		
Lys.	**Description**	**Sum of Leachate**	**Sum of Overflow**	**Sum of Leachate + Overflow**
1	EMPTY	1731	858	2589
2	Cement Control, 4 yr	4783	1126	5909
3	Cement Control, 10 yr	3835	2524	6359
4	Cement Gamma suite, 2 yr	3835	2525	6360
5	Cement Gamma suite, 4 yr	4667	992	5659
6	Cement Gamma suite, 10 yr	3727	2444	6171
7	Cement Tc&I, 4 yr	2829	3811	6640
8	Cement Tc&I, 10 yr	2728	1247	3976
9	Pu(IV)-oxalate, Grass, 2 yr	3791	6267	10058
10	Pu(IV)-oxalate, Grass, 4 yr	2331	3149	5480
11	Pu(IV)-oxalate, Grass, 10 yr	4143	2153	6296
12	Grass Control	5142	1214	6356
13	EMPTY	3622	1172	4794
14	Saltstone Control, 4 yr	3134	2025	5159
15	Saltstone Control, 10 yr	4546	2033	6579
16	Saltstone Gamma suite, 2 yr	4176	1995	6171
17	Saltstone Gamma suite, 4 yr	4688	138	4826
18	Saltstone Gamma suite, 10 yr	2549	3	2552
19	Saltstone Tc&I, 4 yr	1262	2379	3641
20	Saltstone Tc&I, 10 yr	542	596	1138
21	PuO2NH4 (CO3)/OM, 2 yr	1802	214	2016
22	PuO2NH4 (CO3)/OM, 4 yr	184	3103	3287
23	PuO2NH4 (CO3)/OM, 10 yr	3518	2679	6197
24	Instrumented Control	2902	940	3842
25	Sediment Control	2347	4863	7210
26	Gamma suite, 2 yr	3093	19	3112
27	Gamma suite, 4 yr	3405	790	4195
28	Gamma suite, 10 yr	4491	1743	6234
29	Np(V)-nitrate, 1 yr	4815	598	5413
30	Np(V)-nitrate, 4 yr	4885	874	5759
31	Np(IV)O2, 4 yr	3734	3466	7200
32	Np(IV)O2, 10 yr	4583	5555	10138
33	Pu(III)-oxalate, 2 yr	4446	1317	5763
34	Pu(III)-oxalate, 4 yr	1323	3537	4860
35	Pu(III)-oxalate, 10 yr	4245	959	5204
36	EMPTY	4620	2475	7095
37	Instrumented Control	5506	1	5507
38	Pu(IV)-oxalate, 2 yr	4939	982	5921
39	Pu(IV)-oxalate, 4 yr	4881	1478	6359
40	Pu(IV)-oxalate, 10 yr	4620	1768	6388

		7/5/12 through 6/17/13[a]		
Lys.	**Description**	**Sum of Leachate**	**Sum of Overflow**	**Sum of Leachate + Overflow**
41	PuO2NH4 (CO3), 2 yr	4615	1309	5924
42	PuO2NH4 (CO3), 4 yr	2871	726	3597
43	PuO2NH4 (CO3), 10 yr	1831	1627	3458
44	Pu colloids, 2 yr	3648	997	4645
45	Pu colloids, 4 yr	3368	2189	5557
46	Pu colloids, 10 yr	3657	3660	7317
47	EMPTY	3315	2174	5489
48	EMPTY	2392	68	2460
	Average	3502	1849	5351
	Standard Deviation	1253	1414	1791
	Coefficient of variance (%)	35.8	76.5	33.5

[a] It is important to note that not all these lysimeters had identical dates of exposure to rainfall. Details about important data influencing leachate and overflow volumes are presented in Table 3-1.

Table A-2: Total volume of leachate and overflow samples between 7/5/2012 (the start of the experiment) and 6/13/2013 receiving similar amount of rainfall. Data used in calculations on Section 6.0

		7/5/12 through 6/17/13		
Lys.	Description	sum of leachate	Sum of Overflow	Sum of Leachate + Overflow
2	Cement Control, 4 yr	4783	1126	5909
3	Cement Control, 10 yr	3835	2524	6359
4	Cement Gamma suite, 2 yr	3835	2525	6360
5	Cement Gamma suite, 4 yr	4667	992	5659
6	Cement Gamma suite, 10 yr	3727	2444	6171
9	Pu(IV)-oxalate, Grass, 2 yr	3791	6267	10058
10	Pu(IV)-oxalate, Grass, 4 yr	2331	3149	5480
11	Pu(IV)-oxalate, Grass, 10 yr	4143	2153	6296
12	Grass Control	5142	1214	6356
14	Saltstone Control, 4 yr	3134	2025	5159
15	Saltstone Control, 10 yr	4546	2033	6579
16	Saltstone Gamma suite, 2 yr	4176	1995	6171
17	Saltstone Gamma suite, 4 yr	4688	138	4826
25	Sediment Control	2347	4863	7210
26	Gamma suite, 2 yr	3093	19	3112
27	Gamma suite, 4 yr	3405	790	4195
28	Gamma suite, 10 yr	4491	1743	6234
29	Np(V)-nitrate, 1 yr	4815	598	5413
30	Np(V)-nitrate, 4 yr	4885	874	5759
31	Np(IV)O2, 4 yr	3734	3466	7200
32	Np(IV)O2, 10 yr	4583	5555	10138
33	Pu(III)-oxalate, 2 yr	4446	1317	5763
34	Pu(III)-oxalate, 4 yr	1323	3537	4860
35	Pu(III)-oxalate, 10 yr	4245	959	5204
37	Instrumented Control	5506	1	5507
38	Pu(IV)-oxalate, 2 yr	4939	982	5921
39	Pu(IV)-oxalate, 4 yr	4881	1478	6359
40	Pu(IV)-oxalate, 10 yr	4620	1768	6388
41	Pu(V)NH4 (CO3), 2 yr	4615	1309	5924
	Average	**4094**	**1994**	**6088**
	Standard Deviation	924	1527	1367
	Coefficient of variance (%)	23	77	22

Appendix B. Overflow Leachate pH Values

Table B- 1: pH values (litmus paper) of overflow and leachate samples.

		3/7/13	6/11-17/13	
Lys.	**Description**	**pH Overflow**	**pH Sample**	**pH Overflow**
1	EMPTY	5	6	6
2	Cement Control, 4 yr	5	6	6
3	Cement Control, 10 yr	5	6	6
4	Cement Gamma suite, 2 yr	5	6	6
5	Cement Gamma suite, 4 yr	(a)	6	6
6	Cement Gamma suite, 10 yr		6	6
7	Cement Tc&I, 4 yr		6	
8	Cement Tc&I, 10 yr			
9	Pu(IV)-oxalate, Grass, 2 yr	10(b)	6	10
10	Pu(IV)-oxalate, Grass, 4 yr	6	6	6
11	Pu(IV)-oxalate, Grass, 10 yr	5	6	6
12	Grass Control	5	6	6
13	EMPTY	6	6	9
14	Saltstone Control, 4 yr	5	6	6
15	Saltstone Control, 10 yr	5	6	6
16	Saltstone Gamma suite, 2 yr	5	6	6
17	Saltstone Gamma suite, 4 yr		6	6
18	Saltstone Gamma suite, 10 yr			
19	Saltstone Tc&I, 4 yr			
20	Saltstone Tc&I, 10 yr			
21	PuO2NH4 (CO3)/OM, 2 yr	5		
22	PuO2NH4 (CO3)/OM, 4 yr	5		
23	PuO2NH4 (CO3)/OM, 10 yr	5		
24	Instrumented Control	5		
25	Sediment Control	5(b)	6	6
26	Gamma suite, 2 yr	10	6	6
27	Gamma suite, 4 yr	5	6	6
28	Gamma suite, 10 yr	5	6	6
29	Np(V)-nitrate, 1 yr		6	6
30	Np(V)-nitrate, 4 yr	5	6	6
31	Np(IV)O2, 4 yr	5	6	6
32	Np(IV)O2, 10 yr	8(b)	6	7
33	Pu(III)-oxalate, 2 yr	5	6	6
34	Pu(III)-oxalate, 4 yr	5	6	6
35	Pu(III)-oxalate, 10 yr	5	6	6
36	EMPTY	5	6	6
37	Instrumented Control		6	
38	Pu(IV)-oxalate, 2 yr	5	6	6
39	Pu(IV)-oxalate, 4 yr	6	6	7
40	Pu(IV)-oxalate, 10 yr	5	6	6
41	PuO2NH4 (CO3), 2 yr		6	6

		3/7/13	6/11-17/13	
Lys.	**Description**	**pH Overflow**	**pH Sample**	**pH Overflow**
42	PuO2NH4 (CO3), 4 yr	5	5	5
43	PuO2NH4 (CO3), 10 yr	5	5	5
44	Pu colloids, 2 yr	5	5	5
45	Pu colloids, 4 yr	5	5	5
46	Pu colloids, 10 yr	9[(b)]	5	8
47	EMPTY	5	5	
48	EMPTY		5	5
[(a)] Empty cells indicate no pH measurement was made either because of lack of sample or radiological safety limitations. [(b)] Sampled on Feb 27, 2013.				

Distribution:

R. S. Aylward, 773-42A
L. A. Bagwell, 773-42A
T. B. Brown, 773-A
B. T. Butcher, 773-43A
D. R. Click, 999-W
J. S. Contardi, 704-S
A. D. Cozzi, 999-W
D. A. Crowley, 773-43A
S. D. Fink, 773-A
G. P. Flach, 773-42A
J. C. Griffin, 773-A
C. C. Herman, 773-A
E. N. Hoffman, 999-W
P. R. Jackson, DOE-SR, 703-46A
V. Jain, 704-Z
D. I. Kaplan, 773-43A
C. A. Langton, 777-42A
J. N. Leita, 704-Z
D. Li, 773-42A
S. L. Marra, 773-A
J. J. Mayer, 773-42A
A. M. Murray, 773A
F. M. Pennebaker, 773-42A
M. A. Phifer, 773-42A
M. M. Reigel, 999-W
K. A. Roberts, 773-43A
K. H. Rosenberger, 705-1C
S. P. Simner, 249-8H
K. H. Subramanian, 241-156H
G. A. Taylor, 773-43A
W. R. Wilmarth, 773-A

Records Administration (EDWS)