Installation of Water Flux Meters to Measure the Temporal Variation in Water Flux Through the Vadose Zone

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Installation of Water Flux Meters to Measure the Temporal Variation in Water Flux Through the Vadose Zone

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Abstract

The Savannah River Site (SRS) has implemented a comprehensive vadose zone monitoring system (VZMS) at it's low level radioactive waste disposal facility in E-Area. The VZMS consists of nests of advanced tensiometers, water content reflectometers, and suction lysimeters. Results from the VZMS and preceding characterization have provided a robust data set for analyzing the steady state movement of water through the vadose zone.

In recent years, new field and numerical methods have improved the ability to monitor and predict transient movement of water and contaminants in the vadose. One of the advancements is the water flux meter developed by Pacific Northwest National Laboratory (PNNL). The water flux meter is a device that, when it is buried in the subsurface, measures the flux of water infiltrating from the surface. Direct measurement of this parameter is very useful since the flux to groundwater is generally estimated from rainfall data and assumptions related to transpiration by vegetation, runoff, and evaporation, and their seasonal variation. Four water flux meters were installed at the SRS to collect baseline data on the temporal variation in water flux. The flux meters were installed at locations with other vadose zone monitoring equipment to verify operation of various pieces of equipment and to prepare a more complete analysis of water flux in the vadose zone. The flux meters are currently in operation and collecting data.

Background

Recent advances in soil moisture monitoring at SRS have produced detailed data sets pertaining to water movement in the unsaturated zone. Preliminary analysis of this new data to calculate flux has brought our attention to the lack of site specific data pertaining to the *temporal variation* in evapotranspiration (ET) and, heightened our awareness to the value in reducing our uncertainty in estimations of this parameter. Information from this study will be useful for optimization of shallow land burial and it's associated monitoring and, in the ongoing evaluation of remedial technologies including control of infiltration from both rainfall and irrigation.

The Savannah River Site has installed a comprehensive vadose zone monitoring system (VZMS) at it's low level radioactive waste disposal facility to collect the necessary information to calculate contaminant flux. The VZMS includes water content reflectometers, suction lysimeters, advanced tensiometers (ATs), water flux meters, access ports for neutron probes, and a tipping bucket rain gauge.

Water Flux Meter

A water flux meter (WFM) measures the flux of infiltrating precipitation by collecting water from a defined area and diverting it to a tipping bucket rain gauge that has been enhanced for use in the subsurface. Specifically, the tipping bucket rain gauge is sealed inside a 15.2 cm diameter piece of pipe that is equipped with an 21 cm diameter piece of PVC pipe that acts as a chimney to collect water. A funnel inside the chimney directs the collected infiltrating water to a wick that carries water to the rain gauge Figure 1. Water drips off of the wick and into the rain gauge that sends a pulse signal each time 5mL of water has passed through the water flux meter. The pulse signal is transmitted from the rain gauge through a wire to the surface where it is counted and store by a data logger for future analysis.

The tipping bucket rain gauge used in the flux meter is a Rain-O-Matic 100.613 and is manufactured by Pronamic in Denmark. The rain gauge sends a signal each time 5 mL of water has passed through. Since the flux meter chimney is 21cm in diameter, each tip represents

0.0144 cm of water over the area monitored by the flux meter.

Installation

Water flux meters were installed at four existing advanced tensiometers stations, Table 1 and Figure 1. Each water flux meter was installed in a 30.5 cm diameter borehole that was augered to a total depth of 290 cm. Two to three feet of gravel was placed in the bottom of the borehole to provide a sump for infiltrating water and a stable base to support the water flux meter. Native soil removed for the borehole was used to backfill around the water flux meter. The signal transmission cable and tubing for calibration were run from the water flux meter through conduit to a valve box and the datalogger. Figure 2 illustrates a typical water flux meter installation.

Table 1 Location and serial number for water flux meters.

Station Id	Water Flux meter s/n
AT5	WFM2002M
AT9	WFM2002L
AT10	WFM2002Z
AT23	WFM2002Q

Initial Results

AT9

The flux meter at AT9 was placed in operation on May 29, 2002 and first detected flux on September 3, 2002. This lag is a result of the redistribution of water from the first rainfall events following installation of the flux meter into the disturbed soil overlying the flux meter.

The native soil removed for the borehole dried out some when it was stored on the surface during the completion of the borehole and installation of the water flux meter. The “dried” soil was then used to cover the flux meter. Water from the first rains following installation of the flux meter was redistributed by sorption into the four feet of dry soil overlying the flux meter. Once the moisture profile had returned to typical conditions water began to flow through the flux meter.

AT5 and AT10

AT5 and AT10 both measured flux much earlier than AT9, Figure 3. A field visit revealed that there had been subsidence over the flux meter at AT10 and over the valve box at AT5. Furthermore, earthwork at the slit trenches, where AT5 and AT10 are installed, had modified the topography in way that directed runoff toward the flux meters. The total flux at both AT5 and AT10 exceeds the amount of rainfall measured at AT5 due to the runoff toward the flux meters. Corrective actions will be taken after the earthwork is complete at the slit trenches around AT5 and AT10.

AT23

No flux has been detected at AT23. AT23 is installed near the Mega-Trench in E-Area. The topography around AT23 slopes gently toward engineered drainage around the trench.

Conclusions

Four water flux meters were installed and placed in operation in May 2002. Three of the meters have measured flux. The fourth meter has not measured any flux and this is probably due to increased runoff resulting from gently sloped topography around the location. The meters are capable of detecting water flux in the subsurface and continued monitoring will provide valuable information on the temporal variation in water flux through the vadose zone.

Recommendations

The following recommendations have been made based on the initial results from use of the water flux meters in FY2002.

1. The water flux meters should be maintained and operated for at least a couple of years to collect data over several seasons and changes in climatic conditions.
2. Repair small areas of subsidence above meters when earthwork at the trenches has been completed.
3. Install flashing at a predetermined perimeter around the monitoring sites to prevent run-on to the site.
4. Periodically pour a known amount of water into the calibration tubing to confirm proper operation.
5. Incorporate water flux data into conceptual and numerical models used to calculate contaminant flux.

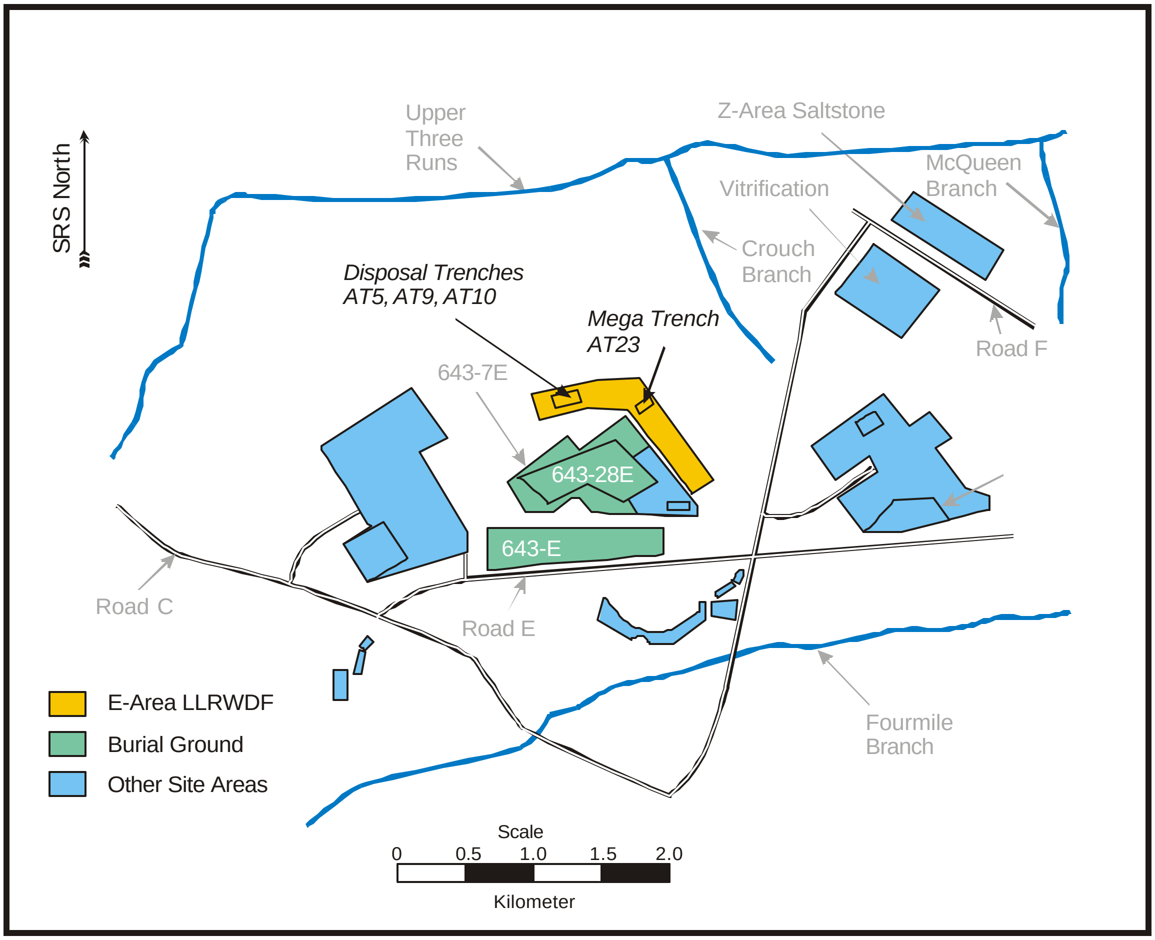

Figure 1 Map showing the location of water flux meters installed during FY2002 at AT5, AT9, AT10, and AT23.

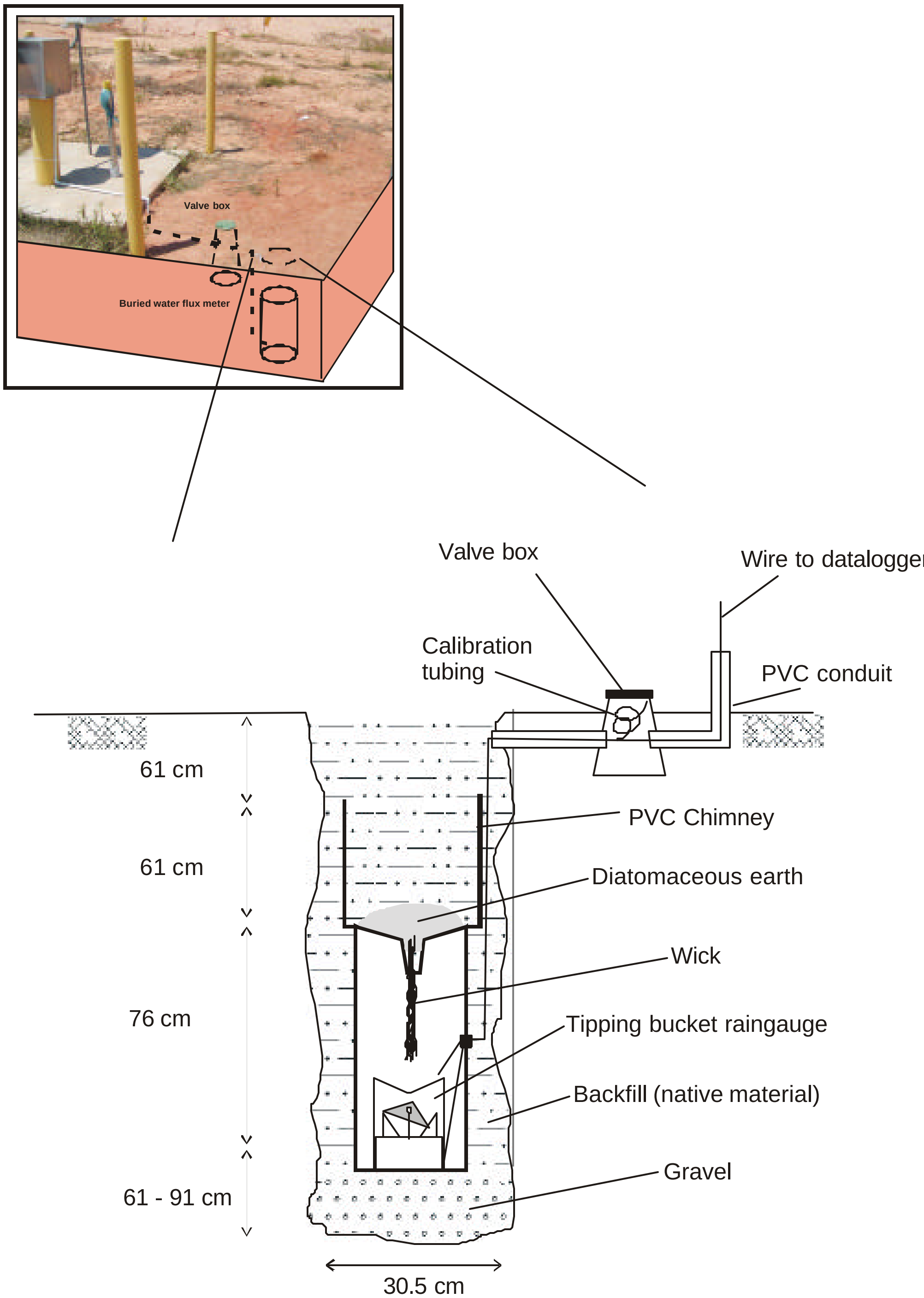

Figure 2 Typical installation of water flux meter at an Advanced Tensiometer site.

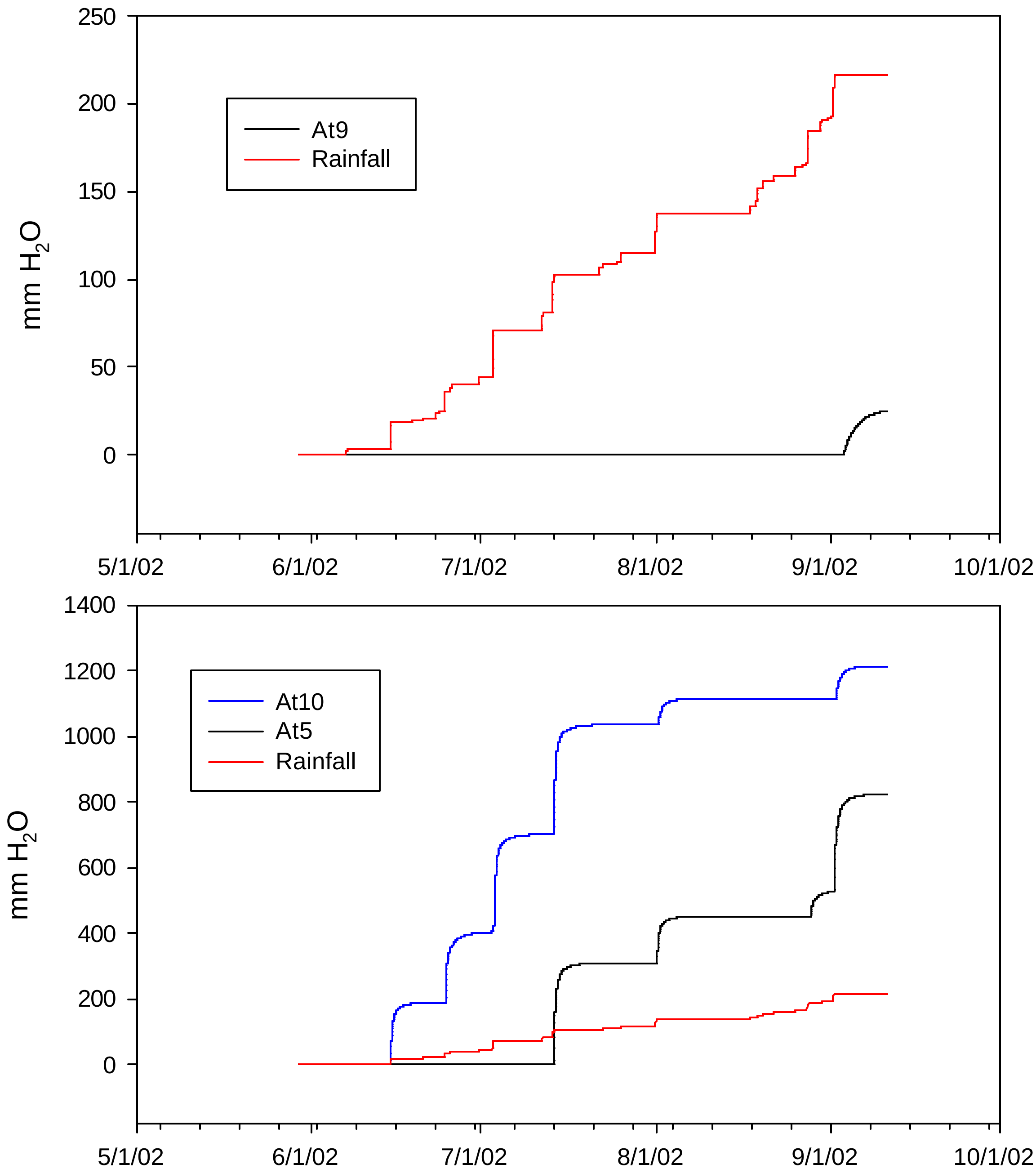

Figure 3 Rainfall and subsurface water flux at AT5, AT9, AT10, AT23.