COLLOID TRANSPORT IN SURFACE RUNOFF THROUGH DENSE VEGETATION

By

CONGRONG YU

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To my family

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Congrong Yu

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Chair: Rafael Muñoz-Carpena
Co-chair: Bin Gao
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Colloids are widely distributed in the aquatic environment, both in groundwater and surface water. The mechanisms related to colloid transport in porous media are intensively investigated because colloids can facilitate contaminant migration in soils and groundwater. However, the migration of colloids in overland flow is not clear. In this dissertation, laboratory runoff experiments were designed to examine the migration dynamics of colloids and tracer (bromide) in overland flow and soil drainage. On a first laboratory experiment on bare ground (rainfall-runoff sand box of 153 cm length under 64 mm/hour rainfall and 0.31 L/min inflow 80 min -30 min bromide/colloid injection and 50 min flushing- events), the surface transport of a colloid (kaolinite, 0.4 μm diameter, inflow concentration of 179 mg/L, zeta potential -33 mV) showed no statistical difference to that of bromide, although colloids were filtered effectively through the sand in the subsurface flow in agreement with existing colloid filtration theory. In a second experiment with dense vegetation (Bahia grass implanted in the same rainfall-runoff box), colloids (carboxylated polystyrene latex microspheres, 0.3 μm diameter, zeta potential -28 mV, inflow concentration 10 mg/l) were removed from the surface runoff on the surface of the plant stems and leaves, or by the soil particles and vegetation roots when infiltrated into soil profile, with a total removal rate of 67% of the colloids compared to 26% in the previous experiment. Through the batch adsorption experiments, we also found that plant parts (leave, stem and root) showed different colloid adsorption capacity (highest for roots). The roles of ionic strength, colloid size, inflow rate, and vegetation type on the removal of colloids by dense vegetation were investigated in a smaller scale runoff experiment through two types of dense vegetation (Bahia and Rye grasses). The Vegetative Filter Strip Modeling System-Transport and Reaction Simulation Engine (VFSMOD-RSE) was used to explore the experimental bromide and colloid transport data. In addition to deposition to vegetation, diffusion driven exchange between colloids in the soil pore water and surface runoff was also considered in the model. Factors identified by porous media classic filtration theory were also found important (and following the same trends) in our surface vegetation studies. The deposition of colloids on the vegetation increased with increases in solution ionic strength and particle size, and with decreases in flow rate. We also found vegetation type played an important role on colloid transport with more deposition onto Rye grass than onto Bahia grass under the same experimental conditions. This dissertation showed that dense vegetation can be an effective pollution control practice effectively reduce the colloid concentration in surface runoff and identified some of the key elements governing the effectiveness of the removal process.

CHAPTER 1
INTRODUCTION

Fate and Transport of Colloids in the Environment

Colloids

One of the biggest challenges in environmental science is to predict the fate of pollutants in groundwater and surface water. Colloids, with high surface area (100-800 m^2g^{-1}) (Kretzschmar and Schafer, 2005) and mobility, are recognized as a third phase of contaminants, after the aqueous phase and stationary solid matrix, which can significantly influence contaminant transport in the environment. Colloids can also be contaminants themselves, such as pathogenic bacteria and viruses.

Colloids are defined as particles with at least one dimension smaller than 10 µm. They can be categorized into (1) inorganic colloids, including colloidal minerals, clays, engineered nanomaterials, etc., and (2) organic colloids, including “particulate” organic matters and biocolloids (i.e., viruses, bacteria, and protozoa). Colloid size range overlaps with the dimension of sediments and molecular solutes (Figure1-1). Usually, in water chemical analyses a 0.45 µm filter is used to divide sediment particles and solutes. Recent studies suggest that this approach needs to be modified to reflect the water quality importance of colloidal particles that because of their small size share solute and particle properties, particularly with respect to contaminant fate and transport and nutrient budgets. In addition, it is unclear whether the transport behavior of colloids in the environment is similar to solutes or sediment, or colloids have their own transport pattern. Understanding colloid fate and transport in the environment is thus of paramount importance.

Colloids in the Aquatic Environment

Aquatic colloids include a variety of organic and inorganic materials. Organic colloids include macromolecular components of “dissolved” organic carbon (DOC), such as humic substances. They also include “biocolloids”, such as microorganisms and viruses. Aquatic inorganic colloids consist of microemulsions of nonaqueous phase liquids, mineral precipitates and weathering products, precipitates of transuranic elements, such as plutonium, and rock and mineral fragments (McCarthy and Zachara, 1989). “Biocolloids’’ pose a pathogenic risk to the water resources, and the mobility of hydrophobic contaminants, metals and radionuclides can be enhanced by both inorganic (clay minerals, oxides, and carbonates etc.) and organic colloids (humic substances and microbial exudates etc.) (Harter *et al.*, 2000). Therefore, it is important to understand the mechanisms that can control the mobility of colloids in the aquatic environment.

Mobile colloidal particles are ubiquitous in soil and groundwater system. Colloids can be generated from mobilization of existing colloid-sized minerals or in situ precipitation of supersaturated mineral phase and organic particles (Ryan and Elimelech, 1996). They are abundant in groundwater with concentration varying from 10^8 to 10^{12} particles per liter (Kaucner *et al.*, 2005).

In surface water, in addition to those from soils, colloids could come from waste of animal feeding operations, municipal wastewater treatment plant effluent, bio-solids and on-site treatment systems. During heavy rainfall events, soil erosion can bring significant amounts of colloidal particles into adjacent water bodies. Disturbance of a land surface can also add colloids (and toxic substances attached to them) to surface water bodies. The amount of colloids in the surface water can be estimated with solution turbidity by measuring the amount of light reflected by the particles. In addition, the concentrations of biocolloids in surface water can also be determined using the viable cell count method. For example, U.S. Geological Survey Fact Sheet 085-98 found that single fecal coliform (i.e., biocolloid) concentration from agricultural basins in North and South Carolina, could be as high as 120,000 – 210,600 colonies per liter (USGS, 1998). The presence of both biocolloids and abiotic colloids in surface water impose a potential risk to the public health.

Colloids in Agriculture

In agricultural fields, waste discharges from animal feeding operations include both abiotic and biocolloids; agricultural irrigation mobilizes colloidal phosphorus complexes and other forms of colloidal particles in soils; rainfall induced soil erosion on farm land could also bring large amounts of colloidal clay minerals into surface runoff and into adjacent water bodies.. Mobile colloids in hydrological paths can deteriorate the water quality not only because some of them are pathogenic contaminants (e.g., bacteria and viruses cause waterborne diseases), but also because they may facilitate the transport of other highly reactive contaminants in streams and groundwater (McCarthy and Zachara, 1989; 2006; Sun et al., 2010; Bin et al., 2011). For example, colloids can facilitate the transport of the phosphorus or chemical toxicants (diverse synthetic and geogenic chemicals) in agricultural effluents. Once entering public waters and drinking water aquifers, these colloids present a risk to the public health. It is therefore important develop effective technologies to remove colloidal particles from agricultural runoff.

Colloid Fate and Transport in Porous Media

Column experiments, field-scale experiments and modeling investigations of colloid transport in porous media are reaching maturity. Colloid retention and transport in porous media can be modeled as being controlled by advection, dispersion, and deposition processes. A good synopsis of the development of transport and deposition models for colloids has been provided by Loveland et al. (2003): "Initially, colloid transport models portrayed the attachment of colloids (and ‘bio-colloids’) to porous media as equilibrium sorption. Later, colloid filtration (irreversible first-order attachment) was introduced in conjunction with equilibrium sorption in two-site models. In most cases, colloid transport in homogeneous porous media was adequately characterized by first order attachment and release.” The Derjaguin, Landau, Verwey and Overbeek (DLVO) theory (Bradford and Torkzaban, 2008) was introduced to explain the attachment mechanisms in the view of energy balance between the electrostatic and the *Van der Waals* forces. In addition, the classical colloid filtration theory (Yao et al., 1973) was developed and successfully applied to describe the retention and transport of colloids in porous media (a brief description of the classical colloid filtration theory can be found in the next section). Up to today, further advances have focused on the dynamics of particle deposition (blocking and ripening), physical retardation mechanisms (e.g., pore straining and film straining), surface geochemical heterogeneity, and physical heterogeneity of the porous media (Bradford et al., 2007). In column experiments, the effect of flow pH and ionic strength, initial input concentration, flow rate on colloid retention and transport in porous media were investigated (Gamerdinger and Kaplan 2001; Zevi, Dathe et al. 2009; Walshe, Pang et al. 2010; Zhuang, Goeppert et al. 2010). Findings from previous studies have indicated that the retention and transport of colloidal particles in the subsurface are mainly affected by three categories of factors and their combinations: 1) structure and surface properties of porous media, 2) physicochemical and/or biological properties of colloids, 3) fluctuations in water saturation, flow velocity and chemistry (e.g., ionic strength and pH).

Classical Colloid Filtration Theory

The classical colloid filtration theory developed by Yao et al. (1973) is the most commonly used approach for predicting particle deposition behavior in saturated porous media. Based on the theory, deposition of colloidal particles onto stationary surfaces during filtration includes two steps: transport and attachment. Transport of colloidal particles from pore fluid to the vicinity of a filter grains in porous media can be described by three independent processes: interception, sedimentation, and Brownian (chemical) diffusion. Transport of particles by interception occurs when a particles moving along a streamline contact the collector due to its small size. Gravitational sedimentation refers to the settling of particles with densities greater than that of the fluid onto the collector surface. Diffusion controls smaller particles to contact with the collector grains. Yao et al. (1973) presented the first water filtration model suggesting that the three transport mechanism are additive. Attachment of colloidal particles to a stationary surface is dominated by the sum of electrical double layer and van der Waals interactions in the framework of the DLVO theory.

In the classic ‘clean-bed’ filtration model presented by Yao et al (1973), the removal of suspended particles is represented by first-order kinetics, resulting in concentrations of suspended and retained particles that decay exponentially with distance, which is a function of time. Laboratory and field experiments were conducted(Gamerdinger and Kaplan 2001; Zevi, Dathe et al. 2009; Walshe, Pang et al. 2010; Zhuang, Goeppert et al. 2010) and results from these studies validated the classical colloidal filtration theory in describing colloid retention and transport in porous media

Fate and Transport of Colloids in Dense Vegetation

Dense Vegetation

Natural dense vegetation (grasslands and meadows) or implanted (vegetative filter strips, VFS) has been proven to be effective in reducing the non-point source pollutions from agricultural field and urban areas. Vegetative filter strips (VFS), a common runoff pollution control practice, are designed to intercept surface runoff located at the down slope field border. They can control erosion caused by runoff and rainfall and remove runoff sediment, nitrogen, dissolved organic carbon, pesticide, phosphorus and fecal bacteria (Stevens and Quinton 2009). These VFS reduce nutrient and pesticide movement to streams by reducing runoff volumes through infiltration in the filter strip’s soil profile, through contact between dissolved phase nutrients and pesticides with soil and vegetation in the filter strip, and by reducing flow velocities to the point where eroded sediment particles (with sorbed nutrient and pesticides) can settle out of the water. It is suggested that a well-installed VFS can remove suspended sediments (up to 90%), phosphorus (75%), nitrogen (87%), and pesticides (40%) (Koelsch et al., 2006; Dosskey et al., 2007; Fox et al., 2010; Muñoz-Carpena et al., 2010). In addition, studies have been conducted to investigate the removal efficiency of VFSs to fecal bacteria from manure in surface runoff. Results from these studies suggested that dense vegetation could reduce the loading of pathogens from surface runoff (Trask et al., 2004; Guber et al., 2007; Fox et al., 2011).

Colloids Fate and Transport in Dense Vegetation

In subsurface flow, the removal of colloids could be viewed as using soil grains as a filter to remove colloidal particles through surface deposition. Similarly, in overland flow water, dense vegetation could be used as a filter to remove colloids through deposition onto plant surfaces.

Currently, research on surface removal and transport of colloids in dense vegetation is mainly focused on biocolloids. It is still at the early stage of empirically testing the effectiveness of dense vegetation to remove pathogens from the surface runoff. The effects of several physical factors, such as length and vegetation type, rainfall intensity, land slope, infiltration capacity, on biocolloids transport were also investigated in laboratory experiments. Tate et al. (2004) and Trask and Kalita (2004) supported the efficacy of vegetative filter strips for retaining Cryptosporidium parvum from cattle feces in laboratory scale experiments. They also investigated the effects of land slopes, vegetation and rainfall intensity. Ferguson, et al. (2007) conducted field scale experiments with natural soil and natural vegetation to quantify the transport of microbial solids and found that transportation efficiency increased with decreasing size of microorganisms. Mankin et al. (2007) found that E. coli sorption to both soil and sand particles was reversible, but E. coli detachment from sand was nearly 100% of attached cells after one washing, whereas a total of less than 15% of cells were detached from soil after three washings. Based on these results, they suggest that differences in sorption and reversibility between sand and soil will lead to different patterns of retention and transport in the environment for those two media. Fox, et al. (2011) recently determined vegetative filter strips (VFS) effectiveness in removing E.coli from runoff relative to inflow rate, infiltration capacity, and flow concentration in a laboratory-scale VFS soil box. Experimental work about the pathogenic bacteria transport in the dense vegetation is continuing, and all the research supports the potential effectiveness of dense vegetation either from the field-scale or laboratory-scale experiment.

Mathematical models have also been developed to simulate biocolloid transport in dense vegetation, but most of the models assumed the transport of biocolloids in surface runoff is similar to that of reactive solute. Pachepsky, et al. (2006) developed a reactive solute transport model to simulate the transport of manure-borne pathogen through dense vegetation in surface runoff and the model simulation matched the experimental data well. Nevertheless, the actual effect on biocolloid removal of surface deposition on dense vegetation cannot be separated from bacterial growth and decay effects in these types of model formulations. Alternative approaches, especially approaches based on the classical colloid filtration theory, thus should be considered in modeling the fate and transport of colloids in dense vegetation in surface runoff.

Theoretical Framework

Overland Flow

Water flow in the dense vegetation can be described by the kinetic wave approximation of the Saint-Vennant's equation (Lighthill and Whitham, 1955).

$$\frac{\partial h}{\partial t}+\frac{\partial q}{\partial x}=i_e(t) \tag{1-1}$$

where h is depth of overland flow [L], q is the flow per unit width of the plane [L^2T^{-1}], and i_e is the rainfall intensity [LT^{-1}].

A uniform flow equation can be used as a link between the q and the h, such as Manning's equation:

$$q=q(h)=\frac{\sqrt{S_0}}{n}h^{\frac{5}{3}} \tag{1-2}$$

where S_0 is the slope of the plane [LL^{-1}], and n is Manning's roughness coefficient, dimensionless.

Colloid Fate and Transport

Transport is defined as concentration change in response to water flow and mass exchange processes. Generally colloid transport in dense vegetation in surface runoff can be summarized into following processes: advection, dispersion, exchange between solid and liquid phase, deposition on the surface of grass stem and soil grains (Grolimund *et al.*, 1998; Socolofsky, 2005; Tufenkji, 2007).

Advection and dispersion

Mathematical models of colloids transport in dense vegetation media generally involve a simplified form of the advection-dispersion equation, which can be derived from the basic mass balance principles.

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} - v\frac{\partial C}{\partial x} \tag{1-3}$$

where C is the colloid concentration in the surface runoff water [ML^{-3}], t is the time [T], x is the distance from colloid pollution source [L], D is the average dispersivity coefficient [L^2T^{-1}] for colloid in the longitudinal direction, v is the average colloidal particle transport velocity [LT^{-1}].

Deposition of colloids on the stem of the grass

We can consider the dense vegetation as a special porous media with high porosity. Under steady state conditions, colloid transport through dense vegetation then can be modeled with the advective-dispersive transport equation including a term of first-order colloid deposition (Eq. 4-4), which is the same as in the classic "clean-bed" filtration model (Kretzschmar *et al.*, 1997):

$$\frac{\partial C}{\partial t} = -v\frac{\partial C}{\partial x} + D\frac{\partial^2 C}{\partial x^2} - K_g C \tag{1-4}$$

where K_g is the first order deposition rate coefficient [T^{-1}].

Exchanges between the liquid phase and the solid phase in soil profile

We assume mass exchange between the overland flow and the soil underneath is also important to colloid transport in dense vegetation (Wallach et al.; 1989, Gao et al., 2004b). The mass conservation of colloids in dense vegetation in the overland flow can then be described based on the combination of the classic "clean bed" filtration model and the exchange layer theory (Gao et al., 2004b; Walter et al., 2007):

$$\frac{\partial \mathrm{C}}{\partial \mathrm{t}} = -\frac{\mathrm{q}}{\mathrm{h}}\frac{\partial \mathrm{C}}{\partial \mathrm{x}} + \mathrm{D}\frac{\partial^2 \mathrm{C}}{\partial \mathrm{x}^2} - \mathrm{k_g C} - \mathrm{k_{ei} C} + \mathrm{k_{eo} C_e} \tag{1-5}$$

$$\frac{\mathrm{d}\theta}{\mathrm{h}}\frac{\partial \mathrm{C_e}}{\partial \mathrm{t}} = \lambda \mathrm{k_{ei} C} - \mathrm{k_{eo} C_e} \tag{1-6}$$

where C is contaminant concentration in the surface runoff water [M L^{-3}], t is the time [T], q is the overland flow rate [L^2 T^{-1}], h is the ponding water depth [L], x is the coordinate parallel to overland flow [L], D is the dispersion coefficient [L^2 T^{-1}], k_g is a rate coefficient describing the deposition onto grass surfaces [T^{-1}], k_{ei} and k_{eo} are rate coefficients of mass exchange between overland flow and the exchange layer [T^{-1}] (Gao et al., 2004b; Walter et al., 2007), d is the exchange layer depth [L], θ is the water content in the soil profile, C_e is the "exchangeable" concentration in the soil exchange layer, and λ is a dimensionless constant controlling the exchangeable concentration in the exchange layer. For non-reactive mass transfer in homogenous soil exchange layer, λ usually equals unity, indicating all the concentration entering the exchange layer is available for mass exchange between the soil and overland flow (Gao et al., 2004b). In this study, because the growth of vegetation would increase the heterogeneity and reactivity of the soil in the exchange layer, thus $0 \leq \lambda < 1$, reflecting part of the concentration in the soil exchange layer is “un-exchangeable” (i.e., trapped in immobile water zone and/or attached on soil surfaces).

Objectives

The purpose of this research is to investigate the removal of colloidal particles from overland flow by dense vegetation and to explore through a combination of experimental and numerical tools the main factors involved in surface removal of colloids by dense vegetation. The specific objectives of this research are:

- To determine the transport behavior of colloids in surface runoff on bare soil as a baseline for comparison with dense vegetation.
- To determine the transport behavior of colloids in surface runoff through dense vegetation
- Investigate the key colloid removal factors in dense vegetation: colloid size, ionic strength, vegetation type and flow rate through a combination of advanced experimental and numerical modeling methods.

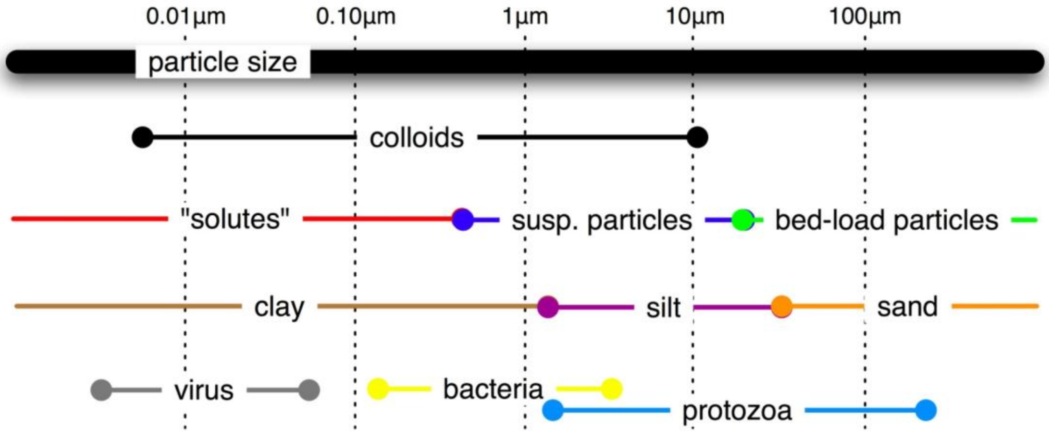

Figure 1-1. Colloids size distribution

CHAPTER 2

A LABORATORY STUDY OF COLLOID AND SOLUTE TRANSPORT IN SURFACE RUNOFF[1]

Introductory Remarks

Colloids (i.e., particles with diameter in the range of 1nm to 10 μm) are widely distributed in the environment (Stumm, 1977). There are mainly two categories of natural colloids: (1) biocolloids including viruses, bacteria, and some of the protozoa, and (2) abiotic colloids including all kinds of colloidal minerals and natural organic matters. Once mobilized by water flow, colloids may pose risks to surface water and groundwater quality not only because many biocolloids are pathogenic, but also because abiotic colloids are effective “carriers” of a variety of common contaminants found in soils and water (Flury and Qiu, 2008; Gao *et al.*, 2011). It is therefore important to study the transmission of colloids and their consequent fate in the hydrological pathways.

In the literature, research of colloids in water resources mainly focuses on their fate and transport in the subsurface, such as groundwater and soil vadose zone. A number of experimental and modeling investigations have been conducted to explore the retention and transport mechanisms of colloids and colloid-contaminant complexes in soils under both water-saturated and unsaturated conditions (Ryan and Elimelech, 1996; McCarthy and McKay, 2004). Findings from laboratory experiments indicate that the transport of colloids in soils is controlled by multiple retention/release mechanisms, such as grain-surface deposition, pore straining, air-water interface deposition, film straining, and immobile-water trapping (Ryan and Elimelech, 1996; Gao *et al.*, 2006).

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[1] Reprinted with permission from Yu, C R et al., 2011. A laboratory study of colloid and solute transport in surface runoff on saturated soil. J Hydrol, 402(1-2): 159-164.

The improved understanding of colloid transport mechanisms informed the construction and refinement of mathematical models to predict their fate and transport in the subsurface environment (Simunek *et al.*, 2006; Flury and Qiu, 2008). Most of these models are based on the advection-dispersion equations coupled with reactions, which are similar to the models developed for solute transport in soils. However, the transport behavior of colloids in soils may differ from that of chemical solute because of the size exclusion effect and the distinct retention mechanisms (Chrysikopoulos and AbdelSalam, 1997; Simunek et al., 2006). The different breakthrough behavior between colloids and solute in soils has been well-documented (Keller *et al.*, 2004; Bradford *et al.*, 2005)

Although colloid-facilitated transport is also an important contamination process to surface water, fate and transport of colloids in overland flow has received relatively less research attention (Haygarth et al., 2006; Leguedois et al., 2008). Colloidal contaminants (e.g. colloid-metal complexes) in surface runoff are often treated as dissolved phase if they can pass through a 0.45 µm filter (Lead and Wilkinson, 2006). Ren et al. (2002, 2005), however, demonstrated that colloidal particles with sizes equal or smaller than 0.45 µm played significant roles in facilitating trace metal transport in surface stream water. Similarly, Heathwaite et al. (2005) showed that the release of phosphorus from agricultural soils to surface runoff was mainly controlled by soil colloids with size between 0.001 to 2 µm. Several laboratory and field studies have also been conducted to examine the fate and transport of biocolloids in surface runoff (Oliver *et al.*, 2005; Kay *et al.*, 2007). Mathematical models of biocolloid transport in overland flow have been proposed and model simulations have been tested against experimental data (Pachepsky *et al.*, 2006; Kouznetsov *et al.*, 2007). Nevertheless, there is still a debate in the literature on how colloidal particles are transported in surface runoff. While some suggested that colloid transport in surface runoff is similar to that of chemical solute (Edwards et al., 1996; Roodsari et al., 2005); others showed that colloids may behave substantially different from chemical solutes in surface runoff (Crane et al., 1983; Dosskey et al., 2007). Further investigations are therefore needed to improve current understanding of the fate and transport of colloids in surface runoff (Kay et al., 2007).

This study used a series of laboratory experiments to examine the transport behavior of colloids in surface runoff. A soil box packed with sand was placed under a laboratory rainfall simulator to compare the transport behavior of colloids and solutes. A natural clay colloid (kaolinite) and a conservative chemical solute (bromide) were applied to one end of the soil box as inflow during a simulated rainfall event. Effluent samples were collected from the other end of the soil box and from four drainage pipes to determine colloid and solute breakthrough concentrations. Multiple runoff experiments were conducted and statistical analysis was conducted to aid in the data interpretation. Our objectives were to 1) identify similarities and differences between colloids and solutes in surface flow as well as in subsurface flow; and 2) determine the governing processes that control the fate and transport of colloids in surface runoff.

Materials and Methods

Materials

Kaolinite powder (Thiele Kaolin Company) was used to make a colloidal kaolinite suspension; about 10 g of dried kaolinite powder (at 100 ^{o}C for 2 hours) was suspended in 700 mL of deionized (DI) water. The kaolinite suspension was shaken, placed in an ultrasonic bath for 30 minutes, and then let stand for 24 hours. The fraction of kaolinite remaining in suspension after 24 hours was siphoned into a second flask. The concentration of kaolinite in an aliquot of this stock suspension was determined gravimetrically before diluting the stock to colloid suspensions used in the experiments. The mean sizes of the kaolinite colloids, as determined by Nanosight LM10-HS with the blue laser, did not vary significantly during the experiments and the average diameters were about 0.4 µm (0.05-1µm) as in Figure 2-1. Additional characteristics of the colloid used are given in Appendix A (Tables A-1 and A-2).

Quartz sand (Standard Sand & Silica Co.) was used as experimental soil. The sand had a size range between 0.5 to 0.6 mm and was used as received. The bulk density of the sand was 1.54 g/cm^3. Sodium bromide (certified, Fisher Scientific) was used in the experiment as the conservative chemical solute. The materials and environmental condition was summarized in Table 2-1.

Surface Runoff System

A stainless steel box with dimensions of 153.1 cm long, 40.2 cm wide, and 10 cm deep was used to hold the experimental soil (Figure 2-2). The bottom of the box was separated into 4 shallow compartments, which were 5 cm deep and each equipped with a drainage outlet to partition infiltration along the flow path (numbered as 1-4 in Figure 2-2). The quartz sand was wet packed in the compartments as saturated soil with a depth of 5 cm, which would prevent any lateral subsurface flow among the compartments. About 12 kg sand was used to fill each compartment. The packed soil box was then placed on an adjustable shelf at a slope of 1.7 degree. A spreader consisting of a PTFE tube with uniformly distributed small holes was placed at the up end of the soil box to distribute inflow (Figure 2-2). A peristaltic pump was connected to each side of the PTFE tube to apply a constant inflow at 0.31 L/minute. A rain-shielded trough was mounted at the lower end of the box to collect outflow. Four PTFE funnels are mounted below at the drainage outlets to collect infiltrating water. Cumulative flow from the surface runoff and drainages outlets were collected and continuously monitored during the experiment with ECH2O Dielectric Aquameters (Decagon Devices, Inc.) that record the water level in the collection containers below the box. The real time data were recorded with a CR 10 data logger every 30 seconds. Additional photos of equipment are in Appendix A (Figure A-1).

This surface runoff system included a rain simulator located in the Water Resources Lab at the University of Florida. The rain simulator used a peristaltic pump and a pressure gauge to supply a constant flow to a tee jet 1/2 HH SS 50 WSQ nozzle (Spraying Systems Co. Wheaton, IL) to generate a simulated rainfall (Figure 2-3). Uniformity tests indicated that the rain simulator can generate uniform rainfall over the entire soil box with uniformity greater than 90% The rainfall intensity was adjusted to a constant rate of 64 mm/hour for all runoff experiment conducted, which was equivalent to a flow rate to the outflow end of the box of 0.66 L/min (i.e., 1.07 L/min/m^2). This rain intensity was chosen because it can represent a typical 10 year storm return period for the duration of 70 minutes in the Alachua County of State of Florida. The soil box was placed to be 2 meters below the rainfall simulator and six manual rain gauges and one electronic rain gauge were used to monitor the intensity during the experiments (Figure 2-4).

Runoff Experiments

To initiate a runoff experiment, simulated rainfall and inflow with colloid-free water were first applied to the soil box for two hours to establish a steady flow condition for the overland flow and subsurface drainage. Once the flow was stabilized, the colloid suspension (100 ppm) was introduced to the inflow spreader for 30 minutes. The inflow was then switched back to water at the same flow rate for another 50 minutes. Water samples were collected from the surface runoff and the four drainage outlets during the colloid injection. Colloid concentrations in the samples were determined by measuring the total extinction of light at a wavelength of 350 nm with UV-visible spectrophotometry. To insure the data quality, transport experiments of colloids were repeated six times.

Bromide was applied to the surface runoff system as a conservative solute for the transport studies. The experimental procedures were the same as those used for the colloid and an ion chromatograph (Dionex Inc. ICS90) was used to determine bromide concentrations in water samples. Similarly, bromide transport experiments were repeated eight times to insure the data quality.

Statistical Analysis

Average breakthrough concentrations for all the bromide and kaolinite experiments were reported in this study with standard error of the mean (SEM). Student’s *t*-test was used to compare the concentration distributions of bromide with kaolinite in surface runoff and drainage. In addition, Spearman’s rank correlation coefficient was used to evaluate the statistical dependence between bromide and kaolinite in the effluents.

Results and Discussion

Flow Distribution

Measurements of flow distribution in the runoff system indicated that surface flow (0.60 L/min) was much higher than drainage flow (0.073, 0.094, 0.079, and 0.081 L/min for drainage # 1-4, respectively). The recorded cumulative flow in the surface runoff and drainage flow was used to determine the water balance of the runoff system. For all the experiments, the total flow recovered from the surface and drainage was close to the total water input with an error smaller than 5%. This result indicated that the surface runoff system was suit for the transport experiments. Because the rainfall intensity used in this study was relatively high, surface runoff accounted for about 2/3 of the total outflow, indicating that surface runoff dominated the transport process in the runoff system.

Subsurface Transport of Bromide and Kaolinite

Subsurface transport of bromide in the soil box showed typical breakthrough behavior (Figure 2-5). After application, bromide was first detected at drainage outlet # 1 and the breakthrough responses increased for all the four drainage outlets with further bromide injection. Only about 29% of the total bromide was recovered from the four drainage outlets, confirming the dominance of surface runoff to the transport process in the system. Drainage # 1 had the highest breakthrough concentrations because bromide concentrations in overland flow were higher in the first segment. Because of rainfall dilution effect, the other three drainage outlets showed much lower breakthrough concentrations than the drainage #1. The breakthrough concentrations of drainage #4, however, were slightly higher than those of drainage #3, probably due to experimental uncertainties.

The breakthrough responses of kaolinite in the four drainage outlets followed similar patterns to those of bromide (Figure 2-6). The normalized breakthrough concentrations (i.e. C/C_0), however, were lower for kaolinite than bromide. This was most obvious at drainage #1 where the average peak breakthrough concentration of bromide reached about 0.4, while that of kaolinite was about 0.3. Only about 23% of the total kaolinite was recovered from the four drainage outlets. The lower breakthrough of kaolinite in the subsurface runoff was due to the filtration of colloids by the sand (Gao *et al.*, 2004a; Chen *et al.*, 2005). After the breakthrough responses were slightly quicker for kaolinite than bromide, which can be attributed to the size exclusion effect of colloids in porous media (Keller *et al.*, 2004; Bradford *et al.*, 2005). Because the sampling interval used in the experiment was not small enough, kaolinite breakthrough at all drainage outlets appeared to be almost instantaneous after the pulse was applied (Figure 2-6).

The t-test with Welch's correction analysis of the kaolinite and bromide concentrations showed that their concentration distributions were statistically different in the subsurface flow ($p = 0.02$). Spearman's test suggested that they were positively correlated with ρ equals to 0.70 in drainage ($p < 0.0001$). Linear regression of kaolinite and bromide concentration in drainages (Figure 2-7) showed that the slope is smaller than one (0.74), confirming that kaolinite had a lower mobility in the subsurface flow than bromide.

Surface Transport of Bromide and Kaolinite

Bromide showed very fast breakthrough in surface runoff after it had been applied, corresponding to the high surface flow rate (Figure 2-8a). The bromide concentrations remained relatively high ($C/C_0 > 0.2$) for almost the entirely bromide injection period and then dropped dramatically when inflow was switched to water. At the end of the experiment, the bromide concentration demonstrated a long tail, indicating the slow releasing of chemicals from the soil into the surface runoff. The release of chemicals from soil to surface runoff may be attributed to several mechanisms including film diffusion (Wallach et al., 1988; Wallach and Vangenuchten, 1990), raindrop-induced exchange (Gao et al., 2004b; 2005; Walter et al., 2007), and pumping exchange

(Packman et al., 2000; Ren and Packman, 2002). Because surface runoff dominated the transport processes, about 50% of the total bromide was recovered from the surface runoff, which was much higher than that from subsurface flow. Although the bromide tracer is nonreactive, its total recovery rate (i.e., sum of the surface and subsurface recovery rates) at the end of the experiment was only close to 80%. This incomplete recovery could be attributed to two reasons: 1) there was still a certain amount of bromide in the soil at the end of the experiment, as evidenced in the breakthrough curves of both drainage and surface flow; and 2) raindrops could splash certain amount of bromide out of the runoff system, particularly in the area close to the edges of the soil box.

Responses of kaolinite in the surface runoff resembled those of bromide and the peak concentrations also covered almost the entire kaolinite injection period (Figure 2-8b). Similarly, about 51 % of the total kaolinite was recovered from the surface runoff, which was also much higher than that from subsurface flow. The kaolinite concentration in the runoff also had a long tail, but it was slightly lower than that of bromide. This is probably because the colloids had a lower concentration in soil pore water compared to bromide, which had no interactions with the sand grains.

The t-test with Welch’s correction analysis of the kaolinite and bromide concentrations in runoff could not prove that their distributions were statistically different in the surface runoff ($p = 0.70$). The Spearman’s test suggested they were strongly positively correlated with ρ equals to 0.99 ($p < 0.0001$). Linear regression results (Figure 2-9) showed that the slope is close to one (0.93), suggesting that kaolinite and bromide transport in surface runoff was almost identical under the experimental conditions tested. The results presented here indicated that colloids in overland flow on bare soils may behave similar to chemical solutes, when the surface runoff dominates the transport processes. Under such conditions, factors such as dispersion/diffusion, and exchanging/pumping may have little effect on the concentration profile of colloids in surface flow. However, these factors could play important roles in controlling the mass transfer processes within the overland flow and between the overland flow and the soil underneath under other conditions. For example, if the overland flow was much slower, colloid and bromide might not behave the same in the surface runoff because of the differences in their dispersion/diffusion rates and release rates from soil to the over land flow. The fate and transport of colloids in surface runoff may also be affected by scale factors, such as travel distance, plot length, soil depth, and source loading, which are also governing factors of hill slope runoff and erosion (Parsons et al., 2006).

Chapter Conclusions

Laboratory runoff experiments were conducted to examine the transport dynamics of kaolinite and bromide in overland flow and soil drainage. We found that the transport of kaolinite in drainage flow was lower than that of bromide, which is in agreement to colloid filtration theory. The transport of kaolinite in surface runoff almost resembled that of bromide and statistical analysis confirmed their strong positive correlation with a slope close to one. The similarity between kaolinite and bromide transport in overland flow can be attributed to the dominance of surface runoff in the transport processes under the experimental condition tested.

Table 2-1. Experimental conditions of colloid transport in surface runoff on bare soil.

	Materials
Colloids	179 mg/L 0.4 μm Kaolinite powder
Tracer	40 ppm Sodium Bromide
Soil Bed	0.5 to 0.6 mm washed quartz sand, porosity 0.43, slope 1.7%, dimension (153.1 * 40.2 *10 cm)
	Environmental Conditions
Inflow rate	0.31 L/Min
Rainfall intensity	64 mm/hour (uniformity > 90%)
Ionic Strength	regular tap water (0.558 mMol)

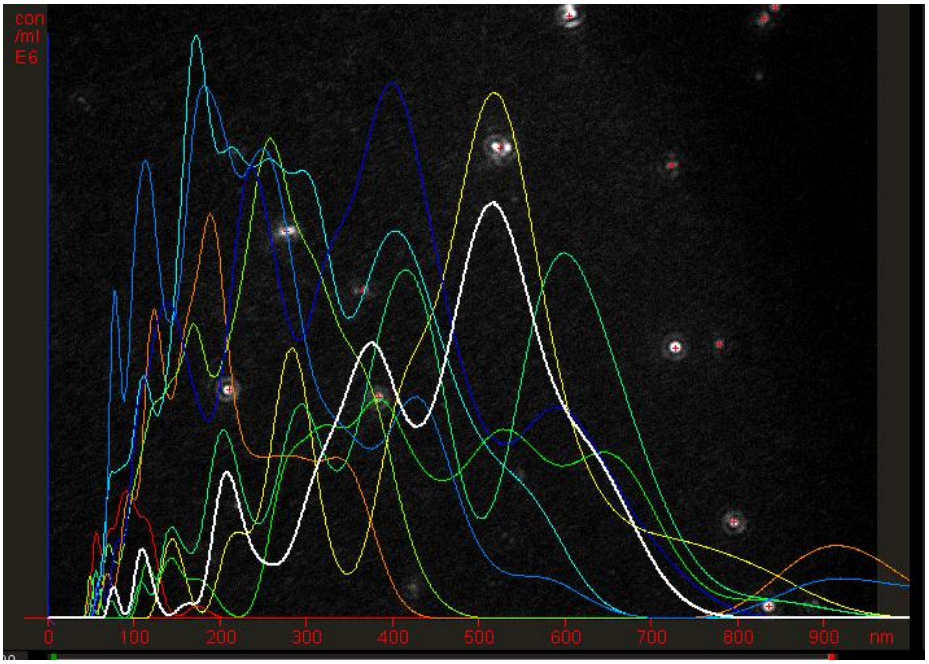

Figure 2-1. Kaolinite diameter distribution measured by nanosight LM10-HS with blue laser. The lines of different colors are independent measurements.

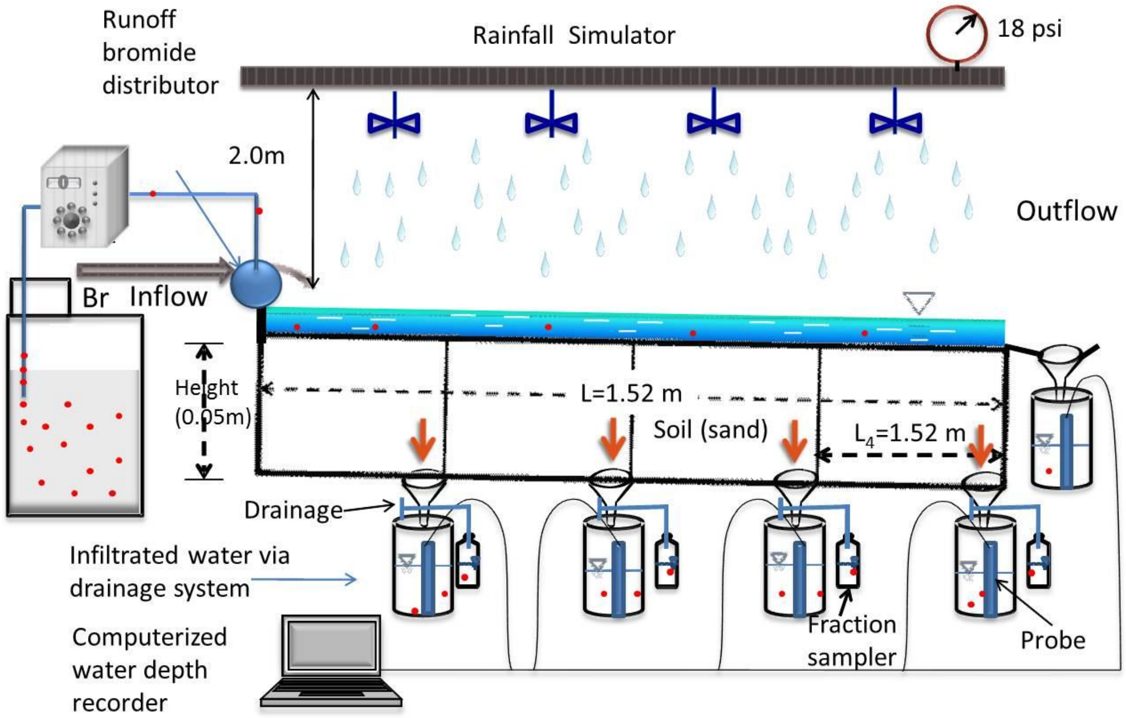

Figure 2-2. Schematic of the laboratory runoff experiment setup. Pictures of some components can be found in Figures 2-3, 2-4 and in Appendix (Figure A-1).

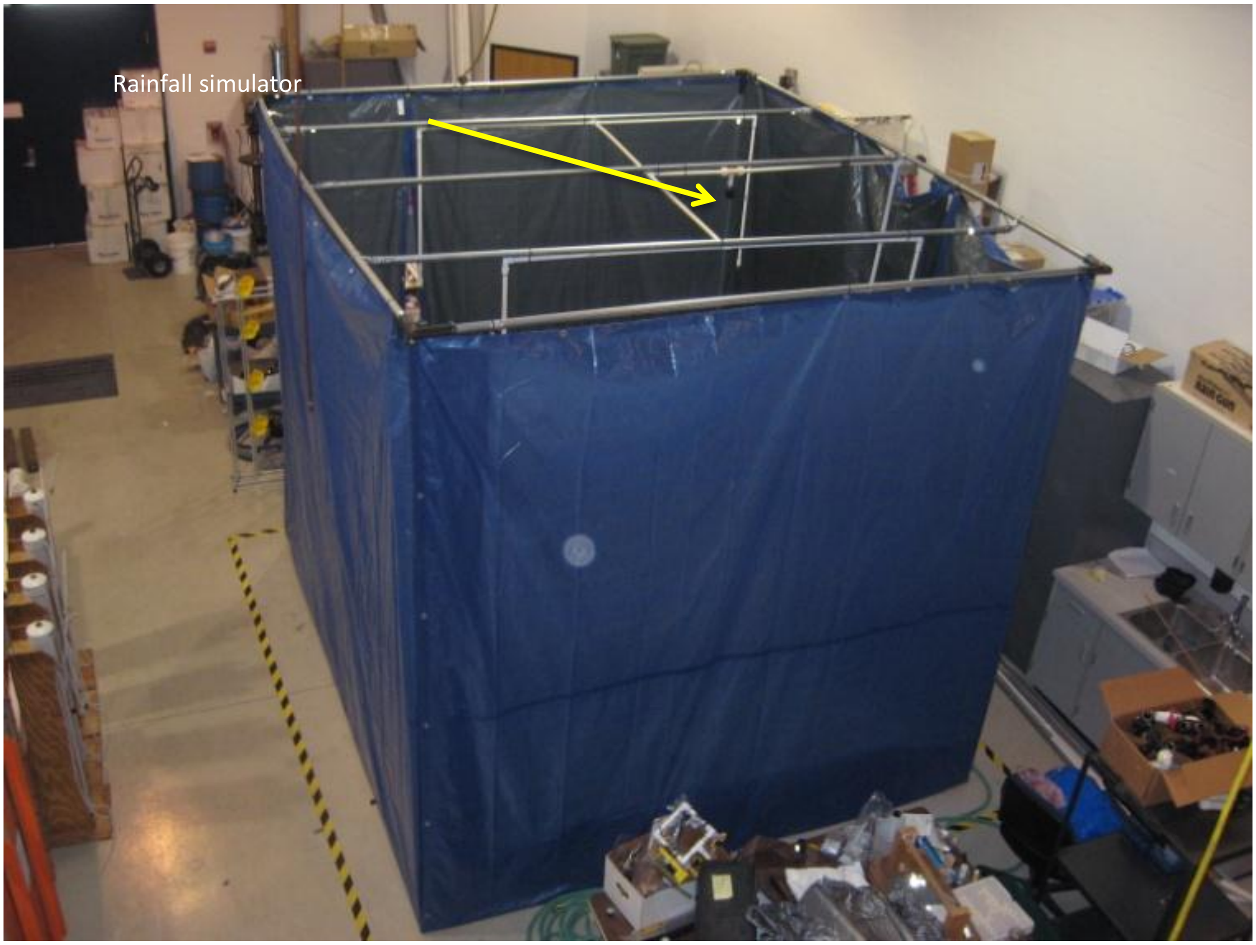

Figure 2-3. Rainfall simulation system for the laboratory runoff experiment

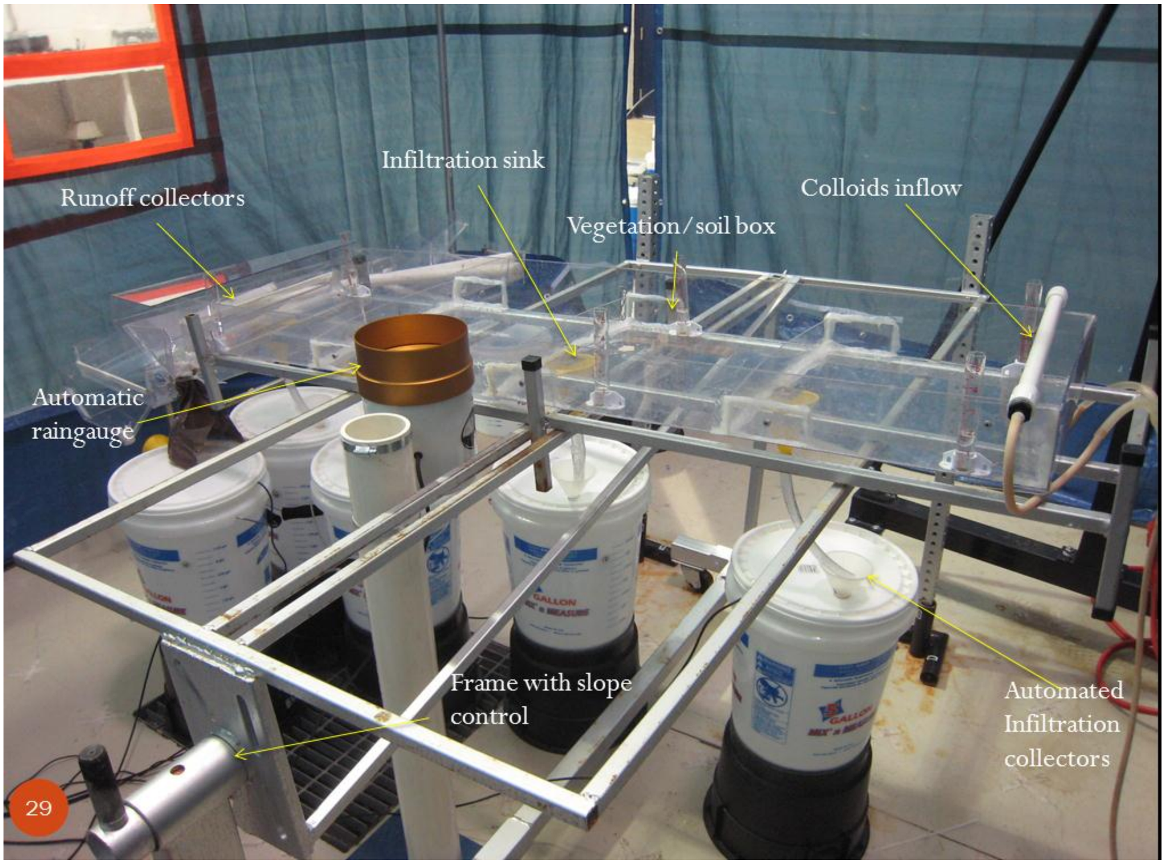

Figure 2-4. Laboratory runoff experiment set up

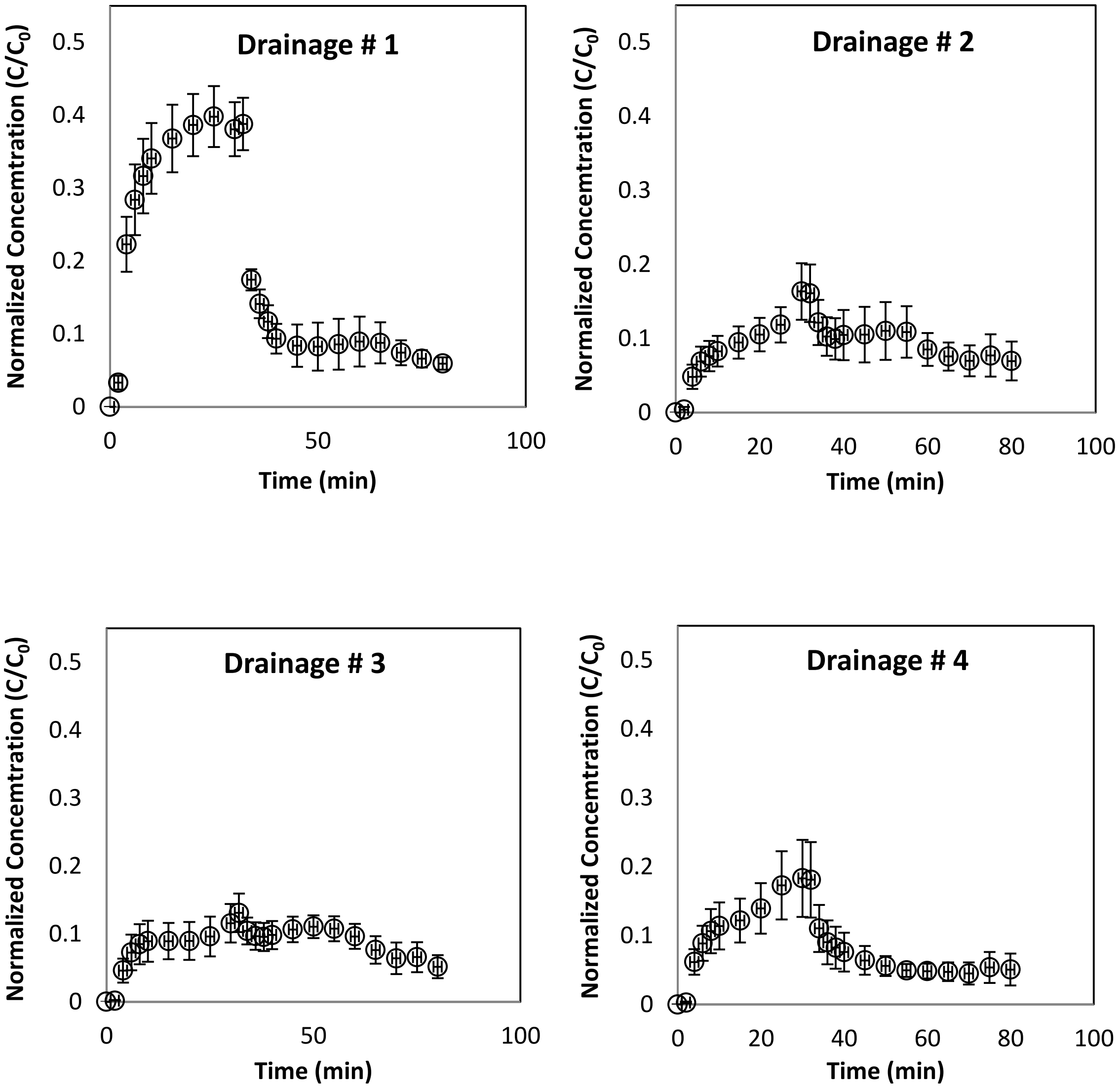

Figure 2-5. Transport of bromide in subsurface flow.

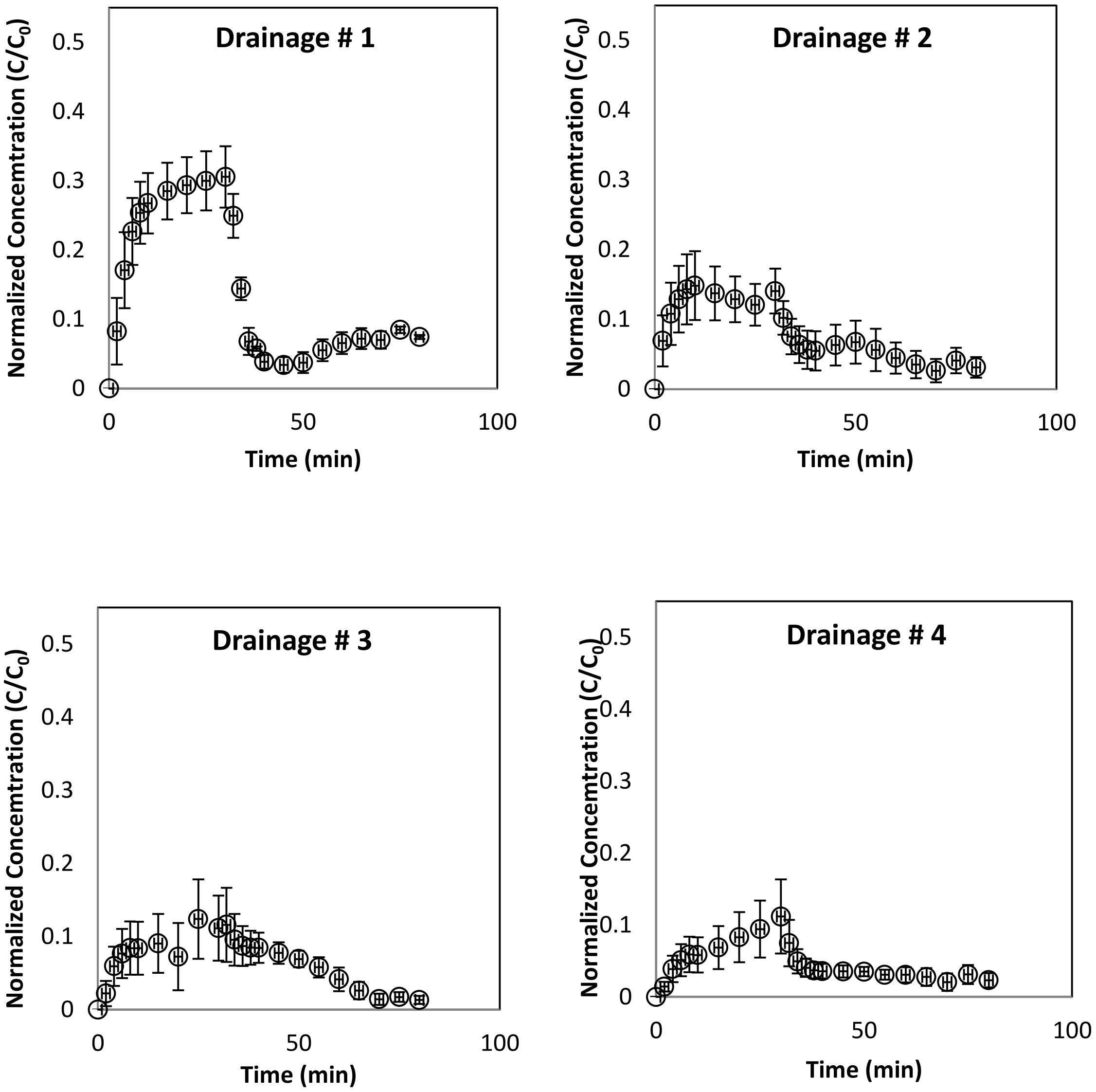

Figure 2-6. Transport of kaolinte in subsurface flow.

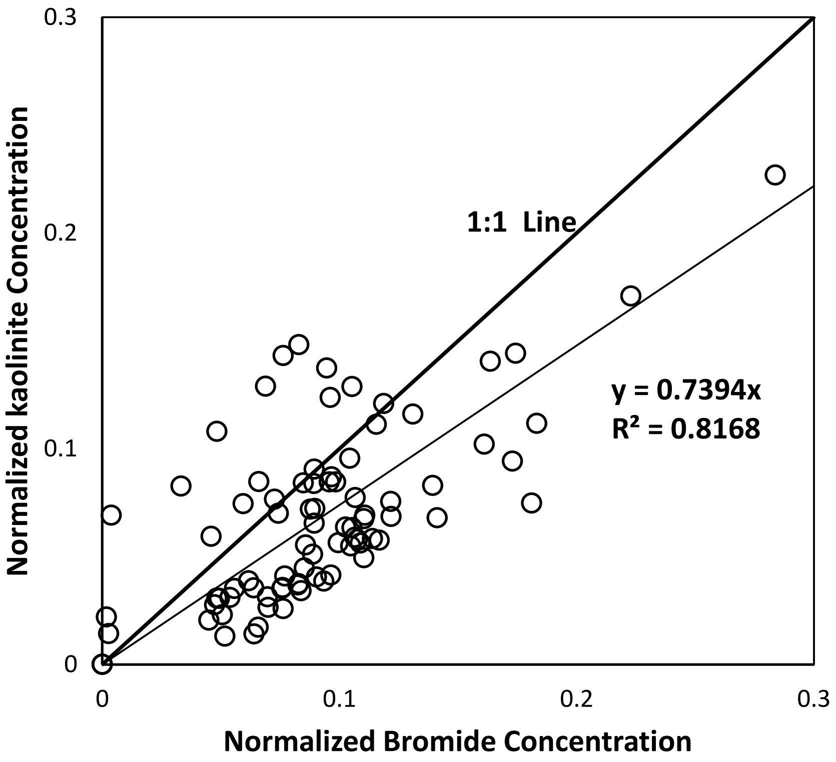

Figure 2-7. Correlation between kaolinite and bromide in subsurface flow.

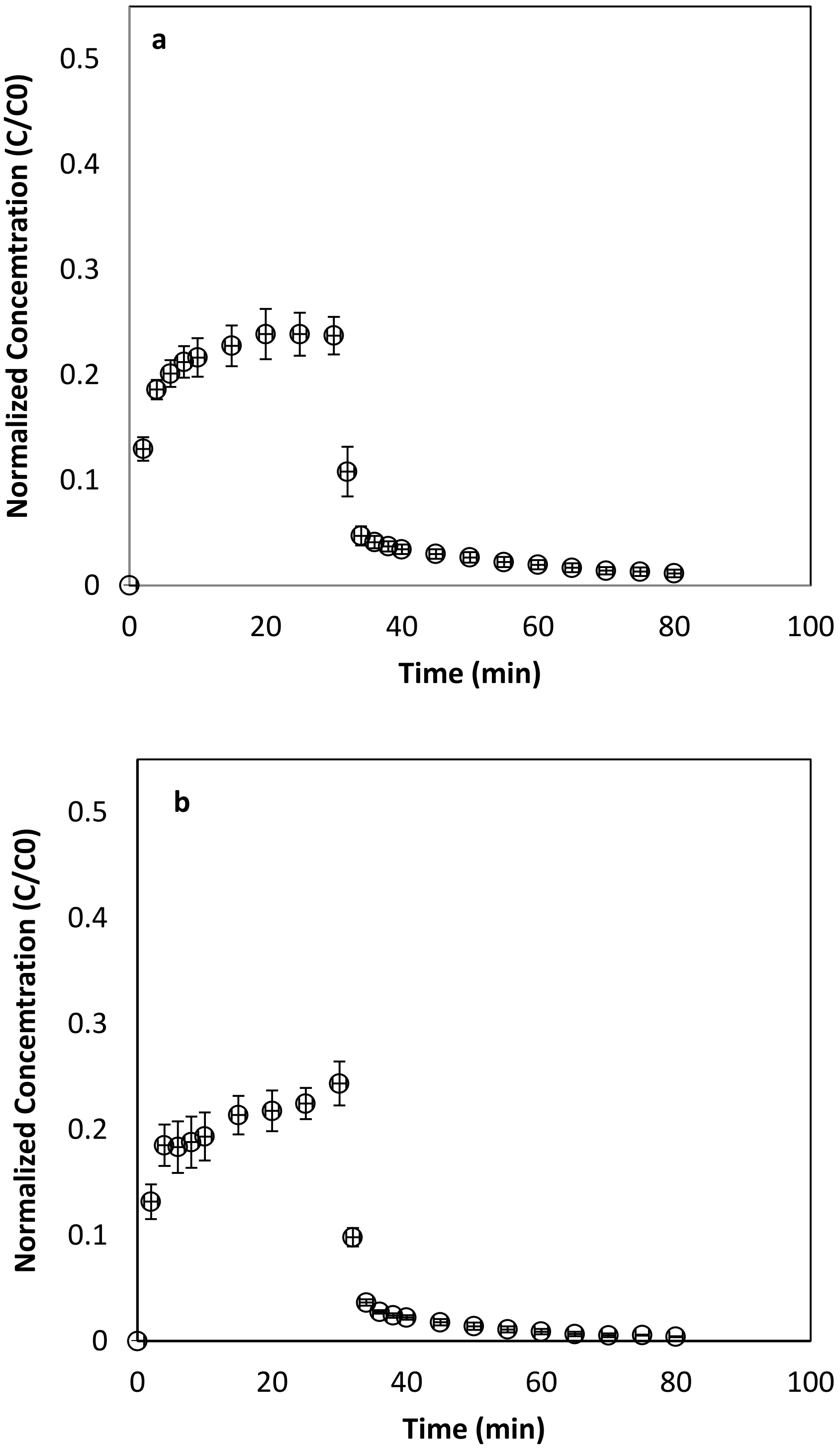

Figure 2-8. Transport of bromide and kaolinite in surface flow: (a) bromide and (b) kaolinite.

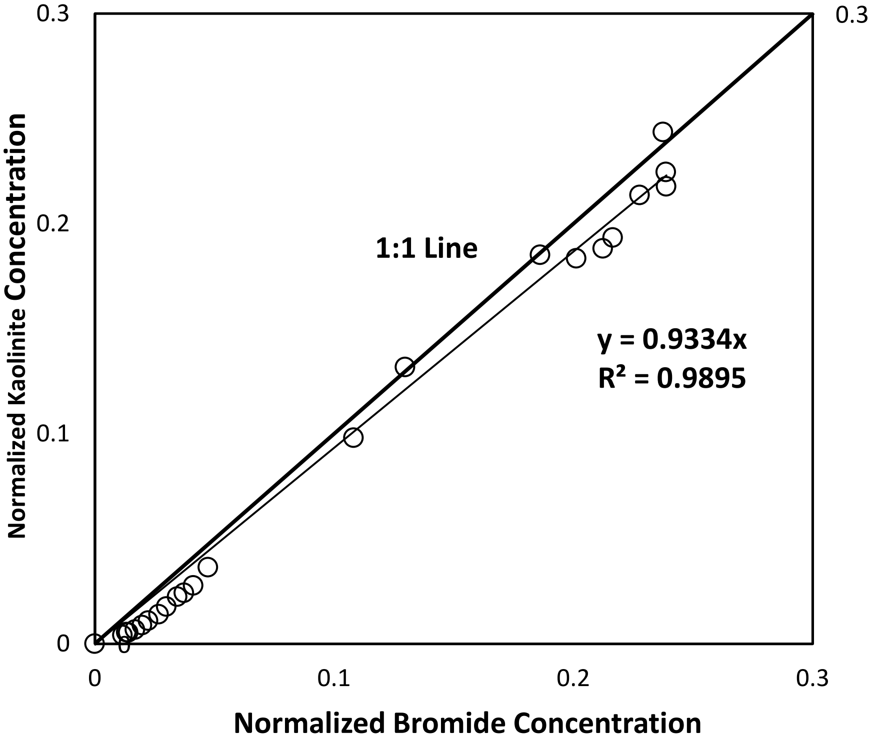

Figure 2-9. Correlation between kaolinite and bromide in surface flow.

CHAPTER 3
EFFECT OF DENSE VEGETATION ON COLLOID TRANSPORT IN SURFACE RUNOFF

Introductory Remarks

Colloids refer to suspended particles with sizes between 1 nm to 10 μm in either abiotic or biotic forms (Stumm, 1977). Once entering the aquatic environment, colloids can play an important role in controlling contaminant fate and transport. Abiotic colloids such as clay particles may carry strongly adsorbed contaminants (i.e. heavy-metals, agrichemicals, etc.) and thus enhance their mobility in subsurface and surface flows to deteriorate the aquatic environment (McCarthy and Zachara, 1989; Sun et al., 2010). Some of the biotic colloids (biocolloids) including pathogenic microorganisms are on the top of the EPA’s toxic pollutant list, which can be released into the aquatic environment from various sources, particularly from agricultural land (Kouznetsov et al., 2007; Steenhuis et al., 2006). Reduction of quantity and mobility of colloids in surface water flow is therefore critical to protect water quality in aquatic systems.

Most of the research of colloids in aquatic systems has been focused on their fate and transport in subsurface environment, such as in soil vadose zone and groundwater (Bin et al., 2011; Flury and Qiu, 2008). Only few studies have investigated colloid transport in surface runoff, which may have an immediate deteriorative effect on water quality. For example, surface runoff from agricultural practices and waste water discharges often contains large amount of colloids (Haygarth et al., 2006; Heathwaite et al., 2005). If those colloids (particularly biocolloids) are not removed from overland flow, they may pose risks to ecosystems when reaching surface-water bodies.

Natural or implanted dense vegetation, such as vegetative filter strips (VFS), has been suggested to be effective in attenuating the loading of chemical contaminants and sediments from agricultural lands to runoff (Abu-Zreig et al., 2004; Dosskey et al., 2007; Fox et al., 2010; Kuo and Muñoz-Carpena, 2009). VFS is a surface filtration system with a land area of either planted or indigenous dense vegetation, which is easy to install, low-cost, and require little maintenance compared to structures like settling basins or other constructed elements. They remove sediments and solutes from surface runoff mainly through two mechanisms: 1) slowing down surface runoff to decrease flow transport capacity and facilitate sedimentation; and 2) enhancing infiltration compared with the source area (Krutz et al., 2005). It has been demonstrated that a well-installed VFS can reduce as high as 60-100% of sediments and nutrients from surface runoff traveled through it (Gharabaghi et al., 2006; Muñoz-Carpena et al., 1999; Sabbagh et al., 2009). Young et al. (1980) used different types of dense vegetation to evaluate VFS effectiveness and showed an average 83% removal of total nutrients and a 70% of fecal coliform. Because VFS has high potential for reducing nonpoint source pollutions, it is among the best management practices recommended by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) for reducing nonpoint source pollutions (Krutz et al., 2005).

Although VFS is suggested to be effective in removing biocolloids (pathogens) from surface runoff, only few laboratory experiments have been conducted to investigate the fate and transport of colloids in dense vegetation (Fox et al., 2011; Guber et al., 2007; Trask et al., 2004). What’s more, some studies indicated that all manure-born constituents are transported primarily in solute phase, thus the transport and fate of biocolloid in surface vegetation should be dominated by mechanisms similar to those of solute transport (Edwards et al., 1996; Roodsari et al., 2005). Other experimental data showed that the transport mechanisms may be different for biocolloids and chemical solutes (Barfield et al., 1998; Crane et al., 1983; Dosskey et al., 2007). As pointed out by Haygarth et al. (2006) and Leguedois et al. (2008), despite the importance of colloids to water quality, theories and mechanisms that govern colloid fate and transport through surface vegetation remain surprisingly poorly understood.

In a previous study (Yu et al., 2011), we compared the transport behavior of clay colloids and bromide in overland flow on a bare soil (i.e. no surface vegetation) in a laboratory runoff system during simulated rainfall events. Kaolinite and bromide were found to behave similarly in overland flow over the bare soil when infiltration is limited and surface runoff dominates the transport processes. As a follow up, this study was designed to determine the effect of dense vegetation on the fate and transport of colloids in surface runoff. A laboratory runoff system was used to compare the transport behavior of colloids (fluorescent microspheres) and bromide in overland flow through dense surface vegetation. The specific objectives were to 1) measure the sorption of colloids onto different vegetation parts; and 2) compare the filtration and transport of colloids and bromide in the surface vegetation system.

Materials and Methods

Materials

Carboxylated polystyrene latex microspheres (Magsphere, Inc) with an average diameter of 0.3 µm were chosen as experimental colloids; they are commonly used as surrogates for both abiotic and biotic natural colloids (Morales et al., 2009; Zevi et al., 2006). The microspheres were fluorescent labeled and had a density of 1.05 g/cm^3. In the experiment, colloid input concentration was adjusted to about 10 mg/L by diluting the stock microsphere suspension. Additional characteristics' of the colloid used are given in Appendix A (Tables A-1 and A-2). Sodium bromide (certified, Fisher Scientific) at the concentration of 40 ppm was used in the experiment as the conservative chemical solute.

Quartz sand (Standard Sand & Silica Co.) with a size range between 0.5 to 0.6 mm was used as experimental soil. The sand was packed into a stainless steel box measured 153.1 cm long, 40.2 cm wide, and 10 cm deep (Figure 3-1a). The bottom of the box was separated by vertical stainless plates into four shallow compartments of 5 cm deep. Each of the compartments was equipped with a drainage outlet to partition infiltration along the flow path. About 12 kg sand was packed to a bulk density of 1.54 g/cm^3 in each compartment at a depth of 5.2 cm, which would eliminate the lateral subsurface flow from one compartment to another.

Bahia grass (*paspalum notatum*), which is a drought resistant turf grass, was selected as experimental vegetation, because it requires low maintenance and is best for warm and humid climate (e.g., Florida). Grass seeds were planted 1 cm deep in the soil box with a density of 76 g/m^2. The vegetated soil box was then frequently irrigated and fertilized for about four months in field conditions to establish the dense vegetation on top of the sand (Figure 3-1b). The dense vegetation in the soil box had an average density of 5791 stems per square meter. The height of the dense vegetation was maintained at 8 cm. The materials and environmental condition was summarized in Table 3-1.

Surface Runoff System

The surface runoff system in this study was similar to the one reported by Yu et al. (2011). Briefly, the soil box with dense vegetation was placed about 10 feet below a rainfall simulator on a metal shelf at a slope of 1.7 degrees. A PTFE spreader was used to apply lateral surface inflow with colloid or bromide solutions to the container from the upper side (Fig. 1a). A peristaltic pump controlled the inflow at a constant rate of 0.31 L/minute. Outflow runoff samples were collected at the lower end of the box, at the same time drainage samples were collected from the four outlets under each of the soil compartments. The cumulative flow from the surface runoff and drainage outlets was measured from water levels in collection containers (Fig. 1b) recorded continuously during the experiment using dielectric probes (ECH2O, Decagon Devices, Inc.) and a CR10 data logger. Uniform rainfall over the dense vegetation was generated by a rainfall simulator equipped with a tee jet 1/2 HH SS 50 WSQ nozzle (Spraying Systems Co. Wheaton, IL) (Figure 3-1a). The rainfall intensity was controlled by a pump and a pressure valve and gauge to a constant rate of 64 mm/hour, which was equivalent to a flow rate into the box of 0.66 L/min (i.e., 1.07 L/min/m^2). Additional details on the runoff system construction and instrumentation are provided by Yu et al. (2011).

Runoff Experiment

Simulated rainfall and inflow with colloid-free water were first applied to the dense vegetation box for about two hours, preconditioning the runoff experiment system to reach steady flows in both surface runoff and drainage outlets (Figure 3-1a). The fluorescent microsphere suspension was then injected to the dense vegetation box through the inflow spreader as a 30 minutes pulse. After that, the inflow was switched back to water to flush the mobile colloids out of the system for an additional 50 minutes. Surface runoff and subsurface drainage samples were collected during the experiment at approximate 2 minute intervals. A fluorescent spectrophotometer (Perkin Elmer LS 45) was used to determine colloid concentrations in the samples at wavelengths of 488 nm (exciting) and 509 nm (emission). Bromide solution was also applied to the surface runoff system as a conservative tracer. The experimental procedures were the same as those used for the colloids. The bromide concentrations in the samples were determined by an ion chromatograph (Dionex Inc. ICS90). Duplicated experiments were conducted for the transport experiments. Average breakthrough concentrations are reported.

Adsorption Experiment

The capacity of colloid adsorption on the vegetation was determined in batch adsorption experiment. Fresh grass samples were collected from the dense vegetation box and cleaned with water. The samples were then divided into three parts: leaf, stem, and root for immediate use in the adsorption experiment. Paper tissues were used to sorb the external water on the samples. In the batch test, about 0.1g (fresh weight) of the adsorbent (i.e., leaf, stem, or root) was added to 50-ml digestion vessels (Environmental Express) filled with 25 mL colloid suspension of different concentrations ranging from 0 to 25 mg/L at room temperature (22±0.5 ˚C). The vessels were shaken at 200 rpm in a mechanical shaker at room temperature for 24 hrs. All the liquid samples were then withdrawn for equilibrium colloid concentrations with the fluorescent spectrophotometer. The amount of colloids adsorbed was determined through mass balance calculation. Blank experiments without adsorbents or colloids were conducted as experimental controls and the adsorption experiments were conducted in triplicate.

Results and Discussion

Adsorption Isotherms

Although the isotherms showed large variances, all the three grass parts demonstrated good ability to remove colloids from water (Figure 3-2). The three adsorption isotherms were L-type and could be described with the Langmuir equation:

$$q_e = \frac{KQC_e}{1 + KC_e} \tag{3-1}$$

where K represents the Langmuir bonding term related to interaction energy (L mg^{-1}), Q denotes the Langmuir maximum capacity (mg kg^{-1}), and C_e is the equilibrium solution concentration (mg L^{-1}) of the sorbent. The Langmuir model barely described the isotherm of grass stem (R^2 = 0.66), but fitted the average isotherm data of grass leaf and root very well with R^2 greater than 0.9 (Table 3-2). The best-fit Langmuir capacities (Q) were between 455.3 and 1188.3 mg kg^{-1} (Table 3-2), suggesting that the dense vegetation can be used as a filter material to remove colloids from colloid contaminated water. A quick survey of the Bahia grass used in this study showed that the leaf, stem, and root of a single grass had an estimated weight of 0.24, 0.12, and 0.33 g, respectively. Based on the Langmuir capacities, it was estimated that the dense vegetation used in this study had potential ability to sorb as many as 703.1 mg colloids from surface runoff (i.e., stem 313.7 mg and leaf 389.4 mg) and 1397.6 mg colloids from subsurface flow (root). In the overland flow, because the contact time between the grass and colloid water was shorter, colloid removal rate by grass would be less than the maximum capacities estimated here.

Flow Distribution in Dense Vegetation System under Simulated Rainfall

Although the dense vegetation on the soil box could alter hydraulic conductivity of the sand in each compartment, flow distribution in the system only slightly differed from that of our previous study that used a bare soil box (Yu et al., 2011). Similar to the previous study, measurements of flow distribution in the dense vegetation system also indicated the dominance of the surface runoff (0.59 L/min), which was much higher than the drainage flows (0.06, 0.12, 0.07, and 0.07 L/min for drainage # 1-4, respectively).

The drainage rates in the experiment were relatively low for saturated sandy soils because of the added water holding effect of the dense grass root system and the small drainage holes on the soil box, which could limit the drainage flows at saturation (Yu et al., 2011).

Colloid Transport through Dense Vegetation

Because surface flow rate was faster than the drainage rates, bromide showed rapid breakthrough in overland flow through the dense vegetation (Figure 3-3). After the pulse injection, the breakthrough concentrations of bromide climbed quickly to a peak and stayed at that level during the application pulse. The relative concentrations (C/C_0) of bromide in the outflow were low (less than 0.15), probably due to the combined effects of rainfall dilution and mass transfer into the soil underneath (Walter et al., 2007). After the inflow was switched to water, bromide breakthrough concentrations dropped quickly but maintained a tailing of low bromide concentrations at the end of the experiment (Figure 3-3).

Colloid transport was lower in the dense vegetation than that of bromide (Figure 3-3). During the pulse injection period, the peak colloid concentrations were slightly lower than bromide peak concentrations. After the inflow was switched to water, colloid breakthrough concentrations also reduced but quickly to zero without the tailing. Mass balance calculation indicated that more than 36.9% of the total bromide was recovered from the surface runoff, which was higher than the recovery rate of colloids (28.7%) (Table 3-3). This result is consistent with the findings from the batch adsorption experiment and suggests that the recovery difference (at least 8.2%) could be attributed to the removal of colloids from surface runoff by the dense vegetation. Under the experimental conditions, the overland flow was shallow (~ 5 mm) and thus we infer that most of the colloids were removed by the stem of the vegetation. The total amount colloids removed by the stem (7.6 mg) was only about 2.4% of the estimated maximum capacity (313.7 mg), suggesting that, in spite of its potentially high colloid sorption ability, the actual removal efficiency of the dense vegetation under the dynamic runoff conditions could be limited because of insufficient contact between colloids and the vegetation. Reducing flow rate or increasing flow residence time therefore could enhance the removal of colloids from surface runoff by dense vegetation.

Colloid Transport in Drainage Flows

Both bromide and the colloids showed low breakthrough behaviors (Figure 3-4) in four drainage outlets. Drainage # 1 showed the highest breakthrough concentrations of both bromide and colloids because it was the closest one to the injection location. Due to the rainfall dilution effect, the other three drainage outlets showed lower breakthrough concentrations than drainage #1. Only less than 1% of colloids were recovered from the drainage #3 and #4 (Table 3-3). The breakthrough responses of the colloids in the four drainage outlets were much lower than those of bromide, the non-reactive tracer, suggesting high removal of colloids (>27.3%) from the subsurface flows (Table 3-3). The lower breakthrough of colloids in the subsurface drainages could be attributed to two reasons: 1) the filtration of colloids by the sand (Chen et al., 2005; Gao et al., 2004); and 2) the adsorption of the colloids onto the grass root, as suggested by the batch sorption experiment (Figure 3-2c).

Although only a shallow soil layer (5cm) was used in this study, colloid removal rate by the soil and grass root was much higher than by dense vegetation on the surface, which is consistent with a recent study by Fox et al. (2011). Both results suggest that enhanced infiltration should be the main removal mechanism when utilizing dense vegetation to reduce colloidal contaminants in surface runoff.

Dense Vegetation Effect on the Removal of Colloids

The recovery differences between colloids and bromide (8.2% for surface and 27.3% for subsurface) represent mainly the colloids deposition and surface exchange processes by the soil/vegetation system. The total amount of colloids removed at the surface (7.6 mg) was only about 2.4% of the estimated maximum capacity of the vegetation stems (313.7 mg from the adsorption studies). Limited contact between colloids and the vegetation in dynamic conditions. Higher removal of colloids (>27.3%) from the subsurface flows because: 1) the filtration of colloids by the sand; 2) the adsorption of the colloids onto the grass root as (suggested by the batch sorption experiment).

The material and environmental condition of surface runoff experiment on bare soil and densely vegetated soil (Table 3-1) were similar, except the model colloids on bare soil was 179 mg/L 0.4 μm kaolinite powder and on densely vegetated soil was 10mg/L 0.3 μm carboxylated polystyrene latex microspheres. However, the characteristic of two colloid models were comparable, as shown in Appendix A (Tables A-2). Both colloids were negatively charged, with similar Zeta potential and colloid size. Thus, the colloid removal rate of bare soil could be compared with densely vegetated soil (Figure 3-5). Because the dense vegetation, 41% more colloids were removed than that from bare soil, with 22% less in surface runoff and 19% less in subsurface drainage water. Dense vegetation can improve the retention of colloidal particle in surface runoff.

Chapter Conclusions

Laboratory experiments were conducted to investigate the effect of dense vegetation on colloid transport and removal in overland flow and subsurface drainage. Batch experiments showed that grass leaf, stem, and root could effectively adsorb aqueous colloids. This was confirmed by the laboratory runoff experiments under a simulated rainfall event. Comparisons of the breakthrough behaviors of bromide and colloids in overland flow through dense vegetation demonstrated that the dense vegetation system could remove colloidal particles from surface runoff. The vegetation effect of the surface removal of colloids is also supported by an earlier study of surface runoff colloidal transport on bare soil, where colloids behaved like the bromide tracer used as a benchmark and experienced no significant removal from the surface flow (Yu et al., 2011). In addition, the soil (and root) underneath the vegetation also showed strong ability to remove colloids from the drainage flows. Our results suggest that naturally dense vegetation, if properly installed and maintained in the form of vegetative filter strips, can be used to reduce the load of colloidal contaminants to surface water.

Table 3-1. Experimental conditions of colloid transport in surface runoff on vegetated soil.

	Materials
Colloids	10mg/L 0.3 μm Carboxylated polystyrene latex microspheres
Tracer	40 ppm Sodium Bromide
Soil Bed	0.5 to 0.6 mm washed quartz sand, porosity 0.43, slope 1.7%, dimension (153.1 * 40.2 *10 cm)
	Environmental Conditions
Inflow rate	0.31 L/Min
Rainfall intensity	64 mm/hour (uniformity > 90%)
Ionic Strength	regular tap water (0.558 mMol)

Table 3-2. Langmuir model results of colloids adsorption onto different grass parts.

Grass Part	*K* (L/mg)	*Q* (mg/kg)	R^2
Leaf	0.729	455.3	0.95
Stems	0.177	733.5	0.66
Roots	0.114	1188.3	0.92

Table 3-3. Water, bromide and colloids distribution in the runoff and drainage.

%Recovery	Runoff	Drainage 1	Drainage 2	Drainage 3	Drainage 4	Total
Water	62.76%	6.82%	12.74%	8.14%	7.22%	97.70%
Bromide*	> 36.93%	> 10.35%	> 15.07%	> 3.89%	> 2.48%	> 68.73%
Colloids	28.72%	1.37%	2.49%	0.37%	0.31%	33.26%

*:Calculated from the incompeleted breakthrough courves, which underestimated the recovery rates.

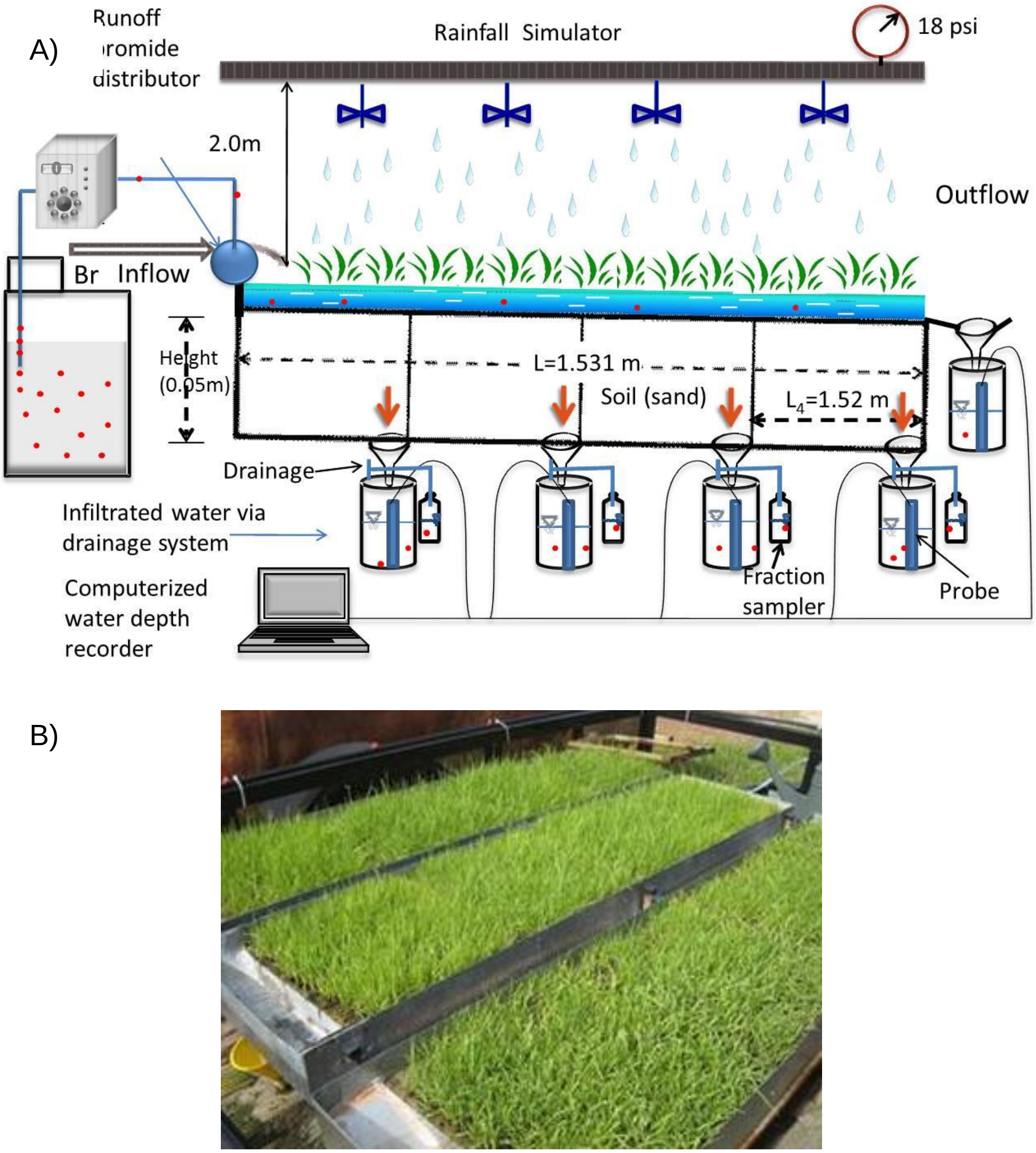

Figure 3-1. Bahia grass planted in laboratory soil box as dense vegetation: A) schematic, B) view of the vegetated soil boxes with Bahia grass.

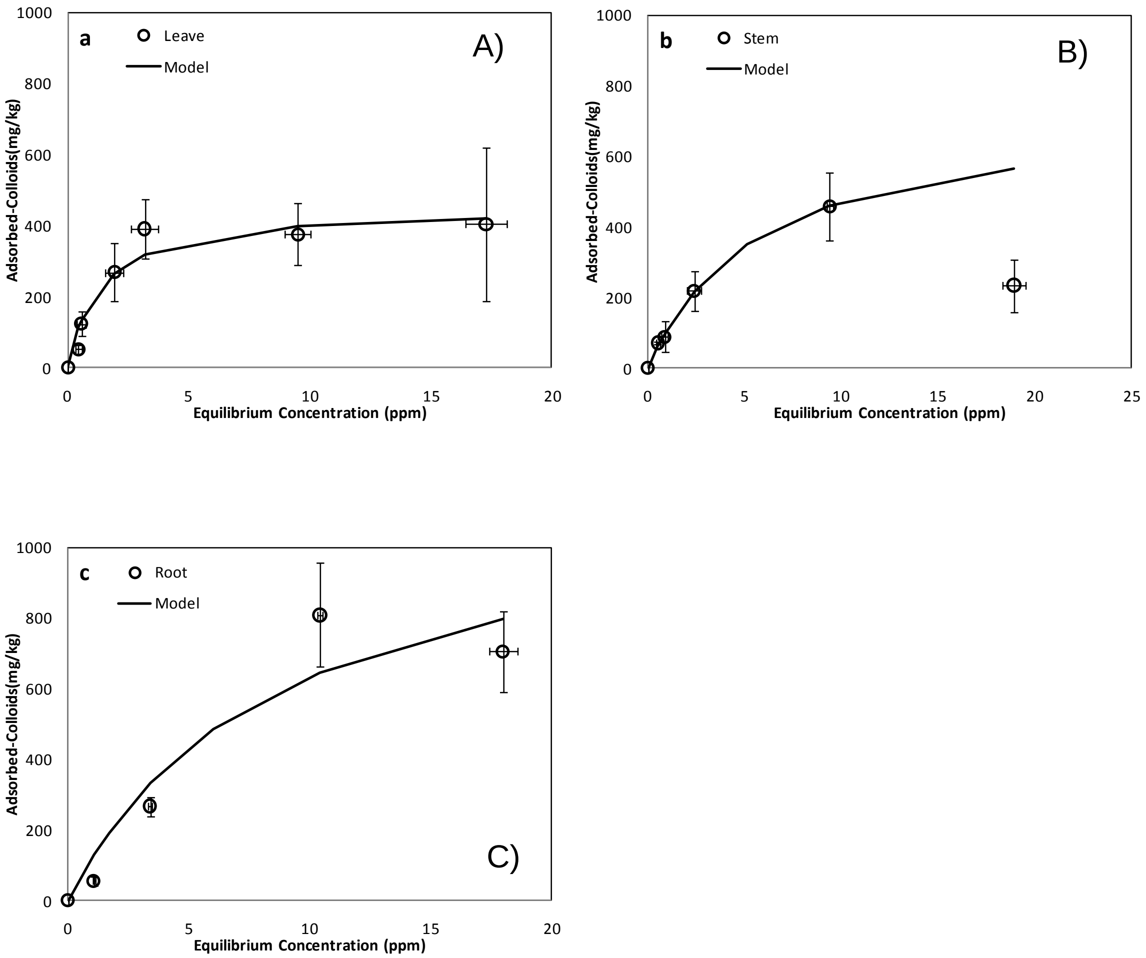

Figure 3-2. Langmuir adsorption isotherms of colloids onto different grass parts: A) leaf, B) stems, and C) roots (symbols = experimental data, lines = model simulations).

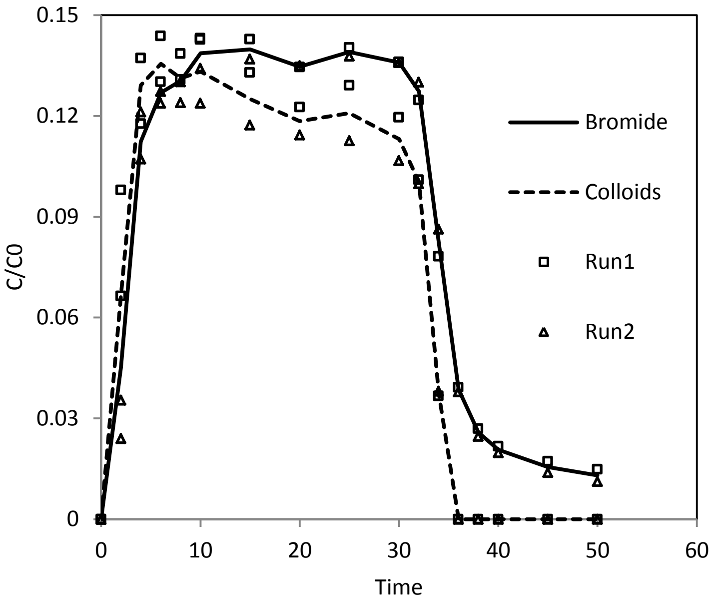

Figure 3-3. Breakthrough concentration of bromide and colloids in overland flow through dense vegetation (symbols = experimental data, lines =average data).

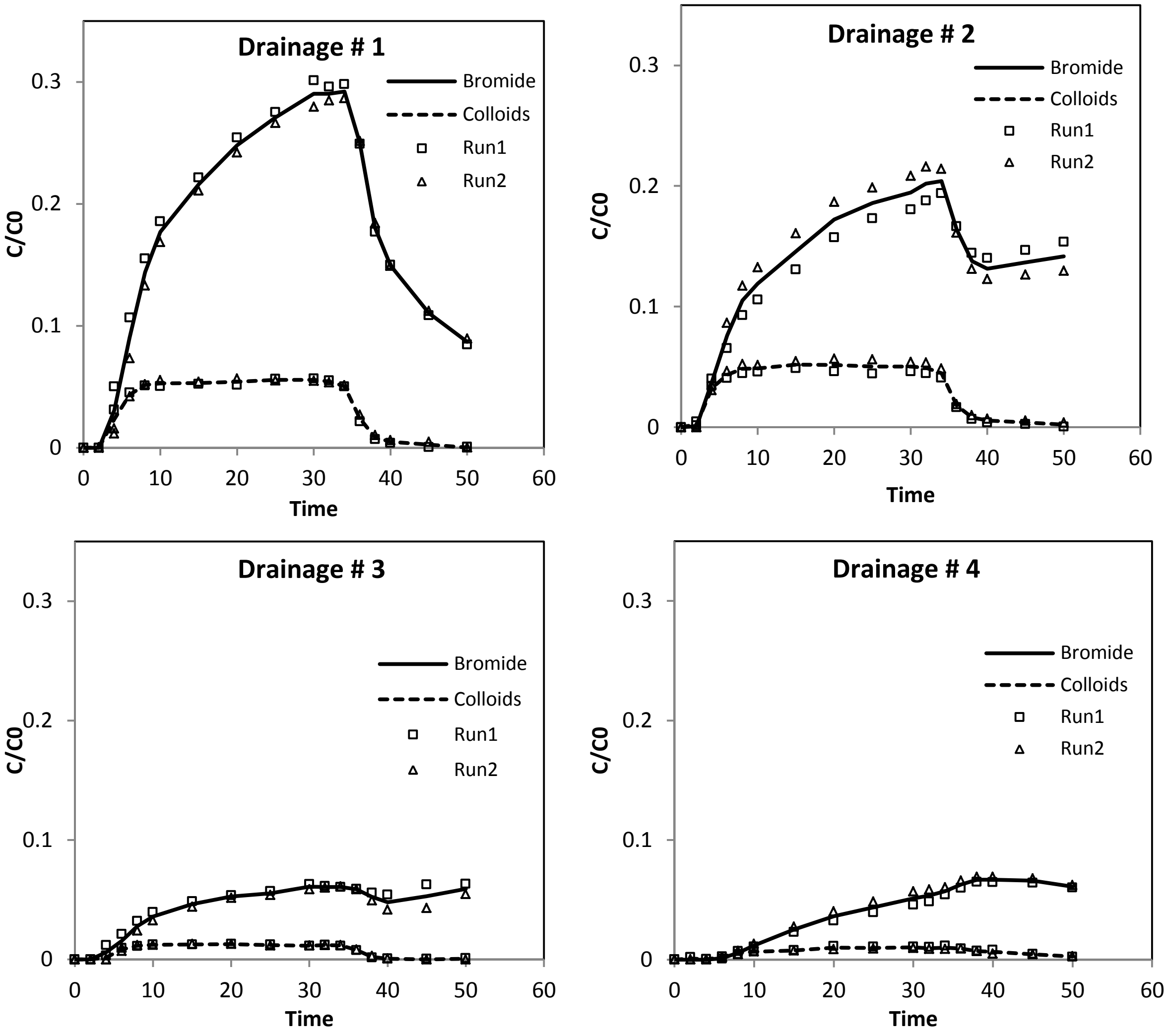

Figure 3-4. Breakthrough concentration of bromide and colloids in drainage flows (symbols = experimental data, lines =average data).

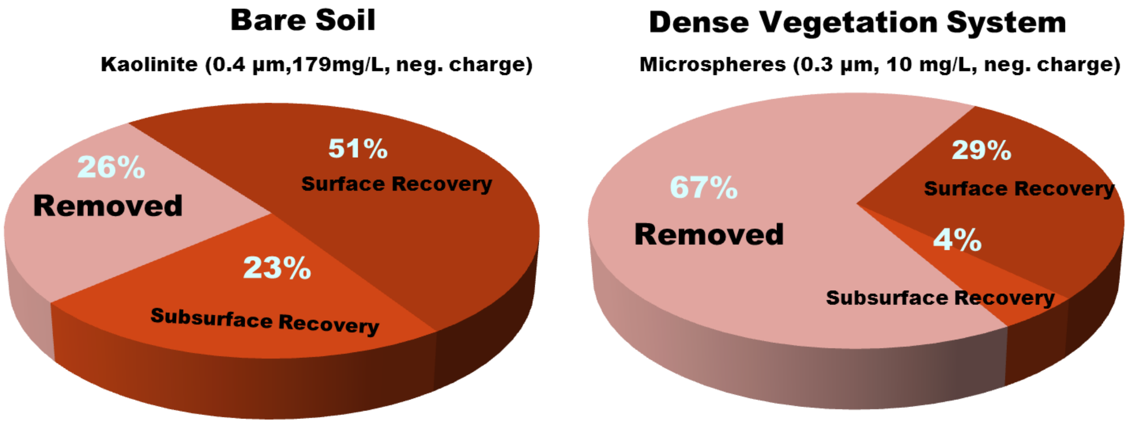

Figure 3-5. Distributions of colloids in bare soil and dense vegetation systems at the end of the runoff experiments.

CHAPTER 4
CHEMICAL AND PHYSICAL FACTORS CONTROLLING THE RUNOFF REMOVAL OF COLLOIDS BY DENSE VEGETATION

Introductory Remarks

Reducing non-point source pollution in agriculture has been one of the most challenging problems of environmental protection. Colloids, which are defined as particles with at least one dimension smaller than 10 μm, are among the most common components in the effluents from agricultural practices. For example, waste discharges from animal feeding operations include both abiotic and bio-colloids; agricultural irrigation mobilizes particulate phosphorus and other forms of colloidal particles in soils; rainfall induced soil erosion on farm land could also bring large amounts of colloidal clay minerals into surface runoff and into adjacent water bodies. Mobile colloids in hydrological paths can deteriorate the water quality not only because some of them are natural-born contaminants (e.g., pathogenic bacteria and viruses), but also because they may facilitate the transport of other reactive contaminants in streams and groundwater (McCarthy and Zachara, 1989; 2006; Sun *et al.*, 2010; Bin *et al.*, 2011). Once entering public waters and drinking water aquifers, these colloids present a risk to the public health.

Although extensive research has been conducted to reduce the contamination risks of colloids in groundwater, there are only few studies in the literature explored the removal and transport of colloids in surface runoff (Pachepsky et al., 2006; Fox et al., 2011; Yu et al., 2011). Due to the nature of surface runoff for rapidly transferring contaminants to surface water bodies, mobile colloids in the surface runoff may present high contamination risks to the environment because they can efficiently facilitate the transport of various water pollutants, such as nutrients, heavy metals, persistent organic pollutant (POPs) and pathogens (Heathwaite *et al.*, 2005; Ren and Packman, 2005; Haygarth *et al.*, 2006; Kouznetsov *et al.*, 2007). Nutrients can cause eutrophication in lakes or rivers and heavy metals' toxicity can result in damage of vital organs of living organisms. POPs can also threat the health of whole ecosystems when they enter the food chain. Pathogens in surface water may cause serious problems to public health, particularly with respect to disease outbreaks.

Natural dense vegetation (grasslands and meadows) or implanted (vegetative filter strips, VFS) is widely relied upon in natural and in agricultural lands for non-point source pollution control. It is suggested that a well-installed VFS can remove suspended sediments (up to 90%), phosphorus (75%), nitrogen (87%), and pesticides (40%) (Koelsch *et al.*, 2006; Dosskey *et al.*, 2007; Fox *et al.*, 2010; Muñoz-Carpena *et al.*, 2010). In addition, dense vegetation has been found to be effective in removing bio-colloids from surface runoff. A number of studies have been conducted to investigate the removal efficiency of VFSs to fecal bacteria from manure. Results from these studies suggested that dense vegetation could reduce the loading of pathogens from surface runoff (Trask *et al.*, 2004; Guber *et al.*, 2007; Fox *et al.*, 2011). Our study presented in Chapter 3 (Yu *et al.*, 2011) also demonstrates that in a laboratory setting, dense vegetation (Bahia grass) grown on a sandy soil box (1.5 m by 0.5 m) can effectively remove abiotic colloids (carboxylated polystyrene latex microspheres, 0.3 μm diameter, zeta potential -28 mV, inflow concentration 10 mg/l) from surface runoff with a removal rate close to 67%.

Several physicochemical factors, including pollutant characteristics, vegetation composition and density, soil properties, and the physical dimensions of the filter strip, have been identified to be important to the effectiveness of VFS to remove chemical solutes and sediments from runoff. Relatively few investigations have been conducted to explore the factors that may impact the filtration and transport of colloidal particles in dense vegetation. In laboratory experiments, Tate et al. (2004) and Trask et al. (2004) found that land slope, vegetation density, and rainfall intensity are among the most important factors that control the removal of *Cryptosporidium parvum* released from cattle feces on soil surface. Similarly, Fox et al. (Fox *et al.*, 2011) recently demonstrated the importance of inflow rate, infiltration capacity, and initial concentration on filtration of E. coli by dense vegetation in a laboratory VFS soil box. Field experiments conducted by Ferguson et al. (Ferguson et al., 2007) also showed that colloid size played an important role in controlling the mobility of microorganisms (biocolloids) in dense vegetation. Additional investigations, especially integrated systematic experimental and modeling studies, are thus needed to advance current understandings of the physicochemical determinants of colloid removal in dense vegetation.

Mathematical models have been developed to aid in the interpretation of biocolloids (pathogenic bacteria) transport and removal in dense vegetation, but most of these models assume that the transport of biocolloids in surface runoff is similar to that of reactiva e solute. Pachepsky, et al. (2006) developed a reactive solute transport model to simulate the transport of manure-borne pathogen (E. coli) through dense vegetation in surface runoff and the model simulation matched the experimental data well. Nevertheless, the actual effect on biocolloid removal of surface deposition on dense vegetation cannot not be separated from bacterial growth and decay effects in these type of model model formulations. Alternative approaches, especially approaches based on the classical colloid filtration theory, thus should be considered in modeling the fate and transport of colloids in dense vegetation in surface runoff.

Theory

Transport is defined as concentration change in response to water flow and mass exchange processes. Generally colloid transport in dense vegetation in surface runoff can be summarized into following processes: advection, dispersion, exchange between solid and liquid phase, deposition on the surface of grass stem and soil grains (Grolimund *et al.*, 1998; Socolofsky, 2005; Tufenkji, 2007). Dynamic flow conditions must be described prior to the interpretation of the fate and transport processes. A short description of the flow and transport theory is provided below as background for the interpretation of the experimental data collected in this study.

Overland Flow

Surface flow in dense vegetation can be described by the kinetic wave approximation of the Saint-Vennant's equation (Lighthill and Whitham, 1955).

$$\frac{\partial h}{\partial t} + \frac{\partial q}{\partial x} = i_e(t) \tag{4-1}$$

where h is depth of overland flow [L], q is the flow per unit width of the plane [L^2T^{-1}], and i_e is the net lateral exchange defined as the difference between rainfall and soil infiltration rates [LT^{-1}].

A uniform flow equation can be used as a link between the q and the h, such as Manning's equation:

$$q = q(h) = \frac{\sqrt{S_0}}{n} h^{\frac{5}{3}} \tag{4-2}$$

where S_0 is the slope of the plane [LL^{-1}], and *n* is Manning's roughness coefficient, dimensionless. This approach has been used successfully to described flow in vegetative filter strips (Muñoz-Carpena et al., 1993a,b; 1999).

Transport (Advection and Dispersion)

Mathematical models of colloids transport in dense vegetation media generally involve a simplified form of the advection-dispersion equation, which can be derived from basic mass balance principles.

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} - v\frac{\partial C}{\partial x} \tag{4-3}$$

where C is the colloid concentration in the surface runoff water [ML^{-3}], t is the time [T], x is the distance from colloid pollution source [L], D is the average dispersivity coefficient [L^2T^{-1}] for colloid in the longitudinal direction, v is the average colloidal particle transport velocity [LT^{-1}].

Deposition of Colloids on Grass Surface

We can consider the dense vegetation as a special porous media with high porosity. Under steady state conditions, colloid transport through dense vegetation then can be modeled with the advective-dispersive transport equation including a term of first order colloid deposition (Eq. 4-4), which is the same as in the classic "clean-bed" filtration model (Kretzschmar *et al.*, 1997):

$$\frac{\partial C}{\partial t} = -v\frac{\partial C}{\partial x} + D\frac{\partial^2 C}{\partial x^2} - K_g C \tag{4-4}$$

where K_g is the first order deposition rate coefficient[T^{-1}].

Exchanges Between the Liquid and Solid Phases in the Topsoil Exchange Layer

We assume mass exchange between the overland flow and the soil underneath is also important to colloid transport in dense vegetation (Wallach et al.; 1989, Gao et al., 2004b) (Figure 4-1). The mass conservation of colloids in dense vegetation in the overland flow can then be described based on the combination of the classic “clean bed” filtration model and the exchange layer theory (Gao et al., 2004b; Walter et al., 2007):

$$\frac{\partial C}{\partial t} = -\frac{q}{h}\frac{\partial C}{\partial x} + D\frac{\partial^2 C}{\partial x^2} - k_g C - k_{ei} C + k_{eo} C_e \tag{4-5}$$

$$\frac{d\theta}{h}\frac{\partial C_e}{\partial t} = \lambda k_{ei} C - k_{eo} C_e \tag{4-6}$$

where C is colloid concentration in the surface runoff water [M L^{-3}], t is the time [T], q is the overland flow rate [L^2 T^{-1}], h is the ponding water depth [L], x is the coordinate parallel to overland flow [L], D is the dispersion coefficient [L^2 T^{-1}], k_g is a rate coefficient describing the deposition onto grass surfaces [T^{-1}], k_{ei} and k_{eo} are rate coefficients of mass exchange between overland flow and the exchange layer [T^{-1}] (Gao et al., 2004b; Walter et al., 2007), d is the exchange layer depth [L], θ is the water content in the soil profile, C_e is the “exchangeable” concentration in the soil exchange layer, and λ is a dimensionless constant controlling the exchangeable concentration in the exchange layer. For non-reactive mass transfer in homogenous soil exchange layer, λ usually equals unity, indicating all the concentration entering the exchange layer is available for mass exchange between the soil and overland flow (Gao et al., 2004b). In this study, because the growth of vegetation would increase the heterogeneity and reactivity of the soil in the exchange layer, thus $0 \leq \lambda < 1$, reflecting part of the concentration in the soil exchange layer is “un-exchangeable” (i.e., trapped in immobile water zone and/or attached on soil surfaces).

This study was designed to explore surface transport and filtration of colloids in dense vegetation under various physicochemical conditions. Laboratory experiments were conducted to determine the effects of runoff inflow ionic strengths, flow velocities, colloid sizes, and vegetation types on colloid removal in a vegetated soil box. The experimental data are interpreted with the aid of a conservative tracer (bromide) study conducted simultaneously on the same dense vegetation system and mathematical model simulations. Our objectives were to 1) understand the effect of physicochemical factors, including ionic strength, colloid size, flow rate and vegetation types, on the attenuation and transport of colloidal particles in dense vegetation, and 2) explore mathematical models to simulate the fate and transport of colloids in overland flow through dense vegetation.

Materials and Methods

Materials

Carboxylated polystyrene latex microspheres (Magsphere, Inc.) with an average diameter of 0.3 µm were chosen as experimental colloids, because they are commonly used as surrogates for both abiotic and biotic natural colloids (Gao et al., 2006; Morales et al., 2009). The microspheres were labeled with yellow/green fluorescence dye and had a density of 1.05 g/cm^3. In the experiment, colloid input concentration was adjusted to about 12 mg/L by diluting the stock microsphere suspension. Sodium bromide (certified, Fisher Scientific) was used in the experiment as the conservative chemical solute. The bromide was mixed with the microsphere suspension to a concentration of 40 mg/L and was applied to the surface runoff system as a conservative tracer.

Quartz sand (Standard Sand & Silica Co.) was used as experimental soil. The sand had a size range between 0.5 to 0.6 mm and a bulk density of 1.54 g/cm^3. The sand was used as received and was paced in a small size soil sunoff box measured 20.32 cm long, 19.05 cm wide, and 10 cm deep (Figure 4-2). The soil box was made of clear polyvinyl chloride (PVC). The box was equipped with a drainage outlet to partition infiltration at the bottom end during the saturate process before the experiment start. Sand was packed to constant bulk density in the box to a depth of 5 cm.

Bahia grass (*Paspalum notatum*) and Perennial Rye grass (*Lolium perenne* L.), which are drought resistant turf grasses, were selected as experimental vegetation, because they require low maintenance and are best for warm and humid climate. Grass seeds were planted 1 cm deep in the soil box with a density of 76 g/m2. The vegetated soil box was then irrigated and fertilized for about three months in a greenhouse to create dense vegetation (distance between the stem was < 2 cm) on top of the sand. The height of the dense vegetation was maintained at 8 cm by clipping.

Runoff Experiment

Surface runoff experiments were conducted using the vegetated soil runoff boxes under different physicochemical conditions (Figure 4-2). To start a transport study, colloid-free water was first applied using a peristaltic pump with an end flow spreader to the vegetated soils box to flush the soil and reach steady flow conditions. Once the overland flow stabilized, the inflow was then switched to the experimental solution containing both colloid and bromide. Because this study was designed to study colloid transport in surface flow, the drainage outlet on the soil box was closed during the experiment. The solution was injected to the dense vegetation box through the inflow spreader as a 10 minutes pulse. After that, the inflow was switched back to water to flush the mobile colloids out of the system. Surface runoff samples were collected during the experiment at different time intervals. A fluorescent spectrophotometer (Perkin Elmer LS 45) was used to determine colloid concentrations in the samples at wavelengths of 488 nm (exciting) and 509 nm (emission). Bromide concentrations in the samples were determined by an ion chromatograph (Dionex Inc. ICS90). Duplicated or triplicated experiments were conducted for the transport experiments. Average breakthrough concentrations were reported. The effects of flow rates, ionic strengths, colloid sizes, and vegetation types on the microspheres and bromide transport and retention in the dense vegetation were tested. Regular tap water with mean ionic strength of about 0.6 mMol (Alstad et al., 2005; Shipley et al., 2009) was used in the study. To study the ionic strength effect, KCl was added to the tap water in some experimental runs to make a high ionic strength stock solution of 100 milliMole/Liter. Small (0.3 µm), medium (2 µm), large (10.5 µm) colloids were used in the study at low ionic strength (i.e., tap water) to test the size effect on colloid transport in dense vegetation systems. All these experiment were conducted at fixed inflow rates of 62 mL/min or 84 mL/min, controlled by the inflow peristaltic pump. Table 4-1 summarizes the experimental conditions.

Modeling Tools

Equations 4.5-4.6 were solved numerically (finite elements method) for a zero initial concentrations, a pulse-input boundary condition at inflow, and a zero-concentration-gradient boundary condition at the outflow.

A computer code for hydrology and reactive transport in vegetative filter strips, was used in this study to solve the governing equations (Perez-Ovilla, 2010). The model consists of the hydrological and water quality numerical model VFSMOD coupled to dynamic multireactive transport component (RSE). Vegetative Filter Strip Modeling System (VFSMOD-W), is a field-scale, mechanistic, storm-based numerical model developed to route the incoming hydrograph and sediment from an adjacent field through a VFS and to calculate the resulting outflow, infiltration, and sediment trapping efficiency (Muñoz-Carpena et al., 1993a,b, 1999; Muñoz-Carpena and Parsons, 2004, 2008). Researchers have successfully tested the model in a variety of field experiments with good agreement between model predictions and measured values of infiltration, outflow, and trapping efficiency for particles (Muñoz-Carpena et al., 1999; Abu-Zreig, 2001; Abu-Zreig et al., 2001; Dosskey et al., 2002; Fox et al., 2005; Han et al., 2005), and phosphorus (particulate and dissolved) (Kuo, 2007; Kuo and Muñoz-Carpena, 2009). VFSMOD-W is currently used in conjunction with other watershed tools and models to develop criteria and response curves to assess buffer performance and placement at the watershed level (Yang and Weersink. 2004; Dosskey et al., 2005, 2006, 2008; Tomer et al., 2009; White and Arnold, 2009). Recent studies have extended the modeling tool to successfully calculate pesticide trapping efficiency (Fox and Sabbagh, 2009; Sabbagh et al., 2009; Poletika et al., 2009). These studies identified that performance of VFS for pesticide trapping depends on hydrologic conditions (precipitation, infiltration, and runoff), the filter design (length, slope, and densities of vegetation cover), and characteristics of the incoming pollutants (sediment and pesticides). VFSMOD-W can be used to describe flow dynamics in dense vegetation systems, including changes in flow derived from sediment deposition, physically based time dependent soil water infiltration. It also handles complex storm pattern and intensity and varying surface conditions along the filter (Munoz-Carpena and Parsons, 1999).

The VFSMOD contains a transport component that solves the Advection-Dispersion-Reaction Equation (ADR) using a split operator scheme of the type Transport-Reaction-Transport at each time step, which means that the pollutant is transported; using half of the time step, then is reacted for the full time step, and then transported for the remaining time step (Pérez-Ovilla, 2011). The transport part of the ADR is solved using a standard Bubnov-Galekin cubic/quadratic Finite Element Method with a time-weighting (Crank-Nicholson algorithm) method for the temporal derivative. The reactive term is based on a user-defined conceptual model RSE (Jawitz et al., 2008; James et al., 2009) where interactions and reactions are input into the program as a XML file, so the source code is not modified depending on the type of kinetics and interactions of the transported pollutant. The elements defined for the reactive term are solved in the form of a system of ordinary differential equations (ODE) using the fourth order Runge-Kutta method. In general, the conceptual model considers the pollutants as mobile or stabile, depending if they move with runoff (i.e. soluble compounds) or stay in the same place during the simulation (i.e. pollutant soil porewater concentration, absorbed pollutant to soil and vegetation, etc). This module has been tested using analytical solutions with simple first order decay reaction and Monod kinetics for single and coupled species under steady state conditions (Perez-Ovilla, 2011).

The modeling tool was parametrized to explore the experimental data. Firstly, the hydrological event was simulated to match the flow conditions (hydrograph) measured at the outlet of the soil runoff box (Fig. 4-2). This yielded a steady surface water depth (h) of 0.16 cm, that closely match the observed values. The measured soil porosity (θ) was 0.43. Exchange layer depth (d_e) depends on the soil surface conditions and the soil properties of texture, strength, and permeability (Ahujia, et al., 1981). Donigian et al. (1977) used a surface layer thickness of 0.2-0.6 cm, Ahuja et al. (1981) calculated the effective average depth which ranged between 0.2-0.3 cm from experiments, and Gao et al. (2004) employed 0.4-0.7cm. Based on these values we used 0.37cm as the effective exchange depth in this model.

The transport of bromide was simulated as a non-reactive tracer with VFSMOD-RSE to estimate the best-fit values of the dispersion coefficient (D), the mass exchange rate (k_{ei} and k_{eo}), and λ. In our exploratory simulations, we assumed that colloids had the same D and k_{ei} as bromide in the system (Gao et al., 2005; Tian et al., 2010). Secondly, VFSMOD-RSE with the parameter values D and k_{ei} was calibrated to simulate the transport of colloids in the system under different physicochemical conditions. The inverse calibration procedure was perform by honoring the range of values reported in previous studies (Appendix A, Table A-3).

Results and Discussion

The optimized values of k_g, k_{eo}, and λ for each type of experiment are summarized on Table 4-1 and a detailed description of the factor effects is provided below.

Effect of Ionic Strength

Because drainage was blocked in the vegetated soil box during the experiment, almost all the inflow (98.5-99.5%) was recovered in the surface runoff, suggesting the system was well controlled and ready for the transport studies. Both bromide and colloids showed quick responses when applied to the surface vegetation systems (Figure 4-3). The peak concentration of bromide reached about 80% of that of stock solution (i.e., $0.80C_0$). Bromide breakthrough concentrations decreased quickly but maintained a tail after the inflow was switch to water (Figure 4-1). The peaks of the two colloid breakthrough curves at different ionic strength conditions were lower than that of bromide and only reached about $0.70C_0$ and $0.65C_0$ for low (0.558milliMoles) and high ionic strength (100.558 milliMoles) conditions, respectively. The tails of the colloid breakthrough curves were also slightly lower than that of bromide breakthrough curve. These results are consistent with our previous findings in a larger scale vegetated soil box that dense vegetation can effectively remove colloidal particles from surface runoff (Yu *et al.*, 2011).

Mass balance calculation indicated that about 80.0% of bromide was recovered from the overland flow at the end of the experiment (Figure 4-1); indicating part of the tracer was trapped in the soil underneath the vegetation. The incomplete exchange of tracer between overland flow and soil could be attributed to that the growth of vegetation may increase the heterogeneity of the soil to create immobile or stagnant zones. Previous studies have demonstrated those immobile water zones in soils can trap both solutes and colloids (Gaudet *et al.*, 1977; Gao *et al.*, 2006). As anticipated, the recovery rates of colloids under the two ionic strength conditions were lower than that of bromide, confirming the removal of colloids from overland flow by the dense vegetation. Slightly fewer colloids were recovered from the runoff under high ionic strength (65.4%) than under low ionic strength (69.8%) conditions. Because bromide is a non-reactive, conservative tracer, relative recovery rate was used in this study to show the interactions between colloids and the surface vegetation:

$$\mathrm{Rel.\,recovery} = \frac{\mathrm{Rec\_Colloid}}{\mathrm{Rec\_Bromide}} \qquad (4\text{-}7)$$

A decreasing trend of relative colloid recovery rate was observed in the experiment when ionic strength increased (Figure 4-7 (b)). Previous studies of colloid transport in porous media suggested that an order of magnitude higher solution ionic strength would promote colloid deposition onto surrounding media significantly by reducing repulsive interaction energies between colloid and medium surfaces (Gao et al., 2004a; Zevi et al., 2009).Although the decreasing colloid relative recovery rate was not as significant as in porous media, the experiment result indicated the deposition of colloids on dense vegetation obey colloid filtration theory. Simulations of the mathematical model described the experimental data of bromide and colloid transport at the two ionic strengths very well (Figure 4-3). The Nash–Sutcliffe model efficiency coefficients of the simulations were larger than 0.90 (Table 4-1). The best-fit parameter k_{ie} of colloidal particles in the system was assumed to be the same as bromide. The best-fit k_g values for low and high ionic strength experiments were 0.003 and 0.009 S^{-1}, respectively (Table 4-1). The deposition rate increased with larger ionic strength, confirming the promoting effect of ionic strength on colloid removal in dense vegetation system. In most of the field conditions, surface runoffs often contain high concentration of ions, such as irrigation may mobilize salts in the some soil types and geologic formations or irrigation water itself with high salt content may be introduced to surface water. Well installed and maintained dense vegetation systems, such as grasslands or vegetative filter strips, therefore would be an effective tool to remove colloidal contaminant from surface runoff.

Effect of Particle Size

The mobility of colloids in the dense vegetation systems decreased with increasing particle size (Figure 4-4). Colloid breakthrough was highest at particle size of 0.3 µm and lowest at particle size of 10.5 µm. Mass balance calculation indicated that the recovery rate of the large and the small colloids in the dense vegetation systems were 72.0% and 56.8%, respectively. A decreasing trend of relative colloid recovery rate was observed with increases in colloidal size(Figure 4-7 (a)). A quantitative relationship between the colloid size and the relative recovery rate can be established with further studies. The model simulations also fitted the experimental data of different colloid sizes very well (Figure 4-4). The best-fit k_g values increased from 0.002 to 0.016 S^{-1} when the particle size increased from 0.3 to 10.5 µm (1), indicates strong dependence of colloidal removal by dense vegetation on particle size. In addition, when assuming the exchange rate k_{ei} of colloids the same as bromide, the best-fit λ decreased from 0.68 to 0.5, illustrating fewer amounts of colloids was available in the exchange process with the colloid size increasing from 0.3 to 10.5 um. It was probably because larger colloids were easier to be retained in the soil profile.

Strong size effect on colloid transport in porous media has also been observed in many previous studies (Elimelech, 1994; Xu et al., 2006). For example, Elimelech (Elimelech, 1994) showed that enhancement in particle deposition rate is not only dependent on particle size but also passes through a maximum as the particle size increases at low ionic strength conditions. Because only three colloid sizes were tested in this study, it is unclear whether there exists such a colloid size at which the enhancement in particle deposition rate reaches maximum. Further investigations are still needed to determine the relationship between particle size and their deposition rate in dense vegetation in overland flow.

Effect of Flow Rate

When a low flow rate (i.e., 64 mL min-1) was used in the experiment, the transport of both bromide and colloids reduced in the vegetative systems (Figure4- 5). The peak concentration of bromide and colloids only reached $0.70C_0$ and $0.60C_0$, respectively. Mass balance calculation indicated that about 70% of bromide and 60% of colloids were recovered from overland flow at the end of the experiment, which was lower than the recovery rates in the high flow rate experiments (i.e., 82 mL min-1) under same conditions. Relative colloid recovery rate also decreased when flow rate decreased (Figure 4-7(c)). The model simulation results indicated the rates of colloid deposition (k_g) and entering the exchange layer (k_{ei}) were higher in the low flow rate experiment than in the high flow rate experiment (Table 4-1). Probably because slow flow can increase the resident time of colloids in the dense vegetation systems and thus promotes their deposition onto grass surfaces and entering soil exchange layer. Lower flow rate can enhance the deposition and exchange process. When dense vegetation is installed as a vegetative filter strip for non-point source pollution, one of its major functions is to reduce flow rate to increase contaminant resident time (Muñoz-Carpena *et al.*, 2010). It is therefore anticipated that a well-installed vegetative filter strip would also increase the resident time of colloidal contaminants and thus could be used to reduce their loading in surface runoff.

Effect of Vegetation Type

The transport of bromide in the Rye grass was higher than that in the Bahia grass under the same experimental conditions (Figure4- 6). About 85% of bromide was recovered from the overland flow in the Rye grass (80% in Bahia), indicating less solute was trapped in the soil stagnate zones. The transport of colloid in the Rye grass, however, was slightly lower than that in the Bahia grass (Figure4- 6). About 65% of colloids was recovered from the overland flow in the Rye grass (69.8% in Bahia), illustrating more colloids were deposited onto the Rye grass surfaces. In Figure 4-7 (d), the colloid relative recovery rate of Bahia grass was much higher than that of Rye grass. The model also described the transport of bromide and colloids in the Rye grass systems fairly well (Figure 4-6). The k_{ei} value of Rye grass was smaller than Bahia's, showing that the root system of Bahia can enhance the bromide diffusion into the soil pore water. As colloids transported through dense vegetation, the best-fit k_{eo} and k_g values in the Rye grass experiments were higher than those in the Bahia grass experiment, which is consistent with the experimental data. The differences in transport behaviors between bromide and colloids in the two grasses emphasized the importance of vegetation type on colloid transport and removal in dense vegetation systems. The differences may be caused by the different grass densities, surface area which can contact with colloids in the surface water, and characteristic of the grasses surface (like surface charge). Although several types of grasses have been used as natural filters (grasslands or vegetative filter strips) for non-point pollution control, there is limited information about the performance of different grass species in dense vegetation to removal contaminants from runoff, particularly with respect to colloidal contaminants, such as pathogenic microorganisms. It is therefore necessary to conduct additional investigations to understand the effect of vegetation type on colloid transport in over land flow through dense vegetation.

Chapter Conclusions

In this study, a number of experiments were conducted to study the transport and removal of colloidal particles in dense vegetation under different conditions. A conceptual model was developed and modeling tools were applied to simulate the experimental data and to help data interpretations. Our results indicated that increases in solution ionic strength and increases in particle size can enhance the removal of colloids in dense vegetation systems. We also found that the performances of the dense vegetation systems various with vegetation types. Although further investigations are still needed, our findings suggested that, when design a dense vegetation system (e.g., vegetative filter strip) for pollution control, factors as solution chemistry, contaminant properties, and vegetation types should be considered in the design, installation, and maintenance, particularly when the system is for removal colloidal contaminants, such as pathogenic microorganisms.

Table 4-1. Summary of the experimental conditions and optimized model parameters for bromide and colloid transport in the dense vegetation systems.

No.	Experimental conditions						Optimized model parameters					
	Solution	Concentration (ppm)[1]	Ionic Strength	Colloid Size (μm)	Flow Rate (mL min^{-1})	Grass Type	D (m^2 s^{-1})	k_g (s^{-1})	k_{ei} (s^{-1})	k_{eo} (s^{-1})	λ	Correlation Coefficient
1	Bromide	40	low	-	84	Bahia	0.050	-	0.029	0.007	0.75	0.9287
2	Colloid	11 (2.6×10^9)	high	2.0	84	Bahia	0.050	0.009	0.029	0.007	0.60	0.9343
3	Colloid	11 (2.6×10^9)	low	2.0	84	Bahia	0.050	0.003	0.029	0.007	0.60	0.9196
4	Colloid	11 (7.6×10^{11})	low	0.3	84	Bahia	0.050	0.002	0.029	0.007	0.68	0.9393
5	Colloid	11 (1.8×10^7)	low	10.5	84	Bahia	0.050	0.016	0.029	0.017	0.50	0.9208
6	Bromide	40	low	-	62	Bahia	0.050	-	0.037	0.005	0.65	0.9454
7	Colloid	11 (7.6×10^{11})	low	0.3	62	Bahia	0.050	0.009	0.037	0.011	0.60	0.9376
8	Bromide	40	low	-	84	Rye	0.050	-	0.025	0.007	0.75	0.8572
9	Colloid	11 (2.6×10^9)	low	2.0	84	Rye	0.050	0.007	0.025	0.009	0.50	0.8630

Note: [1] The numbers in the parentheses indicate the amount of colloidal particles per liter.

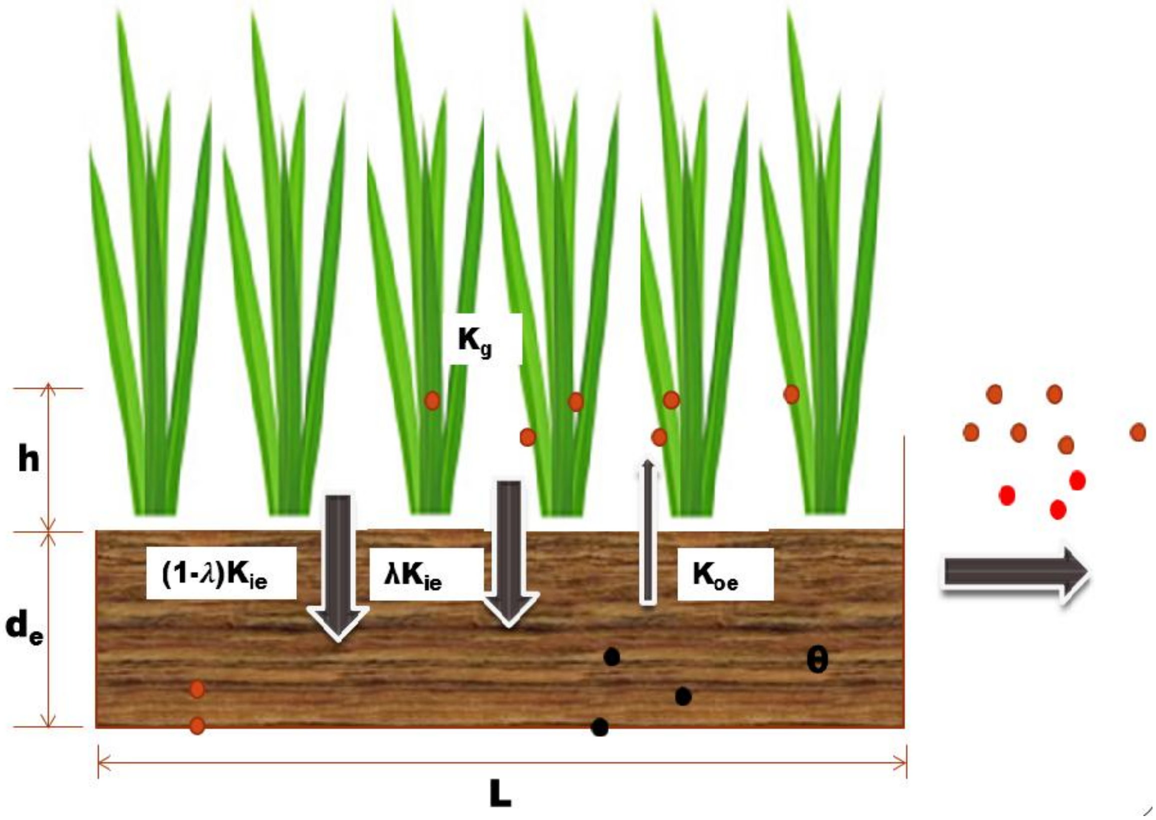

Figure 4-1. Conceptual model for surface transport and removal of colloids by dense vegetation. k_g is a rate coefficient describing the deposition onto grass surfaces, k_{ei} and k_{eo} are rate coefficients of mass exchange between overland flow and soil exchange layer, and λ is a dimensionless constant controlling the exchangeable concentration in the soil exchange layer.

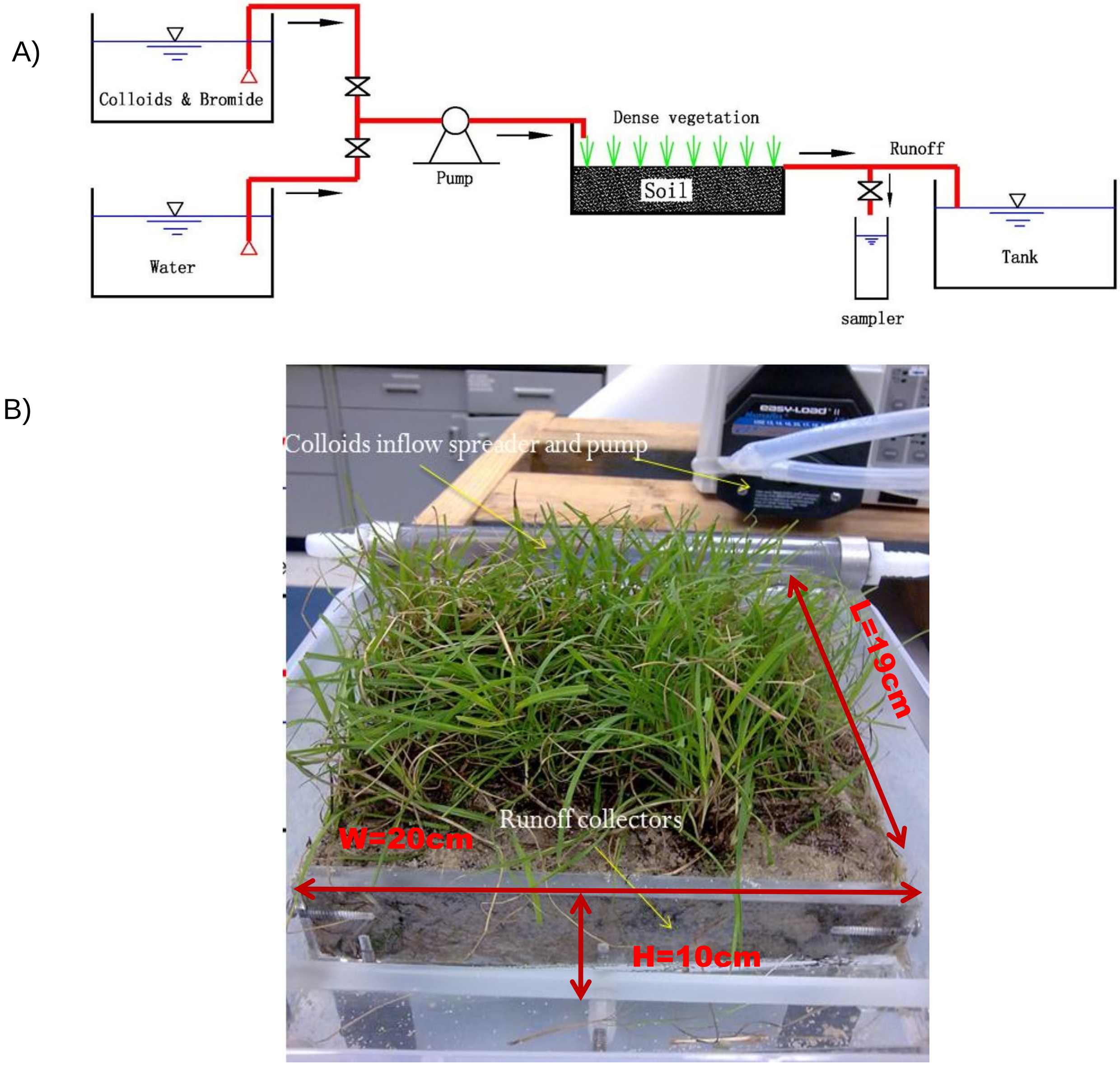

Figure 4-2. Experimental setup employed in the colloid transport studies: A) schematic; B) view of the runoff collector with dense vegetation (Bahia grass).The dimensions of the runoff collector is L20 x W19 x D10 cm, with soil depth 5 cm. The components of the vegetation runoff system are labeled in the figure.

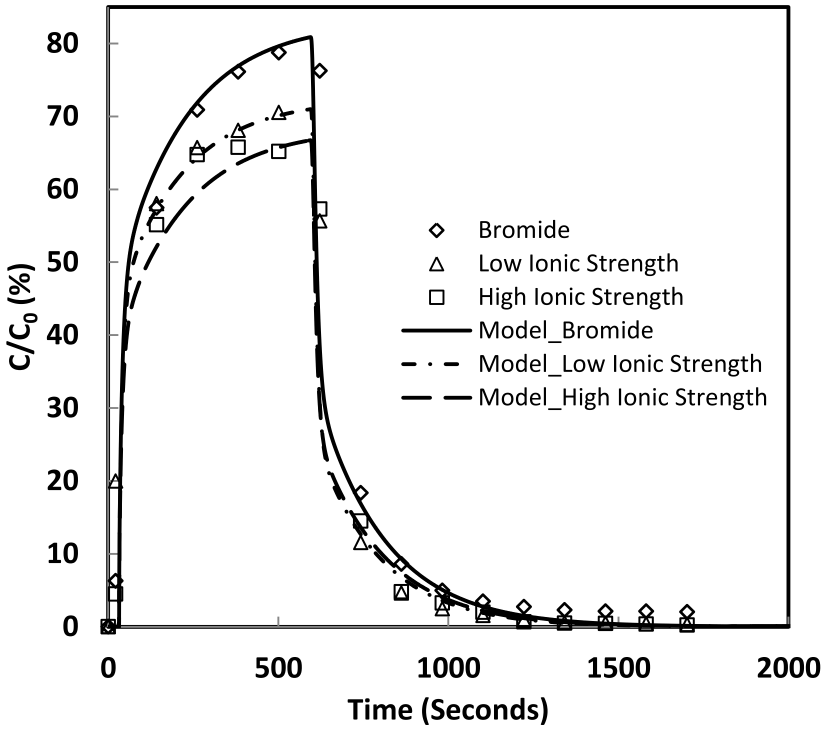

Figure 4-3. Effect of ionic strength on colloid transport in overland flow through dense vegetation (symbols= experimental data line = simulation results).

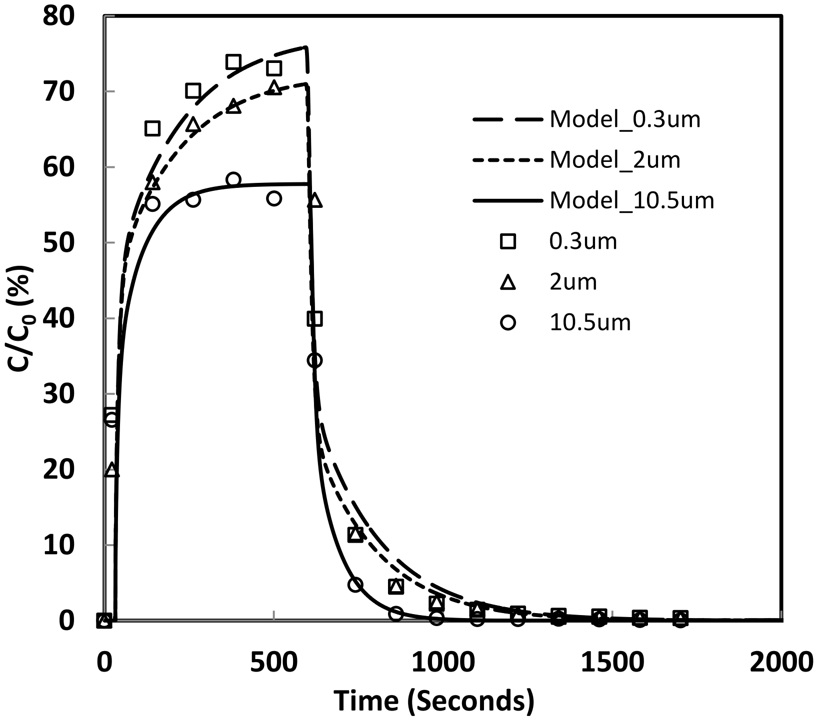

Figure 4-4. Effect of colloid size on colloid transport in overland flow through dense vegetation (symbols= experimental data line = simulation results).

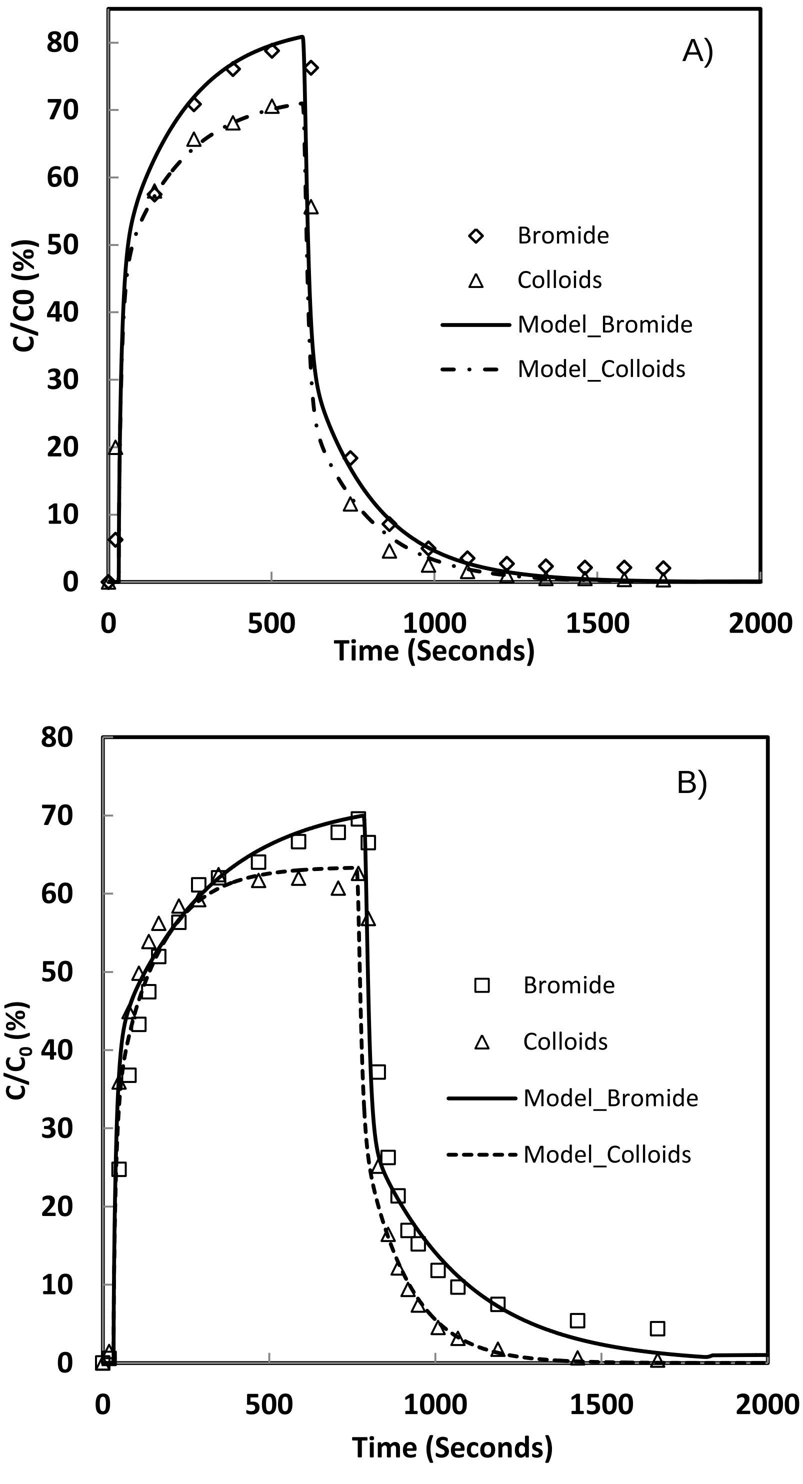

Figure 4-5. Colloid transport in overland flow through dense vegetation at different flow rates: A) high (84 mL/min) and B) low (62 mL/min) (symbols= experimental data line = simulation results).

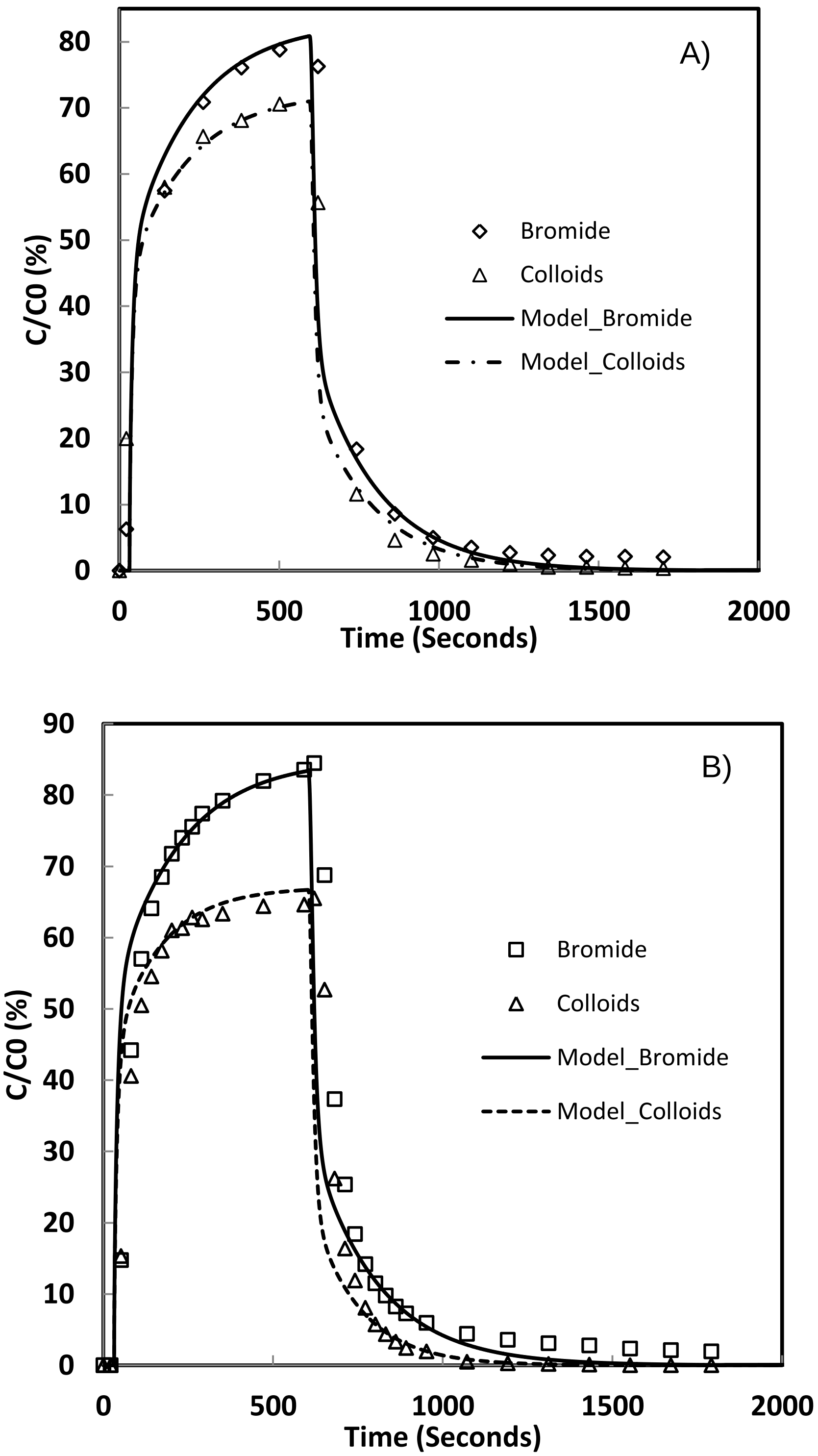

Figure 4-6. Colloid transport in overland flow through different vegetation types: A) Bahia and B) Rye grasses (symbols= experimental data line = simulation results).

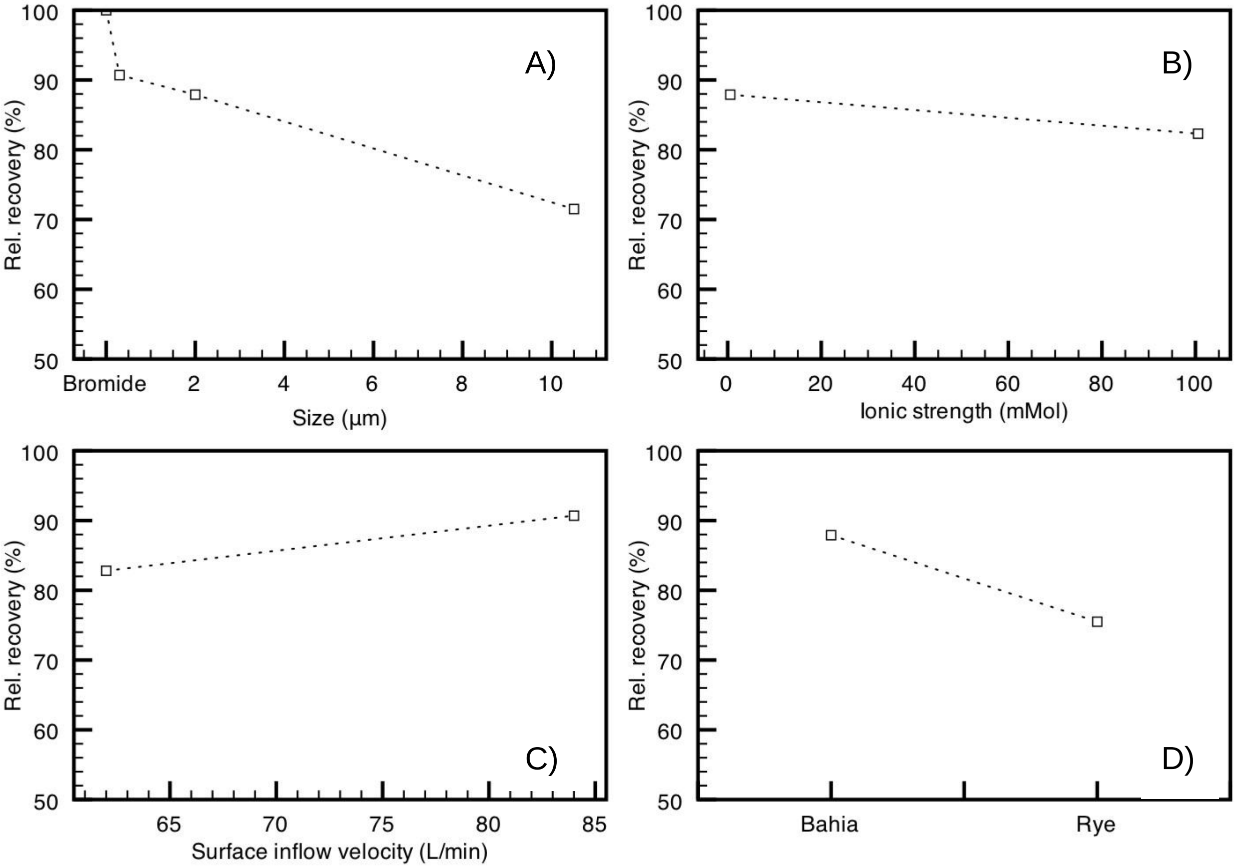

Figure 4-7. Trends of the factor effects on colloids recovery rates: A) colloid size; B) ionic strength; C) surface runoff inflow velocity; and D) vegetation type.

CHAPTER 5
CONCLUSIONS

The surface removal and transport of colloidal particles by dense vegetation has been examined by integration of laboratory experiments and exploratory modeling with the numerical model (VFSMOD-RSE). Laboratory scale surface runoff systems consisting of rainfall simulator, soil boxes, inflow device, runoff and drainage collectors were designed and used in this study. Well controlled runoff experiments were conducted to compare the transport behavior of colloids to bromide in overland flow on bare and vegetated soil surfaces. In addition, chemical and physical factors controlling the surface removal and transport of colloids in dense vegetation were also investigated. A conceptual model was developed based on the experimental findings. VFSMOD-RSE was applied to obtain model simulations of colloid transport through dense vegetation in overland flow. It was found that dense vegetation is effective in removing colloids from surface runoff, and the model developed and tested showed promising capacity to predict the fate and transport of colloids and colloidal contaminants in dense vegetation and the potential for removal.

Colloid Transport in Surface Runoff on Bare Soil

In Chapter 2, laboratory runoff experiments were conducted on bare soil to examine the transport dynamics of kaolinite and bromide in overland flow and soil drainage. The breakthrough curve of Kaolinite and bromide were monitored continuously. The experiment results indicate that the transport of kaolinite in subsurface (soil drainage) flow was lower than that of bromide, which is in agreement to colloid filtration theory. A total of 26% of the input colloids were removed by a 5 cm deep, 153.2 cm long soil bed. However, the transport of kaolinite in surface runoff almost resembled that of bromide, indicating no removal in overland flow.

Colloid Transport in Surface Runoff on Vegetated Soil

In Chapter 3, laboratory runoff experiments similar to those in Chapter 2 were conducted with fluorescent latex microspheres (of equivalent average characteristics to kaolinite from the bare soil experiments) on vegetated soil with Bahia grass. Comparisons of the breakthrough behaviors of bromide and colloids in overland flow through dense vegetation demonstrated that the dense vegetation system also removed effectively colloidal particles from surface runoff. In addition, the soil (and root) underneath the vegetation also showed enhanced ability to remove colloids from the drainage flows. Adsorption batch experiments confirmed that grass leaf, stem, and root could effectively adsorb aqueous colloids, and different grass parts demonstrated different adsorption capacity (root > stem > leave). The recovery differences between colloids and bromide (8.2% for surface and 27.3% for subsurface) represent mainly the colloid deposition and surface exchange processes by the soil/vegetation system. The total amount of colloids removed at the surface (7.6 mg) was only about 2.4% of the estimated maximum capacity of the vegetation stems (313.7 mg from the adsorption studies), because of limited contact between colloids and the vegetation in dynamic conditions. Higher removal of colloids (>27.3%) from the subsurface flows can be attributed to 1) the filtration of colloids by the sand; 2) the adsorption of the colloids onto the grass root as suggested by the batch sorption experiments.

In the runoff experiments in Chapter 2, kaolinite recovery rates in the surface flow and drainage were 51% and 23%, respectively, while 26% of kaolinite was retained in the soil profile. In the runoff experiments through dense vegetation of Chapter 3, 28.7%

microspheres was recovered in overland flow, and 4.5% recovered in the drainage, so the 153 cm length Bahia vegetation retained almost 67% of the inputs colloids. This indicates that dense vegetation, if properly installed and maintained in the form of vegetative filter strips, can be used to reduce the load of colloidal contaminants to surface water.

Factors Controlling Surface Removal of Colloids by Dense Vegetation

In Chapter 4, an analogy between soil porous media and overland flow through dense vegetation is proposed. A number of experiments were conducted to investigate the key factors that have been typically identified by porous media classic filtration theory, which included ionic strength, colloid size, flow rate, and vegetation type. Our results indicated that increases in solution ionic strength and increases in particle size can enhance the removal of colloids in dense vegetation systems. We also found that the performance of the dense vegetation systems varies with vegetation types.

A numerical model, VFSMOD-RSE that incorporated overland flow with transport, classic filtration theory, and a solute soil exchange layer concept was used to interpret the removal of colloids in the dense vegetation under various conditions. In the colloid exchange process, the soil pore water was divided into non-mobile water, in which colloidal particles are retained and mobile water, in which colloids could diffused back to surface water. Based on classic filtration model, the removal of suspended particles is described by first-order kinetics, resulting in concentrations of suspended and retained particles that decay exponentially with time (distance). An excellent agreement was found between model predictions and observations from the runoff experiments. Both experimental and modeling results showed environmental factors, such as ionic strength, can control the deposition and exchange process, thus play an important role in controlling colloid transport and removal in the dense vegetation.

Recommendations for Future Work

Recommendations for future studies are as follow:

- To quantify relationship between solution ionic strength, vegetation density, flow rate and colloid removal rate in dense vegetation
- To conduct field scale experiments of colloid removal in overland flow on vegetated soils
- To develop experimental and/or theoretical methods for model parameterizations
- To upscale and test the model at the field scale or watershed scale.

APPENDIX A
SUMMARY OF EXPERIMENTAL CONDITIONS OF COLLOID TRANSPORT IN SURFACE RUNOFF

Table A-1. Comparison of experimental conditions of colloid transport in overland flow on bare soil (Chapter 2) and densely vegetated soil (Chapter 3)

	Chapter 2	Chapter 3
Colloids	179 mg/L 0.4 μm Kaolinite powder	10mg/L 0.3 μm Carboxylated polystyrene latex microspheres
Tracer	40 ppm Sodium Bromide	40 ppm Sodium Bromide
Soil Bed	0.5 to 0.6 mm washed quartz sand, porosity 0.43, slope 1.7%, dimension (153.1 * 40.2 *10 cm)	0.5 to 0.6 mm washed quartz sand, porosity 0.43, slope 1.7%, dimension (153.1 * 40.2 *10 cm)
Inflow rate	0.31 L/Min	0.31 L/Min
Rainfall intensity	64 mm/hour (uniformity > 90%)	64 mm/hour (uniformity > 90%)
Ionic Strength	regular tap water (0.558 mMol)	regular tap water (0.558 mMol)

Table A-2. Characteristics of colloids used in chapter 2 (kaolinite) and chapter 3 (microspheres)

	kaolinite	Carboxylated polystyrene latex microspheres
Average Size (μm)	0.4 (0.05-1.0)	0.30
Zeta potential (mv)	-33.11	-28.00

Table A-3. Reported parameter values* used in chapter 4 as guidelines to optimize model parameters.

D (m^2 s^{-1})	k_g (s^{-1})	k_{ei} (s^{-1})	k_{eo} (s^{-1})	λ
$> 10^{-13}$	10^{-3} - 10^{-1}	$>10^{-4}$	$>10^{-4}$	0-1

*: Obtained from Gao et al., 2004; Wallach et al.,1989; and Walter et. al., 2007.

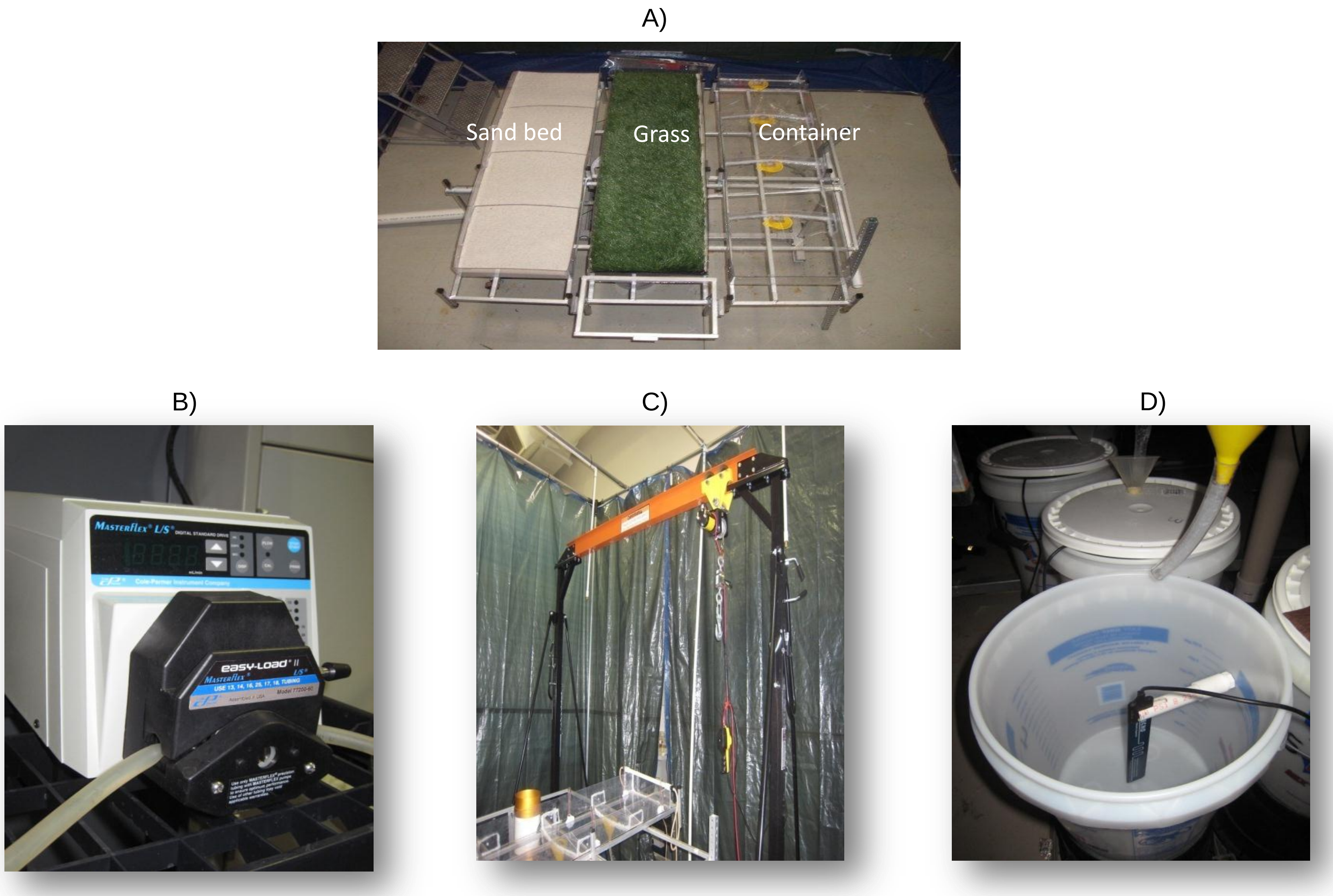

Figure A-1. Experimental set up for surface runoff experiment in Chapter 2 and 3: A) the soil container, B) peristaltic pump, C) scale to measure the weight of the soil box with water, D) ECH2O Dielectric Aquameters.

APPENDIX B
INPUT FILES FOR TRANSPORT AND REACTION SIMULATION ENGINE (RSE)

- BrNoRain.xml

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<?xml version="1.0" encoding="utf-8"?>
<wq version="0.1">
  <reaction_sets>
    <reaction_set name="rs1" full_name="Reaction Set Number 1">
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        <segment>all</segment>
      </coverage>
      <stores>
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               location="element" section="gw" actuator="rsm_wm">
          <name>surface_water</name>
          <components>
            <variables>
              <variable type="mobile">
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                  10.0
                </initial_distribution>
              </variable>
              <variable type="stabile">
                <name full_name="Porewater P">BrInSoil</name>
                <initial_distribution type="constant">
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                </initial_distribution>
              </variable>

            </variables>
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              <parameter units="meter">
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              <parameter units="meter">
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   </parameter>
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   </parameter>
   <parameter units="none">
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    <initial_distribution type="constant">
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    </initial_distribution>
   </parameter>
  </parameters>
 </components>
</store>
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```
      </stores>
      <equations>
        <equation>
          <lhs>BrInRunoff</lhs>
          <rhs>-1*K1*(BrInRunoff)+K2*(BrInSoil)</rhs>
        </equation>
        <equation>
          <lhs>BrInSoil</lhs>
          <rhs>Alfa*K1*(BrInRunoff)-1*K2*(BrInSoil)</rhs>
        </equation>
      </equations>
    </reaction_set>
  </reaction_sets>
</wq>
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- BrNoRain.igr

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2.2   .24   .001   .011   0
------------------------------------------------
 SS(cm)  Vn(s/cm^1/3)  H(cm)  Vn2(s/m^1/3)  ICO(0 or 1)
```

- BrNoRain.irn

```
   4  0       Nrain, rpeak (m/s)
   0  0
   600  0
   1800  0
   2000  0
```

- BrNoRain.iro

```
  0.1905  0.2032       Swidth(m), Slength(m)
   8  0.0000014     nbcroff, bcropeak(m3/s)
   0  0
   1  0.0000014
   10  0.0000014
   600  0.0000014
   1800  0.0000014
   1801  0
```

```
  1900  0
  2500  0
```

- BrNoRain.isd

```
  1   .01   .00001   .42     Npart, Coarse, Ci(g/cm3), Por
  .0023   2.6           Dp(cm), SG(g/cm3)
```

- BrNoRain.iwq

```
3
'BrNoRain.xml' 'BrNoRainOut.xml' 'rs1'
1 BrInRunoff 100 0.05 2.08E-9 0
1 BrInSoil 0
3 K1 0.0265 K2 0.007 Alfa 0.5
0
```

- BrNoRain.ikw

```
Unit9, g8, u183-91
 .15
 .2032   57   .5   .8   350   3   1   1
 4
 0   .4   .03
 .05   .4   .03
 .1   .4   .03
 .2032   .4   .03
 1
------------------------------------
 title
 fwidth
 vl n thetaw cr maxiter npol ielout kpg
 nprop
 sx(iprop), rna(iprop), soa(iprop), iprop=1,nprop
WQ flag=1 if Pesticides Bayer Option has been chosen
```

BrNoRain.isd

```
7    .5    0.034  .434                      'NPART, COARSE, CI(g/cm3), POR
0.0013    2.65                                      'DP(cm),        SG(g/cm3)
----------------------------------------------------------------------------
```

BrNoRain.iso

```
 .0   .08   .425   .425   0   .55

    -------------------------------------
Ks(m/s)   Sav(m)  Theta-s   Theta-i   Sm(m)   Schk(ponding ck)
```

APPENDIX C
EXPERIMENTAL DATA IN CHAPTER 2

Table C-1. Water flow summary for bromide runoff experiments on bare soil

Run	Time	Inflow	DR#1	DR#2	DR#3	DR#4	RO	Rainfall	Area of the box
		L/min						mm/hour	cm2
# 1	July 07,09	0.344	0.0986	0.1442	0.1258	0.1099	0.4763	60.61	6154.62
# 2	July 08,09	0.335	0.0914	0.1466	0.1276	0.1283	0.4465	59.95	6154.62
# 3	Aug 11,09	0.333	0.1048	0.0828	0.1045	0.1375	0.5618	54.44	6154.62
# 4	Aug 13,09	0.299	0.0895	0.0848	0.1006	0.1268	0.5636	54.70	6154.62
# 5	Sep 09,09	0.302	0.1168	0.1202	0.0787	0.1	0.5085	64.17	6228.96
# 6	Sep 12,09	0.307	0.0957	0.1055	0.0624	0.0767	0.5993	65.17	6228.96
# 7	Sep 14,09	0.302	0.0762	0.083	0.0544	0.0579	0.6431	65.22	6228.96
# 8	Oct 14,09	0.303	0.0088	0.0078	0.0055	0.0036	0.8512	62.94	6228.96
# 9	Nov 18,09	0.295	0.0683	0.0459	0.0608	0.0262	0.6841	68.70	6228.96

Table C-2. Bromide run #1 water flow and rainfall data (bromide was applied to the system at time zero, negative time represents prewashing).

Time (min)	DR#1 (L)	DR#2 (L)	DR#3 (L)	DR#4 (L)	RO (L)	Rainfall (mm)
-30.5	0.6994	0.6423	0.7677	0.7725	0.5642	0.0000
-30	0.7161	0.6598	0.7810	0.7935	0.5636	0.7880
-29.5	0.7438	0.6925	0.8172	0.8264	0.5654	1.3130
-29	0.7697	0.7369	0.8561	0.8592	0.5700	1.8380
-28.5	0.8009	0.7773	0.8926	0.8944	0.6017	2.6260
-28	0.8341	0.8269	0.9366	0.9300	0.6893	3.1510
-27.5	0.8680	0.8720	0.9755	0.9604	0.7989	3.6760
-27	0.8953	0.9202	1.0230	1.0007	0.9403	4.4640
-26.5	0.9276	0.9653	1.0666	1.0378	1.0814	4.9890
-26	0.9609	1.0108	1.1140	1.0777	1.2659	5.5140
-25.5	0.9883	1.0587	1.1580	1.1123	1.4586	6.3020
-25	1.0219	1.1085	1.2142	1.1558	1.6448	6.8270
-24.5	1.0555	1.1626	1.2733	1.2054	1.8171	7.3520
-24	1.0976	1.2183	1.3310	1.2501	2.0407	8.1400
-23.5	1.1361	1.2776	1.3882	1.2968	2.2686	8.6650
-23	1.1729	1.3335	1.4421	1.3425	2.4998	9.1900
-22.5	1.2142	1.4069	1.4963	1.3935	2.7382	9.7150
-22	1.2543	1.4766	1.5573	1.4496	3.0137	10.5030
-21.5	1.3006	1.5464	1.6137	1.4928	3.2895	11.0280
-21	1.3425	1.6273	1.6686	1.5356	3.5403	11.8160
-20.5	1.3915	1.6936	1.7180	1.5838	3.7954	12.3410
-20	1.4339	1.7637	1.7678	1.6371	4.0330	12.8660
-19.5	1.4739	1.8288	1.8096	1.6772	4.2820	13.3910
-19	1.5155	1.8847	1.8608	1.7156	4.5323	14.1790
-18.5	1.5676	1.9271	1.9105	1.7662	4.8174	14.7040
-18	1.6122	1.9881	1.9676	1.8313	5.0779	15.2290
-17.5	1.6586	2.0462	2.0270	1.8557	5.3687	15.7540
-17	1.7038	2.1038	2.0850	1.8941	5.6513	16.5420
-16.5	1.7572	2.1733	2.1521	1.9384	5.9234	17.0670
-16	1.8038	2.2338	2.2102	1.9881	6.2051	17.8550
-15.5	1.8430	2.3028	2.2786	2.0315	6.4737	18.3800
-15	1.8821	2.3705	2.3447	2.0841	6.7506	18.9050
-14.5	1.9253	2.4429	2.4217	2.1397	7.0360	19.6930
-14	1.9649	2.5292	2.4836	2.1966	7.3298	20.2180
-13.5	2.0034	2.6056	2.5655	2.2527	7.5812	20.7430
-13	2.0453	2.6850	2.6348	2.3069	7.8646	21.5310
-12.5	2.0888	2.7664	2.7046	2.3674	8.1552	22.0560
-12	2.1302	2.8401	2.7912	2.4207	8.4258	22.5810
-11.5	2.1762	2.9167	2.8485	2.4761	8.6744	23.1060
-11	2.2230	2.9936	2.9167	2.5401	8.9564	23.8940

Table C-2. Continued.

-10.5	2.2477	3.0658	2.9848	2.6011	9.1864	24.1570
-10	2.3612	3.1774	3.0966	2.7995	9.8386	24.4200
-9.5	2.4017	3.2250	3.1381	2.8461	9.8993	24.9450
-9	2.4589	3.2976	3.2144	2.9032	9.9298	25.4700
-8.5	2.4998	3.3645	3.2638	2.9401	9.9909	26.2580
-8	2.5644	3.4103	3.3412	2.9911	10.1138	26.7830
-7.5	2.6112	3.4762	3.4047	3.0518	10.2377	27.3080
-7	2.6770	3.5604	3.4833	3.1225	10.4252	28.0960
-6.5	2.7429	3.6477	3.5460	3.1839	10.6468	28.6210
-6	2.8018	3.7218	3.6170	3.2410	7.7091	29.1460
-5.5	2.8679	3.8046	3.6801	3.2895	0.6567	29.9340
-5	2.9191	3.8934	3.7562	3.3302	0.7046	30.4590
-4.5	2.9823	3.9729	3.8182	3.3853	0.8184	30.9840
-4	3.0365	4.0473	3.8795	3.4312	0.9580	31.7720
-3.5	3.0863	4.1212	3.9479	3.4889	1.1036	32.2970
-3	3.1433	4.2010	4.0266	3.5604	1.2813	32.8220
-2.5	3.2064	4.2737	4.0937	3.6053	1.4711	33.3470
-2	3.2531	4.3423	4.1585	3.6713	1.6609	34.1350
-1.5	3.3016	4.4117	4.2388	3.7173	1.8288	34.6600
-1	3.3412	4.4631	4.2920	3.7728	2.0270	35.1850
-0.5	3.3825	4.5323	4.3608	3.8182	2.2457	35.9730
0	3.4382	4.6023	4.4288	3.8873	2.4696	36.4980
0.5	3.4804	4.6732	4.5149	3.9369	2.6689	37.0230
1	3.5317	4.7449	4.6023	3.9950	2.9032	37.8110
1.5	3.5749	4.7992	4.6732	4.0505	3.1524	38.3360
2	3.6360	4.8723	4.7269	4.1212	3.4256	38.8610
2.5	3.6816	4.9463	4.7810	4.1666	3.6507	39.3860
3	3.7277	5.0212	4.8723	4.2190	3.9213	39.9110
3.5	3.7818	5.0969	4.9278	4.2836	4.1373	40.6990
4	3.8243	5.1928	5.0024	4.3558	4.3676	41.2240
4.5	3.8749	5.2704	5.0779	4.4117	4.6200	41.7490
5	3.9182	5.3490	5.1735	4.4631	4.8723	42.2740
5.5	3.9714	5.4483	5.2509	4.5323	5.1928	42.7990
6	4.0314	5.5289	5.3292	4.5672	5.4885	43.3240
6.5	4.0761	5.6307	5.3885	4.6376	5.7757	44.1120
7	4.1325	5.7132	5.4684	4.7089	6.0306	44.6370
7.5	4.1813	5.7966	5.5289	4.7629	6.3160	45.1620
8	4.2339	5.8809	5.6102	4.8174	6.5881	45.6870
8.5	4.2853	5.9661	5.6719	4.8723	6.8685	46.4750
9	4.3389	6.0522	5.7548	4.9278	7.1330	47.0000
9.5	4.3947	6.1174	5.8176	5.0024	7.4046	47.5250
10	4.4459	6.2051	5.8809	5.0589	7.6578	48.0500

Table C-2. Continued.

10.5	4.4976	6.2715	5.9447	5.1160	7.9169	48.8380
11	4.5672	6.3608	6.0306	5.1735	8.1820	49.3630
11.5	4.6200	6.4510	6.0956	5.2315	8.4258	49.8880
12	4.6732	6.5193	6.1611	5.2900	8.7024	50.4130
12.5	4.7449	6.6111	6.2272	5.3490	8.9280	51.2010
13	4.7992	6.6806	6.2937	5.4084	9.1574	51.7260
13.5	4.8540	6.7741	6.4058	5.4684	9.3614	52.2510
14	4.9092	6.8448	6.4284	5.5289	9.5683	52.7760
14.5	4.9837	6.9399	6.4965	5.5694	9.7479	53.5640
15	5.0400	7.0119	6.5651	5.6307	9.9298	54.0890
15.5	5.0779	7.0844	6.6342	5.6925	1.1649	54.6140
16	5.1351	7.1574	6.7039	5.7340	0.6893	55.4020
16.5	5.1928	7.2309	6.7741	5.7966	0.8047	55.9270
17	5.2509	7.3050	6.8212	5.8387	0.9561	56.4520
17.5	5.3096	7.4046	6.8922	5.9234	1.1277	56.9770
18	5.3490	7.4547	6.9638	5.9661	1.3316	57.7650
18.5	5.4084	7.5304	7.0360	6.0091	1.5392	58.2900
19	5.4684	7.6066	7.1086	6.0739	1.7140	58.8150
19.5	5.5289	7.6834	7.1574	6.1174	1.9071	59.3400
20	5.5694	7.7607	7.2309	6.1831	2.1151	60.1280
20.5	5.6102	7.8125	7.3050	6.2272	2.3550	60.6530
21	5.6719	7.8907	7.3547	6.2937	2.5966	61.1780
21.5	5.7132	8.0222	7.4296	6.3608	2.8413	61.7030
22	5.7548	8.1285	7.4799	6.4058	3.0966	62.4910
22.5	5.8176	8.2627	7.5558	6.4510	3.3618	63.0160
23	5.8598	8.3440	7.6322	6.5193	3.6389	63.5410
23.5	5.9234	8.3985	7.7091	6.5651	3.8826	64.0660
24	5.9876	8.4532	7.7866	6.6111	4.1147	64.8540
24.5	6.0306	8.5081	7.8385	6.6806	4.3372	65.3790
25	6.0739	8.5633	7.8907	6.7506	4.6023	65.9040
25.5	6.1174	8.5910	7.9694	6.7741	4.8723	66.4290
26	6.1611	8.6466	8.0222	6.8212	5.1735	66.9540
26.5	6.2051	8.6744	8.1019	6.8922	5.4885	67.7420
27	6.2493	8.7303	8.1552	6.9399	5.7757	68.2670
27.5	6.2715	8.7865	8.2358	6.9878	6.0522	68.7920
28	6.3160	8.8429	8.3168	7.0601	6.3160	69.5800
28.5	6.3608	8.8712	8.3985	7.1086	6.5881	70.1050
29	6.4284	8.9564	8.4532	7.1574	6.8685	70.6300
29.5	6.4737	9.0135	8.5357	7.2309	7.1330	71.1550
30	6.5421	9.0997	8.6188	7.2802	7.3796	71.6800
30.5	6.5881	9.1574	8.6744	7.3298	7.6322	72.4680
31	6.6342	9.2154	8.7584	7.3796	7.8646	72.9930

Table C-2. Continued.

31.5	6.6806	9.2736	8.8429	7.4296	8.1552	73.5180
32	6.7272	9.3614	8.8995	7.4799	8.3985	74.0430
32.5	6.7741	9.3907	8.9564	7.5558	8.6188	74.5680
33	6.8212	9.4792	9.0135	7.6066	8.8712	75.3560
33.5	6.8685	9.5385	9.0709	7.6578	9.0997	75.8810
34	6.9399	1.2261	9.1574	7.7349	9.3028	76.4060
34.5	6.9878	0.6696	9.2154	7.7866	9.5088	77.1940
35	7.0601	0.6774	9.2736	7.8385	9.6578	77.7190
35.5	7.0844	0.7090	9.3028	7.8907	9.8993	78.2440
36	7.1330	0.7408	9.3614	7.9431	1.2278	78.7690
36.5	7.1818	0.7757	9.4202	7.9958	0.7153	79.2940
37	7.2309	0.8184	9.4792	8.0487	0.8281	80.0820
37.5	7.3050	0.8579	9.5088	8.1285	0.9532	80.6070
38	7.3547	0.8976	9.5683	8.1820	1.1206	81.1320
38.5	7.4046	0.9366	9.5980	8.2358	1.3100	81.6570
39	7.4547	0.9814	9.6279	8.2898	1.5233	82.1820
39.5	7.5051	1.0281	9.6878	8.3440	1.7236	82.9700
40	7.5304	1.0734	9.6878	8.3985	1.9201	83.4950
40.5	7.6066	1.1206	9.7479	8.4532	2.1236	84.0200
41	7.6322	1.1649	9.7781	8.5081	2.3788	84.5450
41.5	7.7091	1.2201	4.6732	8.5633	2.6213	85.3330
42	7.7607	1.2782	0.6686	8.6188	2.8533	85.8580
42.5	7.7866	1.3329	0.6714	8.7024	3.1459	86.3830
43	7.7866	1.4015	0.6900	8.7303	3.3936	86.9080
43.5	7.8646	1.4627	0.7131	8.8147	3.6757	87.6960
44	7.9169	1.5298	0.7458	8.8712	3.9432	88.2210
44.5	7.9694	1.6017	0.7781	8.9280	4.1895	88.7460
45	7.9958	1.6594	0.8105	8.9564	4.3947	89.2710
45.5	8.0487	1.7220	0.8513	9.0135	4.6554	90.0590
46	8.1019	1.8047	0.8872	9.0709	4.9278	90.5840
46.5	8.1552	1.8727	0.9253	9.0997	5.2509	91.1090
47	8.1820	1.9253	0.9648	9.1864	5.5694	91.6340
47.5	8.2358	1.9899	1.0027	9.2154	5.8387	92.1590
48	8.2898	2.0545	1.0394	9.2736	6.1174	92.9470
48.5	8.3440	2.1047	1.0852	9.3028	6.4284	93.4720
49	8.3712	2.1752	1.1211	9.3320	6.6806	93.9970
49.5	8.4258	2.2447	1.1660	9.3907	6.9878	94.5220
50	8.4532	2.3028	1.2101	9.4497	7.2802	95.3100
50.5	8.5081	2.3674	1.2616	9.4792	7.4799	95.8350
51	8.5633	2.4302	1.3056	9.5088	7.7607	96.3600
51.5	8.6188	2.5030	1.3516	9.5385	8.0487	96.8850
52	8.6466	2.5866	1.4096	9.5683	8.2898	97.6730

Table C-2. Continued.

52.5	8.6744	2.6712	1.4655	9.5980	8.5081	98.1980
53	8.7303	2.7534	1.5205	9.6279	8.7584	98.7230
53.5	8.7584	2.8269	1.5920	9.6578	8.9850	99.2480
54	8.8147	2.9081	1.6463	9.6878	9.2154	100.0360
54.5	8.8429	2.9848	1.7006	9.7178	9.3907	100.5610
55	8.8995	3.0709	1.7492	9.7781	9.5980	101.0860
55.5	8.9280	3.1446	1.7997	9.8083	9.7479	101.6110
56	8.9850	3.2157	1.8422	9.8993	9.9603	102.1360
56.5	9.0135	3.2935	1.9001	0.6379	10.1756	102.9240
57	9.0709	3.3618	1.9516	0.6355	10.3938	103.4490
57.5	9.1285	3.4536	2.0124	0.6443	10.7747	103.9740
58	9.1574	3.5346	2.0609	0.6525	10.8713	104.4990
58.5	9.2154	3.6141	2.1141	0.6689	10.9036	105.0240
59	9.2736	3.6920	2.1723	0.6983	10.9359	105.8120
59.5	9.2736	3.7713	2.2299	0.7278	2.0462	106.3370
60	9.3320	3.8611	2.2857	0.7594	0.6817	106.8620
60.5	9.3614	3.9432	2.3364	0.7964	0.7870	107.3870
61	9.3907	4.0330	2.4080	0.8235	0.9049	107.9120
61.5	9.4202	4.1195	2.4750	0.8566	1.0608	108.4370
62	9.4497	4.2010	2.5522	0.8903	1.2464	108.9620
62.5	9.5088	4.2770	2.6281	0.9300	1.4305	109.4870
63	9.5385	4.3574	2.7034	0.9648	1.6212	110.2750
63.5	9.5980	4.4288	2.7652	1.0002	1.8129	110.8000
64	9.6279	4.5149	2.8425	1.0529	2.0016	111.3250
64.5	9.6878	4.5847	2.9044	1.1068	2.2063	111.8500
65	9.7178	4.6554	2.9549	1.1434	2.4334	112.3750
65.5	9.7781	4.7089	3.0087	1.1838	2.6553	112.9000
66	9.8083	4.7810	3.0889	1.2189	2.8788	113.6880
66.5	4.9650	4.8540	3.1551	1.2739	3.1108	114.2130
67	0.6707	4.9278	3.2170	1.3233	3.3673	114.7380
67.5	0.6710	5.0024	3.3030	1.3796	3.6214	115.2630
68	0.6728	5.0779	3.3508	1.4394	3.8641	116.0510
68.5	0.6763	5.1543	3.4158	1.5027	4.0857	116.5760
69	0.6900	5.2315	3.4847	1.5603	4.3037	117.1010
69.5	0.7135	5.3096	3.5547	1.6047	4.5149	117.6260
70	0.7281	5.4084	3.6257	1.6571	4.7629	118.1510
70.5	0.7500	5.4684	3.6816	1.7022	5.0024	118.1510
71	0.7662	5.5086	3.6964	1.7500	5.2315	118.1510
71.5	0.7713	5.5086	3.7158	1.7874	5.4284	118.1510
72	0.7701	5.5086	3.7083	1.8005	5.5694	118.1510
72.5	0.7705	5.5086	3.7068	1.8088	5.6307	118.1510
73	0.7674	5.5086	3.7054	1.8080	5.6307	118.1510

Table C-2. Continued.

73.5	0.7697	5.5289	3.7098	1.8154	5.6513	118.1510
74	0.7685	5.5086	3.7158	1.8163	5.6513	118.1510
74.5	0.7697	5.5086	3.7098	1.8204	5.6513	118.1510
75	0.7765	5.5086	3.7098	1.8238	5.6307	118.1510
75.5	0.7822	5.5086	3.7083	1.8254	5.6513	118.1510
76	0.7826	5.5086	3.7128	1.8304	5.6513	118.1510
76.5	0.7814	5.5086	3.7039	1.8304	5.6513	118.1510
77	0.7810	5.5086	3.7024	1.8330	5.6513	118.1510
77.5	0.7814	5.5086	3.7039	1.8338	5.6513	118.1510
78	0.7822	5.5086	3.7054	1.8397	5.6513	118.1510
78.5	0.7814	5.5086	3.7039	1.8405	5.6513	118.1510
79	0.7814	5.5086	3.7054	1.8430	5.6513	118.1510
79.5	0.7822	5.5086	3.7054	1.8430	5.6513	118.1510
80	0.7814	5.5086	3.7039	1.8422	5.6513	118.1510
80.5	0.7822	5.5086	3.7039	1.8439	5.6513	118.1510
81	0.7822	5.5086	3.6994	1.8439	5.6513	118.1510
81.5	0.7806	5.5086	3.7009	1.8439	5.6513	118.1510
82	0.7802	5.5086	3.7039	1.8464	5.6513	118.1510
82.5	0.7797	5.5086	3.6964	1.8430	5.6513	118.1510
83	0.7793	5.5086	3.7024	1.8472	5.6513	118.1510
83.5	0.7781	5.5086	3.6964	1.8439	5.6513	118.1510
84	0.7793	5.5086	3.7054	1.8481	5.6513	118.1510
84.5	0.7789	5.5086	3.7039	1.8472	5.6513	118.1510
85	0.7793	5.5086	3.7054	1.8481	5.6513	118.1510
85.5	0.7793	5.5086	3.7054	1.8481	5.6513	118.1510
86	0.7789	5.5086	3.7039	1.8489	5.6513	118.1510
86.5	0.7785	5.5086	3.7009	1.8481	5.6513	118.1510
87	0.7797	5.5289	3.7068	1.8540	5.6513	118.1510
87.5	0.7793	5.5086	3.7054	1.8540	5.6513	118.1510
88	0.7793	5.5086	3.7054	1.8540	5.6513	118.1510
88.5	0.7797	5.5289	3.7083	1.8548	5.6513	118.1510
89	0.7789	5.5086	3.7054	1.8523	5.6513	118.1510
89.5	0.7793	5.5086	3.7054	1.8591	5.6513	118.1510
90	0.7781	5.5086	3.7024	1.8565	5.6513	118.1510
90.5	0.7785	5.5086	3.7024	1.8574	5.6513	118.1510
91	0.7789	5.5086	3.7039	1.8582	5.6513	118.1510
91.5	0.7793	5.5086	3.7054	1.8591	5.6513	118.1510
92	0.7797	5.5289	3.7068	1.8633	5.6513	118.1510
92.5	0.7785	5.5086	3.7068	1.8574	5.6513	118.1510
93	0.7773	5.5289	3.7128	1.8667	5.6513	118.1510
93.5	0.7761	5.5086	3.7098	1.8718	5.6513	118.1510
94	0.7765	5.5086	3.7098	1.8744	5.6513	118.1510

Table C-2. Continued.

94.5	0.7781	5.5086	3.7054	1.8744	5.6513	118.1510
95	0.7781	5.5086	3.7024	1.8735	5.6513	118.1510
95.5	0.7773	5.5086	3.7083	1.8847	5.6513	118.1510
96	0.7797	5.5289	3.7158	1.8829	5.6513	118.1510
96.5	0.7781	5.5086	3.7113	1.8838	5.6513	118.1510
97	0.7781	5.5086	3.7068	1.6047	5.6513	118.1510

Note: the relation between the sensor mV and water volume was:
Volume (L) = EXP(-2.05705+0.00624*mV-0.000001695*mV^2)

Table C-3. Bromide run #2 water flow and rainfall data

	Volume (L)					mm
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-30	0.6215	0.6117	0.6149	0.6078	0.5567	0.0000
-29.5	0.6218	0.6123	0.6172	0.6075	0.5573	0.5250
-29	0.6212	0.6146	0.6215	0.6081	0.5564	1.0500
-28.5	0.6228	0.6189	0.6291	0.6097	0.5570	1.5750
-28	0.6245	0.6328	0.6385	0.6117	0.5670	2.1000
-27.5	0.6258	0.6665	0.6696	0.6172	0.5839	2.8880
-27	0.6295	0.7020	0.6962	0.6322	0.6423	3.4130
-26.5	0.6352	0.7438	0.7323	0.6595	0.7146	3.9380
-26	0.6477	0.7882	0.7646	0.6943	0.8071	4.4630
-25.5	0.6717	0.8431	0.8047	0.7323	0.9132	4.9880
-25	0.7002	0.8890	0.8457	0.7685	1.0378	5.7760
-24.5	0.7251	0.9385	0.9008	0.8084	1.1723	6.3010
-24	0.7477	0.9863	0.9356	0.8435	1.3432	6.8260
-23.5	0.7785	1.0404	0.9848	0.8899	1.5027	7.3510
-23	0.8042	1.0884	1.0301	0.9356	1.6586	8.1390
-22.5	0.8349	1.1394	1.0750	0.9726	1.8146	8.6640
-22	0.8720	1.2007	1.1222	1.0153	2.0016	9.1890
-21.5	0.8999	1.2616	1.1660	1.0676	2.1820	9.7140
-21	0.9323	1.3329	1.2290	1.1183	2.3892	10.2390
-20.5	0.9629	1.4156	1.2825	1.1780	2.5777	10.7640
-20	0.9933	1.4864	1.3490	1.2231	2.7805	11.5520
-19.5	1.0163	1.5661	1.4076	1.2844	2.9961	12.0770
-19	1.0337	1.6212	1.4641	1.3477	3.2290	12.6020
-18.5	1.0713	1.6904	1.5140	1.4022	3.4579	13.1270
-18	1.0992	1.7645	1.5816	1.4551	3.6728	13.6520
-17.5	1.1383	1.8296	1.6364	1.5205	3.8903	14.1770
-17	1.1706	1.8993	1.6928	1.5764	4.0873	14.7020
-16.5	1.2177	1.9614	1.7500	1.6326	4.3037	15.2270
-16	1.2471	2.0224	1.8088	1.7061	4.5323	15.7520

Table C-3. Continued.

-15.5	1.2887	2.0850	1.8684	1.7621	4.7810	16.5400
-15	1.3355	2.1464	1.9149	1.8146	5.0400	17.0650
-14.5	1.3757	2.2122	1.9720	1.8787	5.3096	17.5900
-14	1.4123	2.2917	2.0416	1.9288	5.5491	18.1150
-13.5	1.4545	2.3519	2.0953	1.9845	5.7966	18.6400
-13	1.5005	2.4249	2.1627	2.0407	6.0522	19.1650
-12.5	1.5341	2.5041	2.2368	2.1170	6.2937	19.9530
-12	1.5742	2.5821	2.2968	2.1733	6.5193	20.4780
-11.5	1.6114	2.6712	2.3632	2.2408	6.7506	21.0030
-11	1.6571	2.7511	2.4344	2.3150	6.9878	21.5280
-10.5	1.7038	2.8281	2.5106	2.3777	7.2309	22.0530
-10	1.7443	2.9438	2.5855	2.4472	7.4799	22.8410
-9.5	1.7735	3.0049	2.6519	2.5325	7.7091	23.3660
-9	1.8246	3.0825	2.7417	2.6078	7.9431	23.8910
-8.5	1.8633	3.1603	2.8042	2.6758	8.1820	24.4160
-8	1.9123	3.2410	2.8897	2.7546	8.3985	24.9410
-7.5	1.9428	3.3261	2.9661	2.8341	8.6188	25.4660
-7	1.9792	3.4019	3.0087	2.9068	8.8429	25.9910
-6.5	2.0133	3.4819	3.0722	2.9786	9.0422	26.7790
-6	2.0453	3.5720	3.1537	3.0429	9.2154	27.3040
-5.5	2.0963	3.6565	3.2197	3.1199	2.4397	27.8290
-5	2.1255	3.7322	3.2840	3.1879	0.6345	28.3540
-4.5	2.1665	3.8274	3.3604	3.2450	0.7300	28.8790
-4	2.2044	3.9151	3.4312	3.3139	0.8384	29.6670
-3.5	2.2250	3.9965	3.4889	3.3728	0.9672	30.1920
-3	2.2546	4.0777	3.5575	3.4494	1.1107	30.7170
-2.5	2.3049	4.1520	3.6257	3.5088	1.2838	31.2420
-2	2.3467	4.2355	3.6964	3.5821	1.4739	31.7670
-1.5	2.3871	4.3104	3.7502	3.6477	1.6532	32.2920
-1	2.4291	4.3760	3.8259	3.7083	1.8163	32.8170
-0.5	2.4879	4.4459	3.8919	3.7803	1.9989	33.3420
0	2.5303	4.5149	3.9588	3.8611	2.1956	34.1300
0.5	2.5933	4.5847	4.0378	3.9322	2.4017	34.6550
1	2.6258	4.6732	4.1034	4.0076	2.6022	35.1800
1.5	2.6919	4.7269	4.1682	4.0729	2.8042	35.7050
2	2.7488	4.7992	4.2537	4.1422	3.0314	36.2300
2.5	2.7829	4.8723	4.3187	4.2042	3.2585	37.0180
3	2.8377	4.9463	4.3862	4.2670	3.4989	37.5430
3.5	2.9007	5.0212	4.4631	4.3406	3.7532	38.0680
4	2.9611	5.1160	4.5323	4.4288	3.9729	38.5930
4.5	3.0087	5.1928	4.5847	4.4803	4.1585	39.1180
5	3.0556	5.2704	4.6376	4.5497	4.3591	39.6430

Table C-3. Continued.

5.5	3.1069	5.3687	4.7089	4.6200	4.6023	40.4310
6	3.1459	5.4684	4.7992	4.6910	4.8540	40.9560
6.5	3.1892	5.5491	4.8723	4.7629	5.1351	41.4810
7	3.2384	5.6513	4.9278	4.8357	5.3885	42.0060
7.5	3.2827	5.7340	5.0400	4.9278	5.6513	42.5310
8	3.3357	5.8176	5.1160	4.9837	5.9021	43.0560
8.5	3.3714	5.9021	5.1543	5.0589	6.1392	43.8440
9	3.4019	5.9876	5.2315	5.1351	6.3832	44.3690
9.5	3.4438	6.0739	5.3096	5.2121	6.6342	44.8940
10	3.5031	6.1611	5.3885	5.2900	6.8685	45.4190
10.5	3.5532	6.2493	5.4684	5.3490	7.1330	45.9440
11	3.5879	6.3160	5.5289	5.4084	7.3547	46.4690
11.5	3.6316	6.4058	5.6102	5.5086	7.5812	47.2570
12	3.6728	6.4965	5.6719	5.5898	7.8125	47.7820
12.5	3.7173	6.5651	5.7548	5.6307	8.0487	48.3070
13	3.7682	6.6574	5.8387	5.7132	8.2898	48.8320
13.5	3.8152	6.7506	5.9234	5.7757	8.5081	49.3570
14	3.8488	6.8212	6.0091	5.8598	8.7303	50.1450
14.5	3.9089	6.8922	6.0739	5.9234	8.9280	50.6700
15	3.9525	6.9638	6.1174	5.9876	9.1285	51.1950
15.5	4.0060	7.0601	6.1831	6.0522	9.3028	51.7200
16	4.0425	7.1086	6.2493	6.1174	9.4497	52.2450
16.5	4.1002	7.2063	6.3384	6.2051	0.6423	52.7700
17	4.1438	7.2802	6.4058	6.2493	0.7072	53.2950
17.5	4.2059	7.3547	6.4737	6.3384	0.8184	54.0830
18	4.2604	7.4296	6.5421	6.4058	0.9580	54.6080
18.5	4.3070	7.5051	6.6342	6.4737	1.1041	55.1330
19	4.3558	7.5812	6.6806	6.5421	1.2592	55.6580
19.5	4.4117	7.6322	6.7506	6.6111	1.4489	56.1830
20	4.4631	7.7091	6.8212	6.6806	1.6220	56.7080
20.5	4.4976	7.7866	6.8922	6.7506	1.8047	57.4960
21	4.5672	7.8385	6.9638	6.8212	1.9765	58.0210
21.5	4.6200	7.9169	7.0360	6.8922	2.1733	58.5460
22	4.6732	7.9694	7.1086	6.9638	2.3829	59.0710
22.5	4.7089	8.0222	7.1818	7.0360	2.5899	59.5960
23	4.7629	8.1019	7.2555	7.1086	2.8114	60.1210
23.5	4.8174	8.1552	7.3298	7.1818	3.0302	60.6460
24	4.8723	8.2089	7.3796	7.2555	3.2558	61.1710
24.5	4.9278	8.2627	7.4799	7.3298	3.4989	61.9590
25	4.9650	8.3168	7.5304	7.3796	3.7412	62.4840
25.5	5.0024	8.3712	7.5812	7.4547	3.9557	63.0090
26	5.0589	8.4258	7.6578	7.5304	4.1536	63.5340

Table C-3. Continued.

26.5	5.1160	8.4806	7.7349	7.6066	4.3558	64.0590
27	5.1543	8.5357	7.8125	7.6834	4.5847	64.8470
27.5	5.2121	8.5910	7.8646	7.7607	4.8357	65.3720
28	5.2509	8.6466	7.9431	7.8385	5.1160	65.8970
28.5	5.3096	8.7024	8.0222	7.8907	5.3885	66.4220
29	5.3490	8.7584	8.0753	7.9694	5.6513	66.9470
29.5	5.4084	8.8429	8.1552	8.0487	5.9021	67.4720
30	5.4483	8.9280	8.2358	8.1019	6.1392	67.9970
30.5	5.4885	8.9850	8.2898	8.1552	6.3608	68.7850
31	5.5491	9.0709	8.3712	8.2358	6.6111	69.3100
31.5	5.5898	9.1285	8.4258	8.3168	6.8448	69.8350
32	5.6307	9.2154	8.4806	8.3985	7.1086	70.3600
32.5	5.6719	9.3028	8.5633	8.4532	7.3547	70.8850
33	5.7548	1.9836	8.6188	8.5357	7.5812	71.4100
33.5	5.7340	0.6831	8.6744	8.6188	7.8125	72.1980
34	5.7340	0.6686	8.7584	8.6744	8.0487	72.7230
34.5	5.7757	0.6835	8.7865	8.7303	8.2627	73.2480
35	5.8387	0.7187	8.8712	8.7865	8.5081	73.7730
35.5	5.8809	0.7579	8.9280	8.8712	8.7303	74.2980
36	5.9021	0.7976	8.9850	8.8995	8.9280	75.0860
36.5	5.9447	0.8397	9.0135	8.9564	9.1574	75.6110
37	6.0091	0.8831	9.0709	9.0135	9.3320	76.1360
37.5	6.0522	0.9300	9.1285	9.0709	1.1294	76.6610
38	6.0956	0.9755	9.1864	9.1285	0.6936	77.1860
38.5	6.1392	1.0189	9.2154	9.1864	0.8034	77.7110
39	6.1831	1.0697	9.2736	9.2154	0.9314	78.2360
39.5	6.2272	1.1189	9.3028	9.2736	1.0873	79.0240
40	6.2715	1.1677	9.3614	9.3028	1.2483	79.5490
40.5	6.3160	1.2243	9.3614	9.3614	1.4551	80.0740
41	6.3832	1.2764	9.4202	9.3907	1.6448	80.5990
41.5	6.4284	1.3393	9.4497	9.4202	1.8288	81.1240
42	6.4737	1.4176	9.5088	9.4792	2.0215	81.6490
42.5	6.5193	1.4914	9.5385	9.5088	2.2269	82.1740
43	6.5651	1.5661	9.5980	9.5683	2.4525	82.9620
43.5	6.6111	1.6478	9.6578	1.5450	2.6770	83.4870
44	6.6574	1.7236	9.7178	0.6598	2.8812	84.0120
44.5	6.7039	1.7989	4.8723	0.6567	3.1290	84.5370
45	6.7506	1.8642	0.6965	0.6647	3.3701	85.0620
45.5	6.7976	1.9279	0.6714	0.6753	3.6404	85.5870
46	6.8448	1.9944	0.6824	0.6965	3.8672	86.1120
46.5	6.8922	2.0535	0.7068	0.7262	4.0681	86.9000
47	6.9399	2.1207	0.7365	0.7642	4.2853	87.4250

Table C-3. Continued.

47.5	7.0119	2.1849	0.7685	0.7976	4.5149	87.9500
48	7.0360	2.2437	0.8038	0.8341	4.7449	88.4750
48.5	7.0844	2.3130	0.8513	0.8658	5.0400	89.0000
49	7.1330	2.3777	0.8872	0.8999	5.3292	89.5250
49.5	7.1818	2.4482	0.9220	0.9394	5.6102	90.0500
50	7.2309	2.5215	0.9672	0.9848	5.8809	90.8380
50.5	7.2802	2.6078	1.0052	1.0291	6.1174	91.3630
51	7.3050	2.6735	1.0498	1.0798	6.3832	91.8880
51.5	7.3547	2.7581	1.0873	1.1355	6.6342	92.4130
52	7.4046	2.8389	1.1294	1.1826	6.8685	92.9380
52.5	7.4547	2.9265	1.1803	1.2404	7.1330	93.4630
53	7.5051	3.0062	1.2332	1.2844	7.3796	94.2510
53.5	7.5558	3.0979	1.2887	1.3316	7.6066	94.7760
54	7.5812	3.1629	1.3342	1.3823	7.8385	95.3010
54.5	7.6322	3.2437	1.3989	1.4421	8.0753	95.8260
55	7.6834	3.3275	1.4469	1.4822	8.3168	96.3510
55.5	7.7091	3.4103	1.5027	1.5661	8.5357	96.8760
56	7.7607	3.4918	1.5464	1.6167	8.7584	97.4010
56.5	7.7866	3.5734	1.6258	1.6671	8.9850	98.1890
57	7.8385	3.6551	1.6818	1.7046	9.1574	98.7140
57.5	7.8907	3.7457	1.7371	1.7637	9.3320	99.2390
58	7.9431	3.8289	1.7890	1.8229	9.4792	99.7640
58.5	7.9694	3.9136	1.8372	1.8787	0.6954	100.2890
59	8.0222	4.0029	1.8941	1.9314	0.7061	100.8140
59.5	8.0753	4.1018	1.9437	1.9881	0.8080	101.3390
60	8.1285	4.1895	2.0007	2.0453	0.9413	102.1270
60.5	8.1285	4.2587	2.0416	2.0916	1.0906	102.6520
61	8.1820	4.3389	2.0981	2.1560	1.2592	103.1770
61.5	8.2358	4.4117	2.1550	2.2142	1.4414	103.7020
62	8.2627	4.4976	2.2044	2.2716	1.6341	104.2270
62.5	8.3168	4.5672	2.2656	2.3364	1.8005	105.0150
63	8.3712	4.6376	2.3334	2.4017	1.9944	105.5400
63.5	8.3985	4.7089	2.4007	2.4728	2.1849	106.0650
64	8.4258	4.7810	2.4675	2.5347	2.4017	106.5900
64.5	8.4532	4.8540	2.5423	2.6089	2.6056	107.1150
65	8.5081	4.9278	2.6078	2.6919	2.8317	107.6400
65.5	8.5357	5.0024	2.6781	2.7628	3.0441	108.4280
66	8.5910	5.0779	2.7581	2.8257	3.2706	108.9530
66.5	8.6188	5.1543	2.8353	2.8971	3.5103	109.4780
67	8.6466	5.2121	2.9117	2.9636	3.7667	110.0030
67.5	8.7024	5.3096	2.9736	3.0390	4.0029	110.5280
68	8.7303	5.3885	3.0365	3.1160	4.2010	111.0530

Table C-3. Continued.

68.5	8.7865	5.4885	3.1069	3.1919	4.3947	111.5780
69	8.8147	5.5694	3.1721	3.2464	4.6554	112.1030
69.5	8.8712	5.6513	3.2317	3.3125	4.8908	112.8910
70	8.8995	5.7340	3.3016	3.3618	5.1735	113.4160
70.5	8.9280	5.8176	3.3577	3.4256	5.4284	113.4160
71	8.9564	5.8598	3.4130	3.4861	5.6925	113.4160
71.5	8.9850	5.8598	3.4089	3.5174	5.8809	113.4160
72	8.9564	5.8598	3.4075	3.5274	6.0522	113.4160
72.5	8.9850	5.8598	3.4103	3.5360	6.2051	113.4160
73	8.9850	5.8598	3.4075	3.5389	6.3384	113.4160
73.5	8.9850	5.8598	3.4075	3.5417	6.3608	113.4160
74	8.9850	5.8598	3.4089	3.5446	6.3608	113.4160
74.5	8.9850	5.8598	3.4047	3.5503	6.3832	113.4160
75	8.9564	5.8598	3.3963	3.5475	6.3608	113.4160
75.5	8.9850	5.8598	3.4005	3.5518	6.3832	113.4160
76	8.9850	5.8598	3.3977	3.5518	6.3608	113.4160
76.5	8.9850	5.8598	3.4005	3.5590	6.3608	113.4160
77	8.9850	5.8598	3.3991	3.5590	6.3608	113.4160
77.5	8.9850	5.8598	3.3991	3.5590	6.3608	113.4160
78	8.9850	5.8598	3.3991	3.5590	6.3608	113.4160
78.5	8.9850	5.8598	3.4005	3.5590	6.3608	113.4160
79	8.9850	5.8598	3.3977	3.5575	6.3608	113.4160
79.5	8.9850	5.8809	3.3991	3.5604	6.3608	113.4160
80	8.9850	5.8809	3.3991	3.5691	6.3608	113.4160
80.5	8.9850	5.8598	3.4005	3.5691	6.3608	113.4160
81	8.9564	5.8598	3.4019	3.5705	6.3608	113.4160
81.5	8.9564	5.8598	3.3632	3.5792	6.3608	113.4160
82	8.9850	5.8598	3.3687	3.5893	6.3608	113.4160
82.5	8.9850	5.8598	3.4130	3.5908	6.3608	113.4160
83	8.9564	5.8598	3.4144	3.5864	6.3608	113.4160
83.5	8.9850	5.8809	3.4186	3.5922	6.3608	113.4160
84	8.9850	5.8598	3.4158	3.5893	6.3608	113.4160
84.5	8.9850	5.8598	3.4158	3.5893	6.3608	113.4160
85	8.9850	5.8598	3.4200	3.5966	6.3608	113.4160
85.5	8.9850	5.8598	3.4200	3.5951	6.3608	113.4160
86	8.9850	5.8598	3.4186	3.5922	6.3608	113.4160
86.5	8.9850	5.8598	3.4158	3.5908	6.3608	113.4160
87	8.9850	5.8598	3.4005	3.5908	6.3608	113.4160
87.5	8.9850	5.8598	3.4116	3.5908	6.3608	113.6790
88	8.9564	5.8598	3.4228	3.5951	6.3608	113.6790
88.5	8.9564	5.8809	3.4089	3.6009	6.3608	113.6790

Note: Negative time represents pre-washing.

Table C-4. Bromide run #3 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6577	0.6443	0.6318	0.6328	0.5833	0.0000
-9.5	0.6643	0.6470	0.6369	0.6352	0.5833	0.7880
-9	0.6693	0.6494	0.6396	0.6409	0.5953	1.3130
-8.5	0.6717	0.6536	0.6423	0.6464	0.6735	1.8380
-8	0.6749	0.6591	0.6474	0.6567	0.8231	2.6260
-7.5	0.6922	0.6686	0.6584	0.6746	0.9938	3.1510
-7	0.7183	0.6803	0.6788	0.7031	1.2171	3.6760
-6.5	0.7450	0.6994	0.7079	0.7312	1.4614	4.4640
-6	0.7741	0.7244	0.7278	0.7697	1.7014	4.9890
-5.5	0.8051	0.7396	0.7594	0.8059	1.9499	5.5140
-5	0.8315	0.7634	0.7810	0.8375	2.2014	6.3020
-4.5	0.8645	0.7870	0.8151	0.8804	2.4836	6.8270
-4	0.8999	0.8071	0.8414	0.9178	2.7476	7.3520
-3.5	0.9267	0.8371	0.8711	0.9590	3.0479	7.8770
-3	0.9571	0.8618	0.9058	0.9987	3.3480	8.6650
-2.5	0.9873	0.8922	0.9394	1.0456	3.6654	9.1900
-2	1.0174	0.9146	0.9711	1.1014	3.9651	9.7150
-1.5	1.0539	0.9432	1.0083	1.1512	4.2421	10.2400
-1	1.0782	0.9662	1.0399	1.2118	4.5497	11.0280
-0.5	1.1339	0.9780	1.0666	1.2580	4.8723	11.5530
0	1.1575	1.0118	1.1041	1.3088	5.2121	12.0780
0.5	1.1960	1.0250	1.1428	1.3646	5.5694	12.8660
1	1.2446	1.0524	1.1798	1.4325	5.8809	13.3910
1.5	1.2925	1.0873	1.2272	1.4886	6.2272	13.9160
2	1.3477	1.1118	1.2616	1.5421	6.5421	14.4410
2.5	1.3810	1.1456	1.3094	1.6002	6.8448	15.2290
3	1.4197	1.1734	1.3516	1.6686	7.1574	15.7540
3.5	1.4558	1.2001	1.3915	1.7220	7.4547	16.2790
4	1.5005	1.2296	1.4332	1.7800	7.7866	16.8040
4.5	1.5421	1.2641	1.4607	1.8338	8.0753	17.3290
5	1.5957	1.2900	1.5176	1.8889	8.3712	18.1170
5.5	1.6532	1.3278	1.5705	1.9420	8.6466	18.6420
6	1.6873	1.3678	1.6250	1.9908	8.9280	19.1670
6.5	1.7379	1.3975	1.6624	2.0352	9.2154	19.6920
7	1.7866	1.4524	1.6889	2.1019	9.4497	20.2170
7.5	1.8380	1.5076	1.7299	2.1685	1.8676	21.0050
8	1.8710	1.5406	1.7776	2.2358	0.6792	21.5300
8.5	1.9314	1.5749	1.8146	2.2917	0.8294	22.0550
9	1.9711	1.6212	1.8574	2.3591	0.9933	22.5800

Table C-4. Continued.

9.5	2.0061	1.6733	1.8967	2.4376	1.2065	23.1050
10	2.0407	1.7030	1.9437	2.5096	1.4325	23.8930
10.5	2.0832	1.7419	1.9765	2.5699	1.6463	24.4180
11	2.1264	1.7866	2.0133	2.6507	1.8744	24.9430
11.5	2.1685	1.8121	2.0591	2.7406	2.0916	25.7310
12	2.2063	1.8380	2.1075	2.7995	2.3508	26.2560
12.5	2.2487	1.8642	2.1502	2.8873	2.6496	26.7810
13	2.3018	1.9071	2.1946	2.9599	2.9240	27.3060
13.5	2.3550	1.9420	2.2517	3.0238	3.2197	27.8310
14	2.4007	1.9854	2.3069	3.0889	3.5619	28.3560
14.5	2.4546	2.0143	2.3809	3.1669	3.8734	29.1440
15	2.5041	2.0443	2.4175	3.2437	4.1438	29.6690
15.5	2.5766	2.0720	2.4653	3.2949	4.4117	30.1940
16	2.6394	2.0991	2.5096	3.3590	4.7269	30.7190
16.5	2.6907	2.1331	2.5600	3.4242	5.0589	31.5070
17	2.7628	2.1762	2.6112	3.5046	5.4084	32.0320
17.5	2.8126	2.2181	2.6655	3.5821	5.7132	32.5570
18	2.9093	2.2527	2.7359	3.6477	6.0306	33.0820
18.5	2.9599	2.2998	2.7971	3.7232	6.3384	33.8700
19	3.0289	2.3447	2.8606	3.8015	6.6574	34.3950
19.5	3.0863	2.3861	2.9142	3.8826	6.9878	34.9200
20	3.1472	2.4196	2.9699	3.9525	7.3050	35.4450
20.5	3.1800	2.4514	2.9974	4.0155	7.6066	36.2330
21	3.2370	2.4911	3.0645	4.0793	7.9169	36.7580
21.5	3.2962	2.5379	3.1134	4.1601	8.2358	37.2830
22	3.3480	2.5955	3.1590	4.2306	8.5081	37.8080
22.5	3.3991	2.6530	3.2210	4.3187	8.8147	38.3330
23	3.4565	2.6988	3.2719	4.3896	9.0709	39.1210
23.5	3.4989	2.7406	3.3152	4.4631	9.3614	39.6460
24	3.5590	2.7852	3.3770	4.5323	9.5980	40.1710
24.5	3.6068	2.8281	3.4382	4.6200	9.8386	40.6960
25	3.6492	2.8654	3.4819	4.6910	10.0522	41.4840
25.5	3.6861	2.9105	3.5060	4.7629	3.7788	42.0090
26	3.7562	2.9524	3.5864	4.8540	0.6609	42.5340
26.5	3.8000	3.0049	3.6404	4.9278	0.7874	43.0590
27	3.8503	3.0467	3.6787	5.0212	0.9518	43.5840
27.5	3.8934	3.0940	3.7562	5.0779	1.1400	44.3720
28	3.9572	3.1212	3.7939	5.1735	1.3711	44.8970
28.5	4.0171	3.1590	3.8304	5.2509	1.6032	45.4220
29	4.0841	3.2038	3.9136	5.3292	1.8055	45.9470
29.5	4.1163	3.2491	3.9525	5.4084	2.0388	46.7350
30	4.1650	3.2922	4.0108	5.4684	2.2857	47.2600

Table C-4. Continued.

30.5	4.2306	3.3385	4.0761	5.5491	2.5721	47.7850
31	4.2920	3.3811	4.1228	5.6307	2.8485	48.3100
31.5	4.3541	3.4214	4.1699	5.6925	3.1342	48.8350
32	4.3896	3.4579	4.2339	5.7757	3.4776	49.6230
32.5	4.4459	3.4932	4.2587	5.8598	3.7698	50.1480
33	4.5149	3.5374	4.3204	5.9234	4.0649	50.6730
33.5	4.5672	3.5893	4.3947	6.0091	4.3507	51.1980
34	4.6376	3.6462	4.4288	6.0739	4.6200	51.7230
34.5	4.6910	3.6846	4.4803	6.1392	4.9650	52.5110
35	4.7449	3.7247	4.5497	6.2272	5.2900	53.0360
35.5	4.7992	3.7803	4.6200	6.2937	5.6307	53.5610
36	4.8908	3.8213	4.6554	6.3608	5.9661	54.0860
36.5	4.9278	3.8842	4.7089	6.4284	6.2937	54.6110
37	5.0024	3.9322	4.7629	6.4965	6.5881	55.3990
37.5	5.0589	3.9745	4.8174	6.5881	6.9399	55.9240
38	5.0969	4.0155	4.8723	6.6574	7.2555	56.4490
38.5	5.1543	4.0569	4.9463	6.7272	7.5558	57.2370
39	5.2315	4.1034	4.9837	6.7976	7.8385	57.7620
39.5	5.2704	4.1438	5.0589	6.8922	8.1552	58.2870
40	5.3292	4.1960	5.0969	6.9638	8.4532	58.8120
40.5	5.3687	4.2339	5.1543	7.0119	8.7303	59.3370
41	5.4483	4.2786	5.2315	7.0844	9.0135	59.8620
41.5	5.4885	4.3187	5.2704	7.1574	9.3028	60.6500
42	5.5491	4.3507	5.3490	7.2309	4.5149	61.1750
42.5	5.6102	4.3947	5.4084	7.3050	0.6717	61.7000
43	5.6513	4.4459	5.4684	7.3796	0.7981	62.2250
43.5	5.7132	4.4803	5.5289	7.4547	0.9551	62.7500
44	5.7548	4.5323	5.5694	7.5304	1.1501	63.5380
44.5	5.8387	4.5672	5.6307	7.6066	1.3922	64.0630
45	5.8598	4.6023	5.6925	7.7091	1.6440	64.5880
45.5	5.9447	4.6376	5.7548	7.7607	1.8439	65.1130
46	5.9876	4.6732	5.7966	7.8385	2.0878	65.6380
46.5	6.0522	4.7089	5.8598	7.9169	2.3622	66.1630
47	6.0956	4.7629	5.9234	7.9958	2.6281	66.9510
47.5	6.1831	4.7992	5.9876	8.0487	2.9216	67.4760
48	6.2272	4.8357	6.0522	8.1285	3.1866	68.0010
48.5	6.2715	4.8723	6.1174	8.2089	3.4989	68.5260
49	6.3384	4.9092	6.1611	8.2898	3.8122	69.0510
49.5	6.4058	4.9650	6.2051	8.3440	4.0986	69.8390
50	6.4510	5.0024	6.2715	8.4532	4.3727	70.3640
50.5	6.4965	5.0400	6.3160	8.5357	4.6910	70.8890
51	6.5421	5.0589	6.3608	8.5910	5.0024	71.4140

Table C-4. Continued.

51.5	6.6111	5.1351	6.4284	8.6744	5.3687	72.2020
52	6.6574	5.1735	6.4737	8.7303	5.7340	72.7270
52.5	6.7272	5.2121	6.5421	8.8147	6.0522	73.2520
53	6.7976	5.2509	6.5881	8.8995	6.3608	73.7770
53.5	6.8448	5.2900	6.6342	8.9564	6.6574	74.5650
54	6.8922	5.3490	6.6806	9.0135	7.0119	75.0900
54.5	6.9638	5.3885	6.7506	9.0997	7.3298	75.6150
55	7.0119	5.4684	6.7976	9.1574	7.6322	76.1400
55.5	7.0601	5.5086	6.8448	9.2154	7.9169	76.6650
56	7.1086	5.5491	6.8922	9.2736	8.2089	77.4530
56.5	7.1574	5.5898	6.9399	9.3320	8.5081	77.9780
57	7.2063	5.6513	6.9878	9.3907	8.7865	78.5030
57.5	7.2555	5.7132	7.0601	9.4497	9.0709	79.0280
58	7.3298	5.7548	7.1086	9.5088	9.3320	79.5530
58.5	7.3796	5.7966	7.1574	9.5385	3.0479	80.3410
59	7.4296	5.8387	7.2063	9.5980	0.6774	80.8660
59.5	7.4799	5.8809	7.2802	9.6279	0.8235	81.3910
60	7.5304	5.9447	7.3298	9.6878	0.9648	81.9160
60.5	7.5812	5.9876	7.3796	9.7178	1.1815	82.4410
61	7.6322	6.0306	7.4296	9.7479	1.4022	83.2290
61.5	7.6834	6.0739	7.5051	9.8083	1.6265	83.7540
62	7.7349	6.1174	7.5304	9.8386	1.8633	84.2790
62.5	7.7866	6.1611	7.6066	9.8689	2.1010	84.8040
63	7.8385	6.2272	7.6578	9.9298	2.3529	85.5920
63.5	7.8907	6.2715	7.7349	9.9909	2.6303	86.1170
64	7.9431	6.3160	7.7866	3.0416	2.8824	86.6420
64.5	7.9958	6.3608	7.8385	0.6574	3.1972	87.1670
65	8.0487	6.4284	7.8907	0.6630	3.5160	87.6920
65.5	8.0753	6.4510	7.9431	0.6788	3.7894	88.4800
66	8.1552	6.5193	7.9958	0.7105	4.0601	89.0050
66.5	8.1820	6.5421	8.0487	0.7377	4.3389	89.5300
67	8.2627	6.5881	8.1019	0.7658	4.6910	90.0550
67.5	8.3168	6.6342	8.1820	0.8026	4.9837	90.5800
68	8.3440	6.6806	8.2358	0.8341	5.3292	91.3680
68.5	8.3985	6.7272	8.2898	0.8769	5.6719	91.8930
69	8.4532	6.7741	8.3440	0.9127	6.0091	92.4180
69.5	8.5081	6.8212	8.4258	0.9385	6.3384	92.9430
70	8.5357	6.8685	8.4806	0.9750	6.6342	93.4680
70.5	8.5633	6.9161	8.5081	1.0148	6.9638	94.2560
71	8.6188	6.9399	8.5633	1.0613	7.2802	94.7810
71.5	8.6744	6.9878	8.6188	1.1025	7.5812	95.3060
72	8.7024	7.0119	8.6744	1.1575	7.8646	95.8310

Table C-4. Continued.

72.5	8.7584	7.0601	8.7584	1.2112	8.1820	96.6190
73	8.7865	7.1086	8.8147	1.2702	8.4806	97.1440
73.5	8.8429	7.1574	8.8429	1.3088	8.7584	97.6690
74	8.8995	7.1818	8.8995	1.3620	9.0422	98.1940
74.5	8.9280	7.2309	8.9564	1.4156	9.3028	98.7190
75	8.9850	7.2802	9.0135	1.4829	9.5683	99.2440
75.5	9.0422	7.3298	9.0422	1.5305	9.7781	100.0320
76	9.0709	7.3547	9.0997	1.5838	4.7089	100.5570
76.5	9.1285	7.4046	9.1574	1.6478	0.6162	101.0820
77	9.1864	7.4296	9.2154	1.7109	0.6972	101.6070
77.5	9.2154	7.4799	9.2736	1.7629	0.8337	102.3950
78	9.2736	7.5304	9.3028	1.8213	1.0017	102.9200
78.5	9.3028	7.5558	9.3320	1.8847	1.2130	103.4450
79	9.3614	7.6066	9.3907	1.9349	1.4565	103.9700
79.5	9.3907	7.6322	9.4202	1.9729	1.6532	104.4950
80	9.4202	7.6578	9.4792	2.0324	1.8523	105.0200
80.5	9.4497	7.7091	9.5088	2.0850	1.9192	105.0200
81	9.4792	7.7091	9.5088	2.1369	1.9420	105.0200
81.5	9.5088	7.7349	9.5088	2.1502	1.9332	105.0200
82	9.5088	7.7091	9.5088	2.1541	1.9297	105.0200
82.5	9.5088	7.7349	9.5088	2.1579	1.9332	105.0200
83	9.5088	7.7349	9.5088	2.1589	1.9341	105.0200
83.5	9.5088	7.7349	9.5385	2.1665	1.9341	105.0200
84	9.5088	7.7349	9.5088	2.1675	1.9349	105.0200
84.5	9.5088	7.7349	9.5385	2.1685	1.9349	105.0200
85	9.5088	7.7349	9.5088	2.1617	1.9411	105.0200

Table C-5. Bromide run #4 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6315	0.6087	0.6052	0.5981	0.5570	0.0000
-9.5	0.6358	0.6091	0.6068	0.5981	0.5570	0.5250
-9	0.6402	0.6120	0.6130	0.5981	0.5597	1.0500
-8.5	0.6433	0.6159	0.6182	0.5988	0.6169	1.5750
-8	0.6477	0.6185	0.6195	0.6001	0.7427	2.3630
-7.5	0.6515	0.6228	0.6258	0.6020	0.9225	2.8880
-7	0.6570	0.6301	0.6358	0.6071	1.1406	3.4130
-6.5	0.6696	0.6433	0.6512	0.6251	1.3889	3.9380
-6	0.6885	0.6640	0.6700	0.6553	1.6478	4.7260
-5.5	0.7120	0.6874	0.6969	0.6980	1.8439	5.2510

Table C-5. Continued.

-5	0.7369	0.7050	0.7195	0.7270	2.1350	5.7760
-4.5	0.7543	0.7221	0.7528	0.7547	2.4814	6.5640
-4	0.7919	0.7438	0.7830	0.7842	2.7852	7.0890
-3.5	0.8117	0.7697	0.8067	0.8294	3.0940	7.6140
-3	0.8448	0.7981	0.8354	0.8605	3.4242	8.1390
-2.5	0.8720	0.8273	0.8649	0.8981	3.7352	8.6640
-2	0.9054	0.8487	0.8935	0.9328	4.0314	9.4520
-1.5	0.9460	0.8845	0.9215	0.9765	4.3305	9.9770
-1	0.9653	0.9086	0.9547	1.0148	4.6732	10.5020
-0.5	0.9962	0.9323	0.9784	1.0597	5.0212	11.2900
0	1.0276	0.9590	1.0108	1.0971	5.3885	11.8150
0.5	1.0529	0.9868	1.0466	1.1450	5.7340	12.3400
1	1.0804	1.0189	1.0798	1.2007	6.0306	12.8650
1.5	1.1211	1.0472	1.1123	1.2440	6.3160	13.6530
2	1.1524	1.0734	1.1484	1.2919	6.6111	14.1780
2.5	1.1826	1.1030	1.1855	1.3412	6.8922	14.7030
3	1.2189	1.1344	1.2231	1.4015	7.2063	15.2280
3.5	1.2555	1.1586	1.2586	1.4489	7.5051	15.7530
4	1.2900	1.1861	1.2993	1.5119	7.7866	16.5410
4.5	1.3246	1.2166	1.3438	1.5691	8.1019	17.0660
5	1.3724	1.2501	1.3889	1.6288	8.3985	17.5910
5.5	1.3836	1.2807	1.4264	1.6710	8.7024	18.1160
6	1.4244	1.3163	1.4732	1.7283	9.0135	18.6410
6.5	1.4462	1.3516	1.5169	1.7767	9.2736	19.4290
7	1.4914	1.3949	1.5735	1.8279	4.5149	19.9540
7.5	1.5334	1.4380	1.6190	1.8778	0.6553	20.4790
8	1.5772	1.4843	1.6594	1.9332	0.7952	21.0040
8.5	1.6047	1.5190	1.6928	1.9738	0.9696	21.7920
9	1.6563	1.5742	1.7307	2.0224	1.1826	22.3170
9.5	1.7077	1.6227	1.7678	2.0757	1.4285	22.8420
10	1.7323	1.6640	1.8121	2.1407	1.6710	23.3670
10.5	1.7678	1.6975	1.8515	2.2005	1.8967	23.8920
11	1.8129	1.7403	1.8838	2.2606	2.1426	24.6800
11.5	1.8582	1.7816	1.9297	2.3293	2.4154	25.2050
12	1.8924	1.8121	1.9729	2.4017	2.7034	25.7300
12.5	1.9332	1.8481	2.0097	2.4750	3.0238	26.2550
13	1.9729	1.8898	2.0554	2.5325	3.3248	26.7800
13.5	2.0124	1.9349	2.1010	2.6123	3.6580	27.3050
14	2.0343	1.9676	2.1426	2.6815	3.9698	28.0930
14.5	2.0878	2.0061	2.1878	2.7464	4.1780	28.6180
15	2.1179	2.0370	2.2319	2.8221	4.4803	29.1430
15.5	2.1474	2.0591	2.2756	2.8836	4.7992	29.6680

Table C-5. Continued.

16	2.1927	2.0935	2.3334	2.9413	5.1543	30.1930
16.5	2.2112	2.1340	2.3829	3.0049	5.5086	30.7180
17	2.2527	2.1772	2.4408	3.0722	5.8598	31.5060
17.5	2.2958	2.2093	2.4901	3.1381	6.1831	32.0310
18	2.3334	2.2527	2.5423	3.2104	6.4965	32.5560
18.5	2.3705	2.3028	2.6123	3.2665	6.7976	33.0810
19	2.4144	2.3467	2.6610	3.3248	7.1330	33.8690
19.5	2.4632	2.3850	2.7127	3.3894	7.4296	34.3940
20	2.5183	2.4217	2.7793	3.4635	7.7349	34.9190
20.5	2.5600	2.4525	2.8269	3.5360	8.0487	35.4440
21	2.6089	2.5009	2.8776	3.5864	8.3440	35.9690
21.5	2.6781	2.5456	2.9277	3.6624	8.6466	36.7570
22	2.7208	2.5910	2.9836	3.7307	8.9280	37.2820
22.5	2.7746	2.6484	3.0352	3.7909	9.2154	37.8070
23	2.8377	2.6919	3.1005	3.8595	9.4497	38.3320
23.5	2.8873	2.7394	3.1368	3.9260	2.9961	39.1200
24	2.9463	2.7923	3.1826	3.9918	0.6918	39.6450
24.5	2.9911	2.8365	3.2437	4.0617	0.8226	40.1700
25	3.0479	2.8776	3.2881	4.1325	0.9888	40.6950
25.5	3.0889	2.9191	3.3385	4.1960	1.1989	41.4830
26	3.1251	2.9699	3.3853	4.2653	1.4435	42.0080
26.5	3.1905	3.0251	3.4382	4.3271	1.6686	42.5330
27	3.2317	3.0569	3.4932	4.3947	1.9079	43.0580
27.5	3.2679	3.0915	3.5446	4.4803	2.1627	43.8460
28	3.3398	3.1329	3.6009	4.5323	2.4133	44.3710
28.5	3.3659	3.1826	3.6683	4.6200	2.6896	44.8960
29	3.4284	3.2290	3.7143	4.6910	2.9524	45.4210
29.5	3.4720	3.2733	3.7698	4.7629	3.2317	45.9460
30	3.5003	3.3193	3.8091	4.8174	3.4918	46.7340
30.5	3.5460	3.3618	3.8611	4.8908	3.7698	47.2590
31	3.5937	3.4228	3.9260	4.9650	4.0681	47.7840
31.5	3.6272	3.4691	3.9698	5.0212	4.3558	48.3090
32	3.6787	3.5231	4.0330	5.0969	4.6732	48.8340
32.5	3.7188	3.5547	4.0793	5.1928	5.0024	49.3590
33	3.7607	3.6053	4.1292	5.2509	5.3490	50.1470
33.5	3.8061	3.6477	4.1829	5.3096	5.7340	50.6720
34	3.8503	3.6994	4.2421	5.3885	6.0739	51.1970
34.5	3.9043	3.7337	4.2803	5.4483	6.4058	51.7220
35	3.9338	3.7879	4.3389	5.5086	6.7039	52.2470
35.5	3.9950	3.8350	4.3947	5.5898	7.0601	53.0350
36	4.0282	3.8919	4.4459	5.6513	7.3796	53.5600
36.5	4.0857	3.9385	4.4803	5.7132	7.6322	54.0850

Table C-5. Continued.

37	4.1276	3.9855	4.5497	5.7757	7.9169	54.6100
37.5	4.1617	4.0203	4.6023	5.8598	8.2358	55.3980
38	4.2141	4.0665	4.6732	5.9234	8.5357	55.9230
38.5	4.2653	4.1018	4.7089	5.9876	8.8429	56.4480
39	4.3087	4.1487	4.7629	6.0522	9.1285	56.9730
39.5	4.3473	4.1928	4.8174	6.0956	9.3907	57.4980
40	4.4117	4.2388	4.8723	6.1831	4.6376	58.0230
40.5	4.4459	4.2703	4.9463	6.2272	0.7035	58.5480
41	4.4976	4.3020	5.0024	6.2937	0.8303	59.0730
41.5	4.5497	4.3473	5.0589	6.3608	1.0078	59.8610
42	4.6200	4.3879	5.1160	6.4284	1.2296	60.3860
42.5	4.6732	4.4288	5.1735	6.4965	1.4510	60.9110
43	4.7089	4.4631	5.2315	6.5651	1.7109	61.4360
43.5	4.7629	4.4976	5.2900	6.6342	1.9271	61.9610
44	4.8174	4.5497	5.3292	6.7039	2.1617	62.7490
44.5	4.8723	4.6023	5.3885	6.7741	2.4376	63.2740
45	4.9278	4.6376	5.4284	6.8448	2.7289	63.7990
45.5	4.9650	4.6732	5.4684	6.9161	3.0062	64.3240
46	5.0212	4.7269	5.5491	6.9638	3.3302	65.1120
46.5	5.0589	4.7629	5.5898	7.0360	3.6272	65.6370
47	5.1160	4.7992	5.6513	7.0844	3.8950	66.1620
47.5	5.1735	4.8357	5.7132	7.1574	4.1748	66.6870
48	5.2315	4.8908	5.7548	7.2309	4.4631	67.2120
48.5	5.2704	4.9278	5.8176	7.3050	4.7810	67.7370
49	5.3292	4.9837	5.8809	7.3796	5.1160	68.2620
49.5	5.3490	5.0212	5.9234	7.4296	5.4684	68.7870
50	5.4084	5.0589	5.9876	7.5051	5.7966	69.5750
50.5	5.4483	5.0969	6.0306	7.5558	6.0956	70.1000
51	5.4885	5.1543	6.0956	7.6322	6.4284	70.6250
51.5	5.5491	5.1928	6.1392	7.7349	6.7272	71.1500
52	5.6102	5.2315	6.1831	7.7866	7.0360	71.6750
52.5	5.6307	5.2900	6.2272	7.8385	7.3796	72.4630
53	5.6719	5.3292	6.2937	7.9169	7.6578	72.9880
53.5	5.7340	5.3885	6.3384	7.9694	7.9694	73.5130
54	5.7757	5.4483	6.3832	8.0487	8.2627	74.0380
54.5	5.8387	5.5086	6.4510	8.1285	8.5633	74.5630
55	5.8598	5.5491	6.4965	8.1820	8.8429	75.0880
55.5	5.9234	5.5898	6.5421	8.2627	9.1285	75.8760
56	5.9661	5.6513	6.6111	8.3168	9.3614	76.4010
56.5	6.0306	5.6925	6.6574	8.3712	9.5980	76.9260
57	6.0739	5.7548	6.7039	8.4532	4.6200	77.4510
57.5	6.1392	5.7966	6.7506	8.5357	0.6616	77.9760

Table C-5. Continued.

58	6.1831	5.8387	6.7976	8.5910	0.6903	78.7640
58.5	6.2272	5.8809	6.8448	8.6744	0.8337	79.2890
59	6.2715	5.9447	6.9161	8.7303	1.0007	79.8140
59.5	6.3160	5.9876	6.9638	8.8147	1.2042	80.3390
60	6.3832	6.0306	7.0119	8.8712	1.4366	80.8640
60.5	6.4058	6.0739	7.0360	8.9280	1.6671	81.6520
61	6.4510	6.1174	7.1086	8.9850	1.8932	82.1770
61.5	6.4965	6.1611	7.1574	9.0422	2.1179	82.7020
62	6.5421	6.2051	7.2063	9.0997	2.4133	83.2270
62.5	6.5881	6.2493	7.2555	9.1574	2.6632	84.0150
63	6.6574	6.2937	7.3298	9.2154	2.9512	84.5400
63.5	6.6806	6.3608	7.3547	9.3028	3.2424	85.0650
64	6.7506	6.4058	7.4046	9.3320	3.5604	85.5900
64.5	6.7976	6.4510	7.4799	9.3907	3.8365	86.3780
65	6.8448	6.4965	7.5304	9.4497	4.0889	86.9030
65.5	6.8685	6.5421	7.5812	9.5088	4.3490	87.4280
66	6.9399	6.5881	7.6322	9.5385	4.6554	87.9530
66.5	6.9638	6.6342	7.6834	9.5980	4.9650	88.4780
67	7.0360	6.6806	7.7349	9.6279	5.3292	89.2660
67.5	7.0601	6.7272	7.8125	9.6578	5.6719	89.7910
68	7.1330	6.7741	7.8646	9.6878	5.9876	90.3160
68.5	7.1574	6.8212	7.9169	9.7178	6.3160	90.8410
69	7.2063	6.8685	7.9694	9.7781	6.6342	91.3660
69.5	7.2555	6.9161	8.0222	9.8083	6.9399	92.1540
70	7.3050	6.9399	8.0753	9.8386	7.2063	92.6790
70.5	7.3298	6.9878	8.1019	9.8689	7.5051	93.2040
71	7.3796	7.0119	8.1552	1.2042	7.8125	93.7290
71.5	7.4296	7.0601	8.2358	0.6630	8.0753	94.2540
72	7.4799	7.1086	8.2898	0.6623	8.3712	95.0420
72.5	7.5304	7.1574	8.3440	0.6686	8.6744	95.5670
73	7.5812	7.2063	8.3985	0.6867	8.9564	96.0920
73.5	7.6322	7.2309	8.4532	0.7112	9.2154	96.6170
74	7.6834	7.2802	8.5081	0.7446	9.4792	97.1420
74.5	7.7349	7.3298	8.5633	0.7697	9.6878	97.9300
75	7.7607	7.3796	8.6188	0.8092	9.8993	98.4550
75.5	7.8125	7.4296	8.6744	0.8388	10.1138	98.9800
76	7.8385	7.4547	8.7303	0.8764	1.9640	99.5050
76.5	7.8907	7.5051	8.7865	0.9008	0.6623	100.2930
77	7.9169	7.5304	8.8429	0.9418	0.8067	100.8180
77.5	7.9694	7.5812	8.8712	0.9770	0.9662	101.3430
78	8.0222	7.6322	8.9280	1.0113	1.1501	101.8680
78.5	8.0753	7.6578	8.9850	1.0487	1.3737	102.3930

Table C-5. Continued.

79	8.1019	7.7091	9.0422	1.0879	1.5957	102.9180
79.5	8.1552	7.7349	9.0709	1.1294	1.8063	103.7060
80	8.1820	7.7607	9.1285	1.1746	2.0034	104.2310
80.5	8.2358	7.8125	9.1864	1.2195	2.2024	104.2310
81	8.2898	7.8385	9.2154	1.2678	2.2457	104.2310
81.5	8.3168	7.8646	9.2445	1.3031	2.2586	104.2310
82	8.3168	7.8646	9.2445	1.3170	2.2616	104.2310
82.5	8.3168	7.8646	9.2445	1.3208	2.2666	104.2310
83	8.3168	7.8646	9.2445	1.3240	2.2706	104.2310
83.5	8.3168	7.8646	9.2445	1.3278	2.2756	104.2310
84	8.3168	7.8646	9.2445	1.3284	2.2776	104.2310
84.5	8.3168	7.8646	9.2445	1.3303	2.2786	104.2310
85	8.3168	7.8646	9.2445	1.3303	2.2786	104.2310

Table C-6. Bromide run #5 water flow and rainfall data

	Accumulated Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6325	0.6345	0.6133	0.6071	0.5472	0
-9.5	0.6389	0.6406	0.6149	0.6087	0.5475	0.5250
-9	0.6423	0.6494	0.6162	0.6117	0.5489	1.3130
-8.5	0.6484	0.6623	0.6179	0.6176	0.5718	1.8380
-8	0.6682	0.6893	0.6218	0.6248	0.6668	2.3630
-7.5	0.6922	0.7221	0.6332	0.6385	0.7940	2.8880
-7	0.7146	0.7528	0.6474	0.6588	0.9465	3.6760
-6.5	0.7404	0.7911	0.6654	0.6803	1.1305	4.2010
-6	0.7822	0.8239	0.6821	0.7035	1.3233	4.7260
-5.5	0.8138	0.8539	0.7038	0.7304	1.5537	5.2510
-5	0.8453	0.8949	0.7232	0.7466	1.7629	6.0390
-4.5	0.8667	0.9272	0.7497	0.7753	1.9703	6.5640
-4	0.9090	0.9633	0.7681	0.7989	2.1985	7.0890
-3.5	0.9295	1.0007	0.7911	0.8260	2.4397	7.6140
-3	0.9687	1.0435	0.8121	0.8539	2.6942	8.4020
-2.5	1.0078	1.0814	0.8345	0.8813	2.9413	8.9270
-2	1.0472	1.1145	0.8561	0.9067	3.2410	9.4520
-1.5	1.0761	1.1575	0.8769	0.9475	3.5288	10.2400
-1	1.1129	1.1989	0.9040	0.9834	3.8030	10.7650
-0.5	1.1434	1.2380	0.9225	1.0174	4.0330	11.2900
0	1.1838	1.2788	0.9523	1.0435	4.2737	11.8150
0.5	1.2404	1.3297	0.9731	1.0724	4.5323	12.3400
1	1.2975	1.3783	0.9987	1.1211	4.8357	12.8650
1.5	1.3214	1.4380	1.0311	1.1490	5.1543	13.3900

Table C-6. Continued.

2	1.3764	1.4893	1.0539	1.1815	5.4483	14.1780
2.5	1.4298	1.5442	1.0756	1.2231	5.7548	14.7030
3	1.4725	1.6077	1.1003	1.2574	6.0522	15.2280
3.5	1.5334	1.6679	1.1288	1.2943	6.3608	15.7530
4	1.5920	1.7252	1.1614	1.3335	6.6342	16.2780
4.5	1.6326	1.7743	1.1757	1.3750	6.9399	17.0660
5	1.6756	1.8313	1.2207	1.4116	7.2309	17.5910
5.5	1.7156	1.8864	1.2495	1.4871	7.5304	18.1160
6	1.7743	1.9402	1.2739	1.5240	7.8125	18.6410
6.5	1.8154	1.9810	1.3050	1.5794	8.0753	19.1660
7	1.8659	2.0297	1.3425	1.6129	8.3440	19.9540
7.5	1.9062	2.0776	1.3711	1.6609	8.6188	20.4790
8	1.9729	2.1236	1.4096	1.6873	8.8995	21.0040
8.5	2.0179	2.1617	1.4565	1.7331	9.1285	21.5290
9	2.0581	2.2161	1.4725	1.7743	9.3028	22.0540
9.5	2.1132	2.2696	1.5140	1.8088	9.3028	22.5790
10	2.1483	2.3262	1.5457	1.8439	9.9813	23.3670
10.5	2.1849	2.3736	1.5957	1.8795	10.0967	23.8920
11	2.2417	2.4312	1.6326	1.9140	10.2313	24.4170
11.5	2.2947	2.4901	1.6717	1.9649	10.3988	24.9420
12	2.3406	2.5577	1.7101	2.0034	10.5959	25.4670
12.5	2.3965	2.6269	1.7315	2.0370	10.8254	25.9920
13	2.4696	2.7034	1.7670	2.0804	11.0192	26.5170
13.5	2.5237	2.7652	1.7997	2.1340	11.3252	27.3050
14	2.5810	2.8317	1.8405	2.1772	11.4616	27.8300
14.5	2.6405	2.8946	1.8625	2.2289	11.6951	28.3550
15	2.7104	2.9537	1.9001	2.2706	11.9410	28.8800
15.5	2.7758	3.0087	1.9271	2.3201	12.1670	29.4050
16	2.8353	3.0709	1.9587	2.3570	12.4657	30.1930
16.5	2.8995	3.1381	1.9863	2.4217	12.7832	30.7180
17	2.9836	3.1972	2.0070	2.4610	13.0485	31.2430
17.5	3.0302	3.2598	2.0425	2.5183	13.2899	31.7680
18	3.1121	3.3302	2.0813	2.5821	13.5632	32.2930
18.5	3.1839	3.3936	2.1085	2.6382	13.8351	33.0810
19	3.2424	3.4593	2.1464	2.6747	14.1202	33.6060
19.5	3.3084	3.5260	2.1801	2.7452	14.4379	34.1310
20	3.3535	3.5864	2.2122	2.7959	14.7712	34.6560
20.5	3.4242	3.6492	2.2427	2.8582	15.0785	35.4440
21	3.4705	3.7128	2.2887	2.9068	15.3550	35.9690
21.5	3.5131	3.7879	2.3140	2.9636	15.6636	36.4940
22	3.5705	3.8580	2.3622	3.0062	15.9602	37.0190
22.5	3.6184	3.9260	2.4112	3.0569	16.2427	37.8070

Table C-6. Continued.

23	3.6950	4.0060	2.4600	3.1044	16.5337	38.3320
23.5	3.7502	4.0745	2.4944	3.1616	16.8332	38.8570
24	3.8137	4.1422	2.5478	3.2144	17.1153	39.3820
24.5	3.8488	4.2042	2.5888	3.2585	17.4046	39.9070
25	3.9291	4.2753	2.6337	3.3084	17.6740	40.6950
25.5	3.9824	4.3271	2.6632	3.3577	17.9215	41.2200
26	4.0393	4.3913	2.7115	3.4075	18.2023	41.7450
26.5	4.1147	4.4459	2.7523	3.4550	18.4313	42.2700
27	4.1911	4.5149	2.7959	3.5003	18.6641	42.7950
27.5	4.2372	4.5672	2.8353	3.5460	18.8710	43.5830
28	4.3154	4.6200	2.8873	3.6155	19.5154	44.1080
28.5	4.3608	4.6910	2.9142	3.6846	19.5789	44.6330
29	4.4631	4.7449	2.9649	3.7412	19.7026	45.1580
29.5	4.5149	4.7992	2.9886	3.7864	19.8678	45.6830
30	4.5672	4.8357	3.0226	3.8259	20.0302	46.2080
30.5	4.6200	4.9092	3.0632	3.8919	20.2297	46.9960
31	4.7089	4.9650	3.1134	3.9463	20.4401	47.5210
31.5	4.7992	5.0212	3.1381	3.9588	20.6461	48.0460
32	4.8540	5.0779	3.1760	3.9432	20.8717	48.5710
32.5	4.9092	5.1351	3.2104	3.9729	21.0872	49.0960
33	4.9650	5.2121	3.2464	4.0108	21.3321	49.6210
33.5	5.0400	5.2704	3.2881	4.0681	21.5814	50.1460
34	5.1160	5.3292	3.3261	4.1244	21.8534	50.6710
34.5	5.1543	5.4084	3.3467	4.1650	22.1308	51.1960
35	5.2121	5.4684	3.3936	4.2141	22.4156	51.9840
35.5	5.2704	5.5289	3.4298	4.2770	22.7122	52.5090
36	5.3490	5.6102	3.4691	4.3439	22.9696	53.0340
36.5	5.4084	5.6719	3.5145	4.3777	23.2217	53.5590
37	5.4483	5.7340	3.5475	4.4117	23.5087	54.0840
37.5	5.5086	5.8176	3.5879	4.4803	23.8174	54.6090
38	5.5898	5.8809	3.6287	4.5323	24.1220	55.3970
38.5	5.6102	5.9447	3.6624	4.5672	24.4405	55.9220
39	5.6925	6.0091	3.6890	4.6200	24.7308	56.4470
39.5	5.7548	6.0739	3.7322	4.6732	25.0541	56.9720
40	5.8176	6.1611	3.7773	4.7449	25.3447	57.4970
40.5	5.8809	6.2272	3.8030	4.7810	25.6217	58.0220
41	5.9234	6.2937	3.8427	4.8357	25.9312	58.8100
41.5	6.0091	6.3608	3.8873	4.8908	26.2257	59.3350
42	6.0739	6.4284	3.9229	4.9278	26.5032	59.8600
42.5	6.1392	6.4965	3.9745	5.0024	26.7879	60.3850
43	6.2051	6.5651	4.0250	5.0779	27.0531	60.9100
43.5	6.2493	6.6342	4.0633	5.1351	27.3242	61.4350

Table C-6. Continued.

44	6.3160	6.7039	4.0970	5.1735	27.6014	62.2230
44.5	6.3832	6.7506	4.1325	5.2315	27.8560	62.7480
45	6.4510	6.8212	4.1764	5.2900	28.0864	63.2730
45.5	6.5193	6.8685	4.2059	5.3292	28.3207	63.7980
46	6.5651	6.9399	4.2471	5.4084	28.5289	64.3230
46.5	6.6111	6.9878	4.2903	5.4483	28.7400	64.8480
47	6.7039	7.0601	4.3372	5.5086	28.9540	65.3730
47.5	6.7506	7.1086	4.3777	5.5694	28.9540	66.1610
48	6.8212	7.1818	4.4117	5.6102	29.6361	66.6860
48.5	6.8922	7.2555	4.4459	5.6719	29.7398	67.2110
49	6.9399	7.3050	4.4976	5.7132	29.8835	67.7360
49.5	7.0119	7.3547	4.5323	5.7548	30.0467	68.2610
50	7.0601	7.4046	4.5847	5.7966	30.2584	68.7860
50.5	7.1086	7.4547	4.6200	5.8598	30.4638	69.3110
51	7.1818	7.5304	4.6554	5.9021	30.6823	70.0990
51.5	7.2309	7.5812	4.6910	5.9661	30.8933	70.6240
52	7.3050	7.6066	4.7449	6.0522	31.1292	71.1490
52.5	7.3547	7.6578	4.7992	6.0956	31.3884	71.6740
53	7.4296	7.7349	4.8357	6.1174	31.6413	72.1990
53.5	7.4799	7.7866	4.8723	6.1831	31.8990	72.7240
54	7.5558	7.8385	4.9278	6.2272	32.1991	73.5120
54.5	7.6066	7.8907	4.9650	6.2937	32.4900	74.0370
55	7.6578	7.9431	5.0212	6.3160	32.7525	74.5620
55.5	7.7349	7.9958	5.0589	6.3608	33.0141	75.0870
56	7.7607	8.0222	5.0969	6.4284	33.2744	75.6120
56.5	7.8385	8.0753	5.1351	6.4737	33.5740	76.1370
57	7.8646	8.1285	5.1928	6.5421	33.8818	76.9250
57.5	7.9431	8.1820	5.2315	6.5881	34.2049	77.4500
58	7.9958	8.2358	5.2704	6.6574	34.5847	77.9750
58.5	8.0487	8.2627	5.3292	6.6806	34.9416	78.5000
59	8.1019	8.3168	5.3885	6.7506	35.2700	79.0250
59.5	8.1552	8.3440	5.4284	6.7976	35.5651	79.5500
60	8.2358	8.3985	5.4684	6.8448	35.8463	80.0750
60.5	8.2627	8.4258	5.5086	6.8922	36.1358	80.6000
61	8.3168	8.4806	5.5491	6.9399	36.4339	81.3880
61.5	8.3712	8.5081	5.5898	6.9878	36.6889	81.9130
62	8.4258	8.5357	5.6307	7.0360	36.9762	82.4380
62.5	8.4806	8.5910	5.6925	7.0844	37.2709	82.9630
63	8.5357	8.6466	5.7132	7.1574	37.5450	83.4880
63.5	8.5910	8.7024	5.7548	7.2063	37.8252	84.2760
64	8.6466	8.7303	5.7966	7.2555	38.0537	84.8010
64.5	8.6744	8.7865	5.8598	7.3050	38.2860	85.3260

Table C-6. Continued.

65	8.7303	8.8429	5.9021	7.3796	38.4925	85.8510
65.5	8.7865	8.8995	5.9447	7.4046	38.7019	86.3760
66	8.8429	8.9564	5.9661	7.4799	38.9143	86.9010
66.5	8.8995	9.0422	6.0091	7.5304	39.1606	87.6890
67	8.9564	9.0709	6.0522	7.5812	39.4739	88.2140
67.5	8.9850	9.1285	6.0956	7.6322	39.8253	88.7390
68	9.0422	9.1864	6.1392	7.6834	39.8899	89.2640
68.5	9.0997	9.2445	6.1831	7.7349	39.8899	89.7890
69	9.1574	9.3028	6.2051	7.8125	39.9224	90.5770
69.5	9.1864	9.3614	6.2493	7.8385	39.9224	91.1020
70	9.2445	9.4202	6.2937	7.8907	39.9224	91.6270
70.5	9.2736	9.4792	6.3384	7.9431	39.9224	92.1520
71	9.3320	9.5385	6.3608	7.9958	40.6087	92.6770
71.5	9.3614	9.6279	6.4058	8.0222	40.7143	93.2020
72	9.4202	9.6878	6.4510	8.1019	40.8584	93.7270
72.5	9.4497	9.7781	6.4965	8.1285	41.0129	94.2520
73	9.5088	9.8386	6.5193	8.1820	41.2173	95.0400
73.5	9.5683	9.9298	6.5651	8.2358	41.4400	95.5650
74	9.6279	10.0215	6.6111	8.2898	41.6459	96.0900
74.5	9.6578	10.0830	6.6342	8.3440	41.8512	96.6150
75	9.7178	10.1447	6.6806	8.3985	42.0764	97.1400
75.5	9.7781	10.1447	6.7039	8.4532	42.3136	97.6650
76	9.8386	10.8415	6.7506	8.5081	42.5617	98.1900
76.5	9.8689	10.8080	6.7976	8.5357	42.8072	98.9780
77	9.9298	10.8003	6.8212	8.5910	43.0945	99.5030
77.5	9.9603	10.8027	6.8685	8.6466	43.3971	100.0280
78	10.0215	10.8146	6.9161	8.6744	43.6711	100.5530
78.5	10.0522	10.8354	6.9638	8.7303	43.9284	101.0780
79	10.1138	10.8600	6.9878	8.7584	44.1728	101.6030
79.5	10.1756	10.8889	7.0360	8.7865	44.4547	102.1280
80	10.2377	10.9136	7.0601	8.8429	44.7397	102.9160
80.5	10.2999	10.9518	7.1086	8.8712	45.0193	102.9160
81	10.3312	10.9788	7.1330	8.9280	45.1151	102.9160
81.5	10.3625	10.9895	7.1818	8.9564	45.1538	102.9160
82	10.3625	10.9895	7.1818	8.9850	45.1733	102.9160
82.5	10.3625	10.9882	7.1818	9.0135	45.1733	102.9160

Table C-7. Bromide run #6 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6199	0.6026	0.6045	0.5962	0.5670	0.0000
-9.5	0.6199	0.6026	0.6045	0.5962	0.5670	0.5250
-9	0.6222	0.6029	0.6065	0.5962	0.5676	0.5250
-8.5	0.6245	0.6055	0.6087	0.5962	0.5934	0.7880
-8	0.6271	0.6084	0.6107	0.5975	0.7270	0.5250
-7.5	0.6315	0.6133	0.6133	0.5981	0.9058	0.5250
-7	0.6409	0.6232	0.6202	0.5981	1.1079	0.5250
-6.5	0.6588	0.6413	0.6332	0.6013	1.3464	0.7880
-6	0.6771	0.6647	0.6477	0.6117	1.5942	0.5250
-5.5	0.6998	0.6932	0.6703	0.6242	1.8430	0.5250
-5	0.7195	0.7251	0.6831	0.6416	2.0776	0.7880
-4.5	0.7423	0.7500	0.6943	0.6560	2.3612	0.5250
-4	0.7689	0.7854	0.7090	0.6717	2.6382	0.5250
-3.5	0.8001	0.8138	0.7251	0.6907	2.9475	0.5250
-3	0.8290	0.8474	0.7415	0.7127	3.2665	0.5250
-2.5	0.8561	0.8818	0.7610	0.7289	3.5995	0.7880
-2	0.8876	0.9137	0.7765	0.7469	3.8795	0.5250
-1.5	0.9225	0.9427	0.7927	0.7670	4.1601	0.5250
-1	0.9556	0.9740	0.8121	0.7854	4.4631	0.5250
-0.5	0.9839	1.0042	0.8315	0.8159	4.7992	0.5250
0	1.0194	1.0353	0.8566	0.8384	5.1543	0.7880
0.5	1.0618	1.0745	0.8711	0.8561	5.5086	0.5250
1	1.0976	1.1101	0.8903	0.8773	5.8387	0.5250
1.5	1.1217	1.1479	0.9169	0.9045	6.1611	0.5250
2	1.1535	1.1867	0.9361	0.9328	6.5193	0.7880
2.5	1.1896	1.2237	0.9614	0.9604	6.8448	0.5250
3	1.2213	1.2574	0.9740	0.9878	7.1574	0.5250
3.5	1.2543	1.2987	0.9967	1.0224	7.4799	0.7880
4	1.2906	1.3445	1.0179	1.0446	7.8125	0.5250
4.5	1.3310	1.3982	1.0383	1.0687	8.1552	0.5250
5	1.3646	1.4614	1.0629	1.0933	8.4532	0.5250
5.5	1.4123	1.5176	1.0965	1.1222	8.7584	0.5250
6	1.4593	1.5698	1.1112	1.1450	9.0422	0.7880
6.5	1.4991	1.6288	1.1428	1.1884	9.2736	0.5250
7	1.5291	1.6717	1.1603	1.2237	9.5088	0.5250
7.5	1.5772	1.7220	1.2106	1.2477	1.1838	0.7880
8	1.6174	1.7662	1.2278	1.2764	0.8030	0.5250
8.5	1.6756	1.8138	1.2574	1.3144	0.9451	0.5250
9	1.7188	1.8523	1.2776	1.3483	1.1372	0.5250
9.5	1.7597	1.8941	1.2956	1.3737	1.3561	0.5250

Table C-7. Continued.

10	1.7948	1.9393	1.3335	1.4163	1.6227	0.7880
10.5	1.8204	1.9845	1.3522	1.4510	1.8372	0.5250
11	1.8667	2.0179	1.3816	1.4752	2.0935	0.5250
11.5	1.9019	2.0628	1.4002	1.5076	2.3622	0.5250
12	1.9393	2.1151	1.4380	1.5413	2.6621	0.5250
12.5	1.9756	2.1589	1.4850	1.5942	2.9649	0.7880
13	2.0215	2.2083	1.5133	1.6167	3.2895	0.5250
13.5	2.0628	2.2566	1.5522	1.6532	3.6243	0.5250
14	2.0981	2.3079	1.5749	1.6873	3.9541	0.5250
14.5	2.1435	2.3591	1.6077	1.7180	4.2339	0.7880
15	2.1762	2.4112	1.6273	1.7548	4.5323	0.5250
15.5	2.2151	2.4675	1.6555	1.7882	4.8540	0.5250
16	2.2487	2.5150	1.6857	1.8138	5.1928	0.5250
16.5	2.2988	2.5799	1.6998	1.8388	5.5694	0.7880
17	2.3467	2.6371	1.7315	1.8847	5.9234	0.5250
17.5	2.3913	2.6965	1.7670	1.9157	6.2937	0.5250
18	2.4376	2.7534	1.7898	1.9481	6.6111	0.5250
18.5	2.5020	2.8161	1.8138	1.9720	6.9638	0.5250
19	2.5500	2.8776	1.8414	2.0007	7.3050	0.7880
19.5	2.5989	2.9351	1.8693	2.0324	7.6066	0.5250
20	2.6598	2.9861	1.9097	2.0665	7.9431	0.5250
20.5	2.7196	3.0429	1.9218	2.1019	8.2627	0.7880
21	2.7664	3.0953	1.9508	2.1369	8.5910	0.5250
21.5	2.8317	3.1564	1.9818	2.1656	8.8712	0.5250
22	2.9044	3.2104	2.0061	2.2053	9.1574	0.5250
22.5	2.9674	3.2665	2.0352	2.2437	9.3907	0.5250
23	3.0200	3.3248	2.0581	2.2857	9.6279	0.7880
23.5	3.0632	3.3825	2.0757	2.3283	9.8689	0.5250
24	3.1095	3.4410	2.1170	2.3694	10.1138	0.5250
24.5	3.1629	3.5003	2.1445	2.4175	10.3938	0.5250
25	3.2197	3.5575	2.1714	2.4632	2.1170	0.5250
25.5	3.2692	3.6170	2.1898	2.5041	0.7520	0.7880
26	3.3125	3.6713	2.2132	2.5368	0.9003	0.5250
26.5	3.3508	3.7322	2.2467	2.5777	1.0852	0.5250
27	3.3936	3.7985	2.2796	2.6213	1.3163	0.5250
27.5	3.4354	3.8611	2.3150	2.6644	1.5581	0.5250
28	3.4804	3.9213	2.3457	2.7301	1.8063	0.7880
28.5	3.5303	3.9776	2.3944	2.7687	2.0306	0.5250
29	3.5705	4.0409	2.4397	2.8030	2.3272	0.5250
29.5	3.6170	4.1002	2.4707	2.8497	2.6045	0.5250
30	3.6624	4.1568	2.4987	2.8910	2.8788	0.5250
30.5	3.6964	4.2026	2.5161	2.9228	3.1695	0.7880

Table C-7. Continued.

31	3.7427	4.2537	2.5489	2.9649	3.5460	0.5250
31.5	3.7985	4.3087	2.6101	2.9999	3.8641	0.5250
32	3.8442	4.3676	2.6450	3.0352	4.1455	0.5250
32.5	3.8981	4.4288	2.6838	3.0825	4.4631	0.5250
33	3.9432	4.4631	2.7057	3.1225	4.7629	0.7880
33.5	3.9934	4.5323	2.7406	3.1524	5.1351	0.5250
34	4.0521	4.5847	2.7699	3.1919	5.5086	0.5250
34.5	4.0986	4.6376	2.8149	3.2357	5.8387	0.7880
35	4.1536	4.6732	2.8485	3.2719	6.2051	0.5250
35.5	4.1977	4.7269	2.8922	3.3098	6.5651	0.5250
36	4.2587	4.7810	2.9388	3.3426	6.8922	0.5250
36.5	4.3087	4.8357	2.9450	3.3797	7.2309	0.5250
37	4.3608	4.8723	2.9636	3.4200	7.5558	0.5250
37.5	4.4288	4.9278	3.0074	3.4593	7.8646	0.7880
38	4.4803	4.9837	3.0213	3.5017	8.2089	0.5250
38.5	4.5149	5.0589	3.0799	3.5389	8.5357	0.5250
39	4.5672	5.0969	3.0966	3.5835	8.8147	0.5250
39.5	4.6376	5.1543	3.1368	3.6141	9.0997	0.7880
40	4.6910	5.2315	3.1760	3.6507	9.3614	0.5250
40.5	4.7449	5.2900	3.1985	3.6979	0.6980	0.5250
41	4.7810	5.3490	3.2170	3.7277	0.7854	0.5250
41.5	4.8540	5.4084	3.2679	3.7743	0.9585	0.5250
42	4.9092	5.4684	3.2746	3.8182	1.1586	0.5250
42.5	4.9463	5.5491	3.3112	3.8580	1.3909	0.7880
43	5.0024	5.6102	3.3412	3.8965	1.6679	0.5250
43.5	5.0589	5.6719	3.3659	3.9400	1.8941	0.5250
44	5.1160	5.7340	3.4256	3.9792	2.1772	0.5250
44.5	5.1735	5.7966	3.4424	4.0266	2.4610	0.7880
45	5.2121	5.8598	3.4861	4.0697	2.7417	0.5250
45.5	5.2704	5.9234	3.5145	4.1066	3.0569	0.5250
46	5.3096	5.9661	3.5389	4.1471	3.3839	0.5250
46.5	5.3687	6.0306	3.5835	4.1895	3.7083	0.7880
47	5.4284	6.0956	3.6111	4.2339	4.0330	0.5250
47.5	5.4684	6.1611	3.6521	4.2820	4.3087	0.5250
48	5.5086	6.2051	3.6950	4.3288	4.6376	0.5250
48.5	5.5694	6.2715	3.7517	4.3676	4.9650	0.5250
49	5.6307	6.3384	3.7698	4.4288	5.3490	0.7880
49.5	5.6513	6.4058	3.8030	4.4631	5.7132	0.5250
50	5.7340	6.4737	3.8411	4.4976	6.0739	0.5250
50.5	5.7757	6.5193	3.8718	4.5323	6.4058	0.5250
51	5.8176	6.5651	3.8919	4.5672	6.7272	0.7880
51.5	5.8598	6.6342	3.9074	4.6200	7.0844	0.5250

Table C-7. Continued.

52	5.9234	6.7039	3.9698	4.6554	7.4296	0.5250
52.5	5.9876	6.7506	4.0060	4.7089	7.7349	0.5250
53	6.0306	6.8212	4.0489	4.7629	8.0487	0.5250
53.5	6.0956	6.8685	4.0697	4.7992	8.3712	0.5250
54	6.1392	6.9161	4.1098	4.8540	8.6744	0.7880
54.5	6.1831	6.9638	4.1422	4.8908	8.9850	0.5250
55	6.2272	7.0360	4.1895	4.9278	9.2445	0.5250
55.5	6.2715	7.0844	4.2174	4.9650	9.5088	0.5250
56	6.3160	7.1330	4.2488	5.0024	9.6878	0.5250
56.5	6.3832	7.1818	4.2488	5.0589	1.2344	0.7880
57	6.4284	7.2555	4.3372	5.1160	0.7806	0.5250
57.5	6.4737	7.3298	4.3507	5.1735	0.9422	0.5250
58	6.5193	7.3796	4.3930	5.2121	1.1518	0.5250
58.5	6.5881	7.4296	4.4288	5.2509	1.3829	0.5250
59	6.6342	7.4547	4.4631	5.3096	1.6190	0.7880
59.5	6.6806	7.5304	4.4803	5.3490	1.8633	0.5250
60	6.7506	7.5812	4.5323	5.3885	2.0916	0.5250
60.5	6.7976	7.6322	4.5672	5.4284	2.4017	0.5250
61	6.8448	7.6578	4.6023	5.4684	2.6701	0.7880
61.5	6.8922	7.7091	4.6200	5.5086	2.9661	0.5250
62	6.9638	7.7607	4.6554	5.5491	3.3084	0.5250
62.5	7.0119	7.8125	4.6732	5.5898	3.6301	0.5250
63	7.0601	7.8646	4.7269	5.6307	3.9291	0.5250
63.5	7.1086	7.9169	4.7629	5.6719	4.2174	0.7880
64	7.1574	7.9431	4.7992	5.7132	4.4976	0.5250
64.5	7.2063	8.0222	4.8357	5.7757	4.8540	0.5250
65	7.2555	8.0487	4.8540	5.7966	5.2121	0.5250
65.5	7.3298	8.1019	4.8908	5.8598	5.5898	0.5250
66	7.3547	8.1285	4.9278	5.9021	5.9021	0.7880
66.5	7.4046	8.1820	4.9463	5.9234	6.2493	0.5250
67	7.4547	8.2089	5.0024	5.9876	6.5651	0.5250
67.5	7.5051	8.2627	5.0400	6.0306	6.9161	0.5250
68	7.5558	8.2898	5.0779	6.0739	7.2309	0.7880
68.5	7.6066	8.3440	5.1160	6.1174	7.5812	0.5250
69	7.6578	8.3712	5.1543	6.1392	7.9169	0.5250
69.5	7.6834	8.4258	5.1928	6.1831	8.2089	0.5250
70	7.7349	8.4532	5.2315	6.2272	8.5357	0.5250
70.5	7.7866	8.4806	5.2509	6.2715	8.8147	0.7880
71	7.8385	8.5081	5.2900	6.2937	9.0709	0.5250
71.5	7.8907	8.5357	5.3292	6.3608	9.3614	0.5250
72	7.9169	8.5910	5.3687	6.4058	0.6849	0.5250
72.5	7.9694	8.6188	5.4084	6.4284	0.7642	0.5250

Table C-7. Continued.

73	8.0222	8.6466	5.4483	6.4737	0.9290	0.7880
73.5	8.0753	8.7024	5.4885	6.5193	1.1239	0.5250
74	8.1019	8.7303	5.5289	6.5651	1.3567	0.5250
74.5	8.1552	8.7584	5.5694	6.6111	1.6137	0.5250
75	8.2089	8.8147	5.6102	6.6342	1.8388	0.5250
75.5	8.2627	8.8712	5.6307	6.7039	2.0637	0.7880
76	8.3168	8.8995	5.6513	6.7272	2.3498	0.5250
76.5	8.3712	8.9564	5.6925	6.7741	2.6146	0.5250
77	8.3985	9.0135	5.7340	6.8212	2.9130	0.5250
77.5	8.4532	9.0709	5.7548	6.8685	3.2237	0.7880
78	8.4806	9.0997	5.7966	6.8922	3.5662	0.5250
78.5	8.5357	9.1574	5.8387	6.9399	3.8765	0.5250
79	8.5910	9.2154	5.9021	6.9878	4.1487	0.5250
79.5	8.6188	9.2736	5.9447	7.0119	4.4631	0.7880
80	8.6466	9.3028	5.9661	7.0601	4.7629	0.5250
80.5	8.6744	9.3614	6.0091	7.0844	5.0969	0.5250
81	8.7303	9.4202	6.0306	7.1330	5.4084	0.2630
81.5	8.7584	9.4497	6.0522	7.1818	5.5289	0.0000
82	8.7865	9.4792	6.0956	7.2309	5.5694	0.0000
82.5	8.7865	9.4792	6.0956	7.2802	5.5694	0.0000
83	8.7865	9.4792	6.1174	7.2802	5.5694	0.0000
83.5	8.7865	9.4792	6.1174	7.2802	5.5694	0.0000
84	8.7865	9.5088	6.1174	7.2802	5.5694	0.0000
84.5	8.7865	9.5088	6.1174	7.2802	5.5898	0.0000
85	8.7865	9.5088	6.1174	7.2802	5.5898	0.0000
85.5	8.7865	9.5088	6.1174	7.2802	5.5898	0.0000
86	8.7865	9.5088	6.1174	7.2802	5.5898	0.0000
86.5	8.7865	9.5088	6.1392	7.2802	5.5898	0.0000

Table C-8. Bromide run #7 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6242	0.6049	0.6285	0.5962	0.5510	0.0000
-9.5	0.6245	0.6062	0.6322	0.5962	0.5510	0.5250
-9	0.6268	0.6097	0.6423	0.5962	0.5531	0.5250
-8.5	0.6271	0.6127	0.6440	0.5969	0.5956	0.5250
-8	0.6301	0.6159	0.6450	0.5972	0.7213	0.7880
-7.5	0.6325	0.6228	0.6470	0.5972	0.9160	0.5250
-7	0.6433	0.6318	0.6474	0.5985	1.1439	0.5250
-6.5	0.6553	0.6426	0.6539	0.6001	1.4183	0.5250
-6	0.6651	0.6556	0.6647	0.6007	1.6873	0.7880

Table C-8. Continued.

-5.5	0.6813	0.6742	0.6774	0.6039	1.9367	0.5250
-5	0.6962	0.6962	0.6893	0.6127	2.2666	0.5250
-4.5	0.7105	0.7127	0.7057	0.6228	2.5777	0.5250
-4	0.7285	0.7419	0.7153	0.6338	2.8800	0.5250
-3.5	0.7543	0.7642	0.7342	0.6494	3.2491	0.7880
-3	0.7850	0.7895	0.7481	0.6640	3.5980	0.5250
-2.5	0.8117	0.8201	0.7638	0.6817	3.8950	0.5250
-2	0.8341	0.8431	0.7745	0.6980	4.1911	0.5250
-1.5	0.8522	0.8724	0.7927	0.7120	4.5323	0.5250
-1	0.8760	0.8999	0.8067	0.7297	4.9092	0.5250
-0.5	0.9049	0.9253	0.8243	0.7504	5.2900	0.7880
0	0.9304	0.9441	0.8414	0.7681	5.6513	0.5250
0.5	0.9551	0.9667	0.8566	0.7862	5.9661	0.5250
1	0.9799	0.9942	0.8773	0.8047	6.3384	0.5250
1.5	1.0148	1.0276	0.8967	0.8231	6.6806	0.5250
2	1.0353	1.0545	0.9188	0.8431	6.9878	0.5250
2.5	1.0602	1.0804	0.9347	0.8596	7.3796	0.7880
3	1.0960	1.1107	0.9456	0.8782	7.7349	0.5250
3.5	1.1134	1.1434	0.9648	0.8999	8.1019	0.5250
4	1.1512	1.1700	0.9873	0.9197	8.4258	0.5250
4.5	1.1666	1.1966	0.9977	0.9375	8.7584	0.5250
5	1.1908	1.2231	1.0133	0.9595	9.0135	0.5250
5.5	1.2201	1.2616	1.0301	0.9740	9.0709	0.5250
6	1.2513	1.2962	1.0555	1.0098	4.4976	0.7880
6.5	1.2739	1.3240	1.0666	1.0291	0.6932	0.5250
7	1.3019	1.3606	1.0890	1.0435	0.8218	0.5250
7.5	1.3483	1.4062	1.1014	1.0687	1.0174	0.5250
8	1.3829	1.4558	1.1339	1.0890	1.2398	0.5250
8.5	1.4055	1.4942	1.1450	1.1047	1.5076	0.5250
9	1.4441	1.5479	1.1706	1.1305	1.7653	0.5250
9.5	1.4879	1.5905	1.1850	1.1535	2.0324	0.5250
10	1.5198	1.6410	1.2154	1.1821	2.3488	0.5250
10.5	1.5537	1.6694	1.2398	1.2077	2.6678	0.5250
11	1.5883	1.7148	1.2574	1.2231	2.9786	0.7880
11.5	1.6174	1.7516	1.2801	1.2410	3.3180	0.5250
12	1.6478	1.7849	1.3050	1.2696	3.6890	0.5250
12.5	1.6857	1.8121	1.3284	1.3031	4.0029	0.5250
13	1.7315	1.8481	1.3554	1.3316	4.3187	0.5250
13.5	1.7532	1.8847	1.3829	1.3522	4.6554	0.5250
14	1.7997	1.9236	1.4123	1.3849	5.0589	0.5250
14.5	1.8229	1.9561	1.4400	1.4076	5.4684	0.7880
15	1.8633	1.9845	1.4773	1.4407	5.8176	0.5250

Table C-8. Continued

15.5	1.8872	2.0124	1.5005	1.4718	6.2272	0.5250
16	1.9244	2.0462	1.5219	1.4900	6.5651	0.5250
16.5	1.9587	2.0795	1.5457	1.5219	6.9399	0.5250
17	1.9980	2.1104	1.5838	1.5530	7.3050	0.7880
17.5	2.0224	2.1502	1.6122	1.5764	7.6834	0.5250
18	2.0480	2.1820	1.6356	1.6114	8.0222	0.5250
18.5	2.0748	2.2259	1.6640	1.6341	8.3440	0.5250
19	2.1160	2.2726	1.6912	1.6609	8.7024	0.5250
19.5	2.1483	2.3099	1.7148	1.6826	9.0135	0.5250
20	2.1820	2.3519	1.7387	1.7085	9.2736	0.7880
20.5	2.2063	2.3819	1.7443	1.7411	9.6578	0.5250
21	2.2437	2.4154	1.7670	1.7686	0.7972	0.5250
21.5	2.2686	2.4546	1.7907	1.7857	0.8273	0.5250
22	2.3038	2.5106	1.8263	1.8055	0.9883	0.5250
22.5	2.3498	2.5489	1.8422	1.8355	1.2219	0.5250
23	2.3850	2.5989	1.8752	1.8565	1.4907	0.7880
23.5	2.4281	2.6416	1.9045	1.8855	1.7572	0.5250
24	2.4761	2.6907	1.9306	1.9088	2.0133	0.5250
24.5	2.5074	2.7394	1.9516	1.9384	2.3477	0.5250
25	2.5555	2.7864	1.9774	1.9587	2.6337	0.5250
25.5	2.5989	2.8305	1.9980	1.9845	2.9512	0.5250
26	2.6439	2.8703	2.0206	2.0097	3.2881	0.7880
26.5	2.6724	2.9167	2.0434	2.0416	3.6565	0.5250
27	2.7104	2.9537	2.0711	2.0730	3.9918	0.5250
27.5	2.7570	2.9961	2.1000	2.0991	4.3120	0.5250
28	2.8018	3.0314	2.1293	2.1236	4.6554	0.5250
28.5	2.8521	3.0735	2.1637	2.1627	5.0212	0.7880
29	2.8995	3.1212	2.1839	2.1927	5.4084	0.5250
29.5	2.9549	3.1695	2.2083	2.2161	5.7966	0.5250
30	2.9986	3.2131	2.2289	2.2487	6.1611	0.5250
30.5	3.0403	3.2544	2.2537	2.2706	6.5421	0.5250
31	3.0799	3.3016	2.2877	2.3008	6.8922	0.7880
31.5	3.1342	3.3467	2.3150	2.3303	7.2555	0.5250
32	3.1642	3.3797	2.3272	2.3622	7.6066	0.5250
32.5	3.2038	3.4144	2.3643	2.3955	7.9694	0.5250
33	3.2424	3.4550	2.3798	2.4049	8.2898	0.5250
33.5	3.2800	3.5088	2.4165	2.4334	8.6188	0.5250
34	3.3139	3.5590	2.4472	2.4739	8.9280	0.7880
34.5	3.3549	3.5951	2.4675	2.4998	9.2154	0.5250
35	3.3922	3.6374	2.5085	2.5281	9.4497	0.5250
35.5	3.4354	3.6742	2.5423	2.5688	3.4480	0.5250
36	3.4649	3.7247	2.5766	2.6000	0.7489	0.5250

Table C-8. Continued

36.5	3.5017	3.7667	2.5989	2.6337	0.9137	0.7880
37	3.5274	3.8304	2.6292	2.6530	1.1266	0.5250
37.5	3.5691	3.8734	2.6575	2.6953	1.3626	0.5250
38	3.6068	3.9229	2.6884	2.7266	1.6478	0.5250
38.5	3.6374	3.9698	2.7104	2.7546	1.8984	0.5250
39	3.6772	4.0108	2.7243	2.7876	2.1820	0.5250
39.5	3.7009	4.0601	2.7876	2.8209	2.4868	0.7880
40	3.7277	4.1050	2.8090	2.8546	2.7959	0.5250
40.5	3.7577	4.1471	2.8389	2.8849	3.1212	0.5250
41	3.7894	4.1879	2.8654	2.9105	3.4946	0.5250
41.5	3.8442	4.2322	2.9019	2.9376	3.8611	0.5250
42	3.8795	4.2670	2.9203	2.9711	4.1764	0.7880
42.5	3.9182	4.3104	2.9636	3.0125	4.4976	0.5250
43	3.9604	4.3524	2.9836	3.0403	4.8908	0.5250
43.5	4.0108	4.3913	3.0150	3.0658	5.2704	0.5250
44	4.0425	4.4288	3.0505	3.0979	5.6719	0.5250
44.5	4.1034	4.4803	3.0786	3.1264	6.0522	0.5250
45	4.1373	4.5149	3.1069	3.1669	6.4058	0.5250
45.5	4.1813	4.5497	3.1407	3.1972	6.7506	0.5250
46	4.2306	4.6023	3.1669	3.2210	7.1330	0.7880
46.5	4.2803	4.6376	3.2011	3.2450	7.4799	0.5250
47	4.3104	4.6910	3.2210	3.2813	7.8646	0.5250
47.5	4.3608	4.7089	3.2491	3.3112	8.2089	0.5250
48	4.4117	4.7449	3.2935	3.3563	8.5081	0.5250
48.5	4.4459	4.7992	3.3289	3.3963	8.8429	0.7880
49	4.4976	4.8540	3.3508	3.4172	9.0997	0.5250
49.5	4.5497	4.8908	3.3811	3.4452	1.9123	0.5250
50	4.5847	4.9278	3.4144	3.4720	0.7681	0.5250
50.5	4.6200	4.9650	3.4340	3.5103	0.9229	0.5250
51	4.6732	5.0024	3.4748	3.5374	1.1316	0.5250
51.5	4.7089	5.0400	3.5031	3.5734	1.4042	0.7880
52	4.7629	5.0969	3.5374	3.6039	1.6686	0.5250
52.5	4.7992	5.1351	3.5763	3.6462	1.9552	0.5250
53	4.8540	5.1928	3.5879	3.6816	2.2328	0.5250
53.5	4.8908	5.2315	3.6287	3.7068	2.5281	0.5250
54	4.9463	5.2704	3.6580	3.7502	2.8257	0.7880
54.5	4.9837	5.3292	3.6757	3.7803	3.1564	0.5250
55	5.0400	5.3885	3.7128	3.8030	3.5274	0.5250
55.5	5.0779	5.4284	3.7487	3.8411	3.8503	0.5250
56	5.1160	5.4684	3.7833	3.8672	4.1764	0.5250
56.5	5.1735	5.5289	3.8152	3.9089	4.4976	0.5250
57	5.1928	5.5694	3.8365	3.9385	4.8357	0.5250

Table C-8. Continued

57.5	5.2509	5.6307	3.8780	3.9839	5.2509	0.5250
58	5.2704	5.6719	3.9120	4.0139	5.6513	0.7880
58.5	5.3292	5.7132	3.9291	4.0425	6.0306	0.5250
59	5.3687	5.7757	3.9729	4.0761	6.4058	0.5250
59.5	5.4084	5.8176	3.9997	4.1082	6.7506	0.5250
60	5.4483	5.8809	4.0362	4.1422	7.1086	0.5250
60.5	5.4885	5.9021	4.0601	4.1846	7.4547	0.5250
61	5.5289	5.9447	4.0841	4.2092	7.8125	0.7880
61.5	5.5694	6.0091	4.1179	4.2405	8.1552	0.5250
62	5.6102	6.0522	4.1536	4.2720	8.5081	0.5250
62.5	5.6513	6.1174	4.1731	4.3037	8.7865	0.5250
63	5.6925	6.1611	4.2042	4.3524	9.0422	0.5250
63.5	5.7340	6.2051	4.2421	4.3862	3.0226	0.5250
64	5.7757	6.2493	4.2753	4.4117	0.7285	0.5250
64.5	5.8387	6.3160	4.3053	4.4459	0.8813	0.7880
65	5.8809	6.3384	4.3372	4.4803	1.0798	0.5250
65.5	5.9234	6.4058	4.3727	4.5323	1.3107	0.5250
66	5.9447	6.4284	4.3947	4.5672	1.5794	0.5250
66.5	5.9876	6.4737	4.4288	4.5847	1.8254	0.5250
67	6.0306	6.5193	4.4459	4.6200	2.1094	0.7880
67.5	6.0739	6.5651	4.4976	4.6554	2.3934	0.5250
68	6.1174	6.6111	4.5323	4.6910	2.7196	0.5250
68.5	6.1611	6.6574	4.5497	4.7269	3.0314	0.5250
69	6.1831	6.7039	4.5847	4.7810	3.3950	0.5250
69.5	6.2272	6.7506	4.6200	4.8174	3.7472	0.7880
70	6.2937	6.7976	4.6376	4.8540	4.0441	0.5250
70.5	6.3160	6.8212	4.6732	4.8723	4.3743	0.5250
71	6.3608	6.8685	4.7089	4.9092	4.7269	0.5250
71.5	6.4058	6.9161	4.7449	4.9278	5.0779	0.5250
72	6.4510	6.9399	4.7629	4.9650	5.4885	0.7880
72.5	6.4965	6.9878	4.7992	5.0212	5.8809	0.5250
73	6.5193	7.0360	4.8357	5.0589	6.2272	0.5250
73.5	6.5651	7.0844	4.8723	5.0969	6.6111	0.5250
74	6.6111	7.1818	4.9092	5.1351	6.9638	0.5250
74.5	6.6574	7.2309	4.9278	5.1543	7.3298	0.5250
75	6.7039	7.2802	4.9463	5.1928	7.6834	0.5250
75.5	6.7272	7.3298	4.9837	5.2315	8.0222	0.5250
76	6.7741	7.3547	5.0024	5.2704	8.3168	0.7880
76.5	6.8212	7.3796	5.0400	5.3096	8.6466	0.5250
77	6.8685	7.4296	5.0969	5.3292	8.9280	0.5250
77.5	6.9161	7.4547	5.1351	5.3687	9.1864	0.5250
78	6.9399	7.5051	5.1735	5.4084	6.6111	0.5250

Table C-8. Continued

78.5	6.9878	7.5558	5.2121	5.4483	0.7466	0.7880
79	7.0119	7.5812	5.2509	5.4684	0.8337	0.5250
79.5	7.0601	7.6066	5.2704	5.5086	1.0184	0.5250
80	7.0844	7.6578	5.3096	5.5491	1.2338	0.5250
80.5	7.1330	7.6834	5.3292	5.5694	1.4879	0.5250
81	7.1574	7.7091	5.3687	5.5898	1.6129	0.0000
81.5	7.1818	7.7349	5.3885	5.6307	1.6448	0.0000
82	7.2063	7.7607	5.4084	5.6719	1.6402	0.0000
82.5	7.2063	7.7607	5.4084	5.6925	1.6410	0.0000
83	7.2063	7.7607	5.4084	5.7132	1.6402	0.0000
83.5	7.2063	7.7607	5.4284	5.7132	1.6371	0.0000
84	7.2063	7.7607	5.4284	5.7132	1.6364	0.0000
84.5	7.2063	7.7607	5.4284	5.7132	1.6371	0.0000
85	7.2063	7.7607	5.4284	5.7132	1.6356	0.0000
85.5	7.2063	7.7607	5.4483	5.7132	1.6318	0.0000
86	7.2063	7.7607	5.4483	5.7132	1.6303	0.0000
86.5	7.2063	7.7607	5.4483	5.7132	1.6311	0.0000

Table C-9. Bromide run #8 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6332	0.6133	0.6078	0.6068	0.5627	0.0000
-9.5	0.6332	0.6133	0.6087	0.6068	0.5624	0.2630
-9	0.6332	0.6133	0.6113	0.6068	0.5627	0.7880
-8.5	0.6332	0.6133	0.6113	0.6068	0.5630	1.3130
-8	0.6332	0.6133	0.6110	0.6068	0.5636	1.8380
-7.5	0.6332	0.6140	0.6117	0.6068	0.6068	2.3630
-7	0.6332	0.6149	0.6104	0.6068	0.8193	2.8880
-6.5	0.6332	0.6153	0.6110	0.6068	1.1512	3.4130
-6	0.6332	0.6153	0.6110	0.6068	1.5327	3.9380
-5.5	0.6342	0.6153	0.6110	0.6068	1.8898	4.4630
-5	0.6352	0.6153	0.6097	0.6068	2.3252	4.7260
-4.5	0.6352	0.6176	0.6097	0.6071	2.7628	5.2510
-4	0.6352	0.6176	0.6094	0.6068	3.2304	5.7760
-3.5	0.6352	0.6176	0.6097	0.6071	3.7352	6.3010
-3	0.6352	0.6176	0.6087	0.6084	4.1650	6.8260
-2.5	0.6352	0.6176	0.6087	0.6075	4.6200	7.3510
-2	0.6369	0.6176	0.6087	0.6081	5.1351	7.8760
-1.5	0.6375	0.6176	0.6094	0.6084	5.6719	8.4010
-1	0.6375	0.6195	0.6110	0.6087	6.1392	8.9260

Table C-9. Continued

-0.5	0.6375	0.6199	0.6110	0.6081	6.6342	9.4510
0	0.6379	0.6199	0.6110	0.6084	7.1086	9.9760
0.5	0.6399	0.6202	0.6110	0.6078	7.5812	10.5010
1	0.6406	0.6212	0.6110	0.6087	8.0222	11.0260
1.5	0.6419	0.6222	0.6130	0.6087	8.5081	11.5510
2	0.6426	0.6245	0.6130	0.6087	8.9280	12.0760
2.5	0.6460	0.6265	0.6136	0.6087	9.2445	12.6010
3	0.6464	0.6271	0.6149	0.6087	0.7195	13.1260
3.5	0.6470	0.6275	0.6143	0.6087	0.8561	13.6510
4	0.6488	0.6315	0.6146	0.6087	1.1389	14.1760
4.5	0.6525	0.6332	0.6169	0.6087	1.5041	14.7010
5	0.6532	0.6342	0.6176	0.6087	1.8548	15.2260
5.5	0.6560	0.6355	0.6172	0.6087	2.2736	15.4890
6	0.6598	0.6389	0.6182	0.6087	2.7104	16.0140
6.5	0.6626	0.6416	0.6212	0.6087	3.1642	16.5390
7	0.6640	0.6416	0.6205	0.6100	3.6331	17.0640
7.5	0.6640	0.6447	0.6199	0.6097	4.0761	17.5890
8	0.6703	0.6481	0.6222	0.6094	4.5323	18.1140
8.5	0.6732	0.6515	0.6235	0.6107	5.0779	18.6390
9	0.6742	0.6515	0.6245	0.6097	5.6102	19.1640
9.5	0.6756	0.6546	0.6265	0.6100	6.1392	19.6890
10	0.6781	0.6584	0.6281	0.6097	6.6574	20.2140
10.5	0.6821	0.6626	0.6298	0.6107	7.1818	20.7390
11	0.6871	0.6640	0.6332	0.6110	7.6322	21.2640
11.5	0.6853	0.6637	0.6338	0.6104	8.1552	21.7890
12	0.6903	0.6682	0.6342	0.6113	8.6188	22.0520
12.5	0.6943	0.6735	0.6382	0.6110	9.0709	22.5770
13	0.6958	0.6760	0.6402	0.6110	9.5088	23.1020
13.5	0.6998	0.6785	0.6433	0.6117	3.1212	23.6270
14	0.7020	0.6835	0.6512	0.6133	0.7670	24.1520
14.5	0.7050	0.6871	0.6505	0.6133	0.9967	24.6770
15	0.7098	0.6929	0.6577	0.6133	1.3278	25.2020
15.5	0.7127	0.6976	0.6584	0.6133	1.6951	25.7270
16	0.7157	0.6983	0.6598	0.6133	2.0416	26.2520
16.5	0.7187	0.6991	0.6595	0.6136	2.4440	26.7770
17	0.7202	0.7035	0.6612	0.6136	2.8873	27.3020
17.5	0.7262	0.7075	0.6689	0.6143	3.3673	27.8270
18	0.7274	0.7105	0.6700	0.6162	3.8765	28.3520
18.5	0.7339	0.7142	0.6724	0.6162	4.2803	28.8770
19	0.7388	0.7187	0.6703	0.6176	4.7629	29.1400
19.5	0.7442	0.7221	0.6778	0.6179	5.3096	29.6650
20	0.7489	0.7262	0.6838	0.6182	5.8598	30.1900

Table C-9. Continued

20.5	0.7532	0.7346	0.6813	0.6199	6.3608	30.7150
21	0.7575	0.7323	0.6828	0.6208	6.8448	31.2400
21.5	0.7606	0.7342	0.6849	0.6208	7.3547	31.7650
22	0.7654	0.7400	0.6907	0.6218	7.8385	32.2900
22.5	0.7658	0.7442	0.6903	0.6238	8.2627	32.8150
23	0.7693	0.7497	0.6947	0.6265	8.7303	33.3400
23.5	0.7733	0.7532	0.6932	0.6268	9.1864	33.6030
24	0.7765	0.7575	0.7038	0.6285	9.5980	34.1280
24.5	0.7826	0.7630	0.7057	0.6308	6.3832	34.6530
25	0.7862	0.7697	0.7031	0.6322	0.7415	35.1780
25.5	0.7907	0.7701	0.7094	0.6365	0.9600	35.7030
26	0.7935	0.7737	0.7116	0.6355	1.2368	36.2280
26.5	0.7944	0.7761	0.7131	0.6372	1.6114	36.7530
27	0.7985	0.7793	0.7112	0.6355	1.9472	37.2780
27.5	0.8030	0.7854	0.7187	0.6385	2.3447	37.8030
28	0.8076	0.7866	0.7191	0.6399	2.7675	38.3280
28.5	0.8121	0.7931	0.7232	0.6416	3.2384	38.8530
29	0.8180	0.7976	0.7308	0.6447	3.7562	39.3780
29.5	0.8214	0.7993	0.7304	0.6457	4.1503	39.9030
30	0.8286	0.8071	0.7350	0.6488	4.6023	40.4280
30.5	0.8298	0.8047	0.7331	0.6505	5.0969	40.9530
31	0.8328	0.8105	0.7361	0.6532	5.6307	41.4780
31.5	0.8388	0.8142	0.7373	0.6522	6.0956	42.0030
32	0.8444	0.8172	0.7388	0.6553	6.6111	42.5280
32.5	0.8492	0.8226	0.7442	0.6598	7.1086	42.7910
33	0.8548	0.8247	0.7481	0.6616	7.5812	43.3160
33.5	0.8579	0.8281	0.7481	0.6616	8.0487	43.8410
34	0.8605	0.8315	0.7504	0.6612	8.4806	44.3660
34.5	0.8649	0.8367	0.7536	0.6661	8.9280	44.8910
35	0.8684	0.8379	0.7543	0.6686	9.3614	45.4160
35.5	0.8715	0.8418	0.7567	0.6672	9.7479	45.9410
36	0.8760	0.8466	0.7587	0.6682	10.0830	46.4660
36.5	0.8796	0.8479	0.7658	0.6717	10.4567	46.9910
37	0.8849	0.8509	0.7689	0.6735	1.2819	47.5160
37.5	0.8867	0.8518	0.7729	0.6767	0.8427	48.0410
38	0.8922	0.8557	0.7733	0.6746	1.1344	48.5660
38.5	0.8971	0.8614	0.7745	0.6781	1.4496	49.0910
39	0.9017	0.8640	0.7806	0.6774	1.7849	49.3540
39.5	0.9049	0.8640	0.7781	0.6785	2.1878	49.8790
40	0.9095	0.8680	0.7826	0.6799	2.5821	50.4040
40.5	0.9132	0.8769	0.7854	0.6817	3.0037	50.9290
41	0.9178	0.8769	0.7858	0.6864	3.4550	51.4540

Table C-9. Continued

41.5	0.9215	0.8791	0.7899	0.6864	3.9510	51.9790
42	0.9234	0.8822	0.7887	0.6853	4.3794	52.5040
42.5	0.9281	0.8899	0.7919	0.6893	4.8357	53.0290
43	0.9361	0.8976	0.7972	0.6911	5.3490	53.5540
43.5	0.9418	0.9040	0.8047	0.6943	5.8387	54.0790
44	0.9499	0.9049	0.8059	0.6962	6.3384	54.6040
44.5	0.9542	0.9058	0.8076	0.6969	6.8212	55.1290
45	0.9590	0.9150	0.8105	0.6987	7.3050	55.6540
45.5	0.9624	0.9183	0.8138	0.7050	7.7866	56.1790
46	0.9653	0.9243	0.8188	0.7050	8.1820	56.7040
46.5	0.9667	0.9225	0.8180	0.7057	8.5081	57.2290
47	0.9721	0.9290	0.8235	0.7109	8.8429	57.7540
47.5	0.9770	0.9337	0.8252	0.7112	9.2445	58.0170
48	0.9893	0.9385	0.8260	0.7146	2.9649	58.5420
48.5	0.9938	0.9422	0.8354	0.7187	0.7016	59.0670
49	0.9972	0.9499	0.8379	0.7202	0.9295	59.5920
49.5	0.9992	0.9566	0.8457	0.7236	1.2048	60.1170
50	1.0027	0.9590	0.8401	0.7262	1.5566	60.6420
50.5	1.0073	0.9604	0.8479	0.7270	1.9271	61.1670
51	1.0123	0.9662	0.8479	0.7331	2.2988	61.6920
51.5	1.0143	0.9662	0.8513	0.7331	2.6632	62.2170
52	1.0179	0.9711	0.8539	0.7335	3.1186	62.7420
52.5	1.0214	0.9775	0.8601	0.7350	3.6068	63.2670
53	1.0245	0.9789	0.8570	0.7381	4.0393	63.7920
53.5	1.0296	0.9843	0.8631	0.7411	4.4803	64.3170
54	1.0353	0.9918	0.8653	0.7454	4.9278	64.8420
54.5	1.0415	0.9938	0.8693	0.7458	5.4885	65.3670
55	1.0487	0.9992	0.8729	0.7500	6.0091	65.8920
55.5	1.0545	1.0068	0.8818	0.7508	6.4965	66.1550
56	1.0587	1.0057	0.8782	0.7547	6.9638	66.6800
56.5	1.0613	1.0088	0.8818	0.7547	7.4296	67.2050
57	1.0687	1.0118	0.8818	0.7571	7.8907	67.7300
57.5	1.0734	1.0189	0.8935	0.7606	8.3712	68.2550
58	1.0782	1.0245	0.8913	0.7606	8.8147	68.7800
58.5	1.0814	1.0265	0.8922	0.7646	9.2445	69.3050
59	1.0852	1.0337	0.8903	0.7693	1.1637	69.8300
59.5	1.0900	1.0373	0.9017	0.7721	0.8281	70.3550
60	1.0933	1.0389	0.9045	0.7765	1.0745	70.8800
60.5	1.0965	1.0456	0.9090	0.7769	1.4489	71.4050
61	1.1019	1.0503	0.9090	0.7810	1.7841	71.9300
61.5	1.1052	1.0513	0.9127	0.7826	2.1474	72.4550
62	1.1090	1.0550	0.9118	0.7818	2.5533	72.9800

Table C-9. Continued

62.5	1.1150	1.0602	0.9095	0.7858	2.9949	73.5050
63	1.1189	1.0634	0.9183	0.7858	3.4396	74.0300
63.5	1.1244	1.0713	0.9243	0.7907	3.8888	74.5550
64	1.1300	1.0745	0.9262	0.7948	4.3120	74.8180
64.5	1.1372	1.0798	0.9328	0.7989	4.8174	75.3430
65	1.1439	1.0873	0.9370	0.8001	5.3096	75.8680
65.5	1.1855	1.0911	0.9361	0.8055	5.8176	76.3930
66	1.1873	1.0949	0.9427	0.8026	6.3160	76.9180
66.5	1.1873	1.0943	0.9432	0.8047	6.7741	77.4430
67	1.1902	1.0949	0.9446	0.8096	7.2802	77.9680
67.5	1.1960	1.1079	0.9503	0.8101	7.7349	78.4930
68	1.2007	1.1107	0.9532	0.8113	8.1820	79.0180
68.5	1.2042	1.1150	0.9542	0.8159	8.6466	79.5430
69	1.2077	1.1211	0.9604	0.8172	9.0709	80.0680
69.5	1.2095	1.1261	0.9662	0.8214	6.6806	80.5930
70	1.2171	1.1344	0.9643	0.8243	0.7005	81.1180
70.5	1.2219	1.1383	0.9696	0.8281	0.8773	81.6430
71	1.2272	1.1417	0.9755	0.8328	1.1467	82.1680
71.5	1.2284	1.1411	0.9745	0.8286	1.5091	82.6930
72	1.2308	1.1467	0.9839	0.8328	1.8701	83.2180
72.5	1.2362	1.1535	0.9804	0.8320	2.2289	83.7430
73	1.2446	1.1552	0.9893	0.8379	2.6484	84.2680
73.5	1.2489	1.1649	0.9923	0.8401	3.0543	84.7930
74	1.2531	1.1688	0.9903	0.8431	3.4975	85.3180
74.5	1.2580	1.1757	0.9942	0.8466	3.9541	85.8430
75	1.2647	1.1821	1.0052	0.8466	4.3913	86.3680
75.5	1.2678	1.1838	1.0068	0.8492	4.8540	86.6310
76	1.2733	1.1902	1.0057	0.8553	5.3490	87.1560
76.5	1.2782	1.1908	1.0128	0.8548	5.8809	87.6810
77	1.2832	1.1966	1.0138	0.8566	6.3832	88.2060
77.5	1.2863	1.2007	1.0143	0.8596	6.8212	88.7310
78	1.2919	1.2059	1.0179	0.8605	7.3050	89.2560
78.5	1.2968	1.2059	1.0184	0.8631	7.7866	89.7810
79	1.3056	1.2177	1.0260	0.8631	8.2358	90.3060
79.5	1.3119	1.2207	1.0301	0.8680	8.7024	90.8310
80	1.3176	1.2296	1.0363	0.8720	9.0997	91.3560
80.5	1.3208	1.2266	1.0353	0.8729	9.4497	91.8810
81	1.3227	1.2350	1.0394	0.8738	9.8083	92.4060
81.5	1.3316	1.2362	1.0394	0.8764	10.0522	92.4060
82	1.3361	1.2471	1.0435	0.8818	10.1756	92.4060
82.5	1.3412	1.2471	1.0487	0.8854	10.2377	92.4060
83	1.3509	1.2525	1.0513	0.8881	10.2377	92.4060

Table C-9. Continued

83.5	1.3574	1.2580	1.0529	0.8903	10.2377	92.4060
84	1.3620	1.2635	1.0650	0.8931	10.2377	92.4060
84.5	1.3646	1.2671	1.0629	0.8962	10.2377	92.4060
85	1.3698	1.2708	1.0687	0.8990	10.2377	92.4060
85.5	1.3731	1.2720	1.0687	0.9003	10.2377	92.4060
86	1.3764	1.2733	1.0687	0.8999	10.2377	92.4060
86.5	1.3770	1.2764	1.0724	0.9003	10.2377	92.4060
87	1.3770	1.2788	1.0761	0.9017	10.2377	92.4060
87.5	1.3770	1.2801	1.0719	0.9040	10.2377	92.4060
88	1.3770	1.2832	1.0740	0.9067	10.2377	92.4060
88.5	1.3777	1.2807	1.0745	0.9049	10.2377	92.4060
89	1.3816	1.2794	1.0782	0.9063	10.2377	92.4060
89.5	1.3816	1.2794	1.0766	0.9072	10.2377	92.4060
90	1.3810	1.2801	1.0772	0.9086	10.2377	92.4060
90.5	1.3810	1.2801	1.0777	0.9095	10.2377	92.4060
91	1.3836	1.2794	1.0798	0.9086	10.2377	92.4060
91.5	1.3816	1.2794	1.0804	0.9086	10.2377	92.4060
92	1.3823	1.2819	1.0847	0.9090	10.2377	92.4060
92.5	1.3849	1.2838	1.0825	0.9127	10.2377	92.4060
93	1.3856	1.2850	1.0820	0.9118	10.2377	92.4060
93.5	1.3902	1.2838	1.0820	0.9146	10.2377	92.4060
94	1.3902	1.2838	1.0836	0.9141	10.2377	92.4060
94.5	1.3896	1.2838	1.0820	0.9160	10.2377	92.4060
95	1.3902	1.2838	1.0836	0.9160	10.2377	92.4060
95.5	1.3902	1.2838	1.0868	0.9169	10.2377	92.4060
96	1.3902	1.2838	1.0847	0.9169	10.2377	92.4060
96.5	1.3902	1.2838	1.0847	0.9169	10.2377	92.4060
97	1.3902	1.2856	1.0852	0.9164	10.2377	92.4060
97.5	1.3902	1.2856	1.0841	0.9150	10.2377	92.4060
98	1.3902	1.2863	1.0841	0.9150	10.2377	92.4060
98.5	1.3902	1.2863	1.0841	0.9146	10.2377	92.4060
99	1.3915	1.2856	1.0841	0.9169	10.2377	92.4060
99.5	1.3949	1.2900	1.0847	0.9164	10.2377	92.4060
100	1.3949	1.2900	1.0841	0.9183	10.2377	92.4060
100.5	1.3949	1.2919	1.0841	0.9183	10.2377	92.4060
101	1.3962	1.2912	1.0847	0.9192	10.2377	92.4060
101.5	1.3975	1.2919	1.0847	0.9215	10.2377	92.4060

Table C-10. Bromide run #9 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6205	0.6087	0.6026	0.5981	0.5591	0.2630
0.5	0.6232	0.6087	0.6026	0.5981	0.6372	0.7880
1	0.6251	0.6087	0.6026	0.5981	0.8500	1.3130
1.5	0.6278	0.6100	0.6062	0.5981	1.1063	1.8380
2	0.6311	0.6127	0.6081	0.5981	1.3770	2.3630
2.5	0.6358	0.6146	0.6146	0.5988	1.6517	2.8880
3	0.6477	0.6159	0.6179	0.5981	1.9314	3.1510
3.5	0.6640	0.6176	0.6255	0.5981	2.2388	3.6760
4	0.6842	0.6185	0.6436	0.5994	2.5445	4.2010
4.5	0.7042	0.6232	0.6553	0.6004	2.8885	4.7260
5	0.7244	0.6318	0.6735	0.6004	3.2665	5.2510
5.5	0.7388	0.6426	0.6856	0.6004	3.6316	5.7760
6	0.7630	0.6550	0.6998	0.6010	3.9666	6.0390
6.5	0.7781	0.6665	0.7195	0.6026	4.2886	6.5640
7	0.7993	0.6781	0.7458	0.6026	4.6554	7.0890
7.5	0.8239	0.6922	0.7598	0.6033	5.0589	7.6140
8	0.8474	0.7083	0.7903	0.6045	5.4684	8.1390
8.5	0.8592	0.7247	0.8071	0.6062	5.8598	8.6640
9	0.8760	0.7404	0.8294	0.6078	6.2493	8.9270
9.5	0.9008	0.7516	0.8513	0.6117	6.6111	9.4520
10	0.9234	0.7681	0.8711	0.6172	6.9878	9.9770
10.5	0.9441	0.7826	0.8944	0.6285	7.3547	10.5020
11	0.9711	0.8030	0.9146	0.6385	7.6834	11.0270
11.5	0.9918	0.8218	0.9356	0.6453	8.0487	11.5520
12	1.0098	0.8354	0.9484	0.6491	8.3712	12.0770
12.5	1.0286	0.8500	0.9784	0.6577	8.7024	12.6020
13	1.0576	0.8636	0.9873	0.6682	9.0135	13.1270
13.5	1.0820	0.8831	1.0209	0.6760	3.0696	13.6520
14	1.1074	0.9045	1.0368	0.6838	0.7450	13.9150
14.5	1.1333	0.9169	1.0581	0.6922	0.9067	14.4400
15	1.1649	0.9337	1.0814	0.7057	1.1074	14.9650
15.5	1.1884	0.9480	1.0933	0.7105	1.3503	15.4900
16	1.2106	0.9677	1.1222	0.7165	1.6326	16.0150
16.5	1.2368	0.9789	1.1339	0.7202	1.8984	16.5400
17	1.2708	0.9982	1.1626	0.7342	2.1917	16.8030
17.5	1.2900	1.0184	1.1937	0.7489	2.5106	17.3280
18	1.3144	1.0347	1.2007	0.7567	2.8305	17.8530
18.5	1.3432	1.0456	1.2344	0.7666	3.1905	18.3780
19	1.3639	1.0597	1.2635	0.7793	3.5749	18.9030
19.5	1.4217	1.0756	1.2912	0.7887	3.9074	19.4280

Table C-10. Continued

20	1.4407	1.0911	1.3201	0.7927	4.2488	19.6910
20.5	1.4739	1.1068	1.3516	0.8047	4.6023	20.2160
21	1.5062	1.1222	1.3764	0.8105	4.9837	20.7410
21.5	1.5442	1.1445	1.4062	0.8201	5.4284	21.2660
22	1.5749	1.1649	1.4332	0.8281	5.8387	21.7910
22.5	1.6227	1.1826	1.4928	0.8332	6.2272	22.3160
23	1.6517	1.2036	1.5133	0.8418	6.6342	22.5790
23.5	1.6943	1.2278	1.5399	0.8535	6.9878	23.1040
24	1.7315	1.2464	1.5639	0.8579	7.3547	23.6290
24.5	1.7492	1.2665	1.5942	0.8658	7.7349	24.1540
25	1.7825	1.2850	1.6295	0.8729	8.1019	24.6790
25.5	1.8113	1.3037	1.6524	0.8827	8.4806	25.2040
26	1.8397	1.3214	1.6881	0.8926	8.8147	25.7290
26.5	1.8710	1.3477	1.7101	0.8999	9.1285	26.2540
27	1.8950	1.3691	1.7387	0.9086	9.3907	26.7790
27.5	1.9455	1.3949	1.7629	0.9178	9.6878	27.3040
28	1.9765	1.4237	1.7989	0.9272	1.1942	27.5670
28.5	2.0097	1.4489	1.8254	0.9385	0.8231	28.0920
29	2.0398	1.4704	1.8540	0.9489	1.0098	28.6170
29.5	2.0554	1.4977	1.8744	0.9556	1.2483	29.1420
30	2.0823	1.5262	1.9071	0.9629	1.5370	29.6670
30.5	2.1019	1.5479	1.9253	0.9696	1.7890	30.1920
31	2.1455	1.5698	1.9516	0.9770	2.0748	30.7170
31.5	2.1617	1.6017	1.9774	0.9868	2.3902	30.9800
32	2.2053	1.6280	2.0161	0.9967	2.7301	31.5050
32.5	2.2398	1.6578	2.0334	1.0128	3.0684	32.0300
33	2.2746	1.6842	2.0637	1.0255	3.4438	32.5550
33.5	2.2988	1.7093	2.0916	1.0363	3.8182	33.0800
34	2.3447	1.7395	2.1255	1.0477	4.1503	33.6050
34.5	2.3725	1.7589	2.1521	1.0708	4.5149	34.1300
35	2.4059	1.7816	2.1694	1.0852	4.8723	34.6550
35.5	2.4419	1.8080	2.2093	1.0943	5.3096	35.1800
36	2.4750	1.8279	2.2269	1.1129	5.7340	35.7050
36.5	2.5030	1.8489	2.2676	1.1228	6.1174	36.2300
37	2.5500	1.8701	2.2887	1.1383	6.5193	36.4930
37.5	2.5666	1.8889	2.3221	1.1490	6.9161	37.0180
38	2.6224	1.9071	2.3591	1.1643	7.2802	37.5430
38.5	2.6496	1.9244	2.4028	1.1815	7.6578	38.0680
39	2.7023	1.9499	2.4440	1.2024	8.0222	38.5930
39.5	2.7558	1.9685	2.4632	1.2166	8.3712	39.1180
40	2.7995	1.9962	2.4911	1.2338	8.7303	39.6430
40.5	2.8497	2.0124	2.5456	1.2458	9.0709	39.9060

Table C-10. Continued

41	2.8849	2.0315	2.5777	1.2574	9.3614	40.4310
41.5	2.9351	2.0572	2.6011	1.2708	9.6279	40.9560
42	2.9748	2.0748	2.6281	1.2807	9.9298	41.4810
42.5	3.0074	2.0897	2.6758	1.2925	10.2688	42.0060
43	3.0454	2.1094	2.7115	1.3075	10.7106	42.5310
43.5	3.0876	2.1359	2.7476	1.3335	0.8971	43.0560
44	3.1134	2.1531	2.7628	1.3419	0.7972	43.3190
44.5	3.1433	2.1752	2.8042	1.3509	1.0027	43.8440
45	3.1813	2.1946	2.8413	1.3606	1.2574	44.3690
45.5	3.2104	2.2142	2.8776	1.3816	1.5450	44.8940
46	3.2517	2.2319	2.8971	1.4042	1.8304	45.4190
46.5	3.2786	2.2487	2.9376	1.4035	2.1047	45.9440
47	3.3207	2.2776	2.9686	1.4244	2.4270	46.2070
47.5	3.3385	2.2998	3.0037	1.4421	2.7452	46.7320
48	3.3742	2.3252	3.0289	1.4586	3.0966	47.2570
48.5	3.4103	2.3426	3.0505	1.4614	3.4833	47.7820
49	3.4242	2.3684	3.0773	1.5027	3.8473	48.3070
49.5	3.4663	2.3997	3.0992	1.5020	4.1699	48.8320
50	3.4861	2.4249	3.1316	1.5198	4.5323	49.3570
50.5	3.5217	2.4429	3.1511	1.5226	4.9278	49.6200
51	3.5662	2.4664	3.1919	1.5392	5.3687	50.1450
51.5	3.6024	2.4911	3.2197	1.5727	5.7757	50.6700
52	3.6316	2.5226	3.2517	1.5786	6.1611	51.1950
52.5	3.6639	2.5467	3.2881	1.5927	6.5421	51.7200
53	3.6816	2.5799	3.3152	1.6114	6.9161	52.2450
53.5	3.7188	2.6123	3.3453	1.6318	7.3050	52.7700
54	3.7562	2.6439	3.3853	1.6349	7.6578	53.2950
54.5	3.7879	2.6724	3.4200	1.6563	8.0753	53.5580
55	3.8137	2.6953	3.4452	1.6686	8.4258	54.0830
55.5	3.8442	2.7150	3.4875	1.6842	8.7584	54.6080
56	3.9151	2.7429	3.5117	1.6951	9.0709	55.1330
56.5	3.9338	2.7664	3.5417	1.7085	9.3614	55.6580
57	3.9776	2.7900	3.5705	1.7252	1.1966	56.1830
57.5	4.0235	2.8161	3.6068	1.7492	0.7818	56.7080
58	4.0681	2.8449	3.6507	1.7645	0.9653	57.2330
58.5	4.0937	2.8727	3.6713	1.7767	1.2201	57.4960
59	4.1357	2.9007	3.6964	1.7931	1.4949	58.0210
59.5	4.1585	2.9240	3.7277	1.7981	1.7678	58.5460
60	4.1977	2.9438	3.7577	1.8179	2.0554	59.0710
60.5	4.2240	2.9624	3.7864	1.8414	2.3850	59.5960
61	4.2670	2.9936	3.8243	1.8355	2.7185	59.8590
61.5	4.3070	3.0074	3.8519	1.8540	3.0799	60.3840

Table C-10. Continued

62	4.3372	3.0302	3.8919	1.8625	3.4396	60.9090
62.5	4.3947	3.0632	3.9229	1.8778	3.8304	61.4340
63	4.4459	3.0876	3.9619	1.8889	4.1879	61.9590
63.5	4.4803	3.1108	4.0044	1.9131	4.5497	62.4840
64	4.5149	3.1433	4.0266	1.9271	4.9278	63.0090
64.5	4.5497	3.1747	4.0553	1.9341	5.3490	63.2720
65	4.6023	3.1985	4.0937	1.9384	5.7340	63.7970
65.5	4.6200	3.2250	4.1131	1.9836	6.1174	64.3220
66	4.6732	3.2437	4.1552	2.0016	6.5193	64.8470
66.5	4.7089	3.2665	4.1977	2.0133	6.8685	65.3720
67	4.7629	3.2989	4.2174	2.0206	7.2802	65.6350
67.5	4.7629	3.3180	4.2537	2.0334	7.6322	66.1600
68	4.8174	3.3439	4.2836	2.0480	8.0222	66.6850
68.5	4.8357	3.3701	4.3070	2.0665	8.3985	67.2100
69	4.8908	3.3977	4.3423	2.0850	8.7303	67.7350
69.5	4.9278	3.4200	4.3760	2.1057	9.0422	68.2600
70	4.9837	3.4480	4.4117	2.1094	9.3320	68.5230
70.5	5.0024	3.4691	4.4459	2.1207	9.5683	69.0480
71	5.0400	3.4975	4.4631	2.1283	1.9499	69.5730
71.5	5.0779	3.5217	4.4976	2.1560	0.7850	70.0980
72	5.1160	3.5460	4.5149	2.1694	0.9667	70.6230
72.5	5.1351	3.5806	4.5672	2.1868	1.1931	71.1480
73	5.1928	3.6039	4.6023	2.1878	1.4893	71.4110
73.5	5.2315	3.6243	4.6376	2.2093	1.7751	71.9360
74	5.2509	3.6462	4.6554	2.2259	2.0730	72.4610
74.5	5.2900	3.6757	4.6910	2.2427	2.3923	72.9860
75	5.3292	3.7113	4.7089	2.2636	2.6976	73.5110
75.5	5.3687	3.7322	4.7629	2.2706	3.0632	73.7740
76	5.4084	3.7562	4.7992	2.2837	3.4536	74.2990
76.5	5.4284	3.7849	4.8174	2.2988	3.8259	74.8240
77	5.4684	3.8106	4.8723	2.3252	4.1373	75.3490
77.5	5.5086	3.8396	4.9092	2.3344	4.4976	75.8740
78	5.5491	3.8672	4.9278	2.3488	4.8723	76.3990
78.5	5.5694	3.8965	4.9650	2.3560	5.3096	76.9240
79	5.6102	3.9276	5.0024	2.3767	5.7132	77.1870
79.5	5.6513	3.9494	5.0400	2.4017	6.1392	77.7120
80	5.6719	3.9682	5.0779	2.4070	6.4965	78.2370
80.5	5.6925	3.9934	5.0969	2.4228	6.8922	78.7620
81	5.7340	4.0203	5.1351	2.4344	7.2802	79.2870
81.5	5.7757	4.0505	5.1928	2.4525	7.6578	79.8120
82	5.8176	4.0761	5.2121	2.4675	8.0222	80.3370
82.5	5.8598	4.1050	5.2509	2.4804	8.3712	80.6000

Table C-10. Continued

83	5.9021	4.1292	5.2900	2.5041	8.7303	81.1250
83.5	5.9447	4.1536	5.3292	2.5237	9.0422	81.6500
84	5.9876	4.1780	5.3490	2.5336	9.3028	82.1750
84.5	6.0091	4.2010	5.3885	2.5347	9.5683	82.7000
85	6.0306	4.2207	5.4284	2.5577	9.8689	83.2250
85.5	6.0956	4.2438	5.4684	2.5655	10.2688	83.4880
86	6.1174	4.2637	5.4885	2.5732	0.7339	84.0130
86.5	6.1611	4.2920	5.5289	2.6191	0.8522	84.5380
87	6.1831	4.3204	5.5491	2.6179	1.0399	85.0630
87.5	6.2051	4.3389	5.5898	2.6382	1.2925	85.5880
88	6.2493	4.3642	5.6307	2.6575	1.5779	85.8510
88.5	6.2937	4.3879	5.6513	2.6747	1.8523	86.3760
89	6.3384	4.4117	5.6925	2.6930	2.1369	86.9010
89.5	6.3832	4.4288	5.7132	2.7185	2.4589	87.4260
90	6.4058	4.4459	5.7548	2.7254	2.7935	87.9510
90.5	6.4510	4.4631	5.7757	2.7476	3.1329	88.2140
91	6.4737	4.4803	5.8176	2.7640	3.5231	88.7390
91.5	6.4965	4.4976	5.8598	2.7876	3.8981	89.2640
92	6.5651	4.5323	5.8809	2.7959	4.2026	89.7890
92.5	6.5881	4.5497	5.9234	2.8173	4.5323	90.3140
93	6.6111	4.5847	5.9661	2.8293	4.9092	90.8390
93.5	6.6574	4.6023	5.9876	2.8485	5.3292	91.1020
94	6.7039	4.6376	6.0306	2.8679	5.7548	91.6270
94.5	6.7272	4.6554	6.0522	2.8788	6.1611	92.1520
95	6.7506	4.6732	6.0956	2.8958	6.5421	92.6770
95.5	6.7741	4.6910	6.1174	2.9019	6.9161	93.2020
96	6.8212	4.7089	6.1392	2.9290	7.3298	93.4650
96.5	6.8685	4.7269	6.1831	2.9364	7.6834	93.9900
97	6.8922	4.7629	6.2051	2.9587	8.0753	94.5150
97.5	6.9399	4.7992	6.2493	2.9773	8.4258	95.0400
98	6.9638	4.8357	6.2937	2.9786	8.7584	95.5650
98.5	7.0119	4.8723	6.3160	2.9974	9.0422	96.0900
99	7.0360	4.9278	6.3608	3.0251	9.3028	96.6150
99.5	7.0844	4.9650	6.3832	3.0352	9.5683	96.8780
100	7.0844	5.0024	6.4058	3.0467	9.7781	97.4040
100.5	7.1086	5.0400	6.4284	3.0620	9.8689	97.4040
101	7.1330	5.0589	6.4510	3.0876	9.8993	97.4040
101.5	7.1330	5.0589	6.4737	3.0953	9.8993	97.4040
102	7.1330	5.0589	6.4737	3.1044	9.8993	97.4040
102.5	7.1330	5.0589	6.4737	3.1044	9.8993	97.4040
103	7.1330	5.0589	6.4737	3.1095	9.8993	97.4040
103.5	7.1330	5.0589	6.4737	3.1199	9.8993	97.4040

Table C-10. Continued

104	7.1330	5.0589	6.4737	3.1199	9.8993	97.4040
104.5	7.1330	5.0589	6.4737	3.1225	9.8993	97.4040
105	7.1330	5.0589	6.4737	3.1251	9.8993	97.4040
105.5	7.1330	5.0589	6.4737	3.1303	9.8993	97.4040
106	7.1330	5.0589	6.4737	3.1316	9.8993	97.4040
106.5	7.1330	5.0589	6.4737	3.1316	9.8993	97.4040
107	7.1330	5.0589	6.4737	3.1342	9.8993	97.4040
107.5	7.1330	5.0589	6.4737	3.1355	9.8993	97.4040
108	7.1330	5.0589	6.4737	3.1355	9.8993	97.4040
108.5	7.1330	5.0589	6.4737	3.1407	9.8993	97.4040
109	7.1330	5.0589	6.4737	3.1472	9.8993	97.4040
109.5	7.1330	5.0589	6.4737	3.1472	9.8993	97.4040
110	7.1330	5.0589	6.4737	3.1511	9.8993	97.4040
110.5	7.1330	5.0589	6.4737	3.1511	9.8993	97.4040
111	7.1330	5.0589	6.4737	3.1485	9.8993	97.4040
111.5	7.1330	5.0589	6.4737	3.1511	9.8993	97.4040
112	7.1330	5.0589	6.4737	3.1511	9.8993	97.4040
112.5	7.1574	5.0589	6.4737	3.1524	9.9298	97.4040
113	7.1330	5.0589	6.4737	3.1564	9.9298	97.4040
113.5	7.1330	5.0589	6.4737	3.1590	9.9298	97.4040
114	7.1330	5.0589	6.4737	3.1564	9.9298	97.4040
114.5	7.1574	5.0589	6.4737	3.1564	9.9298	97.4040
115	7.1574	5.0589	6.4737	3.1603	9.9298	97.4040
115.5	7.1330	5.0589	6.4737	3.1603	9.9298	97.4040
116	7.1574	5.0779	6.4737	3.1603	9.9298	97.4040
116.5	7.1574	5.0779	6.4737	3.1603	9.8993	97.4040
117	7.1574	5.0779	6.4737	3.1603	9.9298	97.4040
117.5	7.1574	5.0779	6.4737	3.1721	9.8993	97.4040

Table C-11. Bromide normalized concentration in outflow for run #1-9

# 1						# 2					
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0483	0.0003	0.0077	0.0043	0.1272	2	0.0015	0.0306	0.0000	0.0049	0.0826
4	0.3389	0.0151	0.1164	0.1081	0.2160	4	0.2174	0.0914	0.0099	0.0606	0.2001
6	0.4549	0.0302	0.2011	0.1869	0.2545	6	0.3047	0.1282	0.0229	0.0811	0.2293
8	0.5042	0.0430	0.2253	0.2601	0.2819	8	0.3596	0.1303	0.0334	0.0854	0.2483
10	0.5224	0.0373	0.2268	0.2745	0.2979	10	0.3878	0.1371	0.0405	0.0956	0.2706
15	0.5500	0.0454	0.1497	0.2313	0.3219	15	0.4123	0.1580	0.0719	0.1544	0.2848
20	0.5650	0.0589	0.0676	0.2632	0.3731	20	0.4241	0.1796	0.1093	0.2316	0.2945
25	0.5767	0.0700	0.0592	0.4031	0.3442	25	0.4357	0.1810	0.1416	0.3099	0.2988
30			0.0667	0.4713	0.3294	30	0.4411	0.1913	0.1519	0.3223	0.2934
32	0.5434	0.0827	0.0739	0.4732	0.2437	32	0.4288	0.1583	0.1512	0.3022	0.1708
34	0.2170	0.0567	0.0711	0.3006	0.0915	34	0.0965	0.0646	0.1428	0.2051	0.0768
36	0.1226	0.0464	0.0598	0.2680	0.0644	36	0.0766	0.0582	0.1373	0.1896	0.0641
38	0.0844	0.0394	0.0563	0.2597	0.0554	38	0.0404	0.0486	0.1287	0.1690	0.0493
40	0.0646	0.0396	0.0515	0.2417	0.0470	40	0.0197	0.0413	0.1257	0.1478	0.0426
45	0.0343	0.0385	0.0595	0.1839	0.0372	45	0.0000	0.0335	0.1026	0.1151	0.0299
50	0.0228	0.0403	0.0675	0.1391	0.0291	50	0.0000	0.0307	0.0661	0.0707	0.0239
55	0.0262	0.0428	0.0437	0.0814	0.0194	55	0.0000	0.0305	0.0382	0.0364	0.0161
60	0.0395	0.0402	0.0259	0.0496	0.0173	60	0.0000	0.0278	0.0247	0.0184	0.0129
65	0.0576	0.0387	0.0152	0.0377	0.0109	65	0.0174	0.0258	0.0160	0.0091	0.0089
70	0.0761	0.0358	0.0082	0.0240	0.0101	70	0.0308	0.0239	0.0000	0.0052	0.0063

Table C-11 Continued

# 3						# 4					
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0719	0.0000	0.0052	0.0112	0.1723	2	0.0223	0.0000	0.0003	0.0012	0.1471
4	0.3252	0.0147	0.1179	0.1336	0.2066	4	0.2802	0.0166	0.0810	0.1181	0.1956
6	0.3870	0.0264	0.1504	0.1651	0.2130	6	0.3628	0.0334	0.1218	0.1592	0.2238
8	0.4172	0.0322	0.1672	0.1764	0.2205	8	0.4044	0.0423	0.1489	0.1882	0.2328
10	0.4400	0.0348	0.1773	0.1850	0.2220	10	0.4322	0.0516	0.1593	0.2031	0.2432
15	0.4510	0.0447	0.1935	0.1966	0.2311	15	0.4633	0.0577	0.1810	0.2238	0.2439
20	0.4706	0.0538	0.2090	0.2087	0.2405	20	0.4621	0.0558	0.2005	0.2293	0.2403
25	0.4740	0.0599	0.2167	0.2159	0.2380	25	0.4717	0.0573	0.2061	0.2329	0.2494
30	0.4799	0.0629	0.2247	0.2187	0.2441	30	0.4741	0.0597	0.2176	0.2329	0.2334
32	0.4483	0.0651	0.2289	0.2074	0.0777	32	0.4507	0.0595	0.2247	0.2331	0.0599
34	0.1594	0.0531	0.1223	0.0927	0.0355	34	0.1967	0.0485	0.0946	0.0965	0.0133
36	0.0962	0.0388	0.0926	0.0582	0.0298	36	0.1186	0.0360	0.0705	0.0603	0.0238
38	0.0612	0.0310	0.0845	0.0434	0.0262	38	0.0799	0.0276	0.0664	0.0466	0.0204
40	0.0427	0.0253	0.0862	0.0357	0.0231	40	0.0553	0.0215	0.0716	0.0375	0.0179
45	0.0198	0.0167	0.0970	0.0250	0.0165	45	0.0267	0.0133	0.0885	0.0234	0.0137
50	0.0120	0.0063	0.1062	0.0222	0.0112	50	0.0175	0.0068	0.0951	0.0163	0.0098
55	0.0138	0.0080	0.1168	0.0188	0.0078	55	0.0182	0.0100	0.0944	0.0102	0.0068
60	0.0232	0.0207	0.1196	0.0158	0.0054	60	0.0257	0.0210	0.0852	0.0073	0.0059
65	0.0352	0.0385	0.1176	0.0137	0.0040	65	0.0374	0.0392	0.0676	0.0054	0.0053
70	0.0482	0.0530	0.0976	0.0134	0.0022	70	0.0474	0.0485	0.0475	0.0044	0.0050
75	0.0587	0.0585	0.0731	0.0125	0.0014	75	0.0600	0.0532	0.0356	0.0058	0.0025
80	0.0663	0.0635	0.0570	0.0119	0.0018	80	0.0698	0.0549	0.0294	0.0069	0.0018

Table C-10. Continued

# 5						# 6					
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0615	0.0000	0.0001	0.0006	0.0958	2	0.0438	0.0000	0.0009	0.0000	0.1161
4	0.2351	0.1324	0.0217	0.0030	0.1359	4	0.2150	0.0727	0.0082	0.0371	0.1762
6	0.2804	0.1649	0.0447	0.0163	0.1452	6	0.2626	0.0952	0.0200	0.0516	0.1722
8	0.3009	0.1782	0.0507	0.0225	0.1486	8	0.2788	0.1029	0.0255	0.0619	0.1832
10	0.3164	0.1859	0.0553	0.0246	0.1435	10	0.2946	0.1147	0.0278	0.0677	0.1789
15	0.3490	0.2047	0.0664	0.0356	0.1602	15	0.3129	0.1209	0.0276	0.0698	0.1907
20	0.3723	0.2181	0.0732	0.0446	0.1631	20	0.3335	0.1298	0.0300	0.0706	0.1957
25	0.3872	0.2386	0.0776	0.0770	0.1755	25	0.3447	0.1565	0.0350	0.0760	0.2019
30	0.3957	0.3175	0.1342	0.0741	0.1835	30	0.3606	0.2445	0.0665	0.0792	0.2037
32	0.3502	0.3415	0.1858	0.0789	0.0998	32	0.3598	0.2782	0.0947	0.0851	0.0878
34	0.1825	0.2323	0.1934	0.0643	0.0463	34	0.1769	0.2353	0.1120	0.0695	0.0452
36	0.1528	0.2103	0.1945	0.0472	0.0429	36	0.2259	0.1570	0.1175	0.0595	0.0437
38	0.1570	0.2097	0.1995	0.0453	0.0425	38	0.2290	0.1665	0.1234	0.0589	0.0439
40	0.1647	0.2120	0.2046	0.0459	0.0419	40	0.1795	0.2343	0.1296	0.0610	0.0446
45	0.1753	0.2209	0.2125	0.0494	0.0404	45	0.2092	0.2501	0.1372	0.0672	0.0453
50	0.1757	0.2242	0.2093	0.0541	0.0398	50	0.2266	0.2547	0.1412	0.0735	0.0448
55	0.1785	0.2115	0.2006	0.0585	0.0340	55	0.2348	0.2285	0.1359	0.0777	0.0414
60	0.1736	0.1413	0.1580	0.0606	0.0298	60	0.2310	0.1386	0.1061	0.0775	0.0383
65	0.1484	0.0943	0.0808	0.0544	0.0250	65	0.1933	0.0915	0.0581	0.0692	0.0343
70	0.0977	0.0597	0.0545	0.0478	0.0180	70	0.1272	0.0603	0.0437	0.0579	0.0296
75	0.0628	0.0380	0.0393	0.0403	0.0123	75	0.0876	0.0423	0.0327	0.0501	0.0251
80	0.0456	0.0285	0.0283	0.0332	0.0088	80	0.0644	0.0311	0.0272	0.0445	0.0222

Table C-11 Continued

# 7						# 8					
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0168	0.0000	0.0000	0.0000	0.1325	2	0.0000	0.0000	0.0000	0.0000	0.1643
4	0.1712	0.0441	0.0127	0.0329	0.1665	4	0.0000	0.0000	0.0000	0.0000	0.1920
6	0.2175	0.0726	0.0203	0.0493	0.1734	6	0.0005	0.0000	0.0000	0.0000	0.1985
8	0.2381	0.0773	0.0278	0.0574	0.1810	8	0.0288	0.0047	0.0000	0.0000	0.2028
10	0.2503	0.0820	0.0267	0.0610	0.1797	10	0.0809	0.0196	0.0000	0.0000	0.1965
15	0.2741	0.0851	0.0247	0.0634	0.1828	15	0.1306	0.0407	0.0000	0.0000	0.2064
20	0.2834	0.0881	0.0275	0.0671	0.1884	20	0.1802	0.0584	0.0000	0.0000	0.2153
25	0.2917	0.1167	0.0333	0.0685	0.1864	25	0.2028	0.0690	0.0000	0.0001	0.2156
30	0.3035	0.1954	0.0634	0.0670	0.1990	30	0.2101	0.0740	0.0002	0.0000	0.2133
32	0.3042	0.2283	0.0884	0.0685	0.0848	32	0.2172	0.0747	0.0002	0.0000	0.0412
34	0.1456	0.2078	0.0989	0.0543	0.0444	34	0.2194	0.0748	0.0003	0.0000	0.0253
36	0.1144	0.1971	0.1009	0.0394	0.0412	36	0.2223	0.0769	0.0009	0.0000	0.0197
38	0.1127	0.2019	0.1044	0.0370	0.0414	38	0.1702	0.0716	0.0023	0.0000	0.0189
40	0.1220	0.2133	0.1093	0.0386	0.0408	40	0.0993	0.0511	0.0088	0.0000	0.0178
45	0.1550	0.2253	0.1169	0.0463	0.0412	45	0.0503	0.0448	0.0390	0.0012	0.0157
50	0.1775	0.2428	0.1184	0.0563	0.0407	50	0.0305	0.0767	0.0821	0.0145	0.0147
55	0.1946	0.2215	0.1113	0.0679	0.0387	55	0.0203	0.1179	0.1205	0.0444	0.0144
60	0.2078	0.1349	0.0925	0.0751	0.0344	60	0.0148	0.1569	0.1588	0.0824	0.0143
65	0.2000	0.0895	0.0647	0.0738	0.0315	65	0.0129	0.1888	0.1908	0.1165	0.0148
70	0.1530	0.0660	0.0514	0.0646	0.0267	70	0.0138	0.2126	0.2096	0.1426	0.0146
75	0.1071	0.0508	0.0426	0.0558	0.0238	75	0.0198	0.2194	0.1711	0.1585	0.0143
80	0.0844	0.0419	0.0358	0.0469	0.0206	80	0.0257	0.1982	0.1327	0.1609	0.0144

Table C-11 Continued

# 9 Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0342	0.0000	0.0000	0.0000	0.1182
4	0.1150	0.0002	0.0003	0.0000	0.1608
6	0.1433	0.0042	0.0019	0.0021	0.1686
8	0.1607	0.0107	0.0039	0.0059	0.1842
10	0.1709	0.0145	0.0056	0.0079	0.1837
15	0.1877	0.0251	0.0092	0.0116	0.1982
20	0.2017	0.0398	0.0113	0.0134	0.2132
25	0.2275	0.0480	0.0138	0.0166	0.2100
30	0.2353	0.0571	0.0196	0.0165	0.2261
32	0.2245	0.0601	0.0238	0.0196	0.0706
34	0.1488	0.0663	0.0294	0.0196	0.0469
36	0.1323	0.0580	0.0365	0.0172	0.0400
38	0.1329	0.0526	0.0412	0.0136	0.0367
40	0.1410	0.0519	0.0442	0.0121	0.0324
45	0.1565	0.0608	0.0524	0.0113	0.0299
50	0.1660	0.0763	0.0556	0.0137	0.0274
55	0.1707	0.0908	0.0607	0.0240	0.0232
60	0.1561	0.0962	0.0587	0.0406	0.0211
65		0.1054	0.0440	0.0582	0.0174
70	0.1148	0.1085	0.0314	0.0719	0.0149
75	0.0810	0.0882	0.0237	0.0811	0.0123
80	0.0574	0.0613	0.0177	0.0807	0.0094
85	0.0470	0.0447	0.0148	0.0758	0.0069
90	0.0396	0.0317	0.0141	0.0653	0.0060

Table C-12. Water flow summary for kaolinite runoff experiments on bare soil

Run	Time	Inflow	DR#1	DR#2	DR#3	DR#4	RO	Rainfall	Area of the box
		L/min						mm/hour	cm^2
# 1	June 24,09	0.36104	0.1802	0.2331	0.1613	0.1472	0.2682	63.86	6154.62
# 2	July 1,09	0.361	0.1024	0.1845	0.1542	0.1409	0.3808	62.29	6154.62
# 3	July 2,09	0.361	0.0947	0.1739	0.1449	0.1408	0.409	59.57	6154.62
# 4	Sep 23,09	0.298	0.0461	0.0478	0.0356	0.0297	0.7479	62.67	6154.62
# 5	Sep 25,09	0.297	0.0326	0.0363	0.0266	0.024	0.7813	62.94	6228.96
# 6	Oct 01,09	0.304	0.0241	0.0101	0.0185	0.0152	0.8172	62.00	6228.96
# 7	Nov 18,09	0.295	0.0683	0.0459	0.0608	0.0262	0.6841	68.70	6228.96

Table C-13. Kaolinite run #1 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
0	0.6443	0.6162	0.6315	0.6228	0.5636	0.788
0.5	0.6781	0.6477	0.6392	0.6248	0.5645	1.313
1	0.7339	0.7165	0.6570	0.6332	0.5673	1.838
1.5	0.7785	0.7968	0.6922	0.6494	0.5734	2.626
2	0.8397	0.8818	0.7361	0.6774	0.5793	3.151
2.5	0.9058	0.9667	0.7802	0.7187	0.5969	3.676
3	0.9658	1.0529	0.8345	0.7634	0.6460	4.464
3.5	1.0363	1.1036	0.8760	0.7976	0.6998	4.989
4	1.1052	1.1161	0.9281	0.8422	0.7591	5.514
4.5	1.1643	1.1954	0.9609	0.8796	0.8167	6.039
5	1.2320	1.2819	1.0113	0.9188	0.8827	6.827
5.5	1.3246	1.4076	1.0655	0.9638	0.9604	7.352
6	1.4082	1.5356	1.1294	1.0123	1.0317	7.877
6.5	1.4808	1.6671	1.2001	1.0644	1.1250	8.402
7	1.5742	1.7915	1.2714	1.1014	1.2278	9.19
7.5	1.6764	1.9053	1.3477	1.1501	1.3233	9.715
8	1.7548	2.0161	1.4455	1.2142	1.4224	10.24
8.5	1.8439	2.0499	1.5212	1.2635	1.5334	11.028
9	1.9227	2.0508	1.6017	1.3195	1.6152	11.553
9.5	2.0016	2.1113	1.6764	1.3672	1.7022	12.078
10	2.0776	2.2073	1.7411	1.4339	1.8055	12.866
10.5	2.1617	2.3344	1.8080	1.4914	1.9071	13.391
11	2.2358	2.4514	1.8727	1.5617	2.0079	13.916
11.5	2.3395	2.5910	1.9411	1.6295	2.1160	14.704
12	2.4334	2.7301	2.0179	1.6772	2.2319	15.229
12.5	2.5030	2.8691	2.0869	1.7395	2.3508	15.754
13	2.6202	3.0011	2.1608	1.7939	2.4440	16.279
13.5	2.7301	3.1394	2.2368	1.8498	2.5467	17.067
14	2.8473	3.2746	2.3252	1.9079	2.6553	17.592
14.5	2.9761	3.4228	2.4291	1.9658	2.7829	18.117
15	3.0786	3.5676	2.5150	2.0270	2.9105	18.905
15.5	3.1919	3.7039	2.6134	2.0888	3.0429	19.43
16	3.2759	3.8488	2.7046	2.1521	3.1721	19.955
16.5	3.3783	3.9997	2.8138	2.2328	3.3071	20.48
17	3.4946	4.1390	2.9032	2.2968	3.4480	21.268
17.5	3.5922	4.2604	2.9949	2.3622	3.5676	21.793
18	3.6861	4.3862	3.0684	2.4376	3.6920	22.318
18.5	3.7607	4.4976	3.1524	2.5150	3.8198	22.843
19	3.8488	4.6200	3.2384	2.5944	3.9369	23.631
19.5	3.9400	4.7449	3.3302	2.6735	4.0649	24.156

Table C-13. Continued.

20	4.0378	4.8723	3.4200	2.7523	4.1829	24.681
20.5	4.1536	5.0212	3.5074	2.8305	4.3120	25.206
21	4.2537	5.1543	3.6039	2.8934	4.4459	25.994
21.5	4.3591	5.2900	3.6950	2.9624	4.6023	26.519
22	4.4803	5.4284	3.7833	3.0416	4.7449	27.044
22.5	4.5847	5.5898	3.8672	3.1082	4.8908	27.569
23	4.6910	5.7132	3.9479	3.1760	5.0589	28.357
23.5	4.8174	5.8598	4.0521	3.2517	5.2315	28.882
24	4.9092	6.0091	4.1438	3.3098	5.3885	29.407
24.5	5.0212	6.1392	4.2372	3.3825	5.5491	29.932
25	5.1160	6.2715	4.3271	3.4663	5.6925	30.72
25.5	5.2315	6.4284	4.4288	3.5346	5.8598	31.245
26	5.3490	6.5421	4.5497	3.6111	5.9876	31.77
26.5	5.4483	6.6806	4.6376	3.6861	6.1392	32.295
27	5.5491	6.7976	4.7089	3.7622	6.2937	33.083
27.5	5.6102	6.9161	4.7992	3.8335	6.4284	33.608
28	5.7132	7.0360	4.8908	3.9089	6.5651	34.133
28.5	5.8176	7.1574	5.0024	3.9839	6.7039	34.921
29	5.9021	7.2802	5.0969	4.0681	6.8448	35.446
29.5	6.0091	7.4046	5.2121	4.1406	7.0119	35.971
30	6.0956	7.5304	5.2900	4.2256	7.1330	36.496
30.5	6.2051	7.6322	5.3885	4.3020	7.3050	37.284
31	6.3160	7.7607	5.4885	4.3794	7.4296	37.809
31.5	6.4058	7.8646	5.5898	4.4631	7.5812	38.334
32	6.4965	7.9694	5.6925	4.5497	7.7091	39.122
32.5	6.5881	8.0753	5.7966	4.6376	7.8646	39.647
33	6.7039	8.1552	5.8809	4.7089	8.0222	40.172
33.5	6.7976	8.2627	5.9661	4.7992	8.1820	40.697
34	6.8922	8.3440	6.0739	4.8908	8.3168	41.485
34.5	6.9878	8.4258	6.1392	4.9650	8.4532	42.01
35	7.0844	8.4806	6.2272	5.0212	8.5910	42.535
35.5	7.1818	8.5633	6.3384	5.0969	8.7303	43.323
36	7.2802	8.6466	6.4284	5.1928	8.8712	43.848
36.5	7.3547	8.7303	6.5193	5.2704	9.0135	44.373
37	7.4547	8.8429	6.6111	5.3490	9.1574	44.898
37.5	7.5558	8.9564	6.7039	5.4284	9.2736	45.686
38	7.6578	9.0422	6.7976	5.5289	9.3907	46.211
38.5	7.7349	9.1574	6.8922	5.5898	9.5088	46.736
39	7.8385	9.2445	6.9878	5.6513	9.5980	47.524
39.5	7.9169	9.3907	7.0844	5.7340	9.6878	48.049
40	7.9958	9.5088	7.1818	5.8176	6.5881	48.574
40.5	8.1019	9.6578	7.2802	5.8809	0.5946	49.099

Table C-13. Continued.

41	8.1552	1.9543	7.3796	5.9661	0.6325	49.887
41.5	8.2358	0.6595	7.4799	6.0522	0.7016	50.412
42	8.3440	0.6682	7.5812	6.1174	0.7642	50.937
42.5	8.4258	0.7124	7.6578	6.1831	0.8384	51.725
43	8.5081	0.7606	7.7607	6.2715	0.9211	52.25
43.5	8.5633	0.8290	7.8385	6.3384	1.0158	52.775
44	8.6466	0.8958	7.9169	6.4058	1.1250	53.3
44.5	8.7303	0.9682	8.0222	6.4965	1.2380	54.088
45	8.8147	1.0389	8.1019	6.5881	1.3698	54.613
45.5	8.9280	1.1145	8.2358	6.6574	1.4935	55.138
46	9.0135	1.1954	8.3168	6.7272	1.6152	55.663
46.5	9.0997	1.2894	8.4258	6.8212	1.7307	56.451
47	9.1574	1.3922	8.5081	6.8685	1.8557	56.976
47.5	9.2154	1.5083	8.5910	6.9638	1.9827	57.501
48	9.3320	1.6273	8.6744	7.0360	2.1094	58.026
48.5	9.3907	1.7244	8.7584	7.1330	2.2576	58.814
49	9.5088	1.8346	8.8429	7.2063	2.3913	59.339
49.5	9.5980	1.9323	8.8995	7.3050	2.5139	59.864
50	9.6578	2.0297	8.9564	7.3547	2.6678	60.652
50.5	9.7479	2.1217	8.9850	7.4296	2.8042	61.177
51	9.8386	2.2220	8.9850	7.5304	2.9562	61.702
51.5	9.8993	2.3354	9.0422	7.6066	3.1212	62.227
52	10.0215	2.4482	9.1285	7.6834	3.2800	63.015
52.5	10.0830	2.5511	9.1864	7.7607	3.4368	63.54
53	10.2066	2.6827	9.2736	7.8385	3.5966	64.065
53.5	10.3312	2.8042	9.3320	7.9169	3.7412	64.59
54	10.4252	2.9277	9.3907	7.9958	3.8811	65.378
54.5	10.0522	3.0454	9.4202	8.0753	4.0124	65.903
55	0.6817	3.1734	9.4792	8.1820	4.1390	66.428
55.5	0.6896	3.2989	9.5385	8.2358	4.2703	66.953
56	0.7112	3.4368	9.5980	8.3168	4.4117	67.741
56.5	0.7489	3.5662	9.6878	8.3985	4.5672	68.266
57	0.8001	3.6964	9.7781	8.4806	4.7449	68.791
57.5	0.8561	3.8198	9.8386	8.5633	4.8908	69.316
58	0.9155	3.9557	9.1864	8.6466	5.0400	70.104
58.5	0.9692	4.0777	0.6831	8.7303	5.2121	70.629
59	1.0230	4.2026	0.6835	8.7865	5.3687	71.154
59.5	1.0847	4.3406	0.7127	8.8712	5.5491	71.679
60	1.1484	4.4631	0.7516	8.9280	5.7132	72.204
60.5	1.2225	4.5672	0.7866	8.9850	5.8598	72.992
61	1.3006	4.6732	0.8256	9.0709	6.0091	73.517
61.5	1.3862	4.7810	0.8760	9.0997	6.1611	74.042

Table C-13. Continued.

62	1.4496	4.8908	0.9225	9.1574	6.3160	74.83
62.5	1.5205	5.0400	0.9819	9.2445	6.4510	75.355
63	1.6054	5.1735	1.0337	9.3320	6.6111	75.88
63.5	1.6936	5.2900	1.0917	9.3614	6.7506	76.405
64	1.7784	5.4483	1.1563	9.4202	6.9161	77.193
64.5	1.8693	5.5898	1.2142	9.4497	7.0601	77.718
65	1.9490	5.7132	1.2819	5.9447	7.2063	78.243
65.5	2.0343	5.8598	1.3606	0.6379	7.3547	78.768
66	2.1170	6.0091	1.4366	0.6392	7.4799	79.556
66.5	2.1791	6.1392	1.5155	0.6419	7.6322	80.081
67	2.2556	6.2937	1.5987	0.6488	7.7866	80.606
67.5	2.3334	6.4284	1.6803	0.6546	7.9169	81.394
68	2.4207	6.5421	1.7460	0.6735	8.0753	81.919
68.5	2.5248	6.6806	1.8154	0.7038	8.2089	82.444
69	2.6213	6.8212	1.8855	0.7431	8.3440	83.232
69.5	2.7104	6.9399	1.9525	0.7878	8.4806	83.757
70	2.8437	7.0601	2.0233	0.8252	8.6188	84.282
70.5	2.9487	7.1818	2.0953	0.8636	8.7584	84.807
71	3.0658	7.3050	2.1752	0.9067	8.8995	85.595
71.5	3.1669	7.4296	2.2457	0.9561	9.0422	86.12
72	3.2638	7.5558	2.3324	0.9957	9.1864	86.645
72.5	3.3632	7.6578	2.4207	1.0327	9.2736	87.17
73	3.4354	7.7607	2.4944	1.0713	9.3907	87.17
73.5	3.4522	7.7607	2.5194	1.1167	9.3907	87.17

Table C-14. Kaolinite run #2 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
0	0.6242	0.6328	0.6396	0.6001	0.5691	0
0.5	0.6235	0.6325	0.6399	0.5997	0.5688	0.263
1	0.6248	0.6345	0.6416	0.5991	0.5679	0.788
1.5	0.6288	0.6505	0.6481	0.6023	0.5685	1.313
2	0.6315	0.6907	0.6643	0.6065	0.5755	2.101
2.5	0.6348	0.7438	0.6965	0.6110	0.5902	2.626
3	0.6402	0.8005	0.7327	0.6248	0.6440	3.151
3.5	0.6501	0.8627	0.7830	0.6577	0.7198	3.939
4	0.6724	0.9150	0.8264	0.6903	0.8176	4.464
4.5	0.7013	0.9804	0.8698	0.7308	0.9361	4.989
5	0.7297	1.0425	0.9211	0.7575	1.0466	5.777
5.5	0.7524	1.1041	0.9745	0.7907	1.2054	6.302
6	0.7814	1.1711	1.0235	0.8324	1.3593	6.827
6.5	0.8180	1.2452	1.0756	0.8645	1.5226	7.615

Table C-14. Continued.

7	0.8583	1.3151	1.1206	0.8917	1.6803	8.14
7.5	0.8881	1.4096	1.1740	0.9333	1.8388	8.665
8	0.9183	1.4949	1.2326	0.9731	2.0097	9.19
8.5	0.9619	1.6009	1.2869	1.0219	2.1966	9.715
9	0.9868	1.6818	1.3574	1.0581	2.3674	10.503
9.5	1.0184	1.7825	1.4271	1.0976	2.5655	11.028
10	1.0524	1.8650	1.5162	1.1406	2.7699	11.553
10.5	1.0825	1.9446	1.5972	1.2030	2.9624	12.341
11	1.1206	2.0188	1.6594	1.2446	3.1695	12.866
11.5	1.1649	2.0963	1.7180	1.3310	3.3963	13.391
12	1.1913	2.1772	1.7857	1.3457	3.5879	14.179
12.5	1.2338	2.2646	1.8481	1.4062	3.7939	14.704
13	1.2819	2.3488	1.9097	1.4648	3.9871	15.229
13.5	1.3259	2.4302	1.9765	1.5155	4.1748	15.754
14	1.3593	2.5226	2.0425	1.5720	4.3710	16.279
14.5	1.4082	2.6416	2.0991	1.6273	4.6023	17.067
15	1.4572	2.7452	2.1723	1.6733	4.8174	17.592
15.5	1.4963	2.8401	2.2358	1.7275	5.0779	18.117
16	1.5588	2.9351	2.3150	1.7841	5.3292	18.642
16.5	1.6092	3.0238	2.3819	1.8263	5.5694	19.43
17	1.6578	3.1212	2.4696	1.8761	5.7966	19.955
17.5	1.7030	3.2224	2.5358	1.9288	6.0091	20.48
18	1.7476	3.3289	2.6112	1.9765	6.2493	21.005
18.5	1.8030	3.4298	2.6896	2.0288	6.4510	21.53
19	1.8388	3.5274	2.7793	2.0850	6.6806	22.318
19.5	1.8872	3.6316	2.8764	2.1531	6.8922	22.843
20	1.9227	3.7502	2.9611	2.2093	7.1330	23.368
20.5	1.9658	3.8442	3.0264	2.2666	7.3298	24.156
21	2.0124	3.9494	3.1031	2.3334	7.5304	24.681
21.5	2.0535	4.0553	3.1800	2.4038	7.7607	25.206
22	2.0925	4.1568	3.2571	2.4643	7.9694	25.731
22.5	2.1331	4.2521	3.3289	2.5347	8.2089	26.519
23	2.1656	4.3558	3.4019	2.6101	8.4258	27.044
23.5	2.2063	4.4288	3.4593	2.6689	8.6188	27.569
24	2.2576	4.5149	3.5460	2.7324	8.8429	28.094
24.5	2.3028	4.6200	3.6316	2.8054	9.0422	28.882
25	2.3467	4.6910	3.7083	2.8751	9.2154	29.407
25.5	2.3986	4.7810	3.7849	2.9463	9.4202	29.932
26	2.4419	4.8540	3.8549	2.9924	9.5683	30.72
26.5	2.4987	4.9650	3.9338	3.0556	9.7178	31.245
27	2.5434	5.0589	4.0076	3.1225	9.8689	31.77
27.5	2.6134	5.1543	4.0986	3.1879	10.0215	32.295

Table C-14. Continued

28	2.6655	5.2509	4.1682	3.2397	10.1756	32.82
28.5	2.7208	5.3687	4.2471	3.2895	10.3625	33.608
29	2.8018	5.4684	4.3271	3.3563	10.6150	34.133
29.5	2.8727	5.5694	4.3913	3.4312	10.8713	34.658
30	2.9240	5.6719	4.4803	3.4932	10.9359	35.183
30.5	2.9636	5.7966	4.5672	3.5532	10.9684	35.971
31	3.0163	5.8809	4.6376	3.6272	12.2800	36.496
31.5	3.0837	5.9876	4.7089	3.7128	0.6338	37.021
32	3.1212	6.1174	4.7810	3.7939	0.6570	37.546
32.5	3.1655	6.2051	4.8540	3.8672	0.7634	38.071
33	3.2157	6.3160	4.9463	3.9447	0.8658	38.859
33.5	3.2813	6.4284	5.0400	4.0346	0.9972	39.384
34	3.3275	6.5193	5.1351	4.1050	1.1563	39.909
34.5	3.3701	6.6342	5.2121	4.1862	1.3113	40.434
35	3.4144	6.7272	5.2900	4.2703	1.4662	41.222
35.5	3.4705	6.8212	5.3885	4.3439	1.6364	41.747
36	3.4875	6.9161	5.4684	4.4288	1.8071	42.272
36.5	3.5446	7.0119	5.5491	4.5149	1.9472	42.797
37	3.6024	7.1086	5.6307	4.6023	2.1236	43.585
37.5	3.6521	7.1818	5.7132	4.6732	2.3150	44.11
38	3.7083	7.3050	5.7966	4.7629	2.5281	44.635
38.5	3.7532	7.4046	5.9021	4.8540	2.7138	45.16
39	3.7985	7.4799	5.9876	4.9278	2.9117	45.948
39.5	3.8365	7.5812	6.0739	5.0024	3.1264	46.473
40	3.9027	7.6578	6.1611	5.0969	3.3302	46.998
40.5	3.9557	7.7607	6.2272	5.1735	3.5547	47.523
41	3.9997	7.8385	6.3160	5.2509	3.7622	48.311
41.5	4.0697	7.9694	6.4058	5.3292	3.9619	48.836
42	4.1179	8.0222	6.4737	5.4084	4.1325	49.361
42.5	4.1813	8.1019	6.5421	5.4885	4.3104	49.886
43	4.2504	8.1820	6.6342	5.5898	4.5323	50.674
43.5	4.3053	8.2627	6.7272	5.6513	4.7629	51.199
44	4.3676	8.3440	6.8212	5.7340	4.9837	51.724
44.5	4.4288	8.3985	6.8922	5.8176	5.2315	52.249
45	4.4976	8.4532	6.9638	5.9021	5.4885	53.037
45.5	4.5497	8.5357	7.0360	5.9876	5.7132	53.562
46	4.6023	8.5910	7.1086	6.0739	5.9234	54.087
46.5	4.6554	8.6466	7.2063	6.1392	6.1392	54.612
47	4.7449	8.7303	7.2802	6.2272	6.3608	55.137
47.5	4.7992	8.8147	7.3547	6.2937	6.5881	55.925
48	4.8723	8.9280	7.4547	6.3608	6.8212	56.45
48.5	4.9278	9.0135	7.5304	6.4510	7.0360	56.975

Table C-14. Continued

49	4.9837	9.0997	7.6066	6.5421	7.2309	57.5
49.5	5.0589	9.1864	7.6834	6.6342	7.4547	58.288
50	5.1160	9.2736	7.7866	6.7039	7.6578	58.813
50.5	5.1735	9.3907	7.8907	6.7976	7.9169	59.338
51	5.2315	9.4792	7.9431	6.8685	8.1019	59.863
51.5	5.2704	9.5683	8.0222	6.9399	8.2898	60.388
52	5.3292	9.6878	8.1285	7.0360	8.5081	61.176
52.5	5.4084	9.8386	8.2089	7.1086	8.7024	61.701
53	5.4684	4.9092	8.3168	7.2063	8.8712	62.226
53.5	5.5289	0.6556	8.3712	7.2802	9.0709	63.014
54	5.5694	0.6501	8.4532	7.3547	9.2445	63.539
54.5	5.6307	0.6581	8.5357	7.4296	9.4202	64.064
55	5.6719	0.6871	8.6188	7.5051	9.5683	64.589
55.5	5.7132	0.7247	8.7024	7.6066	9.7178	65.114
56	5.7757	0.7757	8.7865	7.6834	2.1094	65.639
56.5	5.8387	0.8281	8.8429	7.7349	0.6318	66.427
57	5.9021	0.8836	8.9280	7.8385	0.7168	66.952
57.5	5.9661	0.9432	8.9850	7.9169	0.8290	67.477
58	6.0306	1.0047	9.0709	7.9958	0.9432	68.002
58.5	6.0739	1.0724	9.1285	8.0753	1.0708	68.79
59	6.1174	1.1372	9.1864	8.1820	1.2243	69.315
59.5	6.1831	1.2083	9.2445	8.2358	1.3843	69.84
60	6.2272	1.2764	9.3028	8.3440	1.5617	70.628
60.5	6.2715	1.3580	9.3614	8.3985	1.7093	71.153
61	6.3384	1.4524	9.3907	8.4806	1.8565	71.678
61.5	6.3832	1.5500	9.4202	8.5633	2.0215	72.466
62	6.4510	1.6532	9.4792	8.6466	2.2014	72.991
62.5	6.5193	1.7460	9.5385	8.7584	2.4144	73.516
63	6.5651	1.8355	9.5683	8.8147	2.5944	74.041
63.5	6.6111	1.9209	9.6578	8.8995	2.7371	74.829
64	6.6806	2.0143	1.9114	8.9850	2.9240	75.354
64.5	6.7272	2.0804	0.6595	9.0422	3.1018	75.879
65	6.7741	2.1627	0.6661	9.0997	3.3139	76.667
65.5	6.8448	2.2586	0.6954	9.1574	3.5389	77.192
66	6.9161	2.3436	0.7266	9.2445	3.7247	77.717
66.5	6.9638	2.4344	0.7701	9.3028	3.9151	78.505
67	7.0360	2.5358	0.8047	9.3614	4.0825	79.03
67.5	7.0601	2.6484	0.8518	9.4202	4.2604	79.555
68	7.1330	2.7546	0.8958	9.4497	4.4459	80.08
68.5	7.1818	2.8618	0.9385	9.5088	4.6376	80.605
69	7.2309	2.9587	0.9918	9.5385	4.8540	81.393
69.5	7.2802	3.0569	1.0435	9.5683	5.0779	81.918

Table C-14. Continued

70	7.3547	3.1642	1.0933	9.6279	5.3292	82.443
70.5	7.4046	3.2786	1.1445	9.6878	5.5491	83.231
71	7.4296	3.3880	1.2007	9.7178	5.7340	83.231
71.5	7.5051	3.4889	1.2507	9.7781	5.9234	83.231
72	7.5304	3.5734	1.2801	9.8386	6.0306	83.231
72.5	7.5812	3.6331	1.3037	9.8689	6.0522	83.231

Table C-15. Kaolinite run #3 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
0	0.7094	0.6640	0.6781	0.6616	0.5657	0
0.5	0.7109	0.6654	0.6792	0.6626	0.5654	0.525
1	0.7150	0.6703	0.6813	0.6728	0.5654	1.05
1.5	0.7187	0.6771	0.6831	0.6742	0.5657	1.575
2	0.7266	0.7135	0.7075	0.6760	0.5814	2.1
2.5	0.7446	0.7606	0.7442	0.6896	0.6094	2.625
3	0.7662	0.8042	0.7814	0.7229	0.6746	3.413
3.5	0.7956	0.8531	0.8226	0.7606	0.7626	3.938
4	0.8269	0.9109	0.8658	0.8092	0.8583	4.463
4.5	0.8605	0.9716	0.9178	0.8483	0.9638	4.988
5	0.8804	1.0306	0.9614	0.8913	1.0814	5.513
5.5	0.9090	1.0890	1.0128	0.9356	1.2213	6.301
6	0.9385	1.1546	1.0560	0.9789	1.3691	6.826
6.5	0.9696	1.2189	1.0998	1.0260	1.5305	7.351
7	1.0007	1.2906	1.1546	1.0687	1.6772	7.876
7.5	1.0281	1.3600	1.2160	1.1250	1.8238	8.401
8	1.0671	1.4558	1.2708	1.1832	1.9836	9.189
8.5	1.0971	1.5406	1.3278	1.2368	2.1512	9.714
9	1.1311	1.6440	1.3982	1.2962	2.3416	10.239
9.5	1.1620	1.7259	1.4773	1.3387	2.5096	10.764
10	1.2024	1.8204	1.5356	1.4069	2.6907	11.289
10.5	1.2428	1.8984	1.6182	1.4655	2.8800	12.077
11	1.2813	1.9640	1.6702	1.5269	3.0722	12.602
11.5	1.3214	2.0407	1.7379	1.5950	3.2854	13.127
12	1.3606	2.1160	1.8138	1.6601	3.5160	13.652
12.5	1.4009	2.2024	1.8667	1.7220	3.7262	14.177
13	1.4565	2.2847	1.9349	1.7816	3.9120	14.965
13.5	1.4942	2.3694	1.9899	1.8355	4.0937	15.49
14	1.5442	2.4568	2.0563	1.9019	4.2720	16.015
14.5	1.5868	2.5533	2.1207	1.9720	4.4803	16.54
15	1.6349	2.6473	2.1820	2.0297	4.7089	17.328

Table C-15. Continued

15.5	1.6873	2.7417	2.2546	2.0841	4.9278	17.853
16	1.7259	2.8389	2.3252	2.1397	5.1928	18.378
16.5	1.7751	2.9364	2.3923	2.2024	5.4284	18.903
17	1.8171	3.0200	2.4847	2.2656	5.6513	19.691
17.5	1.8540	3.1095	2.5644	2.3272	5.8598	20.216
18	1.8967	3.2091	2.6587	2.4028	6.0956	20.741
18.5	1.9367	3.3152	2.7382	2.4814	6.2937	21.266
19	1.9649	3.4089	2.8281	2.5622	6.4965	22.054
19.5	2.0007	3.5017	2.9007	2.6157	6.7039	22.579
20	2.0361	3.6068	3.0037	2.7057	6.9399	23.104
20.5	2.0841	3.7054	3.0786	2.7664	7.1574	23.629
21	2.1207	3.7879	3.1459	2.8138	7.3547	24.417
21.5	2.1598	3.9136	3.2370	2.8995	7.5558	24.942
22	2.1927	4.0076	3.3261	2.9748	7.7607	25.467
22.5	2.2328	4.1212	3.3950	3.0530	7.9694	25.992
23	2.2736	4.2322	3.4875	3.1342	8.1820	26.517
23.5	2.3160	4.3104	3.5647	3.2051	8.3712	27.305
24	2.3601	4.4117	3.6389	3.2827	8.5633	27.83
24.5	2.3902	4.4976	3.7307	3.3412	8.7584	28.355
25	2.4536	4.6023	3.8000	3.4214	8.9564	28.88
25.5	2.4955	4.6732	3.8780	3.4804	9.1285	29.668
26	2.5303	4.7449	3.9416	3.5575	9.3028	30.193
26.5	2.5788	4.8357	4.0203	3.6331	9.4792	30.718
27	2.6405	4.9278	4.1034	3.7024	9.6279	31.243
27.5	2.6804	5.0024	4.1748	3.7713	9.7479	31.768
28	2.7347	5.1160	4.2438	3.8442	9.8993	32.556
28.5	2.8102	5.1928	4.3439	3.9182	10.0522	33.081
29	2.8751	5.2900	4.4117	3.9839	10.2688	33.606
29.5	2.9240	5.3885	4.4976	4.0585	10.4567	34.131
30	2.9798	5.5086	4.5672	4.1341	10.7427	34.919
30.5	3.0327	5.6102	4.6554	4.2108	10.9036	35.444
31	3.0940	5.6925	4.7269	4.2853	10.9359	35.969
31.5	3.1603	5.7966	4.7810	4.3423	10.9359	36.494
32	3.2051	5.9021	4.8723	4.4117	10.9684	37.019
32.5	3.2464	6.0091	4.9463	4.4976	10.9684	37.544
33	3.2962	6.1174	5.0212	4.5672	11.9600	38.332
33.5	3.3426	6.2051	5.1160	4.6554	0.6739	38.857
34	3.3963	6.3160	5.1928	4.7269	0.7567	39.382
34.5	3.4312	6.4284	5.2704	4.7992	0.8627	39.907
35	3.4593	6.4965	5.3490	4.8357	0.9863	40.432
35.5	3.4975	6.5881	5.4284	4.9463	1.1372	41.22
36	3.5417	6.7039	5.4885	5.0024	1.3037	41.745

Table C-15. Continued

36.5	3.5879	6.7976	5.5898	5.0779	1.4836	42.27
37	3.6462	6.8922	5.6719	5.1543	1.6617	42.795
37.5	3.6920	6.9638	5.7548	5.2315	1.8338	43.32
38	3.7247	7.0601	5.8387	5.3292	2.0043	44.108
38.5	3.7743	7.1574	5.9021	5.4084	2.2200	44.633
39	3.8167	7.2555	5.9876	5.4885	2.4376	45.158
39.5	3.8565	7.3547	6.0522	5.5694	2.6394	45.683
40	3.8919	7.4296	6.1392	5.6307	2.8281	46.208
40.5	3.9385	7.5051	6.2272	5.7132	3.0543	46.996
41	3.9839	7.5812	6.2937	5.7966	3.2786	47.521
41.5	4.0378	7.6834	6.3608	5.8809	3.5203	48.046
42	4.0825	7.7349	6.4510	5.9447	3.7698	48.571
42.5	4.1260	7.8125	6.5193	6.0091	4.0076	49.096
43	4.1682	7.9169	6.5881	6.0956	4.2158	49.884
43.5	4.2256	7.9958	6.6574	6.1611	4.4288	50.409
44	4.2820	8.0487	6.7272	6.2272	4.6376	50.934
44.5	4.3372	8.1285	6.7976	6.3160	4.8723	51.459
45	4.3913	8.1820	6.8922	6.3832	5.1351	51.984
45.5	4.4459	8.2627	6.9638	6.4510	5.4084	52.772
46	4.4976	8.3440	7.0360	6.5421	5.6513	53.297
46.5	4.5497	8.3985	7.1086	6.6342	5.8598	53.822
47	4.6023	8.4532	7.1818	6.7272	6.1174	54.347
47.5	4.6554	8.5081	7.2309	6.7741	6.3608	54.872
48	4.7269	8.5910	7.3298	6.8685	6.5881	55.397
48.5	4.7810	8.6466	7.4046	6.9399	6.8212	56.185
49	4.8357	8.7303	7.4799	7.0119	7.0601	56.71
49.5	4.8908	8.8147	7.5558	7.0844	7.3050	57.235
50	4.9463	8.8995	7.6322	7.1574	7.5304	57.76
50.5	5.0024	8.9850	7.7091	7.2309	7.7349	58.285
51	5.0779	9.0709	7.7866	7.3298	7.9694	58.81
51.5	5.1160	9.1285	7.8646	7.3796	8.2089	59.335
52	5.1928	9.2154	7.9431	7.4547	8.4258	60.123
52.5	5.2121	9.3028	7.9958	7.5304	8.6466	60.648
53	5.2704	9.3907	8.0753	7.6066	8.8429	61.173
53.5	5.3490	9.5088	8.1285	7.6834	9.0709	61.698
54	5.3885	3.1394	8.2358	7.7607	9.2736	62.223
54.5	5.4483	0.7198	8.2898	7.8385	9.4497	62.748
55	5.5086	0.7135	8.3985	7.9169	9.6279	63.536
55.5	5.5491	0.7206	8.4532	7.9958	9.8083	64.061
56	5.6102	0.7466	8.5357	8.0753	1.8388	64.586
56.5	5.6307	0.7952	8.5910	8.1552	0.6602	65.111
57	5.6925	0.8422	8.6744	8.2358	0.7536	65.636

Table C-15. Continued

57.5	5.7548	0.8890	8.7303	8.2898	0.8645	66.161
58	5.7966	0.9366	8.7865	8.3712	0.9918	66.949
58.5	5.8598	0.9863	8.8429	8.4532	1.1383	67.474
59	5.9234	1.0399	8.9280	8.5357	1.3151	67.999
59.5	5.9447	1.1019	8.9850	8.5910	1.5005	68.524
60	6.0091	1.1614	9.0422	8.6744	1.6756	69.049
60.5	6.0522	1.2171	9.0997	8.7303	1.8472	69.574
61	6.0956	1.2832	9.1285	8.8147	2.0206	70.099
61.5	6.1611	1.3509	9.2154	8.8712	2.2044	70.887
62	6.2051	1.4230	9.2736	8.9280	2.4122	71.412
62.5	6.2493	1.5133	9.3028	9.0135	2.6236	71.937
63	6.2937	1.5994	9.3614	9.0422	2.8197	72.462
63.5	6.3608	1.6795	9.3907	9.0997	3.0238	72.987
64	6.4058	1.7727	9.4202	9.1864	3.2652	73.512
64.5	6.4510	1.8582	9.4792	9.2445	3.5031	74.037
65	6.5193	1.9297	9.5385	9.3028	3.7367	74.562
65.5	6.5651	2.0052	9.5683	9.3614	3.9354	75.35
66	6.5881	2.0692	9.6279	9.3907	4.1228	75.875
66.5	6.6574	2.1455	9.6878	9.4202	4.3255	76.4
67	6.7039	2.2122	9.7479	9.4792	4.5323	76.925
67.5	6.7741	2.2827	9.8083	9.5088	4.7629	77.45
68	6.8212	2.3674	9.8689	9.5683	4.9837	77.975
68.5	6.8685	2.4397	9.9298	9.5980	5.2704	78.763
69	6.9399	2.5183	9.9909	9.6578	5.5289	79.288
69.5	6.9878	2.6022	10.0215	9.6878	5.7757	79.813
70	7.0119	2.6930	10.0830	9.7178	5.9876	80.338
70.5	7.0601	2.7888	10.1756	9.8083	6.2272	80.601
71	7.1086	2.8582	10.2066	9.8689	6.4284	80.601
71.5	7.1330	2.8666	10.2066	9.9298	6.6111	80.601
72	7.1330	2.8715	10.2377	9.9603	6.6806	80.601
72.5	7.1330	2.8764	10.2377	9.9603	6.6806	80.601

Table C-16. Kaolinite run #4 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6218	0.6087	0.6182	0.6004	0.5531	0.0000
-9.5	0.6255	0.6104	0.6199	0.6017	0.5537	0.5250
-9	0.6318	0.6117	0.6212	0.6049	0.5679	1.0500
-8.5	0.6345	0.6127	0.6218	0.6081	0.6803	1.5750
-8	0.6416	0.6133	0.6232	0.6084	0.9022	2.1000
-7.5	0.6484	0.6149	0.6248	0.6084	1.1694	2.6250

Table C-16. Continued

-7	0.6546	0.6169	0.6265	0.6068	1.4871	2.8880
-6.5	0.6626	0.6208	0.6265	0.6068	1.7825	3.4130
-6	0.6693	0.6285	0.6315	0.6071	2.1179	3.9380
-5.5	0.6598	0.6382	0.6355	0.6081	2.4793	4.4630
-5	0.6665	0.6508	0.6402	0.6094	2.8389	4.9880
-4.5	0.6724	0.6658	0.6450	0.6094	3.2277	5.5130
-4	0.6778	0.6739	0.6512	0.6120	3.6477	6.0380
-3.5	0.6907	0.6849	0.6591	0.6130	4.0235	6.5630
-3	0.7024	0.6932	0.6672	0.6146	4.4288	7.0880
-2.5	0.7116	0.7053	0.6792	0.6166	4.8540	7.3510
-2	0.7229	0.7187	0.6922	0.6195	5.3096	7.8760
-1.5	0.7331	0.7346	0.7057	0.6235	5.6925	8.4010
-1	0.7477	0.7489	0.7027	0.6305	6.0956	8.9260
-0.5	0.7658	0.7646	0.7142	0.6358	6.4965	9.4510
0	0.7761	0.7834	0.7247	0.6433	6.8922	9.9760
0.5	0.7948	0.8038	0.7335	0.6488	7.3050	10.5010
1	0.8101	0.8130	0.7442	0.6577	7.7091	11.0260
1.5	0.8256	0.8294	0.7575	0.6700	8.1285	11.5510
2	0.8479	0.8479	0.7650	0.6774	8.5357	12.0760
2.5	0.8557	0.8636	0.7878	0.6907	8.8712	12.3390
3	0.8778	0.8809	0.7981	0.6922	9.2154	12.8640
3.5	0.8913	0.8953	0.8126	0.7064	4.5847	13.3890
4	0.8990	0.9118	0.8163	0.7105	0.7281	13.9140
4.5	0.9132	0.9323	0.8294	0.7221	0.9026	14.4390
5	0.9290	0.9441	0.8431	0.7285	1.1250	14.9640
5.5	0.9465	0.9643	0.8505	0.7369	1.4197	15.4890
6	0.9624	0.9799	0.8702	0.7450	1.7419	16.0140
6.5	0.9789	0.9903	0.8769	0.7587	2.0343	16.5390
7	0.9928	1.0083	0.8908	0.7681	2.3736	17.0640
7.5	1.0123	1.0291	0.9054	0.7753	2.7301	17.5890
8	1.0240	1.0529	0.9197	0.7846	3.1355	17.8520
8.5	1.0389	1.0650	0.9253	0.7915	3.5245	18.3770
9	1.0524	1.0761	0.9323	0.8059	3.9447	18.9020
9.5	1.0756	1.0911	0.9523	0.8088	4.2853	19.4270
10	1.0927	1.1101	0.9672	0.8226	4.6732	19.9520
10.5	1.1008	1.1239	0.9765	0.8341	5.0969	20.4770
11	1.1217	1.1400	0.9873	0.8453	5.5491	21.0020
11.5	1.1361	1.1586	1.0027	0.8470	5.9876	21.2650
12	1.1552	1.1809	1.0199	0.8627	6.4058	21.7900
12.5	1.1734	1.2007	1.0337	0.8720	6.8212	22.3150
13	1.1913	1.2189	1.0440	0.8809	7.2555	22.8400
13.5	1.2083	1.2356	1.0498	0.8949	7.6322	23.3650

Table C-16. Continued

14	1.2272	1.2604	1.0793	0.9013	8.0222	23.8900
14.5	1.2537	1.2807	1.0895	0.9137	8.3985	24.4150
15	1.2714	1.3050	1.0954	0.9290	8.7584	24.9400
15.5	1.2906	1.3271	1.1134	0.9333	9.1285	25.4650
16	1.3170	1.3470	1.1217	0.9418	9.3614	25.9900
16.5	1.3316	1.3685	1.1411	0.9551	9.6878	26.5150
17	1.3548	1.3982	1.1711	0.9711	1.2452	26.7780
17.5	1.3685	1.4237	1.1711	0.9775	0.7232	27.3030
18	1.3876	1.4545	1.1867	0.9952	0.9370	27.8280
18.5	1.4116	1.4794	1.2148	1.0088	1.1977	28.3530
19	1.4359	1.5083	1.2356	1.0174	1.4907	28.8780
19.5	1.4593	1.5334	1.2392	1.0296	1.7931	29.4030
20	1.4711	1.5588	1.2555	1.0472	2.1066	29.9280
20.5	1.4893	1.5794	1.2739	1.0587	2.4482	30.4530
21	1.5356	1.6062	1.3025	1.0719	2.8054	30.9780
21.5	1.5442	1.6326	1.3075	1.0793	3.2144	31.2410
22	1.5698	1.6617	1.3310	1.0900	3.6068	31.7660
22.5	1.6002	1.6896	1.3399	1.1014	4.0044	32.2910
23	1.6288	1.7156	1.3646	1.1228	4.3574	32.8160
23.5	1.6410	1.7419	1.3803	1.1333	4.7629	33.3410
24	1.6795	1.7637	1.3989	1.1501	5.1928	33.8660
24.5	1.6803	1.7849	1.4312	1.1614	5.6513	34.3910
25	1.7164	1.8071	1.4462	1.1706	6.0739	34.9160
25.5	1.7267	1.8246	1.4579	1.1948	6.4965	35.4410
26	1.7589	1.8456	1.4759	1.1977	6.9161	35.9660
26.5	1.7718	1.8684	1.4970	1.2166	7.3298	36.2290
27	1.7972	1.8941	1.5012	1.2266	7.7349	36.7540
27.5	1.8121	1.9157	1.5291	1.2338	8.1019	37.2790
28	1.8439	1.9376	1.5486	1.2513	8.5081	37.8040
28.5	1.8523	1.9596	1.5742	1.2647	8.8429	38.3290
29	1.8967	1.9836	1.5987	1.2844	9.1864	38.8540
29.5	1.9131	2.0025	1.6084	1.2987	1.0286	39.3790
30	1.9499	2.0206	1.6212	1.3138	0.8418	39.9040
30.5	1.9543	2.0398	1.6356	1.3348	1.0311	40.4290
31	1.9667	2.0628	1.6640	1.3509	1.2962	40.9540
31.5	1.9854	2.0869	1.6710	1.3613	1.6242	41.2170
32	2.0115	2.1047	1.6936	1.3836	1.9455	41.7420
32.5	2.0197	2.1245	1.7109	1.3882	2.2546	42.2670
33	2.0443	2.1435	1.7283	1.4089	2.6484	42.7920
33.5	2.0692	2.1627	1.7548	1.4190	3.0327	43.3170
34	2.0916	2.1839	1.7548	1.4359	3.4312	43.8420
34.5	2.1170	2.2014	1.7816	1.4620	3.8320	44.3670

Table C-16. Continued

35	2.1302	2.2250	1.7981	1.4662	4.1813	44.8920
35.5	2.1397	2.2527	1.8113	1.4850	4.5847	45.4170
36	2.1878	2.2776	1.8229	1.4998	5.0212	45.9420
36.5	2.1917	2.2978	1.8246	1.5119	5.4684	46.2050
37	2.2142	2.3160	1.8506	1.5248	5.9234	46.7300
37.5	2.2437	2.3477	1.8633	1.5363	6.3608	47.2550
38	2.2457	2.3663	1.8872	1.5566	6.7741	47.7800
38.5	2.2706	2.3882	1.8950	1.5786	7.2063	48.3050
39	2.2857	2.4059	1.9062	1.5823	7.6066	48.8300
39.5	2.3109	2.4323	1.9201	1.5994	8.0222	49.3550
40	2.3447	2.4610	1.9411	1.6235	8.3985	49.8800
40.5	2.3488	2.4857	1.9525	1.6295	8.7865	50.4050
41	2.3809	2.5020	1.9792	1.6478	9.0997	50.9300
41.5	2.3902	2.5270	1.9926	1.6586	4.4976	51.4550
42	2.4154	2.5522	1.9980	1.6818	0.7139	51.7180
42.5	2.4493	2.5832	2.0152	1.6975	0.9081	52.2430
43	2.4718	2.6146	2.0499	1.7085	1.1501	52.7680
43.5	2.4901	2.6405	2.0609	1.7172	1.4759	53.2930
44	2.5347	2.6701	2.0795	1.7387	1.7605	53.8180
44.5	2.5522	2.6965	2.1038	1.7629	2.1000	54.3430
45	2.5732	2.7278	2.1207	1.7767	2.4568	54.8680
45.5	2.6022	2.7464	2.1359	1.7816	2.8425	55.3930
46	2.6405	2.7746	2.1455	1.7939	3.2104	55.9180
46.5	2.6621	2.8007	2.1541	1.8113	3.6861	56.4430
47	2.6919	2.8269	2.1646	1.8246	4.0729	56.7060
47.5	2.7150	2.8606	2.2024	1.8405	4.4288	57.2310
48	2.7640	2.8849	2.2083	1.8574	4.8723	57.7560
48.5	2.7864	2.9117	2.2467	1.8744	5.3292	58.2810
49	2.8138	2.9401	2.2457	1.8924	5.7966	58.8060
49.5	2.8485	2.9661	2.3038	1.9036	6.2272	59.3310
50	2.8849	2.9899	2.3008	1.9166	6.6574	59.8560
50.5	2.9081	3.0087	2.3109	1.9402	7.0360	60.3810
51	2.9364	3.0327	2.3385	1.9499	7.5051	60.6440
51.5	2.9686	3.0594	2.3581	1.9685	7.8907	61.1690
52	2.9899	3.0799	2.3913	1.9783	8.2898	61.6940
52.5	3.0264	3.1108	2.3955	1.9953	8.6744	62.2190
53	3.0429	3.1394	2.4165	2.0052	9.0709	62.7440
53.5	3.0773	3.1603	2.4302	2.0206	9.4202	63.2690
54	3.1031	3.1892	2.4493	2.0334	0.6693	63.7940
54.5	3.1238	3.2131	2.4782	2.0480	0.8126	64.3190
55	3.1721	3.2424	2.5041	2.0655	1.0498	64.5820
55.5	3.1813	3.2625	2.5204	2.0860	1.3233	65.1070

Table C-16. Continued

56	3.2157	3.2854	2.5204	2.0972	1.6532	65.6320
56.5	3.2344	3.3112	2.5688	2.1113	1.9605	66.1570
57	3.2571	3.3426	2.5821	2.1264	2.2998	66.6820
57.5	3.2840	3.3701	2.5866	2.1407	2.6758	67.2070
58	3.3071	3.3936	2.6236	2.1569	3.0632	67.7320
58.5	3.3385	3.4172	2.6473	2.1801	3.4946	68.2570
59	3.3494	3.4424	2.6621	2.1966	3.9089	68.7820
59.5	3.3770	3.4677	2.6861	2.2191	4.2720	69.3070
60	3.3853	3.4946	2.7278	2.2378	4.6732	69.5700
60.5	3.4214	3.5174	2.7534	2.2616	5.1351	70.0950
61	3.4508	3.5374	2.7464	2.2746	5.5694	70.6200
61.5	3.4593	3.5647	2.7758	2.2867	6.0091	71.1450
62	3.4875	3.5893	2.8007	2.3038	6.4510	71.6700
62.5	3.5160	3.6155	2.8269	2.3242	6.8685	72.1950
63	3.5374	3.6477	2.8449	2.3416	7.3050	72.7200
63.5	3.5547	3.6787	2.8691	2.3622	7.6834	73.2450
64	3.5893	3.7054	2.8861	2.3850	8.1285	73.7700
64.5	3.6068	3.7307	2.9056	2.4059	8.5081	74.2950
65	3.6272	3.7577	2.9167	2.4249	8.8995	74.5580
65.5	3.6433	3.7818	2.9438	2.4440	9.2154	75.0830
66	3.6728	3.8076	2.9761	2.4568	6.3832	75.6080
66.5	3.6846	3.8304	2.9911	2.4825	0.7765	76.1330
67	3.7247	3.8611	3.0150	2.4987	0.8894	76.6580
67.5	3.7382	3.8934	3.0390	2.5204	1.1183	77.1830
68	3.7577	3.9182	3.0671	2.5336	1.4339	77.7080
68.5	3.7894	3.9416	3.0709	2.5589	1.7395	78.2330
69	3.7985	3.9666	3.0876	2.5799	2.0730	78.7580
69.5	3.8304	3.9934	3.1160	2.6045	2.3923	79.2830
70	3.8611	4.0250	3.1433	2.6236	2.7558	79.8080
70.5	3.8811	4.0409	3.1472	2.6416	3.1394	80.0710
71	3.8811	4.0633	3.1616	2.6553	3.5749	80.5960
71.5	3.9089	4.0889	3.1721	2.6758	3.9510	81.1210
72	3.9494	4.1098	3.2131	2.6988	4.3120	81.6460
72.5	3.9776	4.1390	3.2410	2.7266	4.7629	82.1710
73	3.9997	4.1699	3.2544	2.7347	5.1928	82.6960
73.5	4.0266	4.1911	3.2625	2.7652	5.6513	83.2210
74	4.0521	4.2207	3.2746	2.7864	6.0739	83.7460
74.5	4.0857	4.2421	3.3112	2.8007	6.4965	84.2710
75	4.1098	4.2687	3.3139	2.8054	6.9161	84.7960
75.5	4.1341	4.2886	3.3426	2.8353	7.3298	85.3210
76	4.1748	4.3087	3.3426	2.8389	7.7349	85.8460
76.5	4.1748	4.3322	3.3880	2.8582	8.1019	86.3710

Table C-16. Continued

77	4.2010	4.3541	3.3839	2.8691	8.5081	86.6340
77.5	4.2256	4.3743	3.4103	2.8873	8.8995	87.1590
78	4.2488	4.3947	3.4396	2.9068	9.2154	87.6840
78.5	4.2803	4.4288	3.4494	2.9203	1.9881	88.2090
79	4.3104	4.4459	3.4635	2.9425	0.7927	88.7340
79.5	4.3271	4.4631	3.4918	2.9549	0.9967	89.2590
80	4.3608	4.4803	3.5145	2.9786	1.2440	89.7840
80.5	4.3913	4.4976	3.5317	2.9899	1.5603	90.0470
81	4.4117	4.5323	3.5446	3.0150	1.7148	90.0470
81.5	4.4459	4.5497	3.5662	3.0390	1.7564	90.0470
82	4.4459	4.5847	3.5835	3.0530	1.7605	90.0470
82.5	4.4631	4.5847	3.6097	3.0696	1.7605	90.0470

Table C-17. Kaolinite run #5 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6218	0.6235	0.6004	0.5946	0.5510	0.0000
-9.5	0.6235	0.6242	0.6004	0.5962	0.5510	0.2630
-9	0.6275	0.6265	0.6007	0.5969	0.5774	0.5250
-8.5	0.6285	0.6285	0.6026	0.5962	0.6732	0.5250
-8	0.6311	0.6308	0.6026	0.5972	0.8827	0.5250
-7.5	0.6352	0.6315	0.6026	0.5981	1.1586	0.5250
-7	0.6382	0.6338	0.6026	0.5997	1.5091	0.2630
-6.5	0.6419	0.6365	0.6033	0.6004	1.8548	0.5250
-6	0.6453	0.6389	0.6045	0.6004	2.2191	0.5250
-5.5	0.6419	0.6423	0.6068	0.6004	2.5922	0.5250
-5	0.6443	0.6488	0.6097	0.6010	2.9961	0.5250
-4.5	0.6443	0.6539	0.6120	0.6007	3.4340	0.5250
-4	0.6440	0.6616	0.6182	0.6004	3.8198	0.2630
-3.5	0.6464	0.6693	0.6251	0.6017	4.2075	0.5250
-3	0.6515	0.6799	0.6332	0.6026	4.6732	0.5250
-2.5	0.6532	0.6922	0.6413	0.6052	5.1543	0.5250
-2	0.6512	0.7020	0.6515	0.6062	5.6102	0.5250
-1.5	0.6563	0.7105	0.6598	0.6081	6.0306	0.2630
-1	0.6640	0.7217	0.6672	0.6146	6.4965	0.5250
-0.5	0.6626	0.7323	0.6760	0.6179	6.9399	0.5250
0	0.6654	0.7415	0.6813	0.6232	7.3796	0.5250
0.5	0.6724	0.7547	0.6878	0.6315	7.7866	0.5250
1	0.6792	0.7693	0.6947	0.6409	8.2627	0.2630
1.5	0.6874	0.7842	0.7038	0.6477	8.6744	0.5250
2	0.6980	0.7956	0.7101	0.6563	9.0709	0.5250
2.5	0.7068	0.8038	0.7153	0.6647	9.3907	0.5250
3	0.7131	0.8184	0.7331	0.6436	1.1723	0.5250
3.5	0.7229	0.8315	0.7404	0.6532	0.7989	0.2630
4	0.7312	0.8414	0.7481	0.6602	1.0042	0.5250
4.5	0.7392	0.8492	0.7540	0.6651	1.3208	0.5250
5	0.7500	0.8649	0.7622	0.6710	1.6250	0.5250
5.5	0.7551	0.8760	0.7705	0.6774	1.9358	0.5250
6	0.7705	0.8764	0.7761	0.6882	2.2927	0.2630
6.5	0.7802	0.8872	0.7826	0.6947	2.6724	0.5250
7	0.7887	0.9017	0.7911	0.6998	3.0684	0.5250
7.5	0.7960	0.9164	0.8014	0.7064	3.5103	0.5250
8	0.7972	0.9290	0.8101	0.7127	3.9136	0.5250
8.5	0.8038	0.9427	0.8146	0.7232	4.3104	0.5250
9	0.8163	0.9532	0.8243	0.7285	4.7449	0.5250
9.5	0.8303	0.9653	0.8358	0.7339	5.1928	0.2630

Table C-17. Continued

10	0.8474	0.9814	0.8453	0.7493	5.6513	0.5250
10.5	0.8518	0.9898	0.8522	0.7614	6.1174	0.5250
11	0.8579	1.0017	0.8605	0.7737	6.5651	0.5250
11.5	0.8680	1.0174	0.8715	0.7810	7.0119	0.5250
12	0.8787	1.0250	0.8809	0.7874	7.4547	0.5250
12.5	0.8836	1.0399	0.8926	0.7952	7.8646	0.2630
13	0.8990	1.0560	0.9022	0.8034	8.2898	0.5250
13.5	0.9114	1.0687	0.9137	0.8117	8.6744	0.5250
14	0.9253	1.0825	0.9229	0.8214	9.0709	0.5250
14.5	0.9389	1.0927	0.9342	0.8286	9.3907	0.5250
15	0.9523	1.1118	0.9446	0.8358	1.2148	0.5250
15.5	0.9590	1.1233	0.9537	0.8414	0.8034	0.5250
16	0.9731	1.1389	0.9692	0.8470	1.0545	0.2630
16.5	0.9848	1.1495	0.9765	0.8587	1.3278	0.5250
17	0.9977	1.1643	0.9878	0.8715	1.6486	0.5250
17.5	1.0057	1.1809	1.0007	0.8818	1.9508	0.5250
18	1.0276	1.1908	1.0133	0.8922	2.3324	0.5250
18.5	1.0332	1.2089	1.0209	0.9049	2.7046	0.5250
19	1.0571	1.2249	1.0347	0.9127	3.0799	0.2630
19.5	1.0650	1.2392	1.0451	0.9225	3.5074	0.5250
20	1.0782	1.2592	1.0529	0.9323	3.9494	0.5250
20.5	1.0868	1.2690	1.0618	0.9446	4.3171	0.5250
21	1.1014	1.2850	1.0740	0.9513	4.7269	0.5250
21.5	1.1096	1.3050	1.0873	0.9667	5.1928	0.2630
22	1.1178	1.3189	1.1107	0.9834	5.6719	0.5250
22.5	1.1372	1.3399	1.1355	0.9918	6.1392	0.5250
23	1.1495	1.3522	1.1501	0.9992	6.5881	0.5250
23.5	1.1637	1.3856	1.1660	1.0103	7.0119	0.5250
24	1.1821	1.3989	1.1711	1.0194	7.4296	0.2630
24.5	1.1972	1.4156	1.1878	1.0347	7.8385	0.5250
25	1.2089	1.4325	1.2036	1.0456	8.2358	0.5250
25.5	1.2284	1.4579	1.2231	1.0660	8.6466	0.5250
26	1.2368	1.4752	1.2225	1.0740	9.0135	0.5250
26.5	1.2440	1.4921	1.2452	1.0820	9.3320	0.5250
27	1.2604	1.5176	1.2543	1.0895	9.6578	0.5250
27.5	1.2801	1.5413	1.2678	1.0992	9.9603	0.2630
28	1.2950	1.5559	1.2739	1.1090	10.3625	0.5250
28.5	1.3201	1.5809	1.2925	1.1222	10.8390	0.5250
29	1.3316	1.6062	1.3081	1.1316	0.7146	0.5250
29.5	1.3496	1.6311	1.3278	1.1400	0.8479	0.5250
30	1.3633	1.6433	1.3342	1.1512	1.0927	0.2630
30.5	1.3737	1.6540	1.3412	1.1752	1.3896	0.5250

Table C-17. Continued

31	1.3856	1.6795	1.3483	1.1826	1.7196	0.5250
31.5	1.4062	1.6998	1.3652	1.1919	2.0398	0.5250
32	1.4257	1.7204	1.3777	1.2065	2.4122	0.5250
32.5	1.4332	1.7331	1.3882	1.2231	2.7841	0.5250
33	1.4503	1.7581	1.4029	1.2266	3.1892	0.5250
33.5	1.4683	1.7727	1.4210	1.2356	3.6624	0.2630
34	1.4907	1.7915	1.4319	1.2507	4.0314	0.5250
34.5	1.5190	1.8030	1.4448	1.2690	4.4288	0.5250
35	1.5284	1.8221	1.4641	1.2770	4.8540	0.5250
35.5	1.5442	1.8397	1.4780	1.2887	5.3885	0.5250
36	1.5625	1.8599	1.4886	1.2968	5.8809	0.2630
36.5	1.5831	1.8701	1.4956	1.3208	6.3384	0.5250
37	1.6039	1.8889	1.5091	1.3374	6.7741	0.5250
37.5	1.6265	1.9062	1.5240	1.3483	7.2309	0.5250
38	1.6410	1.9244	1.5428	1.3574	7.6578	0.5250
38.5	1.6440	1.9411	1.5537	1.3685	8.0487	0.5250
39	1.6679	1.9543	1.5654	1.3770	8.4532	0.2630
39.5	1.6826	1.9676	1.5779	1.3922	8.8712	0.5250
40	1.6983	1.9827	1.5912	1.4129	9.2154	0.5250
40.5	1.7188	1.9935	1.6032	1.4285	9.5088	0.5250
41	1.7283	2.0106	1.6159	1.4407	0.6943	0.5250
41.5	1.7532	2.0279	1.6280	1.4510	0.8422	0.5250
42	1.7678	2.0425	1.6463	1.4634	1.1057	0.5250
42.5	1.7890	2.0591	1.6555	1.4746	1.3711	0.2630
43	1.8047	2.0804	1.6694	1.4857	1.7403	0.5250
43.5	1.8113	2.0972	1.6881	1.5005	2.0591	0.5250
44	1.8439	2.1141	1.7006	1.5133	2.4059	0.5250
44.5	1.8659	2.1283	1.7148	1.5298	2.8126	0.5250
45	1.8795	2.1502	1.7299	1.5413	3.2330	0.5250
45.5	1.8872	2.1617	1.7363	1.5749	3.6565	0.2630
46	1.9053	2.1820	1.7484	1.5890	4.0633	0.5250
46.5	1.9236	2.1936	1.7589	1.5979	4.4631	0.5250
47	1.9323	2.2083	1.7710	1.6099	4.8908	0.5250
47.5	1.9587	2.2279	1.7816	1.6152	5.3490	0.5250
48	1.9720	2.2517	1.8005	1.6288	5.8387	0.5250
48.5	1.9917	2.2686	1.8154	1.6387	6.2937	0.5250
49	2.0106	2.2947	1.8288	1.6486	6.7272	0.2630
49.5	2.0279	2.3150	1.8422	1.6563	7.1818	0.5250
50	2.0416	2.3252	1.8565	1.6710	7.6322	0.5250
50.5	2.0600	2.3406	1.8616	1.6920	8.0487	0.5250
51	2.0850	2.3632	1.8769	1.7006	8.4532	0.5250
51.5	2.1010	2.3829	1.8881	1.7077	8.8712	0.5250

Table C-17. Continued

52	2.1047	2.4017	1.9062	1.7220	9.2154	0.5250
52.5	2.1264	2.4175	1.9183	1.7379	6.6806	0.2630
53	2.1445	2.4429	1.9323	1.7662	0.6929	0.5250
53.5	2.1521	2.4578	1.9516	1.7776	0.8894	0.5250
54	2.1685	2.4836	1.9640	1.7857	1.1239	0.5250
54.5	2.1956	2.5096	1.9827	1.7931	1.4489	0.5250
55	2.1966	2.5281	1.9935	1.8063	1.7452	0.5250
55.5	2.2210	2.5445	1.9998	1.8246	2.1226	0.5250
56	2.2279	2.5533	2.0115	1.8263	2.4610	0.2630
56.5	2.2417	2.5888	2.0261	1.8338	2.8691	0.5250
57	2.2576	2.6168	2.0398	1.8464	3.2491	0.5250
57.5	2.2837	2.6371	2.0554	1.8548	3.7158	0.5250
58	2.2998	2.6564	2.0692	1.8633	4.1163	0.5250
58.5	2.3059	2.6793	2.0878	1.8761	4.5149	0.5250
59	2.3303	2.7046	2.1104	1.8864	4.9837	0.2630
59.5	2.3519	2.7312	2.1207	1.9001	5.4483	0.5250
60	2.3663	2.7499	2.1369	1.9097	5.9021	0.5250
60.5	2.3892	2.7687	2.1388	1.9253	6.3384	0.5250
61	2.4091	2.7912	2.1502	1.9358	6.7976	0.5250
61.5	2.4249	2.8114	2.1665	1.9499	7.2309	0.5250
62	2.4440	2.8305	2.1868	1.9587	7.6322	0.5250
62.5	2.4750	2.8618	2.2053	1.9756	8.0753	0.2630
63	2.4933	2.8824	2.2181	1.9890	8.4806	0.5250
63.5	2.5128	2.9056	2.2427	2.0016	8.8995	0.5250
64	2.5183	2.9253	2.2566	2.0197	9.2445	0.5250
64.5	2.5434	2.9450	2.2726	2.0306	6.8212	0.5250
65	2.5710	2.9711	2.2907	2.0471	0.6976	0.5250
65.5	2.5877	2.9899	2.3049	2.0683	0.8505	0.2630
66	2.6033	3.0024	2.3150	2.0720	1.1178	0.5250
66.5	2.6258	3.0213	2.3272	2.0785	1.4298	0.5250
67	2.6575	3.0467	2.3416	2.0888	1.7379	0.5250
67.5	2.6827	3.0645	2.3601	2.1047	2.0591	0.5250
68	2.7023	3.0863	2.3829	2.1236	2.3705	0.2630
68.5	2.7301	3.1069	2.4049	2.1340	2.7912	0.5250
69	2.7687	3.1329	2.4175	2.1521	3.1774	0.5250
69.5	2.7935	3.1577	2.4344	2.1665	3.6257	0.5250
70	2.8138	3.1760	2.4493	2.1781	4.0665	0.5250
70.5	2.8317	3.1879	2.4643	2.2083	4.3862	0.5250
71	2.8521	3.2051	2.4782	2.2220	4.8723	0.2630
71.5	2.8812	3.2330	2.4965	2.2299	5.3292	0.5250
72	2.8885	3.2585	2.5106	2.2388	5.7966	0.5250
72.5	2.9191	3.2746	2.5237	2.2487	6.2051	0.5250

Table C-17. Continued

73	2.9562	3.3003	2.5390	2.2626	6.6806	0.5250
73.5	2.9611	3.3248	2.5644	2.2766	7.1086	0.5250
74	2.9873	3.3412	2.5877	2.2968	7.5304	0.5250
74.5	3.0264	3.3728	2.6000	2.3120	7.9431	0.5250
75	3.0390	3.3880	2.6123	2.3283	8.3712	0.2630
75.5	3.0594	3.4061	2.6269	2.3539	8.7865	0.5250
76	3.0825	3.4270	2.6416	2.3715	9.1574	0.5250
76.5	3.0953	3.4494	2.6587	2.3819	9.4497	0.5250
77	3.1095	3.4734	2.6919	2.4112	0.6756	0.5250
77.5	3.1459	3.4918	2.7115	2.4112	0.8388	0.5250
78	3.1734	3.5103	2.7278	2.4238	1.0660	0.5250
78.5	3.1853	3.5288	2.7441	2.4365	1.3535	0.2630
79	3.1972	3.5561	2.7640	2.4589	1.6679	0.5250
79.5	3.2330	3.5806	2.7805	2.4814	1.9667	0.5250
80	3.2491	3.5908	2.7900	2.4998	2.3529	0.5250
80.5	3.2531	3.6068	2.8078	2.5074	2.6942	0.0000
81	3.2679	3.6301	2.8281	2.5215	2.7841	0.0000
81.5	3.2908	3.6492	2.8437	2.5303	2.8161	0.0000
82	3.3030	3.6698	2.8558	2.5412	2.8197	0.0000
82.5	3.3084	3.6787	2.8630	2.5555	2.8185	0.2630

Table C-18. Kaolinite run #6 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6436	0.6130	0.6045	0.6199	0.5700	0.0000
-9.5	0.6470	0.6133	0.6055	0.6205	0.5697	0.2630
-9	0.6491	0.6153	0.6068	0.6215	0.5921	0.5250
-8.5	0.6519	0.6176	0.6071	0.6222	0.7075	0.5250
-8	0.6546	0.6195	0.6078	0.6208	0.9215	0.5250
-7.5	0.6546	0.6215	0.6087	0.6205	1.2136	0.5250
-7	0.6543	0.6218	0.6087	0.6199	1.5312	0.5250
-6.5	0.6567	0.6242	0.6110	0.6199	1.8633	0.2630
-6	0.6609	0.6265	0.6133	0.6199	2.2063	0.5250
-5.5	0.6626	0.6301	0.6133	0.6199	2.6101	0.5250
-5	0.6651	0.6318	0.6149	0.6199	3.0112	0.5250
-4.5	0.6693	0.6332	0.6176	0.6199	3.4677	0.5250
-4	0.6696	0.6332	0.6179	0.6199	3.8950	0.5250
-3.5	0.6739	0.6352	0.6238	0.6208	4.3288	0.5250
-3	0.6785	0.6315	0.6301	0.6218	4.7810	0.5250
-2.5	0.6828	0.6278	0.6358	0.6218	5.2509	0.2630
-2	0.6882	0.6308	0.6464	0.6242	5.7548	0.5250
-1.5	0.6947	0.6315	0.6525	0.6242	6.2051	0.5250

Table C-18. Continued

-1	0.7027	0.6335	0.6553	0.6261	6.6574	0.5250
-0.5	0.7090	0.6365	0.6647	0.6268	7.1330	0.5250
0	0.7109	0.6369	0.6724	0.6288	7.5812	0.5250
0.5	0.7183	0.6409	0.6796	0.6325	8.0222	0.5250
1	0.7270	0.6426	0.6817	0.6335	8.4532	0.5250
1.5	0.7392	0.6474	0.6893	0.6402	8.8995	0.2630
2	0.7438	0.6522	0.6947	0.6413	9.3028	0.5250
2.5	0.7477	0.6556	0.7027	0.6447	9.6279	0.5250
3	0.7563	0.6574	0.7090	0.6484	1.9446	0.5250
3.5	0.7670	0.6602	0.7187	0.6553	0.7579	0.5250
4	0.7689	0.6616	0.7210	0.6577	0.9839	0.5250
4.5	0.7725	0.6633	0.7213	0.6595	1.2764	0.5250
5	0.7713	0.6658	0.7221	0.6623	1.6174	0.5250
5.5	0.7826	0.6707	0.7244	0.6724	1.9490	0.5250
6	0.7891	0.6771	0.7408	0.6721	2.3354	0.2630
6.5	0.7940	0.6774	0.7327	0.6785	2.7441	0.5250
7	0.8038	0.6817	0.7454	0.6838	3.1537	0.5250
7.5	0.8121	0.6871	0.7462	0.6849	3.5879	0.5250
8	0.8180	0.6929	0.7547	0.6911	3.9934	0.5250
8.5	0.8239	0.6940	0.7587	0.6951	4.3930	0.5250
9	0.8345	0.6958	0.7666	0.6991	4.8357	0.5250
9.5	0.8431	0.7005	0.7753	0.7024	5.3292	0.5250
10	0.8479	0.7031	0.7810	0.7094	5.8387	0.5250
10.5	0.8561	0.7075	0.7927	0.7146	6.2715	0.5250
11	0.8675	0.7083	0.7960	0.7172	6.7506	0.2630
11.5	0.8778	0.7127	0.8059	0.7244	7.2063	0.5250
12	0.8876	0.7142	0.8155	0.7308	7.6578	0.5250
12.5	0.9003	0.7191	0.8197	0.7300	8.0753	0.5250
13	0.9095	0.7225	0.8379	0.7377	8.5081	0.5250
13.5	0.9141	0.7293	0.8505	0.7469	8.9280	0.5250
14	0.9206	0.7327	0.8548	0.7532	9.3028	0.5250
14.5	0.9290	0.7381	0.8684	0.7602	1.9640	0.5250
15	0.9427	0.7450	0.8684	0.7670	0.7587	0.5250
15.5	0.9456	0.7485	0.8764	0.7737	0.9883	0.2630
16	0.9537	0.7536	0.8804	0.7781	1.2906	0.5250
16.5	0.9765	0.7540	0.8885	0.7854	1.6410	0.5250
17	0.9997	0.7622	0.8981	0.7935	1.9499	0.5250
17.5	0.9997	0.7670	0.9090	0.7985	2.3221	0.5250
18	1.0078	0.7713	0.9118	0.8038	2.7324	0.5250
18.5	1.0083	0.7761	0.9215	0.8101	3.1655	0.5250
19	1.0291	0.7826	0.9290	0.8167	3.6053	0.2630
19.5	1.0358	0.7858	0.9456	0.8273	4.0203	0.5250

Table C-18. Continued

20	1.0566	0.7919	0.9475	0.8315	4.4288	0.5250
20.5	1.0618	0.7972	0.9494	0.8358	4.8908	0.5250
21	1.0676	0.8055	0.9503	0.8410	5.4084	0.5250
21.5	1.0814	0.8071	0.9633	0.8470	5.8809	0.5250
22	1.0798	0.8117	0.9662	0.8557	6.3384	0.5250
22.5	1.0890	0.8235	0.9789	0.8627	6.8212	0.5250
23	1.1150	0.8315	0.9799	0.8671	7.2802	0.5250
23.5	1.1172	0.8324	0.9848	0.8729	7.7349	0.2630
24	1.1261	0.8345	0.9918	0.8746	8.1820	0.5250
24.5	1.1339	0.8422	1.0123	0.8840	8.6188	0.5250
25	1.1450	0.8453	1.0189	0.8903	9.0135	0.5250
25.5	1.1575	0.8531	1.0123	0.8990	9.3614	0.5250
26	1.1569	0.8548	1.0291	0.9035	2.0061	0.5250
26.5	1.1700	0.8596	1.0472	0.9109	0.7846	0.5250
27	1.1855	0.8645	1.0650	0.9215	1.0317	0.5250
27.5	1.2042	0.8684	1.0655	0.9253	1.3367	0.2630
28	1.2272	0.8733	1.0772	0.9304	1.6686	0.5250
28.5	1.2237	0.8827	1.0847	0.9403	1.9872	0.5250
29	1.2641	0.8836	1.0933	0.9422	2.3767	0.5250
29.5	1.2647	0.8903	1.1047	0.9503	2.7464	0.5250
30	1.2727	0.8935	1.1063	0.9532	3.1813	0.5250
30.5	1.2931	0.8944	1.1123	0.9575	3.6053	0.2630
31	1.3031	0.9026	1.1206	0.9619	4.0314	0.5250
31.5	1.3201	0.9058	1.1361	0.9687	4.4459	0.5250
32	1.3252	0.9114	1.1428	0.9740	4.8908	0.5250
32.5	1.3399	0.9183	1.1546	0.9789	5.3885	0.5250
33	1.3425	0.9188	1.1580	0.9853	5.8809	0.5250
33.5	1.3731	0.9253	1.1723	0.9878	6.3608	0.5250
34	1.3698	0.9300	1.1844	0.9992	6.7976	0.5250
34.5	1.3909	0.9337	1.1902	1.0078	7.2555	0.2630
35	1.4149	0.9361	1.1977	1.0128	7.6834	0.5250
35.5	1.4237	0.9456	1.2089	1.0235	8.1285	0.5250
36	1.4116	0.9542	1.2148	1.0240	8.5633	0.5250
36.5	1.4149	0.9551	1.2207	1.0394	9.0135	0.5250
37	1.4448	0.9571	1.2392	1.0456	4.5847	0.5250
37.5	1.4278	0.9648	1.2471	1.0487	0.7083	0.2630
38	1.4558	0.9677	1.2568	1.0597	0.9045	0.5250
38.5	1.4773	0.9750	1.2629	1.0660	1.1746	0.5250
39	1.4746	0.9740	1.2819	1.0681	1.4970	0.5250
39.5	1.4711	0.9794	1.2968	1.0836	1.8304	0.5250
40	1.5048	0.9878	1.2968	1.0857	2.1917	0.5250
40.5	1.5048	0.9928	1.3025	1.0949	2.5799	0.5250

Table C-18. Continued

41	1.5248	0.9987	1.3094	1.0960	2.9886	0.2630
41.5	1.5757	1.0027	1.3227	1.1014	3.4242	0.5250
42	1.5551	1.0083	1.3316	1.1107	3.8749	0.5250
42.5	1.5786	1.0118	1.3509	1.1167	4.2886	0.5250
43	1.5823	1.0128	1.3620	1.1316	4.9463	0.5250
43.5	1.6205	1.0133	1.3587	1.1378	5.5086	0.5250
44	1.6295	1.0179	1.3672	1.1462	5.9876	0.2630
44.5	1.6440	1.0224	1.3982	1.1535	6.4510	0.5250
45	1.6609	1.0230	1.3935	1.1631	6.8922	0.5250
45.5	1.6686	1.0281	1.3909	1.1723	7.3547	0.5250
46	1.6904	1.0291	1.4096	1.1803	7.7866	0.5250
46.5	1.6998	1.0373	1.4237	1.1902	8.2358	0.5250
47	1.7196	1.0487	1.4298	1.1925	8.6744	0.5250
47.5	1.7315	1.0513	1.4496	1.2059	9.0709	0.5250
48	1.7395	1.0571	1.4641	1.2183	9.4497	0.2630
48.5	1.7476	1.0650	1.4829	1.2266	0.6965	0.5250
49	1.7597	1.0687	1.4907	1.2296	0.8315	0.5250
49.5	1.7662	1.0761	1.4907	1.2428	1.0761	0.5250
50	1.7964	1.0798	1.5012	1.2543	1.4049	0.5250
50.5	1.7931	1.0814	1.5048	1.2574	1.7283	0.5250
51	1.8105	1.0831	1.5219	1.2665	2.0683	0.2630
51.5	1.8271	1.0992	1.5262	1.2739	2.4419	0.5250
52	1.8288	1.1008	1.5464	1.2844	2.8257	0.5250
52.5	1.8599	1.1041	1.5551	1.2881	3.2949	0.5250
53	1.8684	1.1096	1.5537	1.3012	3.7188	0.5250
53.5	1.8710	1.1172	1.5713	1.3119	4.1195	0.5250
54	1.8975	1.1222	1.6009	1.3259	4.5497	0.5250
54.5	1.9027	1.1288	1.5987	1.3316	5.0212	0.2630
55	1.9131	1.1339	1.6084	1.3374	5.5086	0.5250
55.5	1.9297	1.1372	1.6190	1.3470	6.0091	0.5250
56	1.9464	1.1428	1.6235	1.3580	6.4510	0.5250
56.5	1.9490	1.1512	1.6280	1.3672	6.9161	0.5250
57	1.9676	1.1552	1.6425	1.3829	7.3547	0.5250
57.5	1.9810	1.1603	1.6609	1.3856	7.8125	0.5250
58	1.9998	1.1631	1.6686	1.3982	8.2627	0.5250
58.5	2.0016	1.1734	1.6803	1.4143	8.6744	0.2630
59	2.0179	1.1803	1.7006	1.4251	9.0997	0.5250
59.5	2.0306	1.1861	1.6990	1.4305	9.4497	0.5250
60	2.0379	1.1878	1.7164	1.4441	1.9114	0.5250
60.5	2.0535	1.1925	1.7196	1.4510	0.7543	0.5250
61	2.0591	1.1948	1.7267	1.4620	0.9947	0.5250
61.5	2.0757	1.2007	1.7411	1.4655	1.3025	0.5250

Table C-18. Continued

62	2.0963	1.2089	1.7468	1.4739	1.6517	0.5250
62.5	2.1010	1.2095	1.7653	1.4864	1.9703	0.2630
63	2.1141	1.2177	1.7694	1.4998	2.3416	0.5250
63.5	2.1302	1.2237	1.7710	1.5041	2.7231	0.5250
64	2.1455	1.2332	1.7964	1.5162	3.1511	0.5250
64.5	2.1521	1.2392	1.8096	1.5226	3.5908	0.5250
65	2.1656	1.2495	1.8071	1.5363	4.0092	0.5250
65.5	2.1830	1.2525	1.8154	1.5457	4.3845	0.5250
66	2.1888	1.2555	1.8321	1.5566	4.7992	0.2630
66.5	2.2044	1.2635	1.8372	1.5581	5.3292	0.5250
67	2.2132	1.2708	1.8498	1.5742	5.7966	0.5250
67.5	2.2259	1.2739	1.8489	1.5823	6.2493	0.5250
68	2.2427	1.2863	1.8591	1.5868	6.7272	0.5250
68.5	2.2546	1.2925	1.8778	1.6047	7.1818	0.2630
69	2.2726	1.2950	1.8744	1.6122	7.6322	0.5250
69.5	2.2897	1.3056	1.8915	1.6152	8.0753	0.5250
70	2.2958	1.3163	1.9036	1.6364	8.5081	0.5250
70.5	2.3079	1.3182	1.9088	1.6448	8.8995	0.5250
71	2.3242	1.3221	1.9157	1.6471	9.2736	0.5250
71.5	2.3426	1.3303	1.9314	1.6532	1.1786	0.5250
72	2.3601	1.3361	1.9341	1.6578	0.8354	0.2630
72.5	2.3715	1.3432	1.9428	1.6663	1.0895	0.5250
73	2.3850	1.3503	1.9561	1.6873	1.4170	0.5250
73.5	2.3850	1.3626	1.9720	1.6936	1.7468	0.5250
74	2.4007	1.3704	1.9685	1.7030	2.0767	0.5250
74.5	2.4165	1.3770	1.9890	1.7053	2.4750	0.5250
75	2.4344	1.3882	2.0025	1.7228	2.8800	0.5250
75.5	2.4440	1.3922	2.0034	1.7259	3.2949	0.2630
76	2.4568	1.4002	2.0133	1.7662	3.7262	0.5250
76.5	2.4707	1.4022	2.0306	1.7629	4.1244	0.5250
77	2.4890	1.4123	2.0306	1.7678	4.5323	0.5250
77.5	2.5204	1.4237	2.0416	1.7751	5.0212	0.5250
78	2.5303	1.4305	2.0581	1.7808	5.4885	0.5250
78.5	2.5544	1.4353	2.0748	1.7907	5.9661	0.5250
79	2.5644	1.4448	2.0897	1.7972	6.4510	0.5250
79.5	2.5777	1.4538	2.0944	1.8030	6.8922	0.2630
80	2.5899	1.4579	2.1019	1.8146	7.3298	0.5250
80.5	2.6089	1.4634	2.1075	1.8171	7.7607	0.2630
81	2.6281	1.4746	2.1226	1.8254	8.0487	0.2630
81.5	2.6360	1.4808	2.1293	1.8346	8.1285	0.0000
82	2.6507	1.4886	2.1464	1.8456	8.1552	0.0000
82.5	2.6655	1.5005	2.1455	1.8532	8.1552	0.0000

Table C-18. Continued

83	2.6712	1.5112	2.1675	1.8565	8.1552	0.0000
83.5	2.6735	1.5119	2.1694	1.8667	8.1552	0.0000
84	2.6735	1.5155	2.1685	1.8650	8.1552	0.0000
84.5	2.6724	1.5162	2.1733	1.8667	8.1552	0.0000
85	2.6735	1.5183	2.1743	1.8735	8.1552	0.0000
85.5	2.6724	1.5190	2.1762	1.8710	8.1552	0.0000
86	2.6712	1.5226	2.1772	1.8718	8.1552	0.0000
86.5	2.6724	1.5233	2.1772	1.8718	8.1552	0.0000

Table C-19. Kaolinite run #7 water flow and rainfall data

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
-10	0.6205	0.6087	0.6026	0.5981	0.5591	0.2630
0.5	0.6232	0.6087	0.6026	0.5981	0.6372	0.7880
1	0.6251	0.6087	0.6026	0.5981	0.8500	1.3130
1.5	0.6278	0.6100	0.6062	0.5981	1.1063	1.8380
2	0.6311	0.6127	0.6081	0.5981	1.3770	2.3630
2.5	0.6358	0.6146	0.6146	0.5988	1.6517	2.8880
3	0.6477	0.6159	0.6179	0.5981	1.9314	3.1510
3.5	0.6640	0.6176	0.6255	0.5981	2.2388	3.6760
4	0.6842	0.6185	0.6436	0.5994	2.5445	4.2010
4.5	0.7042	0.6232	0.6553	0.6004	2.8885	4.7260
5	0.7244	0.6318	0.6735	0.6004	3.2665	5.2510
5.5	0.7388	0.6426	0.6856	0.6004	3.6316	5.7760
6	0.7630	0.6550	0.6998	0.6010	3.9666	6.0390
6.5	0.7781	0.6665	0.7195	0.6026	4.2886	6.5640
7	0.7993	0.6781	0.7458	0.6026	4.6554	7.0890
7.5	0.8239	0.6922	0.7598	0.6033	5.0589	7.6140
8	0.8474	0.7083	0.7903	0.6045	5.4684	8.1390
8.5	0.8592	0.7247	0.8071	0.6062	5.8598	8.6640
9	0.8760	0.7404	0.8294	0.6078	6.2493	8.9270
9.5	0.9008	0.7516	0.8513	0.6117	6.6111	9.4520
10	0.9234	0.7681	0.8711	0.6172	6.9878	9.9770
10.5	0.9441	0.7826	0.8944	0.6285	7.3547	10.5020
11	0.9711	0.8030	0.9146	0.6385	7.6834	11.0270
11.5	0.9918	0.8218	0.9356	0.6453	8.0487	11.5520
12	1.0098	0.8354	0.9484	0.6491	8.3712	12.0770
12.5	1.0286	0.8500	0.9784	0.6577	8.7024	12.6020
13	1.0576	0.8636	0.9873	0.6682	9.0135	13.1270
13.5	1.0820	0.8831	1.0209	0.6760	3.0696	13.6520

Table C-19. Continued

14	1.1074	0.9045	1.0368	0.6838	0.7450	13.9150
14.5	1.1333	0.9169	1.0581	0.6922	0.9067	14.4400
15	1.1649	0.9337	1.0814	0.7057	1.1074	14.9650
15.5	1.1884	0.9480	1.0933	0.7105	1.3503	15.4900
16	1.2106	0.9677	1.1222	0.7165	1.6326	16.0150
16.5	1.2368	0.9789	1.1339	0.7202	1.8984	16.5400
17	1.2708	0.9982	1.1626	0.7342	2.1917	16.8030
17.5	1.2900	1.0184	1.1937	0.7489	2.5106	17.3280
18	1.3144	1.0347	1.2007	0.7567	2.8305	17.8530
18.5	1.3432	1.0456	1.2344	0.7666	3.1905	18.3780
19	1.3639	1.0597	1.2635	0.7793	3.5749	18.9030
19.5	1.4217	1.0756	1.2912	0.7887	3.9074	19.4280
20	1.4407	1.0911	1.3201	0.7927	4.2488	19.6910
20.5	1.4739	1.1068	1.3516	0.8047	4.6023	20.2160
21	1.5062	1.1222	1.3764	0.8105	4.9837	20.7410
21.5	1.5442	1.1445	1.4062	0.8201	5.4284	21.2660
22	1.5749	1.1649	1.4332	0.8281	5.8387	21.7910
22.5	1.6227	1.1826	1.4928	0.8332	6.2272	22.3160
23	1.6517	1.2036	1.5133	0.8418	6.6342	22.5790
23.5	1.6943	1.2278	1.5399	0.8535	6.9878	23.1040
24	1.7315	1.2464	1.5639	0.8579	7.3547	23.6290
24.5	1.7492	1.2665	1.5942	0.8658	7.7349	24.1540
25	1.7825	1.2850	1.6295	0.8729	8.1019	24.6790
25.5	1.8113	1.3037	1.6524	0.8827	8.4806	25.2040
26	1.8397	1.3214	1.6881	0.8926	8.8147	25.7290
26.5	1.8710	1.3477	1.7101	0.8999	9.1285	26.2540
27	1.8950	1.3691	1.7387	0.9086	9.3907	26.7790
27.5	1.9455	1.3949	1.7629	0.9178	9.6878	27.3040
28	1.9765	1.4237	1.7989	0.9272	1.1942	27.5670
28.5	2.0097	1.4489	1.8254	0.9385	0.8231	28.0920
29	2.0398	1.4704	1.8540	0.9489	1.0098	28.6170
29.5	2.0554	1.4977	1.8744	0.9556	1.2483	29.1420
30	2.0823	1.5262	1.9071	0.9629	1.5370	29.6670
30.5	2.1019	1.5479	1.9253	0.9696	1.7890	30.1920
31	2.1455	1.5698	1.9516	0.9770	2.0748	30.7170
31.5	2.1617	1.6017	1.9774	0.9868	2.3902	30.9800
32	2.2053	1.6280	2.0161	0.9967	2.7301	31.5050
32.5	2.2398	1.6578	2.0334	1.0128	3.0684	32.0300
33	2.2746	1.6842	2.0637	1.0255	3.4438	32.5550
33.5	2.2988	1.7093	2.0916	1.0363	3.8182	33.0800
34	2.3447	1.7395	2.1255	1.0477	4.1503	33.6050
34.5	2.3725	1.7589	2.1521	1.0708	4.5149	34.1300

Table C-19. Continued

35	2.4059	1.7816	2.1694	1.0852	4.8723	34.6550
35.5	2.4419	1.8080	2.2093	1.0943	5.3096	35.1800
36	2.4750	1.8279	2.2269	1.1129	5.7340	35.7050
36.5	2.5030	1.8489	2.2676	1.1228	6.1174	36.2300
37	2.5500	1.8701	2.2887	1.1383	6.5193	36.4930
37.5	2.5666	1.8889	2.3221	1.1490	6.9161	37.0180
38	2.6224	1.9071	2.3591	1.1643	7.2802	37.5430
38.5	2.6496	1.9244	2.4028	1.1815	7.6578	38.0680
39	2.7023	1.9499	2.4440	1.2024	8.0222	38.5930
39.5	2.7558	1.9685	2.4632	1.2166	8.3712	39.1180
40	2.7995	1.9962	2.4911	1.2338	8.7303	39.6430
40.5	2.8497	2.0124	2.5456	1.2458	9.0709	39.9060
41	2.8849	2.0315	2.5777	1.2574	9.3614	40.4310
41.5	2.9351	2.0572	2.6011	1.2708	9.6279	40.9560
42	2.9748	2.0748	2.6281	1.2807	9.9298	41.4810
42.5	3.0074	2.0897	2.6758	1.2925	10.2688	42.0060
43	3.0454	2.1094	2.7115	1.3075	10.7106	42.5310
43.5	3.0876	2.1359	2.7476	1.3335	0.8971	43.0560
44	3.1134	2.1531	2.7628	1.3419	0.7972	43.3190
44.5	3.1433	2.1752	2.8042	1.3509	1.0027	43.8440
45	3.1813	2.1946	2.8413	1.3606	1.2574	44.3690
45.5	3.2104	2.2142	2.8776	1.3816	1.5450	44.8940
46	3.2517	2.2319	2.8971	1.4042	1.8304	45.4190
46.5	3.2786	2.2487	2.9376	1.4035	2.1047	45.9440
47	3.3207	2.2776	2.9686	1.4244	2.4270	46.2070
47.5	3.3385	2.2998	3.0037	1.4421	2.7452	46.7320
48	3.3742	2.3252	3.0289	1.4586	3.0966	47.2570
48.5	3.4103	2.3426	3.0505	1.4614	3.4833	47.7820
49	3.4242	2.3684	3.0773	1.5027	3.8473	48.3070
49.5	3.4663	2.3997	3.0992	1.5020	4.1699	48.8320
50	3.4861	2.4249	3.1316	1.5198	4.5323	49.3570
50.5	3.5217	2.4429	3.1511	1.5226	4.9278	49.6200
51	3.5662	2.4664	3.1919	1.5392	5.3687	50.1450
51.5	3.6024	2.4911	3.2197	1.5727	5.7757	50.6700
52	3.6316	2.5226	3.2517	1.5786	6.1611	51.1950
52.5	3.6639	2.5467	3.2881	1.5927	6.5421	51.7200
53	3.6816	2.5799	3.3152	1.6114	6.9161	52.2450
53.5	3.7188	2.6123	3.3453	1.6318	7.3050	52.7700
54	3.7562	2.6439	3.3853	1.6349	7.6578	53.2950
54.5	3.7879	2.6724	3.4200	1.6563	8.0753	53.5580
55	3.8137	2.6953	3.4452	1.6686	8.4258	54.0830
55.5	3.8442	2.7150	3.4875	1.6842	8.7584	54.6080

Table C-19. Continued

56	3.9151	2.7429	3.5117	1.6951	9.0709	55.1330
56.5	3.9338	2.7664	3.5417	1.7085	9.3614	55.6580
57	3.9776	2.7900	3.5705	1.7252	1.1966	56.1830
57.5	4.0235	2.8161	3.6068	1.7492	0.7818	56.7080
58	4.0681	2.8449	3.6507	1.7645	0.9653	57.2330
58.5	4.0937	2.8727	3.6713	1.7767	1.2201	57.4960
59	4.1357	2.9007	3.6964	1.7931	1.4949	58.0210
59.5	4.1585	2.9240	3.7277	1.7981	1.7678	58.5460
60	4.1977	2.9438	3.7577	1.8179	2.0554	59.0710
60.5	4.2240	2.9624	3.7864	1.8414	2.3850	59.5960
61	4.2670	2.9936	3.8243	1.8355	2.7185	59.8590
61.5	4.3070	3.0074	3.8519	1.8540	3.0799	60.3840
62	4.3372	3.0302	3.8919	1.8625	3.4396	60.9090
62.5	4.3947	3.0632	3.9229	1.8778	3.8304	61.4340
63	4.4459	3.0876	3.9619	1.8889	4.1879	61.9590
63.5	4.4803	3.1108	4.0044	1.9131	4.5497	62.4840
64	4.5149	3.1433	4.0266	1.9271	4.9278	63.0090
64.5	4.5497	3.1747	4.0553	1.9341	5.3490	63.2720
65	4.6023	3.1985	4.0937	1.9384	5.7340	63.7970
65.5	4.6200	3.2250	4.1131	1.9836	6.1174	64.3220
66	4.6732	3.2437	4.1552	2.0016	6.5193	64.8470
66.5	4.7089	3.2665	4.1977	2.0133	6.8685	65.3720
67	4.7629	3.2989	4.2174	2.0206	7.2802	65.6350
67.5	4.7629	3.3180	4.2537	2.0334	7.6322	66.1600
68	4.8174	3.3439	4.2836	2.0480	8.0222	66.6850
68.5	4.8357	3.3701	4.3070	2.0665	8.3985	67.2100
69	4.8908	3.3977	4.3423	2.0850	8.7303	67.7350
69.5	4.9278	3.4200	4.3760	2.1057	9.0422	68.2600
70	4.9837	3.4480	4.4117	2.1094	9.3320	68.5230
70.5	5.0024	3.4691	4.4459	2.1207	9.5683	69.0480
71	5.0400	3.4975	4.4631	2.1283	1.9499	69.5730
71.5	5.0779	3.5217	4.4976	2.1560	0.7850	70.0980
72	5.1160	3.5460	4.5149	2.1694	0.9667	70.6230
72.5	5.1351	3.5806	4.5672	2.1868	1.1931	71.1480
73	5.1928	3.6039	4.6023	2.1878	1.4893	71.4110
73.5	5.2315	3.6243	4.6376	2.2093	1.7751	71.9360
74	5.2509	3.6462	4.6554	2.2259	2.0730	72.4610
74.5	5.2900	3.6757	4.6910	2.2427	2.3923	72.9860
75	5.3292	3.7113	4.7089	2.2636	2.6976	73.5110
75.5	5.3687	3.7322	4.7629	2.2706	3.0632	73.7740
76	5.4084	3.7562	4.7992	2.2837	3.4536	74.2990
76.5	5.4284	3.7849	4.8174	2.2988	3.8259	74.8240

Table C-19. Continued

77	5.4684	3.8106	4.8723	2.3252	4.1373	75.3490
77.5	5.5086	3.8396	4.9092	2.3344	4.4976	75.8740
78	5.5491	3.8672	4.9278	2.3488	4.8723	76.3990
78.5	5.5694	3.8965	4.9650	2.3560	5.3096	76.9240
79	5.6102	3.9276	5.0024	2.3767	5.7132	77.1870
79.5	5.6513	3.9494	5.0400	2.4017	6.1392	77.7120
80	5.6719	3.9682	5.0779	2.4070	6.4965	78.2370
80.5	5.6925	3.9934	5.0969	2.4228	6.8922	78.7620
81	5.7340	4.0203	5.1351	2.4344	7.2802	79.2870
81.5	5.7757	4.0505	5.1928	2.4525	7.6578	79.8120
82	5.8176	4.0761	5.2121	2.4675	8.0222	80.3370
82.5	5.8598	4.1050	5.2509	2.4804	8.3712	80.6000
83	5.9021	4.1292	5.2900	2.5041	8.7303	81.1250
83.5	5.9447	4.1536	5.3292	2.5237	9.0422	81.6500
84	5.9876	4.1780	5.3490	2.5336	9.3028	82.1750
84.5	6.0091	4.2010	5.3885	2.5347	9.5683	82.7000
85	6.0306	4.2207	5.4284	2.5577	9.8689	83.2250
85.5	6.0956	4.2438	5.4684	2.5655	10.2688	83.4880
86	6.1174	4.2637	5.4885	2.5732	0.7339	84.0130
86.5	6.1611	4.2920	5.5289	2.6191	0.8522	84.5380
87	6.1831	4.3204	5.5491	2.6179	1.0399	85.0630
87.5	6.2051	4.3389	5.5898	2.6382	1.2925	85.5880
88	6.2493	4.3642	5.6307	2.6575	1.5779	85.8510
88.5	6.2937	4.3879	5.6513	2.6747	1.8523	86.3760
89	6.3384	4.4117	5.6925	2.6930	2.1369	86.9010
89.5	6.3832	4.4288	5.7132	2.7185	2.4589	87.4260
90	6.4058	4.4459	5.7548	2.7254	2.7935	87.9510
90.5	6.4510	4.4631	5.7757	2.7476	3.1329	88.2140
91	6.4737	4.4803	5.8176	2.7640	3.5231	88.7390
91.5	6.4965	4.4976	5.8598	2.7876	3.8981	89.2640
92	6.5651	4.5323	5.8809	2.7959	4.2026	89.7890
92.5	6.5881	4.5497	5.9234	2.8173	4.5323	90.3140
93	6.6111	4.5847	5.9661	2.8293	4.9092	90.8390
93.5	6.6574	4.6023	5.9876	2.8485	5.3292	91.1020
94	6.7039	4.6376	6.0306	2.8679	5.7548	91.6270
94.5	6.7272	4.6554	6.0522	2.8788	6.1611	92.1520
95	6.7506	4.6732	6.0956	2.8958	6.5421	92.6770
95.5	6.7741	4.6910	6.1174	2.9019	6.9161	93.2020
96	6.8212	4.7089	6.1392	2.9290	7.3298	93.4650
96.5	6.8685	4.7269	6.1831	2.9364	7.6834	93.9900
97	6.8922	4.7629	6.2051	2.9587	8.0753	94.5150
97.5	6.9399	4.7992	6.2493	2.9773	8.4258	95.0400

Table C-19. Continued

98	6.9638	4.8357	6.2937	2.9786	8.7584	95.5650
98.5	7.0119	4.8723	6.3160	2.9974	9.0422	96.0900
99	7.0360	4.9278	6.3608	3.0251	9.3028	96.6150
99.5	7.0844	4.9650	6.3832	3.0352	9.5683	96.8780
100	7.0844	5.0024	6.4058	3.0467	9.7781	97.4040
100.5	7.1086	5.0400	6.4284	3.0620	9.8689	97.4040
101	7.1330	5.0589	6.4510	3.0876	9.8993	97.4040
101.5	7.1330	5.0589	6.4737	3.0953	9.8993	97.4040
102	7.1330	5.0589	6.4737	3.1044	9.8993	97.4040
102.5	7.1330	5.0589	6.4737	3.1044	9.8993	97.4040
103	7.1330	5.0589	6.4737	3.1095	9.8993	97.4040
103.5	7.1330	5.0589	6.4737	3.1199	9.8993	97.4040
104	7.1330	5.0589	6.4737	3.1199	9.8993	97.4040
104.5	7.1330	5.0589	6.4737	3.1225	9.8993	97.4040
105	7.1330	5.0589	6.4737	3.1251	9.8993	97.4040
105.5	7.1330	5.0589	6.4737	3.1303	9.8993	97.4040
106	7.1330	5.0589	6.4737	3.1316	9.8993	97.4040
106.5	7.1330	5.0589	6.4737	3.1316	9.8993	97.4040
107	7.1330	5.0589	6.4737	3.1342	9.8993	97.4040
107.5	7.1330	5.0589	6.4737	3.1355	9.8993	97.4040
108	7.1330	5.0589	6.4737	3.1355	9.8993	97.4040
108.5	7.1330	5.0589	6.4737	3.1407	9.8993	97.4040
109	7.1330	5.0589	6.4737	3.1472	9.8993	97.4040
109.5	7.1330	5.0589	6.4737	3.1472	9.8993	97.4040
110	7.1330	5.0589	6.4737	3.1511	9.8993	97.4040
110.5	7.1330	5.0589	6.4737	3.1511	9.8993	97.4040
111	7.1330	5.0589	6.4737	3.1485	9.8993	97.4040
111.5	7.1330	5.0589	6.4737	3.1511	9.8993	97.4040
112	7.1330	5.0589	6.4737	3.1511	9.8993	97.4040
112.5	7.1574	5.0589	6.4737	3.1524	9.9298	97.4040
113	7.1330	5.0589	6.4737	3.1564	9.9298	97.4040
113.5	7.1330	5.0589	6.4737	3.1590	9.9298	97.4040
114	7.1330	5.0589	6.4737	3.1564	9.9298	97.4040
114.5	7.1574	5.0589	6.4737	3.1564	9.9298	97.4040
115	7.1574	5.0589	6.4737	3.1603	9.9298	97.4040
115.5	7.1330	5.0589	6.4737	3.1603	9.9298	97.4040
116	7.1574	5.0779	6.4737	3.1603	9.9298	97.4040
116.5	7.1574	5.0779	6.4737	3.1603	9.8993	97.4040
117	7.1574	5.0779	6.4737	3.1603	9.9298	97.4040
117.5	7.1574	5.0779	6.4737	3.1721	9.8993	97.4040

Note: The flow data was the same as bromide run #9

Table C-20. Kaolinite normalized concentration in outflow for run #1-7

# 1						# 2					
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.3017	0.2210	0.1072	0.0320	0.0840	2	0.0948	0.0759	0.0222	0.0356	0.1519
4	0.3260	0.2376	0.1138	0.0508		4	0.2628	0.1310	0.1378	0.0907	0.1707
6	0.3602	0.2486	0.1348	0.0829	0.1127	6	0.3192	0.1458	0.1734	0.1082	0.1794
8	0.3691	0.2619	0.1370	0.0983	0.1204	8	0.3441	0.1599	0.1902	0.1230	0.1788
10	0.3768	0.2586	0.1425	0.0972	0.1260	10	0.3575	0.1720	0.1546	0.1008	0.2056
15	0.3746	0.2287	0.1459	0.1160	0.1414	15	0.3777	0.1915	0.1465	0.0927	0.2352
20	0.3878	0.2066	0.1680	0.1348	0.1514	20	0.3864	0.1875	-0.0081	0.1331	0.2641
25	0.4000	0.1691	0.1967	0.1204	0.1680	25	0.3925	0.1566	0.2534	0.1989	0.2581
30	0.4088	0.2033	0.1845	0.1436	0.1691	30	0.4005	0.1546	0.2211	0.1653	0.3159
32	0.1691	0.1414	0.1127	0.1083	0.0873	32	0.3515	0.0874	0.2016	0.0934	0.1149
34	0.0851	0.0972	0.0807	0.0707	0.0442	34	0.1559	0.0349	0.1815	0.0786	0.0397
36		0.0840	0.0718	0.0519	0.0243	36	0.0874	0.0188	0.1633	0.0692	0.0296
38	0.0586	0.0674	0.0674	0.0431	0.0177	38	0.0531	0.0101	0.1559	0.0679	0.0269
40	0.0586	0.0652	0.0685	0.0398	0.0155	40		0.0087	0.1559	0.0659	0.0255
45	0.0663	0.0575	0.0641	0.0276	0.0066	45	0.0228	0.0040	0.1250	0.0612	0.0208
50	0.0740	0.0420	0.0552	0.0276	0.0022	50	0.0148	0.0013	0.0887	0.0390	0.0168
55	0.0751	0.0243	0.0254	0.0210	0.0011	55	0.0161	-0.0020	0.0511	0.0242	0.0121
60	0.0773	0.0077	0.0055	0.0110	0.0000	60	0.0235	-0.0054	0.0181	0.0134	0.0108
65	0.0674	0.0000	0.0000	0.0033	0.0000	65	0.0336	-0.0114	0.0060	0.0081	0.0087
70	0.0486	0.0000	0.0000	0.0000	0.0000	70	0.0410	-0.0161	0.0013	0.0000	0.0081

Table C-20 Continued

# 3						# 4					
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0995	0.1184	0.0027	0.0176	0.1001	2	0.0000	0.0000	0.0000	0.0000	0.1165
4	0.2842	0.2355	0.1035	0.0913	0.1252	4	0.0838	0.0341	0.0007	0.0000	0.1805
6	0.3221	0.2848	0.1441	0.1089	0.1204	6	0.1226	0.0579	0.0061	0.0061	0.1894
8	0.3471	0.3133	0.1658	0.1184	0.1272	8	0.1438	0.0668	0.0102	0.0136	0.1914
10	0.3586	0.3166	0.1935	0.1353	0.1313	10	0.1547	0.0763	0.0109	0.0164	0.1921
15	0.3748	0.2429	0.2348	0.1813	0.1955	15	0.1744	0.0818	0.0123	0.0184	0.1976
20	0.3762	0.2077	0.2578	0.2037	0.1820	20	0.1853	0.0818	0.0129	0.0198	0.1983
25	0.3917	0.2185	0.2774	0.2145	0.2118	25	0.1949	0.1008	0.0136	0.0198	0.2044
30	0.4032	0.2240	0.2219	0.3261	0.2165	30	0.1901	0.1717	0.0388	0.0218	0.2248
32	0.3403	0.0873	0.3187	0.2091	0.1258	32	0.2024	0.1989	0.0552	0.0232	0.0913
34	0.1421	0.0399	0.2172	0.1055	0.0433	34	0.1247	0.1935	0.0743	0.0273	0.0368
36	0.0778	0.0298	0.1698	0.0798	0.0311	36	0.0729	0.1853	0.0811	0.0279	0.0334
38	0.0562	0.0257	0.1455	0.0677	0.0250	38	0.0559	0.1867	0.0899	0.0273	0.0320
40	0.0392	0.0223	0.1245	0.0609	0.0210	40	0.0545	0.1880	0.0967	0.0293	0.0307
45	0.0230	0.0210	0.0846	0.0548	0.0129	45	0.0702	0.2037	0.1104	0.0375	0.0286
50	0.0210	0.0230	0.0609	0.0474	0.0068	50	0.0940	0.2133	0.1158	0.0456	0.0245
55	0.0284	0.0250	0.0352	0.0298	0.0047	55	0.1138	0.1955	0.1220	0.0525	0.0204
60	0.0386	0.0250	0.0088	0.0237	0.0020	60	0.1226	0.1240	0.1104	0.0572	0.0164
65	0.0467	0.0203	0.0020	0.0129	0.0000	65	0.1294	0.0784	0.0749	0.0559	0.0129
70	0.0487	0.0135	0.0000	0.0061	0.0000	70	0.1145	0.0491	0.0450	0.0443	0.0095
						75	0.0906	0.0334	0.0286	0.0347	0.0061
						80	0.0729	0.0238	0.0204	0.0286	0.0048

Table C-20 Continued

# 5						# 6					
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.1952	2	0.0000	0.0000	0.0000	0.0000	0.1431
4	0.0384	0.0098	0.0000	0.0000	0.2076	4	0.0298	0.0000	0.0000	0.0000	0.2420
6	0.1158	0.0293	0.0000	0.0000	0.2486	6	0.1210	0.0068	0.0009	0.0000	0.2505
8	0.1555	0.0403	0.0000	0.0000	0.2616	8	0.1627	0.0170	0.0017	0.0000	0.2496
10	0.1724	0.0429	0.0000	0.0000	0.2570	10	0.1857	0.0230	0.0017	0.0000	0.2488
15	0.1965	0.0488	0.0000	0.0020	0.2577	15	0.2130	0.0307	0.0034	0.0009	0.2547
20	0.2024	0.0566	0.0000	0.0039	0.2642	20	0.2232	0.0324	0.0034	0.0026	0.2462
25	0.1991	0.0566	0.0000	0.0091	0.2609	25	0.2215	0.0239	0.0017	0.0026	0.2445
30	0.2011	0.0638	0.0000	0.0104	0.2746	30	0.2300	0.0256	0.0017	0.0034	0.2607
32	0.2030	0.0638	0.0026	0.0098	0.0657	32	0.2300	0.0341	0.0051	0.0051	0.1039
34	0.1497	0.0469	0.0104	0.0098	0.0260	34	0.2079	0.0409	0.0094	0.0043	0.0290
36	0.0768	0.0202	0.0189	0.0085	0.0241	36	0.1176	0.0443	0.0170	0.0060	0.0239
38	0.0495	0.0104	0.0260	0.0065	0.0215	38	0.0724	0.0383	0.0230	0.0085	0.0222
40	0.0384	0.0059	0.0312	0.0046	0.0202	40	0.0494	0.0392	0.0307	0.0136	0.0213
45	0.0000	0.0416	0.0410	0.0039	0.0189	45	0.0222	0.0520	0.0392	0.0281	0.0187
50	0.0026	0.0573	0.0482	0.0059	0.0189	50	0.0179	0.0682	0.0460	0.0452	0.0153
55	0.0748	0.0104	0.0527	0.0078	0.0150	55	0.0239	0.0843	0.0605	0.0486	0.0128
60	0.0931	0.0130	0.0540	0.0098	0.0124	60	0.0375	0.1039	0.0520	0.0690	0.0119
65	0.1028	0.0143	0.0299	0.0104	0.0091	65	0.0520	0.1099	0.0426	0.0750	0.0094
70	0.1022	0.0150	0.0117	0.0091	0.0078	70	0.0656	0.0971	0.0273	0.0699	0.0077
75	0.0878	0.0137	0.0052	0.0065	0.0046	75	0.0758	0.0758	0.0179	0.0520	0.0060
80	0.0703	0.0104	0.0020	0.0039	0.0033	80	0.0801	0.0596	0.0170	0.0366	0.0043

Table C-20 Continued

# 7 Time (min)	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0531	0.0000	0.0000	0.0052	0.1550
4	0.1540	0.0000	0.0000	0.0010	0.2019
6	0.1821	0.0073	0.0021	0.0042	0.2102
8	0.2008	0.0146	0.0052	0.0094	0.2258
10	0.2092	0.0187	0.0073	0.0125	0.2248
15	0.2185	0.0312	0.0135	0.0166	0.2383
20	0.2331	0.0479	0.0166	0.0187	0.2487
25	0.2518	0.0614	0.0166	0.0229	0.2445
30	0.2591	0.0656	0.0229	0.0229	0.2601
32	0.2373	0.0708	0.0260	0.0260	0.0853
34	0.1644	0.0739	0.0302	0.0260	0.0541
36	0.1405	0.0656	0.0354	0.0219	0.0437
38	0.1332	0.0583	0.0375	0.0094	0.0395
40	0.1322	0.0562	0.0406	0.0146	0.0343
45	0.1322	0.0593	0.0447	0.0125	0.0281
50	0.1270	0.0614	0.0458	0.0146	0.0239
55	0.1270	0.0645	0.0468	0.0187	0.0187
60	0.1217	0.0645	0.0406	0.0239	0.0166
65	0.0989	0.0676	0.0281	0.0281	0.0125
70	0.0676	0.0624	0.0187	0.0312	0.0094
75	0.0437	0.0479	0.0125	0.0323	0.0083
80	0.0281	0.0302	0.0083	0.0312	0.0062
85	0.0208	0.0208	0.0062	0.0250	0.0042
90	0.0156	0.0135	0.0052	0.0208	0.0031

APPENDIX D
EXPERIMENTAL DATA IN CHAPTER 3

Table D-1. Adsorption isotherms of colloids onto different grass parts (leaf, stems, and roots).

	X-mean	Y-mean	X-SEM	Y-SEM	Model
Leave	0	0	0	0	0.000
	0.439	51.858	0.124	11.683	110.405
	0.558	123.679	0.191	35.093	131.586
	1.923	268.309	0.380	81.393	265.756
	3.165	390.961	0.579	82.114	317.624
	9.504	375.653	0.533	87.359	397.875
	17.288	403.879	0.871	217.070	421.830
Stem	0	0	0	0	0.000
	0.515	71.462	0.118	4.307	61.270
	0.861	88.276	0.140	43.361	97.008
	2.383	219.027	0.357	56.168	217.622
	5.154				349.923
	9.399	458.289	0.151	97.321	458.129
	18.918	234.165	0.592	74.246	564.819
Root	0	0	0	0	0.000
	1.057	55.931	0.052	13.179	127.842
	1.698				192.760
	3.391	266.902	0.069	26.871	331.318
	6.034				484.276
	10.409	808.606	0.104	147.160	644.872
	17.982	705.448	0.573	113.608	798.691

Table D-2. Water flow summary for runoff experiments on densely vegetated soil

Run	Time	Inflow	DR#1	DR#2	DR#3	DR#4	RO	Rainfall	Area of the box
		L/min						mm/hour	cm^2
# 1	Aug 10,10	0.2518	0.07	0.12	0.08	0.07	0.56	66.47	6228.96
# 2	Aug 14,10	0.2485	0.05	0.12	0.07	0.06	0.62	66.47	6228.96

Table D-3. Run #1 water flow and rainfall data (bromide and colloid were mixed in the inflow).

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
0	0.8243	0.7543	0.7331	0.6803	0.6436	0
0.5	0.8205	0.7528	0.7331	0.6799	0.6436	0.263
1	0.8209	0.7500	0.7339	0.6796	0.6436	0.526
1.5	0.8209	0.7504	0.7335	0.6796	0.6443	1.051
2	0.8222	0.7504	0.7316	0.6778	0.6433	1.576
2.5	0.8180	0.7481	0.7285	0.6767	0.6413	2.101
3	0.8180	0.7481	0.7285	0.6763	0.6406	2.626
3.5	0.8167	0.7485	0.7293	0.6749	0.6413	3.151
4	0.8184	0.7500	0.7300	0.6753	0.6413	3.676
4.5	0.8176	0.7489	0.7293	0.6739	0.6416	4.201
5	0.8151	0.7485	0.7270	0.6728	0.6413	4.464
5.5	0.8172	0.7458	0.7278	0.6856	0.6470	4.989
6	0.8281	0.7481	0.7331	0.6907	0.6682	5.514
6.5	0.8315	0.7493	0.7373	0.6940	0.7709	6.039
7	0.8388	0.7547	0.7415	0.6969	1.0214	6.564
7.5	0.8440	0.7737	0.7536	0.7042	1.4062	7.089
8	0.8539	0.8126	0.7685	0.7061	2.0052	7.352
8.5	0.8631	0.8518	0.7919	0.6994	2.7115	7.877
9	0.8800	0.8985	0.8328	0.7020	3.6199	8.402
9.5	0.9192	0.9418	0.8649	0.7020	4.6732	8.927
10	0.9760	0.9858	0.9109	0.7180	5.8598	9.452
10.5	0.9997	1.0363	0.9484	0.7365	7.1818	9.715
11	1.0301	1.0992	0.9770	0.7489	8.8147	10.24
11.5	1.0587	1.1734	1.0194	0.7931	10.4883	10.765
12	1.0841	1.2398	1.0692	0.8063	12.1053	11.29
12.5	1.1288	1.3151	1.1156	0.8388	14.0819	11.815
13	1.1654	1.4116	1.1666	0.8760	16.1742	12.34
13.5	1.2001	1.5027	1.2183	0.9031	18.4789	12.603
14	1.2326	1.5727	1.2671	0.9351	20.6267	13.128
14.5	1.2598	1.6601	1.3025	0.9677	22.8742	13.653
15	1.3451	1.7866	1.3580	0.9992	24.8770	14.178
15.5	1.3843	1.8710	1.4129	1.0270	27.0019	14.703
16	1.4170	1.9614	1.4683	1.0847	29.1228	15.228
16.5	1.4690	2.0739	1.5312	1.1134	31.1557	15.753
17	1.5312	2.1936	1.5927	1.1832	33.0229	16.016
17.5	1.6174	2.3181	1.6410	1.2142	34.6623	16.541
18	1.6563	2.4472	1.7006	1.2112	36.0934	17.066
18.5	1.7792	2.6000	1.7613	1.2801	37.3265	17.591
`	1.8659	2.7628	1.8129	1.3252	38.3177	18.116

Table D-3. Continued.

19.5	1.8907	2.9044	1.8924	1.3554	39.0779	18.379
20	1.9543	3.0556	1.9525	1.3836	39.5837	18.904
20.5	2.0043	3.2064	2.0152	1.4510	39.8421	19.429
21	2.0480	3.3742	2.0832	1.4787	39.8695	19.954
21.5	2.1445	3.5403	2.1685	1.5779	37.9392	20.479
22	2.2132	3.7307	2.2417	1.6212	1.0245	21.004
22.5	2.2857	3.9229	2.3313	1.6842	1.1546	21.529
23	2.3809	4.1195	2.4291	1.7148	1.5537	22.054
23.5	2.4536	4.3507	2.5139	1.7492	2.0508	22.317
24	2.5655	4.5497	2.5922	1.8213	2.6269	22.842
24.5	2.6168	4.7629	2.7023	1.9209	3.4075	23.367
25	2.7324	5.0024	2.8138	1.9175	4.3811	23.892
25.5	2.8341	5.2315	2.9253	2.0242	5.5694	24.417
26	2.9093	5.4684	3.0188	2.0711	6.8685	24.942
26.5	2.9798	5.7132	3.0940	2.1694	8.1552	25.205
27	3.0696	6.0091	3.2131	2.2656	9.6279	25.73
27.5	3.2064	6.2937	3.2949	2.3283	11.7978	26.255
28	3.2935	6.5651	3.3977	2.4112	13.6367	26.78
28.5	3.4033	6.7976	3.4975	2.4281	15.6184	27.305
29	3.5446	7.0844	3.6155	2.5347	17.8497	27.83
29.5	3.6580	7.3796	3.7592	2.5544	20.1483	28.355
30	3.7577	7.7607	3.8734	2.6348	22.2977	28.88
30.5	3.9012	8.0753	4.0108	2.7138	24.6544	29.405
31	3.9918	8.3712	4.1260	2.7971	26.6500	29.668
31.5	4.1292	8.7024	4.2421	2.8824	28.8242	30.193
32	4.2504	9.0422	4.3947	2.9861	30.7907	30.718
32.5	4.4117	9.3614	4.5149	3.0773	32.6839	31.243
33	4.4976	9.7479	4.6554	3.1472	34.3547	31.768
33.5	4.7089	10.0830	4.7810	3.1695	35.9135	32.293
34	4.8540	10.4252	4.9463	3.2773	37.1744	32.818
34.5	4.9837	10.7747	5.1160	3.4061	38.2164	33.343
35	5.1160	11.1641	5.2509	3.4889	39.0037	33.606
35.5	5.2509	11.5285	5.4084	3.5676	39.5372	34.131
36	5.4284	11.7978	5.4885	3.6964	39.8196	34.656
36.5	5.5694	12.1742	5.6307	3.8030	39.8775	35.181
37	5.7132	12.6632	5.7757	3.8981	39.7324	35.706
37.5	5.8598	13.1270	5.9234	3.9635	39.4059	36.231
38	5.9661	13.4535	6.0522	4.0777	38.9576	36.756
38.5	6.1831	13.8584	6.2937	4.1390	1.0954	37.281
39	6.3160	14.2320	6.4510	4.2421	1.1344	37.544
39.5	6.5193	14.6489	6.6574	4.3490	1.5148	38.069
40	6.6806	15.0718	6.8685	4.3896	1.9516	38.594

Table D-3. Continued

40.5	6.8448	15.4613	7.0360	4.4803	2.4901	39.119
41	6.9878	15.8159	7.2309	4.7269	3.2558	39.644
41.5	7.1818	16.2142	7.4547	4.7992	4.0187	40.169
42	7.2802	16.6169	7.6066	4.8540	5.0212	40.694
42.5	7.4296	17.0648	7.8125	4.9837	6.0956	40.957
43	7.6066	17.4762	8.0487	5.0969	7.3796	41.482
43.5	7.9958	18.0586	8.2627	5.1928	8.7584	42.007
44	8.2089	18.4367	8.4532	5.3292	10.3312	42.532
44.5	8.3440	18.8176	8.6188	5.5086	12.1397	43.057
45	8.6188	19.2866	8.8429	5.7966	13.9327	43.582
45.5	8.8429	19.8023	9.0709	5.7757	16.0942	44.107
46	8.9850	20.1917	9.2736	5.8176	17.9332	44.632
46.5	9.0997	20.6267	9.4202	5.9447	19.9319	44.895
47	9.3028	21.0639	9.5980	6.0522	22.1207	45.42
47.5	9.5385	21.4590	9.8993	6.1831	24.2091	45.945
48	9.7178	21.9439	10.1138	6.2493	26.3411	46.47
48.5	9.7781	22.2977	10.3312	6.4510	28.5240	46.995
49	9.9298	22.7410	10.6468	6.4965	30.3804	47.258
49.5	10.1756	23.2297	10.8713	6.7741	32.1459	47.783
50	10.3312	23.7192	11.0986	6.7741	33.7916	48.308
50.5	10.6150	24.2091	11.3288	7.0119	35.0946	48.833
51	10.6787	24.6099	11.4950	7.1086	36.4995	49.358
51.5	10.9359	25.0549	11.7640	7.2555	37.6424	49.883
52	11.2628	25.4994	12.0709	7.3796	38.5671	50.408
52.5	11.5285	25.8987	12.3476	7.6066	39.2432	50.671
53	11.7640	26.3411	12.5927	7.6578	39.6589	51.196
53.5	11.8998	26.7821	12.9833	7.9169	39.8622	51.721
54	12.1742	27.2212	13.2716	8.0222	39.8214	52.246
54.5	12.4873	27.6145	13.4535	8.0753	38.3177	52.771
55	12.6986	28.0492	13.6736	8.3168	0.9947	53.034
55.5	12.8761	28.3949	13.8584	8.5910	1.1552	53.559
56	13.1631	28.8670	14.0819	8.7584	1.4718	54.084
56.5	13.4900	29.2502	14.3451	8.8995	1.9774	54.609
57	13.7104	29.7143	14.7253	9.1574	2.4217	55.134
57.5	13.8584	30.1320	14.9944	9.2736	3.1498	55.659
58	14.1944	30.5451	15.3049	9.4497	3.9027	56.184
58.5	14.3451	30.9128	15.6184	9.7781	4.8908	56.709
59	14.6871	31.3165	15.8555	9.8083	5.9876	56.972
59.5	14.8788	31.6355	16.1342	9.9909	7.2555	57.497
60	15.3049	31.9900	16.3748	10.1138	8.7303	58.022
60.5	15.5005	32.4165	16.7386	10.3312	10.2999	58.547
61	15.6973	32.6839	16.9421	10.3938	11.6964	59.072

Table D-3. Continued

61.5	15.8555	32.9855	17.1467	10.4883	13.4170	59.597
62	16.2142	33.3930	17.4349	10.6787	15.3439	60.122
62.5	16.3748	33.7557	17.7249	10.8068	17.2700	60.385
63	16.7386	34.1459	18.0167	11.0660	19.3723	60.91
63.5	16.9421	34.4580	18.3103	11.2298	21.5911	61.435
64	17.2700	34.8303	18.6480	11.4617	23.6747	61.96
64.5	17.4762	35.0618	18.9451	11.6290	25.6326	62.485
65	17.8081	35.3212	19.2438	11.8318	27.7016	63.01
65.5	17.9749	35.6060	19.5869	12.0709	29.6723	63.535
66	18.1423	35.9437	19.8455	12.2088	31.5163	63.798
66.5	18.4789	36.2407	20.1483	12.5224	32.7975	64.323
67	18.7327	36.4711	20.4524	12.6632	35.2569	64.848
67.5	19.1583	36.7226	20.6703	12.7694	36.4711	65.373
68	19.3723	37.0185	21.0200	13.1270	37.6188	65.898
68.5	19.5869	37.2510	21.2832	13.3078	38.5855	66.423
69	19.8023	37.4746	21.6351	13.5266	39.2432	66.686
69.5	20.0617	37.6893	21.8998	13.6367	39.6741	67.211
70	20.3654	37.8948	22.2534	14.0072	39.8724	67.736
70.5	20.6267	38.0696	22.4749	14.0819	39.8214	68.261
71	20.8450	38.2573	22.7854	14.3451	39.5507	68.786
71.5	21.0200	38.3966	23.1408	14.2696	39.0250	69.311
72	21.3271	38.5671	23.4076	14.5726	38.3852	69.574
72.5	21.5911	38.7450	23.6747	14.8020	37.4848	70.099
73	21.8115	38.8944	23.8973	14.9944	36.5675	70.362
73.5	22.2977	39.0633	24.1200	15.2659	35.1733	70.625
74	22.4749	39.1490	24.3872	15.2659	34.2651	70.888
74.5	22.7410	39.2301	24.6989	15.6184	34.1254	71.413
75	23.0519	39.3667	25.0549	15.9747	34.0198	71.938
75.5	23.3187	39.4561	25.3662	16.0543	34.0198	72.463
76	23.6302	39.5276	25.6326	16.4150	33.9844	72.988
76.5	23.8973	39.5925	25.8543	16.4957	33.9135	73.513
77	24.1200	39.6665	26.1201	16.5360	35.4169	74.038
77.5	24.4763	39.7167	26.3853	16.6169	0.8461	74.563
78	24.6989	39.7769	26.7380	16.9830	0.7024	74.826
78.5	25.0105	39.8237	26.9579	17.4762	0.6623	75.351
79	25.1884	39.8485	27.3087	17.6004	0.6436	75.876
79.5	25.5882	39.8687	27.6145	17.8497	0.6311	76.401
80	25.8100	39.8818	28.0058	18.0586	0.6205	76.926
80.5	26.0315	39.8830	28.3086	18.2263	0.6113	77.451
81	26.2527	39.8731	28.6100	18.5633	0.6192	77.976
81.5	26.5177	39.8555	28.8670	18.7327	0.8146	78.239
82	26.8700	39.8254	29.0802	18.9026	1.0884	78.764

Table D-3. Continued

82.5	27.2212	39.7843	29.2077	19.0303	1.4815	79.289
83	27.5272	39.7449	29.5461	19.2438	2.0034	79.814
83.5	27.7887	39.6918	29.8819	19.5010	2.5944	80.339
84	28.1358	39.6219	30.1735	19.8023	3.4691	80.864
84.5	28.3086	39.5507	30.3804	19.8887	4.3271	81.389
85	28.6100	39.4282	30.5862	20.2785	5.3885	81.652
85.5	28.7815	39.3480	30.8315	20.4524	6.6806	82.177
86	29.0802	39.2485	31.1153	20.6703	8.2358	82.702
86.5	29.2077	39.1548	31.3165	20.7576	9.8083	83.227
87	29.3772	39.0400	31.5163	21.0200	11.4950	83.227
87.5	29.6723	38.8850	31.7147	21.2832	12.6986	83.49
88	29.9237	38.7691	31.9508	21.5911	13.0550	83.49
88.5	30.1735	38.6472	32.1459	21.6792	13.2353	83.49
89	30.3391	38.5378	32.3780	21.9439	13.3078	83.49
89.5	30.5040	38.4434	32.4932	21.9881	13.1992	83.49
90	30.5862	38.3852	32.6459	22.0765	13.2353	83.49
90.5	30.5862	38.3459	32.6839	22.3420	13.1631	83.49
91	30.6272	38.3060	32.7975	22.3863	13.1270	83.49
91.5	30.6272	38.2657	32.7975	22.4306	13.0910	83.49

Table D-4. Run #2 water flow and rainfall data.

	Volume (L)					mm
Time(min)	DR#1	DR#2	DR#3	DR#4	RO	Rainfall
0	2.1483	0.6020	0.6026	0.6045	0.5633	0
0.5	2.1541	0.6013	0.6026	0.6045	0.5630	0.263
1	2.1550	0.6010	0.6026	0.6045	0.5630	0.788
1.5	2.1550	0.6013	0.6026	0.6045	0.5627	1.313
2	2.1560	0.6033	0.6026	0.6045	0.5630	1.838
2.5	2.1560	0.6033	0.6026	0.6045	0.5636	2.363
3	2.1560	0.6026	0.6026	0.6045	0.5737	2.626
3.5	2.1550	0.6029	0.6026	0.6045	0.5758	3.151
4	2.1550	0.6026	0.6026	0.6045	0.5786	3.676
4.5	2.1560	0.6026	0.6026	0.6045	0.6110	4.201
5	2.1560	0.6029	0.6026	0.6045	0.6162	4.726
5.5	2.1589	0.6026	0.6026	0.6052	0.5889	5.251
6	2.1579	0.6029	0.6042	0.6068	0.6342	5.514
6.5	2.1868	0.6033	0.6055	0.6068	0.7225	6.039
7	2.2546	0.6071	0.6081	0.6087	0.8470	6.564
7.5	2.2958	0.6146	0.6100	0.6087	1.0373	7.089
8	2.3120	0.6251	0.6136	0.6110	1.2653	7.614
8.5	2.3416	0.6440	0.6189	0.6127	1.5298	8.139
9	2.6258	0.6689	0.6305	0.6133	1.7662	8.402

Table D-4. Continued

9.5	0.6831	0.6940	0.6443	0.6166	2.0288	8.927
10	0.6447	0.7153	0.6539	0.6205	2.3272	9.452
10.5	0.6423	0.7454	0.6647	0.6285	2.6269	9.977
11	0.6419	0.7810	0.6806	0.6413	2.9562	10.502
11.5	0.6413	0.8126	0.6969	0.6563	3.2935	11.027
12	0.6402	0.8461	0.7109	0.6689	3.6316	11.29
12.5	0.6399	0.8782	0.7281	0.6871	3.9463	11.815
13	0.6399	0.9141	0.7466	0.7024	4.2438	12.34
13.5	0.6399	0.9518	0.7626	0.7153	4.5847	12.865
14	0.6406	0.9863	0.7802	0.7327	4.9650	13.39
14.5	0.6399	1.0194	0.7960	0.7497	5.3292	13.653
15	0.6399	1.0539	0.8130	0.7701	5.6925	14.178
15.5	0.6392	1.0943	0.8375	0.7858	6.0522	14.703
16	0.6379	1.1300	0.8548	0.7993	6.3832	15.228
16.5	0.6399	1.1878	0.8649	0.8197	6.7506	15.753
17	0.6399	1.2089	0.8953	0.8367	7.0844	16.278
17.5	0.6392	1.2586	0.9239	0.8531	7.4046	16.541
18	0.6392	1.3050	0.9437	0.8693	7.8125	17.066
18.5	0.6385	1.3567	0.9643	0.8917	8.1285	17.591
19	0.6382	1.4102	0.9848	0.9067	8.4258	18.116
19.5	0.6416	1.4607	1.0052	0.9281	8.7584	18.379
20	0.6419	1.5162	1.0204	0.9542	9.0709	18.904
20.5	0.6440	1.5654	1.0440	0.9765	9.3320	19.429
21	0.6440	1.6032	1.0602	0.9928	9.5683	19.954
21.5	0.6443	1.6663	1.0857	1.0103	1.3355	20.479
22	0.6443	1.7156	1.1014	1.0240	0.7300	20.742
22.5	0.6443	1.7694	1.1266	1.0245	0.8627	21.267
23	0.6443	1.8263	1.1479	1.0250	1.0487	21.792
23.5	0.6443	1.8847	1.1706	1.0347	1.2838	22.317
24	0.6443	1.9332	1.1983	1.0415	1.5248	22.842
24.5	0.6457	1.9747	1.2338	1.0608	1.7645	23.367
25	0.6443	2.0197	1.2592	1.0777	2.0052	23.892
25.5	0.6450	2.0730	1.2863	1.1025	2.2998	24.155
26	0.6470	2.1160	1.3138	1.1277	2.5390	24.68
26.5	0.6443	2.1646	1.3367	1.1439	2.8281	25.205
27	0.6443	2.2142	1.3639	1.1683	3.1485	25.73
27.5	0.6457	2.2736	1.3982	1.1931	3.4946	26.255
28	0.6453	2.3283	1.4359	1.2177	3.8000	26.518
28.5	0.6443	2.3850	1.4620	1.2586	4.0825	27.043
29	0.6453	2.4440	1.4949	1.2838	4.3777	27.568
29.5	0.6470	2.5030	1.5284	1.3151	4.7089	28.093
30	0.6481	2.5644	1.5559	1.3399	5.0779	28.618

Table D-4. Continued.

30.5	0.6474	2.6405	1.5883	1.3672	5.4483	29.143
31	0.6481	2.6919	1.6137	1.3909	5.7966	29.668
31.5	0.6484	2.7523	1.6425	1.4257	6.1392	30.193
32	0.6491	2.8161	1.6717	1.4469	6.4737	30.718
32.5	0.6519	2.8861	1.7022	1.4787	6.7741	30.981
33	0.6519	2.9401	1.7267	1.5076	7.1330	31.506
33.5	0.6529	3.0011	1.7581	1.5341	7.4799	32.031
34	0.6539	3.0645	1.7825	1.5610	7.8125	32.556
34.5	0.6556	3.1251	1.8096	1.5853	8.1552	33.081
35	0.6581	3.1866	1.8372	1.6129	8.5081	33.344
35.5	0.6598	3.2450	1.8608	1.6425	8.7865	33.869
36	0.6630	3.3030	1.8838	1.6679	9.0997	34.394
36.5	0.6710	3.3645	1.9062	1.6904	9.3320	34.919
37	0.6821	3.4312	1.9332	1.7117	9.3907	35.182
37.5	0.6925	3.5031	1.9631	1.7363	0.7083	35.707
38	0.7031	3.5662	1.9827	1.7670	0.7646	36.232
38.5	0.7139	3.6214	2.0052	1.7898	0.9272	36.757
39	0.7285	3.6875	2.0352	1.8080	1.1288	37.282
39.5	0.7469	3.7502	2.0665	1.8338	1.3374	37.807
40	0.7559	3.8076	2.0907	1.8481	1.5786	38.332
40.5	0.7685	3.8718	2.1170	1.8855	1.8229	38.857
41	0.7870	3.9354	2.1474	1.9027	2.0683	39.12
41.5	0.8055	4.0013	2.1723	1.9271	2.3798	39.645
42	0.8188	4.0601	2.1985	1.9614	2.6101	40.17
42.5	0.8354	4.1228	2.2269	1.9836	2.8995	40.695
43	0.8522	4.1879	2.2517	2.0061	3.2397	41.22
43.5	0.8724	4.2421	2.2927	2.0306	3.5691	41.483
44	0.8867	4.3037	2.3242	2.0609	3.8795	42.008
44.5	0.8949	4.3541	2.3426	2.0795	4.1406	42.533
45	0.9197	4.4117	2.3674	2.1038	4.4459	43.058
45.5	0.9399	4.4631	2.4038	2.1293	4.8174	43.583
46	0.9575	4.5149	2.4387	2.1569	5.1543	43.846
46.5	0.9716	4.5672	2.4707	2.1878	5.5491	44.371
47	0.9957	4.6200	2.5096	2.2142	5.8809	44.896
47.5	1.0078	4.6910	2.5500	2.2447	6.2051	45.421
48	1.0327	4.7449	2.5877	2.2847	6.4965	45.946
48.5	1.0581	4.7992	2.6247	2.3170	6.8212	46.471
49	1.0766	4.8540	2.6610	2.3467	7.1574	46.734
49.5	1.0976	4.9092	2.7023	2.3663	7.4799	47.259
50	1.1134	4.9837	2.7441	2.3986	7.8125	47.784
50.5	1.1383	5.0400	2.7758	2.4365	8.1285	48.309
51	1.1592	5.0969	2.8078	2.4643	8.4532	48.834

Table D-4. Continued.

51.5	1.1769	5.1735	2.8473	2.4998	8.7865	49.359
52	1.1983	5.2315	2.8788	2.5336	9.0709	49.622
52.5	1.2332	5.3096	2.9142	2.5688	9.3320	50.147
53	1.2464	5.3687	2.9500	2.6089	9.5683	50.672
53.5	1.2825	5.4483	2.9873	2.6598	0.7528	51.197
54	1.2975	5.5086	3.0200	2.6873	0.8570	51.46
54.5	1.3246	5.5898	3.0505	2.7104	1.0306	51.985
55	1.3554	5.6513	3.0876	2.7441	1.2243	52.51
55.5	1.3896	5.7132	3.1277	2.7864	1.4531	53.035
56	1.4076	5.7757	3.1524	2.8209	1.6803	53.56
56.5	1.4524	5.8387	3.1813	2.8558	1.9114	53.823
57	1.4641	5.9234	3.2144	2.8824	2.1502	54.348
57.5	1.5005	5.9876	3.2477	2.8983	2.4101	54.873
58	1.5298	6.0522	3.2813	2.9302	2.6678	55.398
58.5	1.5486	6.1174	3.3166	2.9686	2.9450	55.923
59	1.5809	6.1831	3.3494	3.0112	3.2719	56.448
59.5	1.6265	6.2493	3.3866	3.0403	3.5966	56.973
60	1.6448	6.3160	3.4270	3.0722	3.8780	57.498
60.5	1.6772	6.3832	3.4593	3.1095	4.1309	58.023
61	1.6881	6.4510	3.4861	3.1329	4.4117	58.286
61.5	1.7307	6.4965	3.5231	3.1590	4.7449	58.811
62	1.7556	6.5651	3.5590	3.1985	5.0969	59.336
62.5	1.7857	6.6342	3.5908	3.2210	5.4483	59.861
63	1.8188	6.7039	3.6316	3.2544	5.7966	60.386
63.5	1.8372	6.7741	3.6713	3.2854	6.1174	60.649
64	1.8591	6.8448	3.7068	3.3166	6.4510	61.174
64.5	1.9062	6.9161	3.7397	3.3508	6.7272	61.699
65	1.9297	6.9638	3.7788	3.3825	7.0601	62.224
65.5	1.9499	7.0119	3.8167	3.4172	7.3796	62.487
66	1.9729	7.0844	3.8488	3.4382	7.6834	63.012
66.5	1.9863	7.1330	3.8826	3.4705	8.0222	63.537
67	2.0279	7.1818	3.9198	3.5017	8.2898	64.062
67.5	2.0526	7.2555	3.9541	3.5331	8.6188	64.587
68	2.0785	7.3298	3.9934	3.5604	8.8712	65.112
68.5	2.0916	7.3796	4.0362	3.5980	9.1574	65.375
69	2.1340	7.4547	4.0729	3.6301	9.3907	65.9
69.5	2.1531	7.5051	4.1098	3.6654	4.8540	66.425
70	2.1820	7.5558	4.1455	3.7024	0.6846	66.95
70.5	2.2132	7.6066	4.1764	3.7427	0.8026	67.475
71	2.2477	7.6578	4.2125	3.7667	0.9873	67.738
71.5	2.2736	7.7091	4.2421	3.7879	1.1671	68.263
72	2.2988	7.7607	4.2753	3.8198	1.3989	68.788

Table D-4. Continued.

72.5	2.3211	7.8125	4.3070	3.8503	1.6756	69.313
73	2.3591	7.8907	4.3490	3.8934	1.9062	69.576
73.5	2.3923	7.9431	4.3879	3.9338	2.1772	70.101
74	2.4355	7.9958	4.4288	3.9682	2.4376	70.626
74.5	2.4482	8.0487	4.4631	4.0013	2.7057	71.151
75	2.4922	8.0753	4.4976	4.0409	2.9836	71.676
75.5	2.5412	8.1285	4.5323	4.0809	3.2949	71.939
76	2.5611	8.1820	4.5672	4.1066	3.6214	72.464
76.5	2.5710	8.2089	4.6200	4.1325	3.9120	72.989
77	2.6439	8.2627	4.6554	4.1699	4.1764	73.514
77.5	2.6621	8.3168	4.6910	4.1993	4.4631	74.039
78	2.7046	8.3712	4.7269	4.2339	4.8174	74.564
78.5	2.7266	8.3985	4.7629	4.2687	5.1928	74.827
79	2.7593	8.4532	4.7992	4.3003	5.5289	75.352
79.5	2.8245	8.4806	4.8357	4.3339	5.9021	75.877
80	2.8401	8.5081	4.8723	4.3727	6.2051	76.402
80.5	2.8885	8.5633	4.9092	4.3947	6.5193	76.665
81	2.9167	8.5910	4.9463	4.4288	6.8212	77.19
81.5	2.9611	8.6466	5.0024	4.4631	7.1818	77.715
82	2.9899	8.6744	5.0400	4.4976	7.4799	78.24
82.5	3.0378	8.7303	5.0779	4.5323	7.7866	78.765
83	3.0722	8.7584	5.1160	4.5672	8.1019	79.29
83.5	3.1044	8.8147	5.1543	4.6200	8.3985	79.815
84	3.1472	8.8712	5.2121	4.6554	8.7024	80.078
84.5	3.1708	8.9564	5.2315	4.6732	8.9850	80.603
85	3.2144	9.0135	5.2704	4.7269	9.2445	81.128
85.5	3.2558	9.0422	5.3292	4.7629	9.4792	81.653
86	3.2908	9.0997	5.3490	4.7810	9.7178	82.178
86.5	3.3152	9.1574	5.3885	4.7810	9.9909	82.441
87	3.3467	9.2154	5.4284	4.7810	10.2377	82.441
87.5	3.3770	9.2736	5.4684	4.7810	10.3938	82.441
88	3.4033	9.3320	5.5086	4.7810	10.4252	82.441
88.5	3.4368	9.3614	5.5491	4.7810	10.4567	82.441
89	3.4452	9.4202	5.5694	4.7992	10.4883	82.441
89.5	3.4607	9.4497	5.5898	4.8357	10.4883	82.441
90	3.4932	9.4792	5.6102	4.8540	10.4883	82.441
90.5	3.4918	9.5088	5.6307	4.8540	10.4883	82.441
91	3.4975	9.5088	5.6513	4.9278	10.4883	82.441
91.5	3.4960	9.5088	5.6513	4.9278	10.4883	82.441
92	3.4960	9.5385	5.6719	4.9463	10.4883	82.441
92.5	3.4960	9.5385	5.6719	4.9463	10.4883	82.441
93	3.4960	9.5385	5.6719	4.9463	10.4883	82.441

Table D-4. Continued.

93.5	3.4960	9.5385	5.6719	4.9650	10.4883	82.441
94	3.4960	9.5385	5.6719	4.9650	10.4883	82.441
94.5	3.4960	9.5385	5.6925	4.9837	10.4883	82.441
95	3.4960	9.5385	5.6925	4.9837	10.4883	82.441
95.5	3.4960	9.5385	5.6925	4.9837	10.4883	82.441
96	3.4975	9.5385	5.6925	5.0024	10.4883	82.441
96.5	3.4975	9.5385	5.6925	5.0024	10.4883	82.441
97	3.4975	9.5385	5.6925	5.0024	10.4883	82.441
97.5	3.5017	9.5385	5.6925	5.0212	10.4883	82.441
98	3.4989	9.5385	5.6925	5.0212	10.4883	82.441
98.5	3.4975	9.5385	5.6925	5.0400	10.4883	82.441
99	3.4975	9.5385	5.6925	5.0589	10.4883	82.441
99.5	3.5017	9.5385	5.6925	5.0589	10.4883	82.441
100	3.4989	9.5385	5.6925	5.0779	10.4883	82.441
100.5	3.5031	9.5385	5.6925	5.0779	10.4883	82.441
101	3.5017	9.5385	5.6925	5.0779	10.4883	82.441
101.5	3.4354	9.5385	5.6925	5.0779	10.4883	82.441
102	3.0479	9.5385	5.6925	5.0969	10.4883	82.441
102.5	3.0188	9.5385	5.6925	5.0969	10.4883	82.441
103	3.0226	9.5385	5.6925	5.1351	10.4883	82.441
103.5	3.0213	9.5385	5.6925	5.1351	10.4883	82.441
104	3.0049	9.5385	5.6925	5.1351	10.4883	82.441
104.5	2.9986	9.5385	5.6925	5.1351	10.4883	82.441
105	2.9986	9.5385	5.6925	5.1351	10.4883	82.441
105.5	2.9986	9.5385	5.6925	5.1351	10.4883	82.441
106	2.9986	9.5385	5.6925	5.1351	10.4883	82.441

Note: Bromide and colloid were mixed in the inflow

Table D-5. Bromide and colloid normalized concentration in outflow for run #1

	Bromide					Colloids				
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2		0.0015	0.0000		0.0664	0.0045	0.0000	0.0018	0.0000	0.0979
4	0.0501	0.0402	0.0120		0.1176	0.0340	0.0031	0.0004	0.0312	0.1372
6	0.1066	0.0655	0.0211	0.0005	0.1302	0.0406	0.0095	0.0025	0.0452	0.1438
8	0.1550	0.0928	0.0320	0.0044	0.1308	0.0446	0.0111	0.0070	0.0510	0.1385
10	0.1855	0.1057	0.0396	0.0105	0.1431	0.0458	0.0124	0.0067	0.0503	0.1427
15	0.2215	0.1307	0.0487	0.0229	0.1428	0.0488	0.0124	0.0076	0.0523	0.1329
20	0.2544	0.1573	0.0536	0.0325	0.1345	0.0463	0.0130	0.0112	0.0516	0.1226
25	0.2751	0.1732	0.0571	0.0392	0.1404	0.0443	0.0124	0.0106	0.0563	0.1291
30	0.3010	0.1806	0.0629	0.0457	0.1360	0.0463	0.0113	0.0108	0.0568	0.1195
32	0.2960	0.1878	0.0614	0.0485	0.1247	0.0447	0.0121	0.0103	0.0552	0.1010
34	0.2980	0.1941	0.0606	0.0542	0.0782	0.0409	0.0114	0.0114	0.0501	0.0366
36	0.2490	0.1665	0.0589	0.0598	0.0392	0.0164	0.0077	0.0091	0.0216	0.0000
38	0.1769	0.1443	0.0557	0.0649	0.0269	0.0066	0.0015	0.0072	0.0071	0.0000
40	0.1498	0.1401	0.0542	0.0645	0.0216	0.0039	0.0007	0.0081	0.0039	0.0000
45	0.1085	0.1467	0.0628	0.0642	0.0172	0.0026	0.0004	0.0046	0.0006	0.0000
50	0.0844	0.1536	0.0631	0.0600	0.0149	0.0005	0.0011	0.0022	0.0006	0.0000
55	0.0731	0.1497	0.0732	0.0495	0.0159	0.0000	0.0000	0.0040	0.0000	0.0000
60	0.0920	0.1458	0.0702	0.0469	0.0160	0.0000	0.0000	0.0015	0.0000	0.0000
65	0.1238	0.1223	0.0698	0.0283	0.0160	0.0000	0.0000	0.0017	0.0000	0.0000
70	0.1627	0.0859	0.0604		0.0155	0.0000	0.0000	0.0006	0.0000	0.0000
75	0.1919	0.0526	0.0452		0.0141	0.0000	0.0000	0.0000	0.0000	0.0000
80	0.2044	0.0300	0.0327		0.0133	0.0000	0.0000	0.0000	0.0000	0.0000

Table D-6. Bromide and colloid normalized concentration in outflow for run #2

			Bromide				Colloids			
Time (min)	DR#1	DR#2	DR#3	DR#4	RO	DR#1	DR#2	DR#3	DR#4	RO
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0001	0.0000	0.0000	0.0239	0.0354	0.0004	0.0000	0.0000	0.0000
4	0.0116	0.0351	0.0000	0.0000	0.1072	0.1211	0.0159	0.0306	0.0000	0.0000
6	0.0734	0.0866	0.0097	0.0020	0.1238	0.1273	0.0420	0.0464	0.0072	0.0023
8	0.1330	0.1173	0.0241	0.0073	0.1301	0.1240	0.0520	0.0522	0.0119	0.0044
10	0.1685	0.1325	0.0325	0.0130	0.1342	0.1238	0.0553	0.0515	0.0121	0.0066
15	0.2108	0.1608	0.0441	0.0274	0.1369	0.1173	0.0541	0.0547	0.0129	0.0074
20	0.2419	0.1869	0.0516	0.0403	0.1349	0.1144	0.0567	0.0566	0.0129	0.0087
25	0.2663	0.1986	0.0539	0.0484	0.1378	0.1126	0.0550	0.0563	0.0117	0.0090
30	0.2796	0.2085	0.0588	0.0569	0.1359	0.1067	0.0547	0.0542	0.0116	0.0096
32	0.2848	0.2159	0.0600	0.0585	0.1301	0.0998	0.0537	0.0536	0.0120	0.0087
34	0.2864	0.2143	0.0610	0.0603	0.0863	0.0380	0.0511	0.0487	0.0119	0.0087
36	0.2514	0.1613	0.0586	0.0659	0.0379	0.0000	0.0269	0.0192	0.0083	0.0092
38	0.1843	0.1313	0.0494	0.0690	0.0247	0.0000	0.0103	0.0098	0.0029	0.0069
40	0.1491	0.1229	0.0417	0.0691	0.0198	0.0000	0.0062	0.0070	0.0007	0.0048
45	0.1122	0.1265	0.0430	0.0677	0.0139	0.0000	0.0048	0.0054	0.0000	0.0042
50	0.0894	0.1296	0.0548	0.0621	0.0112	0.0000	0.0002	0.0039	0.0000	0.0027
55	0.0681	0.1293	0.0643	0.0562	0.0106	0.0000	0.0002	0.0022	0.0005	0.0022
60	0.0699	0.1275	0.0693	0.0510	0.0102	0.0000	0.0000	0.0044	0.0000	0.0021
65	0.1107	0.1212	0.0707	0.0456	0.0105	0.0000	0.0000	0.0009	0.0000	0.0009
70	0.1784	0.0925	0.0690	0.0332	0.0124	0.0000	0.0000	0.0006	0.0008	0.0000
75	0.2157	0.0649	0.0584	0.0231	0.0121	0.0000	0.0000	0.0006	0.0000	0.0005
80	0.2387	0.0422	0.0428	0.0363	0.0128	0.0000	0.0000	0.0000	0.0000	0.0000

APPENDIX E
EXPERIMENTAL DATA IN CHAPTER 4

Table E-1. Ionic strength effect (C/C_0*100%)

Time (min)	Bromide	Low	High
0.00	0.0000	0.0000	0.0000
0.37	6.2610	19.9812	4.4985
2.37	57.4662	58.0051	55.1070
4.37	70.8690	65.6969	64.7623
6.37	76.0888	68.0917	65.7352
8.37	78.7505	70.5462	65.1728
10.37	76.2539	55.6603	57.2884
12.37	18.3586	11.5505	14.4735
14.37	8.5963	4.6123	4.7779
16.37	4.9813	2.4812	3.2579
18.37	3.4818	1.5436	1.9804
20.37	2.7131	0.9352	0.6671
22.37	2.2893	0.5207	0.5063
24.37	2.1037	0.4871	0.4378
26.37	2.1167	0.3863	0.3496
28.37	2.0177	0.3189	0.2091

Table E-2. Colloid size effect (C/C_0*100%)

Time (min)	0.3 µm	2 µm	10.5 µm
0.00	0.0000	0.0000	0.0000
0.37	27.1763	19.9812	26.5382
2.37	65.1038	58.0051	55.1083
4.37	70.0979	65.6969	55.6667
6.37	73.8699	68.0917	58.3076
8.37	73.0645	70.5462	55.8462
10.37	39.9312	55.6603	34.4218
12.37	11.3159	11.5505	4.7289
14.37	4.4643	4.6123	0.8617
16.37	2.2473	2.4812	0.3358
18.37	1.4122	1.5436	0.1890
20.37	0.9023	0.9352	0.2129
22.37	0.6196	0.5207	0.2251
24.37	0.5234	0.4871	0.1443
26.37	0.3687	0.3863	0.0580
28.37	0.3223	0.3189	0.0319

Table E-3. Inflow rate effect-62ml/min. (C/C_0*100%)

Time (min)	Bromide	Colloids
0.00	0.0000	0.0000
0.32	0.5785	1.4895
0.82	24.7566	35.9265
1.32	36.7871	44.9156
1.82	43.3073	49.8245
2.32	47.4679	53.8823
2.82	51.9492	56.2117
3.82	56.3308	58.4441
4.82	61.1328	59.2616
5.82	62.0422	62.4421
7.82	64.0401	61.7217
9.82	66.6711	62.0054
11.82	67.8489	60.7436
12.82	69.5593	62.6176
13.32	66.5369	56.8277
13.82	37.2140	25.1755
14.32	26.2790	16.4514
14.82	21.3462	12.1734
15.32	16.9260	9.4147
15.82	15.2410	7.3988
16.82	11.8246	4.5617
17.82	9.6887	3.1656
19.82	7.5090	1.7545
23.82	5.3998	0.6794
27.82	4.3716	0.3920
38.82	3.2940	0.1717

Table E-4. Vegetation type effect (C/C_0*100%)

Time (min)	Bromide	Colloids
0.00	0.0000	0.0000
0.37	0.0000	0.0000
0.87	14.7569	15.3165
1.37	44.2194	40.6102
1.87	57.0094	50.5143
2.37	64.0846	54.5724
2.87	68.5029	58.1746
3.37	71.7535	61.0173
3.87	73.9968	61.3308
4.37	75.5667	62.8507
4.87	77.3854	62.5648
5.87	79.2005	63.3444
7.87	81.9711	64.4241
9.87	83.5386	64.6281
10.37	84.4649	65.5237
10.87	68.7915	52.7084
11.37	37.3563	26.2069
11.87	25.3632	16.4084
12.37	18.4316	11.8926
12.87	14.1887	8.0726
13.37	11.4937	5.7488
13.87	9.7774	4.3625
14.37	8.2643	3.3118
14.87	7.2690	2.4559
15.87	5.9610	1.9510
17.87	4.4205	0.5163
19.87	3.5935	0.2767
21.87	3.0852	0.1819
23.87	2.7951	0.1098
25.87	2.3473	0.0385
27.87	2.1355	0.0035
29.87	1.9384	0.0212

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BIOGRAPHICAL SKETCH

Congrong Yu was born in Yunnan, China. In 2003, she obtained the degree of Bachelor of Science in the major of environmental sciences and in 2006, the Master of Science in environmental management and planning, both from Nankai University of China. In 2006, she came to US and received her Ph.D. in Agricultural and Biological Engineering with a Hydrologic Sciences concentration from the University of Florida in the summer of 2011.