MODELING HYDROLOGY AND SEDIMENT TRANSPORT IN VEGETATIVE FILTER STRIPS

by

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ABSTRACT

MUÑOZ-CARPENA, RAFAEL. Modeling hydrology and sediment transport in vegetative filter strips. (Under the direction of John E. Parsons and R. Wayne Skaggs).

Sediment carried by runoff from non-point sources has long been recognized as a major pollutant of water bodies. Sediment bounded pollutants, such as phosphorous and some pesticides, are also major pollution concerns. Vegetative filter strips (VFS) are bands of planted or indigenous vegetation that may control transport of sediment and reduce non-point source pollution off-site. The effectiveness of these buffer areas is governed by a complex interaction, in time and space, among the soil-plant-water phases. The purpose of this research was to develop and validate a model to study the hydrology and sediment movement in VFS. This was accomplished in four steps.

The first step sets the basis for the numerical solution of the overland flow equations to be used in the modeling process. The solution to the overland flow kinematic wave equations is subject to numerical problems when a rapid change in parameters is encountered (kinematic shock). An improved finite element method, i.e. a Petrov-Galerkin (PG) formulation, is presented. This formulation reduces the amplitude and frequency of the oscillations as compared to a more classic formulation. The formulation depends on four parameters. A procedure for the calculation of the PG parameters for a wide range of conditions is presented. The PG method decreased the mean sum of square error by about 65%.

In the second step the finite element overland flow solution is modified and linked to the Green-Ampt infiltration equation. This combination forms a hydrology model specifically developed for the Vegetative Filter Strip problem. An analysis of the effect of different filter properties (soil type, slope, surface roughness, buffer length) and events (storm pattern and field inflow) on the major hydrological outputs (runoff volume, velocity and peak flow rate) is made. Optimal filter performance (i.e. reduction in runoff

volume, velocity and peak flow rate) is found for soils with high infiltration capacity, dense grass cover and small slopes.

The third step adds a sediment transport/filtration submodel to the hydrology submodel. This sediment component is based on the model developed at the University of Kentucky for the filtration of suspended solids by grass. The interaction between submodels and an application case to illustrate the capability of the model is presented in detail. The model is shown to be able to predict runoff hydrographs, sediment pollutographs and sediment deposition for the complex set of transient conditions from a natural event.

The last step is a study of the inputs of the model, in which an analysis of sensitivity and a field validation are performed. The analysis of sensitivity indicates that the most sensitive parameters are soil initial water content and vertical saturated hydraulic conductivity for the hydrology submodel and particle class (particle size, fall velocity and sediment density) and grass spacing for the sediment submodel. Critical attention should be given in the selection of these parameters. The predicted data of the model was compared with a set of natural events from an experimental site in the North Carolina Piedmont. This type of data set is considered to be more valuable in assessing the capability of this type of models than the quasi-steady-state conditions created in rainfall simulator studies. In general the model performs well. The model does not handle concentrated flow through the buffers or interflow (baseflow) in riparian areas, which may constitute a limitation of the model in some instances of natural field events.

DEDICATION

A mis padres, Rafael y María Antonia, cuya entrega y ejemplo han sido
(To my parents, Rafael and María Antonia, whose dedication and example provided me)

grandes lecciones de vida. Ellos, más que nadie, con el carácter que en mi
(with life's great lessons. They, more than anybody else, made possible to achieve this, my)

imprimeron, hicieron posible la consecución de este hito.
(personal goal.)

A mi novia, Aida, ella es mi gran compañera y un pedacito de mi patria en
(To my girlfriend, Aida, my companion and a little piece of my homeland in these)

estas tierras lejanas.
(far away lands.)

A los 500 años de esa gran gesta española que fue el Descubrimiento de
(To the 500th anniversary of that great Spanish feat: The Discovery of)

América.
(America.)

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INTRODUCTION

Protecting the quality of soil and water while using these resources for the benefit of people is a major challenge facing the world community as it enters the 21st Century. Serious degradation of soil and water resources is occurring in both developed and developing countries. Perhaps the only difference is the speed at which is happening (Larson et al., 1990).

In a recent workshop at the University of Minnesota (Larson et al., 1990) six national research and education priorities concerning soil erosion and productivity were established. Among these were understanding the fundamental processes of soil and water erosion, and modeling for decision-making systems. Specific research needs include consideration of both systematic and random local non-uniformities in flow characteristics and hydraulic parameters that affect sediment transport and deposition and hydrology (infiltration, overland flow and other surface and subsurfaces processes). Researchers at this meeting established the need for models able to simulate redistribution of sediment and chemicals in a landscape at all scales, and to predict: (a) erosion, transport and deposition; (b) off-site delivery of sediment and chemicals, and (c) predict long-term consequences of management alternatives. The ASAE Soil and Water research priorities for 1988 (Meyer, 1989) also support these areas of research, i.e. developing conservation technology and protecting water quality.

Sediment leaving agricultural and other disturbed lands contributes significantly to non-point source pollution of streams and lakes. Besides being a pollutant itself, sediment can carry nitrogen and phosphorus into water ecosystems, and can accelerate eutrophication of lakes. Off-site sediment delivery can be reduced by inducing deposition through a reduction in the transport capacity of surface runoff near the edge of a field or disturbed area. Vegetative filter strips (VFS) are bands of planted or indigenous vegetation that may be used in this way to control sediment yield and non-point source pollution (Flanagan et al., 1989). Riparian areas are zones adjacent to streams or waterways, with a characteristic mixture of natural vegetation and soil cover that act in a similar way as the VFS. Vegetation reduces surface runoff by decreasing the amount of precipitation reaching the soil surface, by increasing infiltration, by roughening the soil surface, and by contributing to rainwater interception and transpiration. Both retardation of flow and decrease in runoff discharge reduce the kinetic energy of runoff, and thus lower its sediment transport capacity (Foster, 1982). Sediment-bound nutrients can then be removed from runoff in vegetative zones as sediment is deposited. If nutrients are predominantly sediment bound, then the deposition process will largely control the effectiveness of the buffer area.

There are no permanent nutrient sinks in nature. Existing nutrient sinks are transformed into nutrient sources as circumstances change. In this context, so-called best management practices (BMP's) could be defined as means of promoting the capacity of nutrient sinks in terrestrial systems and of reducing the transformations of sinks to sources. VFS are under consideration as BMP's.

Vegetative filters, however, may conflict with other land uses since they can occupy large cropland surface areas or zones needed for other purposes (machinery turning and trafficking). Therefore, an appropriate means of determining optimal placement, dimensions, and arrangements of these buffer areas must be developed if they are to be used effectively and economically (Swift, 1986). In evaluating the effectiveness of VFS and riparian areas it is desirable to identify those characteristics which affect the efficiency of nutrient and sediment reduction.

This document is divided into four papers that stand alone. Each paper focuses on a specific objective:

1- Study of the nature of the numerical solution to the overland flow equations, and development of an improved solution method.

2- Development of a VFS specific hydrology model to handle natural runoff sediment filtration events. The model should include the basic processes and be able to handle field variability through a distributed parameter approach. The model selected would be a field scale, event type of model.

3- Linkage of the hydrology model to a sediment deposition/filtration model, able to predict the efficiency of the filter for a given storm event, and show the applicability of the model.

4- Analysis of sensitivity and field validation of the model.

REFERENCES

Flanagan, D.C., G.R. Foster, W.H. Neibling, J.P. Burt. 1989. Simplified equations for filter strip design. Trans. of ASAE 32(6), 2001-2007.

Foster, G.R. 1982. Modeling the erosion process: Upland Erosion, In Hydrologic modeling of small watersheds. Ed. by C.T Haan, H.P. Johnson and D.L. Brakensiek, pp304-312, ASAE monograph, St. Joseph, MI.

Larson, W.E., G.R. Foster, R.R. Allmaras, C.M. Smith. 1990. Research issues in soil erosion/productivity. Executive Summary of the meeting. University of Minnesota, St. Paul,Minnesota, USA.

Meyer, L.D., R.W. Skaggs and T.A. Howell. 1989. Challenges in soil and water research.Trans. of ASAE 32(3), 887-893.

Swift, L.W. 1986. Filter strip widths for forest roads in the southern Appalachian. Southern J. Appl. For. 10: 27-34.

CHAPTER I

A Quadratic Petrov-Galerkin Solution for Kinematic Wave Overland Flow

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1. Abstract

A Petrov-Galerkin (PG) finite element method was developed to solve the kinematic wave formulation of the overland flow equations. The resultant model uses quadratic basis functions and test functions that are modified by polynomials of cubic and quartic order, yielding a formulation that includes four PG parameters. The PG model was found to reduce the mean sum of square error of the solution compared to a conventional Bubnov-Galerkin finite element solution by about a factor of three as the Courant number (Cr) approached one. Good results were also achieved with the PG method for problems that resulted in shock formation, which are typical of many applied problems of concern. PG parameters were found to depend strongly upon the Courant number and weakly upon the number of nodes in the system. Polynomial expressions were derived to approximate the PG parameters over the range $0 < Cr < 1$. As the number of nodes in the system increased, a single parameter version of the model yielded solutions approaching the accuracy of the four-parameter model.

2. Introduction

Overland flow routing is the term used to describe the movement of water over a surface and implies the calculation of flow rates at positions along a hill slope at different time steps [Lane et al., 1987]. The movement of surface water can be described by continuity and momentum equations applied to an incompressible fluid (Saint-Venant equations).

An accurate, stable, and efficient solution to the Saint-Venant equations is necessary for several common problems. Originally these equations were used to describe river and channel routing problems. Since then they have been applied to overland flow, watershed modeling, and runoff determination. Flow solutions of this type are also the foundation upon which sediment transport and non-point source pollutant transport models are based.

Since overland flow processes are transient, the description of such processes requires the simultaneous solution of a coupled system of partial differential equations. Simplification of the Saint-Venant equations is appropriate for many common problems. One such simplification is the kinematic wave approximation. Since its formulation by Lighthill and Whitham [1955] and its application to watershed modeling by Henderson and Wooding [1964] using the method of characteristics (MOC), many researchers have used the kinematic wave approach for runoff and overland flow problems [Brakensiek, 1967; Woolhiser, 1969; Eagleson, 1970; Li et al., 1975; Borah et al., 1980].

Under certain conditions the kinematic wave equations give rise to sharp-front solutions, in which values of the dependent variable change rapidly in space and time over a portion of the domain [Taylor, 1976; Ross et al., 1979; Vieux et al., 1990]. These sharp-fronts have been termed kinematic shock waves [Lighthill and Whitham, 1955; Kibler and Woolhiser, 1972; Li et al., 1975; Singh, 1975; Borah et al., 1980; Zhang and Cundy, 1989]. While the method of characteristics is well suited to the solution of sharp-front problems, the common occurrence of irregularly shaped domains with spatially varying properties has led to the routine application of Eulerian methods for solution of kinematic wave problems. However, Eulerian methods are prone to phase errors, oscillations in the solution, and numerical dispersion when used to approximate such sharp-front problems [Zienkiewicz, 1977; Huyakorn and Pinder, 1983; Hromadka and DeVries, 1988; Ponce, 1991]. Recent advances in Petrov-Galerkin (PG) finite element methods (FEMs) have resulted in reductions in such errors compared to conventional Eulerian formulation for advective-dominated transport and multiphase flow and transport problems [Westerink and Shea, 1989; Cornew and Miller, 1990; Mayer and Miller, 1990; Miller and Cornew, 1992]. The purpose of this work is to develop and evaluate a PG FEM solution for the kinematic wave equations.

3. Background

3.1 Overland Flow

Overland flow may be described by the classical Saint-Venant equations, which include a dynamic continuity equation and a dynamic linear momentum equation applied to an incompressible fluid for a one-dimensional system, as [Bras, 1990]

$$\frac{\partial h}{\partial t} + \frac{\partial q}{\partial x} = r = i - f \tag{1}$$

$$\frac{\partial v}{\partial t} + v\frac{\partial v}{\partial x} + g\frac{\partial h}{\partial x} = g(S_o - S_f) - \frac{vr}{h} \tag{2}$$

where $h(x,t)$ is the vertical flow depth (m); $q(x,t)$ is the discharge per unit width (m^2/s); r is the rainfall excess, or lateral inflow (m/s); i is the rainfall intensity (m/s); f is the infiltration rate (m/s); v is the depth-averaged velocity (m/s); g is the gravitational constant (m/s^2); S_o is the bed slope; S_f is the friction slope; x is the direction of flow (m); and $q = vh$.

Depending on the case studied, several simplifications of the momentum equation, Equation (2), are possible [Bedient and Huber, 1988]. The kinematic wave equations result from the assumption that the hydrodynamic terms of the momentum equation are negligible, which is reasonable for the case where no backwater exists [Lighthill and Whitham, 1955]. In this case, the momentum equation becomes $S_f = S_o$.

A constitutive relation is needed to express the discharge, q, as a function of h. Manning's equation is often used for this relation

$$q(h) = \frac{\sqrt{S_o}}{n} h^{5/3} \tag{3}$$

where n is Manning's roughness coefficient.

The numerical solution to the kinematic wave equations can be characterized in terms of three dimensionless parameters [Lighthill and Whitham, 1955; Henderson, 1966; Woolhiser and Liggett, 1967]

$$Fr = \frac{v}{\sqrt{gh}} \tag{4}$$

$$k = \frac{LS_o g}{v^2} \tag{5}$$

$$Cr = \frac{c\Delta t}{\Delta x} \tag{6}$$

for

$$c = \frac{\partial q}{\partial h} = \frac{5\sqrt{S_o}}{3n} h^{2/3} \tag{7}$$

where Fr is the Froude number, k is the kinematic flow number, Cr is the Courant number, Δt is the temporal grid spacing, Δx is the spatial grid spacing, and c is the celerity of the kinematic wave [Lighthill and Whitham, 1955; Bras, 1990].

The Fr is a ratio of inertial to gravitational forces. For normal floods in natural rivers, or overland flow processes, dynamic wave fronts attenuate very rapidly as long as $Fr < 1.5$, and kinematic waves dominate the flood response. A kinematic wave does not dissipate, but it changes in shape (steepens) due to the dependency of the velocity on the depth. If the steepening process stops, the result is a monoclinal steady-state wave [Henderson, 1966].

A restriction on the kinematic number of $k > 10$ ensures that the kinematic wave assumptions introduce less than a 10% error in the solution [Woolhiser and Liggett, 1967]. Only for very flat ($S_o < 0.002$) or very steep ($S_o > 0.10$) slopes is the kinematic assumption violated.

The Cr is a measure of the temporal discretization relative to the spatial discretization and the characteristic wave velocity of the system. The Cr affects the stability and accuracy of the solution in the explicit case and accuracy of the solution for the implicit case [Vieux and Segerlind, 1989; Blandford and Meadows, 1990; Mohtar et al., 1990]. A stability criterion for the explicit case requires $Cr < 1$, while solution accuracy improves as the Cr decreases to 0.2 [Viessman et al., 1977]. Implicit formulations are unconditionally stable, but the accuracy of solution improves as Cr decreases [Blandford and Meadows, 1990; Vieux et al., 1990].

Two additional parameters of interest for case of steady rainfall over an impermeable plane are

$$q_m = rL \tag{8}$$

$$t_e = \left(\frac{L}{\alpha r^{2/3}}\right)^{3/5} \tag{9}$$

where L is the length of the domain, q_m is the maximum discharge, t_e is the time to equilibrium for a point a distance L away from the boundary, and α is the leading coefficient from Manning's equation, which may be defined as

$$\alpha = \frac{\sqrt{S_o}}{n} \tag{10}$$

The initial and boundary conditions considered herein can be described as

$$h(t = 0, 0 \leq x \leq L) = 0 \tag{11}$$

$$h(t > 0, 0) = h_o \tag{12}$$

Note that the boundary condition can be modified for different cases. One case could be when no up-slope inflow occurs (h_o=0) for a general overland flow problem, where $x = 0$ is the beginning of the slope. A second case could be a constant up-slope inflow $[h(t, x = 0) > 0]$. A more realistic case is a boundary condition where $h(t, x = 0) = h_o(t)$, depending on the inflow hydrograph from an adjacent field up slope. Eulerian methods accommodate such changes in auxiliary conditions easily.

The rainfall excess, r, is the rainfall rate less the infiltration rate, which may be expected to vary in space and time for typical field conditions. The infiltration rate can be handled using any of the approximate methods available such as Green-Ampt, Philip, Holtan and Horton [Skaggs et al., 1969] or a more exact method based on a solution to Richards' equation [Richards, 1931]. Schmid [1989] investigated the implicit assumption in the model that infiltration is independent of overland flow so that only the weak coupling of both processes is taken into account. He found that the errors introduced were in most cases smaller that 5% and always less than 11%. Compared to the uncertainty introduced by spatial variability in subsurface conditions, the weak coupling assumption seems appropriate.

3.2 Solution Methods

Solutions of kinematic wave equation problems have been formulated and applied for almost 40 years. Characteristic, finite difference, finite element, and control volume finite element methods have been used in these solution schemes. A detailed description of each of these solutions is beyond the scope of this work. However, several results of solutions in the literature pertain to the development of new methods.

For domains in which model parameters are not spatially variable, the method of characteristics (MOC) is an appropriate solution approach [Izzard, 1946; Lighthill and Whitham, 1955; Henderson and Wooding, 1964; Wooding, 1965; Crawford and Linsley, 1966; Woolhiser and Liggett, 1967]. The success of the MOC is not surprising. The kinematic wave equation is a hyperbolic partial differential equation—a class of problem for which the MOC is well suited. Others have extended the MOC to irregularly shaped domains and temporally variable model parameters [Eagleson, 1970; Harley et al., 1970; Singh, 1976; Woolhiser, 1975; Sherman and Singh, 1976; Borah et al., 1980; Parlange et al., 1981; Cundy and Tento, 1985; Eggert, 1987; Woods and Ibbitt, 1988; Sander et al., 1990].

While MOC solutions are theoretically attractive, practical problems associated with extension to field conditions have inhibited the widespread use of the MOC [Ross, 1977; Zhang and Cundy, 1989; Sander et al., 1990]. Surface slope (S_o), roughness (n), and rainfall excess (r) are parameters that vary in space. When such changes are abrupt, discontinuities in h, or kinematic shocks, result [Kibler and Woolhiser, 1972]. While such problems can be solved using the MOC [Borah et al., 1980; Hunt, 1987], a more common approach has been to use Eulerian methods, i.e., finite differences [Stoker, 1953; Brakensiek, 1967; Liggett and Woolhiser, 1967;

Amein, 1968; Amein and Fang, 1970; Kibler and Woolhiser, 1972; Price, 1974; Li et al., 1975; Zhang and Cundy, 1989], finite elements [Judah, 1972; Ross et al., 1979; Vieux and Segerlind, 1989; Blandford and Meadows, 1990; Vieux et al., 1990, Goodrich et al., 1991], mixed formulations (MOC and finite differences) [Singh, 1975], or a control volume scheme [Mohtar et al., 1990].

While Eulerian methods allow for the simple incorporation of spatially variable parameters, they are not well suited to the solution of hyperbolic equations. Recent work has suggested using Eulerian solution methods with refined spatial and temporal discretization, and smoothed values of spatially variable parameters to avoid numerical errors associated with kinematic shocks [Ponce, 1991; Vieux et al., 1990].

Upstream weighting methods have been used to reduce errors associated with the application of Eulerian methods to sharp-front problems [Hughes, 1978; Heinrich and Zienkiewicz, 1977; Wait and Mitchell, 1985]. In particular, recent advances have been made in applying PG methods to solve advective-dominated transport problems [Westerink and Shea, 1989; Cantekin and Westerink, 1990; Cornew and Miller, 1990; Miller and Cornew, 1992] and multiphase flow and transport problems [Mayer and Miller, 1990]. The success of these applications suggests that similar methods may be applicable to kinematic wave problems.

4. Solution Formulation

Based upon results achieved for other sharp-front problems [Westerink and Shea, 1989; Cantekin and Westerink, 1990; Cornew and Miller, 1990; Mayer and Miller, 1990] a PG approach may be formulated to solve the kinematic wave equations. The formulation is a straightforward extension of methods that have been developed and applied successfully to problems that pose many of the same numerical difficulties as the kinematic wave equations. However, evaluating the improvements offered by such a method, determining optimal parameters for the approach, and testing the approach on shock-type problems are not trivial and are necessary to advance the understanding of such Eulerian strategies for solving kinematic wave problems.

Equation (1) may be written in a weak weighted residual form as

$$\int_{\mathcal{D}} W_i \left(\frac{\partial \hat{h}}{\partial t} + \frac{\partial \hat{q}}{\partial x} - r \right) dx = 0 \text{ for } i = 1, ..., n_n \tag{13}$$

for trial solutions described over an element of the form

$$\hat{h}(x) = \sum_{j=1}^{n_{ne}} N_j(x) h_j \tag{14}$$

$$\hat{q}(x) = \sum_{j=1}^{n_{ne}} N_j(x) q_j = \sum_{j=1}^{n_{ne}} \alpha(x) N_j(x) {h_j}^{5/3} \tag{15}$$

where W_i is a weighting, or test, function corresponding to node i; N_j are standard Lagrange polynomial basis functions; n_n is the number of nodes in the domain, $\mathcal{D}$; and n_{ne} is the number of nodes in an element. Resolving the time derivative using a variably-weighted finite difference approximation gives

$$\int_{\mathcal{D}} W_I \left[\hat{h}^{l+1} + \theta \Delta t \left(\frac{\partial \hat{q}}{\partial x}^{l+1} - r^{l+1} \right) \right] dx =$$

$$\int_{\mathcal{D}} W_I \left[\hat{h}^{l} - (1-\theta) \Delta t \left(\frac{\partial \hat{q}}{\partial x}^{l} - r^{l} \right) \right] dx \tag{16}$$

where l is a time-step index; θ is a time-weighting coefficient, which is equal to 0.5 for Crank-Nicolson weighting; and the capital subscript, I, on W is used to denote a system of equations (one equation for each of the nodes in the domain).

The basis functions may be specified as quadratic Lagrange polynomials in natural coordinates ($-1 \leq \xi \leq 1$) for every element by

$$N_j(\xi) = \prod_{\substack{n=1 \\ n \neq j}}^{3} \frac{(\xi - \xi_n)}{(\xi_j - \xi_n)} \tag{17}$$

which yields piecewise continuous basis functions of the usual form [Zienkiewicz, 1977].

The weighting functions are modified by cubic (M_3) and quartic (M_4) functions giving [Westerink and Shea, 1989]

$$W_1(\xi) = N_1(\xi) - \alpha_c M_3(\xi) - \beta_c M_4(\xi) \tag{18}$$

$$W_2(\xi) = N_2(\xi) + 4\alpha_m M_3(\xi) + 4\beta_m M_4(\xi) \tag{19}$$

$$W_3(\xi) = N_3(\xi) - \alpha_c M_3(\xi) - \beta_c M_4(\xi) \tag{20}$$

for

$$M_3(\xi) = \frac{5}{8}\xi(\xi + 1)(\xi - 1) \tag{21}$$

$$M_4(\xi) = -\frac{21}{16}(\xi^4 - \xi^2) \tag{22}$$

The constants α_c, β_c, α_m, and β_m are PG parameters required to specify the form of the weighting functions for the corner-element ($\xi = \pm 1$) and mid-element ($\xi = 0$) nodes, respectively.

The PG finite element solution yields a system of linear equations of the form

$$[A]\{h\}^{l+1,m+1} = \{b\} = \{b_l\}^l + \{b_n\}^{l+1,m} \tag{23}$$

where m is the iteration level of the solution, $[A]$ is a banded coefficient matrix that contains only linear terms, $\{b\}$ is a vector that contains all terms evaluated at the l time level and the $\hat{q}$ term evaluated at the new time level but lagged an iteration level, $\{b_l\}^l$ is the linear portion of $\{b\}$, and $\{b_n\}^{l+1,m}$ is the nonlinear portion of $\{b\}$.

The global matrix $[A]$ and vectors $\{b_l\}^l$ and $\{b_n\}^{l+1,m}$ result from the summation of elemental contributions of the form

$$[A] = \sum_{n_e=1}^{ne} [A_e^{n_e}] \tag{24}$$

$$\{b_l\}^l = \sum_{n_e=1}^{ne} \{b_{el}^{n_e}\}^l \tag{25}$$

$$\{b_n\}^{l+1,m} = \sum_{n_e=1}^{ne} \{b_{en}^{n_e}\}^{l+1,m} \tag{26}$$

where

$$[A_e^{n_e}] = \frac{\Delta x_{n_e}}{2} \begin{bmatrix} \int_{-1}^{1} W_1 N_1 \, d\xi & \int_{-1}^{1} W_1 N_2 \, d\xi & \int_{-1}^{1} W_1 N_3 \, d\xi \\ \int_{-1}^{1} W_2 N_1 \, d\xi & \int_{-1}^{1} W_2 N_2 \, d\xi & \int_{-1}^{1} W_2 N_3 \, d\xi \\ \int_{-1}^{1} W_3 N_1 \, d\xi & \int_{-1}^{1} W_3 N_2 \, d\xi & \int_{-1}^{1} W_3 N_3 \, d\xi \end{bmatrix} \tag{27}$$

$$\{b_{el}^{n_e}\}^l = \frac{\Delta x_{n_e}}{2} \left\{ \begin{array}{l} \int_{-1}^{1} W_1 \left\{ \hat{h}^l + \Delta t \left[(1-\theta) \left(r^l - \frac{2}{\Delta x_{n_e}} \frac{\partial \hat{q}}{\partial \xi}^l \right) + \theta r^{l+1} \right] \right\} d\xi \\ \int_{-1}^{1} W_2 \left\{ \hat{h}^l + \Delta t \left[(1-\theta) \left(r^l - \frac{2}{\Delta x_{n_e}} \frac{\partial \hat{q}}{\partial \xi}^l \right) + \theta r^{l+1} \right] \right\} d\xi \\ \int_{-1}^{1} W_3 \left\{ \hat{h}^l + \Delta t \left[(1-\theta) \left(r^l - \frac{2}{\Delta x_{n_e}} \frac{\partial \hat{q}}{\partial \xi}^l \right) + \theta r^{l+1} \right] \right\} d\xi \end{array} \right\} \tag{28}$$

$$\{b_{en}^{n_e}\}^{l+1,m} = -\theta\Delta t \left\{ \begin{array}{l} \int_{-1}^{1} W_1 \frac{\partial \hat{q}}{\partial \xi}^{l+1,m} d\xi \\ \int_{-1}^{1} W_2 \frac{\partial \hat{q}}{\partial \xi}^{l+1,m} d\xi \\ \int_{-1}^{1} W_3 \frac{\partial \hat{q}}{\partial \xi}^{l+1,m} d\xi \end{array} \right\} \quad (29)$$

n_e is an element index, and ne is the number of elements in the domain.

For a given time step solution, $l+1$, Equation (23) was solved using Picard iteration and a direct banded solver [Allen et al., 1988] until

$$\frac{\max \left| h_j^{l+1,m+1} - h_j^{l+1,m} \right|}{\max \left| h_j^{l+1,m+1} \right|} < \epsilon \quad (30)$$

where the error tolerance, ϵ, was set equal to 10^{-10} in this study.

5. Solution Validation

Kinematic wave solutions were solved in two forms: (1) the depth of flow $[h = h(t,x)]$ over the surface at each time step, or h-based; and (2) the outflow at the end of the domain for each time step $[q = q(t, x = L)]$, or q-based, which describes a hydrograph. Both of these forms of the solution are useful for a variety of applications.

As a check of the accuracy of the PG solution, a simplified case was considered first. In this case a constant r, S_o, and n exist for a period of time sufficient to build an equilibrium profile over the surface. For these simplified conditions, an analytical solution can be derived by integrating the steady-state form of Equation (1), after substituting Manning's equation for q, which gives [Henderson and Wooding, 1964; Woolhiser, 1975]

$$
\begin{aligned}
q &= \alpha (rt)^{5/3}, && \text{for } 0 < t < t_e \\
q &= q_m, && \text{for } t \geq t_e
\end{aligned}
\tag{31}
$$

For the h-based form, an analytical solution based on the method of characteristics [Henderson and Wooding, 1964] is

$$
h = \min \left[\left(\frac{rx}{\alpha} \right)^{3/5}, rt \right], \qquad \text{for } t \geq 0 \tag{32}
$$

Model validation was performed using physical and model parameters summarized in Table 1 as Case 1 conditions. Figure 1 shows results of the standard Bubnov-Galerkin linear and quadratic finite element solutions; a PG finite element solution, using optimal parameters described below; and the MOC analytical solution, along with the errors associated with the approximate solutions compared to the analytical solution. These graphs illustrate that the PG method reduces the amplitude of the oscillations compared to Bubnov-Galerkin solutions.

Table 1. Summary of Simulation Parameters

Case	Section	L (m)	r (m/s)	t_r (s)	n	S_o	n_n	Δx (m)	Δt (s)	Cr	Fr	k
1	—	15.0	3.33×10^{-6}	t_s	0.048	0.0576	51	0.3	3.60	1.00	0.505	3390.
2	1	8.0	1.08×10^{-3}	30	0.009	0.0200	9	1.0	0.42	0.55	2.37	2.58
	2	8.0	6.38×10^{-4}	30	0.009	0.0150	8	1.0	0.42	0.60	2.18	3.17
	3	8.0	8.00×10^{-4}	30	0.009	0.0100	8	1.0	0.42	0.62	1.89	2.98
3	1	7.5	3.33×10^{-6}	1500	0.048	0.0576	26	0.3	3.60	0.76	0.471	2950.
	2	7.5	3.33×10^{-6}	1500	0.100	0.0576	25	0.3	3.60	0.64	0.261	8180.
4	1	5.0	3.33×10^{-6}	1500	0.100	0.0400	17	0.31	6.24	0.74	0.198	5680.
	2	5.0	3.33×10^{-6}	1500	0.100	0.0100	16	0.31	6.24	0.56	0.114	3740.
	3	5.0	3.33×10^{-6}	1500	0.100	0.0025	16	0.31	6.24	0.44	0.064	2330.
5	—	10–50	1.00×10^{-6}	t_s	0.006–0.007	0.01–0.02	11–201	0.25–1.0	0.07–9.9	0.05–1.00	1.50	500.
6	—	25.0	1.00×10^{-6}	t_s	0.00647	0.0137	51	0.5	0.18–3.7	0.05–1.00	1.50	500.

t_r is the duration of rainfall, and t_s is the time simulated

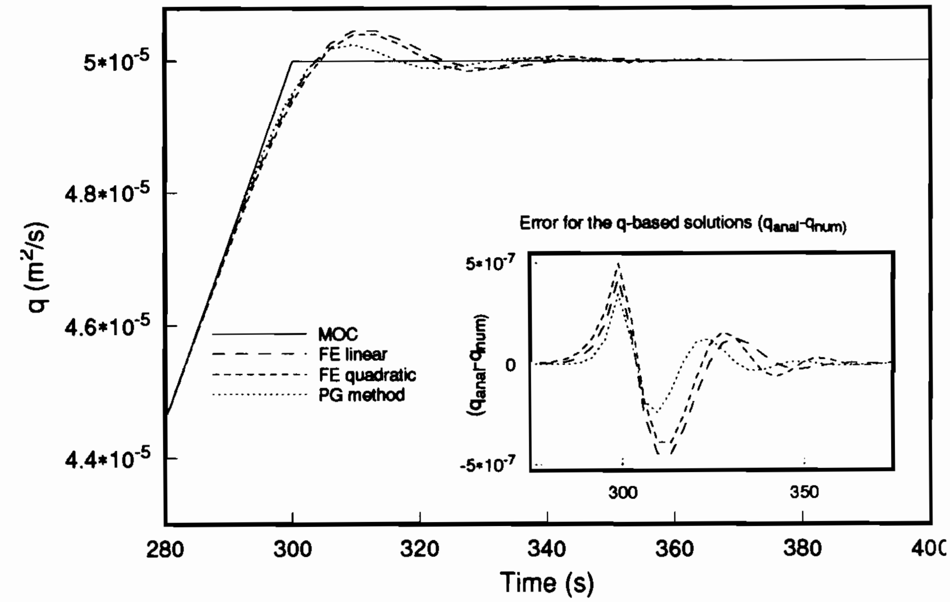

Fig. 1. Comparison of q-based solutions to kinematic wave equation for the case of a constant rainfall over an impermeable plane.

A complex shock-producing case was studied by Iwagaki [1955]. Runoff was measured from a three-plane cascade, which was made out of a three-section metal flume, with characteristics summarized in Table 1 as Case 2 conditions. Over each section of the flume, a different rainfall rate was applied and then stopped at 10, 20, and 30 seconds in three separate experiments. Borah et al. [1980] proposed a kinematic wave shock-fitting model (MOC) to simulate this case. The 30-s rainfall problem was simulated using the Petrov-Galerkin model, with inputs summarized in Table 1 as Case 2 conditions. The results shown on Figure 2 illustrate a good agreement among the experimental data, the Borah et al. [1980] shock fitting model, and the PG model developed in this work. Borah et al. [1980] note that a standard finite difference method tends to smooth such shocks. The PG method performs well in this case depicting a shock in the solution comparable to the MOC, with only minimal oscillations even for a relatively coarse discretization (25 nodes). It should be noted that some variation is expected between the experimental data and kinematic wave solutions, since the $Fr > 1.5$ and $k < 10$.

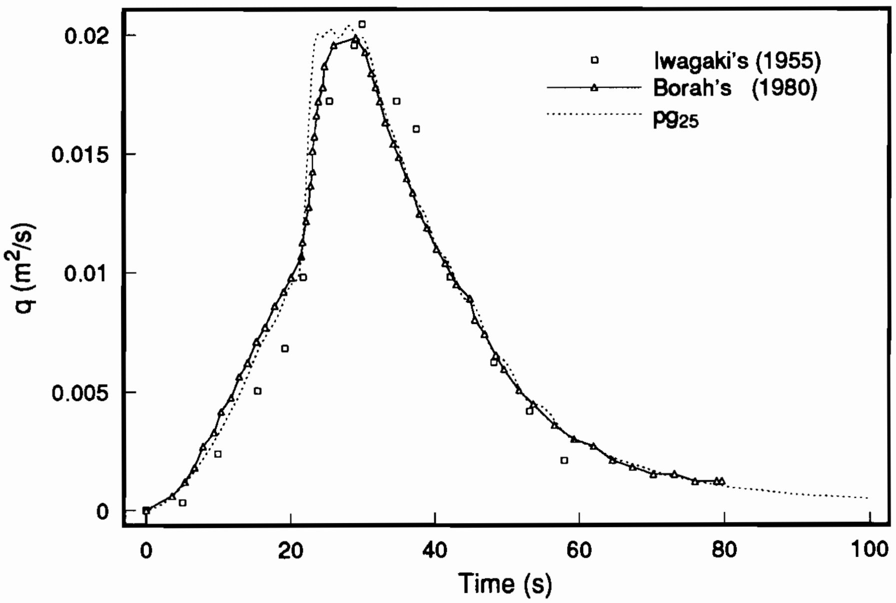

Fig. 2. Comparison of model simulation results and experimental data [Iwagaki, 1955] for a three-slope domain (Table 1, Case 2).

An additional check was performed for the case of a plane with two equal sections with different Manning's roughnesses and a constant rainfall, stopping at 1500 s to produce a recession hydrograph (Case 3 in Table 1). A shock is formed at the change of roughness point (7.5 m). This translates into a change of slope in the hydrograph. Figure 3 shows a comparison between all the three FEMs studied (linear, quadratic and Petrov-Galerkin). A similar simulation was set up for a three plane cascade with a uniform roughness and all the other parameters the same as in the previous case (Case 4 in Table 1).

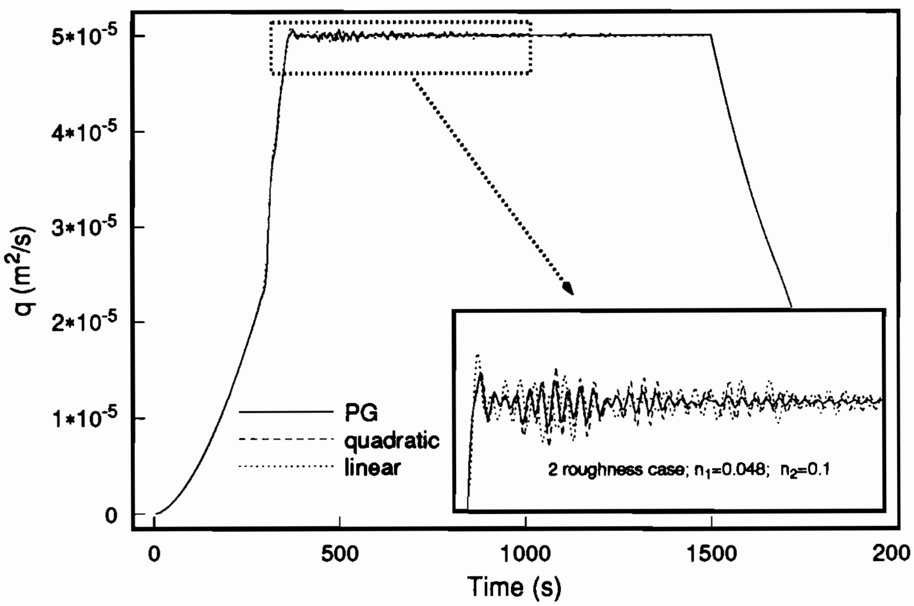

Fig. 3. Comparison of q-based solutions for a two roughness coefficient domain and a limited duration rainfall (Table 1, Case 3).

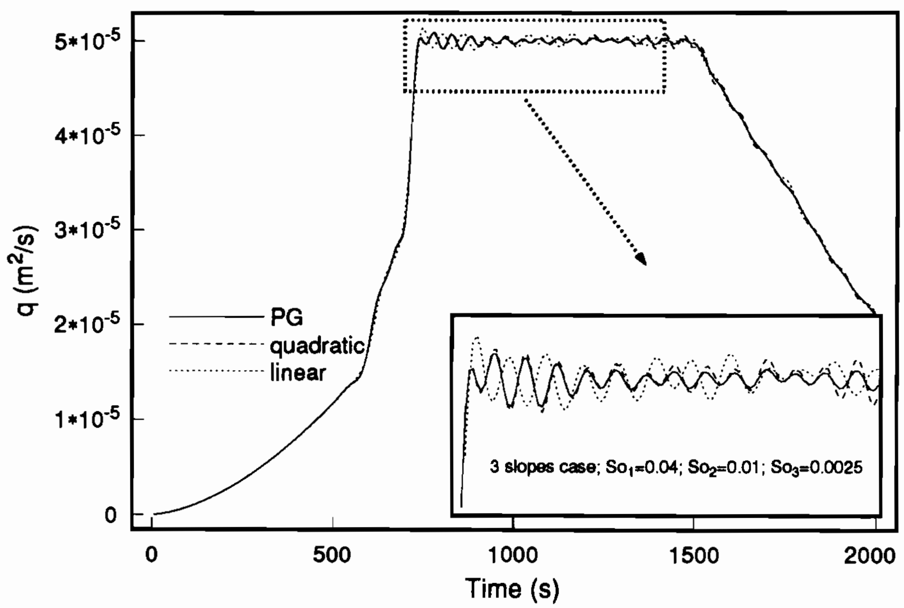

Fig. 4. Comparison of q-based solutions for a three-slope domain and a limited duration rainfall (Table 1, Case 4).

Figure 4 shows the shock in the rising hydrograph caused by the three-slope case. The PG method reduced the amplitude and duration of the errors compared to the linear and quadratic FEM solutions, though all methods perform reasonably well. The solutions were compared with a finely discretized solution (10000 nodes) to determine errors associated with each method (Table 2).

Table 2. Summary of Errors for Case 4

Error	PG FEM	QBG FEM	LBG FEM
MSE-q	1.13×10^{-13}	1.74×10^{-13}	1.95×10^{-13}
ME	3.31×10^{-6}	3.31×10^{-6}	3.63×10^{-6}
MAE	1.92×10^{-7}	2.63×10^{-7}	2.64×10^{-7}

QBG—quadratic Bubnov Galerkin
LBG—linear Bubnov Galerkin

Four measures of q- and h-based error were used to judge solution accuracy in this work, mean square error for the h-based solution

$$\text{MSE-}h = \frac{\sum_{l=1}^{n_t} \sum_{j=1}^{n_n} \left(h_{fj}^l - h_{cj}^l\right)^2}{n_t n_n} \tag{33}$$

mean square error for the q-based solution

$$\text{MSE-}q = \frac{\sum_{l=1}^{n_t} \left(q_f^l - q_c^l\right)^2}{n_t} \tag{34}$$

maximum error

$$\mathrm{ME} = \max\left|q_f^l - q_c^l\right| \qquad \text{for } l = 1, ..., n_t \tag{35}$$

and mean absolute error

$$\mathrm{MAE} = \frac{\sum_{l=1}^{n_t}\left|q_f^l - q_c^l\right|}{n_t} \tag{36}$$

where n_t is the number of time steps, the subscript f denotes the fine-grid ($n_n =$ 10000) approximation, and the subscript c denotes a course-grid approximation. The validations presented in this section used optimal PG parameters (α_c, α_m, β_c, β_m). Methods used to determine these optimal parameters, the resulting parameter values, and implications for trends in the optimal values are discussed in the following sections.

6. Parameter Estimation

An important problem associated with application of the PG method is a determination of the PG parameters $(\alpha_c, \alpha_m, \beta_c, \beta_m)$ as a function of relevant system parameters. Truncation error analysis, Fourier analysis, and numerical minimization procedures are typically used [Westerink and Shea, 1989]. Each method has advantages and disadvantages, but minimization procedures, sometimes called numerical experimentation, have the advantage of acting more directly on the quantity of concern: the difference between a model prediction and the true solution. Truncation analysis usually concentrates on the elimination of low-order truncation error, assuming that the importance of error terms decreases as order increases. Recently Miller and Cornew [1992] found a significant nonmonotonic error contribution from increasing order terms for an advective-dominated transport problem.

Fourier analysis methods can yield insight into a problem in terms of errors related to frequencies of a solution, but these have not generally been used to quantitatively predict PG parameters [Westerink and Shea, 1989; Cornew and Miller, 1990; Miller and Cornew, 1992].

A minimization on an h-based PG solution was performed using

$$\min_{\alpha_c,\beta_c,\alpha_m,\beta_m} \sum_{l=1}^{n_t} \sum_{j=1}^{n_n} \left(h_{aj}^{l} - h_{mj}^{l}\right)^2 \tag{37}$$

where h_a is the analytical solution for depth as a function of space and time, and h_m is the PG model solution for depth as a function of space and time.

The optimization problem described by Equation (37) was solved using a Levenberg-Marquardt method (LMDIF) from the MINPACK mathematical libraries [Garbow et al., 1980], on a Convex C240 supercomputer. The minimization procedure was solved repeatedly for varying values Cr, Fr, and k. The validity of the results were verified by selecting different starting conditions of the parameters sought and by performing a grid search analysis to inspect the error surface. LMDIF proved to be a robust and reliable estimator of the PG parameters that minimized the objective function, Equation (37).

Results from the minimization procedure showed that the PG parameters were not only a function of the Cr, but also of the number of nodes in the domain (n_n). However, the parameters were independent of Fr and k. That is, identical optimal PG parameters were determined for a given Cr regardless of the Fr and the k. Upon confirming this finding by an extensive grid search, optimizations were performed for $0.05 \leq Cr \leq 1.00$ in increments of 0.05 and $11 \leq n_n \leq 201$ (Table 1, Case 5). This process yielded 200 sets of optimal PG parameters as a sole function of Cr and n_n. Figures 5 through 8 summarize optimal values from this parameter estimation, while least-squares regression of each PG parameter value (for the 201 node case) against Cr yielded the results given in Table 3.

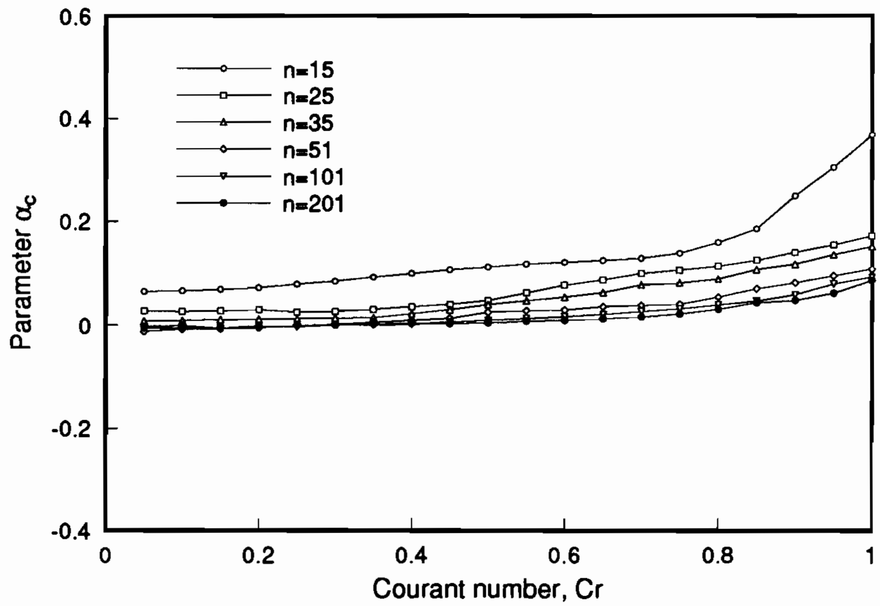

Fig. 5. Optimal values of α_c for the PG method.

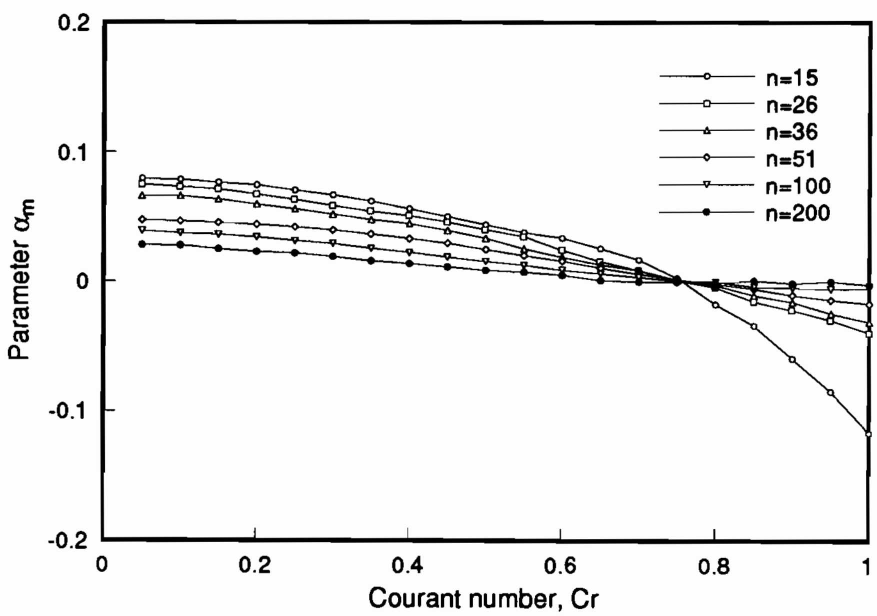

Fig. 6. Optimal values of α_m for the PG method.

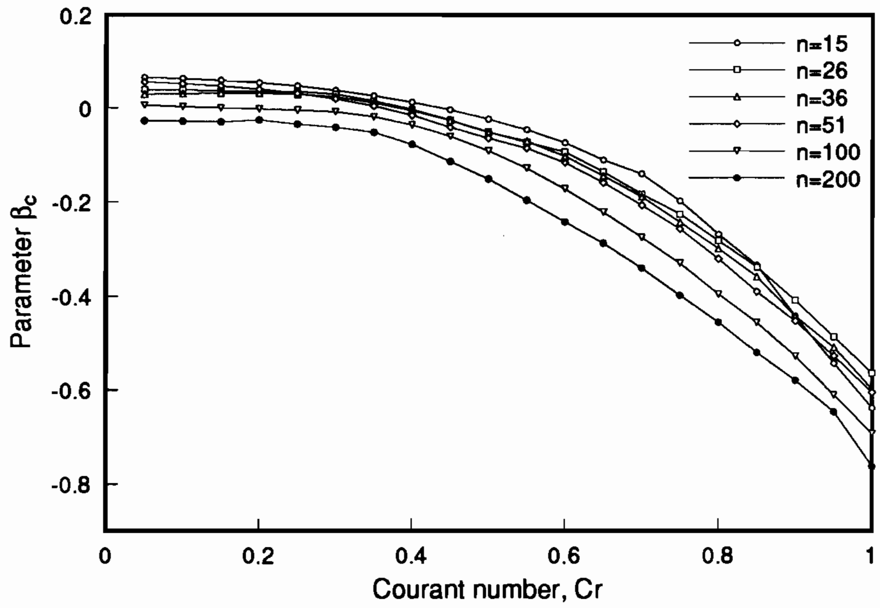

Fig. 7. Optimal values of β_c for the PG method.

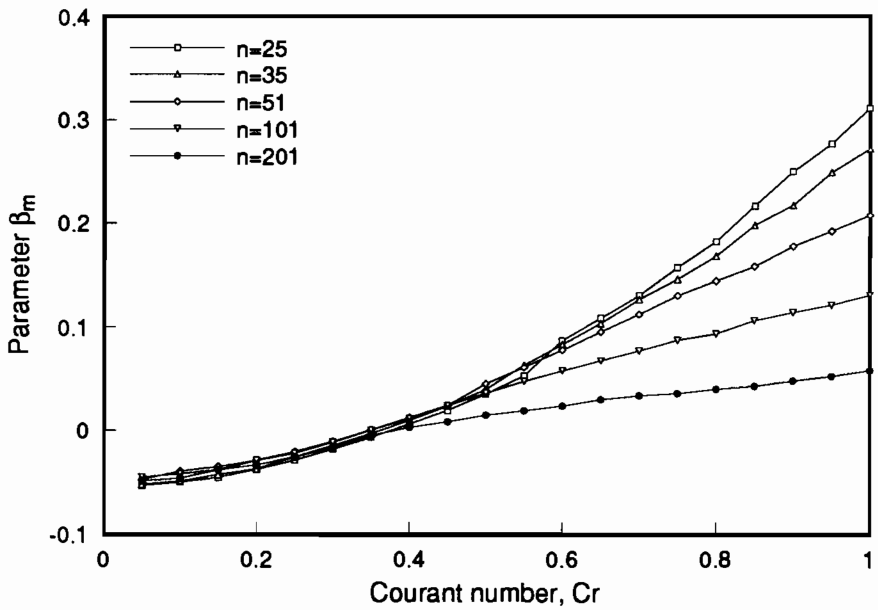

Fig. 8. Optimal values of β_m for the PG method.

Table 3. Least-Squares Fits of Petrov-Galerkin Parameters

Parameter	a_0	a_1	a_2	a_3	r^2
α_c	-0.00863106	0.0710183	-0.205402	0.223070	0.989
α_m	0.0302084	-0.0225457	-0.0722190	0.0637837	0.992
β_c	-0.0486437	0.369278	-1.22373	0.160394	0.999
β_m	-0.0616601	0.174084	-0.0489402	0.00902134	0.994
where PG parameter $= \sum_{k=0}^{3} a_k x^k$					

Table 4. Model Formulation Summary

Case	Method	Optimal Parameters
lin_{51}	Linear Bubnov-Galerkin FEM	—
quad_{51}	Quadratic Bubnov-Galerkin FEM	—
pg_{51}	Quadratic Petrov-Galerkin FEM	Optimal for $n_n = 51$
pg_{201}	Quadratic Petrov-Galerkin FEM	Optimal for $n_n = 201$
mpg_{201}	Modified Quadratic Petrov-Galerkin[1] FEM	Optimal for $n_n = 201$
1. Single parameter PG model ($\alpha_c = \alpha_m = \beta_m = 0$)		

7. Discussion

As the number of nodes increases, optimal values of the PG parameters shown in Figures 5–8 become insensitive to increased discretization for α_c, α_m, and β_m. Based upon this observation, simulations were performed to evaluate solution errors as a function of PG parameter values and Cr. Case 6 in Table 1 summarizes simulation parameters for results shown in Figures 9–13, while Table 4 summarizes model formulations investigated.

Figure 9 shows that the MSE-h is less for the PG method than for the standard quadratic method for all discretizations. The reduction in error is a maximum for $Cr = 1$, with a 65% reduction observed for the tailored PG run compared to a linear FEM solution. Figure 9 also shows comparisons for MSE-h as a function of PG parameters used. The lowest errors were achieved for optimal parameters based upon the number of nodes in the system (51).

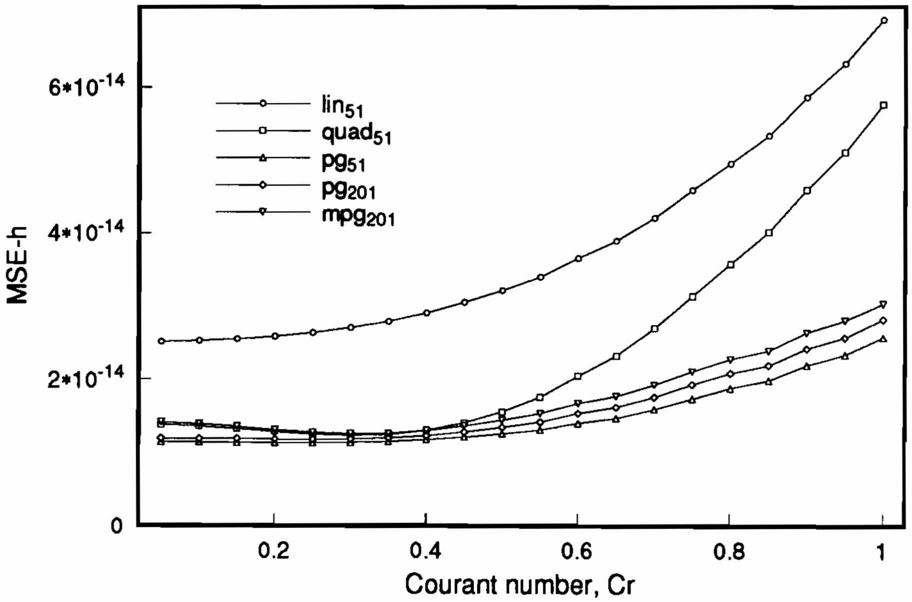

Fig. 9. MSE-h as a function of model formulation, described in Table 4 (Table 1, Case 6).

However, using optimal PG parameters from a 201 node case for a 51 node system increased the solution errors only slightly. This is significant because it reduces the functional dependence of the optimal PG parameters to just one variable, Cr. It should be noted that for a very small number of nodes ($n_n < 20$), the difference between the optimal and approximate PG solutions described above is greater than shown for this 51 node case. Figure 10 shows a similar trend for MSE-q.

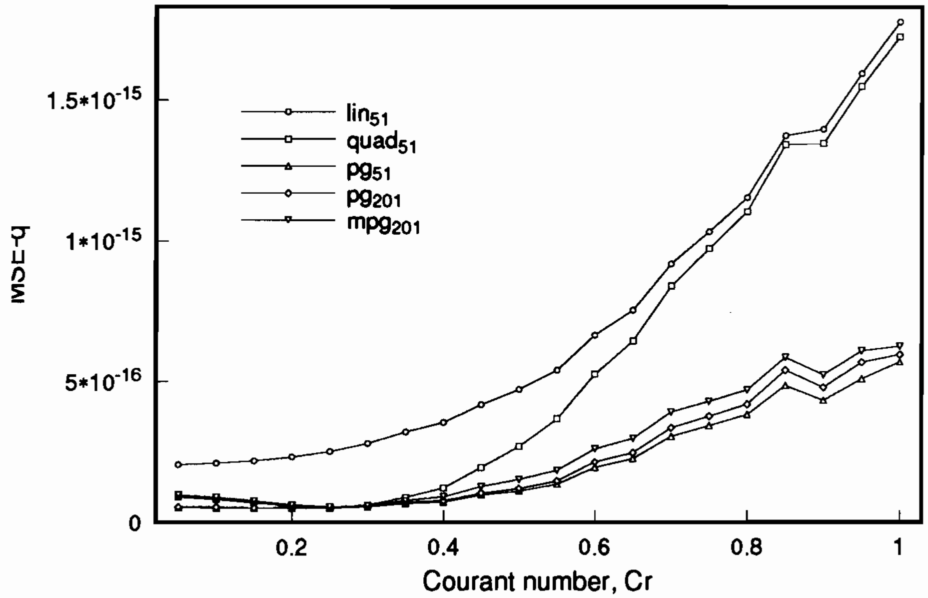

Fig. 10. MSE-q as a function of model formulation, described in Table 4 (Table 1, Case 6).

The previous observation that α_c, α_m, and β_m approach zero as the number of nodes increases (Figures 5–8) suggests a second level of simplification. This modification is to set all PG parameters to zero except for β_c, giving test functions of the form

$$W_1(\xi) = N_1(\xi) - \beta_c M_4(\xi) \tag{38}$$

$$W_2(\xi) = N_2(\xi) \tag{39}$$

$$W_3(\xi) = N_3(\xi) - \beta_c M_4(\xi) \tag{40}$$

Use of these functions reduces the computational effort compared to the full PG method, while still increasing the accuracy and rate of convergence of the solution over the standard quadratic method. Results from this simplification are shown in Figures 9 and 10 by the run noted as mpg_{201}.

The trends noted above for MSE are consistent with results obtained for other measures of error as well. ME and MAE errors are shown in Figures 11 and 12, respectively. All methods are mass conserving, so mass balance error was negligible for all problems analyzed in this work, therefore not a good measure of solution accuracy.

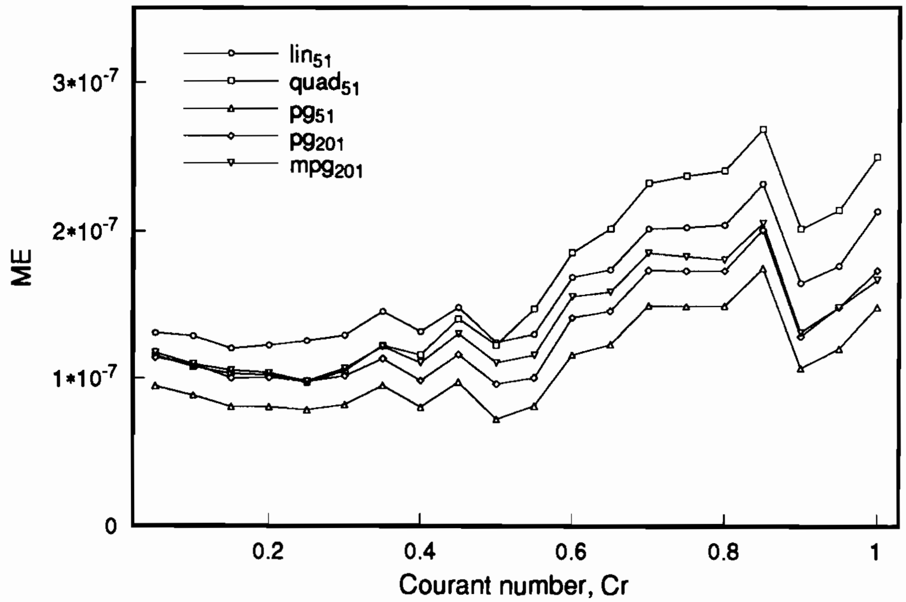

Fig. 11. ME as a function of model formulation, described in Table 4 (Table 1, Case 6).

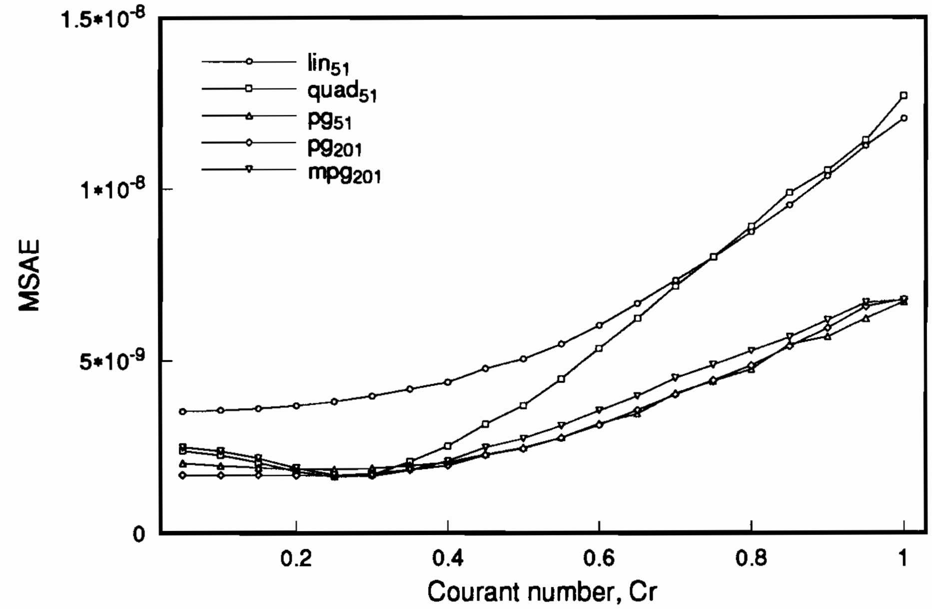

Fig. 12. MAE as a function of model formulation, described in Table 4 (Table 1, Case 6).

CPU timing results are shown in Figure 13 for a 51 node system and a simulation time needed to reach a steady-state condition. The CPU times are dependent upon the number of time steps taken to approach steady-state conditions (i.e., Cr) and the number of iterations needed to converge at each time step. For $Cr < 0.8$, the standard quadratic model (quad) required the least CPU time. However, the CPU time for the quadratic model increased rapidly for $Cr > 0.8$. A similar trend in CPU time was observed for the optimal PG simulations (pg_{51}) as a function of $Cr > 0.8$. The lowest CPU time for all methods occurred for $Cr \approx 0.60$. In view of the error results shown in Figures 9 to 12, this suggests efficient solutions can be obtained using the PG method in terms of both CPU time and solution error at $Cr = 0.6$.

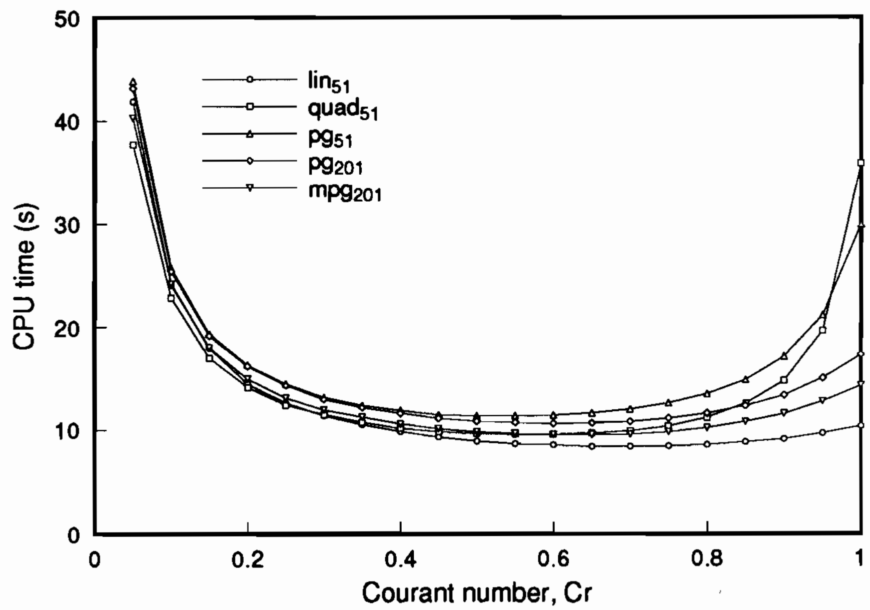

Fig. 13. CPU times as a function of model formulation, described in Table 4 (Table 1, Case 6)

8. Conclusions

A quadratic Petrov-Galerkin (PG) solution to the kinematic wave overland flow equations was developed and compared to standard linear and quadratic Bubnov-Galerkin finite element solutions and an analytical solution derived from the method of characteristics. Model results were investigated for both water depth profiles (h-based) and outflow hydrographs (q-based). The PG method required the determination of four parameters, which were evaluated using a Levenberg-Marquardt method. The PG method decreased the mean sum of square error by about 65% compared to a conventional Bubnov-Galerkin linear finite element approximation for a Courant number (Cr) of 1. Encouraging results were also found for shock-type problems, which result from variations in surface slope or roughness. The four PG parameters in the formulation depended strongly upon the Cr and weakly upon the number of nodes (n_n) in the system. A reasonable approximation to the optimal solution was achieved using parameters based upon a fixed number of nodes ($n_n = 201$). Good solutions were also achieved using a single-parameter simplification of the general PG model. Minimum CPU times were achieved for $Cr \approx 0.6$ for all formulations investigated.

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References

Allen, M.B., I. Herrera, and G.F. Pinder, Numerical Modeling in Science and Engineering, Wiley Interscience, New York, 1988.

Amein, M., An implicit method for numerical flood routing, Water Resour. Res., 4(4), 719–726, 1968.

Amein, M. and C.S. Fang, Implicit flood routing in natural channels, J. Hydraul. Div., Am. Soc. Civ. Eng., 96(HY12), 2481–2500, 1970.

Bedient B.P., and W.C. Huber, Hydrology and Floodplain Analysis, Addison Wesley, New York, 1988.

Blandford, G.E., and M. Meadows, Finite element simulation of non-linear kinematic surface runoff, J. Hydrol., 119, 335–356, 1990.

Borah, D.K., S.N. Prasad, and C.V. Alonso, Kinematic wave routing incorporating shock fitting, Water Resour. Res., 16(3), 529–541, 1980.

Brakensiek, D.L., Kinematic flood routing, Trans. of Am. Soc. Agr. Eng., 10(3), 340–343, 1967.

Bras, L.R., Hydrology: An Introduction to Hydrological Science, Addison Wesley, New York, 1990.

Cantekin, M.E., and J.J. Westerink, Non-diffussive N+2 degree Petrov-Galerkin methods for two-dimensional transient transport computations, Int. J. Numer. Methods Eng., 30, 397–418, 1990.

Cornew, F. H., and C. T. Miller, An adaptive Petrov-Galerkin finite element method for approximating advective-dispersive-reactive equation, in Computational Methods in Subsurface Hydrology, edited by G. Gambolati, A. Rinaldo, C.A. Brebbia, W.G. Gray, and G.F. Pinder, pp. 437–442, Computational Mechanics Publications, Southhampton, U.K. and Springer-Verlag, Berlin, 1990.

Crawford, N.H., and R.K. Linsley, Digital simulation in hydrology: Stanford Watershed Model IV, Tech. Rept. 39, Dept. Civil Eng, Stanford Univ., Stanford, CA, 1966.

Cundy, T.W., and S.W. Tento, Solution to the kinematic wave approach to overland flow routing with rainfall excess given by Philip's equation, Water Resour. Res., 21(8), 1132–1140, 1985.

Eagleson, P.S., Dynamic Hydrology, McGraw-Hill, New York, 1970.

Eggert, K.G., Upstream calculation of characteristics for kinematic wave routing, J. Hydr. Eng., Am. Soc. Civ. Eng., 113(6), 743–752, 1987.

Garbow, B.S., K.E. Hillstrom, and J.J. More, MINPACK Project, Argonne National Laboratory, March, 1980.

Goodrich, D.C., D.A. Woolhiser, and T.O. Keefer, Kinematic routing using finite elements on a triangular irregular network, Water Resour. Res., 27(6), 995–1003, 1991.

Harley, B.M., F.E. Perkins, and P.S. Eagleson, A modular distributed model of catchment dynamics, Hydrodynamics Rept. 133, M.I.T., Cambridge, MA, 1970.

Heinrich, J.C., and O.C. Zienkiewicz, Quadratic finite element schemes for two dimensional convective transport problems, Int. J. Numer. Methods Eng., 11, 131–143, 1977.

Henderson, F.M., Open Channel Flow, pp. 125–164 and 285–398, MacMillan, New York, 1966.

Henderson, F.M., and R.A. Wooding, Overland flow and ground water flow from a steady rainfall of finite duration, J. Geophys. Res., 69(8), 1531–1540, 1964.

Hromadka II, T.V., and J.J. DeVries, Kinematic wave routing and computational error, J. of Hydr. Eng., 114(2), 207–217, 1988.

Hughes, T.J.R., A simple scheme for developing upwind finite elements, Int. J. Numer. Methods Eng., 12, 1359–1365, 1978.

Hunt, B., A perturbation solution of the flood routing problem, J. Hydraulic Res., 25(3), 215–234, 1987.

Huyakorn, P.S. and G.F. Pinder, Computational Methods in Subsurface Flow, Academic Press, New York, 1983.

Iwagaki, Y., Fundamental studies on runoff analysis by characteristics, Bull. 10, Disaster Prev. Res. Inst., Kyoto Univ., Kyoto, Japan, 1955.

Izzard, C.F., Hydraulics of runoff from developed surfaces, Proc. of the Annual Meeting of the Highway Research Board, 26, 126–146, 1946.

Judah, O.M., Simulation of runoff hydrographs from natural watersheds by finite element method, PhD Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA, 1972.

Kibler, D.F., and D.A.Woolhiser, Mathematical properties of the kinematic cascade, J. Hydrol., 15, 131–147, 1972.

Lane, L.J., G.R. Foster, and A.D. Nicks, Use of fundamental erosion mechanics in erosion prediction, paper presented at the 1987 Winter Meeting of Am. Soc. Agr. Eng., paper No. 87-2540, Chicago, 1987.

Li, R.M., D.B. Simons, and M.A. Stevens, Nonlinear kinematic wave approximation for water routing, Water Resour. Res., 11(2), 245–252, 1975.

Liggett, J.A., and D.A. Woolhiser, Difference solutions of the shallow water equation, J. Eng. Mech. Div., Am. Soc. Civil Eng. 93(EM2), 39–71, 1967.

Lighthill, M.J., and C.B. Whitham, On kinematic waves: flood movement in long rivers, Proc. Roy.. Soc. London. Ser. A, 229, 281–316, 1955.

Mayer, A.S., and C.T. Miller, A compositional model for simulating multiphase flow, transport and mass transfer in groundwater systems, in Computational Methods in Subsurface Hydrology, edited by G. Gambolati, A. Rinaldo, C.A. Brebbia, W.G. Gray, and G.F. Pinder, pp. 217–222, Computational Mechanics Publications, Southhampton, U.K. and Springer-Verlag, Berlin, 1990.

Miller, C.T., and F.H. Cornew, A Petrov-Galerkin method for resolving advective-dominated transport, in Computational Methods in Water Resources IX, Vol. 1: Numerical Methods in Water Resources, edited by T.F. Russell, R.E. Ewing, C.A. Brebbia, W.G. Gray, and G.F. Pinder, pp. 157–164, Computational Mechanics Publications, Southhampton, U.K. and Elsevier Applied Science, London, 1992.

Mohtar, R.H., B.E. Vieux, and L.J. Segerlind, Control volume finite element solution for surface flow equations, presented at the 1990 Winter Meeting of Am. Soc. Agr. Eng., Dec.1990, paper No. 90-2631, Chicago, 1990.

Parlange, J.-Y., C.W. Rose, and G.C. Sander, Kinematic flow approximation of runoff on a plane: an exact analytical solution, J. Hydrol., 52, 171–176, 1981.

Ponce, V.M., The kinematic wave controversy, J.Hydraulic Eng., Am. Soc. Civ. Eng., 117(4), 511–525, 1991.

Price, R.K., Comparison of four numerical methods for flood routing, J.Hydraul.Div., Am. Soc. Civ. Eng., HY7, 879–899, 1974.

Richards, L.A., Capillary conduction of liquids in porous mediums, Physics, 1, 318–333, 1931.

Ross, R.B., Finite element simulation of overland flow and channel flow, Trans. of Am. Soc. Agr. Eng., 20(4), 705–712, 1977.

Ross, R.B., D.N. Contractor, and V.O. Shanholtz, A finite element model of overland and channel flow for assessing the hydrologic impact of land-use change, J. Hydrol., 41, 11–30, 1979.

Sander, G.C., J.-Y. Parlange, W.L. Hogarth, C.W. Rose, and R. Haverkamp, Kinematic flow approximation to runoff on a plane: solution for infiltration rate exceeding rainfall rate, J. Hydrol., 113, 193–206, 1990.

Schmid, B.H., On overland flow modelling: Can rainfall excess be treated as independent of flow depth?, J.Hydrol., 107, 1–8, 1989.

Sherman, B., and V.J. Singh, A distributed converging overland flow model: 1. Mathematical solutions, Water Resour. Res., 12(5), 889–896, 1976.

Singh, V.J., Hybrid formulation of kinematic wave models of watershed runoff, J. Hydrol., 27, 33–50, 1975.

Singh, V.J., A distributed converging overland flow model: 3. Application to natural watersheds, Water Resour. Res., 12(5), 902–907, 1976.

Skaggs, R.W., L. E. Huggins, E.J. Monke, and G.R. Foster, Experimental evaluation of infiltration equations, Trans. of Am. Soc. Agr. Eng., 12(6), 822–828, 1969.

Stoker, J.J., Numerical solution of flood prediction and river regulation problems, Report I—Derivation of basic theory and formulation of numerical methods of attack, Rept. No. IMM-200, New York Univ., Inst. Mathematical Sci., New York, 1953.

Taylor, C., A computer simulation of direct run-off, Finite Elements in Water Res., W.G. Gray, G.F. Pinder and C.A. Brebbia, eds., Pentech Press, London, U.K., 4.149–4.163, 1976.

Viessman, W., Jr., J.W. Knapp, G.L. Lewis and T.E. Harbaugh, Introduction to Hydrology, Second Edition, Harper and Row, New York, 1977.

Vieux, B.E., V.F. Bralts, L.J. Segerlind, and R.B. Wallace, Finite element watershed modeling: one-dimensional elements, J. Water Resour. Planning and Mgmt. Div., Am. Soc. Civ. Eng., 116(6), 803–819, 1990.

Vieux, B.E., and L.J. Segerlind, Finite element solution accuracy of an infiltrating channel, Proceedings of 7th International Conference on Finite Element Methods in Flow Problems, University of Alabama, Huntsville, AL, 1989.

Wait, R., and A.R. Mitchell, Finite Element Analysis and Applications, John Wiley, London, 1985.

Westerink, J.J., and D. Shea, Consistent higher degree Petrov-Galerkin methods for the solution of the transient convection-diffusion equation, Int. J. Numer. Methods Eng., 28, 1077–1101, 1989.

Wooding, R.A., A hydraulic model for the catchment-stream problem: II. Numerical solutions. J. Hydrol. 3, 268–282. 1965.

Woods, R.A. and R.P. Ibbitt, Analytical solution for kinematic flow over an infiltrating plane, in Proceedings of the International Symposium on Modeling Agricultural, Forest and Rangeland Hydrology, Chicago, IL, Am. Soc. Agr. Eng., 1988.

Woolhiser, D.A., and J.A. Liggett, Unsteady, one-dimensional flow over a plane—the rising hydrograph, Water Resour. Res., 3(3), 753–771, 1967.

Woolhiser, D.A., Overland flow on a converging surface, Trans. of Am. Soc. Agr. Eng., 12(4), 460–462, 1969.

Woolhiser, D.A., Simulation of unsteady overland flow, in Unsteady Flow in Open Channels, Vol. II, edited by K. Mahmood and V. Yevjevich, Water Resources Publication, 2, pp. 485–508, Fort Collins, CO, 1975.

Zhang, W., and T.W. Cundy, Modeling of two-dimensional overland flow, Water Resour. Res., 25(9), 2019–2035, 1989.

Zienkiewicz, O. C., The Finite Element Method, Third Edition, McGraw-Hill Book Company, UK, 1977.

CHAPTER II

Numerical Approach to the Overland Flow Process in Vegetative Filter Strips[1]

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Abstract

Agricultural and other disturbed lands contribute to non-point source pollution of water bodies (streams and lakes). Vegetative filter strips (VFS) are often recommended to reduce off-site impacts. Design guidelines to optimize the performance of VFS are not readily available. A process based model is presented to simulate the hydrology of a Vegetative Filter Strip for a given event. The model consists of a quadratic finite element overland flow submodel, based on the kinematic wave approximation, coupled with an infiltration submodel based on a modification of the Green-Ampt equation for unsteady rainfall. The model is used to study the effect of soil type, slope, surface roughness, buffer length, storm pattern and field inflow on the VFS performance. Filter performance, i.e. reduction of the runoff volume, velocity and peak, is higher for denser grass cover, smaller slopes and soils with higher infiltration capacity. Time to peak(s) depended mainly on the roughness-slope combination.

Introduction

The sediment leaving disturbed areas, besides being a pollutant itself, can carry nitrogen and phosphorus into water ecosystems, thereby accelerating eutrophication of lakes (Flanagan et al., 1989). In many cases, conservation management practices and structures can reduce off-site impacts. One such accepted management practice is vegetative filter strips (VFS) which are bands of planted or indigenous vegetation that may control transport of sediment and reduce non-point source pollution off-site.

Vegetation reduces surface runoff by increasing infiltration, augmenting roughness of the soil surface, boosting evapotranspiration, and contributing to rainwater interception. Both the retardation of flow and reduction in runoff discharge reduce the kinetic energy of runoff, and thus lower the sediment transport capacity (Foster, 1982). Sediment-bound nutrients are removed from runoff in these vegetative zones as sediment is deposited (Flanagan et al., 1989). For nutrients attached to sediment the deposition process largely controls the effectiveness of the buffer area. For soluble nutrients, infiltration is the controlling factor.

Parsons et al. (1990) showed that large reductions of runoff from an adjacent field are experienced in buffers. The length of the filter is an important factor in its performance, as are other parameters such as slope, surface roughness and soil type. An appropriate means of determining optimal placement, dimensions, and arrangements of buffer areas must be developed if they are to be effective and economical (Swift, 1986). In evaluating the effectiveness of VFS and riparian areas it is desirable to identify those characteristics which affect the efficiency of nutrient and sediment reduction.

This study deals with modeling the surface flow component in VFS and evaluating the effect of a number of parameters on surface runoff hydrographs. The model developed is width-averaged, which translates into a one dimensional (1-D) approach. The solutions obtained from the formulation are given in terms of unit width of surface (in the direction of the movement of the flood wave). This technique is specially useful in the VFS problem where the surface to model is a band of vegetation of a certain width and an extension of results would be desirable for other widths as well. Grass and other uniform soil covers fit the assumptions of this approach. The objective of this modeling approach is the design of strips, not the management of these areas, i.e.

specify required strip lengths to give a specific runoff reductions. The "state of the art" in specifying buffer strip requirements indicates that this process based approach will provide a check for approximate methods and a better understanding of the processes involved.

Background

Overland flow routing describes the water movement over the land surface and implies the calculation of flow rates at positions along the hillslope (Lane et al., 1987). The solution of the overland flow routing equation is needed to solve the sediment transport problem of interest in non-point source pollution studies. Proper representation of the land surface is the basic issue in modeling overland flow (Lane and Woolhiser, 1977). Foster and Meyer (1972) treated surfaces as areas of broad, uniform sheet flow dissected by areas of concentrated flow in rills. This approach is used in the WEPP hillslope model to predict runoff peak rate for unsteady, nonuniform flow (Lane et al., 1987). The kinematic approach of the WEPP model considers a total hydraulic resistance, f_r, as the summation of a soil friction factor, a microtopographic irregularities friction factor (random roughness), and friction factors due to residue and plant cover on the soil. This total f_r, factor represents the total surface resistance to flow. WEPP can generate hydrographs, runoff rates with time, but the erosion component only uses peak rates from a steady-state solution (Lane et al., 1987).

New efforts to account for variability of the land surface on the overland flow process can be found in the literature. Rawls and Brakensiek (1988) address the problem of surface variability in time and space in a model that accounts for the effect of management practices on infiltration. The model is a solution to the Green-Ampt equation for unsteady rainfall. One of the factors specifically included in the model is percentage of grass cover, its seasonal variation, and composition of this cover. Springer and Cundy (1988) consider the effects of excess rainfall generation on erosion. In particular they looked at the effects of spatial variation in saturated conductivity (K_S) on erosion resulting from overland flow. They used a mathematical routing model and concluded that overestimation errors of 9-45% are introduced by neglecting spatial variability of K_S. This error decreased as rainfall and antecedent moisture increased. However, this variability in K_S did not lead to differential deposition along the slope.

One important aspect of the field problem is finding the correct mass balance at the surface. To achieve this, infiltration must be considered. There are different alternatives among the existing models. If inputs can be defined accurately, the most exact approach is solving the governing partial differential equations for infiltration, i.e. some form of Richards' equation (1931), subject to the appropriate boundary and initial conditions. These solutions are computationally expensive and subject to numerical instabilities. Alternative models have been devised based on simplified concepts that lead to an algebraic formulation of the infiltration rate or cumulative infiltration in terms of time and soil parameters. Skaggs and Khaleel (1982) reviewed the empirical models of Kostiakov, Horton, Philip and Holtan, and the physically based models of Green-Ampt, Smith and Smith-Parlange. Some comparative studies show that the fitness of the method employed varies greatly depending on the estimation of the parameters of each of the equations (Skaggs et al., 1969).

Panda et al. (1988) found that the cause of error in Green-Ampt infiltration models is often the estimates of antecedent water content. They proposed a model that overcomes this problem by providing a daily accounting of soil water content in the root zone, incorporating predictions of infiltration, evapotranspiration, and deep percolation for unsteady rainfall.

Cundy and Tento (1985), Stone et al. (1992) and Woolhiser et al. (1990) developed models that account for the interaction of overland flow and infiltration handled by the approximate methods of Philips, Green-Ampt and Smith-Parlange, respectively. The first two models, however, consider the land area as a plane with only one inflow source, i.e. rainfall over the plane. This approach does not allow for the singularities of the VFS, namely, the inflow from some uphill field area is much larger than rainfall atop the buffer, and irregularities at the surface (changes in slope or roughness throughout the filter). The last model, KINEROS (Woolhiser et al., 1990), solves the problem as a series of cascade planes, and can be applied for the case of inflow from the field. This model is based on the finite difference, four-point implicit scheme solution to the kinematic wave equations..

The modeling effort developed herein is based on the numerical solution of the mathematical formulation of the surface water routing described by a set of partial differential equations (PDE) linked to the Green-Ampt infiltration model for unsteady rainfall.

Hydraulic Routing Submodel

Mathematical Formulation

The mathematical formulation of the one-dimensional (1-D) hydraulic routing process was first derived by Barre de Saint-Venant in 1881. It is based on a mass and momentum balance within a control volume (of unit width). For the 1-D case the general PDE's can be described as,

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

$$\frac{\partial v}{\partial t}+v\frac{\partial v}{\partial x}+g\frac{\partial h}{\partial x}=g(S_o-S_f)-\frac{vi_e}{h} \tag{2}$$

where x = flow direction axis (m), t = time scale (s), $h(x,t)$ = vertical flow depth (m), $q(x,t)$ = discharge per unit width (m^2/s), i_e = rainfall excess (m/s), r = rainfall intensity (m/s), f = infiltration rate (m/s), v = depth averaged velocity (m/s), g = gravitational constant (m/s^2), S_o = bed slope (m/m), S_f= friction slope and also $q = vh$.

The kinematic wave equations result from simplification of the Saint-Venant equations. Lighthill and Whitham (1955) proposed that the hydrodynamic terms of the momentum equation were negligible for the case where no backwater effects occurred. In this case, the momentum equation results in $S_o = S_f$ and the relationship between q and h in equation (1) can be expressed by means of a uniform flow equation. One widely used relation for the overland flow case is Manning's equation (Bedient and Huber, 1988; Lane and Woolhiser, 1977; Woolhiser, 1975),

$$q=\alpha h^m=\frac{\sqrt{S_o}}{n}h^{\frac{5}{3}} \tag{3}$$

where α and m are the parameters of the uniform flow equation and n = Manning's roughness coefficient dependent on soil surface condition and vegetative cover. Values for n for different surface types can be found on the literature (Engman, 1986; Woolhiser, 1975).

In a natural flood, two kinds of waves originate, kinematic and dynamic. The dynamic waves propagate at a speed faster than the main flood wave. The celerity of the wave (c) is the speed associated with the dynamic wave (Bras, 1990),

$$c = \frac{\partial q}{\partial h} = \frac{5}{3}\frac{\sqrt{S_o}}{n} h^{\frac{2}{3}} \tag{4}$$

The kinematic wave assumption (Henderson, 1966) is that the speed of the kinematic wave is equal to the velocity of the main flood wave, which is achieved when the Froude number (Fr) is less than 1.5, where,

$$F_r = \frac{v}{\sqrt{gh}} < 1.5 \tag{5}$$

The kinematic postulation is violated for very flat ($S_o < 0.002$) or very steep slopes ($S_o >$ 0.1). For overland flow processes, the dynamic wave fronts attenuate very rapidly ($Fr <$ 1.5), and kinematic waves dominate the flood response (Henderson, 1966).

Woolhiser and Ligget (1967) analyzed characteristics of the rising overland flow hydrograph and found that the kinematic wave assumption is accurate to within 10% if,

$$k = \frac{LS_o}{F_r^2 h_o} > 10 \tag{6}$$

where k = kinematic number, L = length of the domain (m), h_o = depth of the flow at the end of the domain at steady state condition (m).

The initial and boundary conditions (BC) of the PDE can be described as:

$$\begin{aligned} h(x,0) &= 0 \quad ; 0 \le x \le L \\ h(x,t) &= h_{bc} \; ; \; t > 0 \end{aligned} \tag{7}$$

Note that the boundary condition can be modified for different cases. One case is when no uphill inflow occurs, where $h_{bc} = 0$ at the beginning of the slope. A second case is constant inflow from an uphill region out of the domain (x < 0), then $h_{bc} > 0$. A more realistic case would be a varying BC where $h_{bc} = h_{bc}(t)$, depending on the hydrograph off the uphill adjacent field.

Parameters (friction coefficient, slope) are included in α that allow modifications of the flow by soil surface, irregular microtopography and vegetal cover (Lane et al., 1987).

The load in the PDE is rainfall excess, i_e. Schmid (1989) investigated the implicit assumption in the model that infiltration is independent of overland flow so that the weak coupling of both processes (i.e. infiltration influences runoff but not vice versa) is taken into account. He found that the errors introduced were in most cases smaller than 5% and always less than 11%. Compared to the uncertainty introduced by the soil data in his analysis, he concluded, this is an acceptable assumption.

Numerical Solution

Kinematic routing was first discussed by Horton (1945) and Izzard (1946), defined by Lighthill and Whitham (1955) and later used to model the overland flow process (Henderson and Wooding, 1964; Henderson, 1966 Brakensiek, 1967; Ligget and Woolhiser, 1967; Eagleson, 1970). Eggert (1987) generalized the analytical solution for overland flow with the kinematic wave method using the method of characteristics (MOC). Eggert's model describes the rate of flow off the end of a uniform slope subject to a sequence of different spatially-uniform, time-different, non-negative inflows. Others presented solutions for kinematic flow over an infiltrating plane (Cundy and Tento, 1985; Woods and Ibbitt, 1988; Stone et al., 1992; Woolhiser et al., 1990). They point out the necessity to account for variation in the parameters of this model, spatially and temporally.

Several numerical procedures can be used to solve the mathematical formulation of the overland flow problem for the 1-D case. These methods include Lagrangian or variable grid methods, such as characteristics, and Eulerian or fixed grid methods, such as different forms of finite differences (FD) and finite elements (FE) methods. The ideal method for this type of hyperbolic partial differential equation would be MOC. However, the difficulties associated with the application of the method to a space varying domain, such as in a field situation, make the method difficult. On the other hand, some solutions from Eulerian methods are not stable and exhibit convergence problems for abrupt changes of the physical properties of the system, often referred to as kinematic shocks. Recent work, using Eulerian methods with refined spatial and temporal discretization and smoothed values of spatially variable parameters, avoids numerical errors associated with kinematic shocks (Ponce, 1991; Vieux et al., 1991). The use of non-standard FE method, i.e. quadratic Petrov-Galerkin FE, has also been presented as an effective means of reducing such errors (Muñoz-Carpena et al., 1993). The FE has been applied on several occasions to the 1-D problem (Judah, 1972; Ross, 1977; Ross et al. 1979a,b; Blandford and Meadows, 1990; Vieux, 1988; Vieux and Segerlind, 1989; Vieux et al., 1991).

A fundamental parameter for the numerical solution is the Courant number defined as,

$$Cr = \frac{c\Delta t}{\Delta x} \tag{8}$$

where Δx and Δt are space and time increments. Implicit formulations, such as the one proposed are unconditionally stable, however, as the value of Cr decreases, the accuracy of the solution increases, at the expense of computational time (Blandford and Meadows, 1990; Vieux et al., 1991).

Using the standard Galerkin finite element method, the weak energy formulation of equation (1) is expressed as,

$$\int_D W_i \left(\frac{\partial \hat{h}}{\partial t} + \frac{\partial \hat{q}}{\partial x} - i_e \right) dx = 0 \; ; for\, i = 1, n_n \tag{9}$$

where W_i is a weight or test function at node i, $\hat{h}$ and $\hat{q}$ are approximations of h and q, based on a continuous distribution expressed in terms of the actual value at selected points (nodes), h_j,

$$\begin{aligned} \hat{h}(x) &= \sum_{j=1}^{n_n} N_j(x) h_j \\ \hat{q}(x) &= \sum_{j=1}^{n_n} N_j(x) q_j = \sum_{j=1}^{n_n} \alpha(x) N_j(x) h_j^{\frac{5}{3}} \end{aligned} \tag{10}$$

and,

$$\frac{\partial \hat{q}(x)}{\partial x} = \frac{\partial}{\partial x}\left[\sum_{j=1}^{n_n} N_j(x) q_j \right] = \sum_{j=1}^{n_n} \frac{dN_j}{dx} q_j \tag{11}$$

n_n is the number of nodes in the domain and N_j are termed basis functions, standard Lagrange interpolation polynomials in natural coordinates ($-1 \le \xi \le 1$) for every element of the system,

$$N_j(\xi) = \prod_{\substack{n=1 \\ n \neq j}}^{3} \frac{(\xi - \xi_n)}{(\xi_j - \xi_n)} \tag{12}$$

For the Bubnov-Galerkin formulation (standard finite element method) the weighting functions are set equal to the basis functions (Lagrange polynomials), ie $W_i = N_i$ for i=1, n_n.

The formulation also makes use of the finite difference Crank-Nicolson time-weighting scheme, with parameter θ, equal to 0.5 (semi-implicit scheme) chosen by experimentation. Letting l and $l+1$ be the known and unknown time levels for the numerical scheme, and using a shorthand notation in which the set of n_n integrals is represented under the subscript I, equation (9) becomes,

$$\int_D N_I \left[\frac{\hat{h}^{l+1}}{\Delta t} + \theta \left(\frac{\partial \hat{q}^{l+1}}{\partial x} - i_e^{l+1} \right) \right] dx = \int_D N_I \left[\frac{\hat{h}^{l}}{\Delta t} + (1-\theta) \left(\frac{\partial \hat{q}^{l}}{\partial x} - i_e^{l} \right) \right] dx \tag{13}$$

Using equation (11), we can relate q to h. A modified Picard iteration scheme was chosen to solve the resulting system of non-linear equations in h. Defining m, $m+1$ as the last and current iteration, a linear set of equations results,

$$[A]\{h\}^{l+1,m+1} = \{b\} = \{b_o\}^l + \{b_m\}^{l+1,m} \tag{14}$$

where $[A]$ is a banded coefficient matrix that groups only linear terms in $l+1$, $m+1$ from equation (13), $\{b\}$ is the vector that contains all the other terms, this is terms in l and $l+1,m$. The q terms are evaluated at the new time level, but lagged an iteration step, $q^{l+1,m}$, known after the initial and boundary condition (7) are applied. $\{b_o\}$ is the linear portion of $\{b\}$, and $\{b_m\}$ is the non-linear part. The matrix $[A]$ is formed only once at the beginning of the numerical procedure, and a part of the vector *{b}* is calculated only once for each time step, $\{b_o\}$, and then modified by another part for each iteration step, $\{b_m\}$, until convergence for each time step was reached. As convergence criteria, we used (Huyakorn and Pinder, 1986):

$$\frac{\max_{j=1}^{n_n} \left| h_j^{l+1,m+1} - h_j^{l+1,m} \right|}{\max_{j=1}^{n_n} \left| h_j^{l+1,m+1} \right|} < \varepsilon \tag{15}$$

where ε is arbitrarily set equal to 10^{-8} for the simulations.

The system (13) is solved for each iteration using a direct solver such as a Lower Upper Decomposition (LUD) algorithm for banded matrices.

Each of the terms of (12) was transformed to natural coordinates (ξ) and evaluated through a Gauss quadrature integration rule. The members of equation (14) result from the summation over the total number of elements, N_e, of elemental matrices and vectors such,

$$\begin{aligned} [A] &= \sum_{n_e=1}^{N_e} [A_e^{n_e}] \\ \{b_o\}^l &= \sum_{n_e=1}^{N_e} \{b_{o_e}^{n_e}\}^l \\ \{b_m\}^{l+1,m} &= \sum_{n_e=1}^{N_e} \{b_{m_e}^{n_e}\}^{l+1,m} \end{aligned} \tag{16}$$

where,

$$[A_e^{n_e}] = \frac{\Delta x_{n_e}}{2\Delta t} \begin{bmatrix} \int_{-1}^{1} N_1 N_1 d\xi & \int_{-1}^{1} N_1 N_2 d\xi & \int_{-1}^{1} N_1 N_3 d\xi \\ \int_{-1}^{1} N_2 N_1 d\xi & \int_{-1}^{1} N_2 N_2 d\xi & \int_{-1}^{1} N_2 N_3 d\xi \\ \int_{-1}^{1} N_3 N_1 d\xi & \int_{-1}^{1} N_3 N_2 d\xi & \int_{-1}^{1} N_3 N_3 d\xi \end{bmatrix} \tag{17}$$

$$\{b_{o_e}^{n_e}\}^l = \frac{\Delta x_{n_e}}{2}\begin{Bmatrix} \int_{-1}^{1} N_1\left[\frac{\hat{h}^l}{\Delta t} + (1-\theta)\left(i_e^l - \frac{2}{\Delta x_{n_e}}\frac{\partial \hat{q}^l}{\partial \xi}\right) + \theta i_e^{l+1}\right]d\xi \\ \int_{-1}^{1} N_2\left[\frac{\hat{h}^l}{\Delta t} + (1-\theta)\left(i_e^l - \frac{2}{\Delta x_{n_e}}\frac{\partial \hat{q}^l}{\partial \xi}\right) + \theta i_e^{l+1}\right]d\xi \\ \int_{-1}^{1} N_3\left[\frac{\hat{h}^l}{\Delta t} + (1-\theta)\left(i_e^l - \frac{2}{\Delta x_{n_e}}\frac{\partial \hat{q}^l}{\partial \xi}\right) + \theta i_e^{l+1}\right]d\xi \end{Bmatrix} \tag{18}$$

$$\{b_{m_e}^{n_e}\}^{l+1,m} = -\theta\begin{Bmatrix} \int_{-1}^{1} N_1 \frac{\partial \hat{q}^{l+1,m}}{\partial \xi}\, d\xi \\ \int_{-1}^{1} N_2 \frac{\partial \hat{q}^{l+1,m}}{\partial \xi}\, d\xi \\ \int_{-1}^{1} N_3 \frac{\partial \hat{q}^{l+1,m}}{\partial \xi}\, d\xi \end{Bmatrix} \tag{19}$$

The values of i_e are calculated for each node and time step according to an infiltration equation (i.e. Green-Ampt) and a given hyetograph (described in the next section). The incoming hydrograph from the adjacent field is input as a time dependent boundary condition at the first node of the finite element grid. Any combination of unsteady storm and incoming hydrograph types can be used. The program allows for spatial variation of the parameters n and S_o over the nodes of the system (Fig. 1). This feature of the program ensures a good representation of the field conditions for different rainfall events.

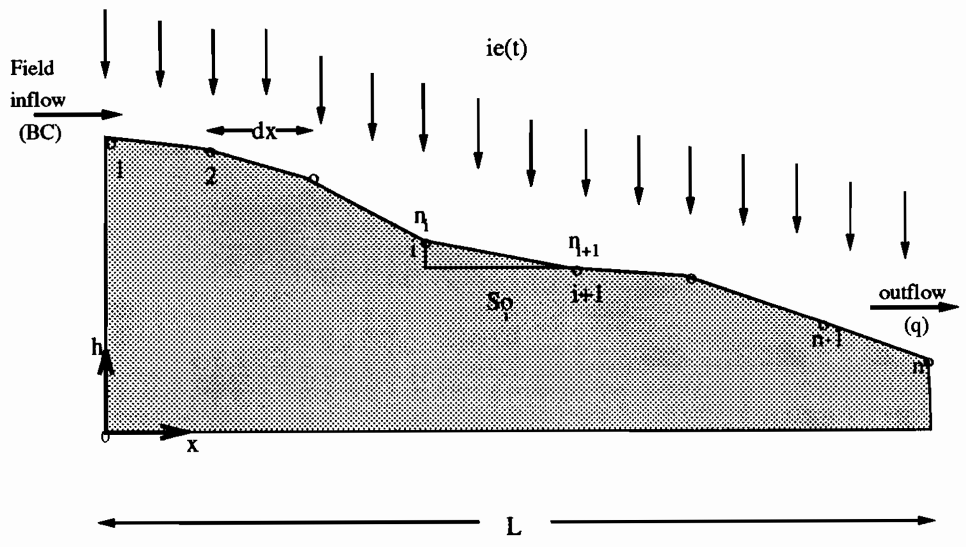

Figure 1:Field discretization for the finite element overland flow model.

Infiltration submodel: Modified Green-Ampt

The Green-Ampt infiltration model (Green and Ampt, 1911) was proposed as an application of Darcy's Law with the following simplifications: i) homogeneous soil profile and uniform distribution of antecedent soil moisture, ii) the water moves in the soil in the form of an advancing wetting front and thus diffusion of soil moisture is neglected, iii) surface ponding. The equation is,

$$f_p = K_s + \frac{K_s\, M\, S_{av}}{F_p} \tag{20}$$

where f_p is the instantaneous infiltration rate, or capacity, for a ponded soil (m/s), K_s is the saturated hydraulic conductivity (m/s), $M = \theta_s - \theta_i$, is the initial soil-water deficit

(m^3/m^3), S_{av} is the average suction across the wetting front (m), and F_p is the cumulative infiltration (m). This model does a good job describing infiltration during a rainfall event, with adequate estimation of the field parameters (Skaggs et al. 1969; Chu, 1978).

Mein and Larson (1971, 1973) applied the Green-Ampt model to natural rainfall conditions by integrating equation (20) with an initial condition that allows for some cumulative infiltration to occur before ponding. This yielded an implicit function of time,

$$K_s(t - t_p - t_s) = F - M\,S_{av}\,ln\left(1 + \frac{F}{M\,S_{av}}\right) \tag{21}$$

where t is the actual time (s), t_p the time to ponding, and t_s is the shift of the time scale to the effect of having cumulative infiltration at the ponding time, or pseudotime.

The determination of the t_p and t_s parameters for an unsteady rainfall was described by Chu (1978). In this method the unsteady storm is divided into constant rainfall periods. For each period a ponding indicator, C_u , is calculated to check if ponding at the surface at the end of the period is reached (C_u>0) or not (C_u<0) and its effect on infiltration,

$$C_u = P(t_n) - RO(t_{n-1}) - \frac{K_s M\,S_{av}}{r - K_s} \tag{22}$$

where $P(t_n)$ is the total cumulative infiltration including the actual rainfall period and $RO(t_{n-1})$ is the total cumulative runoff (m), or cumulative rainfall excess, until the last rainfall period. At the beginning of the storm (no ponding) the value of C_u is checked. If no ponding at the end of the period occurs, the infiltration is set equal to rainfall (i_e=0). If surface ponding occurs, it begins at t_p calculated as

$$t_p = t_{n-1} + \left(\frac{K_s M S_{av}}{r - K_s} - P(t_{n-1}) + RO(t_{n-1}) \right) \frac{1}{r} \tag{23}$$

where $P(t_{n-1})$ and $RO(t_{n-1})$ are the total cumulative infiltration and runoff (m) until the last rainfall period and t_{n-1} is the time at the end of the last rainfall period. The pseudotime, t_s, can now be calculated from equation (21), setting $F=F_p$ (from equation 20). The calculation of the cumulative infiltration, F, requires an iterative method using equation (21). A Newton-Raphson non-linear solution procedure was used such as,

$$F_{m+1} = F_m - \frac{g(F_m)}{g'(F_m)} \tag{24}$$

where $g(F)$ is an implicit function in F derived from equation (21), i.e.

$$g(F) = F - K_s(t - t_p - t_s) - M S_{av} ln\left(1 + \frac{F}{M S_{av}}\right) \tag{25}$$

$g'(F)$ its derivative, and the subscript m denotes the iteration level. The infiltration rate is calculated with equation (20) and then $i_e>0$. If a new rainfall period starts with surface ponding, new parameters t_p and t_s are calculated and a check for the ponding status at the end of the period is done. If there is still ponding, infiltration and rainfall excess are calculated as above, otherwise, the infiltration is set to rainfall for the time after ponding ends. This procedure is repeated until the end of the storm.

The filter strip situation suggests several modifications to the above model. The most important one is that the major input for the overland flow is not rainfall as in a regular situation but inflow at the upslope edge of the filter. This is due to the relative difference in areas between field and filter strip, i.e. the field is typically from 3.5 to 7 times bigger than the buffer area (Parsons et al., 1990). Agricultural fields also display low infiltration rates, K_S , due to surface compaction. The basic assumption made here is that after the beginning of the runoff event, a moving film of water, coming mostly from the field, will be covering the surface (flood wave). This represents a sufficient volume to provide for the maximum potential infiltration. A further assumption of the model is that depressional storage (DS) effects are not considered important for the overall behavior of the filter. Filters should be settled and maintained over a fairly leveled area. DS is less important than in the case of an agricultural field, since a uniform vegetation cover is maintained throughout the year and no cultural practices are applied. This assumption will be violated if channelization develops or the filter is otherwise eroded. The amount of water flooding the filter from the adjacent field will fill up any existing DS at the beginning of the runoff event, and will have little effect on the overland flow process afterwards

The infiltration submodel was formulated as follows:

1.-Rainfall starts. No uphill field inflow (delay). The boundary condition for the hydraulic routing submodel (BC) is set to 0. The VFS acts as an isolated soil. The Green-Ampt model is applied as described above and only the rainfall excess (i_e), equally applied to every element of the system for each time step, is routed on the overland flow model.

2.-Field inflow starts. The BC at the first node of the system is changed for every time step following the inflow hydrograph. A check is made on the first and last node of the system (h values) to find flooding of the surface by field inflow. At this time a signal is sent to the infiltration submodel to proceed as a ponded surface case, where the infiltration is allowed to reach its maximum, and the rainfall excess to be less than 0 in certain cases (rainfall is less than this assumed ponded infiltration). An example case is discussed in the next section to illustrate this point. This concept is important in order to explain the field experimental data where large reductions of the incoming flow rate are obtained at the end of the filters (Parsons et al., 1990).

3.-Field inflow stops, the BC is set back to 0 and a signal is sent to the infiltration subroutine to proceed as the normal case until the end of the storm.

The above procedures show how different soil types are handled by the model through the Green-Ampt parameters (K_s, M, S_{av}). The assumption of ponding after the first and last node of the system are flooded is analyzed in Appendix 2. This assumption will be compromised for soils with extreme infiltration properties, such as fine sands.

Model Application

A set of 144 simulations was conducted for a range of parameters to compare filter strip performance. A summary of the inputs used is given in Tables 1-3.

Table 1. Rainfall distribution used in simulations

Time (s)	Rainfall (m/s)
0	8.4667e-07
300	6.7733e-06
600	1.1007e-05
900	1.9473e-05
1200	1.9473e-05
1500	1.5240e-05
1800	5.0800e-06
2100	1.6933e-06
2400	2.5400e-06
2700	8.4667e-07
3000	0

Table 2. Range of parameters used in the simulations.

Parameter	**Symbol**	**Values**	**Comments**
Surface roughness	n	0.04 0.4	Sparse vegetation Dense vegetation
Strip lengths	L	2,4,6,8,12,19	meters from field edge
Strip Slope	S_o	1,2,4,6,8,10 %	Slope
Soil Types	A, B	Sandy-loam, Clay	See Table 3

Two soil types, A and B were selected. Soil A is of sandy-loam texture at the surface. This surface layer controls infiltration. Field and lab tests were conducted on this soil. Soil B, in contrast, is a deep homogeneous clay soil (Chu, 1978). The soil parameters for the simulations are included in Table 3.

Table 3. Soil parameters used in the simulations

[1]Layer (cm)	Texture	p	e	db (g/cm^3)	ds (g/cm^3)	K_{sv} (cm/h)	K_{sh} (cm/h)	θ_s (cm^3/cm^3)	θ_r (cm^3/cm^3)	S_{av} (cm)	M (cm^3/cm^3)	$S_{av} \cdot M$ (cm)
						SOIL A -SANDY LOAM						
[2]Ap 0-23	SL	0.319	0.470	1.66	2.43	**6.02**	7.85	0.311	0.090	35.7	0.16	**5.71**
Bt1 23-41	C	0.298	0.380	1.61	2.22	4.78	4.74	0.436	0.147	1.8	-	-
Bt2 41-69	SC	0.442	0.795	1.35	2.42	4.93	2.02	0.376	0.129	31.4	-	-
Bt3 69-94	SCL	0.470	0.887	1.50	2.82	4.19	0.60	0.445	0.119	9.2	-	-
						SOLID B- CLAY (Chu, 1978)						
profile	C	-	-	-	-	**0.21**	-	-	-	-	-	**6.10**

[1]Nomenclature: p = Total porosity; e = Void ratio; db = Bulk density; ds = Particle density; S,C,L = Sand, Clay, Loam; K_{sv} = Vertical saturated Conductivity; K_{sh} = Horizontal saturated Conductivity; θ_s, θ_r = Saturated and residual water contents; S_{av} = Average suction at the wetting front; M = initial water content

[2]The Ap layer was the only one considered active for infiltration calculations

The effect of the different hydraulic properties of each of these soils is illustrated in Figures 2a-2b.

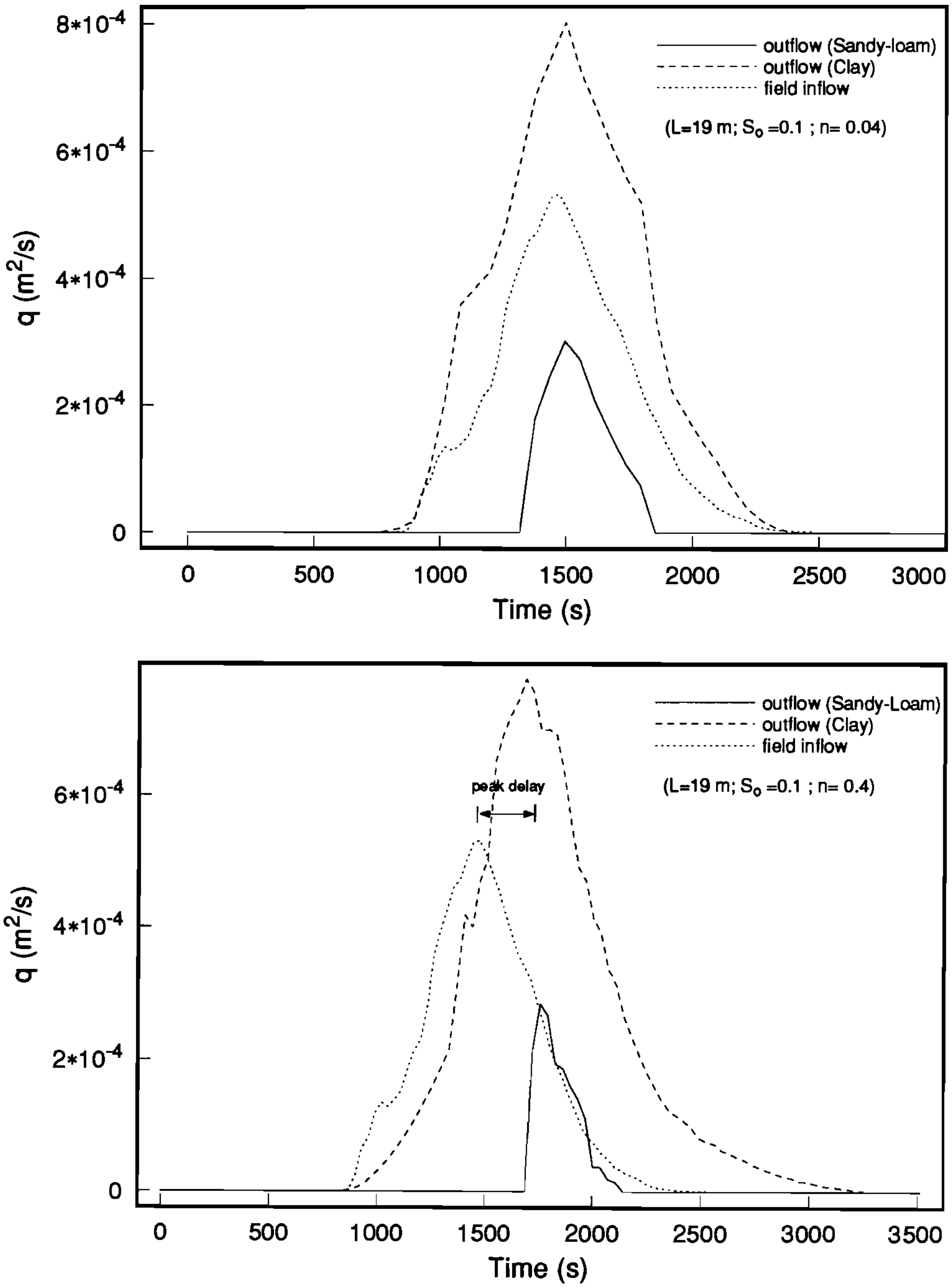

Figure 2a-b: Runoff event over a VFS with sparse(a) and dense (b) grass for two types of soils.

These graphs were obtained using the assumptions discussed for the infiltration submodel and for the storm event in Table 1. The sandy-loam soil shows a marked reduction in total runoff (area under the q curve), as compared to field inflow, due to infiltration. Conversely, the clay soil shows an increase in runoff due to the addition of the rainfall atop to the runoff flow and the small infiltration capacity. These figures also illustrate the effect of vegetation type (Manning's n) on the outflow. For the dense grass (n=0.4), there is a distinctive delay in the time to reach the q-peak. Figures 3-4 show the water balance, as given by the infiltration submodel, for both soils and the case depicted on Fig. 2b. When the surface starts to be inundated by the flood wave, the maximum potential infiltration is achieved. The difference between the two soils can be seen in terms of the effective infiltration values (i_e). Soil A has high rates of infiltration (i_e mostly negative). Soil B is less permeable (i_e mostly positive) resulting in different filter behavior.

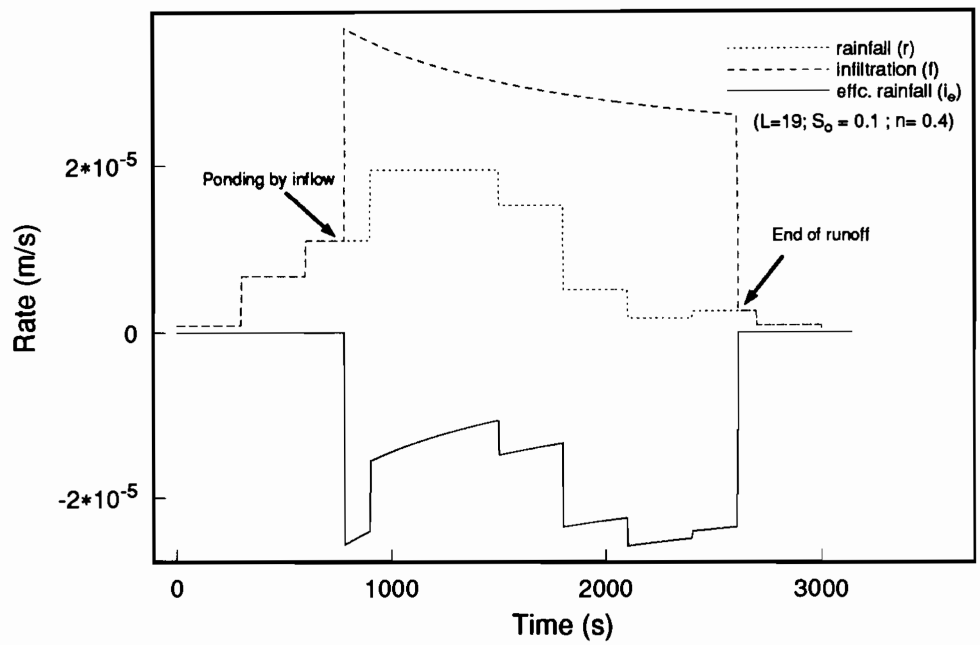

Figure 3: Water balance for the sandy-loam soil using the modified Green-Ampt model (storm on Table 1).

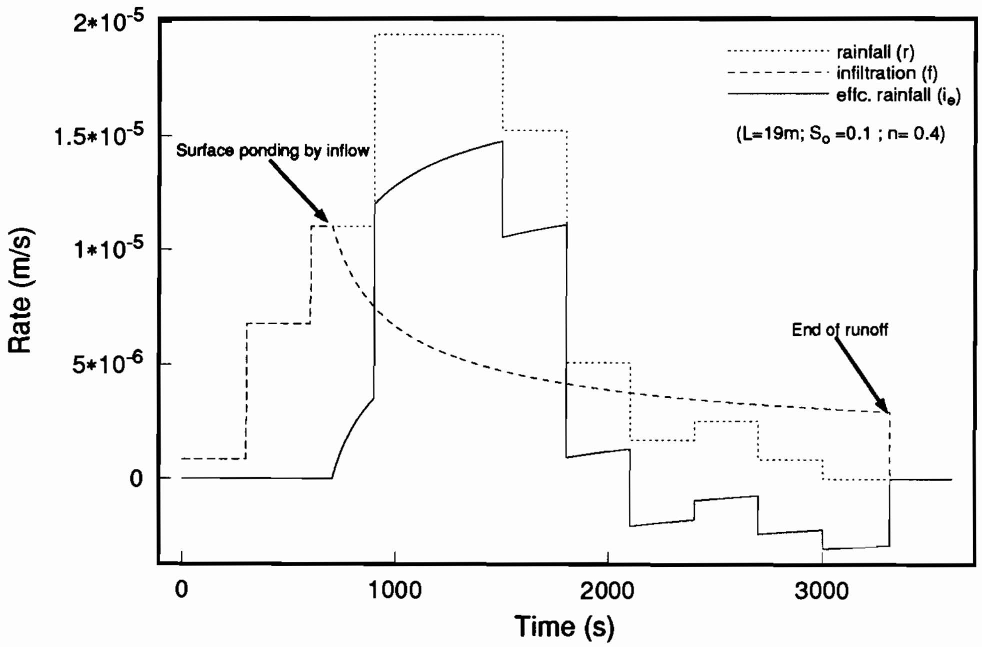

Figure 4: Water balance for the clay soil using the modified Green-Ampt (storm on Table 1).

Soil type has the biggest effect on runoff volume (Fig. 5), q_{vol} (m^3/m filter width), and depth-averaged velocity at the peak (Fig. 6), v_{peak} (m/s). The trend in these results (regardless of n and S_o combinations) is inverted, i.e. for soil A the runoff volume decreases with length whereas, for soil B it increases with length. The sandy-loam acts as a predominantly infiltrating media for this event. Thus as the area (length) increases, the mass of water entering the soil profile increases; reducing the runoff volume. In the clay (soil B) as the area increases, the catchment of direct rainfall also increases and, since infiltration is minimal, the runoff volume increases. In both cases, as the length of the filter approaches zero, the volume equals that of the inflow from the adjacent field (0.32 m^3/m). The effect of grass density (n) and slope (S_o) was very similar for both soil types. The retardation of the flow produced by a dense grass stand and small slope slightly increased infiltration. This combination yielded the lower runoff volumes in each soil. For the same grass density, decreasing the slope results in smaller volumes. Velocity at the peak flow is also reduced by the above combination (Fig. 6).

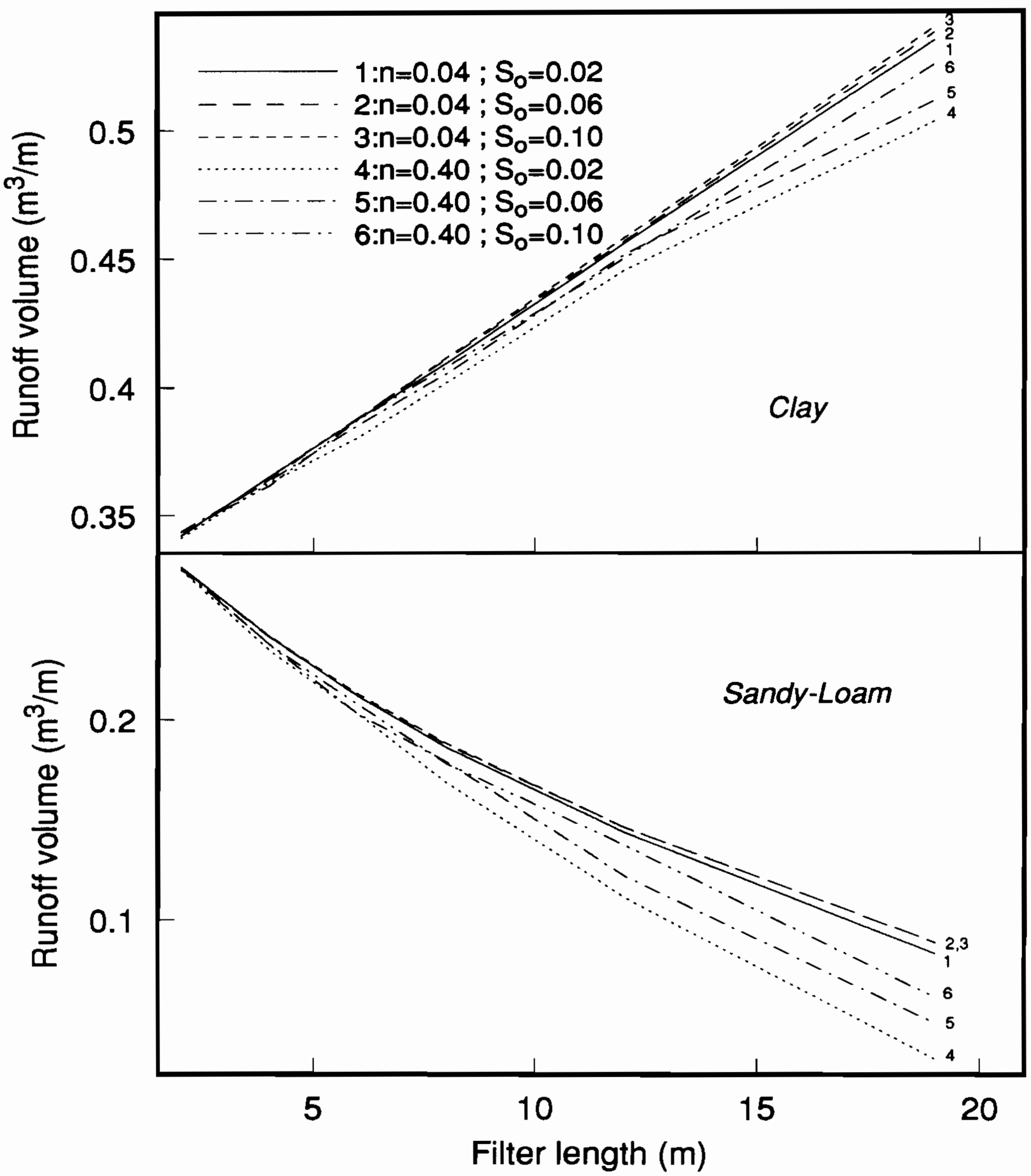

Figure 5: Effect of surface cover (roughness, *n*), field slope (S_0) and soil type on the total runoff volume.

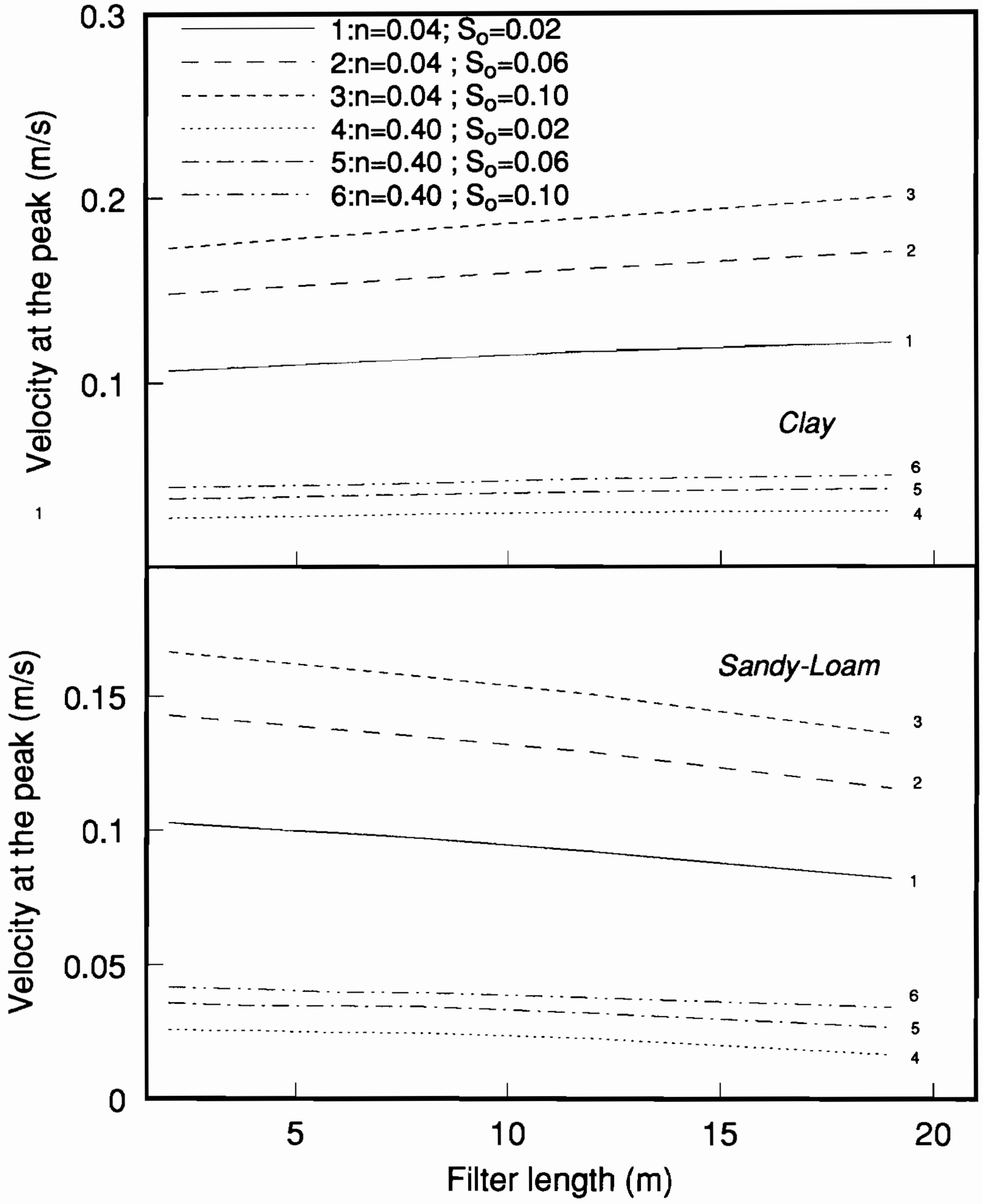

Figure 6: Effect of surface cover (roughness, n) field slope (S_o) and soil type on the peak velocity

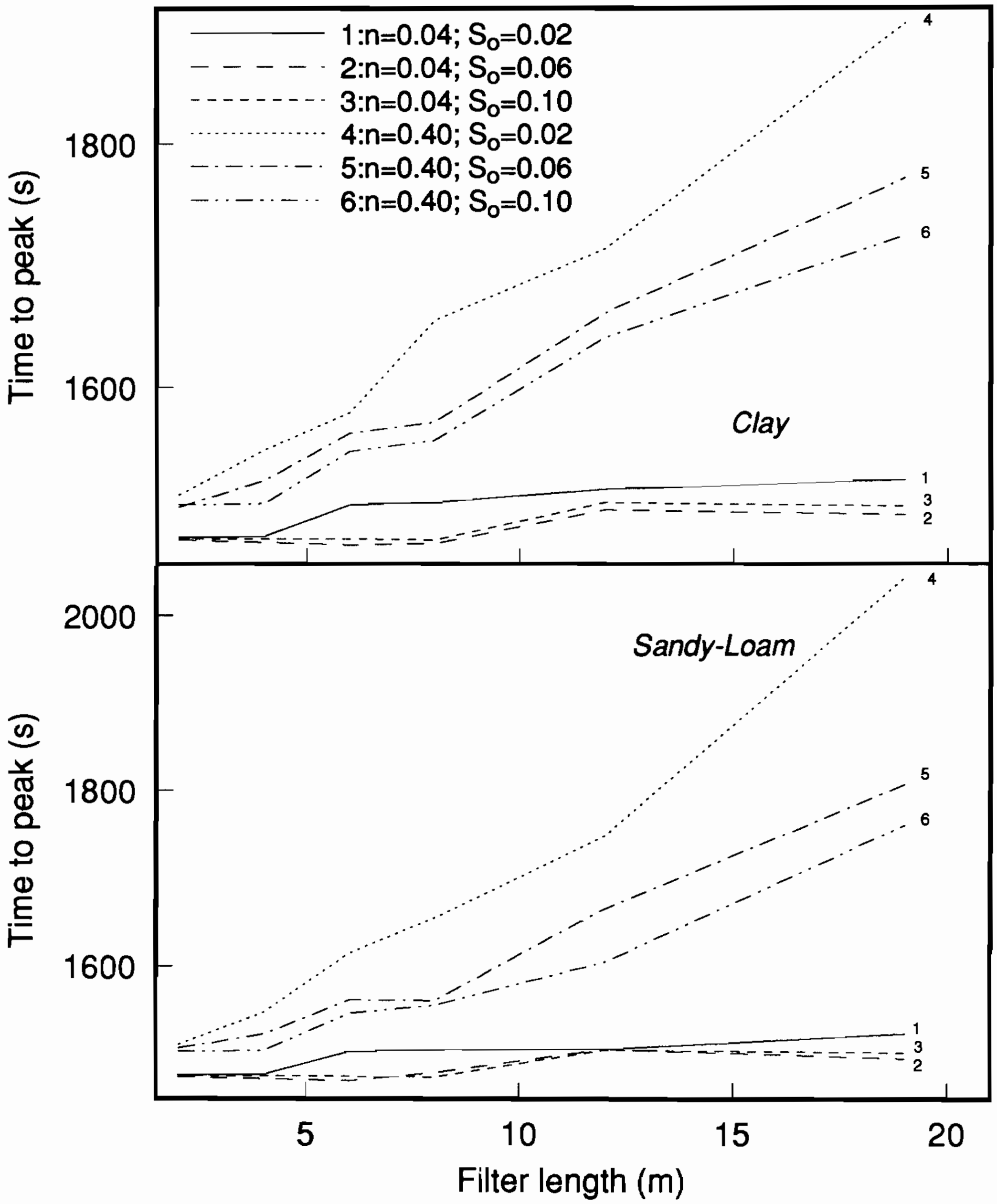

Figure 7: Effect of surface cover (roughness, n), field slope (S_o) and soil type on the time to peak.

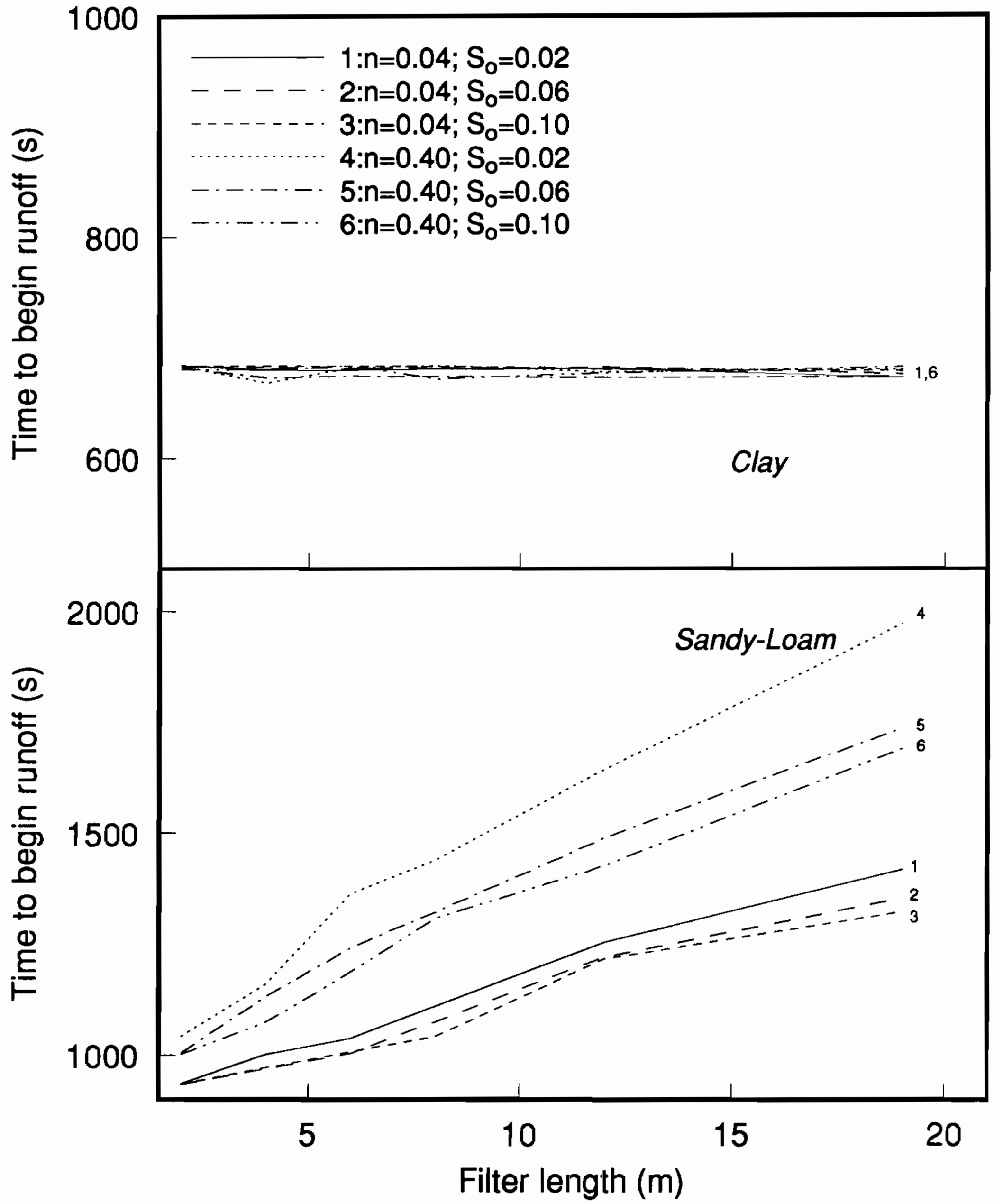

Figure 8: Effect of surface cover (roughness, *n*) field slope (S_0) and soil type on the delay time

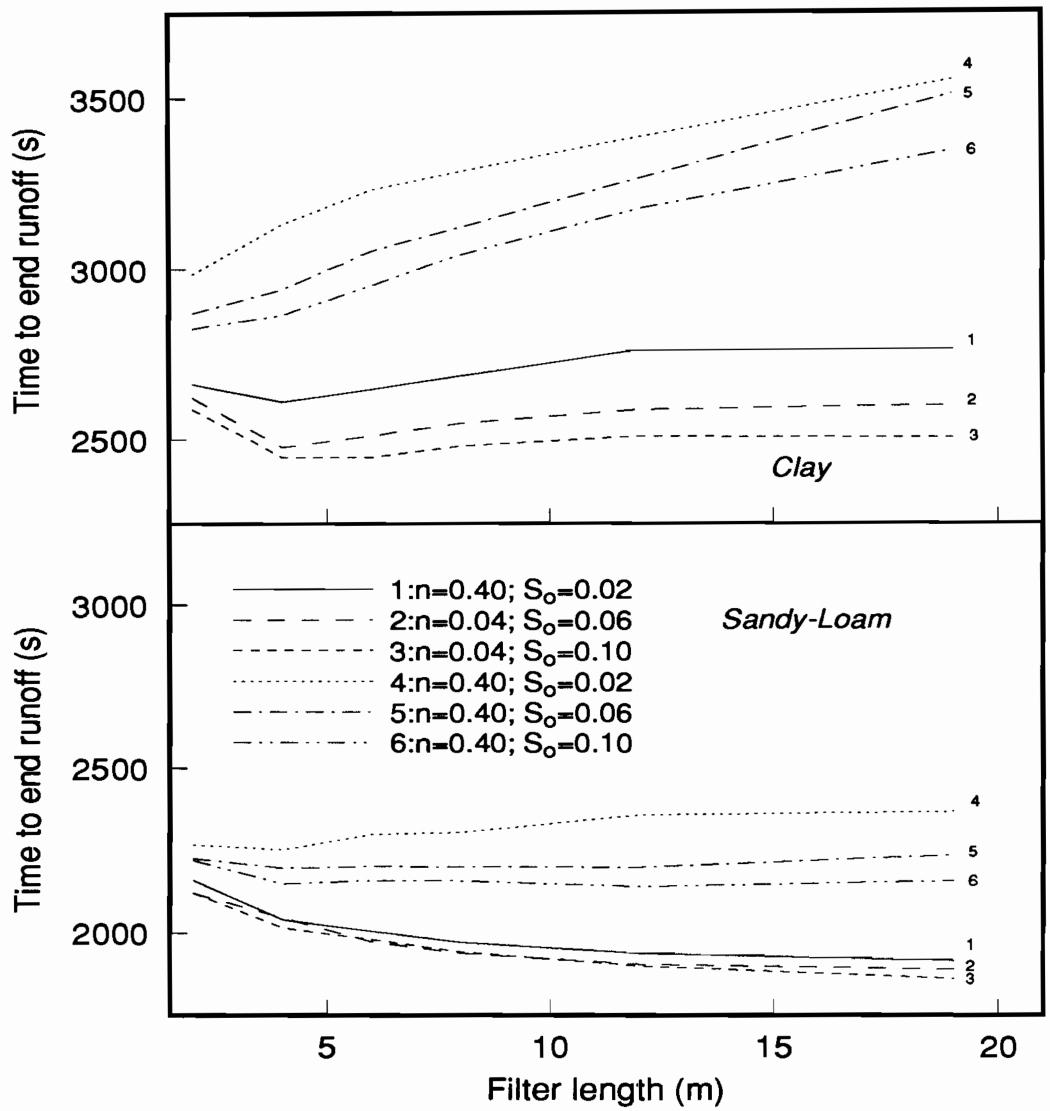

Figure 9: Effect of surface cover (roughness, n), field slope (S_0) and soil type on the time to end runoff.

The time to peak(s) is not significantly affected by soil type but rather by the roughness-slope combination (Fig. 7). The greater the resistance to flow and smaller the slope, the longer it will take for the hydrograph to reach its peak with similar times for both soils. Therefore, a delay in reaching the peak could be extended by manipulating the properties of the filter (long filter, small slope, dense vegetation) to a point where the direct rainfall has stopped, thus reducing the flow wave.

The time to the beginning of the runoff event(s) is affected by soil type (Fig. 8). For soil A, denser grass and smaller slope delays the beginning of the event. Again, more water is infiltrated before ponding at the surface is reached. For the clay (soil B), there is no significant change in this value for any of the parameter combinations.

. The tail of the hydrograph (time to end) is different for each combination of parameters (Fig. 9). For soil A and sparse vegetation, there is a decrease in the time as L and S_o increase. For the dense vegetation the effect of length is insignificant. For soil B, and sparse grass, L does not influence the time to end after 4 meters, but it takes longer to reach the end of the hydrograph (around 2600 s compared to 2200 s for soil A)

Conclusions

A numerical model to study and simulate flow in Vegetative Filter Strips is presented. The model is composed of two submodels. A kinematic wave approximation for overland flow is solved numerically with quadratic finite elements. A second submodel describes infiltration for unsteady rainfall, based on the Green-Ampt equation, provides mass balance for the system. The infiltration equation is solved iteratively for each time step and the resulting effective rainfall value is fed to the numerical overland flow model at each time step.

Several field parameters can be specified in the model. These include slope, surface cover, length of filter and soil type. The model also handles natural rainfall events and inflow from an adjacent field, thus providing great flexibility for analysis of events.

Different combinations of the input parameters were selected for analysis. The results show the importance of soil type in runoff formation on the filters. Filter performance, i.e. reduction of the runoff volume and velocity, is higher for denser grass cover, smaller slopes and soils with higher infiltration capacity. The runoff volume and velocity at the peak of the hydrograph could increase or decrease with length of the filter depending on soil type (high and low infiltration capacities, respectively). The velocity of the flow is mainly controlled by slope and density of the vegetation, where denser and smaller slopes give the smallest values. The time to beginning of runoff is soil dependent, i.e. length of the filter does not affect this parameter for soils with low infiltration capacity.

Management practices for the buffer areas could be suggested in the light of these results. If the clay content of the soils is high any practice to improve infiltration is advisable. Special care should be given at the time of implantation of the buffers (leveling of the surface to a small slope in the buffers, dense grass, subsoiling, etc.) and later avoiding any activities that could compact the areas, such as traffic.

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References

Bedient, B.P. and W.C. Huber. 1988. Hydrology and floodplain analysis. New York: Addison Wesley.

Blandford, G.E. and M. Meadows. 1990. Finite element simulation of non-linear kinematic surface runoff. J. Hydrol, 119:335-356.

Brakensiek, D.L. 1967. Kinematic flood routing. Trans. ASAE, 10(3):340-343.

Bras, L.R. 1990. Hydrology: An Introduction to Hydrological Science. New York: Addison Wesley.

Chu, S.T. 1978. Infiltration during unsteady rain. Water Resour. Res., 14(3):461-466.

Cundy, T.W. and S.W. Tento. 1985. Solution to the kinematic wave approach to overland flow routing with rainfall excess given by Phillip's equation. Water Resour. Res., 21(8):1132-1140.

Eagleson, P.S. 1970. Dynamic Hydrology. New York: McGraw-Hill Book Co.

Eggert, K.G. 1987. Upstream calculation of characteristics for kinematic wave routing. J. of Hydr. Eng. ASCE., 113(6):743-752.

Engman, E.T. 1986. Roughness coefficients for routing surface runoff. J. Irrigation and Drainage Eng. ASCE, 112(1):39-53.

Flanagan, D.C., G.R. Foster, W.H. Neibling and J.P. Burt. 1989. Simplified equations for filter strip design. Trans. ASAE 32(6):2001-2007.

Foster, G.R. 1982. Modeling the erosion process: Upland Erosion. In Hydrologic modeling of small watersheds. Ed. by C.T. Haan, H.P. Johnson and D.L. Brakensiek, 304-312. St. Joseph, MI, ASAE.

Foster, G.R. and L.D. Meyer. 1972. Transport of soil particles by shallow flow. Trans. ASAE, 15(1):99-102.

Green, W.H. and G. Ampt. 1911. Studies in soil physics, part I.-the flow of air and water through soils. J. Agricultural Sci. 4:1-24.

Henderson, F.M. and R.A. Wooding. 1964. Overland Flow and ground water flow from a steady rainfall of finite duration. J. Geophys. Res., 69(8):1531-1540.

Henderson, F.M. 1966. Open Channel Flow. New York: McMillan.

Horton, R.E. 1945. Erosional development of streams and their drainage basins, hydrophysical approach to quantify morphology. Bull. Geol. Soc. of Amer., 56:275-370.

Huyakorn, P.S. and G.F. Pinder. 1986. Computational Methods in Subsurface Flow. San Diego: Academic Press.

Izzard, C.F. 1946. Hydraulics of runoff from developed surfaces. In Proc. 26th annual meeting of the highway research board, 26:126-146.

Judah, O.M. 1972. Simulation of runoff hydrographs from natural watersheds by finite element method. Ph.D. Dissertation. Virginia Polytechnic Institute and State University, Blacksburg.

Lane, L.J., G.R. Foster and A.D. Nicks. 1987. Use of fundamental erosion mechanics in erosion prediction. Paper presented at the 1987 Winter Meeting of ASAE Paper No. 87-2540, Dec. 1987, Chicago.

Lane, L.J. and D.A. Woolhiser. 1977. Simplifications of watershed geometry affecting simulation of surface runof. J. Hydrol. 35:173-190.

Ligget, J.A. and D.A. Woolhiser. 1967. The use of the shallow water equations in runoff computation. In Proc. 3rd Annual Amer. Water Resources Conf. 117-126. San Francisco., CA, AWRA.

Lighthill, M.J. and C.B. Whitham. 1955. On kinematic waves: flood movement in long rivers. Proc. R. Soc. London Ser. A. 22:281-316.

Mein, R.G. and C.L. Larson. 1971. Modeling the infiltration component of the rainfall-runoff process. Bulletin 43. Minneapolis, MN. Water Resources Research Center, University of Minnesota.

Mein, R.G. and C.L. Larson. 1973. Modeling infiltration during a steady rain. Water Resourc. Res. 9(2):384-394.

Muñoz-Carpena, R., C.T. Miller and J.E. Parsons. 1993. A quadratic Petrov-Galerkin solution for kinematic wave overland flow. Water Resources Res. (in press).

Panda, J.C., S.A. Nielsen and I.D. Moore. 1988. A hydrological model for small agricultural catchments in the semiarid tropics. In: Modeling agricultural forest and rangeland hydrology, Ed. ASAE. St. Joseph: ASAE.

Parsons, J.E., R.D. Daniels, J.W. Gilliam and T.A. Dillaha. 1990. Water quality impacts of vegetative filter strips riparian areas. Paper presented at the 1990 Winter Meeting of ASAE. Paper No. 90-2501. Chicago. St. Joseph: ASAE

Ponce, V.M. 1991. The kinematic wave controversy. J. Hydraulic Eng. ASCE. 117(4):511-525.

Rawls, W.J. and D.L. Brakensiek. 1988. An infiltration model for evaluation of agricultural and range management models. In Modeling Agricultural Forest and Rangeland Hydrology. Ed. ASAE, St. Joseph, ASAE.

Richards, L.A. 1931. Capillary conduction of liquids in porous mediums. Physics, 1:318-333.

Ross, R.B. 1977. Finite element simulation of overland flow and channel flow. Trans. of ASAE 20(4)705-712.

Ross, R.B., D.N. Contractor and V.O. Shanholtz. 1979a. A finite element model of overland and channel flow for assessing the hydrologic impact of land-use change. J. Hydrol., 41:11-30.

Ross, R.B., V.O. Shanholtz and D.N. Contractor. 1979b. A spatially responsive hydrologic model to predict erosion and sediment transport. Water Resources Bulletin, AWRA, 16(3):538-545.

Schmid, B.H. 1989. On overland flow modelling. Can rainfall excess be treated as independent of flow depth? J. Hydrol.. 107:1-8.

Skaggs, R.W., L.E. Huggins, E.J. Monke and G.R. Foster. 1969. Experimental evaluation of infiltration equations. Trans. of ASAE 12(6):822-828.

Skaggs, R.W. and R. Khaheel. 1982. Infiltration. In Hydrologic modeling of small watersheds. Ed. by C.T. Haan, H.P. Johnson and D.L. Brakensiek, 139-149. St. Joseph, MI. ASAE.

Springer, E.P. and T.W. Cundy. 1988. The effects of spatially-varying soil properties on soil erosion. In Modeling Agricultural Forest and Rangeland Hydrology, Ed. ASAE. St. Joseph, MI. ASAE.

Stone, J.J., L.J. Lane and E.D. Shirley. 1992. Infiltration and runoff simulation on a plane. Trans. ASAE 35(1):161-170.

Swift, L.W. 1986. Filter strip widths for forest roads in the southern Appalachian. Southern J. Appl. For., 10:27-34.

Vieux, B.E. 1988. Finite element analysis of hydrologic response areas using geographic information systems. Ph.D. Dissertation, Michigan State University, East Lansing, MI.

Vieux, B.E., V.F. Bralts, L.J. Segerlind and R.B. Wallace. 1991. Finite element watershed modeling: one-dimensional elements. J. Water Resour., Planning and Mgmt. Div. ASCE., 116(6):803-819.

Vieux, B.E. and L.J. Segerlind. 1989. Finite element solution accuracy of an infiltrating channel. In Proc. 7th Int. Conf. on finite element methods in flow problems. University of Alabama, Huntsville, AL.

Woods, R.A. and R.P. Ibbitt. 1988. Analytical solution for kinematic flow over an infiltrating plane. In Modeling Agricultural Forest and Rangeland Hydrology. Ed. ASAE. St. Joseph, MI. ASAE.

Woolhiser, D.A. 1975. Simulation of unsteady overland flow. In Unsteady Flow in Open Channels. Vol. II Ed. K. Mahmood and V. Yevjevich, 485-508, Fort Collins, CO, Water Resources Publications.

Woolhiser, D.A., J.A. Liggett. 1967. Unsteady, one-dimensional flow over a plane, the rising hydrograph. Water Resources Res. 3(3):753-771.

Woolhiser ,D.A., R.E. Smith and D.C. Goodrich. 1990. KINEROS, A Kinematic Runoff and Erosion Model: Documentation and User Manual. USDA-ARS. ARS-Publication no. 77.

CHAPTER III

Modeling Overland Flow and Sediment Transport in Vegetative Filter Strips:
(1) Model development and application

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Abstract

Vegetative filter strips, when properly maintained, are an effective means of reducing runoff and transport of sediment and sediment bound pollutants from disturbed sites. Three mathematical submodels are linked together to describe the principal mechanisms in natural buffers: a Petrov-Galerkin finite element kinematic wave overland flow submodel, a modified Green-Ampt infiltration submodel and the University of Kentucky sediment filtration model for grass areas. This formulation describes the time and space dependency among the variables involved and is able to handle natural field scale events. Major outputs of the model are water outflow and sediment trapping on the strip. An application case is presented to illustrate the capabilities of the model.

Introduction

Sediment carried by runoff from non-point sources has long been recognized as a major pollutant of water bodies. Sediment bonded pollutants such as phosphorous and some pesticides are also a major pollution concern. Several management practices have been suggested to control runoff quantity and quality from disturbed areas. One such management practice is vegetative filter strips (VFS), which are bands of planted or indigenous vegetation that may control transport of sediment and reduce non-point source pollution off site. These masses of vegetation at the downstream edge of disturbed areas effectively reduce runoff volume and peak velocity by sharply increasing the hydraulic roughness of the surface and augmenting infiltration. This decrease in volume and velocity of the flow translates into sediment deposition in the filter due to a decrease in transport capacity (Foster, 1982) (fig. 1).

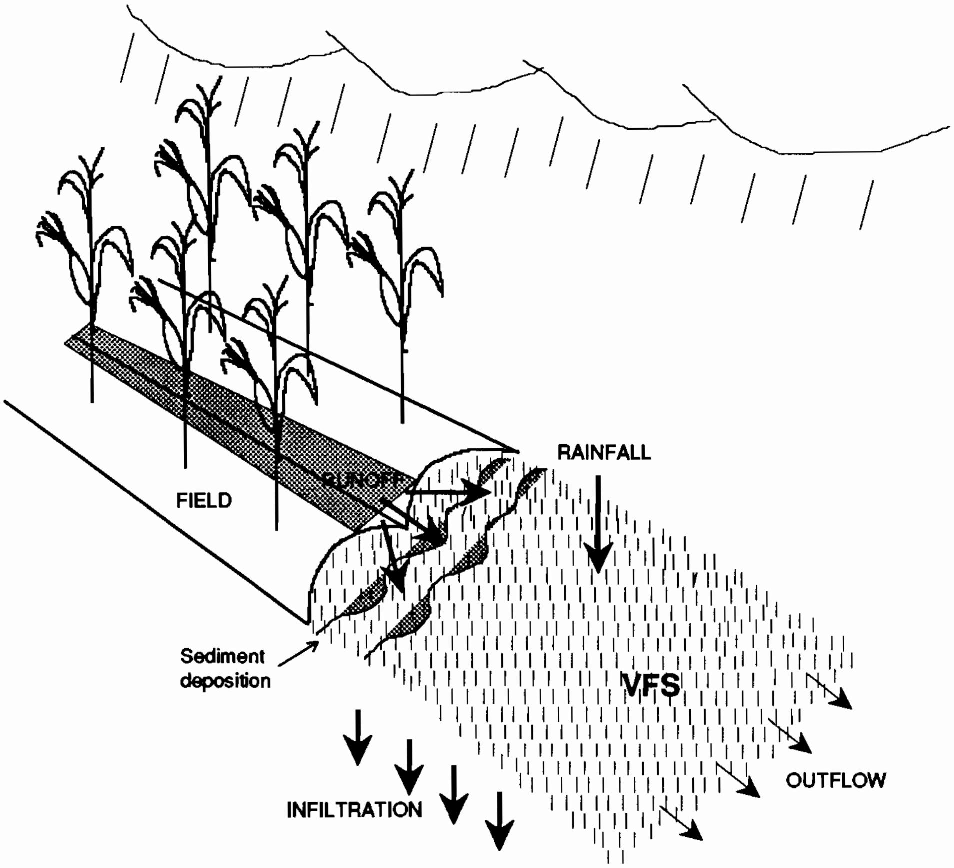

Figure 1. Effect of a vegetative filter strip on sediment deposition.

Sediment-bound nutrients are removed from runoff in these vegetative zones as sediment is deposited (Flanagan et al., 1989). For nutrients attached to sediment, the deposition process largely controls the effectiveness of the buffer area. For soluble nutrients, infiltration is the controlling factor. Variations in total phosphorous (TP) and total volatile suspended solids (TVSS) yields in surface runoff are strongly correlated to the variations in total suspended sediments. Suspended sediment yields can be used to estimate TP and TVSS (Bolton et al., 1991). Nitrogen may be difficult to relate to sediment because it is less likely to be sediment bound. Monke et al.(1981) found that 90% of the phosphorous in Indiana runoff samples from an agricultural watershed was sediment bound, but only 50% of the TN was sediment bound (Schreiber et al., 1980). Other researchers have found that the filter length (L) controls sediment trapping up to a certain maximum L value, and, after that maximum length is reached, similar filters behave in the same way (Dillaha et al., 1989; Parsons et al., 1990). This maximum length depends on the source area, topography, and the hydraulic characteristics of the strip.

Modeling Sediment Transport in Vegetative Filter Strips

Several processes must be described to simulate soil hydrology and sediment transport in buffer strips. The problem can be divided into two major mechanisms: overland flow routing and sediment transport. Overland flow routing describes the water movement over the land surface and implies the calculation of flow rates at positions along the hill slope (Lane et al., 1988). Sediment transport involves predicting the distribution of sediment concentrations along the hill slope at different time steps. The solution of the overland flow routing equation is needed for the transport problem solution.

The sediment filtration by vegetative buffers is a complex interaction in time and space among vegetation-soil-water. A mathematical model is needed that takes into account these principal mechanisms. It can be used as a tool to predict effectiveness of VFS and evaluate changes after a runoff event.

Two models are linked together to describe the overall problem for a single event at the field scale: (1) hydrology model, composed of a modified Green-Ampt and overland flow routing subroutines, and (2) sediment filtration model.

Hydrology Model

The model, presented elsewhere (Muñoz-Carpena, 1993; Muñoz-Carpena et al., 1993a,b), consists first of a Petrov-Galerkin quadratic finite element (FE) overland flow submodel, based on the kinematic wave approximation (Lighthill and Whitham, 1955),

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

$$q=\alpha h^m=\frac{\sqrt{S_o}}{n}h^{\frac{5}{3}} \qquad (2)$$

where x = flow direction axis (m), t = time scale (s), $h(x,t)$ = vertical flow depth (m), $q(x,t)$ = discharge per unit width (m^2/s), i_e = rainfall excess (m/s), r = rainfall intensity (m/s), f = infiltration rate (m/s), S_o = bed slope (m/m), S_f = friction slope, α and m are the parameters of the coupling uniform flow (Manning's) equation 2, n = Manning's roughness coefficient dependent on soil surface condition and vegetative cover, and also by mass conservation $q = Vh$ (V = depth averaged velocity, m/s).

The overland flow model was coupled, for each time step, with an infiltration submodel based on a modification of the Green-Ampt equation for unsteady rainfall (Green and Ampt, 1911; Chu, 1978; Mein and Larson 1971, 1973; Muñoz-Carpena et al., 1993b; Skaggs and Khaheel, 1982),

$$f_p=K_s+\frac{K_s M S_{av}}{F_p} \qquad (3)$$

$$K_s(t-t_p-t_s)=F-M S_{av}\, ln\left(1+\frac{F}{M S_{av}}\right) \qquad (4)$$

where f_p is the instantaneous infiltration rate, or capacity, for a ponded soil (m/s), K_s is the saturated hydraulic conductivity (m/s), $M = \theta_s - \theta_i$, is the initial soil-water deficit (m^3/m^3), S_{av} is the average suction across the wetting front (m), F_p is the cumulative infiltration (m), t is the actual time (s), t_p the time to ponding, and t_s is the shift of the time scale to the effect of having cumulative infiltration at the ponding time, or pseudotime.

The values of i_e in equation 1 are calculated for each node and time step according to the infiltration model and a given rainfall distribution. The incoming hydrograph from the adjacent field is input as the time dependent boundary condition at the first node of the finite element grid. This could also be a linkage to other water quality models describing the runoff source area. Any combination of unsteady storm and incoming hydrograph types can be used. The program allows for spatial variation of the parameters n and S_o over the nodes of the system (fig. 2).

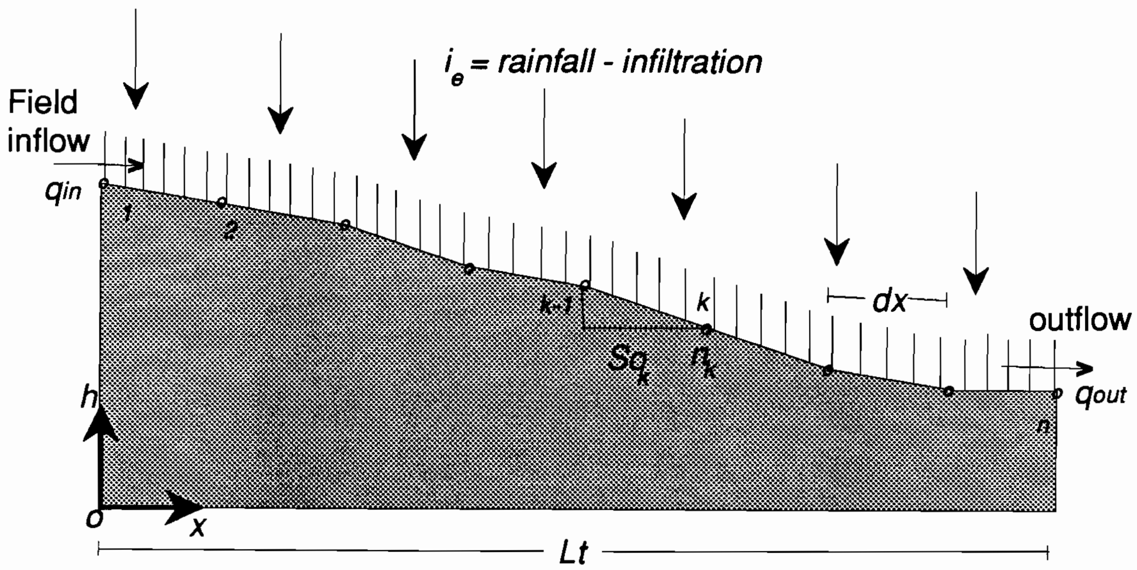

Figure 2. Field discretization for the finite element model.

This feature of the program ensures a good representation of the field conditions for different rainfall events. The model provides information on the effect of soil type (infiltration), slope, surface roughness, buffer length, storm pattern and field inflow on the VFS performance (i.e. reduction of the runoff peak, volume and velocity). It also describes the flow rate (*q*), velocity (*V*), and depth (*h*) components throughout the filter for each time step.

The numerical solution is subject to kinematic shocks, or oscillations in the solution that develop when a sudden change in conditions (slope, roughness) occurs. When linking this model with the sediment transport model, the surface conditions are changed for each time step, thus increasing the complexity of the problem. The Petrov-Galerkin formulation (non-standard finite element method in which the weighting functions are dissimilar to the shape functions) is used to solve equations 1 and 2. This solution procedure reduces the amplitude and frequency of oscillations with respect to the standard Bubnov-Galerkin method (Muñoz-Carpena et al., 1993a). This is critical since the sediment model will use flow values from this solution.

Sediment Transport Model

Researchers at the University of Kentucky (Barfield et al. 1978, 1979; Hayes et al., 1979, 1984; Tollner et al., 1976, 1977, Wilson et al, 1981) developed and tested a model for filtration of suspended solids by artificial grass media, and later tested it for field conditions. It is based on the hydraulics of flow, transport and deposition profiles of sediment in laboratory conditions. The model presents the advantage of being developed specifically for the filtration of suspended solids by grass.

In this approach the inflow, with sediment load per unit width g_{si} [$ML^{-1}T^{-1}$], reaches the edge of the filter where the sudden increase in hydraulic resistance slows the flow, thus lowering the transport capacity of the flow, $T_c < g_{si}$. At this point a triangular wedge of deposited sediment starts forming at the beginning of the filter and adjacent field area (fig. 3a),

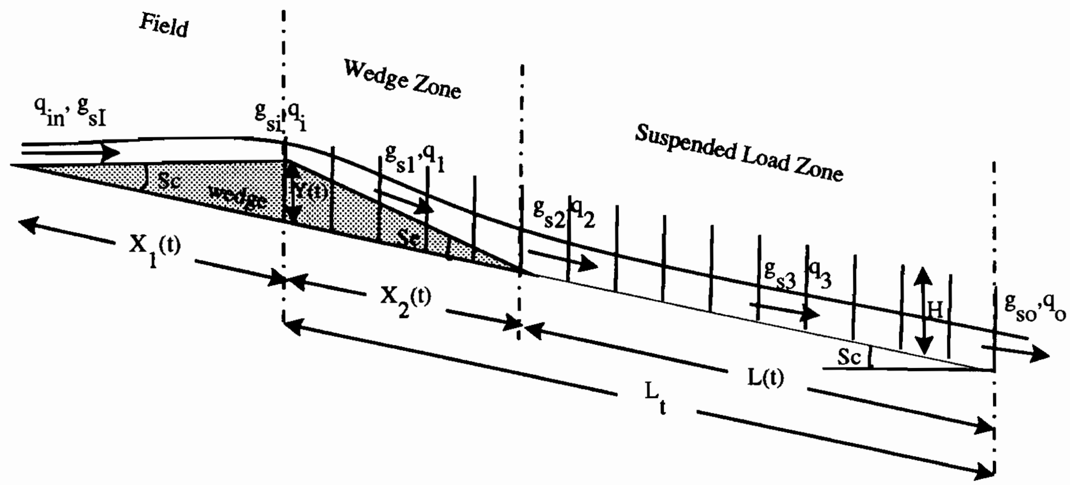

Figure 3a. Diagram showing the triangular shape at the initial stages (mod. from Wilson et al., 1981)

and increases in length, $X_1(t)+X_2(t)$ [L], and height, $Y(t)$ [L], until it reaches the "effective" top of the vegetation, H [L]. After that time, a trapezoidal wedge develops, with an equilibrium deposition slope S_e for each time step (fig. 3b).

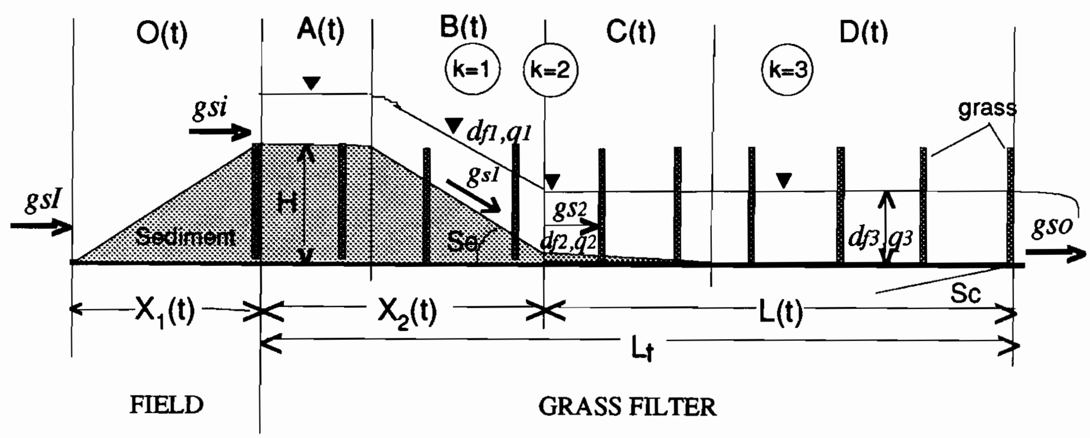

Figure 3b. Diagram showing trapezoidal wedge and filter zones (mod. Barfield et al., 1979)

This process of water flow and sediment transport can be described by dividing the filter into four zones (A(t), B(t), C(t), D(t)), with lengths changing with time (fig. 3b). An additional zone O(t), external to the filter, is important in explaining field observations where much of the sediment is actually being deposited in the field area adjacent to the filter, along with deposition in the filter.

The first two filter zones can be termed "sediment wedge zone". No sediment is deposited in zone A(t) and the initial load, g_{si}, moves through to the next zone. In B(t) deposition occurs uniformly with distance at the deposition edge with transport mostly as bed load.

Zones C(t) and D(t) are termed "suspended load zone", or effective filter length, L(t). On C(t), sediment has covered the rugosities of the surface so that bed load transport occurs but the channel slope, S_c , is not significantly changed. All sediment reaching the bed in D(t) is trapped, no bed load transport occurs, and thus transport is mostly as suspended sediment.

Different transport relationships must be considered. For zones B(t), C(t), a form of Einstein bed load transport equation (Barfield et al.,1978) is used,

$$\frac{\gamma_s - \gamma}{\gamma} \frac{d_p}{R_{s_k} S_k} = 1.08 \left[\frac{g_{s_k}}{\gamma_s \sqrt{\frac{\gamma_s - \gamma}{\gamma} g d_p^3}} \right]^{-0.28} \tag{5}$$

where γ, γ_s are the water and sediment density (g/cm^3) respectively; d_p is the particle diameter (cm), g_{s_k} is the sediment load (g/cm-s) at the point k (k=1,2, fig. 3b) with $g_{s_1} = (g_{si}+g_{s_2})/2$; S_k is the total slope at those points , i.e. $S_1=S_{et}=S_e+S_c$ and $S_2=S_c$; g is the gravitational constant (cm/s^2), R_{sk} is the spacing hydraulic radius at the point k, defined as,

$$R_{s_k} = \frac{S_s df_k}{2df_k + S_s} \tag{6}$$

S_s is the grass spacing (cm), and df_k is the modified flow depth (cm). The modified flow depth (Tollner et al., 1976) is obtained for the flow rate at a point, q_k (cm^3/s/cm), running through cylindrical media of spacing S_s , by continuity and open channel theory (Manning's equation),

$$q_k = V_k df_k \tag{7}$$

$$V_k = \frac{\sqrt{S_o}}{n} R_{s_k}^{\frac{2}{3}} \tag{8}$$

V_k is the mean velocity (cm/s) at the point k, and n is the modified Manning's coefficient (Hayes and Dillaha, 1992), set to 0.012 for cylindrical media. An iterative solution is used in the calculation of R_{s2} and V_1.

For the conditions of the suspended load zone, Tollner el al. (1976) developed an expression for trapping capacity of suspended sediment, T_r, on artificial grass. The equation is based on a probabilistic approach of turbulent diffusion for non-submerged flow,

$$T_r = \frac{g_{s_2} - g_{so}}{g_{s_2}} = e^{\left[-1.05x10^{-3}\left(\frac{V_3 R_{s_3}}{\nu}\right)^{0.82}\left(\frac{V_f L(t)}{V_3 h_3}\right)^{-0.91}\right]} \tag{9}$$

V_3 is the mean flow velocity (cm/s) at the point k=3, ν is the kinematic viscosity of water (cm^2/s), V_f is fall velocity (cm/s). The quantity g_{s_2} is the sediment transport capacity, gsd, at the end of the deposition wedge.

A further assumption of the model is that the flow conditions for zone D(t) can be extrapolated to zone C(t), points 2 and 3 in fig. 3b, to calculate the sediment load, g_{s_2} .

To account for the effects of upstream deposition in zone O(t), before entering zone A(t), a relationship is defined as,

$$g_{si} = g_{sI} - \frac{S_e(g_{sI} - g_{s_2})}{S_e + S_c} \tag{10}$$

with g_{sI} being the sediment load upstream the trapezoidal wedge, and g_{si} being the actual sediment load entering zone A(t) after the initial deposition (fig. 3b). Note that an iterative solution is needed to find the value S_e that will satisfy both equations 5 (k =1) and 10. As initial guess for $S_e,$ the value from the last time step is used. The total trapping in the filter, T_T, becomes,

$$T_T = \frac{g_{sI} - g_{so}}{g_{sI}} \tag{11}$$

The height, $Y(t)$, and advancement, $X_2(t)$, of the trapezoidal wedge are described as,

$$\begin{aligned}
Y_f(t) &= \begin{cases} \sqrt{\dfrac{2(gsI - gsd)S_e S_c}{\gamma_{sb}(S_e + S_c)}(t_f - t_i) + Y_i(t)^2} & ;for\, Y_f(t) < H \\ H & ;for\, Y_f(t) \geq H \end{cases} \\
X_{2f}(t) &= \begin{cases} \sqrt{\dfrac{2(gsI - gsd)S_c}{\gamma_{sb} S_e (S_e + S_c)}(t_f - t_i) + X_{2i}(t)^2} & ;for\, Y_f(t) < H \\ \dfrac{gsI - gsd}{H\gamma_{sb}}(t_f - t_i) + X_{2i}(t) & ;for\, Y_f(t) \geq H \end{cases} \\
X_{1f}(t) &= \left\{ \dfrac{Y_f(t)}{S_c} \right. & ;for\, all\, Y_f(t)
\end{aligned} \tag{12}$$

where γ_{sb} is the bulk density of the sediment (g/cm^3) and the subscripts $_f$ and $_i$ denote values at beginning and end of the time step.

After solving equation 12, the effective length of the filter becomes $L(t)=L_t$ - $X_2(t)$, and g_{so}, sediment outflow for the time step, can now be calculated in equation 9.

Deposition effect in suspended sediment zone.

Equation 9 is based on the assumption that sediment reaching the bed is trapped in the filter. This is acceptable at the beginning of filter life when there are indentations and stools at the surface to prevent bed load transport. This assumption will not hold when those rugosities are filled up with the sediment deposited by the filtration action. A correction factor, multiplier of T_r in equation 9, was proposed (Wilson et al., 1981) as,

$$C_{DEP} = \frac{e^{-3\,DEP} + e^{15\,DEP(0.2-DEP)}}{2} \tag{13}$$

where *DEP* is the cumulated sediment depth on the surface of the suspended sediment area (zones *C* and *D* in fig. 3b). To calculate *DEP*, it is assumed that the sediment is deposited uniformly over the suspended load zone. The total value for a given time step, *l*, is the summation of the amounts deposited for each time step ($i = 1, l$),

$$DEP = \sum_{i=1}^{l}\left[\frac{g_{s2_i} - g_{so_i}}{\gamma_{sb} L(t)_i}\Delta t_i\right] \tag{14}$$

Sediment transport algorithm

A modification suggested by Wilson et al. (1981) is implemented where only *coarse sediment* ($d_p > 0.0037$ cm) is considered for the wedge zone, g_{si}, with the *fine sediment* ($d_p < 0.0037$ cm) running through to the filter's suspended sediment zone.

The equations discussed assume that the sediment inflow load, g_{si}, is greater than the downstream sediment transport capacity, *gsd*. The program calculates the *gsd* value for each new set of values for each time step and compares the value with the sediment inflow. If $gsd > g_{si}$, all sediment is transported through the first part of the filter (wedge), and the suspended sediment zone (lower part of the filter) works as usual (equation 9). If $gsd < g_{si}$, all the transport formulas (equations 5 to 15) are applied as described above.

Choosing particle class for the sediment model, d_{50}

The effective particle size concept, d_{50} (Woolhiser et al., 1990), is used in the model. It represents an effective mean particle size value for the sediment carried at the entry point of the filter. The sediment transport relations are rather sensitive to this value. These values were estimated using USDA (1975) textural classification based on elementary particle composition (Table 1).

Table 1. Elementary particle classes and aggregates (USDA, 1975)

Particle class	Diameter(cm) Range	d_p	Fall velocity, V_f (cm/s)	Particle density, γ_s (g/cm^3)
Clay	<0.0002	0.0002	0.0004	2.60
Silt	0.0002 - 0.005	0.0010	0.0094	2.65
Sand	0.005 - 0.2	0.0200	3.7431	2.65
Small aggregate	---	0.0030	0.0408	1.80
Large aggregate	---	0.0300	3.0625	1.60

Estimated values for d_{50} for various soil textures are given in Table 2 (Woolhiser et al., 1990). The particle size for aggregates is generally larger than the silt or clay, and the effective density is smaller. These are often an important portion of the transported sediment.

Table 2. Estimated range of mean particle size for various soil textures (mod. Woolhiser et al., 1990)

Soil texture	Sand (%)	Silt (%)	Clay (%)	Expected, d_{50} ($x10^{-4}$cm)
Clay	0 - 45	0 - 40	55 - 100	1 - 45
Silty clay	0 - 20	40 - 60	40 - 60	2 - 45
Silty clay loam	0 - 20	40 - 73	27 - 40	3 - 46
Silt loam	0 - 50	50 - 87	0 - 27	3 - 50
Silt	0 - 20	80 -100	0 - 13	8 - 30
Loam	23 - 52	28 - 50	7 - 27	9 - 60
Clay loam	20 - 45	15 - 53	27 - 40	5 - 30
Sandy loam	43 - 85	0 - 50	0 - 20	35 -160
Loamy sand	70 - 90	0 - 30	0 - 15	90 -180
Sandy loam	45 - 65	0 - 20	30 - 55	2 -130
Sandy clay loam	45 - 80	0 - 28	20 - 35	21 -160
Sand	85 -100	0 - 15	0 - 10	140-200+

Once the $d_p=d_{50}$ is selected, the particle density, γ_s, is interpolated from particle class from Table 1, and the particle fall velocity (V_f) will be calculated with (Fair and Geyer, 1954),

$$V_f = \sqrt{\frac{4g(\gamma_s - 1)d_p}{3C_d}} \tag{15}$$

where C_d is the drag coefficient which is a function of Reynolds number (R_n).

$$C_d = \frac{24}{R_n} + \frac{3}{\sqrt{R_n}} + 0.34$$
$$R_n = \frac{V_f\, d_p}{\nu} \qquad (16)$$

V_f can also be calculated with the empirical formula proposed by Barfield et al. (1981), using observed data, as a polynomial of $log_{10} d_p$.

$$log_{10} V_f = -0.342463\, (log_{10} d_p)^2 + 0.989122\, log_{10} d_p + 1.146128 \qquad (17)$$

Interaction between submodels

Flow conditions at three points of the filter are needed for the sediment transport calculations (fig. 3b). The original sediment model uses a simple approach to calculating those values and does not consider the complex effects of rainfall, infiltration, and flow delay caused by the buffer. A more accurate description of the flow conditions can be obtained from the hydrology submodel presented above. The hydrology model, however, does not account for changes in surface conditions (topography, roughness) due to sediment deposition during the event. The transport model supplies this information for each time step, *dt*.

The interaction between the models consists of a feedback between the hydrology and sediment models. The hydrology model supplies the flow conditions at those locations (Table 3).

Table 3. Flow components from the hydrology model and its use in the sediment transport model.

Point	Flow values	Location, x(cm)	To calculate
①	q_1	$X_2(t)$- 0.5 H/Se	R_{s1}, Set
②	q_2	$X_2(t)$	R_{s2}, g_{s2}
③	q_3	L_t - L(t)/2	R_{s3}, T_T

After solving the sediment transport problem for a time step, values of n and S_o (equation 2) are selected as nodal values for the finite element grid. The parameters are fed back into the hydrology model for the next time step. Surface changes are accounted for in this way ,

$$S_o = \begin{cases} S_{et} & if \quad x \subset B(t) \\ S_c & if \quad x \not\subset B(t) \end{cases}$$
$$n = \begin{cases} n_1 & if \quad 0 < x < A(t) \\ n_2 & if \quad A(t) < x < L_t \end{cases} \tag{18}$$

where x is the distance (m) from beginning of the buffer (fig. 2) , and n_1, n_2 are values for the Manning's roughness coefficient for bare soil and grass cover, respectively. Values for n can be found in the literature (Engman, 1986; Woolhiser, 1975). Changes in surface K_s values are considered negligible. This interaction among models is summarized in fig. 4,

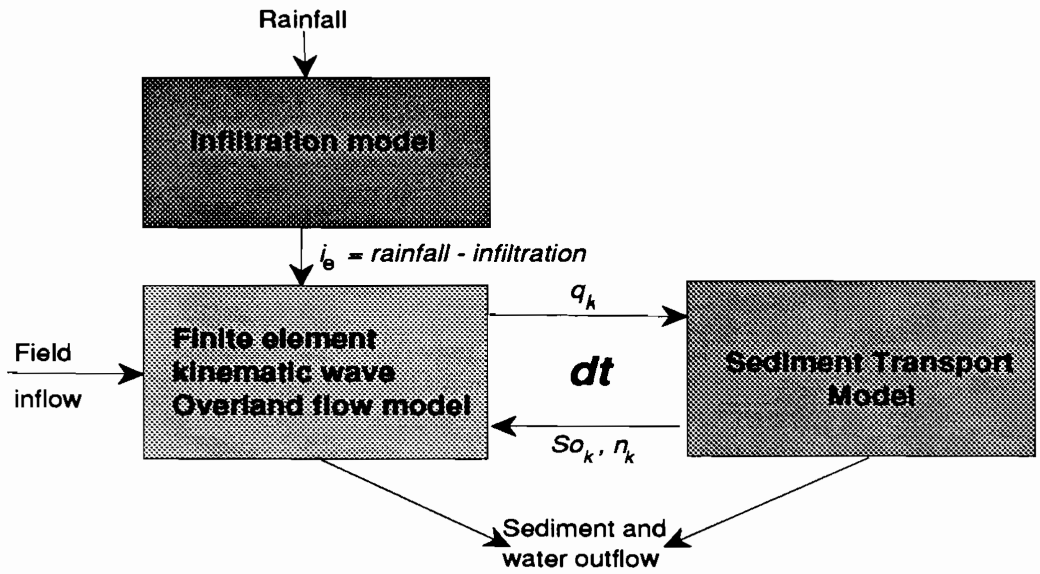

Figure 4. Diagram showing the interaction between the hydrology and sediment transport models.

The time step for the simulations is selected by the kinematic wave model to satisfy convergence and computational criteria of the FE method (Muñoz-Carpena et al., 1993a,b). A flow chart of the overall model (fig. 5) is included below,

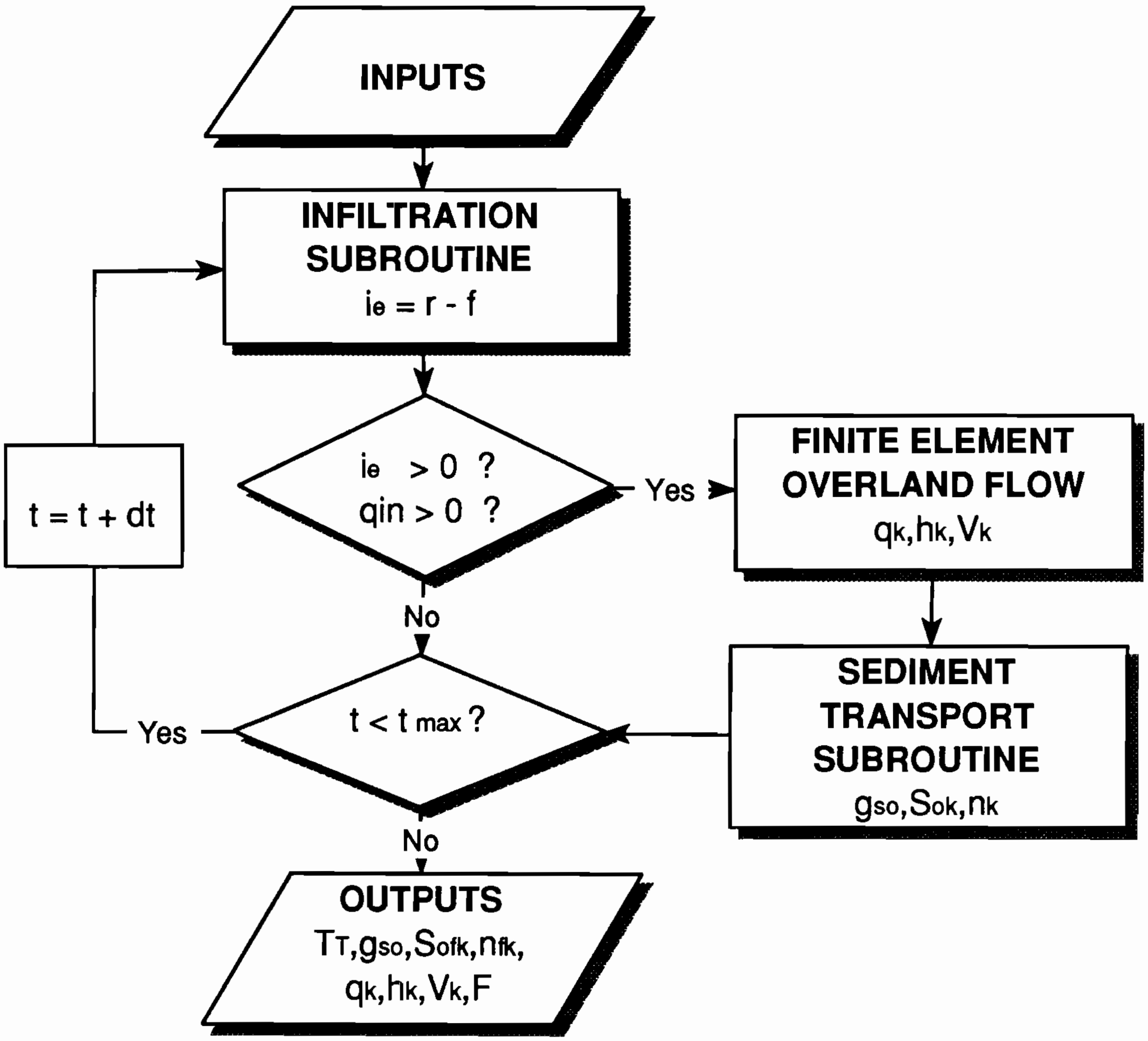

Figure 5. Flow chart for the overall model, showing the major subprograms.

The major inputs and outputs of the combined model are summarized in Table 4, along with the units.

Table 4. Summary of inputs/outputs for the overall grass filter model

MODEL	Inputs		Outputs	
	Symbol	**Description**	**Symbol**	**Description**
Hydrology	L_t	Filter length (m)		
	dx	Nodal distance(m)	hk	Flow depth (m)
	r	Rainfall hyetograph (m/s)		
	$n1_k$, $n2_k$	Manning's roughness for bare and grass surface ($s/m^{1/3}$)	qk	Flow rate per unit width (m^2/s)
	So_k	Nodal slope (m/m)	Vk	Depth averaged velocity (m/s)
	qin	Field inflow into buffer (m/s^2)	F	Total infiltration (m)
	Ks	Vertical saturated conductivity (m/s)	fp	Infiltration rate (m/s)
	A, B	Green-Ampt parameters		
Sediment	n	Modified Manning's n ($s/cm^{1/3}$)		
	dp	Particle diameter (cm)	gso	Sediment load outflow (g/cm.s)
	γs	Sediment density (g/cm^3)	$X(t)$	Advance distance of the deposition wedge (cm)
	Vf	Fall velocity (m/s)		
	Ss	Spacing (cm)	$Y(t)$	Deposition depth at upstream edge of VFS (cm)
	gsi	Sediment load inflow(g/cm.s)	Sof_k, nf_k	Final surface profile
	H	Media height (cm)		
	p	Porosity of the deposited sediment	TT	Total sediment trapping

Application

A case study was selected to illustrate an application of the model. An 8.5 m grass (fescue-bluegrass) filter strip with an initial slope of 3%, a height (H) of 15 cm, over a sandy-loam soil, and silt (USDA) as runoff sediment class, was used. Rainfall and field inflow distributions, as well as soil parameters, were selected from a field experimental site. The inflow sediment load is the product of the incoming runoff hydrograph and a fixed concentration of Ci =1.0 g/cm^3. This value chosen here is an extreme value to illustrate the ability of the model to predict inundation of the filter by sediment. The input variables are summarized in Table 5.

Table 5. Summary of inputs for the application case

MODEL	Symbol	Description	Value
Hydrology	L_t	Filter length (m)	8.50
	dx	Nodal distance(m)	0.17
	$n1_k$, $n2_k$	Manning's roughness for bare and grass surface	0.04, 0.1
	So_k	Initial nodal slope (m/m)	0.03
	Ks	Vertical saturated conductivity (m/s)	1.67e-5
	$Ks.M.Sav$	Green-Ampt parameter B(m^2/s)	9.54e-7
	r	Rainfall distribution (cm/s)	(see Fig. 6)
	q_{in}	Inflow rate from adjacent field (m^2/s)	(see Fig. 7)
Sediment	dp	Particle diameter (cm)	0.0029
	γ_s	Sediment density (g/cm^3)	2.65
	Vf	Fall velocity (cm/s)	0.076
	n	Modified Manning's n (s/cm$^{1/3}$)	0.012
	Ss	Spacing (cm)	1.25
	Ci	Sediment inflow concentration(g/cm^3)	1.00
	H	Media height (cm)	15.00
	p	Porosity of the deposited sediment	0.434

The rainfall distribution used along with the results from the Green-Ampt infiltration model can be seen in fig. 6. The model considers the following calculation procedure: First rainfall starts and no uphill field inflow occurs (delay from field). No surface ponding is achieved since the rainfall, *r*, is less than the saturated hydraulic conductivity value, *Ks*. The rainfall excess, $i_e = r$ - *infiltration (f)*= 0. The method checks for ponding at the surface for each time step. Ponding can be reached by one of two ways: by rainfall exceeding infiltration capacity, *fp*, or by flooding from the incoming field inflow. This point is labeled "*ponding by inflow*" in fig. 6. At this point enough water is assumed to supply the maximum infiltration rate as dictated by the Green-Ampt model, $i_e < 0$. After the field inflow stops, infiltration follows the rainfall until the cessation of the rain. Since $r < fp$ and no other water supply is available, in this case, i_e is zero again (point labeled "*end of runoff*" in fig. 6).

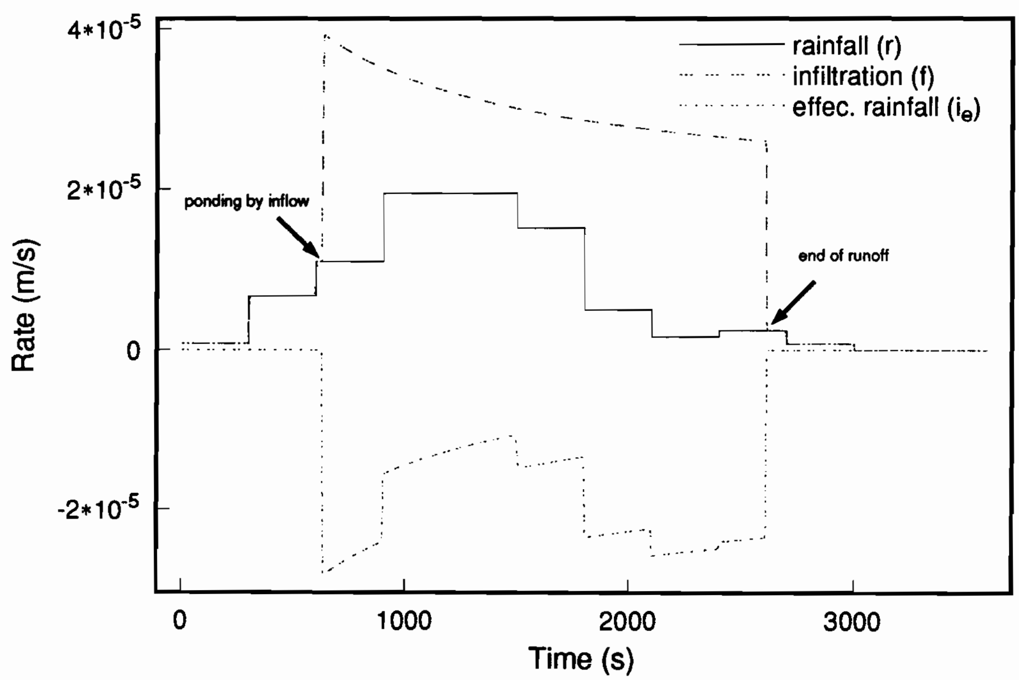

Figure 6. **Rainfall inputs and results from the infiltration model whese** $i_e = r - f$.

The results from the overland flow component are shown in fig. 7. q_{in} is the inflow rate from the field, and is an input to the problem. The flow rate is given at four points for each time step: q_1 is the flow rate at the transition point of the wedge (k=1 in fig. 3b), q_2 is the flow rate at downstream end of the wedge (k=2), q_3 is the flow rate at k=3, and q_{out} is the runoff from the filter. The graph illustrates both the peak reduction and delay caused by the filter. The reduction in the area under the hydrograph (total runoff) is due to infiltration. The soil in the buffer is a sandy-loam, with good infiltration characteristics. Changes in slope and roughness (from grass down slope to bare soil up slope) during the simulation are the cause of some numerical oscillations on the overland flow model (tail of the hydrograph in fig. 7). The Petrov-Galerkin formulation employed here gives a more stable solution than the standard finite element method (Muñoz-Carpena et al., 1993a).

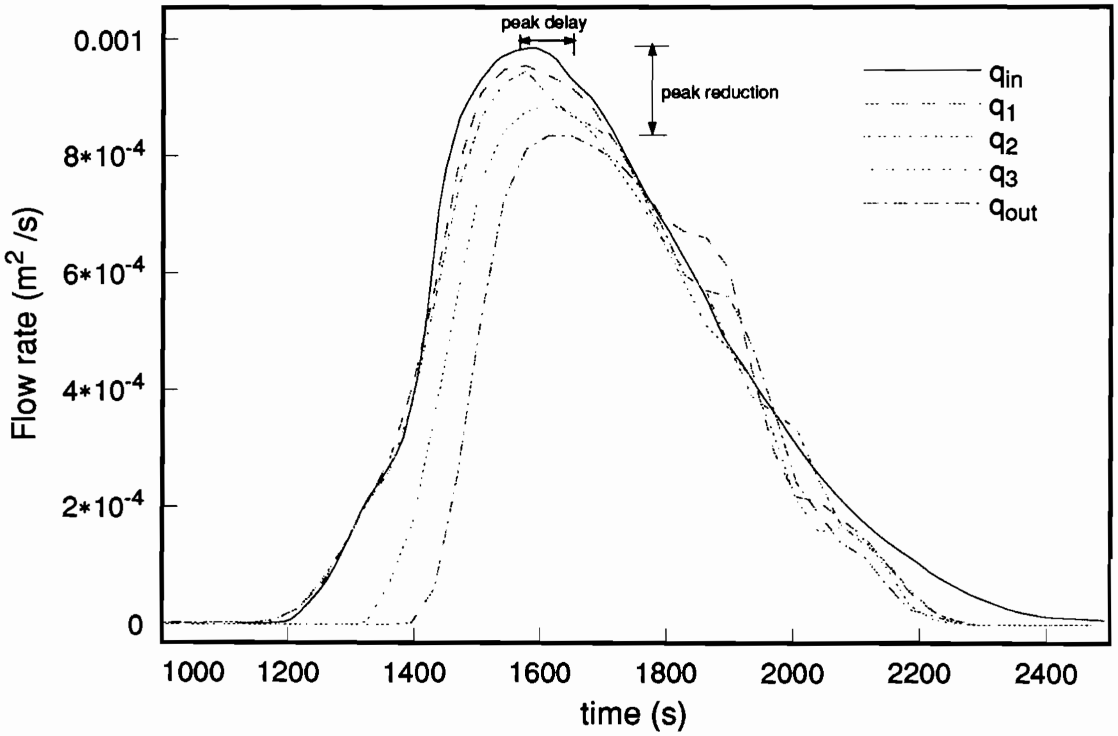

Figure 7. Variation of the flow rates at different points in the filter during the simulation period

Figure 8 shows the sediment load, both the cumulative curve for the event (g/cm) and the instantaneous rate (g/cm-s). A sediment trapping efficiency of 99% is observed for this event. It should be taken into account that the conditions simulated are ideal, those of a uniform, dense stand of vegetation, where the flow is sheet flow (not concentrated).

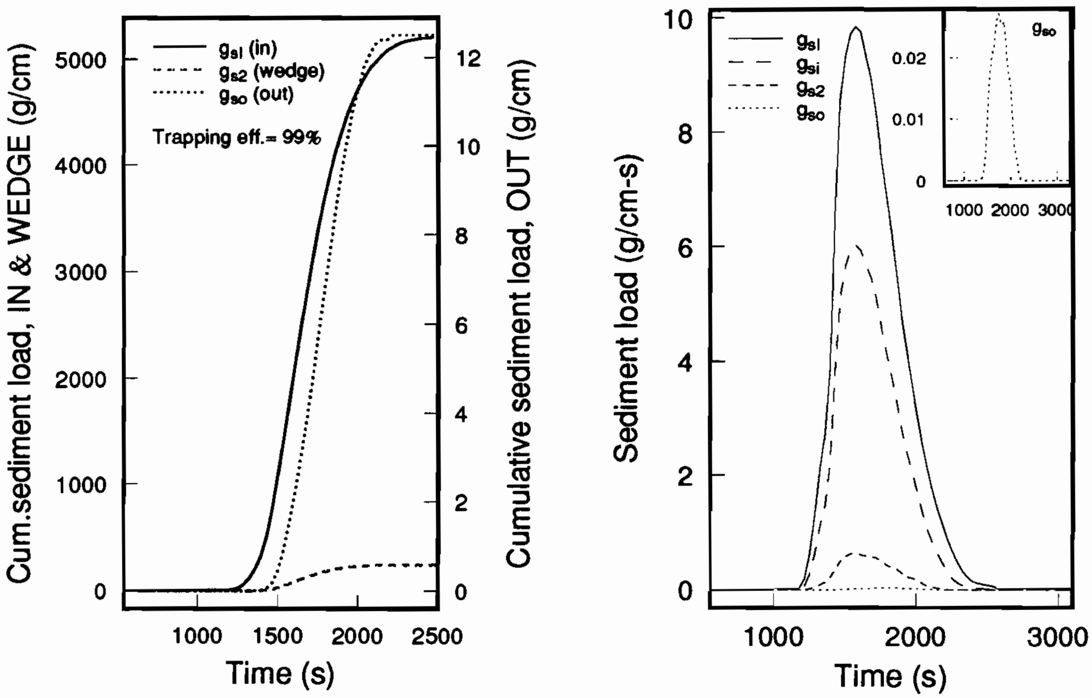

Figure 8. Sediment outflow for the simulated runoff event

The deposition at the field is illustrated by the decrease in load values between g_{sI} and g_{si} in fig. 8 (41.9% of total sediment inflow). The deposition at the filter wedge is given by the decrease between g_{si} and g_{s2} (52.4% of total). The suspended zone filtration is given by the decrease between g_{s2} and g_{so} (5.5% of total). The inflow sediment peak load is 10 g/cm-s. Peak field values in the Piedmont, North Carolina, for the years 1991-

1992, are in the range of 0.001-0.40 g/cm-s, which indicates that inundation is not a common process. In natural conditions, the natural vegetation growth can counteract inundation.

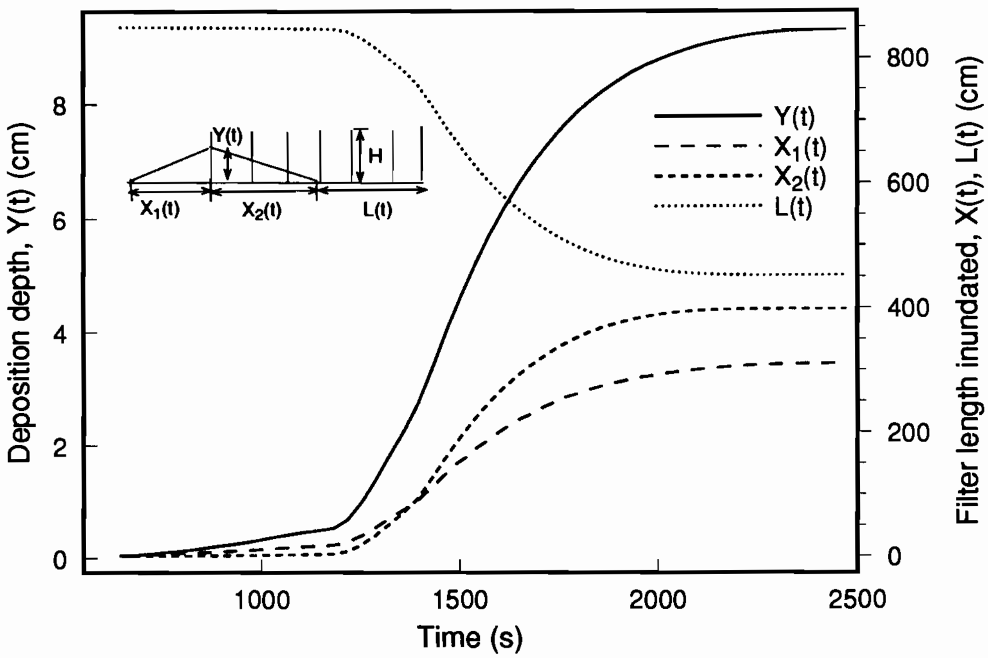

Figure 9. Predicted advancement and depth of the deposition wedge

Figure 9 shows the field tail, $X_1(t)$, and advancement of the sediment wedge, $X_2(t)$. For the sediment inflow used in the problem, at the end of the event (t =2600 s), roughly half the filter is affected by the triangular wedge (3.9 m), and sediment is deposited up into the field for 3.1 m. For this example the deposition depth, $Y(t)$, never reaches its maximum value, media height H, so that the wedge is always triangular. The shape of the deposition wedge along with the advancement can also be seen in a snap-shot of the deposition profiles (fig. 10). A uniform slope of S_o=3% is observed at the beginning of the simulation (t =0 s). In time, sediment is deposited, forming the triangular wedge between field and beginning of the filter. The upslope side is horizontal up to the begining of the filter and the downslope face has a total slope of S_{et} , changing with time as the wedge depth increases and the tail advances.

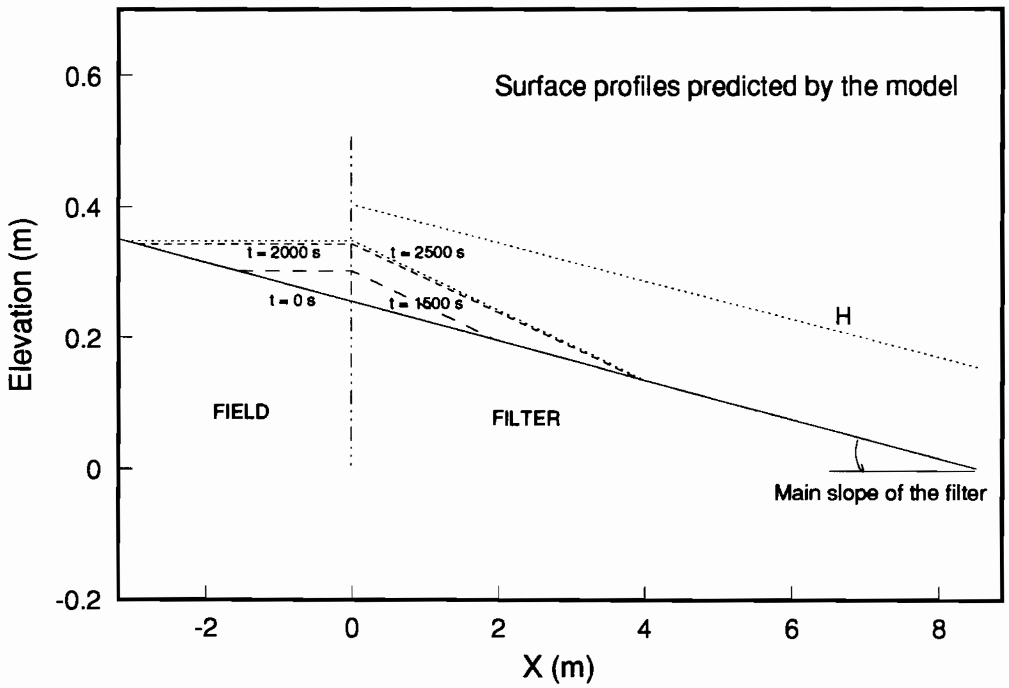

Figure 10. Snap-shots of the advancement and depth of the deposition wedge for different times

Conclusions

A single event, field scale type model is presented to simulate the hydrology and sediment filtration in vegetative filter strips (VFS). Three submodels complement each other: a modified Green-Ampt infiltration routine, a finite element kinematic wave overland flow, and the University of Kentucky sediment filtration model. The result is a comprehensive model to account for field variability and changes along the simulation period.

The hydrology section of the model (overland+infiltration) provides a good description of the flow rate along the filter. This information is utilized by the sediment filtration model. Simultaneously, the sediment subroutine provides a description of the changes taking place in the filter with sediment deposition, and this information is fed back into the hydrology model.

Major inputs of the model are buffer properties (length, slope, hydraulic roughness, grass spacing, media height), soil infiltration parameters, sediment and water inflow from the adjacent agricultural field and sediment properties. Major outputs of the model are runoff from the filter, infiltration rate and total infiltration, sediment outflow, sediment deposition, and filter trapping efficiency.

An application case illustrating the behavior of the model for an extreme field-type event is presented. In this case, high sediment trapping efficiencies are obtained (99%)and filter inundation by sediment is predicted. The filter, however, behaves ideally, since only sheet flow over a uniform, dense stand of vegetation is considered. The types of outputs from the model are analyzed. The hydrology submodel predicts runoff from the filter that presents reduction in peak and total volume and peak delay. The sediment filtration submodel predicts not only total sediment outflow and pollutograph, but also sediment deposition within the filter (52% of total sediment inflow in this example). An important part of this deposition is the formation of a field tail, prior to the filter (42% of total).

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Bibliography

Barfield B.J., E.W. Tollner and J.C. Hayes. 1978. The use of grass filters for sediment control in strip mining drainage. Vol. I: Theoretical studies on artificial media. Pub. no. 35-RRR2-78. Institute for Mining and Minerals Research, University of Kentucky, Lexington.

Barfield B.J., E.W. Tollner and J.C. Hayes. 1979. Filtration of sediment by simulated vegetation I. Steady-state flow with homogeneous sediment. Trans. ASAE. 22(5):540-545.

Barfield, B.J., L.G. Wells, and C.T. Haan. 1981. Applied Hydrology and Sedimentology for Disturbed Areas. Oklahoma Technical Press. Stillwater.

Bolton, S.M., T.J. Ward and R.A. Cole. 1991. Sediment-related transport of nutrients from southwestern watersheds. J. Irr. Drain. Eng. ASCE. 117(5):736-747.

Chu, S.T. 1978. Infiltration during unsteady rain. Water Resour. Res., 14(3):461-466.

Dillaha, T.A., R.B. Reneau, S. Mostaghimi and D. Lee. 1989. Vegetative filter strips for agricultural non-point source pollution control. Trans. ASAE. 32(2):513-519.

Engman, E.T. 1986. Roughness coefficients for routing surface runoff. J. Irrigation and

Drainage Eng. ASCE, 112(1):39-53.

Flanagan, D.C., G.R. Foster, W.H. Neibling and J.P. Burt. 1989. Simplified equations for filter strip design, Trans. ASAE 32(6):2001-2007.

Foster G.R. 1982. Modeling the erosion processes. In Hydrologic Modeling of Small Watersheds, ed. C.T. Haan, H.P. Johnson and D.L. Brakensiek, 295-380. ASAE Monograph no. 5. St. Joseph: ASAE.

Fair, G.M. and J.C. Geyer. 1954. Water Supply and Wastewater Disposal. New York: John Wiley and Sons.

Green, W.H. and G. Ampt. 1911. Studies in soil physics, part I.-the flow of air and water through soils. J. Agricultural Sci. 4:1-24.

Hayes, J.C., B.J. Barfield and R.I. Barnhisel. 1984. Performance of grass filters under laboratory and field conditions. Trans. ASAE. 27(5):1321-1331.

Hayes, J.C., B.J. Barfield and R.I. Barnhisel. 1979. Filtration of sediment by simulated vegetation II. Unsteady flow with non-homogeneous sediment. Trans. ASAE. 22(5):1063-1967.

Hayes, J.C. and T.A. Dillaha. 1992. Vegetative filter strips: I. site suitability and procedure. ASAE Paper no. 92-2102. St Joseph: ASAE.

Lane, L.J., E.D. Shirley and V.P. Singh. 1988. Modelling erosion on hillslopes. In Modelling Geomorphological Systems, ed. M.G. Anderson, 287-308. Wichester: John Wiley and Sons.

Lighthill, M.J. and C.B. Whitham. 1955. On kinematic waves: flood movement in long rivers. Proc. R. Soc. London Ser. A. 22:281-316.

Mein, R.G. and C.L. Larson. 1971. Modeling the infiltration component of the rainfall-runoff process, Bull. 43, Univ. of Minnesota, MN, Water Resources Research Center.

Mein, R.G. and C.L. Larson. 1973. Modeling infiltration during a steady rain. Water Resourc. Res. 9(2):384-394.

Monke, E.J., D.W. Nelson, D.B. Beasley and A.B. Bottcher (1981). Sediment and nutrient movement from the Black Creek watershed. Trans. ASAE. 23(2):391-395.

Muñoz-Carpena, R. 1993. Modeling hydrology and sediment transport on vegetative filter strips. Ph.D. dissertation, North Carolina State Univ., Raleigh.

Muñoz-Carpena, R., C.T. Miller, J.E. Parsons. 1993a. A quadratic Petrov-Galerkin solution for kinematic wave overland flow. Water Resour. Res. (in press).

Muñoz-Carpena, R., J.E. Parsons and J.W. Gilliam. 1993b. Numerical approach to the overland flow process in vegetative filter strips. Trans. ASAE (in press).

Parsons, J.E., R.D. Daniels, J.W. Gilliam and T.A. Dillaha. 1990. Water quality impacts of vegetative filter strips riparian areas. Paper presented at the Winter Meeting of ASAE, Paper No. 90-2501. St. Joseph: ASAE.

Schreiber, H. A., P.D. Duffy and D.C. McClurkin. 1980. Aqueous and sediment-phase nitrogen yields from five southern pine watersheds. Soil Sci. Soc. Am. J. 44(2):401-407.

Skaggs, R.W. and R. Khaheel. 1982. Infiltration. In Hydrologic modeling of small watersheds. Ed. by C.T. Haan, H.P. Johnson and D.L. Brakensiek, 139-149, St. Joseph: ASAE.

Tollner, E.W., B.J. Barfield, C.T. Haan and T.Y. Kao. 1976. Suspended sediment filtration capacity of simulated vegetation. Trans. ASAE. 19(4):678-682.

Tollner, E.W., B.J. Barfield, C. Vachirakornwatana and C.T. Haan. 1977. Sediment deposition patterns in simulated grass filters. Trans. ASAE. 20(5):940-944.

Wilson, B.N., B.J. Barfield and I.D. Moore. 1981. A Hydrology and Sedimentology

Watershed Model, Part I: Modeling Techniques.. Technical Report. Department of Agricultural Engineering. University of Kentucky. Lexington.

Woolhiser, D.A. 1975. Simulation of unsteady overland flow. In Unsteady Flow in Open Channels. Vol. II Ed. K. Mahmood and V. Yevjevich, 485-508, Fort Collins, CO, Water Resources Publications.

Woolhiser, D.A., R.E. Smith and D.C. Goodrich. 1990. KINEROS, A Kinematic Runoff and Erosion Model: Documentation and User Manual. USDA-ARS. ARS-Publication no. 77.

CHAPTER IV

Modeling Overland Flow and Sediment Transport in Vegetative Filter Strips:
(2) Field validation and sensitivity analysis.

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Abstract

Vegetative filter strips are an effective non-point-source pollution control practice. The performance of these areas is governed by complex mechanisms. Models can help simulate the field conditions and predict the buffer effectiveness. A model (presented in a companion paper) to study the hydrology and sediment filtration in buffer strips is evaluated. A study of the input parameters, analysis of sensitivity and field testing of the model is presented. The sensitivity analysis of indicates that the most sensitive parameters are soil initial water content and vertical saturated hydraulic conductivity for the hydrology submodel and particle class (particle size, fall velocity and sediment density) and grass spacing for the sediment submodel. A set of 24 natural runoff events (rainfall amounts from 0.3 to 3.0 cm) from a North Carolina Piedmont site was used in the validation of the hydrology submodel, and a subset of 9 events for the sediment submodel. Four quantities were compared between observed and predicted hydrographs: total runoff volume, delay time, time to peak and peak flow rate. Two measures of agreement between observed and predicted data were calculated: Pearson weighted moment (PWM), with a range of (0.75 - 0.92) and sample coefficient of correlation for the 1:1 regression line ($R_{1:1}$) with a range of (0.74-0.98) .

Introduction

Soil erosion has long been recognized as detrimental to soil productivity. Tolerable soil losses (T-factors) for sustained productivity have been defined for various soil-landscape systems. However, these T-factors may allow off-site sediment loss and movement of sediment, nutrients and pesticides to streams, lakes and reservoirs. This degradation of surface water quality often has adverse economic and ecological impacts.

One conservation practice to minimize off-site effects of agricultural runoff is the use of vegetative filter strips and riparian areas. These zones buffer a pollutant source area from receiving waters, such as streams and lakes. The agricultural runoff is filtered through the buffers, trapping sediment and many chemicals adsorbed to the sediment. The increased surface roughness due to the vegetation also reduces the velocity of the runoff and enables more surface water to infiltrate. Thus, the quantity and quality of the water reaching the water bodies is reduced and improved, respectively.

Many researchers have investigated grass buffer areas. Barfield et al. (1979) reported that grass filter strips have high sediment trapping efficiencies as long as the flow is shallow and uniform and the filter is not submerged. Several recent short-term studies have concentrated on evaluating the effectiveness of grass buffer strips in trapping sediment and nutrients (Young et al., 1980; Daniels and Gilliam, 1989; Dillaha et al., 1988, 1989; Magette et al., 1989). They reported trapping efficiencies exceeding 50% for sediment and nutrients adsorbed to sediment, while dissolved nutrient trapping was not as efficient.

Other researchers have been investigating the effectiveness of riparian areas (Lowrance et al., 1984; Peterjohn and Correll, 1984; and Jacobs and Gilliam, 1985). Much of this effort has concentrated on the removal of nitrogen as subsurface water moves through riparian areas. All of the studies have concluded that riparian areas are extremely effective for removing nitrogen; however, sediment removal and hence the removal of pollutants adsorbed to sediment was not as conclusive. Cooper et al. (1987)

estimated that as much as 90% of the sediment was deposited in the riparian area for a North Carolina watershed. Lowrance et al. (1986) concluded that riparian areas in Georgia were effective sinks for sediment. Cooper and Gilliam (1987) estimated that riparian areas trapped only 50% of the phosphorus entering.

A model to study the hydrology and sediment filtration in buffer strips has been presented (Muñoz-Carpena et al. 1993b). This model is composed of three mathematical submodels linked together to describe the principal mechanisms in natural buffers: a Petrov-Galerkin finite elements kinematic wave overland flow submodel (Muñoz-Carpena et al. 1993a,c), a modified Green-Ampt infiltration submodel (Green and Ampt, 1911; Chu, 1978; Mein and Larson 1971, 1973; Muñoz-Carpena et al., 1993a) and the University of Kentucky sediment filtration model for grass areas (Barfield et al. 1978, 1979, 1981; Hayes, 1979; Hayes et al. 1984; Tollner et al., 1976, 1977, Wilson et al., 1981). This formulation presents the ability of effectively handling complex sets of inputs from natural runoff/filtration events. The purpose of this paper is to study the sensitivity of the model to the various input parameters and to validate the model with field data from an experimental site in North Carolina.

Field Experimental Setup

A field site in the North Carolina Piedmont was selected to monitor the performance of vegetative filter strips and riparian areas (Parsons et al., 1991). The site is located at the North Carolina State University Unit 9 Research Unit in Raleigh. The soil is a clay kaolinitc thermic Typic Hapludult with a sandy-loam surficial horizon (table 1).

Table 1. Soil parameters at the experimental site

(*)Layer	Depth (cm)	Texture	n	e	db (g/cm3)	ds (g/cm3)	Ksv (cm/h)	Ksh (cm/h)	Os (cm3/cm3)	Or	Sav (cm)
					(Grass buffer area)						
Ap	0-23	SL	0.319	0.470	1.66	2.43	4.78	7.85	0.311	0.090	37.90
B1t	23-41	C	0.298	0.380	1.61	2.22	2.37	4.74	0.436	0.147	7.50
Bt2	41-69	SC	0.443	0.795	1.35	2.42	4.93	2.02	0.376	0.129	2.30
	69-94	SCL	0.470	0.887	1.50	2.82	4.19	0.60	0.445	0.119	3.40
					(Riparian area)						
Ap	0-20	S-L	0.306	0.444	1.69	2.44	6.14	2.29	0.306	0.056	8.825
B1t	20-56	--	0.416	0.712	1.44	2.46	6.44	2.75	0.416	0.166	1.141
Bt2	56-104	--	0.545	1.197	1.15	2.52	1.20	2.79	0.545	0.295	29.031
Bt3	104-127	--	0.567	1.312	1.11	2.55	0.72	3.70	0.567	0.317	15.856

(*) n= Total porosity; e= Void ratio; S, C, L= Sand, Clay, Loam; Sav= Average suction at the wetting front; Os, Or= Saturated and residual water contents; Ksv,Ksh= Vertical/horizontal saturated conductivity; db= Soil bulk density; ds= Soil particle density

The site consists of six runoff plots with 4 m wide by 37 m long cropland source areas. The slopes on the plots are approximately 5-7%. Field rows are parallel to the slope to maximize runoff and erosion and to enable testing of the filters under the worst conditions.

Surface runoff is collected at the field edge or base of two of the plots at the site. Runoff from these plots with no filter (controls) is assumed to equal the inflow to the adjacent plots with filters. The other four plots have grass filter strips either 4.3 m or 8.5 m long. For these buffers the ratio of the area of the field to the filter is 9:1 and 4.5:1, respectively. Riparian areas are located down slope at the site. The surface runoff from the two non-filter plots at each site is distributed to the two riparian plots. The riparian plots are 1.3 m wide with lengths of either 4.3 or 8.5 m (area ratio of 27:1 and 13.5:1).

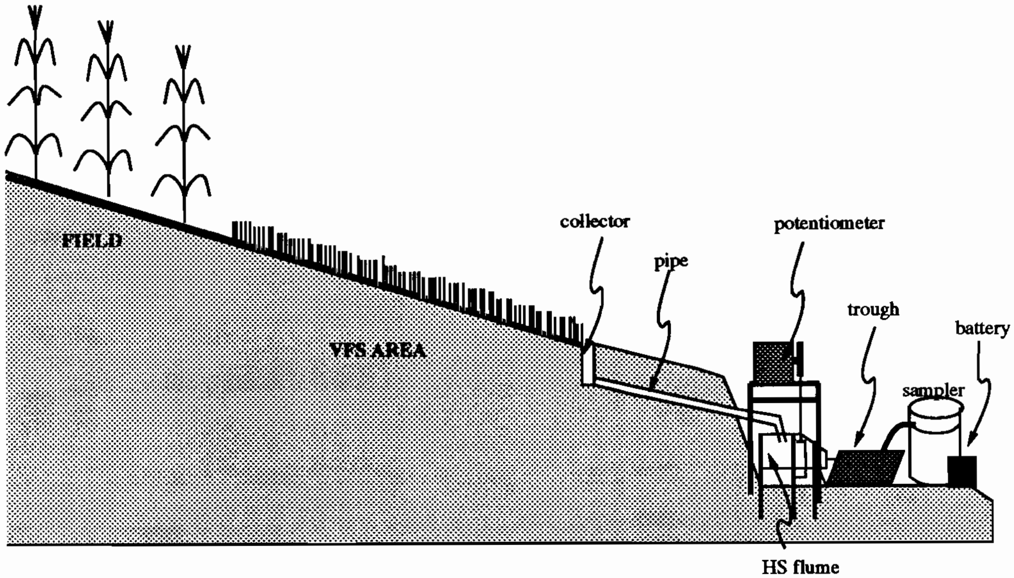

Figure 1. Layout of field instrumentation at the experimental site

The field instrumentation is depicted in figure 1. A portable datalogger is used at the site to monitor rainfall and surface runoff, and activate the water quality samplers. A tipping bucket raingauge measures rainfall intensities and volumes at 5 minute intervals.

The quantity of runoff from each plot is measured with HS type flumes (0.15 m depth) (Brakensiek et al. 1979). The runoff from each plot section is collected by a rain gutter and then piped to the flumes. Water levels in the HS flumes are monitored with a potentiometer - float assembly. A half bridge with a 2-v excitation is used with the potentiometers to monitor the water levels in the flumes.

Discrete automatic water quality samplers were installed on each of the 6 plots at each site. The samplers contain 24 1-liter bottles and are activated by the datalogger. The inlets for the samplers are located in catch basins downstream of the flume. Collected samples are analyzed for sediment concentrations and particle size distributions using standard analytical procedures. Portions of the samples are also refrigerated at 4 °C for nitrogen and phosphorus analyses.

The datalogger monitors and records the flume water levels during storm events every 30 seconds. The water quality sampler takes a sample whenever the flume water level increases or decreases by 2 mm or more.

Input Parameters and Sensitivity Analysis

Hydrology Submodel

The input parameters for the hydrology part of the model (overland flow+infiltration) are summarized in table 2.

Different procedures need to be applied in order to identify these parameters for a field testing of the model. An example of these procedures is given for the validation in the experimental site .

Table 2. Field parameters governing the overland flow model

Symbol	Description	Units
L	Filter length	m
w	Filter width	m
So_k	Nodal slope	m/m
n_k	Manning's roughness for grass surface	$s/m^{1/3}$
Ks	Vertical saturated conductivity	m/s
θ_s	Saturated water content	cm^3/cm^3
θ_i	Initial water content	cm^3/cm^3
S_{av}	Suction at the wetting front	m

The filter length and width were measured directly in the field. Nodal slopes were determined by a topographical field survey. A dense grid was laid down on the areas (a total of 191 points : 24 points in each of the short strips, 45 in each long strips). The transversal values of slope (to the direction of flow) were averaged to obtain a width averaged set of slopes for each strip. These values were used for simulation purposes. A 1-D grid of 50 nodes was selected for each strip with 7 to 14 segments of equal slope. A summary of these results can be found in table 3.

Table 3. Average field slopes for the filters at the experimental site

Point	x(m)	g4-1	g4-2	g8-1	g8-2	r-1	r-2
1	0.00	0.021	0.068	0.039	0.067	0.130	0.308
2	0.61	0.021	0.068	0.039	0.067	0.130	0.308
3	1.22	0.106	0.000	0.058	0.007	0.226	0.151
4	1.83	0.054	0.104	0.054	0.089	0.187	0.183
5	2.44	0.072	0.025	0.106	0.044	0.186	0.276
6	3.05	0.057	0.026	0.035	0.029	0.313	0.138
7	3.66	0.085	0.042	0.022	0.017	0.090	0.305
8	4.39	0.080	0.047	0.036	0.024	0.148	0.148
9	4.88	--	--	0.037	0.021	--	0.388
10	5.49	--	--	0.075	0.008	--	0.186
11	6.10	--	--	0.092	0.176	--	0.250
12	6.71	--	--	0.067	0.092	--	0.186
13	7.32	--	--	0.075	0.074	--	0.319
14	7.92	--	--	0.043	0.039	--	0.208
15	8.61	--	--	0.054	0.070	--	0.109
	Mean values=	6.8%	4.5%	5.7%	5.4%	18.3%	22.5%

Manning's roughness coefficients were obtained from tables and field inspection (Woolhiser, 1975; Engman, 1986; Woolhiser et al. 1990; Arcement and Schneider, 1989). These values will change seasonally as a function of the vegetative conditions of the cover (higher values in summer, lower values in winter). Based on the references mentioned above, the range considered in our field validation was 0.1-0.5 for grass buffers and 0.05-0.25 for riparian vegetation. Previous research (Muñoz-Carpena et al., 1993a) has shown that n controls mainly the time to peak of the outgoing hydrograph.

The saturated water content, θ_s, and suction at the front, S_{av}, were measured and calculated in the lab from soil cores extracted from each filter area (table 1). An analysis of sensitivity was performed on these parameters, and it was found that the variation of these parameters was not significant as compared with the next two parameters in table 2

(K_s, θ_i). The lab values for θ_s and S_{av} were used for each soil type in the validation process.

Saturated vertical hydraulic conductivity values were also measured from soil cores in the lab. However, infiltrometer tests conducted in the field (10/23/90) showed lower values than those obtained with the cores (0.1 vs. 4.8 cm/h). This field test cannot be considered conclusive due to lack of replications, but gives an idea of the enormous variability of the field parameter K_s at the surface. A detailed analysis of sensitivity was conducted for these two parameters (K_s, θ_i) and Manning's n. The rainfall distribution and field inflow from a natural field event (06/30/91) from our experimental site was selected for this analysis. Starting with lab values (K_{sl}=1.3x10^{-5} m/s, θ_s=0.311 cm^3/cm^3), 3 sets of 115 simulations each were performed for a range of ($0.05\ K_{sl} < K_s < 4\ K_{sl}$), and ($0.5\ \theta_s < \theta_i < \theta_s$). For each one of those sets a different n was selected (n=0.1, 0.3, 0.5)

The following quantities were obtained and compared for each simulation (figure 2): delay time (t_d), time to peak (t_p), peak flow rate (Q_p), and total runoff volume (Vol).

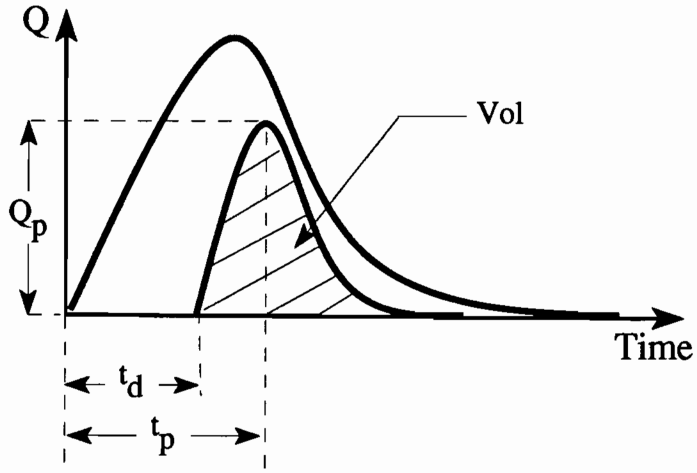

Figure 2. Diagram showing comparison quantities for the hydrology model.

The results from the simulations are summarized in figure 3.

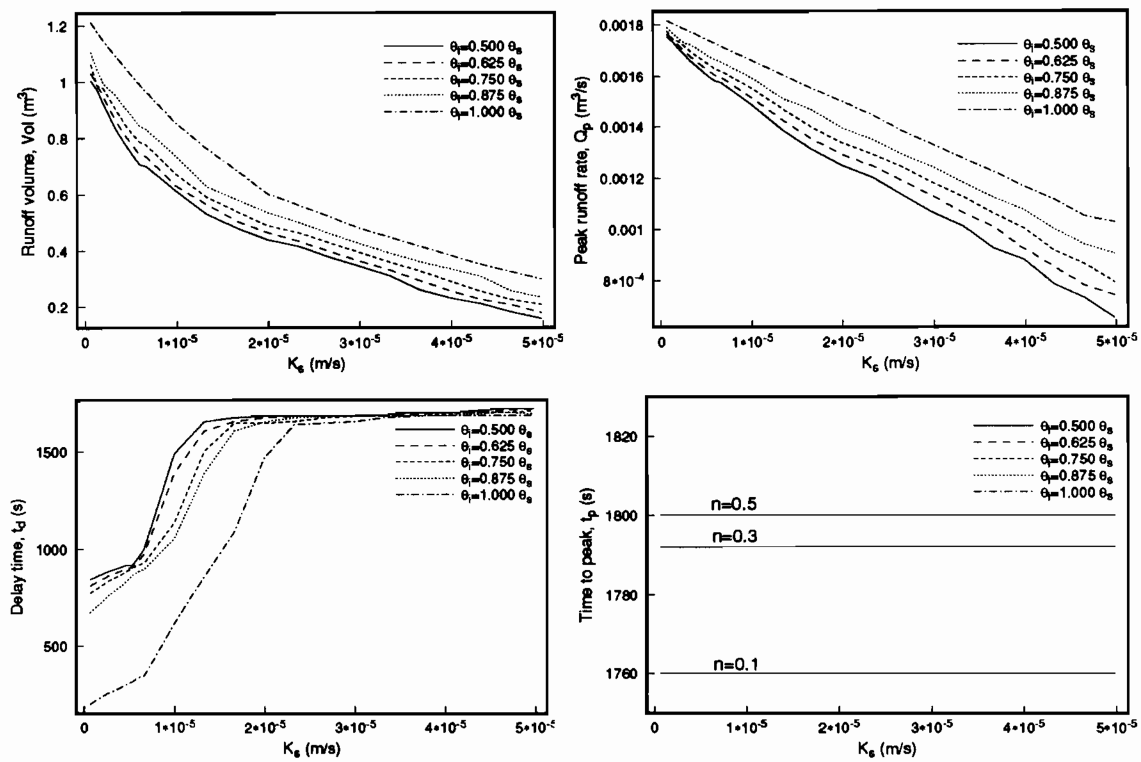

Figure 3. Results from the analysis of sensitivity of θ_i, K_s and n for the hydrology submodel.

The results of this analysis of sensitivity show the output values for *Vol*, t_d, and Q_p to be sensitive to two parameters (K_s, θ_i), but independent of n (figure 3). However, t_p varies only with the Manning's roughness coefficient, n. In figure 3 we observe how an increase in K_s, for a given fixed value of θ_i (i.e. each one of the curves), results in a decrease in runoff volume and peak flow rate. A summary of the variation trends is found in table 4. For the study case a ±50% variation in the lab value of K_{sl} brings a −30%/+17% variation in *Vol*, ±10% in Q_p and a non-uniform variation in t_d depending on the θ_i selected. The variation in *Vol* and Q_p is uniform for the spectrum of K_s values.

Table 4. Variation trends found in the analysis of sensitivity

θi (cm^3/cm^3)	Ks (m/s)	Δ%	Vol (m^3)	Δ%	Q_p (m^3/s)	Δ%	t_d (s)	Δ%
0.500 θs	6.64e-06	50.0	0.701	-32.1	0.0016	-13.2	1000	39.7
	1.33e-05	0.0	0.531	0.0	0.0014	0.0	1657	0.0
	1.99e-05	-50.0	0.440	17.0	0.0012	10.2	1685	-1.7
0.625 θs	6.64e-06	50.0	0.735	-30.2	0.0016	-11.7	975	39.4
	1.33e-05	0.0	0.565	0.0	0.0014	0.0	1609	0.0
	1.99e-05	-50.0	0.466	17.5	0.0013	9.7	1677	-4.2
0.750 θs	6.64e-06	50.0	0.777	-31.4	0.0016	-10.1	929	38.2
	1.33e-05	0.0	0.591	0.0	0.0015	0.0	1503	0.0
	1.99e-05	-50.0	0.490	17.1	0.0013	9.2	1649	-9.7
0.875 θs	6.64e-06	50.0	0.832	-32.5	0.0017	-9.4	898	35.3
	1.33e-05	0.0	0.628	0.0	0.0015	0.0	1389	0.0
	1.99e-05	-50.0	0.536	14.6	0.0014	7.9	1657	-19.3
1.000 θs	6.64e-06	50.0	0.965	-26.6	0.0017	-6.8	346	59.8
	1.33e-05	0.0	0.762	0.0	0.0016	0.0	859	0.0
	1.99e-05	-50.0	0.604	20.8	0.0015	6.8	1467	-70.8

In the case of t_d, the increase/decrease in K_s will produce an increase/decrease in delay time, higher with higher initial water content. This effect will be negligible after a value of K_s=K_{sc}=2.3x10^{-5} m/s, regardless of the initial water content chosen (figure 3). An explanation for this is that for lower values than K_{sc} delay time is controlled mostly by the soil moisture deficit (higher deficit, greater delay), but for higher K_s values, infiltration is great enough to absorb the instantaneous rainfall intensity+field inflow, regardless of the initial moisture deficit (again for this specific case).

In the field calibration process initial values of $K_s = K_{sl}$ and $\theta_i < 0.875\ \theta_s$ are chosen and then varied ±20% to fit the observed data. The optimal values are used in the validation of hydrographs from other strips within the same date-event.

Sediment Submodel

The field parameters that describe the sediment filtration process in this model are summarized in table 5

.

Table 5. Field inputs governing the sediment filtration model

Symbol	Description	Units
L	Filter length	m
w	Filter width	m
So_k	Nodal slope	m/m
n	Modified Manning's roughness	s/cm$^{1/3}$
dp	Particle diameter	cm
γs	Sediment density	g/cm^3
Vf	Fall velocity	cm/s
Ss	Spacing	cm
H	Media height	cm
p	Porosity of the deposited sediment	---

The first three parameters on table 5 are the same as discussed before for the hydrology model. The *modified n* and grass spacing, Ss, values were selected from the type of vegetation at the grass filters (Haan et al., 1993). For a fescue/bluegrass/ bermudagrass mixture found in our experimental sites, a value of n=0.012 s /cm$^{1/3}$ and Ss=2.2 cm is recommended. The spacing value matches vegetation counts carried out in the experimental site used in this validation (R. Daniels, 1993 personal communication). For the riparian area an Ss=10.0 cm was selected by field inspection. An analysis of sensitivity was performed on n. The results showed the model not to be very sensitive to n compared to the other parameters discussed bellow.

The parameter H was selected as 15 cm for our field situation, where the grass was maintained at least at that height. The porosity of the deposited sediment, p, was selected as 0.434 (Hayes, 1979).

Particle size, fall velocity and density are chosen from the range available for the texture of the soil following the procedures described elsewhere (Muñoz-Carpena et al., 1993b). This is a value greatly dependent not only on soil texture but on flow conditions (energy of the overland flow). Since fall velocity is related to particle size, the term *particle class* will be used to denote these two characteristics and particle density. An analysis of sensitivity was performed for five particle classes (figures 4 and 5) and the combination of particle class and grass spacing (figure 6). These particle classes are: clay, silt, sand, small aggregates and large aggregates (USDA, 1975). A grass strip of L=4.3 m, uniform slope of 6%. Ss=2.2 m; n=0.012cm/s$^{1/3}$ and H=15 cm is used in this analysis. Figure 4 shows that for a given sediment load inflow from the field, gsI (g/cm-s), a great variation in sediment outflow from the strip, gso (g/cm-s), is experienced when varying the particle class carried by the flow. Figure 5 presents the same results in terms of cumulative sediment load over the span of the event. Sediment trappings (amount of inflow sediment trapped by filter) from 19.4% to 99.9% are obtained when varying the particle class from clay to sand, respectively.

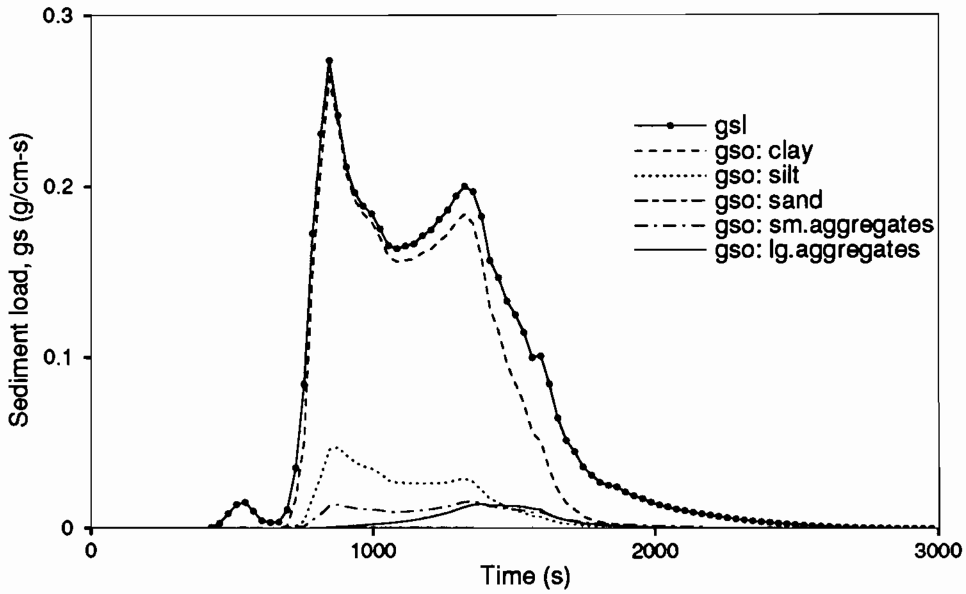

Figure 4. Sediment outflow load results from the analysis of sensitivity for particle class

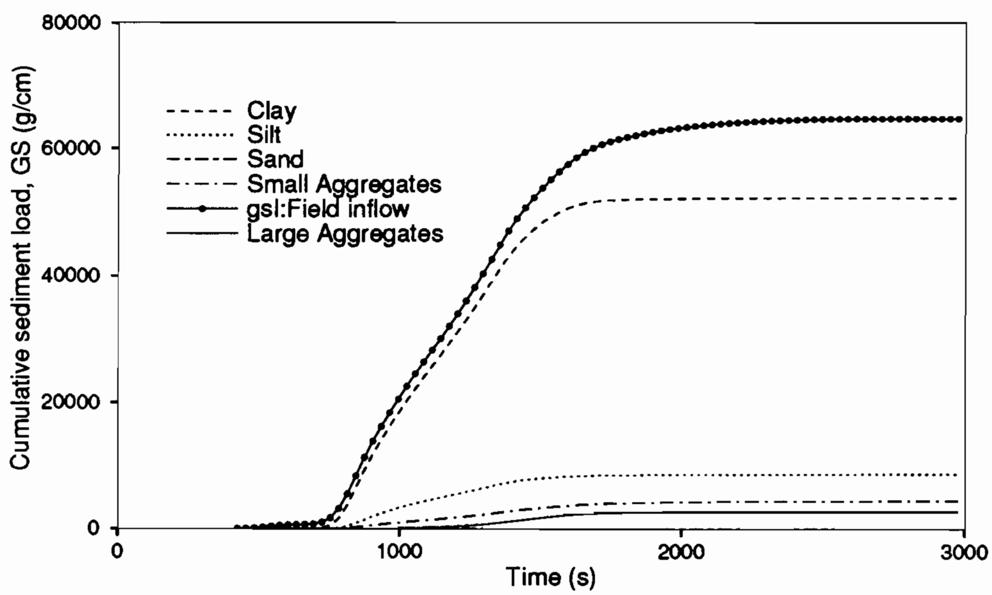

Figure 5. Cumulative sediment outflow results from the analysis of sensitivity on particle class

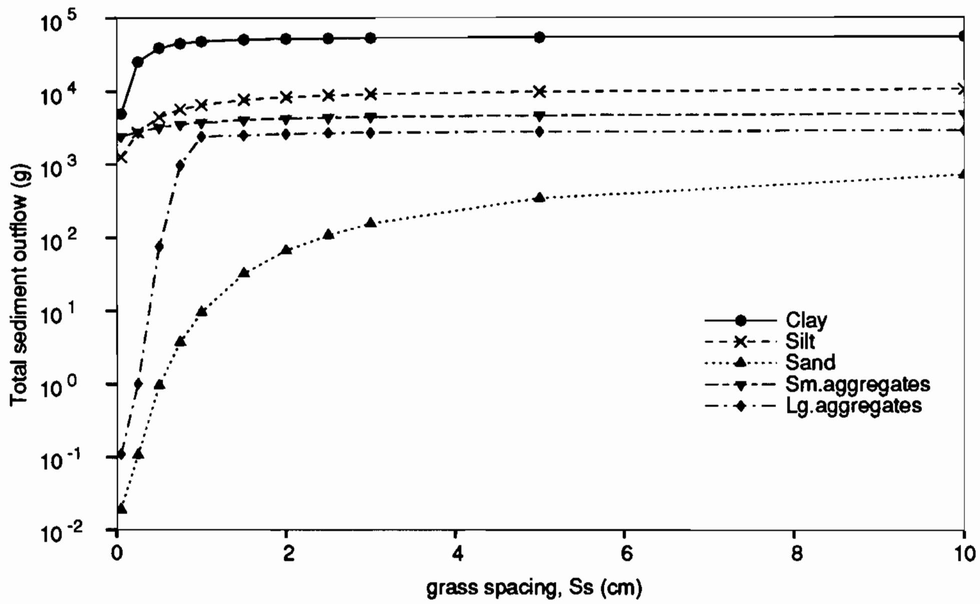

Figure 6. Sensitivity of the model to particle class and grass spacing.

Figure 6 shows the results of the sediment model to be very sensitive to particle class and grass spacing. Reductions in total sediment outflow predictions of -50% to -99% took place for each of the USDA (1975) particle classes when *Ss* was decreased from 10 to 0.05 cm. Most of these reductions took place in the lower range of the values (*Ss* < 3 cm), specially for coarser sediment (large aggregates and sand).

For the surficial sandy-loam soil of our experimental site, a range of particle size of 0.0002-0.013 cm, i.e d_{50} of clay to silt, is selected (Woolhiser et al. 1990)

Field Testing

Statistical Parameters Used in the Validation Process

Several types of statistics provide measures of the degree of agreement between simulated and recorded quantities. The Pearson Weighted Moment (*PWM*), Pearson Square Moment (*PSM*) (James and Burgues, 1982; McCuen and Snyder, 1975), sample coefficient of correlation for the 1:1 line ($R_{1:1}$), sample square coefficient of correlation for the 1:1 line ($R^2_{1:1}$), root mean square error (*RMSE*), and mean square error (*MSE*) will be used in this study. These last four statistics are defined as,

$$R_{1:1} = \sqrt{1 - \frac{\left(\dfrac{\sum_{i=1}^{n} (y_{obs_i} - y_{pred_i})^2}{n-2} \right)}{\left(\dfrac{\sum_{i=1}^{n} (y_{obs_i} - \bar{y}_{obs})^2}{n-1} \right)}} \; ; R^2_{1:1} = (R_{1:1})^2 \qquad (1)$$

$$CSS = \sum_{i=1}^{n} (y_{obs_i} - y_{pred_i})^2 - \frac{1}{n} \left[\sum_{i=1}^{n} (y_{obs_i} - y_{pred_i}) \right]^2 \qquad (2)$$

$$RMSE = \sqrt{\frac{CSS}{n}} \qquad ; MSE = \frac{CSS}{n-1} \qquad (3)$$

Where *CSS* is the correlated sum of squares. The optimal value for *PWM* and $R_{1:1}$ is ±1.0 or +1 for the square quantities (*PSM* and .$R^2_{1:1}$).

Field Testing of the Hydrology Submodel

A set of 24 natural events from the site (1991-93) were chosen to compare the predictions of the model with the field values. Table 6 summarizes these results. Under the column labeled "strip", the codes g4, g8, r1, r2 denote grass areas of 4.3 and 8.5 m length and riparian areas of 4.3 and 8.5 m length, respectively. The comparison between predicted and observed values is given in terms of % error. The quality of the predictions was generally good, though the goodness of the solution varied for each case. An example of this variation can be seen in figures 7a-b. Figure 7a shows an event through a riparian area where a good prediction was obtained (*PWM* =0.84, $R_{1:1}$ =0.88), whereas figure 7b shows an event for a grass area where the prediction was poor (*PWM* =0.47, $R_{1:1}$ =0.52). Some of the possible reasons for this variability will be addressed in a later section.

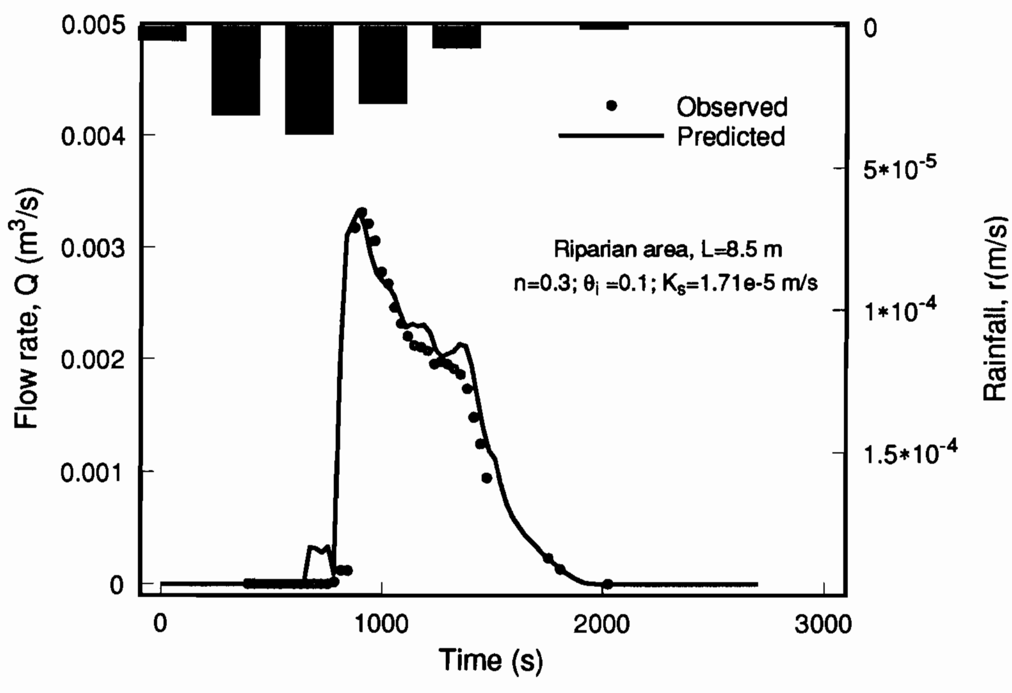

Figure 7a. Example of validation result for an event through the riparian area on 06/26/1992

Table 6. Summary of results for the field testing of the hydrology submodel

#	Event	Strip	node	n	K_s (m/s)	θi	S_{av} (m)	*Vol* Pred. (m^3)	*Vol* Obs. (m^3)	Error (%)	t_d Pred. (s)	t_d Obs. (s)	Error (%)	t_p Pred. (s)	t_p Obs. (s)	Error (%)	Q_p Pred. (m^3/s)	Q_p Obs. (m^3/s)	Error (%)
1	06/30/91	g4	29	0.10	1.33e-5	0.20	0.379	1.088	1.121	-2.9	1186	812	46.1	1653	1622	1.9	2.06e-3	1.89e-3	9.0
2		g8	57	0.10	1.33e-5	0.20	0.379	0.421	0.443	-4.9	1686	1622	3.9	1793	1802	-0.5	1.34e-3	9.68e-4	38.5
3	04/23/92	g4	57	0.40	1.33e-5	0.31	0.379	0.167	0.187	10.6	619	695	-11.0	1122	1295	-13.4	3.88e-4	3.46e-4	12.1
4		g8	57	0.45	1.33e-5	0.31	0.379	0.052	0.055	- 4.7	623	755	-17.5	1480	1625	-8.9	1.14e-4	8.55e-5	33.8
5		r1	57	0.45	2.10e-5	0.20	0.088	0.139	0.113	23.5	892	815	9.5	1071	1355	-21.0	2.99e-4	2.62e-5	14.1
6	05/30/92b	g4	57	0.40	5.00e-6	0.31	0.379	0.187	0.190	-1.6	803	544	47.4	1610	1865	-13.7	1.62e-4	1.25e-4	30.4
7	06/16/92a	g4	29	0.40	5.00e-6	0.28	0.379	0.107	0.118	9.7	416	455	8.4	909	1025	11.3	2.04e-4	1.66e-4	-23.1
8		g8	57	0.40	5.00e-6	0.30	0.379	0.040	0.047	14.1	789	1055	25.1	1128	1085	-4.0	1.30e-4	7.92e-5	-64.1
9	06/26/92a	g4	29	0.40	1.33e-5	0.10	0.379	1.652	1.612	-2.5	645	694	7.0	915	935	2.2	3.15e-3	2.50e-3	-25.7
10		g8	29	0.40	1.33e-5	0.10	0.379	1.363	1.471	7.3	648	425	-52.6	1027	965	-6.4	3.24e-3	2.52e-3	-28.5
11		r1	29	0.30	1.71e-5	0.10	0.088	1.999	2.298	13.0	455	455	0.1	863	935	7.7	3.26e-3	3.70e-3	11.9
12		r2	29	0.30	1.71e-5	0.10	0.088	1.843	1.790	-3.0	459	425	-8.1	891	905	1.5	3.33e-3	3.31e-3	-0.6
13	11/06/92	g8	57	0.40	1.00e-5	0.31	0.379	0.294	0.290	-1.5	311	245	-27.2	747	665	-12.4	1.05e-3	5.06e-4	-107.8
14		r1	29	0.30	3.50e-5	0.10	0.088	0.110	0.112	1.4	541	575	5.9	603	635	5.0	1.53e-3	1.54e-4	-89.3
15		r2	29	0.30	1.00e-5	0.31	0.088	0.551	0.625	11.7	309	334	7.6	618	1265	51.1	1.86e-3	6.47e-4	-188.1
16	11/30/92a	g4	29	0.40	1.33e-5	0.31	0.379	0.648	0.641	-1.1	316	395	19.8	598	545	-9.7	2.28e-4	2.46e-4	7.0
17		g8	29	0.40	1.33e-5	0.31	0.379	0.496	0.524	5.3	316	395	20.0	720	725	0.7	1.63e-3	1.44e-3	-12.8
18		r2	29	0.30	1.71e-5	0.31	0.088	0.669	0.712	6.1	303	395	23.2	589	665	11.5	1.79e-3	1.83e-3	2.0
19	11/30/92c	g4	29	0.40	1.33e-5	0.31	0.379	0.771	0.740	-4.2	777	515	-50.9	1166	1115	-4.6	1.09e-3	9.00e-4	-21.0
20		g8	29	0.40	2.50e-6	0.31	0.379	1.086	1.035	-4.9	306	365	16.1	1245	1115	-11.7	1.30e-3	1.06e-3	-22.1
21		r2	29	0.30	3.00e-5	0.20	0.088	0.561	0.507	-10.6	788	365	-116	1162	1055	-10.1	8.87e-4	5.67e-4	-56.3
22	01/24/93	g4	29	0.40	1.00e-5	0.31	0.379	0.340	0.369	7.9	369	395	6.6	992	1175	15.6	5.42e-4	5.68e-4	4.7
23		g8	29	0.60	1.00e-5	0.31	0.379	0.167	0.161	-3.7	560	395	-41.9	1308	1475	11.3	3.35e-4	2.82e-4	-18.8
24		r1	29	0.30	3.50e-5	0.20	0.088	0.280	0.272	-3.2	519	605	14.2	1192	1475	19.2	4.48e-4	3.95e-4	-13.4

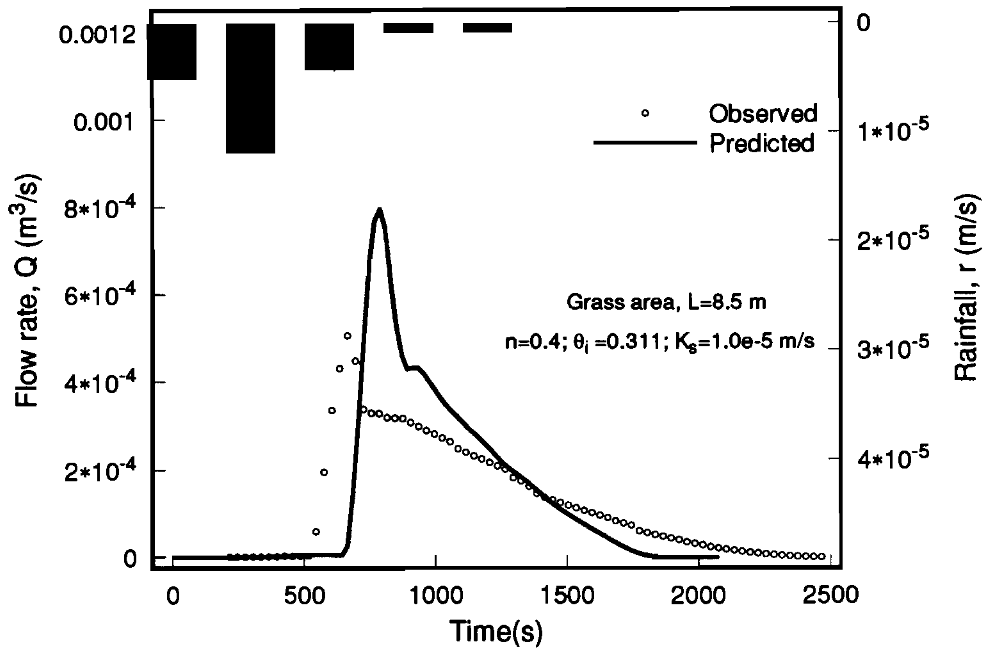

Figure 7b. Example of validation result for an event through the grass area on 11/06/1992.

The predicted set of results presented in table 6 was compared with the observed values for the four quantities introduced in figure 2. These values were plotted against a 1:1 line (line of perfect agreement) in figures 8a-b. Good predictions are obtained in general though some outliers are found in the t_d and Q_p sets.

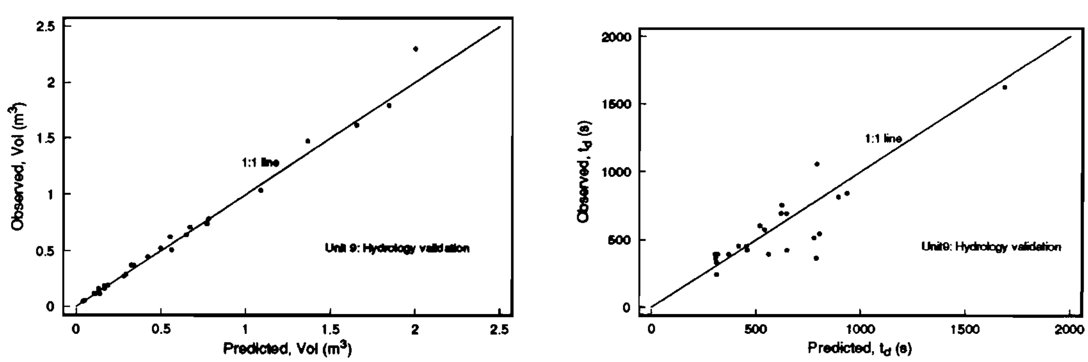

Figure 8a. Results from the field validation of the hydrology submodel for *Vol* and t_d .

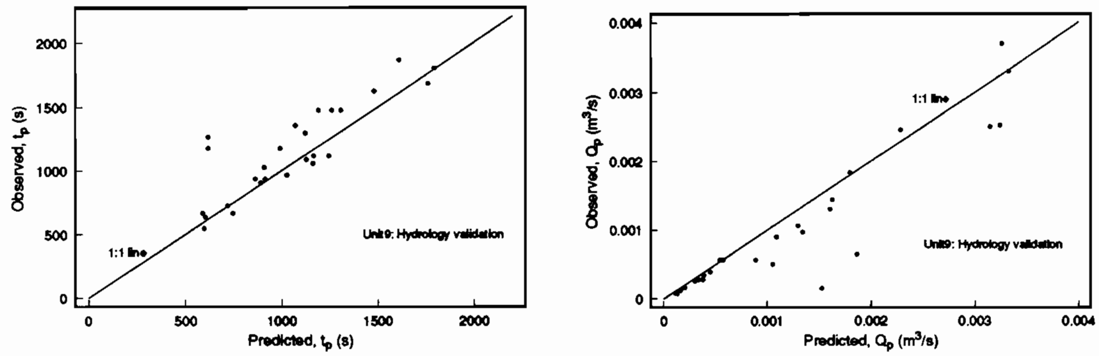

Figure 8a. Results from the field validation of the hydrology submodel for t_p and Q_p

Statistics were obtained for all these quantities and are summarized in table 7. The best model predictions were for the total volume, followed by the peak flow rate.

Table 7. Summary of statistics for the validation of the hydrology model.

Quantity	Wgh.Pearson Moment	Pearson Sq. Moment	$R_{1:1}$	$R^2_{1:1}$	RMSE	MSE
Vol	0.91	0.91	0.99	0.98	0.674e-1	0.472e-2
t_d	0.79	0.71	0.85	0.72	0.147e+3	0.222e+5
t_p	0.79	0.68	0.79	0.63	0.188e+3	0.368e+5
Q_p	0.88	0.80	0.89	0.80	0.390e-3	0.159e-6

Field Testing of the Sediment Submodel

Following the procedures discussed in the hydrology section, the objective here was to compare the model predictions with the field data. A subset of natural events from the experimental site (1992-93) were simulated. A sample of predictions for two events is given in figures 9a-b. Figure 9a shows a validation example from an event where the water runoff and sediment load from the field area was routed through a grass filter of L=4.3 m. The other parameters used in the validation of this event were: silt as the particle class carried by the runoff; a grass spacing of S_s=2.2 cm; n= 0.012 cm/s$^{1/3}$; H=15 cm; and p=0.434. The statistics calculated for this case were $R_{1:1}$=0.92 and PWM=0.91.

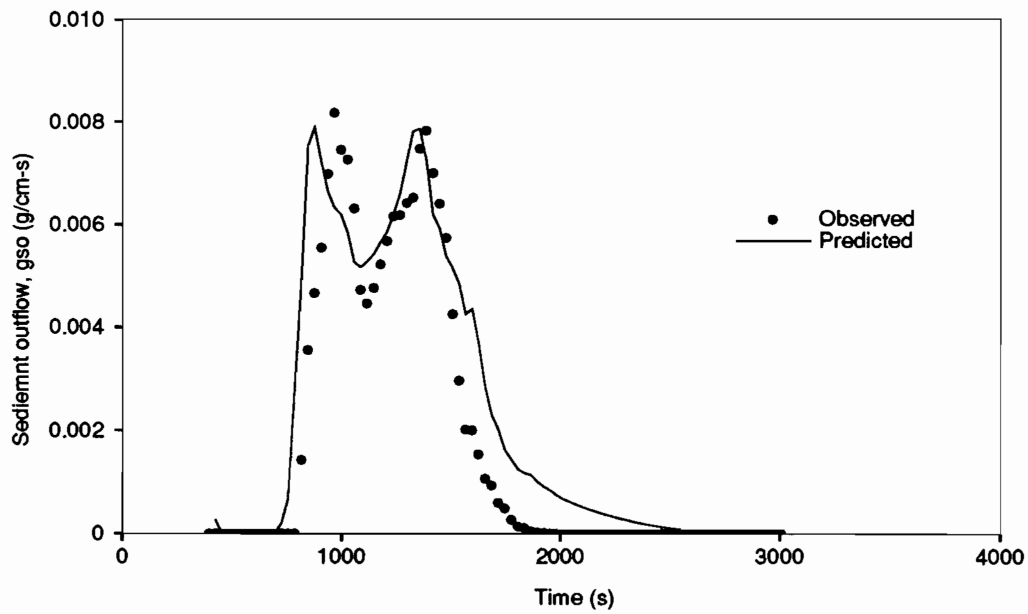

Figure 9a. Example of validation result for an event through the grass area on 06/26/1992

Figure 9b shows another validation example from an event on 01/24/93 where the water runoff and sediment load from the field area were routed through a grass filter of L=4.3 m. A simulation was performed using the same parameters as discussed above.

The statistics obtained for this case were $R_{1:1}$=0.91 and PWM=0.87.

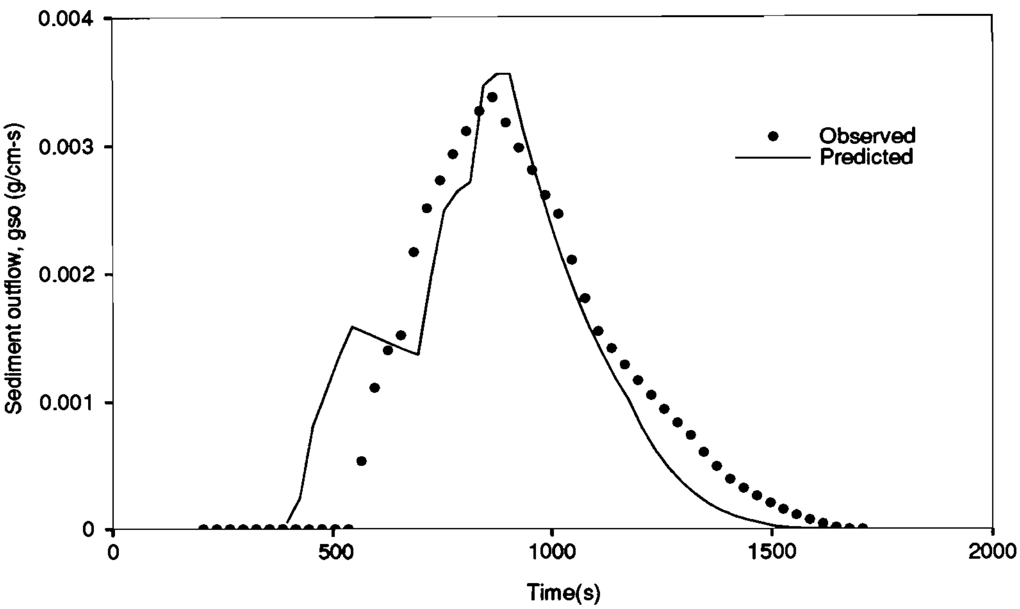

Figure 9b. Example of validation result for an event through the grass area on 01/24/1993

All predicted pollutographs were compared with the observed data and the *PWM* and $R_{1:1}$ statistics calculated. Table 8 summarizes these results. Good predictions are obtained with the model, with statistics values greater than 0.80 in all but two cases. Additional statistics were calculated for the total sediment outflow predictions (columns 8 and 9 in table 8) giving an $R_{1:1}$=0.99, and a PWM =0.87.

Table 8. Summary of results for field testing of the sediment submodel

#	Date	Strip	L (m)	Particle class d_{50}	Ss (cm)	Sed. in (g)	Sed out Pred. (g)	Sed.out Obs.(g)	Error (%)	*PWM*	$R_{1:1}$
1	04/23/92	grass	4.3	Clay	2.2	188.8	37.9	35.0	-8.2	0.81	0.84
2	04/23/92	riparian	4.3	Silt	10.0	188.8	14.2	16.3	12.9	0.80	0.82
3	05/30/92	grass	4.3	Clay	2.2	557.4	15.4	20.0	23.1	0.86	0.90
4	06/26/92	grass	4.3	Silt	2.2	64759.5	2229.0	1738.3	-28.2	0.91	0.92
5	06/26/92	grass	8.5	Silt	2.2	54884.2	4340.4	3989.2	-8.8	0.75	0.74
6	06/26/92	riparian	8.5	Silt	10.0	54884.2	12475.5	12862.1	3.0	0.78	0.85
7	11/30/92	grass	4.3	Silt	2.2	2521.7	1249.8	1376.6	9.2	0.86	0.94
8	11/30/92	grass	8.5	Silt	2.2	2521.7	442.3	429.2	-3.1	0.92	0.98
9	01/24/93	grass	4.3	Silt	2.2	6187.8	619.0	619.4	0.1	0.87	0.91

Discussion of results

In the interpretation of the results several factors must be taken into account. Emphasis must be placed on the fact that the field data collected corresponds to *"natural"* data; that is, the runoff was generated when the combination of rainfall and soil moisture conditions were appropriate. In the year 1992 roughly two dozen of such day-events were collected for our Piedmont site. We consider this type of data to be much more valuable in field testing of this type of models than controlled experiments such as rainfall simulator events. The results presented above are generally satisfactory. In some cases, however, outcome from the model did not match field results. Other than experimental error in the collection of field data for a specific event, other sources of error or model limitations should be considered.

The first limitation comes from the overland flow model implicit assumption: sheet flow. The model does not handle concentrated flow through the filter. The possibility of channelization has been pointed out by some researchers (Dillaha et al., 1988, 1989; Magette et al., 1989). However, concentrated flow through the filter, if properly maintained, should not happen. This should be a major goal in managing the filter. In our conditions no observable channelization took place in the grass filters, although we found some concentrated flow occurring in the riparian areas after large events.

In riparian areas interflow or base flow could be an important factor, due to the nature of the surficial part of these soils with a thick horizon of leaves, litter and root channels. This process is not included in the model. Base flow would reduced surface flow volume, thus degrading the predictions of the model.

Field variability of key parameters can be pointed out as another source of differences between observed and predicted values. The model tries to explain the filter behavior by selecting a limited set of inputs hoping that they represent physical reality. This is an implicit problem in any modeling approach. Special care should be given to field data collection. The analysis of sensitivity provided in this paper should serve as a guidance in assessing errors from this source.

A range of saturated hydraulic conductivity values was used in the calibration/validation process (Table 6). Researchers (Edwards et al., 1979; Enright, 1988; Hoogmoed and Bouma, 1980; Montas and Madramootoo, 1991; Shirmohammadi and Skaggs, 1984) have found this parameter to greatly vary (up to a factor of 3) depending on surface cover, changes in surface conditions by raindrop impact, initial water content, freezing and thawing in winter and faunal activity.

The overland flow model is based on the kinematic wave assumptions: turbulent flow, no backwater effects, slopes within range. Although such conditions generally hold on natural field conditions, deviation from them will degrade the predictions of the model.

The interaction of the overland and Green-Ampt method is subject to certain assumptions. A first assumption is that after initial flooding of the soil by the field inflow, the flood wave can sustain maximum infiltration as dictated by Green-Ampt. A further assumption of the model is that advancement of the flood wave is fast enough to allow for a check at only the first and last node of the finite element mesh. This assumptions, though validated for the soil in our experimental field, could be violated with soils with different soil texture, namely sandy soils (Muñoz-Carpena , 1993).

The numerical solution to the overland flow kinematic equations is also subject to some numerical errors. Considerable work was done in providing an improved solution method in this model. A Petrov-Galerkin method was implemented (Muñoz-Carpena et al., 1993c). This non-standard finite element method provides better handling of kinematic shock problems than the more classical Eulerian methods (finite elements, finite differences).

The sediment model has some limitations handling delay in the outflow pollutograph, due to the simplification of the model by which sediment/flow conditions are handled only at a few points in the filter. The points are considered representative of each of the "filter zones" (Muñoz-Carpena et al., 1993b).

The overall model is relatively insensitive to small events (large relative errors). In terms of absolute values this is not a significant source of error.

Summary and Conclusions

Selection and analysis of inputs, and field testing of the model presented in the companion paper (Muñoz-Carpena el al., 1993b) is discussed.

The analysis of sensitivity indicates that the most sensitive parameters are soil initial water content and vertical saturated hydraulic conductivity for the hydrology submodel and particle class (particle size, fall velocity and sediment density), and grass spacing for the sediment submodel. Critical attention should be given in the selection of these parameters.

The model was tested for a North Carolina Piedmont site in Raleigh. In general, good agreement is obtained between observed and predicted values. Some sources of variability are discussed. One such source is the complexity of the "natural" events as compared to controlled events such as rainfall simulators. The handling of overland flow as sheet flow could pose some problems when a filter is not properly maintained. Base flow (interflow) in riparian areas could also be a factor. Field variability is an inherent source of error in any model validation. A range of variation in the saturated conductivity parameters was needed to fit the model. This variation is explain by changes in surfaces conditions due to seasonal ans biological factors. The nature of the mathematical formulation of the overland flow model and its numerical solution are also considered. Eulerian methods (finite elements, finite differences) suffer from numerical oscillations when sudden changes in field conditions occur (kinematic shocks). The problem is minimized in this model by the use of an improved numerical method, presented elsewhere (Muñoz-Carpena el al., 1993c).

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Blibliography

Arcement, G.J, V.R. Schneider. 1989. Guide for selecting Manning's roughness coefficients for natural channels and flood plains. U.S. Geological Survey water-supply paper 2339. USGS.

Barfield B.J., E.W. Tollner and J.C. Hayes. 1978. The use of grass filters for sediment control in strip mining drainage. Vol. I: Theoretical studies on artificial media. Pub. no. 35-RRR2-78. Institute for Mining and Minerals Research, University of Kentucky, Lexington.

Barfield B.J., E.W. Tollner and J.C. Hayes. 1979. Filtration of sediment by simulated vegetation I. Steady-state flow with homogeneous sediment. Trans. ASAE. 22(5):540-545.

Barfield, B.J., L.G. Wells, and C.T. Haan. 1981. Applied Hydrology and Sedimentology for Disturbed Areas. OKlahoma Technical Press. Stillwater.

Brakensiek, D. L., H. B. Osborn, and W. J. Rawls, coordinators. 1979. Field Manual for Research in Agricultural Hydrology. U. S. Department of Agriculture, Agriculture Handbook No. 224. 550 pp., illus.

Chu, S.T. 1978. Infiltration during unsteady rain. Water Resour. Res., 14(3):461-466.

Cooper, J. R. and J. W. Gilliam. 1987. Phosphorus redistribution from cultivated fields into riparian areas. Soil Sci. Soc. Am. J. 51:1600-1604.

Cooper, J. R., J. W. Gilliam, R. B. Daniels and W. P. Robarge. 1987. Riparian areas as filters for agricultural sediment. Soil Soc. Am. Proc. 51:416-420.

Daniels, R. B. and J. W. Gilliam. 1989. Effect of grass and riparian filters on runoff and water quality. North Carolina Soil Science Soc. Proc. 32:37-45.

Dillaha, T. A., R. B. Reneau, S. Mostaghimi, and D. Lee. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. Trans. of the ASAE 32(2):491-496.

Dillaha, T. A., J. H. Sherrard, D. Lee, S. Mostaghimi, and V. O. Shanholtz. 1988. Evaluation of vegetative filter strips as a best management practice for feedlots. J. of the Water Poll. Cont. Fed. 60:1231-1238.

Edwards, W.M., R.R. Van Der Ploeg and W. Ehlers. 1979. A numerical study of the effects of noncapillary-sized pores upon infiltration. Soil Sci. Soc. Am.J. 43:851-856.

Engman, E.T. 1986. Roughness coefficients for routing surface runoff. J. Irrigation and Drainage Eng. ASCE, 112(1):39-53.

Enright, P.E. 1988. Simulation of rainfall execss on flat rural watersheds in Quebec. M.S. thesis, Dept. of Agricultural engineering, McGill University, Montreal, Canada.

Green, W.H. and G. Ampt. 1911. Studies in soil physics, part I.-the flow of air and water through soils. J. Agricultural Sci. 4:1-24.

Hayes, J.C. 1979. Evaluation of design procedures for vegetal filtration of sediment from flowing water. Ph.D. dissertation, Univ. of Kentucky, Lexington.

Hayes, J.C., B.J. Barfield and R.I. Barnhisel. 1984. Performance of grass filters under laboratory and field conditions. Trans. ASAE. 27(5):1321-1331.

Haan, C.T., B.J. Barfield, and J.C. Hayes. 1993. Design Hydrology and Sedimentology of Small Catchments. New York: Academic Press (in press).

Jacobs, T. J. and J. W. Gilliam. 1985. Riparian losses of nitrate from agricultural drainage waters. J. Environ. Qual. 14:472-478.

James, L.D. and S.J. Burgues. 1982. Selection, Calibration, and Testing of Hydrologic Models. In Hydrologic Modeling of Small Watersheds, ed. C.T. Haan, H.P. Johnson and D.L. Brakensiek, 295-380. ASAE Monograph no. 5. St. Joseph: ASAE.

Lowrance, R. R., R. L. Todd and L. E. Asmussen. 1984. Nutrient cycling in an agricultural watershed: Streamflow and artificial drainage. J. Environ. Qual. 13:27-32.

Lowrance, R. R., J. K. Sharpe and J. M. Sheridan. 1986. Long-term sediment deposition in the riparian zone of a Coastal Plain Watershed. J. Soil and Water Cons. 41:266-271.

Magette, W. L., R. B. Brinsfield, R. E. Palmer, and J. D. Wood. 1989. Nutrient and sediment removal by vegetated filter strips. Trans. of the ASAE 32(2):663-667.

Mein, R.G. and C.L. Larson. 1971. Modelling the infiltration component of the rainfall-runoff process, Bulletin 43, University of Minnesota, MN, Water Resources Research Center.

Mein, R.G. and C.L. Larson. 1973. Modeling infiltration during a steady rain. Water Resourc. Res. 9(2):384-394.

McCuen R.H. and W.M. Snyder. 1975. A proposed index for comparing hydrographs.

Water. Resour. Res. AGU. 11(6):1021-1024.

Montas, H.J. and C.A. Madramootoo. 1991. Using the ANSWERS model to predict runoff and soil loss in Southwestern Quebec. Trans. ASAE. 34(4):1754-1762.

Muñoz-Carpena, R. 1993. Modeling Hydrology and sediment transport in vegetative filter strips. Ph.D. dissertation. North Carolina State University. Raleigh.

Muñoz-Carpena, R, J.E. Parsons and J.W. Gilliam. 1993a. Numerical approach to the overland flow problem in vegetative filter strips. Trans. of the ASAE (in press).

Muñoz-Carpena, R, J.E. Parsons and J.W. Gilliam. 1993b. Modeling overland flow and sediment transport in vegetative filter strips: (1) Model development and application. Submitted to Trans. of the ASAE (companion paper).

Muñoz-Carpena, R., C.T. Miller, J.E. Parsons. 1993c. A quadratic Petrov-Galerkin solution for kinematic wave overland flow. Water Resour. Res. (in press).

Peterjohn, W. T. and D. T. Correll. 1984. Nutrient dynamics in an agricultural watershed: Observations on the role of a riparian forest. Ecology. 65:1466-1475.

Parsons, J. E., R. B. Daniels, J. W. Gilliam and T. A. Dillaha. 1991. The effect of vegetation filter strips on sediment and nutrient removal from agricultural runoff. In Proc. of the Environmentally Sound Agriculture Conference, ed. A.B. Bottcher, K.L. Campbell and W.D. Graham, 324-332. Orlando, FL, 16-18 April.

Shirmohammadi, A. and R.W. Skaggs. 1984. Effect of soil surface conditions on infiltration for shallow water table soils. Trans. ASAE. 27(6):1780-1787.

Tollner, E.W., B.J. Barfield, C.T. Haan and T.Y. Kao. 1976. Suspended sediment filtration capacity of simulated vegetation. Trans. ASAE. 19(4):678-682.

Tollner, E.W., B.J. Barfield, C. Vachirakornwatana and C.T. Haan. 1977. Sediment deposition patterns in simulated grass filters. Trans. ASAE. 20(5):940-944.

Wilson, B.N., B.J. Barfield and I.D. Moore. 1981. A Hydrology and Sedimentology Watershed Model, Part I: Modeling Techniques.. Technical Report. Department of Agricultural Engineering. University of Kentucky. Lexington.

Woolhiser, D.A. 1975. Simulation of unsteady overland flow. In Unsteady Flow in Open Channels. Vol. II Ed. K. Mahmood and V. Yevjevich, 485-508, Fort Collins, CO, Water Resources.

Woolhiser ,D.A., R.E. Smith and D.C. Goodrich. 1990. KINEROS, A Kinematic Runoff and Erosion Model: Documentation and User Manual. USDA-ARS. ARS-Publication no. 77.

Young, R. A., R. Huntrods, and W. Anderson. 1980. Effectiveness of vegetative buffer strips in controlling pollution from feedlot runoff. J. Environ. Qual. 9:483-487.

APPENDICES

APPENDIX 1

SOIL SAMPLING AND SIMULATION PARAMETERS

Introduction

Several actions have been undertaken to obtain a better understanding of the nature of the soils in the experimental sites and to gather a basic data set of soil properties to be used on undergoing research. Physical properties were paid special attention by means of on-field experiments and lab determinations, namely:

1. - Infiltration test.

2. - Soil profile description.

3. - Soil textures

4. - Soil bulk (*db*)and particle density (*ds*)

5. - Soil porosity (*n*) and void ratio (*e*).

6. - Saturated hydraulic conductivity (K_s)

7. - Suction curves ($\theta(h)$).

8. - Calculation of the unsaturated conductivity relationships at the grass buffers (K_{uns}).

9. - Determination of the Green-Ampt parameters at the grass buffers (*A*,*B*).

10.- Surface topography (S_o).

11- Estimation of grass spacing (S_s).

Field Work

Infiltrometer tests.

Infiltration measurements, when enhanced by simultaneous measurement of such other quantities as soil water content or potential, provide in-situ, large-sample techniques for determination of soil hydraulic properties (Amerman, 1983). The parameters thus obtained are a good indication of the real infiltration capacity of the field surface and its variation.

The infiltrometer used was a double ring infiltrometer of the Muntz type. This simple device auto-regulates the water level inner ring by air pressure, while the outer ring was supplied with a big container at regular intervals. Eight of these infiltrometers were built and calibrated. A number of measurements were conducted in the Unit 9 site, over the grass and field areas. The huge variability of the results obtained make the use of the results from this test impractical. They are, however, used as an indication of the natural variability in our soils.

Soil profile description

Pits for the soil profile description were open in both experimental sites under the direction of Dr. Daniels (Soil Science, NCSU) with the aid of a small tractor. Five were open in Unit 9 (Raleigh), three in the field, one in each third of the down slope dimension, one in the grass buffer and one in the riparian area. Six were open in the Kinston site, three in the field, two in the grass buffer at different points in the length, and one in the riparian two (Figs. 1 and 2). The profile was then described and the layers marked by Dr. Daniels. This initial study proved to be an essential step in the soil core extraction.

Extraction of soil cores

Following the soil layering, cores were extracted for each layer down to the third or fourth, depending on the amount of stones found in each pit. Two types of cores were

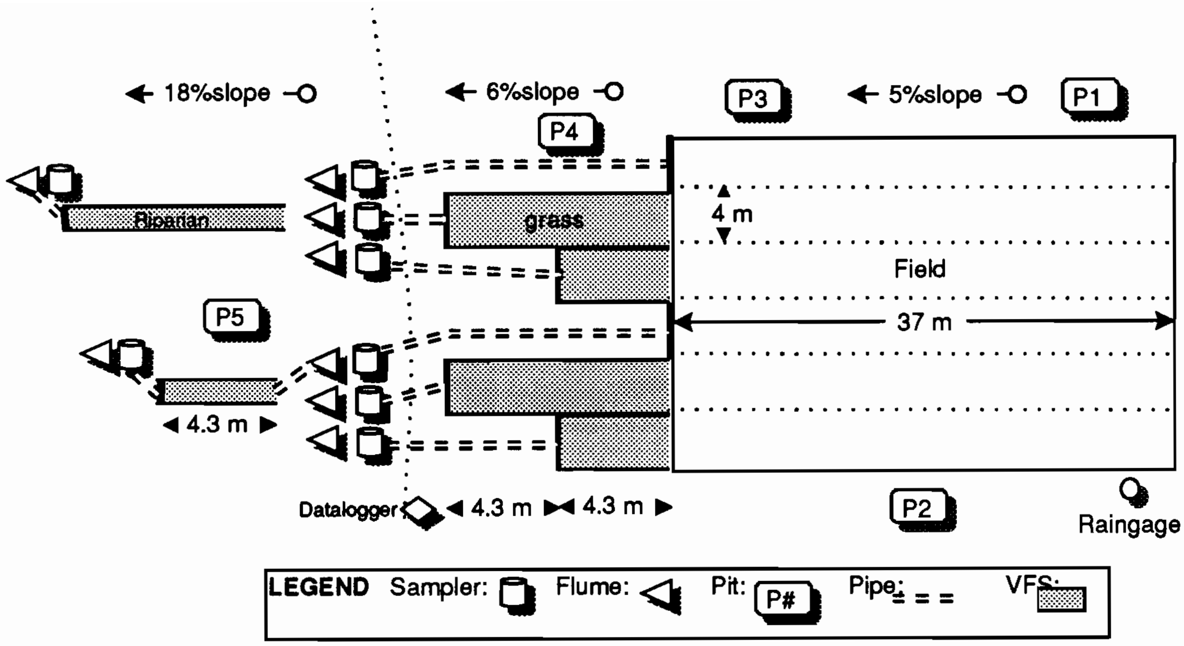


Figure 1. Raleigh field experimental layout showing location of pits for soil sampling

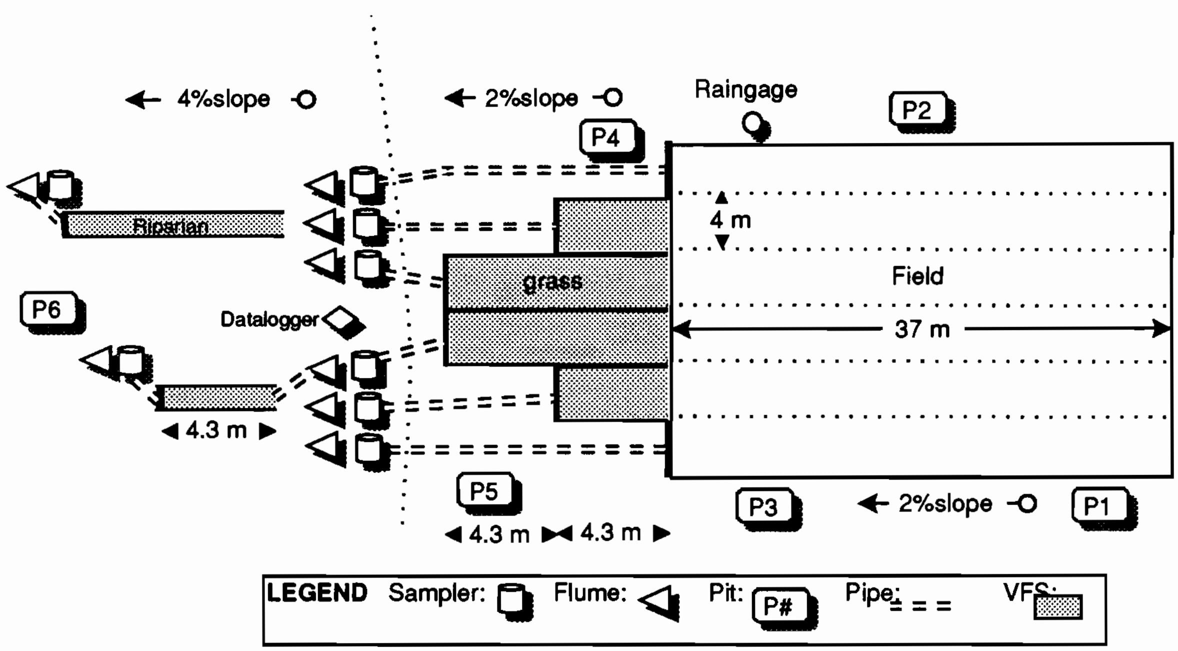


Figure 2. Kinston field experimental layout showing location of pits for soil sampling

extracted (with replications), horizontal and vertical, to study the effect of orientation on the physical properties. The core rings were aluminum rings of 7.62 cm of diameter and 7.62 cm of height. To avoid disturbance of the samples as much as possible, a double-cylinder, hammer driven core sampler (Blake and Hartge, 1986) was used for the vertical cores and steel couplings for the horizontal. A total of 56 cores was taken in Unit 9 and 55 at Kinston. Unit 9 presented difficulties due to the presence of gravel in the profile.

Laboratory Analyses And Calculations

Saturated hydraulic conductivity (K_s).

The constant head method was implemented using the simple apparatus proposed by Klute and Dirksen (1986), based on the application of Darcy's Law. Special care was given to slowly wetting the samples during a 24 h. period to avoid air entrapment. Some samples were discarded at this stage since preferential flow, caused by some gravel and think roots, gave unrealistic results. Readings were taken every 2 to 8 hours over a 48 h. period or until equilibrium was reached.

Soil and water characteristic curves ($\theta(h)$).

After the wetting period (24 h.) some of the cores were prepared for the soil and water characteristic curve (SWCC) determination. The curve measured is the drainage curve using a positive pressure device with ceramic porous plate of bubbling pressure of 1 bar (10 m of water) (Klute, 1986). Thirteen pressure steps were taken for each curve, from 0-600 cm of water. For each pressure step, volumes drained after 24 h. were measured. A bleed type air pressure regulator was used along with a high capacity air compressor. The pressure in the cells was measured with a water manometer for up to 100 mm and then with a mercury manometer. After the last pressure step the cores were weighted, dried in an oven at 105°C for 24 h and weighted again to obtain the residual saturation after the last pressure step. The curves were constructed backwards, adding up volumes of water until saturation for each step. Temperature was monitored and a control beaker placed to correct for evaporation effects. Again, air entrapment was considered negligible in this procedure.

Soil density and porosity.

Additional calculations to determine the mass and volume of the soil in the cores were made. The assumption here was that at sampling time all cores were full, i.e. and initial volume of the soil sample was equal to that of the core. An additional assumption is that air and moisture entrapment (after drying) are negligible. This is equivalent to saying that the total water content at saturation is equal to porosity. With these values the following parameters were calculated (Skaggs, 1990):

-*total porosity* (n= volume of pore space [Vv] divided by total volume [Vt]),

-*void ratio* (e= Vv divided by volume of solids or dry soil [Vs])

-*bulk density* (db= Mass of dry soil [Ms] divided by Vt)

-*particle density* (ds= Ms/Vs)

Particle size distribution

Cores were grouped by layer for each field location, mixed, grinded, put into soil boxes and labeled. They were then sent to the USDA Soils Lab (Method Rd.) for particle size distribution analysis (Gee and Bauder, 1986).

Additional calculations.

Additional calculations were made with the data from the buffer strips to obtain the Green-Ampt parameters needed in the simulations. Unsaturated conductivity relationships (*Kuns(h))* were obtained from the SWCC, for each layer using the Millington and Quirk (1956) procedure. The average suction at the front, *Sav* was then estimated as the area under the *Kuns* curve.

Results from Soil Sampling

General results

Tables 1a-1b summarize the data for both field sites. The Raleigh site has more clay deeper into the soil profile than the Kinston site. Both sites are sandy-loam or loamy-sand at the surface layer (Ap) but in the Raleigh site the clay content increases with depth, whereas the sandy texture remains homogenous in Kinston. The typical ranges for vertical saturated hydraulic conductivity are 0.3-7.1 cm/h and 0.6-7.1cm/h (mean for horizontal ones.

Table 1a. Mean soil properties at Unit 9 (Raleigh, NC).

Pit No.	Layer	Depth (cm)	Texture	n<>Os	e	db (g/cm3)	ds (g/cm3)	Ksv (cm/h)	Ksh (cm/h)	Os (cm3/cm3)	Or (cm3/cm3)	Sav (cm)
1	Ap	0-18	S-L	0.341	0.518	1.64	2.49	2.11	4.93	0.341	0.091	--
Upper	B1t	18-43	S-C-L	0.374	0.597	1.57	2.51	0.60	14.46	0.374	0.124	--
Field	Bt2	43-71	S-C-L	0.428	0.756	1.47	2.58	5.18	2.50	0.428	0.178	--
	Bt3	71-104	SC	0.405	0.686	1.48	2.49	1.87	2.16	0.405	0.155	--
2	Ap	0-20	S-L	0.303	0.436	1.66	2.38	1.28	0.94	0.303	0.053	--
Mid	B1t	20-38	S-C	0.373	0.596	1.53	2.44	0.36	13.83	0.373	0.123	--
Field	Bt2	38-61	--	0.439	0.783	1.45	2.59	1.94	1.81	0.439	0.189	--
	Bt3	61-107	C	0.482	0.931	1.48	2.86	1.32	1.96	0.482	0.232	--
3	Ap	0-23	S-L	0.319	0.470	1.66	2.43	13.56	0.97	0.319	0.069	--
Lower	B1t	23-43	S-C-L	0.298	0.380	1.61	2.22	26.05	2.55	0.298	0.048	--
Field	Bt2	43-91	C	0.443	0.795	1.35	2.42	1.17	--	0.443	0.193	--
	Bt3	91-107	--	0.470	0.887	1.50	2.82	2.46	2.46	0.470	0.220	--
4	Ap	0-23	S-L	0.324	0.480	1.72	2.54	4.78	7.85	0.311	0.090	38.30
Grass	B1t	23-41	C	0.438	0.779	1.29	2.29	2.37	4.74	0.436	0.147	7.50
buffer	Bt2	41-69	S-C	0.433	0.775	1.50	2.64	4.93	2.02	0.376	0.129	2.30
	Bt3	69-94	S-C-L	0.460	0.850	1.52	2.81	4.19	0.60	0.445	0.119	3.40
5	Ap	0-20	S-L	0.306	0.444	1.69	2.44	6.14	2.29	0.306	0.056	8.825
Riparian	B1t	20-56	--	0.416	0.712	1.44	2.46	6.44	2.75	0.416	0.166	1.141
	Bt2	56-104	--	0.545	1.197	1.15	2.52	1.20	2.79	0.545	0.295	29.031
	Bt3	104-127	--	0.567	1.312	1.11	2.55	0.72	3.70	0.567	0.317	15.856

Nomenclature: n= Total porosity; e= Void ratio; db= Bulk density; ds= Particle density

The values for porosity (<>θs) range 0.31-0.57 (mean=0.40) at Unit 9 and 0.29-0.46 (mean=0.36) in Kinston due to the higher sand content. Bulk and particle density have mean values of 1.5 and 2.5 g/cm respectively.

Table 1b. Mean soil properties at Kinston, NC.

Pit No.	Layer	Depth	Texture	db (**g/cm3)	e (**)	ds (**g/cm3)	Ksv (cm/h)	Ksh (cm/h)	Os (cm3/cm3)	Or (cm3/cm3)	Sav (cm)
1	Ap	0-25	L-S	1.55	0.550	2.40	4.79	25.80	0.354	0.104	--
Upper	E	25-48	L-S	1.75	0.428	2.49	0.58	-	0.299	0.049	--
Field	Bt1	48-79	S-L	1.57	0.534	2.40	0.31	-	0.348	0.098	--
	Bt2	79-99	-	-	-	-	-	-	-	-	-
	Bt3	99-114	-	-	-	-	-	-	-	-	-
2	Ap	0-28	L-S	1.60	0.407	2.25	5.34	6.08	0.289	0.039	--
Mid	E	28-43	L-S	1.69	0.562	2.64	7.09	-	0.359	0.109	--
Field	Bt1	43-69	S-L	1.62	0.430	2.32	0.39	0.39	0.296	0.046	--
	Bt2	69-89	-	-	-	-	-	-	-	-	-
	Bt3	89-117	-	-	-	-	-	-	-	-	-
3	Ap	0-28	L-S	1.61	0.595	2.56	3.15	5.71	0.371	0.121	--
Lower	Bt1	28-43	S-L	1.55	0.598	2.48	0.29	0.30	0.374	0.124	--
Field	Bt2	43-94	-	-	-	-	-	-	-	-	-
	Bt3	94-117	-	-	-	-	-	-	-	-	-
4	Ap	0-23	L-S	1.55	0.598	2.48	3.62	6.56	0.374	0.124	5.40
Grass	IIAB	23-41	L-S	1.56	0.593	2.52	4.45	-	0.370	0.120	1.50
buffer	IIEb	41-69	-	-	-	-	-	-	-	-	-
	IIBt	69-89	-	-	-	-	-	-	-	-	-
5	Ap	0-25	L-S	1.59	0.501	2.39	4.21	4.36	0.327	0.077	3.90
Grass	IIAB	25-44	L-S	1.56	0.500	2.34	1.52	4.15	0.332	0.082	1.40
buffer	IIEb	44-65	-	-	-	-	-	-	-	-	-
	IIBt1b	65-94	-	-	-	-	-	-	-	-	-
	IIBt2b	94-132	-	-	-	-	-	-	-	-	-
6	A1	0-13	S-L	1.21	0.873	2.27	6.15	4.50	0.564	0.135	1.698
Riparian	E	13-25	L-S	1.39	0.631	2.27	7.08	-	0.373	0.104	5.872
	BA	25-36	S-C-L	1.41	0.832	2.58	0.87	0.61	0.446	0.204	0.635
	Bt1	36-58	-	-	-	-	-	-	-	-	-
	Bt2	58-91	-	-	-	-	-	-	-	-	-

Nomenclature:

e= Void ratio
db= Bulk density
ds= Particle density
S, L= Sand, Loam

Ksv= Vertical saturated Conductivity
Ksh= Horizontal saturated Conductivity
Os, Or= Saturated and residual water contents
Sav= Average suction at the wetting front

Tables 2a-2b summarize the data for the SWCC, volumetric water content (cm^3/cm^3) vs. suction (cm), for both sites. The Layer/H or V symbol at the head of the column stands for vertical or horizontal cores.

Table 2a. Suction curves for soil cores extracted at the Piedmont site.

	Pit #1		Pit #2		Pit #3		Pit #4		Pit #5		Pit #1		Pit #2		Pit #3		Pit #4		Pit #5	
cm3/cm3	Ap/V	Ap/H	Ap/V	Ap/H	Ap/V	Ap/H	Ap/V	Ap/H	Ap/V	Ap/H	Bt1/V	Bt1/H	Bt1/V	Bt1/H	Bt1/V	Bt1/H	Bt1/V	Bt1/H	Bt1/V	Bt1/H
cm																				
0.0	0.337	0.345	0.315	0.292	0.307	0.332	0.315	0.333	0.334	0.279	0.373	0.375	0.355	0.390	0.298	0.251	0.439	0.437	0.409	0.423
3.8	0.323	0.341	0.313	0.288	0.304	0.329	0.311	0.317	0.332	0.251	0.366	0.370	0.351	0.388	0.281	0.211	0.436	0.434	0.383	0.390
5.9	0.323	0.341	0.313	0.287	0.304	0.329	0.311	0.316	0.332	0.250	0.355	0.370	0.351	0.388	0.277	0.205	0.436	0.434	0.381	0.373
14.1	0.320	0.341	0.313	0.274	0.301	0.329	0.311	0.313	0.295	0.250	0.342	0.363	0.340	0.359	0.255	0.199	0.364	0.403	0.374	0.367
24.0	0.315	0.341	0.313	0.258	0.301	0.309	0.311	0.299	0.275	0.227	0.335	0.360	0.332	0.344	0.248	0.189	0.346	0.377	0.363	0.357
33.8	0.307	0.341	0.313	0.251	0.301	0.292	0.311	0.290	0.262	0.222	0.329	0.355	0.327	0.336	0.239	0.172	0.335	0.368	0.358	0.351
44.1	0.300	0.341	0.313	0.248	0.274	0.281	0.281	0.283	0.252	0.219	0.326	0.349	0.321	0.330	0.235	0.167	0.323	0.362	0.354	0.348
54.0	0.292	0.296	0.304	0.241	0.266	0.271	0.275	0.277	0.244	0.216	0.322	0.344	0.318	0.324	0.232	0.166	0.318	0.355	0.350	0.345
64.0	0.287	0.285	0.291	0.237	0.261	0.260	0.271	0.268	0.236	0.213	0.319	0.342	0.314	0.320	0.229	--	0.315	0.352	0.345	0.342
104.2	0.238	0.236	0.259	0.214	0.238	0.222	0.249	0.241	0.216	0.203	0.311	0.330	0.302	0.307	0.219	--	0.305	0.342	0.337	0.335
153.9	0.207	0.204	0.243	0.199	0.212	0.198	0.226	0.215	0.203	0.196	0.304	0.321	0.294	0.298	0.215	--	0.300	0.334	0.329	0.329
203.8	0.193	0.190	0.231	0.191	0.197	0.185	0.212	0.201	0.193	0.190	0.295	0.314	0.288	0.292	0.212	--	0.298	0.329	0.322	0.324
403.8	0.174	0.158	0.218	0.175	0.177	0.166	0.187	0.174	0.174	0.174	0.279	0.300	0.273	0.278	0.207	--	0.295	0.318	0.308	0.314
603.8	0.163	0.146	0.209	0.165	0.163	0.155	0.174	0.159	0.161	0.164	0.273	0.290	0.265	0.272	0.205	--	--	0.311	0.298	0.305
739.8	0.156	0.144	0.199	0.161	0.154	0.148	0.166	0.152	0.152	0.158	0.260	0.284	0.259	0.262	0.202	--	--	0.308	0.292	0.299

	Pit #1		Pit #2		Pit #3		Pit #4		Pit #5		Pit #1		Pit #2		Pit #3		Pit #4		Pit #5	
cm3/cm3	Bt2/V	Bt2/H	Bt2/V	Bt2/H	Bt2/V	Bt2/H	Bt2/V	Bt2/H	Bt2/V	Bt2/H	Bt3/V	Bt3/H	Bt3/V	Bt3/H	Bt3/V	Bt3/H	Bt3/V	Bt3/H	Bt3/V	Bt3/H
cm																				
0.0	0.388	0.468	0.435	0.443	0.443	--	0.387	0.479	0.545	--	0.435	0.376	0.466	0.498	0.470	--	0.460	--	0.550	0.584
3.8	0.368	0.445	0.432	0.429	0.431	--	0.376	0.467	0.535	--	0.406	0.365	0.445	0.479	0.453	--	0.445	--	0.547	0.558
8.6	0.359	0.445	0.432	0.429	0.431	--	0.376	0.467	0.535	--	0.396	0.365	0.444	0.479	0.431	--	0.439	--	0.544	0.545
13.8	0.351	0.442	0.432	0.429	0.431	--	0.376	0.467	0.535	--	0.391	0.365	0.444	0.479	0.424	--	0.428	--	0.542	0.540
23.8	0.336	0.432	0.432	0.423	0.421	--	0.376	0.458	0.535	--	0.380	0.365	0.444	0.479	0.416	--	0.416	--	0.536	0.526
33.8	0.326	0.422	0.432	0.412	0.411	--	0.370	0.450	0.535	--	0.374	0.362	0.444	0.477	0.409	--	0.408	--	0.527	0.515
43.8	0.319	0.413	0.406	0.409	0.404	--	0.361	0.447	0.527	--	0.368	0.362	0.444	0.475	0.404	--	0.389	--	0.521	0.506
53.8	0.310	0.401	0.400	0.397	0.393	--	0.353	0.444	0.519	--	0.363	0.361	0.444	0.472	0.398	--	0.383	--	0.520	0.497
63.8	0.304	0.394	0.396	0.393	0.385	--	0.350	0.441	0.516	--	0.360	0.358	0.444	0.469	0.388	--	0.376	--	0.516	0.481
103.8	0.293	0.370	0.384	0.367	0.375	--	0.338	0.430	0.513	--	0.348	0.345	0.420	0.463	0.381	--	0.333	--	0.504	0.466
153.8	0.274	0.348	0.377	0.359	0.358	--	0.322	0.417	0.502	--	0.337	--	0.411	0.443	--	--	0.321	--	0.496	0.463
203.8	--	0.332	0.371	--	0.341	--	--	0.407	--	--	0.331	--	0.402	--	--	--	0.298	--	0.487	--
403.8	--	0.298	0.360	--	--	--	--	0.388	--	--	0.317	--	--	--	--	--	--	--	0.467	--
603.8	--	0.281	0.351	--	--	--	--	0.378	--	--	0.305	--	--	--	--	--	--	--	0.455	--

NOTE: Areas with "--" are those data points where leaks developed. The curves could be wrong in these cases due to drying of the core.

Table 2b. Suction curves for soil cores extracted at the Coastal Plain site

		Pit# 1				Pit# 2							Pit# 3		
cm3/cm3 cm	Ap/V	Ap/H	E/H	Bt1/V	Ap/V	Ap/H	E/H	E/V	Bt1/V	Bt1/H	Ap/V	Ap/V	Ap/H	Bt1/V	Bt1/H
0.0	0.357	0.347	0.313	0.334	0.342	0.342	0.279	0.281	0.355	0.344	0.564	0.318	0.207	0.348	0.414
3.8	0.332	0.324	0.281	0.317	0.307	0.330	0.254	0.279	0.304	0.321	0.528	0.289	0.190	0.301	0.368
6.3	0.332	0.324	0.281	0.317	0.307	0.330	0.254	0.279	0.304	0.321	0.527	0.289	0.190	0.301	0.365
13.8	0.329	0.298	0.281	0.313	0.306	0.327	0.251	0.270	0.304	0.312	0.498	0.286	0.182	0.296	0.365
33.8	0.310	0.269	0.274	0.300	0.293	0.304	0.242	0.244	0.304	0.301	0.435	0.275	0.159	0.288	0.305
63.8	0.270	0.206	0.223	0.285	0.267	0.238	0.210	0.195	0.289	0.291	0.379	0.217	0.110	0.276	0.287
103.8	0.172	0.148	0.164	0.262	0.240	0.169	0.164	0.158	0.275	0.272	0.315	0.157	0.055	0.256	0.273
203.8	0.127	0.125	0.127	0.243	0.143	0.140	0.130	0.126	0.255	0.249	0.281	0.136	0.029	0.233	0.256
403.8	0.117	0.097	0.114	0.228	0.117	0.111	0.107	0.115	0.249	0.235	0.166	0.111	0.009	0.213	0.247
603.8	0.104	0.086	0.111	0.216	0.102	0.098	0.097	0.115	0.240	0.224	0.148	0.103	0.009	0.200	0.241

		Pit# 4				Pit# 5				Pit# 6			
cm3/cm3 cm	Ap/V	Ap/H	IIAB/V	IIAB/H	Ap/V	Ap/H	IIApb/V	IIApb/H	Ap/V	Ap/H	E/V	E/H	Bt1/H
0.0	0.349	0.377	0.385	0.365	0.379	0.202	0.331	0.386	0.564	0.419	0.373	0.417	0.446
3.8	0.338	0.339	0.353	0.311	0.356	0.187	0.300	0.364	0.528	0.396	0.359	0.353	0.397
6.3	0.335	0.339	0.352	0.311	0.319	0.187	0.300	0.357	0.527	0.396	0.359	0.351	0.397
13.8	0.315	0.335	0.350	0.311	0.183	0.182	0.297	0.351	0.498	0.365	0.350	0.351	0.397
33.8	0.299	0.316	0.316	0.302	0.083	0.164	0.277	0.319	0.435	0.319	0.293	0.314	0.397
63.8	0.260	0.290	0.273	0.236	0.054	0.144	0.199	0.268	0.379	0.249	0.221	0.245	0.377
103.8	0.182	0.204	0.179	0.184	0.045	0.075	0.121	0.250	0.315	0.201	0.166	0.201	0.357
203.8	0.142	0.164	0.142	0.146	0.042	0.031	0.110	0.250	0.281	0.166	0.146	0.155	0.319
403.8	0.134	0.141	0.116	0.131	0.036	0.012	0.093	0.250	0.166	0.132	0.115	0.150	0.302
603.8	0.131	0.132	0.106	0.115	0.033	0.012	0.086	0.250	0.148	0.112	0.104	0.138	0.285

Results for computer simulations

Data from the buffer strips at each site was selected and additional calculations were performed as described in section 2.5 (Tables 3a-3b). Final values from the two Kinston buffer area pits (No. 4 and 5) were averaged to come to a representative set of values.

Table 3a. Simulation parameters for grass area in Piedmont site

(*)Layer	Depth (cm)	Texture	n	e	db (g/cm3)	ds (g/cm3)	Ksv (cm/h)	Ksh (cm/h)	Os (cm3/cm3)	Or	Sav (cm)
					(Grass buffer area)						
Ap	0-23	SL	0.319	0.470	1.66	2.43	4.78	7.85	0.311	0.090	37.90
B1t	23-41	C	0.298	0.380	1.61	2.22	2.37	4.74	0.436	0.147	7.50
Bt2	41-69	SC	0.443	0.795	1.35	2.42	4.93	2.02	0.376	0.129	2.30
	69-94	SCL	0.470	0.887	1.50	2.82	4.19	0.60	0.445	0.119	3.40
					(Riparian area)						
Ap	0-20	S-L	0.306	0.444	1.69	2.44	6.14	2.29	0.306	0.056	8.825
B1t	20-56	--	0.416	0.712	1.44	2.46	6.44	2.75	0.416	0.166	1.141
Bt2	56-104	--	0.545	1.197	1.15	2.52	1.20	2.79	0.545	0.295	29.031
Bt3	104-127	--	0.567	1.312	1.11	2.55	0.72	3.70	0.567	0.317	15.856

(*) n= Total porosity; e= Void ratio; S, C, L= Sand, Clay, Loam; Sav= Average suction at the wetting front; Os, Or= Saturated and residual water contents; Ksv,Ksh= Vertical/horizontal saturated conductivity; db= Soil bulk density; ds= Soil particle density

Table 3b. Simulation parameters for grass area in Coastal Plain site

Layer	Depth (cm)	Texture	db (g/cm3)	e	ds (g/cm3)	Ksh (cm/h)	Ksv (cm/h)	Os (cm3/cm3)	Or (cm3/cm3)	Sav (cm)
					Pit #4 - Grass					
Ap	0-23	L-S	1.55	0.598	2.48	6.56	3.62	0.374	0.124	5.40
IIAB	23-41	L-S	1.56	0.593	2.52	-	4.45	0.370	0.120	1.50
IIEb	41-69	-	-	-	-	-	-	-	-	-
IIBt	69-89	-	-	-	-	-	-	-	-	-
					Pit #5 - Grass					
Ap	0-25	L-S	1.59	0.501	2.39	4.36	4.21	0.327	0.077	3.90
IIAB	25-44	L-S	1.56	0.500	2.34	4.15	1.52	0.332	0.082	1.40
IIEb	44-65	-	-	-	-	-	-	-	-	-
IIBt1b	65-94	-	-	-	-	-	-	-	-	-
IIBt2b	94-132	-	-	-	-	-	-	-	-	-
					Mean values grass area					
Ap	0-24	L-S	1.57	0.549	2.44	5.46	3.92	0.350	0.100	4.65
IIAB	24-42.5	L-S	1.56	0.547	2.43	4.15	2.99	0.351	0.101	1.45
					Pit#6 - Riparian					
A1	0-13	S-L	1.21	0.873	2.27	6.15	4.50	0.564	0.135	1.70
E	13-25	L-S	1.39	0.631	2.27	7.08	-	0.373	0.104	5.87
BA	25-36	S-C-L	1.41	0.832	2.58	0.87	0.61	0.446	0.204	0.63

Key: e= Void ratio; db= Bulk density; ds= Particle density; Ksv= Vertical saturated Conductivity; Ksh= Horizontal saturated Conductivity; Os, Or= Saturated and residual water content; S, L= Sand, Loam; Sav= Average suction at the wetting front

Topographical Survey

Nodal slopes were determined by a topographical field survey. A dense grid was laid down on the areas (a total of 191 points per site: 24 points in each of the short strips, 45 in each long strips). The transversal values of slope (to the direction of flow) were averaged to obtain a width averaged set of slopes for each strip. These values were used for simulation purposes. A 1-D grid of 50 nodes was selected for each strip with 7 to 14 segments of equal slope corresponding to the later average slopes. A summary of these results can be found in Tables 4a-b. A diagram showing the filter dimensions used in the simulations (Fig. 3) and a contour map prepared with the results from the surveys at Unit 9 is also included (Fig. 4).

Table 4a. Average field slopes for The filters in the Piedmont experimental site

Point	x(m)	g4-1	g4-2	g8-1	g8-2	r-1	r-2
1	0.0000	0.0208	0.0678	0.0389	0.0667	0.1299	0.3083
2	0.6096	0.0208	0.0678	0.0389	0.0667	0.1299	0.3083
3	1.2192	0.1056	0.0002	0.0583	0.0069	0.2264	0.1514
4	1.8288	0.0542	0.1042	0.0542	0.0889	0.1875	0.1826
5	2.4384	0.0722	0.0250	0.1056	0.0444	0.1861	0.2757
6	3.0480	0.0569	0.0264	0.0347	0.0292	0.3125	0.1375
7	3.6576	0.0847	0.0417	0.0222	0.0167	0.0903	0.3049
8	4.3942	0.0805	0.0471	0.0356	0.0241	0.1483	0.1477
9	4.8768	--	--	0.0368	0.0211	--	0.3877
10	5.4864	--	--	0.0750	0.0083	--	0.1861
11	6.0960	--	--	0.0917	0.1764	--	0.2500
12	6.7056	--	--	0.0667	0.0917	--	0.1861
13	7.3152	--	--	0.0750	0.0736	--	0.3194
14	7.9248	--	--	0.0431	0.0389	--	0.2083
15	8.6106	--	--	0.0543	0.0704	--	0.1086
	Mean values=	6.78%	4.46%	5.66%	5.41%	18.30%	22.53%

Table 4b. Average field slopes for The filters at the Coastal Plain experimental site

Point	x(m)	g4-1	g4-2	g8-1	g8-2	r-1	r-2
0	0.00	--	--	--	--	--	--
1	0.50	0.0051	0.0240	0.0471	0.0384	0.071	0.058
2	1.00	0.1422	0.0224	0.0278	0.0322	0.032	0.039
3	1.50	0.0042	0.0196	0.0053	0.0213	0.022	0.028
4	2.00	0.0098	0.0189	0.0089	0.0216	0.025	0.049
5	3.00	0.0262	0.0260	0.0118	0.0186	0.052	0.052
6	4.00	0.0031	0.0087	0.0191	0.0079	0.066	0.054
7	5.00	--	--	0.0083	0.0020	--	0.031
8	6.00	--	--	0.0159	0.0028	--	0.010
9	7.00	--	--	0.0138	0.0160	--	0.023
10	8.00	--	--	0.0003	0.0112	--	0.015
Mean values=		3.18%	1.99%	1.58%	1.72%	4.47%	3.60%

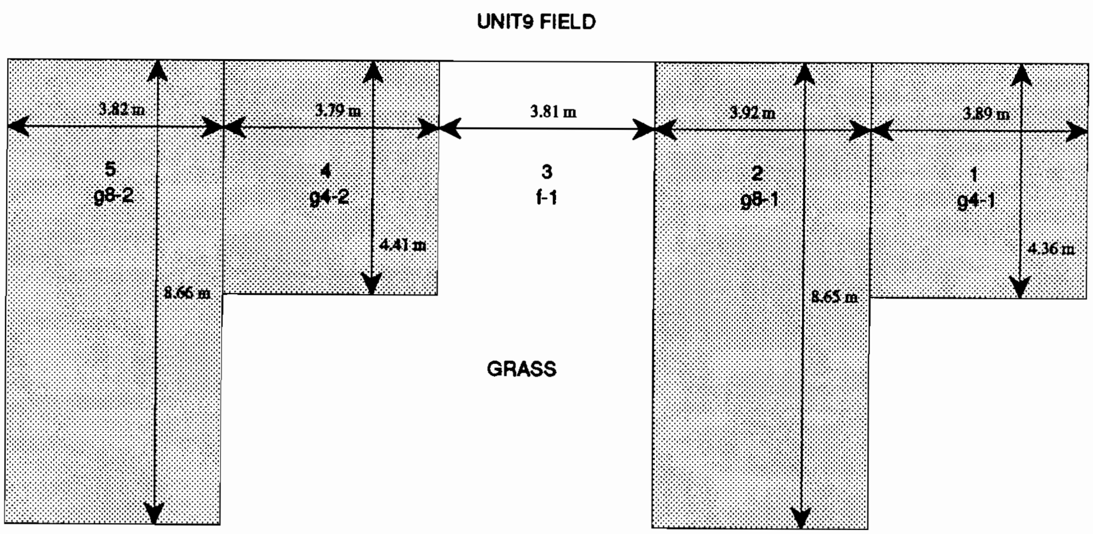


Fig. 3. Filter dimensions at the grass area at Unit 9 (Raleigh, 03/07/93)

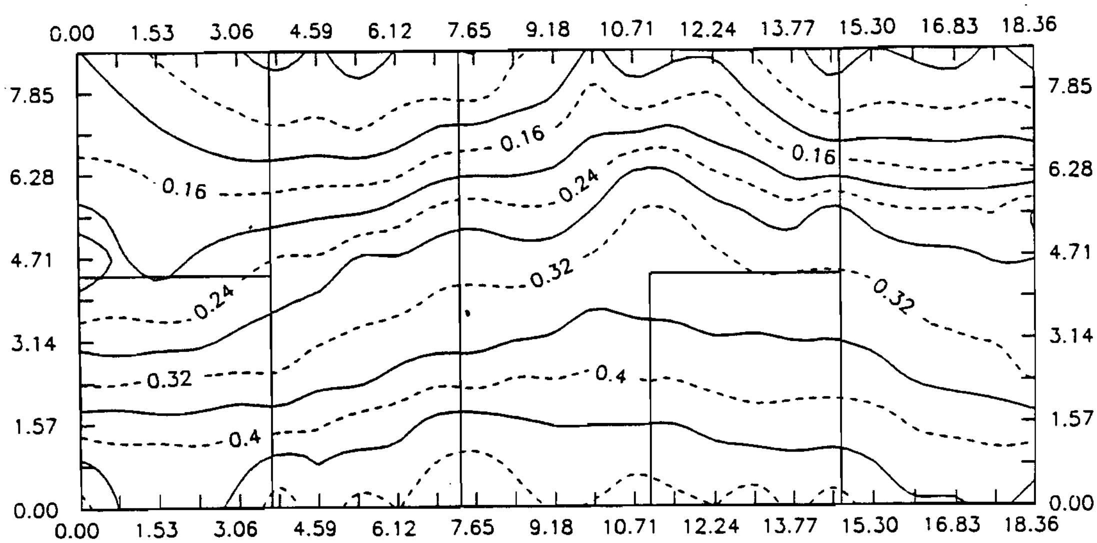


Figure 4. Contour map for the grass filters at Unit 9 (Raleigh, 03/07/93)

Grass Spacing

Data on vegetation cover was collected at the experimental sites. The main objective of these surveys was to a) catalog plant species present, and b) determine vegetation cover. None of these surveys was specifically oriented to the determination of the grass spacing (S_s) value.

The procedure followed was to mark transects, 1 m apart, across the slope for each filter. In each line the length of the different bare spots found was recorded. This was expressed as a percentage of bareness for each line (Tables 5a-b). Haan et al (1993) assign a maximum grass density for the grass species found in the field. These values are 6500, 6250 and 3583 stems/m^2 for fescue, blue grass and grass mixture respectively. For both sites the grass areas where are mostly fescue. In the Coastal plain site, the riparian area 1 (rip-2) is made of sparse dog-fennel (maximum density 250 stems/m^2), whereas riparian 2 was composed mostly of fescue. The %cover values were multiplied by the maximum densities to obtain an actual grass density (AGD), (Tables 5a-b). From the definition of S_S (Wilson et al (1981), and after some manipulation the grass spacing value can be calculated as:

$$S_s = 100\sqrt{\frac{1}{ADG}} \qquad (1)$$

The results of these calculations are obtained for the one survey with sufficient data. For the Piedmont site the average value for grass areas is 2.65 cm. For the Coastal Plain site, the average value for grass areas and riparian area is 2.01 and 12.59 cm respectively. These are starting values in the assessment of field values for this parameter.

Table 5a. Determination of the grass spacing parameter at the Piedmont site (06/26/92).

Plot	cover (%)	AGD (stems/m^2)	S_S (cm)
g4_1	78%	2535	2.81
g8_1	94%	3055	2.56
g4_2	89%	2892	2.63
g8_2	92%	2990	2.59

Table 5b. Determination of the grass spacing parameter at the Coastal Plain site (03/02/93).

d (m)	cover (%)	AGD (stems/m^2)	S_S (cm)	cover (%)	AGD (stems/m^2)	S_S (cm)	cover (%)	AGD (stems/m^2)	S_S (cm)	cover (%)	AGD (stems/m^2)	S_S (cm)	cover (%)	AGD (stems/m^2)	S_S (cm)	cover (%)	AGD (stems/m^2)	S_S (cm)
1.00	69%	4496	2.11	74%	4810	2.04	72%	4680	2.07	63%	4095	2.21	45%	2925	13.33	85%	5525	1.90
2.00	75%	4875	2.03	72%	4680	2.07	79%	5135	1.97	72%	4680	2.07	65%	4225	11.09	75%	4875	2.03
3.50	81%	5265	1.95	83%	5395	1.93	85%	5525	1.90	74%	4810	2.04	45%	2925	13.33	78%	5070	1.99
5.00	--	--	--	83%	5395	1.93	80%	5200	1.96	--	--	--	--	--	--	77%	5005	2.00
7.00	--	--	--	84%	5460	1.91	79%	5135	1.97	--	--	--	--	--	--	75%	4875	2.03

Bibliography

Amerman, C.R. 1983. Infiltration measurements. In Proceedings of the National Conference on Advances in Infiltration, Dec. 12-13, 1983, Chicago, Illinois.

Blake, G.W. and K.H. Hartge. 1986. Bulk density. In Methods of Soil Analysis, 2nd Ed., Part 1. Physical and Mineralogical Properties. Am. Soc. Agron. Monograph 9:1.

Bower, H. 1986. Cylinder infiltrometers. In Methods of Soil Analysis, 2nd Ed., Part 1. Physical and Mineralogical Properties. Am. Soc. Agron. Monograph 9:1.

Gee, G.W. and J.W. Bauder. 1986. Particle size analysis. In Methods of Soil Analysis, 2nd Ed., Part 1. Physical and Mineralogical Properties. Am. Soc. Agron. Monograph 9:1.

Klute, A. 1986. Water retention: Laboratory methods. In Methods of Soil Analysis, 2nd Ed., Part 1. Physical and Mineralogical Properties. Am. Soc. Agron. Monograph 9:1.

Klute, A. and C.Dirksen. 1986. Hydraulic conductivity and diffusivity: Laboratory methods. In Methods of Soil Analysis, 2nd Ed., Part 1. Physical and Mineralogical Properties. Am. Soc. Agron. Monograph 9:1.

Roquero, C. and J.Porta. 1986. Agenda de campo para el estudio del suelo. . 4th. Ed. UPM-ETS Ingenieros Agrónomos, Madrid, Spain. 190pp

Skaggs, R.W. 1990. Advance Dainage I. Class notes. BAE depart. NCSU, Raleigh, NC.

Wilson, B.N., B.J. Barfield and I.D. Moore. 1981. A Hydrology and Sedimentology Watershed Model, Part I: Modeling Techniques.. Technical Report. Department of Agricultural Engineering. University of Kentucky. Lexington.

APPENDIX 2: FLOOD WAVE ASSUMPTION

The interaction between the overland flow and the Green-Ampt (G-A) model is based on the assumption that the flood wave from the field will supply enough water to sustain maximum infiltration as dictated by the G-A model. A check for flooding at the surface is made to determine when the field inflow covers the surface of the buffer to switch infiltration to the maximum rate. By default, the hydrology model checks the first and last nodes of the buffer while running G-A following the regular procedure at the beginning of the simulation. When runoff is detected (h>0) at the first (x=0) and last node (x=L), the infiltration is changed to the maximum infiltration capacity for the last rainfall period when the flood was detected. This assumption could cause problems for the case of soils with high infiltration capacity, where a significant amount of water could be infiltrated before the flood wave reaches the last node of the system. An analysis of sensitivity was performed on 3 soils. The first soil is the Cecil Sandy Loam from our experimental field, the second is a Portsmouth Loamy-Sand and the last one is a hypothetical sand with an extreme infiltration rate (Table 1).

Table 1: Soil parameters used in study

[1]Layer (cm)	Texture	K_{sv} (cm/h)	K_{sh} (cm/h)	θ_s (cm^3/cm^3)	θ_r (cm^3/cm^3)	S_{av} (cm)	θ_i (cm^3/cm^3)
			Cecil Sandy Loam				
[2]Ap 0-23	**SL**	**6.02**	7.85	0.311	0.090	35.7	0.20
			Portsmouth Fine Sandy Loam				
[2]Ap 0-30	**SL**	**7.48**	14.97	0.365	0.12	2.0	0.20
			Hypothetical Sandy				
[2]Ap 0-30	**SL**	**41.18**	82.40	0.365	0.12	2.0	0.20

[1]Nomenclature: K_{sv} = Vertical saturated Conductivity K_{sh} = Horizontal saturated Conductivity
θ_s,θ_r = Sat. and residual water contents S_{av} = Average suction at the wetting front
S,C,L = Sand, Clay, Loam θ_i= initial water content

[2]The Ap layer was the only one considered active for infiltration calculations

The rainfall distribution inflow boundary and other field parameters were taken from the event on 06/30/91. The procedure followed consists on moving the downslope node were the check for flooding is made (*nchk*), starting from the upper edge (*nchk*=1) to the last node of the FE mesh (*nchk*=*N*). Results are summarized on table 2.

Table 2. Analysis of sensitivity for the flooding hypothesis

Node	X (m)	Vol_out (m3)	Vol_inf (m3)	td (s)	tp (s)	Qp (m3/s)	tend (s)
			CECIL SANDY LOAM (L=4.39 m)				
1	0.00	1.088	0.658	1186	1653	2.064e-03	2263
3	0.31	1.088	0.658	1186	1653	2.064e-03	2263
6	0.78	1.088	0.658	862	1653	2.064e-03	2227
9	1.26	1.088	0.658	862	1653	2.064e-03	2227
12	1.73	1.088	0.658	862	1653	2.064e-03	2227
15	2.20	1.087	0.658	862	1653	2.064e-03	2227
17	2.51	1.087	0.658	862	1653	2.064e-03	2227
20	2.98	1.087	0.658	862	1653	2.064e-03	2227
23	3.45	1.088	0.658	862	1653	2.064e-03	2227
26	3.92	1.087	0.658	862	1653	2.064e-03	2227
29	4.39	1.087	0.659	862	1653	2.064e-03	2227
			PORTSMOUTH FINE SANDY LOAM (L=8.66 m)				
1	0.00	0.919	1.248	1295	1690	1.948e-03	2230
6	0.77	0.919	1.248	863	1690	1.948e-03	2194
11	1.55	0.919	1.248	863	1690	1.948e-03	2194
17	2.47	0.922	1.246	863	1690	1.947e-03	2194
23	3.40	0.921	1.246	863	1690	1.947e-03	2194
29	4.33	0.921	1.247	863	1690	1.947e-03	2194
34	5.10	0.916	1.251	863	1690	1.948e-03	2194
40	6.03	0.920	1.248	863	1690	1.947e-03	2194
46	6.95	0.923	1.245	863	1690	1.947e-03	2194
51	7.73	0.921	1.247	863	1690	1.947e-03	2194
57	8.66	0.920	1.248	863	1690	1.948e-03	2194
			HYPOTHETICAL SANDY (L=8.66 m)				
1	0.00	0.000e+00	2.167	0	0	0.000e+00	0
6	0.77	5.118e-45	2.167	863	863	1.423e-46	899
11	1.55	1.747e-44	2.167	863	935	3.436e-46	935
17	2.47	1.747e-44	2.167	863	935	3.436e-46	935
23	3.40	9.743e-37	2.167	863	1079	2.709e-38	1079
29	4.33	4.772e-31	2.167	863	1115	1.327e-32	1115
34	5.10	4.772e-31	2.167	863	1115	1.327e-32	1115
40	6.03	6.527e-26	2.167	863	1151	1.815e-27	1151
46	6.95	4.567e-20	2.167	863	1187	1.270e-21	1187
51	7.73	4.567e-20	2.167	863	1187	1.270e-21	1187
57	8.66	4.567e-20	2.167	863	1187	1.270e-21	1187

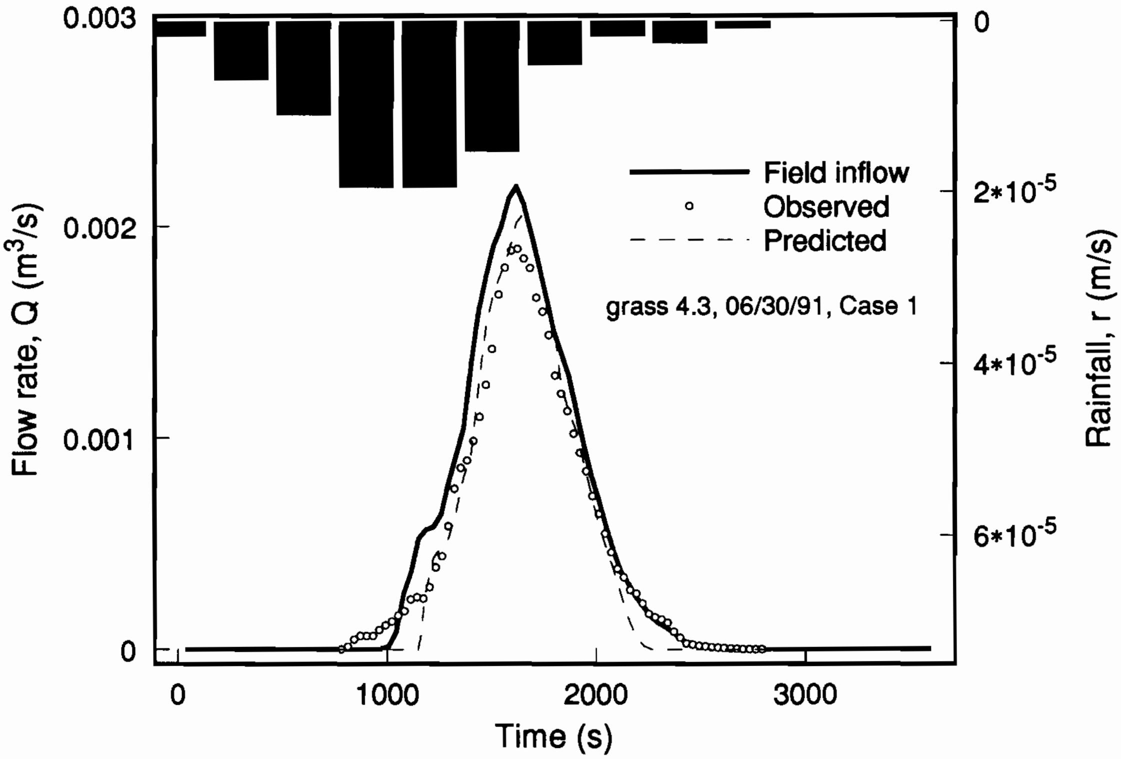
This analysis shows that the assumption has little bearing on the model results for the first two soils but significantly affects the predictions for a very sandy soil.

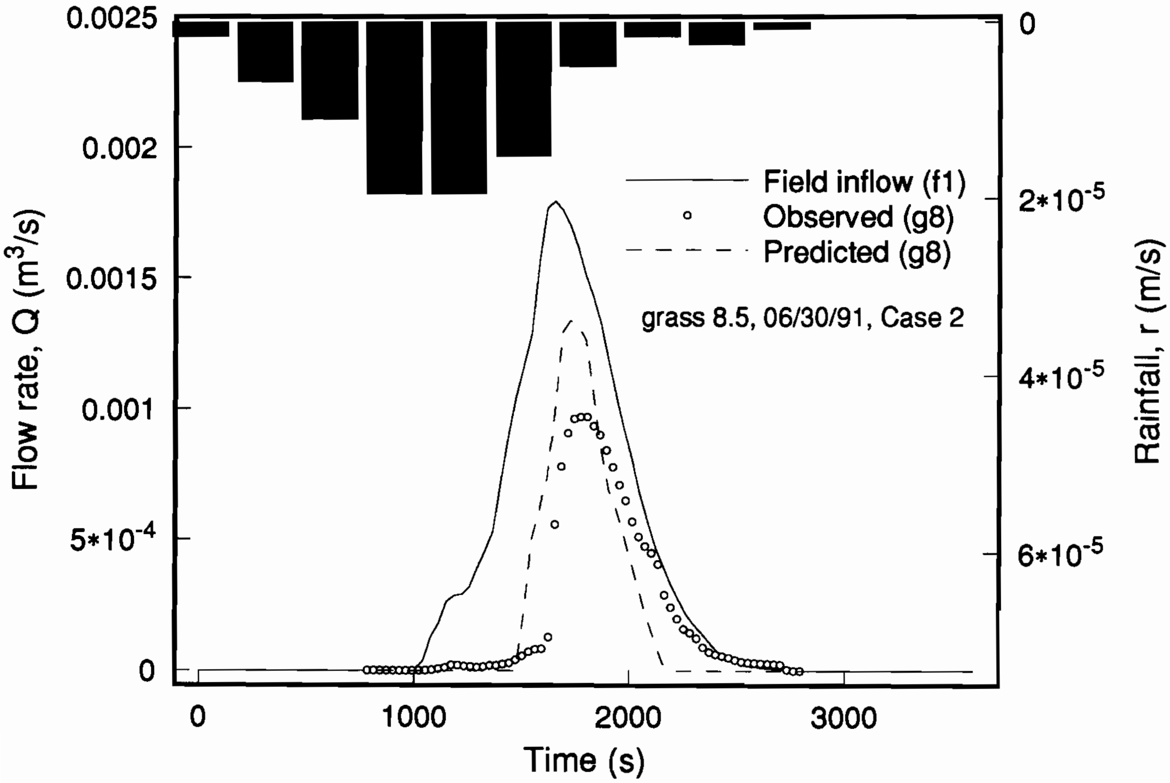
In view of these results, an additional model input, *schk*, is added to the 'soil.in' file in the computer model. this new parameter is the relative distance from the upper filter edge where the check for flooding will be made (i.e. *schk*=1.0, end of the filter;*schk*=0.5 mid filter point; *schk*=0.0, beginning of the filter). A default value of 1 is suggested but some experimentation is suggesting when using soils with very high conductivity values.

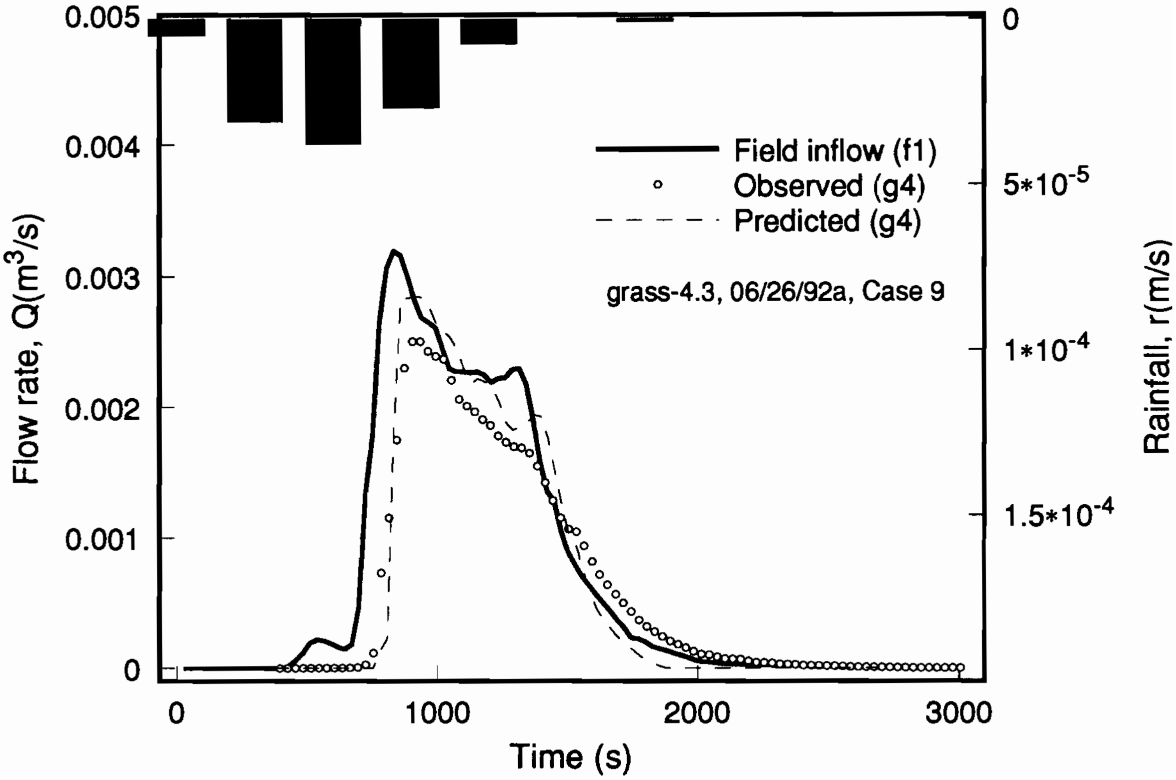
APPENDIX 3: OTHER SIMULATION RESULTS

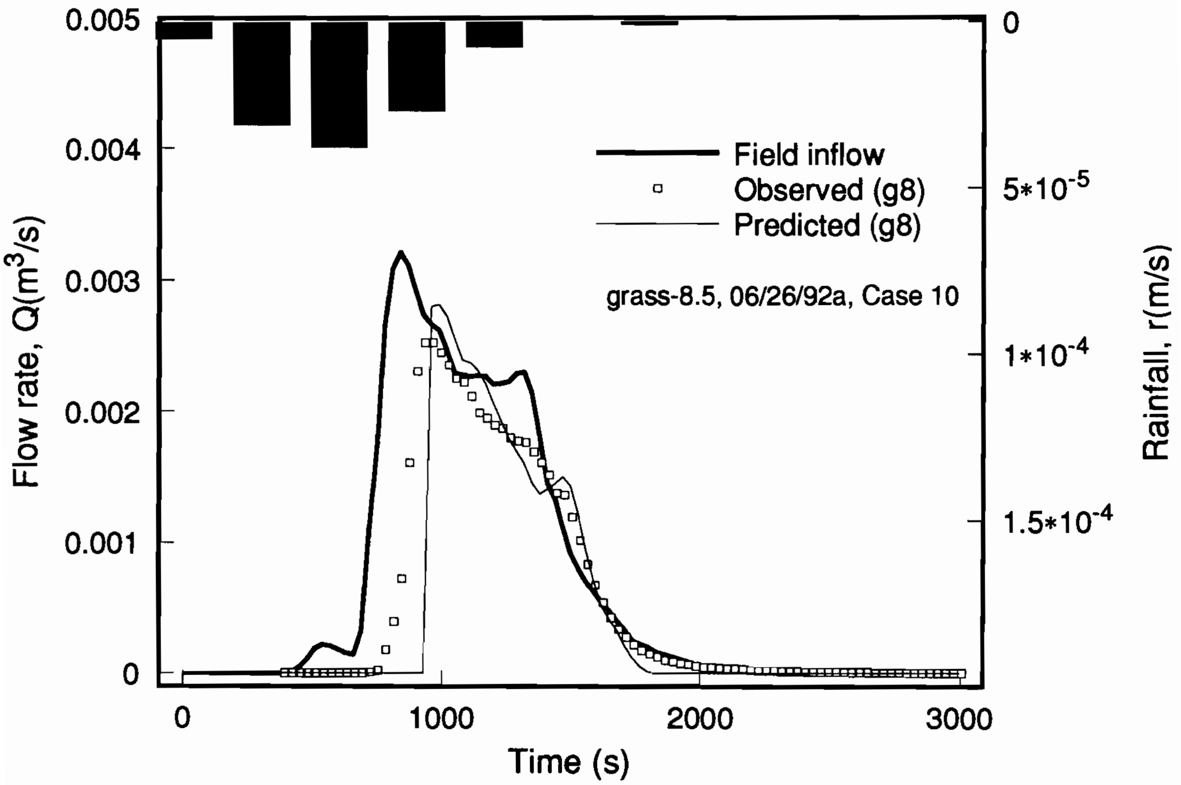
Additional simulations are included in this appendix. The legends refer to the cases described in table 6 of Chapter 4 for hydrology results, and table 8 for sediment results. The dates for each one of the sediment events are given in julian dates and its equivalence in given in the following table:

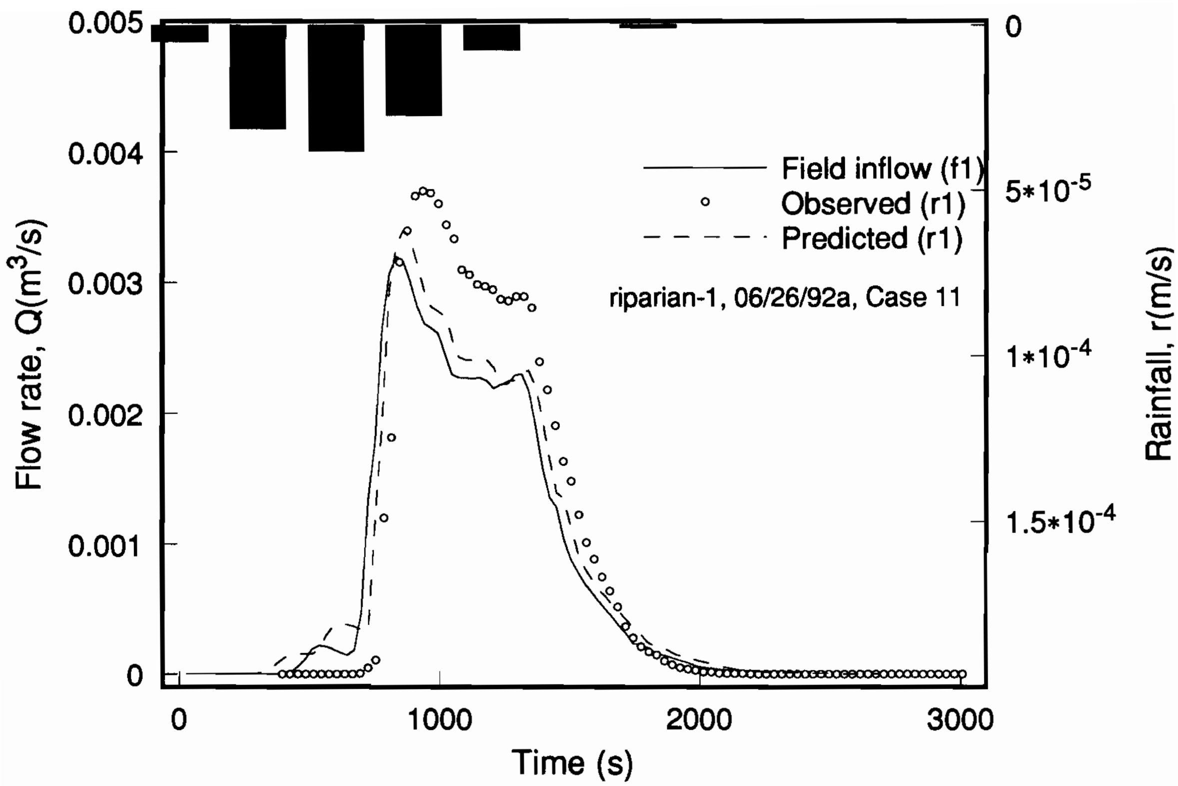
Julian	Gregorian	Storm in date
u183-91	06/30/91	---
u112-92	04/23/92	---
u151b-92	05/30/92	second
u168a-92	06/16/92	first
u178a-92	06/26/92	first
u309-92	11/06/92	---
u331a-92	11/30/92	first
u331c-92	11/30/92	third
u024-93	01/24/93	---

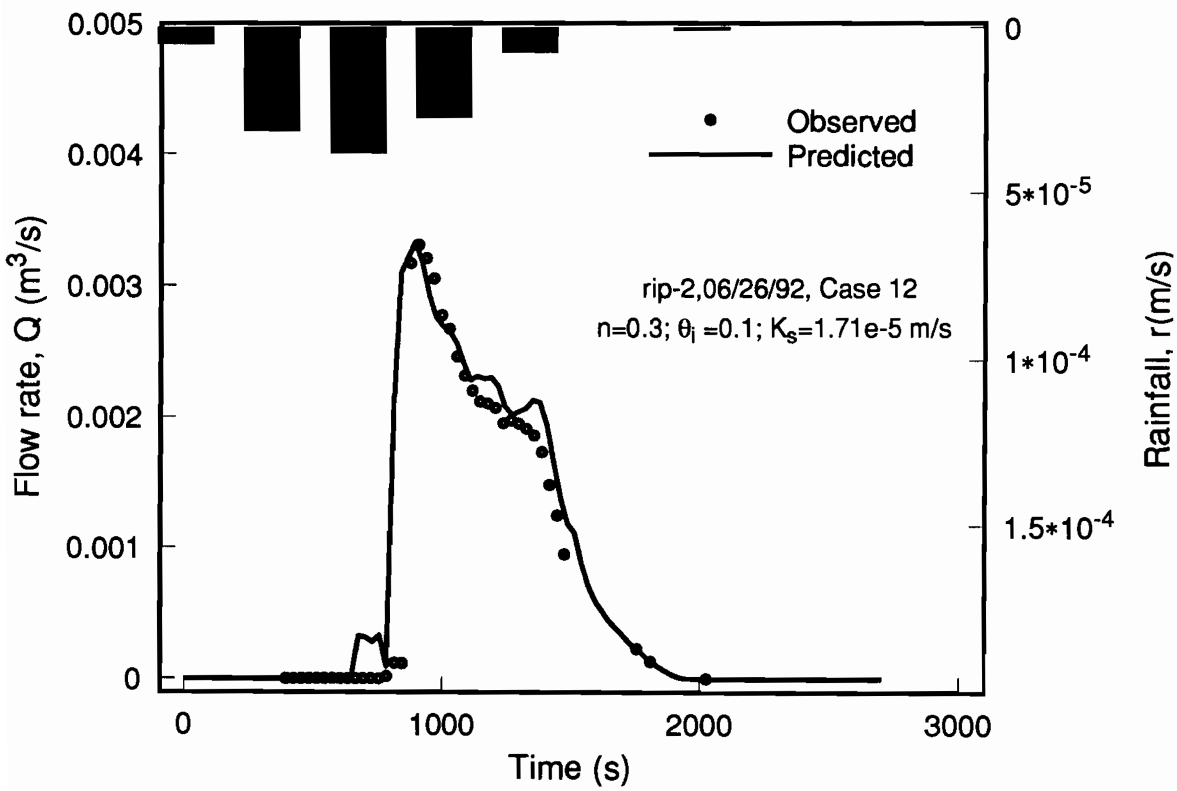

0.003
0.002
0.001
0
Flow rate, Q (m3/s)
0
2*10-5
4*10-5
6*10-5
Rainfall, r (m/s)
Field inflow
Observed
Predicted
grass 4.3, 06/30/91, Case 1
0
1000
2000
3000
Time (s)

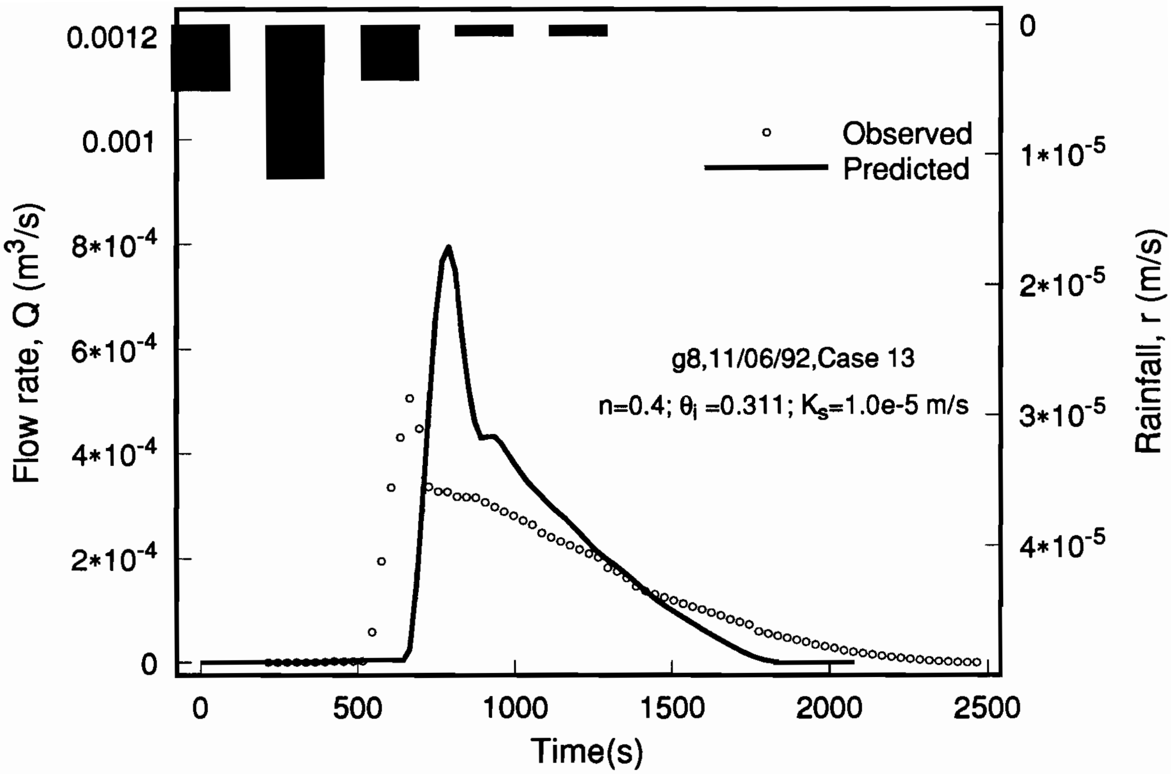

0.0025
0.002
0.0015
0.001
5*10-4
0
Flow rate, Q (m3/s)
0
2*10-5
4*10-5
6*10-5
Rainfall, r (m/s)
Field inflow (f1)
Observed (g8)
Predicted (g8)
grass 8.5, 06/30/91, Case 2
0
1000
2000
3000
Time (s)

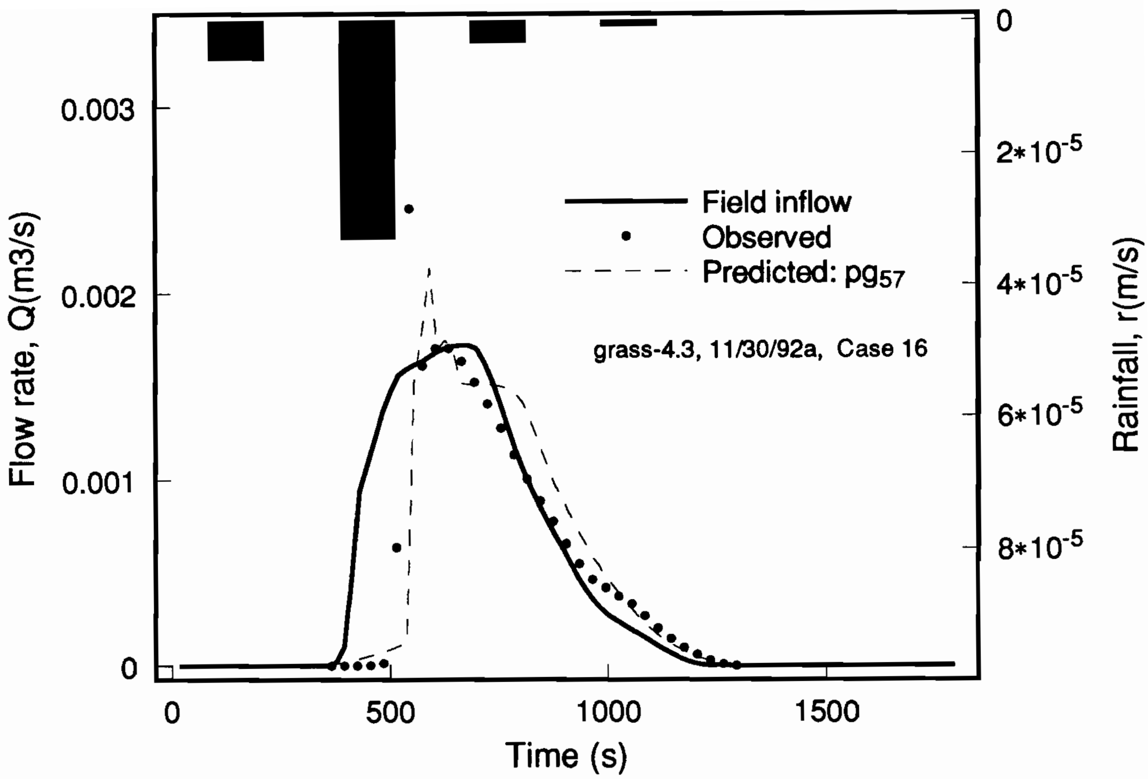

0.005
0.004
0.003
0.002
0.001
0
Flow rate, Q(m^3/s)
0
5*10^-5
1*10^-4
1.5*10^-4
Rainfall, r(m/s)
Field inflow (f1)
Observed (g4)
Predicted (g4)
grass-4.3, 06/26/92a, Case 9
0
1000
2000
3000
Time (s)


0.005
0.004
0.003
0.002
0.001
0
Flow rate, Q(m^3/s)
0
5*10^-5
1*10^-4
1.5*10^-4
Rainfall, r(m/s)
Field inflow
Observed (g8)
Predicted (g8)
grass-8.5, 06/26/92a, Case 10
0
1000
2000
3000
Time (s)

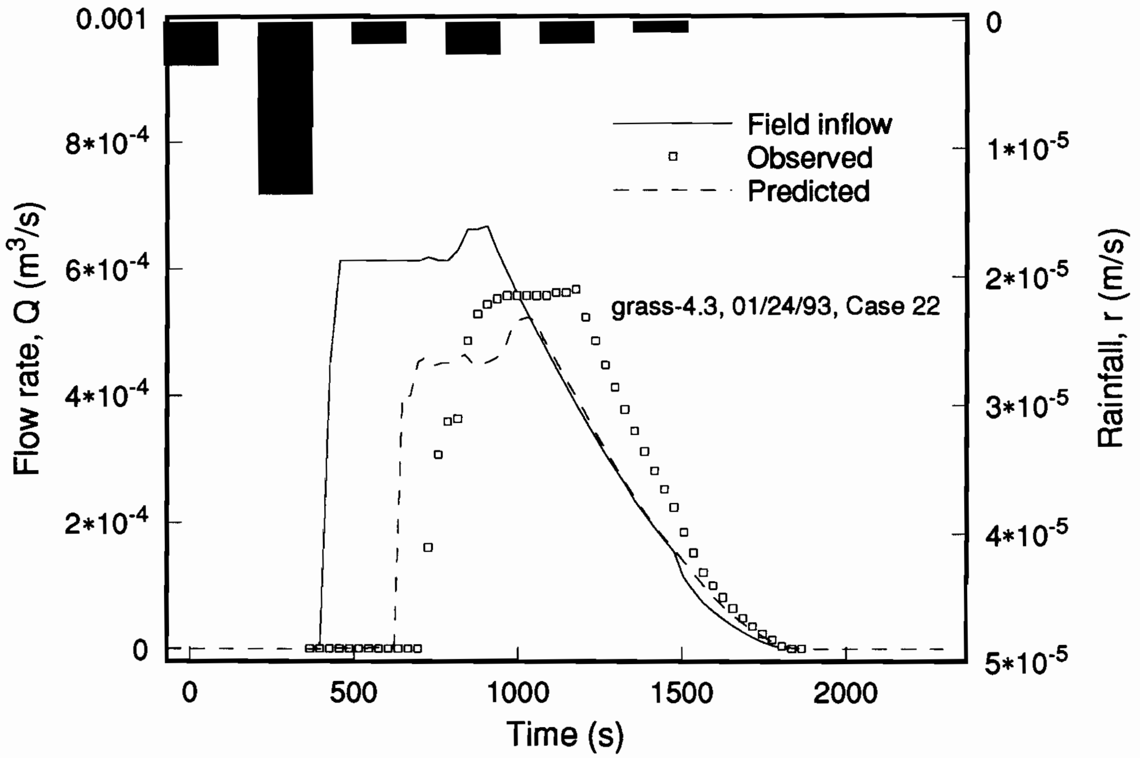

0.005
0.004
0.003
0.002
0.001
0
Flow rate, Q(m^3/s)
0
$5*10^{-5}$
$1*10^{-4}$
$1.5*10^{-4}$
Rainfall, r(m/s)
Field inflow (f1)
Observed (r1)
Predicted (r1)
riparian-1, 06/26/92a, Case 11
0
1000
2000
3000
Time (s)


0.005
0.004
0.003
0.002
0.001
0
Flow rate, Q (m^3/s)
0
$5*10^{-5}$
$1*10^{-4}$
$1.5*10^{-4}$
Rainfall, r(m/s)
Observed
Predicted
rip-2,06/26/92, Case 12
n=0.3; θ_i =0.1; K_s=1.71e-5 m/s
0
1000
2000
3000
Time (s)

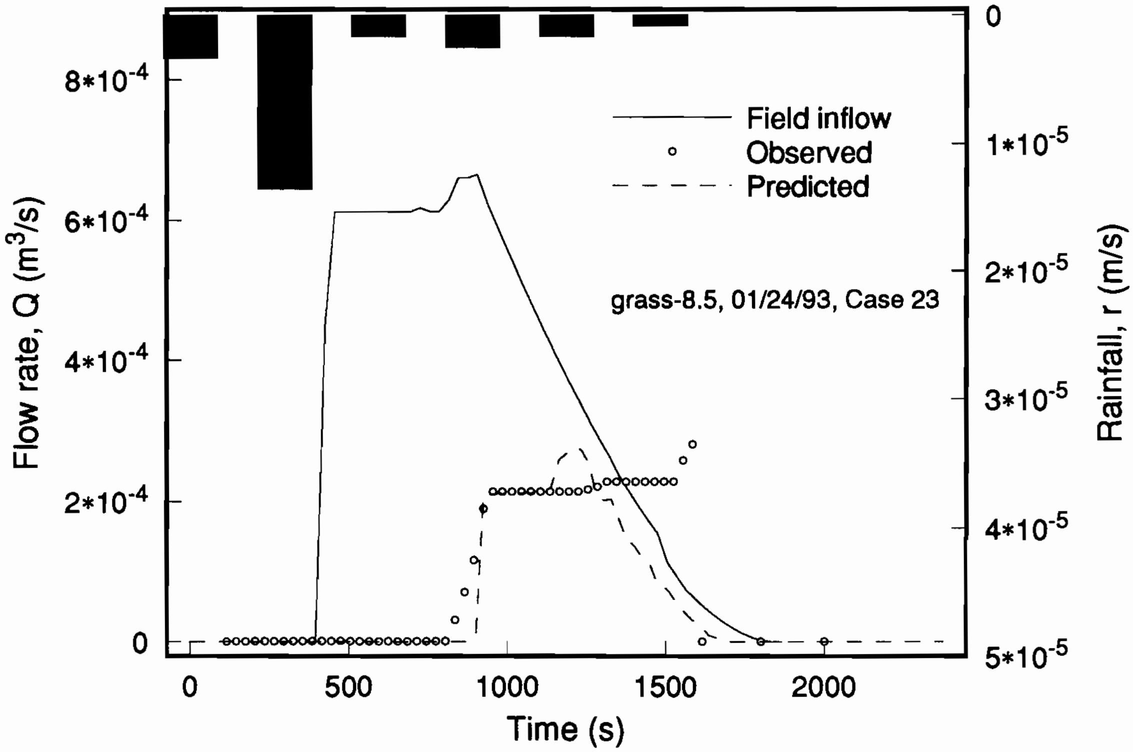

0.0012
0.001
8*10-4
6*10-4
4*10-4
2*10-4
0
Flow rate, Q (m3/s)
0
1*10-5
2*10-5
3*10-5
4*10-5
Rainfall, r (m/s)
Observed
Predicted
g8,11/06/92,Case 13
n=0.4; θi =0.311; Ks=1.0e-5 m/s
0
500
1000
1500
2000
2500
Time(s)



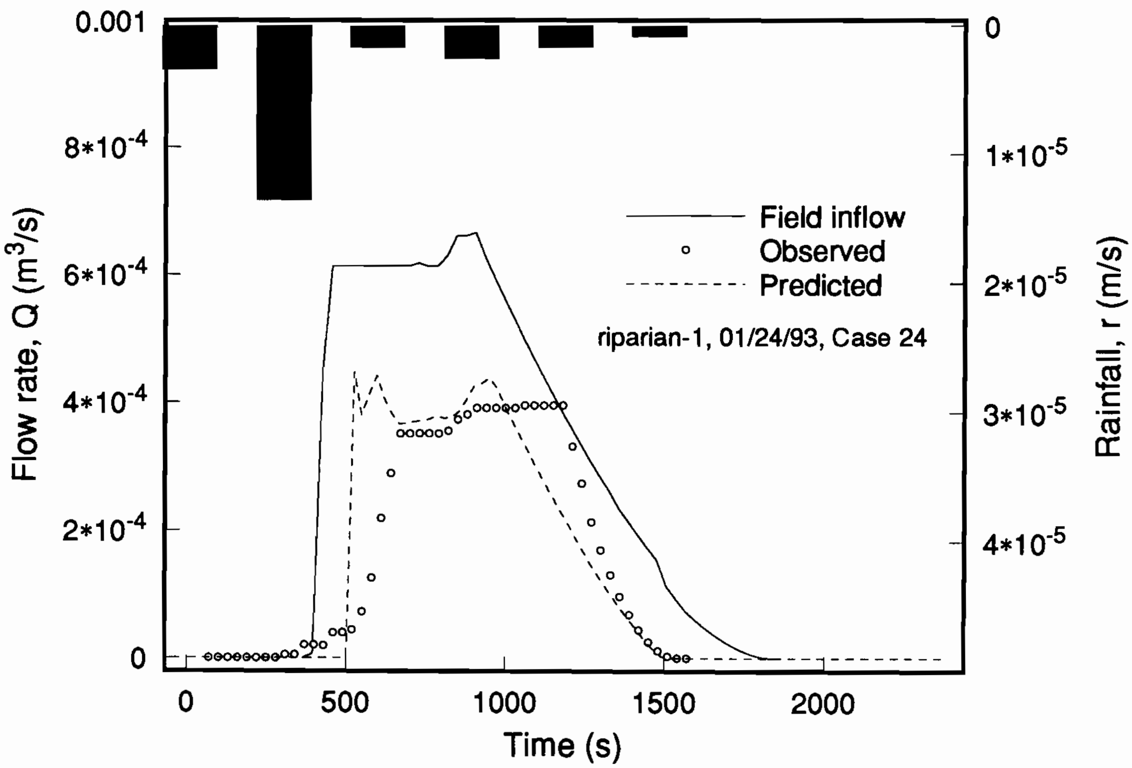
Field inflow
Observed
Predicted: pg57
grass-4.3, 11/30/92a, Case 16
Flow rate, Q(m3/s)
Rainfall, r(m/s)
Time (s)
0
0.001
0.002
0.003
500
1000
1500
2*10-5
4*10-5
6*10-5
8*10-5



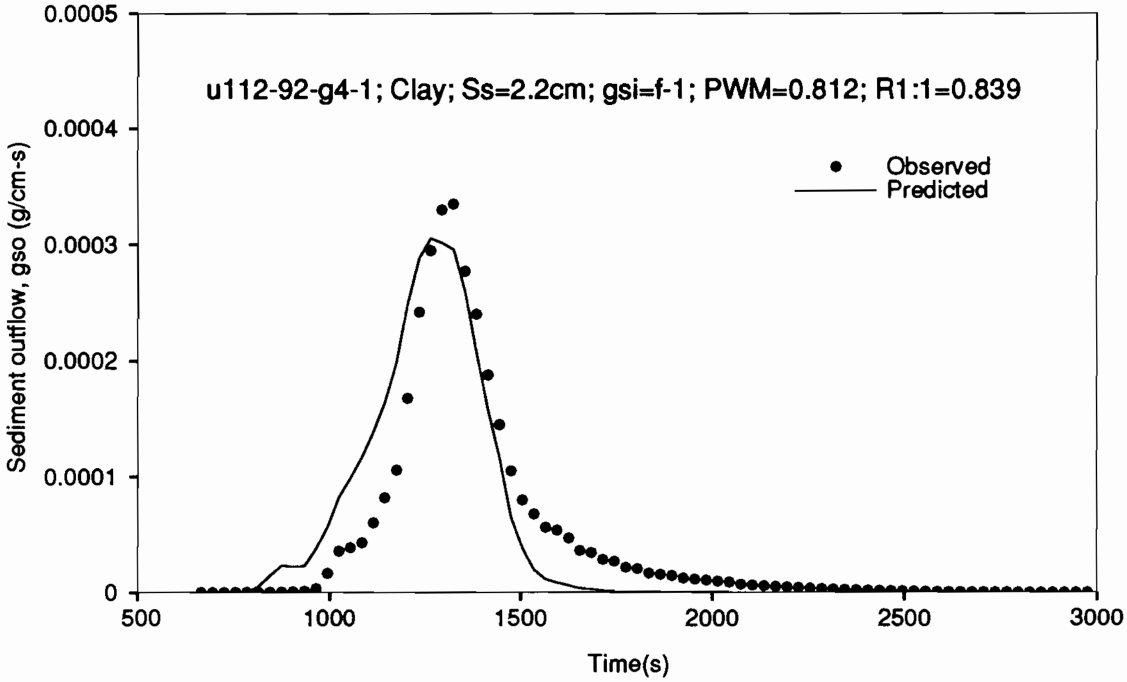
Field inflow
Observed
Predicted
grass-4.3, 01/24/93, Case 22
Flow rate, Q (m3/s)
Rainfall, r (m/s)
Time (s)
0
2*10-4
4*10-4
6*10-4
8*10-4
0.001
500
1000
1500
2000
1*10-5
2*10-5
3*10-5
4*10-5
5*10-5

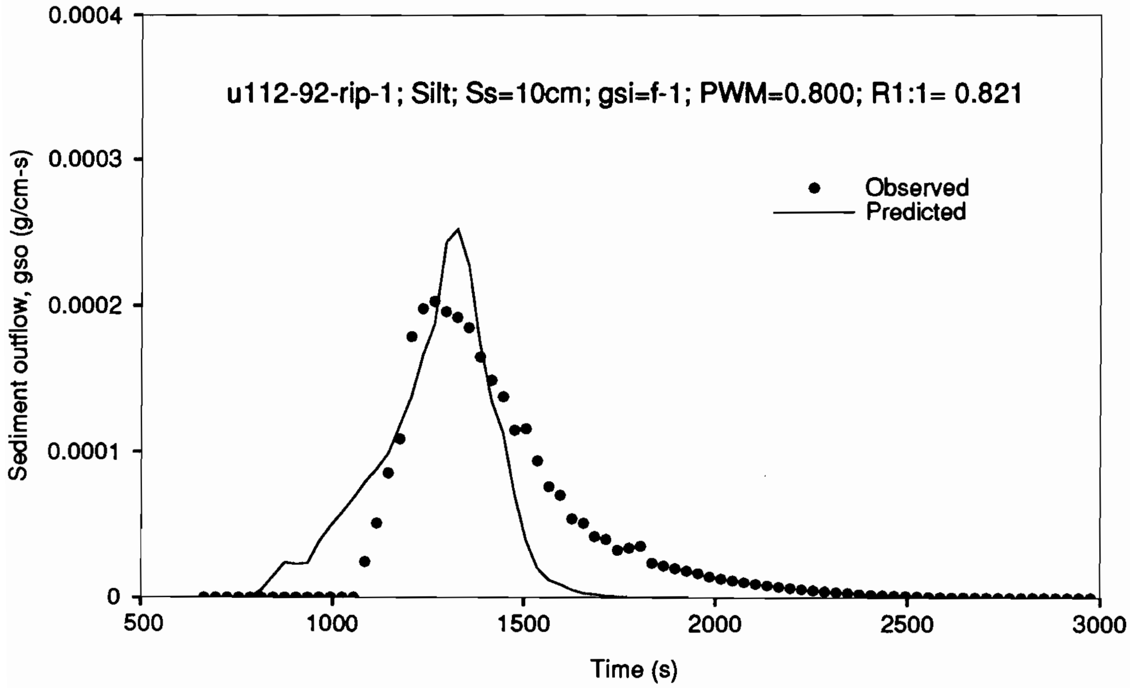


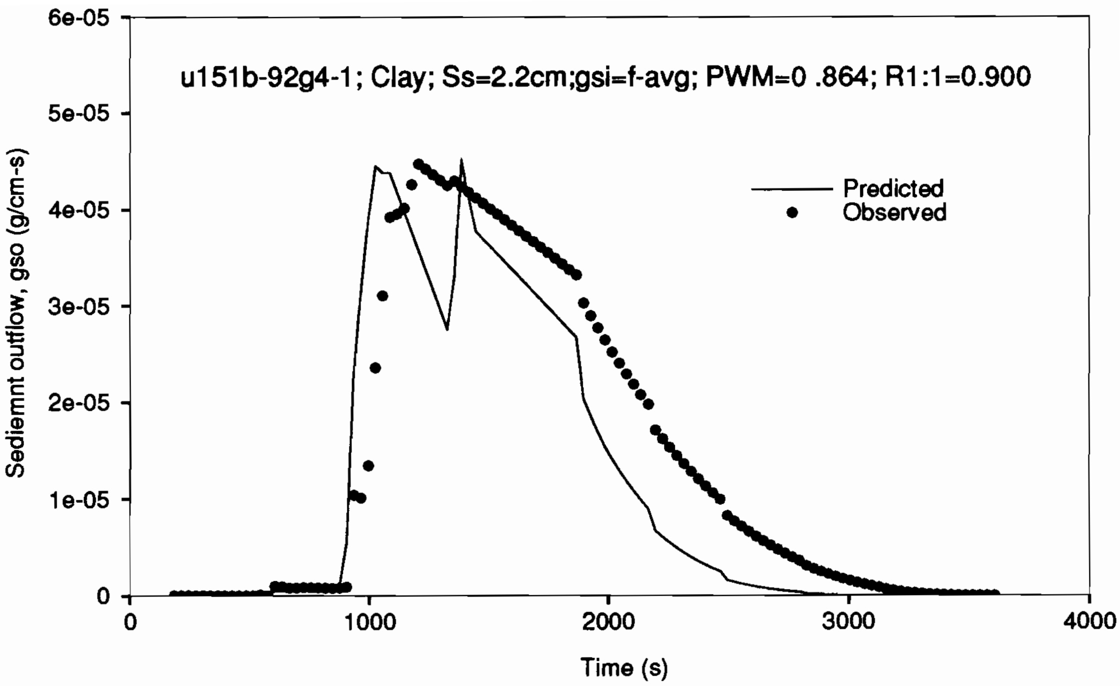
Field inflow
Observed
Predicted
grass-8.5, 01/24/93, Case 23
Flow rate, Q (m³/s)
Rainfall, r (m/s)
Time (s)

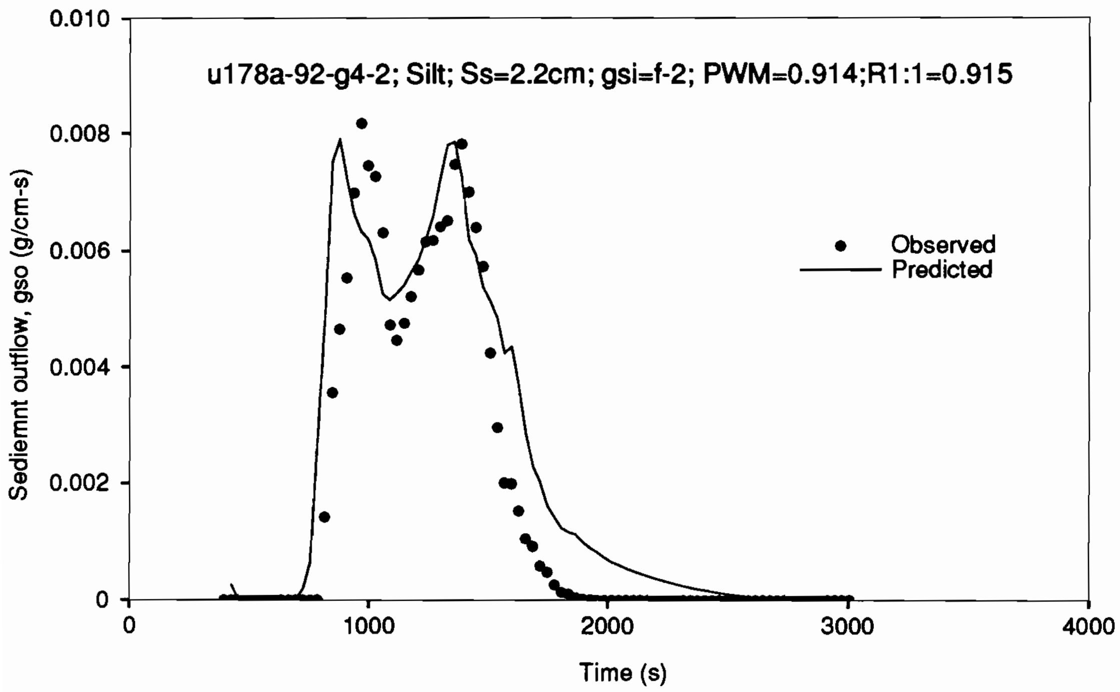


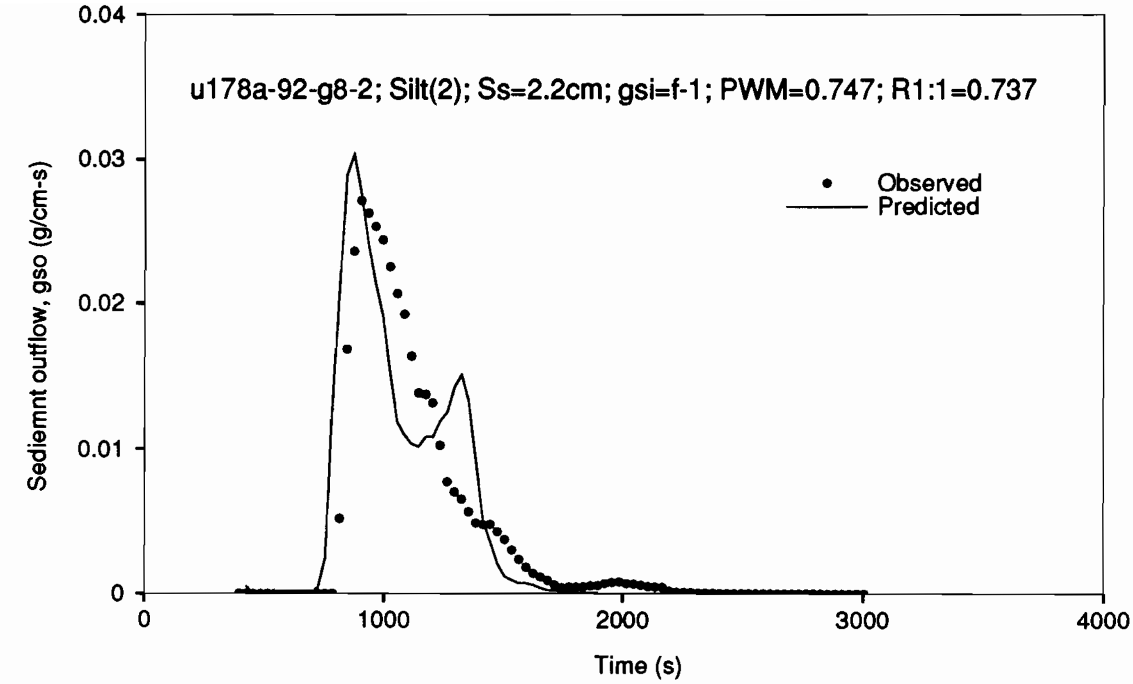
Field inflow
Observed
Predicted
riparian-1, 01/24/93, Case 24
Flow rate, Q (m³/s)
Rainfall, r (m/s)
Time (s)

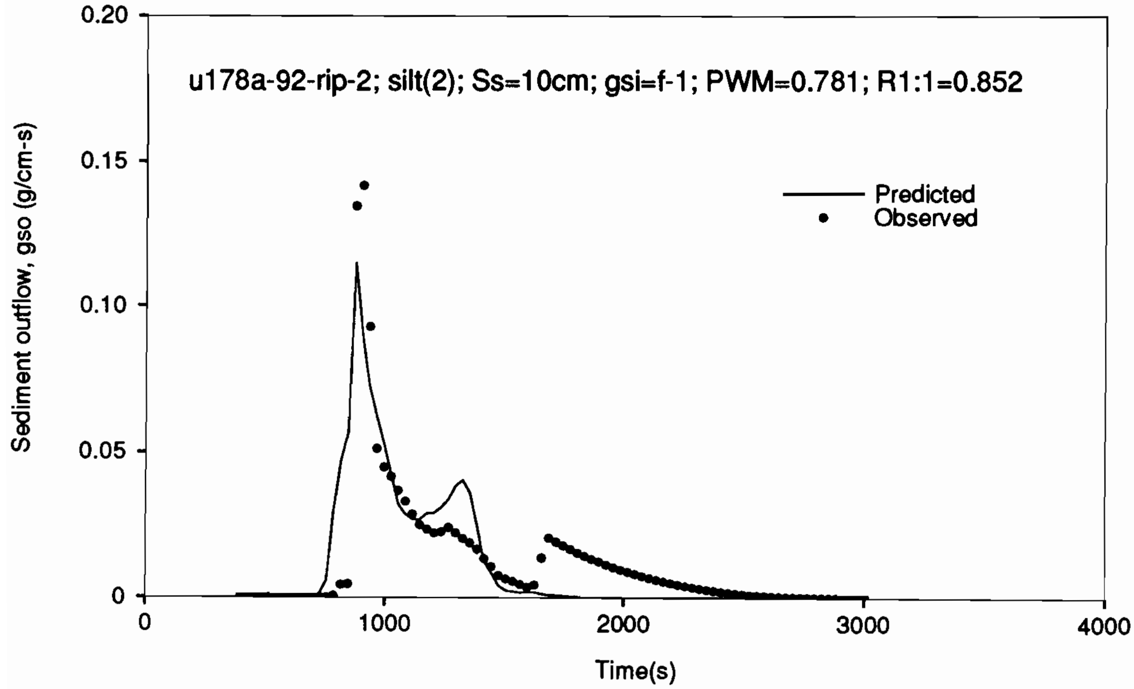

u112-92-g4-1; Clay; Ss=2.2cm; gsi=f-1; PWM=0.812; R1:1=0.839
Observed
Predicted
Sediment outflow, gso (g/cm-s)
0.0005
0.0004
0.0003
0.0002
0.0001
0
500
1000
1500
2000
2500
3000
Time(s)

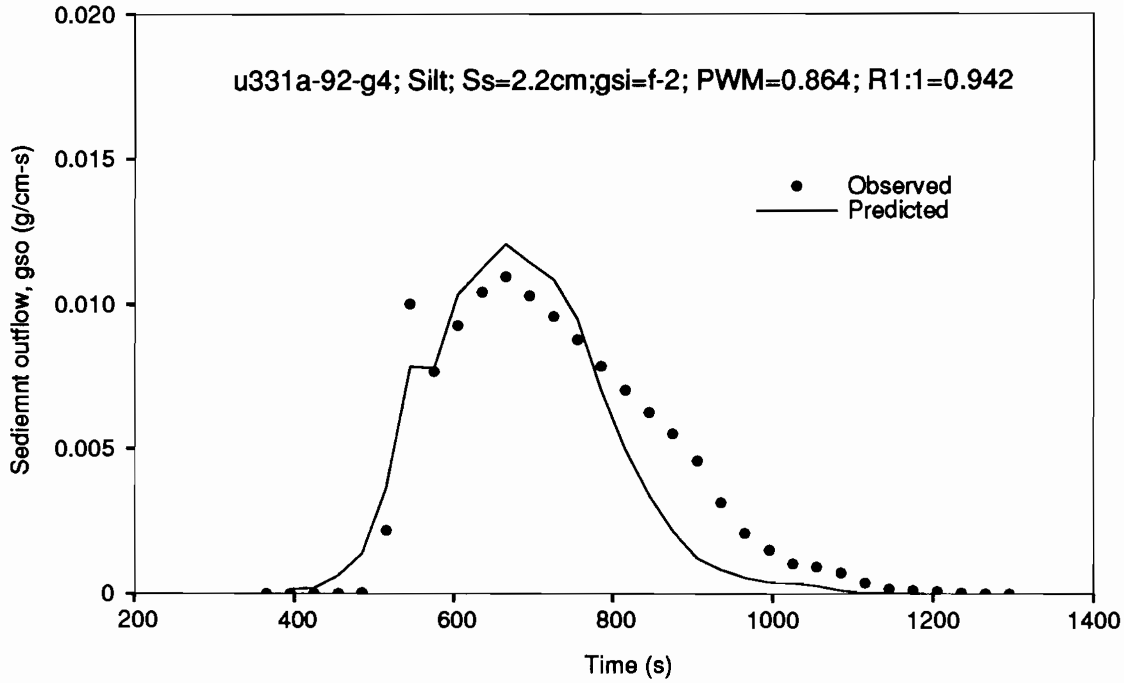

u112-92-rip-1; Silt; Ss=10cm; gsi=f-1; PWM=0.800; R1:1= 0.821
Observed
Predicted
Sediment outflow, gso (g/cm-s)
0.0004
0.0003
0.0002
0.0001
0
500
1000
1500
2000
2500
3000
Time (s)

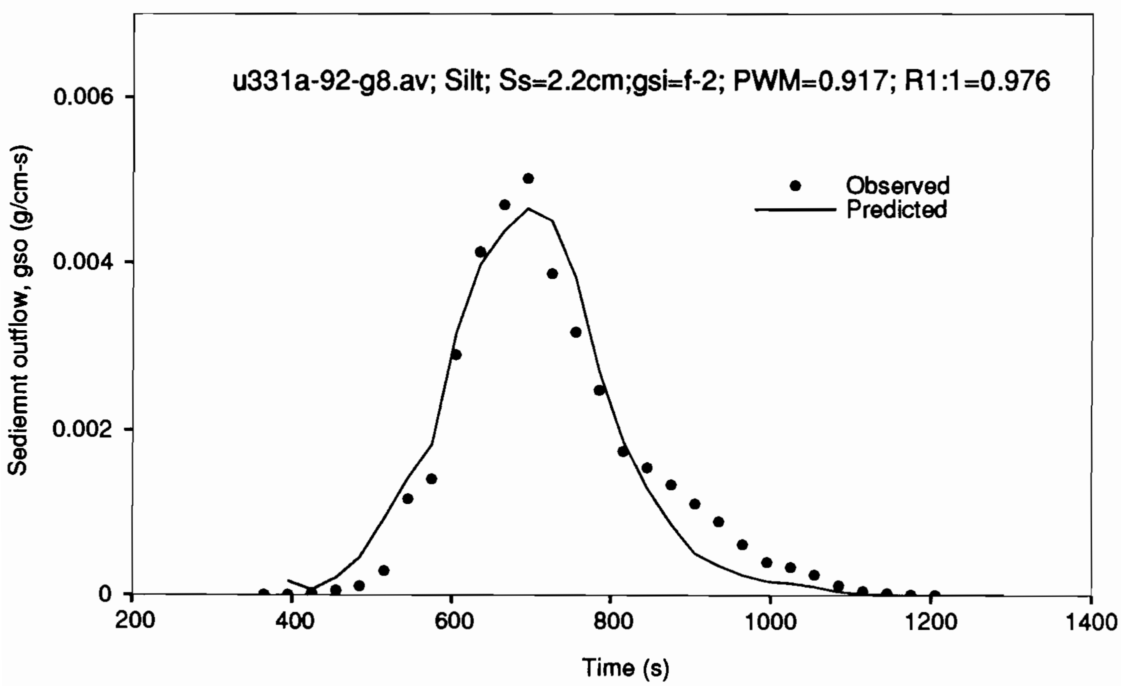

u151b-92g4-1; Clay; Ss=2.2cm;gsi=f-avg; PWM=0 .864; R1:1=0.900
Predicted
Observed
Sediemnt outflow, gso (g/cm-s)
6e-05
5e-05
4e-05
3e-05
2e-05
1e-05
0
0
1000
2000
3000
4000
Time (s)

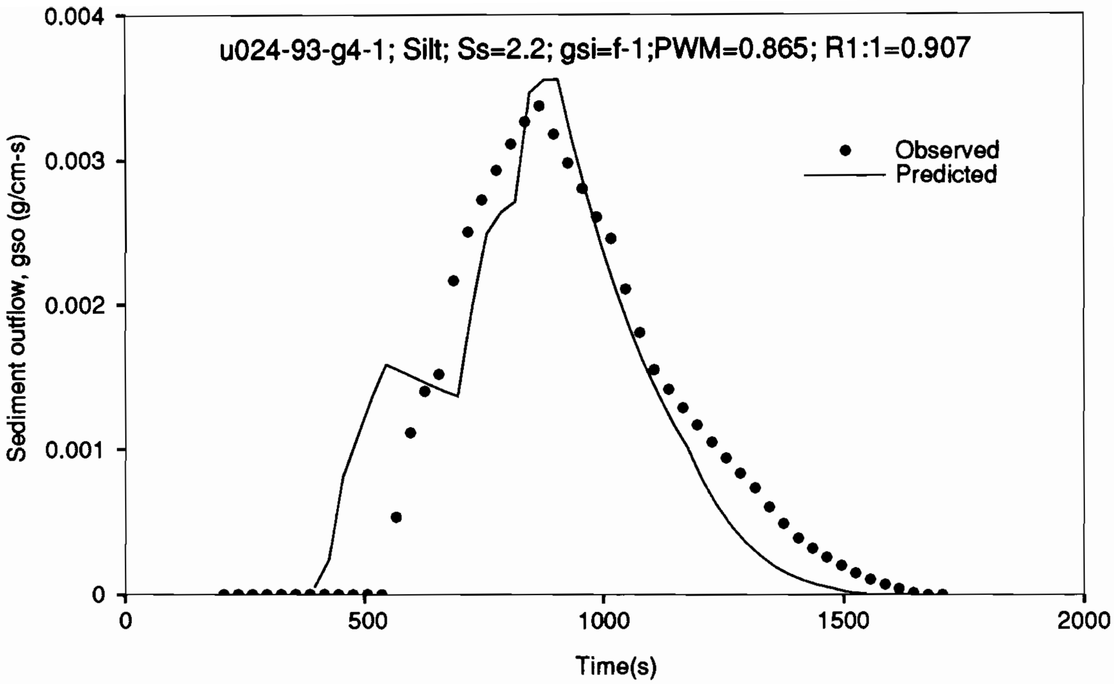

u178a-92-g4-2; Silt; Ss=2.2cm; gsi=f-2; PWM=0.914;R1:1=0.915
Observed
Predicted
Sediemnt outflow, gso (g/cm-s)
0.010
0.008
0.006
0.004
0.002
0
0
1000
2000
3000
4000
Time (s)

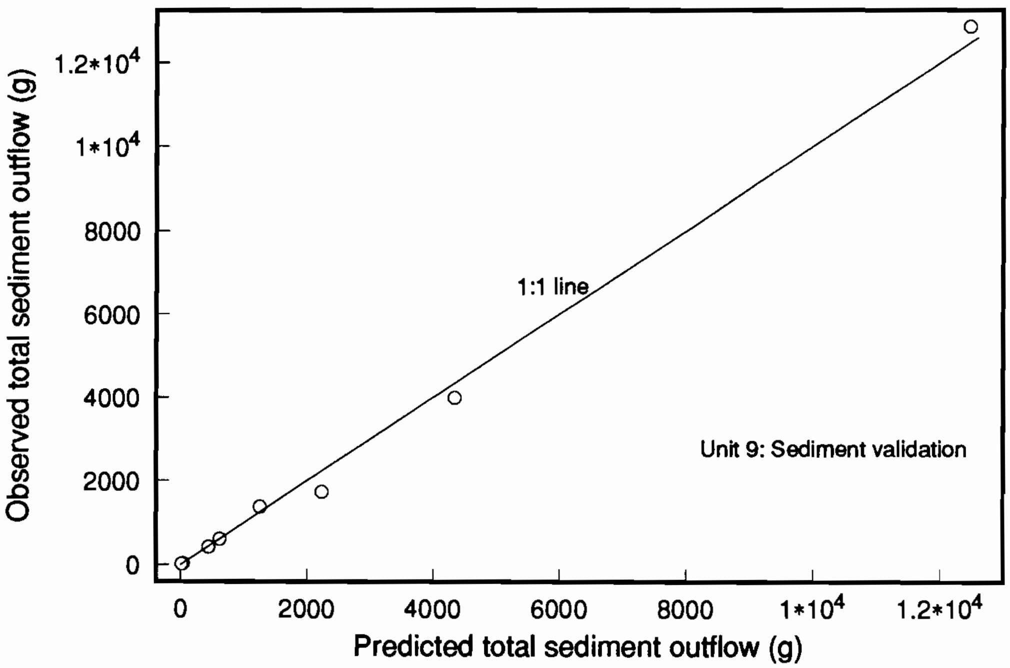

u178a-92-g8-2; Silt(2); Ss=2.2cm; gsi=f-1; PWM=0.747; R1:1=0.737
Observed
Predicted
Sediemnt outflow, gso (g/cm-s)
0.04
0.03
0.02
0.01
0
0
1000
2000
3000
4000
Time (s)


u178a-92-rip-2; silt(2); Ss=10cm; gsi=f-1; PWM=0.781; R1:1=0.852
Predicted
Observed
Sediment outflow, gso (g/cm-s)
0.20
0.15
0.10
0.05
0
0
1000
2000
3000
4000
Time(s)


u331a-92-g4; Silt; Ss=2.2cm;gsi=f-2; PWM=0.864; R1:1=0.942
Observed
Predicted
Sediemnt outflow, gso (g/cm-s)
0.020
0.015
0.010
0.005
0
200
400
600
800
1000
1200
1400
Time (s)


u331a-92-g8.av; Silt; Ss=2.2cm;gsi=f-2; PWM=0.917; R1:1=0.976
Observed
Predicted
Sediemnt outflow, gso (g/cm-s)
0.006
0.004
0.002
0
200
400
600
800
1000
1200
1400
Time (s)


u024-93-g4-1; Silt; Ss=2.2; gsi=f-1;PWM=0.865; R1:1=0.907
Observed
Predicted
Sediment outflow, gso (g/cm-s)
0.004
0.003
0.002
0.001
0
0
500
1000
1500
2000
Time(s)


Observed total sediment outflow (g)
1.2*10^4
1*10^4
8000
6000
4000
2000
0
1:1 line
Unit 9: Sediment validation
0
2000
4000
6000
8000
1*10^4
1.2*10^4
Predicted total sediment outflow (g)

APPENDIX 4: FIELD DATA FOR MODEL TESTING (1992-1993)

A summary of the processed field data is presented in this appendix. Tables 1 and 2 present a summary of the field data (total runoff, m^3, and sediment outflow, g) for the years (1992-January 1993) at both experimental sites. The dates are given in julian dates (the number of days from the beginning of the year, up to 365 for a regular year). The letters (a, b, etc) after some of the dates indicate that several runoff events took place at the same date and one of them was selected. Each column is designated by the filter from which the data was collected. The terms field_1, field_2 and field refer to the two no-filter collectors of 4 m width and the average of its values, respectively. The terms g4_ or g8_ refer to grass buffers of 4 m width, and 4.3 and 8.5 m length, respectively, whereas rip_1 and rip_2 refer to the riparian strips of 1.3 m width and length 4.3 and 8.3 m respectively. Note that the events presented on these tables are only those in which water quality samples were collected.

The next 9 tables represent a a collection of the field data set used for the validation process in paper 4. It is thus data for 26 events from Unit 9 (9 dates). All the other data presented in tables 1 and 2 is available electronically from the computer at the Department of Biological and Agricultural Engineering, Raleigh, NC. Tables 3-11 include observed hydrographs and pollutographs for each field collector, a summary of the observed hydrograph quantities used in paper 4 (total runoff volume, time delay , time to peak, peak flow rate), and rainfall distribution and total for the event.

Table 1. Summary of field events for Piedmont site (Raleigh,NC)

		Tot. Sediment (g) field_1	Total runoff (m^3) field_1	Tot. Sediment (g) field_2	Total runoff (m^3) field_2	Avg.Tt.sed. (g) field	Avg.Tt.runoff (m^3) field	Tot. Sediment (g) g4_1	Total runoff (m^3) g4_1	Tot. Sediment (g) g4_2	Total runoff (m^3) g4_2	Tot. Sediment (g) g8_1	Total runoff (m^3) g8_1	Tot. Sediment (g) g8_2	Total runoff (m^3) g8_2	Tot. Sediment (g) rip_1	Total runoff (m^3) rip_1	Tot. Sediment (g) rip_2	Total runoff (m^3) rip_2
										1992									
1	u112-92	189	0.253	385	0.280	287	0.266	38	0.197	32	0.177	--	0.055	15	0.069	16	0.113	--	--
2	u151b-92	968	0.405	163	0.156	565	0.280	20	0.155	247	0.228	--	--	--	--	--	--	--	--
3	u161b-92	889	0.189	683	0.146	786	0.168	--	--	52	0.004	--	--	--	--	4	0.003	--	--
4	u161c-92	382	0.233	95	0.122	238	0.177	--	--	137	0.159	6	0.054	136	0.457	180	0.226	--	--
5	u168a-92	2448	0.379	1017	0.337	1733	0.358	119	0.140	122	0.097	--	--	--	--	14	0.025	--	--
6	u168b-92	--	--	--	--	--	--	--	--	3	0.005	--	--	--	--	1	0.002	--	--
7	u173-92	--	--	2403	0.426	2403	0.426	1920	0.675	1334	0.562	467	0.536	980	0.459	2016	0.730	269	0.229
8	u178a-92	54837	2.009	74637	1.798	64737	1.904	5010	1.612	1739	0.379	2395	1.471	3989	1.848	19802	2.298	12862	1.790
9	u178b-92	--	--	4396	0.076	4396	0.076	4541	0.756	--	--	1878	0.523	1433	0.703	--	--	141	0.015
10	u178c-92	68053	2.064	13076	0.638	40564	1.351	516	2.163	--	--	--	--	471	0.530	Flooded	8.157	--	--
11	u178d-92	31647	0.643	73197	1.101	52422	0.872	1390	1.225	--	--	153	0.537	--	--	13898	1.141	--	--
12	u185-92	--	--	0	0.001	0	0.001	--	--	--	--	--	--	--	--	--	--	--	--
13	u188-92	--	--	14	0.003	14	0.003	--	--	--	--	--	--	--	--	--	--	--	--
14	u309-92	2582	0.698	1075	0.347	1829	0.523	1390	0.943	2451	1.307	158	0.290	419	1.022	--	--	1996	0.625
15	u317a-92	0	0.000	5	0.002	3	0.001	3	0.002	--	--	--	--	6	0.001	--	--	--	--
16	u317b-92	312	0.168	60	0.076	186	0.122	139	0.362	--	--	--	--	347	0.069	--	--	--	--
17	u317c-92	209	0.099	155	0.098	182	0.098	30	0.132	--	--	--	--	--	--	--	--	--	--
18	u317d-92	176	0.067	246	0.087	211	0.077	336	0.264	--	--	48	0.021	179	0.125	--	--	--	--
19	u330-92	173	0.063	369	0.068	271	0.066	69	0.120	298	0.248	--	--	2	0.003	--	--	--	--
20	u331-92	12734	2.175	5523	2.325	9129	2.250	1537	1.914	3789	1.583	299	1.614	814	3.022	--	--	--	--
20-a	u331a-92	9084	0.732	2665	0.750	5875	0.741	1377	0.641	3617	0.841	151	0.524	707	0.777	--	--	--	--
20-c	u331c-92	3410	1.391	2751	1.532	3081	1.462	137	1.161	--	--	--	--	129	1.036	--	--	--	--
21	u345-92	262	0.074	68	0.247	165	0.161	16	0.111	--	--	--	--	145	0.007	--	--	--	--
22	u355-92	7	0.008	--	--	7	0.008	24	0.058	13	0.012	--	--	0	0.000	--	--	--	--
	Total 92 =	175867	9.527	177567	8.334	180127	9.188	17098	10.829	10218	4.762	5405	5.101	8935	8.315	35932	12.695	15267	2.659
										1993									
1	u005-93	847	0.269	100	0.086	474	0.177	1	0.011	--	--	--	--	--	--	--	--	104	0.048
2	u007-93	10	0.009	--	--	10	0.009	31	0.252	13	0.047	--	--	1	0.000	--	--	1	0.014
3	u008-93	103	0.077	119	0.065	111	0.071	--	--	--	--	--	--	48	0.030	--	--	31	0.055
4	u024-93	6183	0.539	--	--	6183	0.539	619	0.369	406	0.392	66	0.011	149	0.310	--	--	--	--

Table 2. Summary of field events for Coastal Plain site (Kinton,NC)

	Tot. Sediment (g) field_1	Total runoff (m^3) field_1	Tot. Sediment (g) field_2	Total runoff (m^3) field_2	Avg.Tt.sed. (g) field	Avg.Tt.runoff (m^3) field	Tot. Sediment (g) g4_1	Total runoff (m^3) g4_1	Tot. Sediment (g) g4_2	Total runoff (m^3) g4_2	Tot. Sediment (g) g8_1	Total runoff (m^3) g8_1	Tot. Sediment (g) g8_2	Total runoff (m^3) g8_2	Tot. Sediment (g) rip_1	Total runoff (m^3) rip_1	Tot. Sediment (g) rip_2	Total runoff (m^3) rip_2
									1992									
1 k086-92	2	0.034	45	0.061	23	0.048	4	0.010	--	--	--	--	--	--	--	--	24	0.006
2 k129-92	0	0.002	0	0.015	0	0.009	--	--	--	--	--	--	--	--	--	--	--	--
3 k139-92	6	0.763	187	1.001	96	0.882	22	0.164	16	0.114	0	0.145	11	0.645	27	0.741	1	0.038
4 k147-92	193	0.020	471	0.045	332	0.033	--	--	--	--	--	--	--	--	--	--	1	0.001
5 k161a-92	1445	0.305	1533	0.241	1489	0.273	--	--	--	--	--	--	--	--	186	0.086	--	--
6 k161b-92	1187	0.345	1054	0.289	1121	0.317	41	0.019	--	--	--	--	--	--	203	0.214	--	--
7 k172-92	4681	0.578	3487	0.587	4084	0.583	104	0.041	--	--	--	--	21	0.121	1072	0.343	14	0.013
8 k176-92	12925	2.235	13795	2.765	13360	2.500	8271	2.956	3135	2.056	3352	2.286	4323	2.962	7403	5.563	29693	7.824
9 k178-92	--	--	2870	0.471	2870	0.471	111	0.061	--	--	--	--	243	0.158	--	--	--	--
10 k186a-92	267	0.067	1132	0.144	700	0.106	--	--	--	--	--	--	0	0.000	--	--	--	--
11 k186b-92	3432	0.787	3312	0.626	3372	0.706	3108	0.881	1256	0.381	2789	1.358	1758	0.789	3530	1.364	--	--
12 k205-92	3747	0.329	--	--	3747	0.329	--	--	--	--	1	0.003	--	--	127	0.067	--	--
13 k208-92	10212	1.304	--	--	10212	1.304	3553	1.047	1774	0.769	2420	0.844	3071	1.166	8264	2.188	--	--
14 k216-92	7477	1.196	7121	1.181	7299	1.188	1978	0.740	581	0.405	1016	0.506	1672	0.875	--	--	7355	1.770
15 k218-92	--	--	9367	1.501	9367	1.501	5018	1.706	2956	1.079	4025	1.379	4677	1.727	13568	2.795	17399	5.175
16 k225a-92	2882	0.551	--	--	2882	0.551	131	0.054	--	--	--	--	107	0.048	547	0.177	--	--
17 k225b-92	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	0.002	--	--
18 k226-92	6357	1.266	5324	1.039	5840	1.152	2458	1.079	487	0.720	1734	1.044	392	1.451	6360	1.687	12500	3.879
19 k227a-92	0	0.006	--	--	0	0.006	--	--	--	--	--	--	--	--	--	--	--	--
20 k227b-92	4460	2.838	5682	1.486	5071	2.162	1163	1.058	268	0.988	60	0.125	--	--	--	--	--	--
21 k228-92	--	--	--	--	--	--	--	--	282	1.485	3905	2.451	--	--	--	--	--	--
22 k248-92	89	0.015	1829	0.439	959	0.227	121	0.045	2	0.002	1	0.022	16	0.011	1453	0.409	--	--
23 k251-92	100	0.054	440	0.077	270	0.066	--	--	--	--	--	--	--	--	30	0.012	--	--
24 k290-92	18354	0.929	2910	0.988	10632	0.958	684	0.309	--	--	18	0.033	261	0.126	1162	0.866	3868	0.795
25 k318-92	1918	0.188	279	0.426	1098	0.307	7	0.021	--	--	--	--	--	--	548	0.249	--	--
26 k331-92	13381	1.189	1270	1.187	7325	1.188	367	1.516	--	--	--	--	--	--	1576	0.746	--	--
27 k332-92	763	0.266	9	0.159	386	0.213	7	0.018							14	0.205	--	--
28 k345a-92	--	--	10	0.129	10	0.129	3	0.006	--	--	--	--	--	--	8	0.023	830	0.195
29 k345b-92	16	0.005	--	--	16	0.005	--	--	0	0.001	2	0.018	775	1.052	4	0.013	132	0.260
30 k345c-92	4852	0.558	--	--	4852	0.558	80	0.461	--	--	58	0.730	102	0.533	593	0.329	32	0.524
					0	0.000												
Total 92 =	98746	15.829	62127	14.858	97415	17.770	27231	12.191	10757	8.000	19380	10.944	17429	11.664	46680	18.078	71848	20.480
									1993									
1 k008a-93	176	0.020	0	0.001	88	0.011	--	--	--	--	--	--	--	--	13	0.019	--	--
2 k008b-93	294	0.100	--	--	294	0.100	24	0.236	--	--	13	0.063	--	--	398	0.366	--	--
3 k008c-93	5462	0.562	584	0.351	3023	0.456	30	0.321	--	--	18	0.426	--	--	218	0.268	--	--

Table 3. Summary of field data for event on (06/30/91)

TABLE OF RUNOFF DATA(06/30/91)

Time (h)	field 1 q(m^3/s)	field 1 q(m^3/s)	g4_1 q(m^3/s)	g4_2 q(m^3/s)	g8_1 q(m^3/s)	g8_2 q(m^3/s)	rip-1 q(m^3/s)	rip-2 q(m^3/s)
21.8002	0	0	0	0	0	0	0	0
21.8085	0	0	1.2670e-5	0	5.6561e-8	0	1.8025e-8	2.7248e-8
21.8169	8.9338e-8	0	4.6516e-5	0	6.3997e-7	0	6.9568e-8	9.9232e-8
21.8252	5.6080e-7	5.7239e-8	6.3489e-5	0	1.3017e-6	0	6.9568e-8	1.5101e-13
21.8336	5.6080e-7	5.7239e-8	6.3489e-5	0	1.3017e-6	0	6.9568e-8	1.5101e-13
21.8419	5.6080e-7	5.7239e-8	6.3489e-5	0	1.3017e-6	0	6.9568e-8	1.5101e-13
21.8502	5.3496e-7	3.1600e-6	9.1584e-5	0	9.1302e-7	0	1.5985e-7	3.0738e-8
21.8585	1.2809e-6	8.0446e-6	0.000114	3.3863e-7	1.2639e-6	4.4949e-8	1.5985e-7	3.0738e-8
21.8669	1.7457e-6	2.0538e-5	0.000132	3.3863e-7	2.1071e-6	1.6370e-7	1.5985e-7	3.0738e-8
21.8752	1.7457e-6	0.000122	0.000165	3.3863e-7	2.5961e-6	1.2054e-6	1.5985e-7	1.0550e-7
21.8836	1.7457e-6	0.000292	0.000181	1.0379e-7	2.5961e-6	3.0211e-6	4.2533e-7	2.2020e-7
21.8919	2.2666e-6	0.000357	0.000237	6.6651e-7	3.7022e-6	7.0189e-6	2.7710e-7	1.0550e-7
21.9002	3.4609e-6	0.000507	0.000248	6.6483e-7	4.9662e-6	1.1418e-5	2.7790e-7	1.0608e-7
21.9086	4.8558e-6	0.000578	0.000241	6.6483e-7	5.6602e-6	2.1617e-5	2.7790e-7	1.0608e-7
21.9169	4.1347e-6	0.000552	0.000295	3.3691e-7	4.9662e-6	2.0344e-5	4.2633e-7	2.2102e-7
21.9252	4.8558e-6	0.000593	0.000388	6.6483e-7	5.6602e-6	1.6734e-5	2.7790e-7	1.0608e-7
21.9336	4.8558e-6	0.000647	0.000440	1.0725e-6	5.6602e-6	1.5600e-5	2.7790e-7	1.0608e-7
21.9419	4.1347e-6	0.000783	0.000582	6.6483e-7	4.9662e-6	1.2410e-5	4.2633e-7	3.7375e-7
21.9502	4.1718e-6	0.000899	0.000758	6.7947e-7	5.7057e-6	1.4541e-5	5.9716e-7	5.5408e-7
21.9586	8.2339e-6	0.000962	0.000856	1.5709e-6	1.2611e-5	1.9152e-5	4.1939e-7	3.6651e-7
21.9669	5.5727e-5	0.001150	0.000891	1.0894e-6	2.5682e-5	1.9152e-5	4.1939e-7	3.6651e-7
21.9752	0.000119	0.001473	0.000983	1.5709e-6	4.0836e-5	2.4312e-5	4.1939e-7	3.6651e-7
21.9836	0.000214	0.001631	0.001098	1.0894e-6	3.7565e-5	2.8532e-5	5.9716e-7	5.5408e-7
21.9919	0.000330	0.001763	0.001252	4.1103e-6	4.4220e-5	4.1211e-5	5.9716e-7	5.5408e-7
22.0002	0.000405	0.001898	0.001422	6.5273e-6	5.8726e-5	5.5792e-5	6.0863e-7	5.6629e-7
22.0086	0.000493	0.001950	0.001677	1.5072e-5	8.4027e-5	7.2391e-5	8.1855e-7	7.9124e-7
22.0169	0.000725	0.002065	0.001804	0.0001110	8.1772e-5	8.1396e-5	8.1855e-7	7.9124e-7
22.0252	0.001196	0.002173	0.001885	0.000308	7.9544e-5	8.3720e-5	3.1197e-6	3.7661e-7
22.0336	0.001393	0.002192	0.001893	0.000549	8.1772e-5	0.000128	0.000309	1.2785e-5
22.0419	0.001481	0.002106	0.001847	0.000754	7.9544e-5	0.000558	0.000956	6.7438e-5
22.0502	0.001547	0.001986	0.001802	0.000799	7.9386e-5	0.000778	0.001217	0.000393
22.0586	0.001570	0.001878	0.001663	0.000834	0.000100	0.000907	0.001338	0.000708
22.0669	0.001578	0.001739	0.001597	0.000852	0.000182	0.000961	0.001354	0.000825
22.0752	0.001553	0.001613	0.001487	0.000846	0.000232	0.000968	0.001371	0.000983
22.0836	0.001485	0.001483	0.001296	0.000852	0.000260	0.000968	0.001396	0.001071
22.0919	0.001439	0.001403	0.001209	0.000857	0.000279	0.000933	0.001481	0.001126
22.1002	0.001358	0.001325	0.001125	0.000857	0.000287	0.000899	0.001475	0.001117
22.1086	0.001258	0.001184	0.001017	0.000840	0.000283	0.000840	0.001468	0.001114
22.1169	0.001161	0.001058	0.000927	0.000823	0.000283	0.000776	0.001445	0.001057
22.1252	0.001080	0.000911	0.000840	0.000800	0.000287	0.000708	0.001305	0.000980
22.1336	0.000989	0.000798	0.000723	0.000694	0.000263	0.000649	0.001235	0.000913
22.1419	0.000895	0.000709	0.000640	0.000610	0.000252	0.000571	0.001097	0.000836
22.1502	0.000782	0.000598	0.000546	0.000525	0.000226	0.000512	0.000982	0.000750
22.1586	0.000707	0.000504	0.000458	0.000463	0.000201	0.000475	0.000847	0.000625
22.1669	0.000626	0.000399	0.000381	0.000404	0.000184	0.000450	0.000778	0.000526
22.1752	0.000553	0.000342	0.000341	0.000353	0.000159	0.000407	0.000658	0.000430
22.1836	0.000475	0.000300	0.000281	0.000300	0.000138	0.000289	0.000569	0.000359
22.1919	0.000410	0.000246	0.000264	0.000258	0.000124	0.000242	0.000462	0.000280
22.2002	0.000349	0.000209	0.000217	0.000223	0.000107	0.000198	0.000383	0.000229
22.2086	0.000296	0.000160	0.000167	0.000189	8.7447e-5	0.000159	0.000311	0.000183
22.2169	0.00025	0.000139	0.000151	0.000157	7.3545e-5	0.000144	0.000247	0.000153
22.2252	0.000211	0.000111	0.000141	0.000131	6.2672e-5	0.000123	0.000184	0.000121
22.2336	0.000177	9.9544e-5	0.000125	0.000111	5.0714e-5	8.9386e-5	0.000152	8.5289e-5
22.2419	0.000138	7.7503e-5	8.2233e-5	7.8769e-5	4.3083e-5	7.0772e-5	0.00011	6.1046e-5
22.2502	0.000110	4.8644e-5	5.4228e-5	6.9655e-5	3.4545e-5	6.2142e-5	7.8849e-5	4.8359e-5
22.2586	8.2124e-5	3.2967e-5	2.6886e-5	5.6805e-5	2.6828e-5	5.5949e-5	5.8060e-5	2.8881e-5
22.2669	6.1930e-5	2.5141e-5	2.2024e-5	3.9489e-5	1.9963e-5	5.0045e-5	2.6727e-5	1.5055e-5
22.2752	4.2298e-5	1.9435e-5	1.6407e-5	2.9340e-5	1.3986e-5	4.0956e-5	1.2469e-5	7.4044e-6
22.2836	3.0306e-5	1.5454e-5	1.3541e-5	1.7699e-5	1.0750e-5	3.4240e-5	4.9971e-6	2.3218e-6
22.2919	2.1240e-5	1.1817e-5	9.9156e-6	1.3900e-5	7.0351e-6	3.0964e-5	8.5212e-7	6.0233e-8
22.3002	1.8374e-5	9.5370e-6	7.6294e-6	1.1605e-5	6.0892e-6	2.9346e-5	6.9002e-7	3.6656e-8
22.3085	1.5667e-5	7.4614e-6	5.5890e-6	9.4650e-6	5.1989e-6	2.7760e-5	5.4402e-7	1.8527e-8
22.3169	1.3136e-5	5.6077e-6	3.8186e-6	7.4974e-6	4.3696e-6	2.6214e-5	4.1495e-7	6.2452e-9
22.3252	1.0787e-5	3.9852e-6	2.3367e-6	5.7125e-6	3.6029e-6	2.4706e-5	3.0294e-7	3.3505e-10
22.3335	8.6281e-6	2.6057e-6	1.1691e-6	4.1208e-6	2.9004e-6	2.3238e-5	2.0812e-7	0
22.3419	2.4274e-6	5.0010e-7	3.6154e-7	1.1039e-6	7.1326e-7	4.2896e-6	5.3564e-8	4.8395e-8
22.3502	0	0	0	0	0	0	0	0
22.3586	0	0	0	0	0	0	0	0

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 21.583088889 h
Event on u183-91

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.8329E+00	842.	1742.	.1578E-02	2762.
field_2	.1325E+01	872.	1622.	.2192E-02	2762.
g4_1	.1121E+01	812.	1622.	.1893E-02	2762.
g4_2	.4465E+00	992.	1862.	.8574E-03	2762.
g8_1	.1518E+00	812.	1952.	.2868E-03	2762.
g8_2	.4429E+00	992.	1802.	.9681E-03	2762.
rip_1	.6998E+00	812.	1832.	.1481E-02	2762.
rip_2	.4535E+00	2732.	1832.	.1126E-02	2762.
field_avg	.1079E+01	842.	1652.	.1793E-02	2762.
g4_avg	.7838E+00	812.	1682.	.1301E-02	2762.
g8_avg	.2974E+00	812.	1802.	.6142E-03	2762.

RAINFALL DATA FOR EVENT u183-91

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 21.583088889 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.1693E-05
.2999E+03	.6773E-05
.5998E+03	.1101E-04
.9000E+03	.1947E-04
.1200E+04	.1947E-04
.1500E+04	.1524E-04
.1800E+04	.5080E-05
.2100E+04	.1693E-05

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.1693E-05
.2999E+03	.6773E-05
.5998E+03	.1101E-04
.9000E+03	.1947E-04
.1200E+04	.1947E-04
.1500E+04	.1524E-04
.1800E+04	.5080E-05
.2100E+04	.1693E-05
.2400E+04	.2540E-05
.2700E+04	.8467E-06
.3001E+04	.0000E+00
.3603E+04	.0000E+00

Total rainfall volume= 2.515 cm

Table 4. Summary of field data for event on (04/23/92)

TABLE OF SEDIMENT AND RUNOFF DATA (04/23/92)

Files used= u112-92.q u112-92.sedin
Collector= g4_1
Number of field samples= 4

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
21.434400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
21.442800	.7036E-07	.5451E-02	.3835E-06	.1160E-04
21.451100	.4585E-06	.1084E-01	.4969E-05	.1601E-03
21.459400	.1096E-05	.1622E-01	.1778E-04	.6915E-03
21.467800	.2444E-05	.2168E-01	.5298E-04	.2294E-02
21.476100	.3577E-05	.2706E-01	.9679E-04	.5186E-02
21.484400	.3577E-05	.3245E-01	.1161E-03	.8653E-02
21.492800	.4882E-05	.3790E-01	.1850E-03	.1425E-01
21.501100	.4882E-05	.4329E-01	.2113E-03	.2056E-01
21.509400	.8843E-05	.4867E-01	.4304E-03	.3342E-01
21.517800	.2331E-04	.5412E-01	.1262E-02	.7158E-01
21.526100	.1063E-03	.5951E-01	.6324E-02	.2605E+00
21.534400	.2105E-03	.6490E-01	.1366E-01	.6687E+00
21.542800	.2105E-03	.7035E-01	.1481E-01	.1116E+01
21.551100	.2105E-03	.7828E-01	.1648E-01	.1609E+01
21.559400	.2238E-03	.1029E+00	.2303E-01	.2297E+01
21.567800	.2445E-03	.1278E+00	.3124E-01	.3241E+01
21.576100	.2659E-03	.1523E+00	.4051E-01	.4452E+01
21.584400	.3548E-03	.1798E+00	.6378E-01	.6358E+01
21.592800	.4053E-03	.2270E+00	.9199E-01	.9139E+01
21.601100	.4096E-03	.2736E+00	.1121E+00	.1249E+02
21.609400	.3918E-03	.3203E+00	.1255E+00	.1624E+02
21.617800	.3577E-03	.3568E+00	.1276E+00	.2010E+02
21.626100	.3250E-03	.3247E+00	.1055E+00	.2325E+02
21.634400	.3127E-03	.2926E+00	.9149E-01	.2598E+02
21.642800	.2743E-03	.2602E+00	.7137E-01	.2814E+02
21.651100	.2416E-03	.2281E+00	.5510E-01	.2979E+02
21.659400	.2040E-03	.1960E+00	.3998E-01	.3098E+02
21.667800	.1813E-03	.1675E+00	.3036E-01	.3190E+02
21.676100	.1568E-03	.1641E+00	.2573E-01	.3267E+02
21.684400	.1338E-03	.1606E+00	.2150E-01	.3331E+02
21.692800	.1307E-03	.1572E+00	.2055E-01	.3393E+02
21.701100	.1171E-03	.1538E+00	.1801E-01	.3447E+02
21.709400	.9212E-04	.1504E+00	.1385E-01	.3489E+02
21.717800	.8946E-04	.1469E+00	.1315E-01	.3528E+02
21.726100	.7574E-04	.1435E+00	.1087E-01	.3561E+02
21.734400	.7328E-04	.1401E+00	.1027E-01	.3592E+02
21.742800	.6069E-04	.1367E+00	.8297E-02	.3617E+02
21.751100	.5846E-04	.1333E+00	.7792E-02	.3640E+02
21.759400	.4884E-04	.1299E+00	.6344E-02	.3659E+02
21.767800	.4680E-04	.1264E+00	.5918E-02	.3677E+02
21.776100	.4480E-04	.1230E+00	.5512E-02	.3693E+02
21.784400	.3947E-04	.1196E+00	.4723E-02	.3707E+02
21.792800	.3761E-04	.1162E+00	.4370E-02	.3721E+02
21.801100	.3578E-04	.1128E+00	.4036E-02	.3733E+02
21.809400	.3399E-04	.1094E+00	.3718E-02	.3744E+02
21.817800	.3224E-04	.1059E+00	.3415E-02	.3754E+02
21.826100	.2622E-04	.1025E+00	.2688E-02	.3762E+02
21.834400	.2465E-04	.9913E-01	.2444E-02	.3769E+02
21.842800	.2312E-04	.9568E-01	.2212E-02	.3776E+02
21.851100	.2163E-04	.9228E-01	.1996E-02	.3782E+02
21.859400	.2018E-04	.8888E-01	.1794E-02	.3787E+02
21.867800	.1878E-04	.8543E-01	.1604E-02	.3792E+02
21.876100	.1741E-04	.8203E-01	.1428E-02	.3797E+02
21.884400	.1609E-04	.7862E-01	.1265E-02	.3800E+02
21.892800	.1481E-04	.7518E-01	.1114E-02	.3804E+02
21.901100	.1358E-04	.7177E-01	.9746E-03	.3807E+02
21.909400	.1239E-04	.6837E-01	.8471E-03	.3809E+02
21.917800	.1125E-04	.6492E-01	.7302E-03	.3811E+02
21.926100	.1015E-04	.6152E-01	.6244E-03	.3813E+02
21.934400	.9099E-05	.5812E-01	.5288E-03	.3815E+02
21.942800	.8096E-05	.5467E-01	.4426E-03	.3816E+02
21.951100	.7143E-05	.5127E-01	.3662E-03	.3817E+02
21.959400	.6239E-05	.4786E-01	.2986E-03	.3818E+02
21.967800	.5387E-05	.4442E-01	.2393E-03	.3819E+02

21.976100	.4587E-05	.4101E-01	.1881E-03	.3819E+02
21.984400	.3841E-05	.3761E-01	.1445E-03	.3820E+02
21.992800	.3151E-05	.3416E-01	.1077E-03	.3820E+02
22.001100	.2519E-05	.3076E-01	.7747E-04	.3820E+02
22.009400	.1946E-05	.2736E-01	.5322E-04	.3821E+02
22.017800	.1435E-05	.2391E-01	.3432E-04	.3821E+02
22.026100	.9910E-06	.2051E-01	.2032E-04	.3821E+02
22.034400	.6170E-06	.1710E-01	.1055E-04	.3821E+02
22.042800	.3195E-06	.1366E-01	.4363E-05	.3821E+02
22.051100	.1078E-06	.1025E-01	.1106E-05	.3821E+02
22.059400	.2506E-08	.6849E-02	.1716E-07	.3821E+02
22.067800	.0000E+00	.3404E-02	.0000E+00	.3821E+02
22.076100	.0000E+00	.0000E+00	.0000E+00	.3821E+02

Total runoff volume going through collector g4_1 = .197296194 m^3
Total sediment going through collector g4_1 = 38.207356413 g

Collector= field_1
Number of field samples= 7

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
21.434400	.0000E+00	.5213E+00	.0000E+00	.0000E+00
21.442800	.4197E-05	.4061E+00	.1705E-02	.5155E-01
21.451100	.6608E-04	.3035E+00	.2006E-01	.6508E+00
21.459400	.2006E-03	.2736E+00	.5487E-01	.2290E+01
21.467800	.2903E-03	.2433E+00	.7064E-01	.4426E+01
21.476100	.3177E-03	.2134E+00	.6782E-01	.6453E+01
21.484400	.3177E-03	.1986E+00	.6309E-01	.8338E+01
21.492800	.3421E-03	.2864E+00	.9798E-01	.1130E+02
21.501100	.3421E-03	.3732E+00	.1277E+00	.1512E+02
21.509400	.3462E-03	.4601E+00	.1593E+00	.1988E+02
21.517800	.3462E-03	.5479E+00	.1897E+00	.2561E+02
21.526100	.3462E-03	.6347E+00	.2198E+00	.3218E+02
21.534400	.3502E-03	.7216E+00	.2527E+00	.3973E+02
21.542800	.3460E-03	.8094E+00	.2801E+00	.4820E+02
21.551100	.3460E-03	.8963E+00	.3101E+00	.5746E+02
21.559400	.3502E-03	.9831E+00	.3443E+00	.6775E+02
21.567800	.3543E-03	.1071E+01	.3795E+00	.7923E+02
21.576100	.3543E-03	.1158E+01	.4102E+00	.9148E+02
21.584400	.3469E-03	.1245E+01	.4317E+00	.1044E+03
21.592800	.3435E-03	.1332E+01	.4577E+00	.1182E+03
21.601100	.3119E-03	.1409E+01	.4394E+00	.1314E+03
21.609400	.2740E-03	.1417E+01	.3883E+00	.1430E+03
21.617800	.2380E-03	.1426E+01	.3394E+00	.1532E+03
21.626100	.2212E-03	.1434E+01	.3173E+00	.1627E+03
21.634400	.1725E-03	.1397E+01	.2410E+00	.1699E+03
21.642800	.1517E-03	.1047E+01	.1589E+00	.1747E+03
21.651100	.1320E-03	.7379E+00	.9743E-01	.1776E+03
21.659400	.1188E-03	.6660E+00	.7913E-01	.1800E+03
21.667800	.1036E-03	.5932E+00	.6145E-01	.1818E+03
21.676100	.9408E-04	.5213E+00	.4905E-01	.1833E+03
21.684400	.8028E-04	.4494E+00	.3608E-01	.1844E+03
21.692800	.7842E-04	.3767E+00	.2954E-01	.1853E+03
21.701100	.7212E-04	.3048E+00	.2198E-01	.1859E+03
21.709400	.6604E-04	.2329E+00	.1538E-01	.1864E+03
21.717800	.6432E-04	.1694E+00	.1090E-01	.1867E+03
21.726100	.4690E-04	.1655E+00	.7762E-02	.1870E+03
21.734400	.4540E-04	.1616E+00	.7336E-02	.1872E+03
21.742800	.3695E-04	.1576E+00	.5824E-02	.1873E+03
21.751100	.3559E-04	.1537E+00	.5470E-02	.1875E+03
21.759400	.3105E-04	.1498E+00	.4651E-02	.1877E+03
21.767800	.2979E-04	.1458E+00	.4343E-02	.1878E+03
21.776100	.2854E-04	.1419E+00	.4049E-02	.1879E+03
21.784400	.2441E-04	.1379E+00	.3366E-02	.1880E+03
21.792800	.2326E-04	.1340E+00	.3116E-02	.1881E+03
21.801100	.2213E-04	.1300E+00	.2878E-02	.1882E+03
21.809400	.2103E-04	.1261E+00	.2652E-02	.1883E+03
21.817800	.1995E-04	.1221E+00	.2437E-02	.1883E+03
21.826100	.1763E-04	.1182E+00	.2084E-02	.1884E+03
21.834400	.1663E-04	.1143E+00	.1900E-02	.1885E+03
21.842800	.1565E-04	.1103E+00	.1726E-02	.1885E+03
21.851100	.1469E-04	.1064E+00	.1563E-02	.1886E+03
21.859400	.1376E-04	.1025E+00	.1410E-02	.1886E+03
21.867800	.1285E-04	.9850E-01	.1266E-02	.1886E+03
21.876100	.1197E-04	.9458E-01	.1132E-02	.1887E+03
21.884400	.1111E-04	.9065E-01	.1007E-02	.1887E+03
21.892800	.1028E-04	.8668E-01	.8909E-03	.1887E+03
21.901100	.9473E-05	.8275E-01	.7839E-03	.1887E+03
21.909400	.8694E-05	.7883E-01	.6853E-03	.1888E+03
21.917800	.7942E-05	.7486E-01	.5945E-03	.1888E+03
21.926100	.7218E-05	.7093E-01	.5120E-03	.1888E+03
21.934400	.5706E-05	.6701E-01	.3824E-03	.1888E+03
21.942800	.5075E-05	.6304E-01	.3199E-03	.1888E+03
21.951100	.4474E-05	.5911E-01	.2644E-03	.1888E+03
21.959400	.3903E-05	.5519E-01	.2154E-03	.1888E+03
21.967800	.3365E-05	.5121E-01	.1723E-03	.1888E+03
21.976100	.2859E-05	.4729E-01	.1352E-03	.1888E+03
21.984400	.2387E-05	.4336E-01	.1035E-03	.1889E+03
21.992800	.1949E-05	.3939E-01	.7678E-04	.1889E+03
22.001100	.1548E-05	.3547E-01	.5491E-04	.1889E+03
22.009400	.1185E-05	.3154E-01	.3738E-04	.1889E+03
22.017800	.8620E-06	.2757E-01	.2376E-04	.1889E+03
22.026100	.5816E-06	.2364E-01	.1375E-04	.1889E+03
22.034400	.3473E-06	.1972E-01	.6849E-05	.1889E+03
22.042800	.1642E-06	.1575E-01	.2586E-05	.1889E+03

22.051100	.4078E-07	.1182E-01	.4821E-06	.1889E+03
22.059400	.0000E+00	.7897E-02	.0000E+00	.1889E+03
22.067800	.0000E+00	.3925E-02	.0000E+00	.1889E+03
22.076100	.0000E+00	.0000E+00	.0000E+00	.1889E+03

Total runoff volume going through collector field_1 = .253421039 m^3
Total sediment going through collector field_1 = 188.857836265 g

Collector= g4_2
Number of field samples= 3

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
21.434400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
21.442800	.0000E+00	.8355E-01	.0000E+00	.0000E+00
21.451100	.0000E+00	.1661E+00	.0000E+00	.0000E+00
21.459400	.0000E+00	.2487E+00	.0000E+00	.0000E+00
21.467800	.3565E-06	.3322E+00	.1184E-03	.3582E-02
21.476100	.6902E-06	.4148E+00	.2863E-03	.1214E-01
21.484400	.6902E-06	.4973E+00	.3433E-03	.2239E-01
21.492800	.1587E-05	.5809E+00	.9216E-03	.5026E-01
21.501100	.1587E-05	.6635E+00	.1053E-02	.8172E-01
21.509400	.1103E-05	.7460E+00	.8228E-03	.1063E+00
21.517800	.6902E-06	.7874E+00	.5435E-03	.1227E+00
21.526100	.6605E-05	.5613E+00	.3707E-02	.2335E+00
21.534400	.1899E-04	.3559E+00	.6758E-02	.4354E+00
21.542800	.3255E-04	.2903E+00	.9452E-02	.7213E+00
21.551100	.4685E-04	.2336E+00	.1095E-01	.1048E+01
21.559400	.7190E-04	.2299E+00	.1653E-01	.1542E+01
21.567800	.9327E-04	.2262E+00	.2110E-01	.2180E+01
21.576100	.1422E-03	.2225E+00	.3164E-01	.3125E+01
21.584400	.1888E-03	.2188E+00	.4131E-01	.4360E+01
21.592800	.2261E-03	.2151E+00	.4863E-01	.5831E+01
21.601100	.2811E-03	.2114E+00	.5942E-01	.7606E+01
21.609400	.3005E-03	.2077E+00	.6239E-01	.9470E+01
21.617800	.3324E-03	.2039E+00	.6779E-01	.1152E+02
21.626100	.3489E-03	.2002E+00	.6987E-01	.1361E+02
21.634400	.3531E-03	.1965E+00	.6940E-01	.1568E+02
21.642800	.3531E-03	.1928E+00	.6808E-01	.1774E+02
21.651100	.2856E-03	.1891E+00	.5401E-01	.1935E+02
21.659400	.2134E-03	.1854E+00	.3956E-01	.2054E+02
21.667800	.2105E-03	.1817E+00	.3824E-01	.2169E+02
21.676100	.2009E-03	.1780E+00	.3576E-01	.2276E+02
21.684400	.1506E-03	.1743E+00	.2624E-01	.2354E+02
21.692800	.1480E-03	.1706E+00	.2525E-01	.2431E+02
21.701100	.1455E-03	.1669E+00	.2428E-01	.2503E+02
21.709400	.1401E-03	.1632E+00	.2286E-01	.2572E+02
21.717800	.1377E-03	.1594E+00	.2195E-01	.2638E+02
21.726100	.1352E-03	.1557E+00	.2106E-01	.2701E+02
21.734400	.1328E-03	.1520E+00	.2020E-01	.2761E+02
21.742800	.8817E-04	.1483E+00	.1308E-01	.2801E+02
21.751100	.8612E-04	.1446E+00	.1245E-01	.2838E+02
21.759400	.8409E-04	.1409E+00	.1185E-01	.2874E+02
21.767800	.8208E-04	.1372E+00	.1126E-01	.2908E+02
21.776100	.8009E-04	.1335E+00	.1069E-01	.2940E+02
21.784400	.7811E-04	.1298E+00	.1014E-01	.2970E+02
21.792800	.7616E-04	.1261E+00	.9601E-02	.2999E+02
21.801100	.7423E-04	.1224E+00	.9083E-02	.3026E+02
21.809400	.7231E-04	.1187E+00	.8582E-02	.3052E+02
21.817800	.7042E-04	.1149E+00	.8093E-02	.3076E+02
21.826100	.3682E-04	.1112E+00	.4096E-02	.3088E+02
21.834400	.3536E-04	.1075E+00	.3803E-02	.3100E+02
21.842800	.3393E-04	.1038E+00	.3522E-02	.3110E+02
21.851100	.3252E-04	.1001E+00	.3256E-02	.3120E+02
21.859400	.3113E-04	.9643E-01	.3002E-02	.3129E+02
21.867800	.2977E-04	.9269E-01	.2759E-02	.3137E+02
21.876100	.2843E-04	.8899E-01	.2530E-02	.3145E+02
21.884400	.2711E-04	.8530E-01	.2312E-02	.3152E+02
21.892800	.2582E-04	.8156E-01	.2106E-02	.3158E+02
21.901100	.2455E-04	.7787E-01	.1912E-02	.3164E+02
21.909400	.2331E-04	.7418E-01	.1729E-02	.3169E+02
21.917800	.2209E-04	.7044E-01	.1556E-02	.3174E+02
21.926100	.2090E-04	.6675E-01	.1395E-02	.3178E+02
21.934400	.7047E-05	.6305E-01	.4443E-03	.3179E+02
21.942800	.6288E-05	.5931E-01	.3730E-03	.3180E+02
21.951100	.5563E-05	.5562E-01	.3094E-03	.3181E+02
21.959400	.4873E-05	.5193E-01	.2531E-03	.3182E+02
21.967800	.4219E-05	.4819E-01	.2033E-03	.3183E+02
21.976100	.3602E-05	.4450E-01	.1603E-03	.3183E+02
21.984400	.3023E-05	.4080E-01	.1234E-03	.3184E+02
21.992800	.2485E-05	.3707E-01	.9210E-04	.3184E+02
22.001100	.1988E-05	.3337E-01	.6633E-04	.3184E+02
22.009400	.1535E-05	.2968E-01	.4555E-04	.3184E+02
22.017800	.1128E-05	.2594E-01	.2927E-04	.3184E+02
22.026100	.7719E-06	.2225E-01	.1717E-04	.3184E+02
22.034400	.4702E-06	.1856E-01	.8724E-05	.3184E+02
22.042800	.2298E-06	.1482E-01	.3405E-05	.3184E+02
22.051100	.6213E-07	.1112E-01	.6912E-06	.3184E+02
22.059400	.0000E+00	.7431E-02	.0000E+00	.3184E+02
22.067800	.0000E+00	.3693E-02	.0000E+00	.3184E+02
22.076100	.0000E+00	.0000E+00	.0000E+00	.3184E+02

Total runoff volume going through collector g4_2 = .177308648 m^3
Total sediment going through collector g4_2 = 31.843865222 g

Collector= g8_2
Number of field samples= 2

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
21.434400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
21.442800	.0000E+00	.4172E-01	.0000E+00	.0000E+00
21.451100	.0000E+00	.8295E-01	.0000E+00	.0000E+00
21.459400	.0000E+00	.1242E+00	.0000E+00	.0000E+00
21.467800	.5012E-07	.1659E+00	.8315E-05	.2514E-03
21.476100	.0000E+00	.2071E+00	.0000E+00	.2514E-03
21.484400	.0000E+00	.2483E+00	.0000E+00	.2514E-03
21.492800	.5012E-07	.2901E+00	.1454E-04	.6911E-03
21.501100	.5012E-07	.3313E+00	.1660E-04	.1187E-02
21.509400	.0000E+00	.3725E+00	.0000E+00	.1187E-02
21.517800	.0000E+00	.4142E+00	.0000E+00	.1187E-02
21.526100	.0000E+00	.4555E+00	.0000E+00	.1187E-02
21.534400	.4508E-07	.4967E+00	.2239E-04	.1856E-02
21.542800	.0000E+00	.5384E+00	.0000E+00	.1856E-02
21.551100	.0000E+00	.5796E+00	.0000E+00	.1856E-02
21.559400	.0000E+00	.6209E+00	.0000E+00	.1856E-02
21.567800	.0000E+00	.6626E+00	.0000E+00	.1856E-02
21.576100	.4508E-07	.7038E+00	.3173E-04	.2804E-02
21.584400	.0000E+00	.7450E+00	.0000E+00	.2804E-02
21.592800	.0000E+00	.7868E+00	.0000E+00	.2804E-02
21.601100	.0000E+00	.8280E+00	.0000E+00	.2804E-02
21.609400	.0000E+00	.8692E+00	.0000E+00	.2804E-02
21.617800	.0000E+00	.9109E+00	.0000E+00	.2804E-02
21.626100	.0000E+00	.9522E+00	.0000E+00	.2804E-02
21.634400	.0000E+00	.9934E+00	.0000E+00	.2804E-02
21.642800	.0000E+00	.1035E+01	.0000E+00	.2804E-02
21.651100	.1216E-05	.1019E+01	.1239E-02	.3982E-01
21.659400	.2710E-04	.6268E+00	.1698E-01	.5473E+00
21.667800	.6608E-04	.2827E+00	.1868E-01	.1112E+01
21.676100	.8625E-04	.2770E+00	.2389E-01	.1826E+01
21.684400	.9845E-04	.2712E+00	.2670E-01	.2624E+01
21.692800	.9845E-04	.2654E+00	.2613E-01	.3414E+01
21.701100	.1061E-03	.2597E+00	.2756E-01	.4238E+01
21.709400	.1087E-03	.2539E+00	.2761E-01	.5063E+01
21.717800	.1087E-03	.2481E+00	.2698E-01	.5878E+01
21.726100	.1087E-03	.2424E+00	.2636E-01	.6666E+01
21.734400	.1087E-03	.2366E+00	.2573E-01	.7435E+01
21.742800	.1087E-03	.2308E+00	.2510E-01	.8194E+01
21.751100	.1087E-03	.2251E+00	.2447E-01	.8925E+01
21.759400	.9429E-04	.2193E+00	.2068E-01	.9543E+01
21.767800	.9018E-04	.2135E+00	.1925E-01	.1012E+02
21.776100	.8615E-04	.2077E+00	.1790E-01	.1066E+02
21.784400	.7537E-04	.2020E+00	.1522E-01	.1111E+02
21.792800	.7165E-04	.1962E+00	.1406E-01	.1154E+02
21.801100	.6802E-04	.1904E+00	.1295E-01	.1193E+02
21.809400	.6446E-04	.1847E+00	.1191E-01	.1228E+02
21.817800	.6099E-04	.1789E+00	.1091E-01	.1261E+02
21.826100	.5181E-04	.1731E+00	.8968E-02	.1288E+02
21.834400	.4866E-04	.1674E+00	.8144E-02	.1312E+02
21.842800	.4560E-04	.1616E+00	.7367E-02	.1335E+02
21.851100	.4263E-04	.1558E+00	.6642E-02	.1354E+02
21.859400	.3975E-04	.1501E+00	.5965E-02	.1372E+02
21.867800	.3696E-04	.1442E+00	.5330E-02	.1388E+02
21.876100	.3425E-04	.1385E+00	.4744E-02	.1403E+02
21.884400	.3164E-04	.1327E+00	.4200E-02	.1415E+02
21.892800	.2912E-04	.1269E+00	.3696E-02	.1426E+02
21.901100	.2669E-04	.1212E+00	.3234E-02	.1436E+02
21.909400	.2435E-04	.1154E+00	.2811E-02	.1444E+02
21.917800	.2211E-04	.1096E+00	.2424E-02	.1452E+02
21.926100	.1997E-04	.1039E+00	.2074E-02	.1458E+02
21.934400	.1675E-04	.9812E-01	.1644E-02	.1463E+02
21.942800	.1486E-04	.9231E-01	.1372E-02	.1467E+02
21.951100	.1307E-04	.8656E-01	.1131E-02	.1470E+02
21.959400	.1138E-04	.8081E-01	.9196E-03	.1473E+02
21.967800	.9794E-05	.7499E-01	.7345E-03	.1475E+02
21.976100	.8314E-05	.6925E-01	.5757E-03	.1477E+02
21.984400	.6942E-05	.6350E-01	.4408E-03	.1478E+02
21.992800	.5680E-05	.5768E-01	.3276E-03	.1479E+02
22.001100	.4531E-05	.5194E-01	.2353E-03	.1480E+02
22.009400	.3497E-05	.4619E-01	.1615E-03	.1481E+02
22.017800	.2583E-05	.4037E-01	.1043E-03	.1481E+02
22.026100	.1793E-05	.3462E-01	.6207E-04	.1481E+02
22.034400	.1132E-05	.2888E-01	.3269E-04	.1481E+02
22.042800	.6088E-06	.2306E-01	.1404E-04	.1481E+02
22.051100	.2333E-06	.1731E-01	.4038E-05	.1481E+02
22.059400	.2537E-07	.1156E-01	.2933E-06	.1481E+02
22.067800	.0000E+00	.5747E-02	.0000E+00	.1481E+02
22.076100	.0000E+00	.0000E+00	.0000E+00	.1481E+02

Total runoff volume going through collector g8_2 = .069066289 m^3
Total sediment going through collector g8_2 = 14.8118803 g

Collector= field_2
Number of field samples= 13

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
21.434400	.0000E+00	.6046E+00	.0000E+00	.0000E+00
21.442800	.3214E-05	.4602E+00	.1479E-02	.4472E-01
21.451100	.1484E-04	.4734E+00	.7026E-02	.2547E+00

21.459400	.4631E-04	.1506E+01	.6976E-01	.2339E+01
21.467800	.1140E-03	.2455E+01	.2798E+00	.1080E+02
21.476100	.3282E-03	.2778E+01	.9118E+00	.3804E+02
21.484400	.3282E-03	.3017E+01	.9903E+00	.6763E+02
21.492800	.4005E-03	.2684E+01	.1075E+01	.1001E+03
21.501100	.4005E-03	.2381E+01	.9534E+00	.1286E+03
21.509400	.4412E-03	.2251E+01	.9933E+00	.1583E+03
21.517800	.4598E-03	.2121E+01	.9752E+00	.1878E+03
21.526100	.4505E-03	.1992E+01	.8972E+00	.2146E+03
21.534400	.4227E-03	.1879E+01	.7944E+00	.2383E+03
21.542800	.4185E-03	.1881E+01	.7874E+00	.2621E+03
21.551100	.4199E-03	.1884E+01	.7909E+00	.2858E+03
21.559400	.3993E-03	.1886E+01	.7529E+00	.3083E+03
21.567800	.4009E-03	.1790E+01	.7176E+00	.3300E+03
21.576100	.3982E-03	.1075E+01	.4279E+00	.3428E+03
21.584400	.3780E-03	.4499E+00	.1701E+00	.3478E+03
21.592800	.3374E-03	.4403E+00	.1486E+00	.3523E+03
21.601100	.2911E-03	.4307E+00	.1254E+00	.3561E+03
21.609400	.2697E-03	.4212E+00	.1136E+00	.3595E+03
21.617800	.2418E-03	.4135E+00	.9999E-01	.3625E+03
21.626100	.2052E-03	.4181E+00	.8581E-01	.3651E+03
21.634400	.1869E-03	.4222E+00	.7890E-01	.3674E+03
21.642800	.1572E-03	.4218E+00	.6631E-01	.3694E+03
21.651100	.1409E-03	.4146E+00	.5843E-01	.3712E+03
21.659400	.1227E-03	.3633E+00	.4458E-01	.3725E+03
21.667800	.1184E-03	.3180E+00	.3765E-01	.3736E+03
21.676100	.9669E-04	.3148E+00	.3044E-01	.3746E+03
21.684400	.8130E-04	.3117E+00	.2534E-01	.3753E+03
21.692800	.7992E-04	.3085E+00	.2465E-01	.3761E+03
21.701100	.7635E-04	.3053E+00	.2331E-01	.3768E+03
21.709400	.6657E-04	.3022E+00	.2012E-01	.3774E+03
21.717800	.6530E-04	.2990E+00	.1952E-01	.3779E+03
21.726100	.5242E-04	.2958E+00	.1551E-01	.3784E+03
21.734400	.5127E-04	.2927E+00	.1501E-01	.3789E+03
21.742800	.4308E-04	.2895E+00	.1247E-01	.3792E+03
21.751100	.4203E-04	.2863E+00	.1204E-01	.3796E+03
21.759400	.3771E-04	.2832E+00	.1068E-01	.3799E+03
21.767800	.3672E-04	.2800E+00	.1028E-01	.3802E+03
21.776100	.3574E-04	.2768E+00	.9894E-02	.3805E+03
21.784400	.3323E-04	.2737E+00	.9094E-02	.3808E+03
21.792800	.3229E-04	.2705E+00	.8733E-02	.3811E+03
21.801100	.3136E-04	.2674E+00	.8384E-02	.3813E+03
21.809400	.3044E-04	.2642E+00	.8043E-02	.3815E+03
21.817800	.2954E-04	.2610E+00	.7709E-02	.3818E+03
21.826100	.2723E-04	.2579E+00	.7021E-02	.3820E+03
21.834400	.2637E-04	.2547E+00	.6716E-02	.3822E+03
21.842800	.2552E-04	.2515E+00	.6418E-02	.3824E+03
21.851100	.2468E-04	.2484E+00	.6129E-02	.3826E+03
21.859400	.2385E-04	.2452E+00	.5849E-02	.3827E+03
21.867800	.2304E-04	.2420E+00	.5576E-02	.3829E+03
21.876100	.2224E-04	.2389E+00	.5312E-02	.3831E+03
21.884400	.2145E-04	.2357E+00	.5055E-02	.3832E+03
21.892800	.2067E-04	.2325E+00	.4806E-02	.3834E+03
21.901100	.1990E-04	.2294E+00	.4565E-02	.3835E+03
21.909400	.1915E-04	.2262E+00	.4332E-02	.3836E+03
21.917800	.1841E-04	.2230E+00	.4106E-02	.3838E+03
21.926100	.1768E-04	.2199E+00	.3888E-02	.3839E+03
21.934400	.1813E-04	.2167E+00	.3929E-02	.3840E+03
21.942800	.1741E-04	.2135E+00	.3717E-02	.3841E+03
21.951100	.1670E-04	.2104E+00	.3512E-02	.3842E+03
21.959400	.1600E-04	.2072E+00	.3315E-02	.3843E+03
21.967800	.1531E-04	.2040E+00	.3124E-02	.3844E+03
21.976100	.1464E-04	.2009E+00	.2941E-02	.3845E+03
21.984400	.1398E-04	.1977E+00	.2765E-02	.3846E+03
21.992800	.1334E-04	.1945E+00	.2594E-02	.3846E+03
22.001100	.1270E-04	.1914E+00	.2431E-02	.3847E+03
22.009400	.1208E-04	.1882E+00	.2274E-02	.3848E+03
22.017800	.1148E-04	.1850E+00	.2124E-02	.3849E+03
22.026100	.1088E-04	.1819E+00	.1980E-02	.3849E+03
22.034400	.1031E-04	.1787E+00	.1842E-02	.3850E+03
22.042800	.9739E-05	.1755E+00	.1710E-02	.3850E+03
22.051100	.9187E-05	.1724E+00	.1584E-02	.3851E+03
22.059400	.8649E-05	.1692E+00	.1464E-02	.3851E+03
22.067800	.0000E+00	.1465E+00	.0000E+00	.3851E+03
22.076100	.0000E+00	.0000E+00	.0000E+00	.3851E+03

Total runoff volume going through collector field_2 = .279560758 m^3
Total sediment going through collector field_2 = 385.109252618 g

Collector= rip_1
Number of field samples= 8

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
21.434400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
21.442800	.1803E-07	.1723E-01	.3106E-06	.9391E-05
21.451100	.1803E-07	.3425E-01	.6174E-06	.2784E-04
21.459400	.1803E-07	.5128E-01	.9243E-06	.5546E-04
21.467800	.0000E+00	.6850E-01	.0000E+00	.5546E-04
21.476100	.1803E-07	.8553E-01	.1542E-05	.1015E-03
21.484400	.1803E-07	.1026E+00	.1849E-05	.1568E-03
21.492800	.1803E-07	.1198E+00	.2159E-05	.2220E-03
21.501100	.1803E-07	.1368E+00	.2466E-05	.2957E-03
21.509400	.6957E-07	.1538E+00	.1070E-04	.6155E-03
21.517800	.6957E-07	.1711E+00	.1190E-04	.9753E-03
21.526100	.6957E-07	.1881E+00	.1308E-04	.1366E-02

21.534400	.1938E-07	.2051E+00	.3975E-05	.1485E-02
21.542800	.7216E-07	.2223E+00	.1604E-04	.1970E-02
21.551100	.7216E-07	.2394E+00	.1727E-04	.2486E-02
21.559400	.7216E-07	.2564E+00	.1850E-04	.3039E-02
21.567800	.1938E-07	.2681E+00	.5196E-05	.3196E-02
21.576100	.1945E-04	.2446E+00	.4756E-02	.1453E+00
21.584400	.4436E-04	.2192E+00	.9726E-02	.4359E+00
21.592800	.8980E-04	.1814E+00	.1629E-01	.9285E+00
21.601100	.1394E-03	.1489E+00	.2075E-01	.1549E+01
21.609400	.2299E-03	.1483E+00	.3410E-01	.2567E+01
21.617800	.2551E-03	.1477E+00	.3768E-01	.3707E+01
21.626100	.2624E-03	.1472E+00	.3863E-01	.4861E+01
21.634400	.2543E-03	.1466E+00	.3729E-01	.5975E+01
21.642800	.2500E-03	.1461E+00	.3651E-01	.7079E+01
21.651100	.2421E-03	.1455E+00	.3522E-01	.8132E+01
21.659400	.2169E-03	.1449E+00	.3144E-01	.9071E+01
21.667800	.1964E-03	.1444E+00	.2835E-01	.9929E+01
21.676100	.1830E-03	.1438E+00	.2632E-01	.1072E+02
21.684400	.1525E-03	.1438E+00	.2193E-01	.1137E+02
21.692800	.1491E-03	.1476E+00	.2201E-01	.1204E+02
21.701100	.1190E-03	.1500E+00	.1785E-01	.1257E+02
21.709400	.1014E-03	.1431E+00	.1452E-01	.1300E+02
21.717800	.9867E-04	.1365E+00	.1347E-01	.1341E+02
21.726100	.7848E-04	.1321E+00	.1036E-01	.1372E+02
21.734400	.7604E-04	.1276E+00	.9699E-02	.1401E+02
21.742800	.6580E-04	.1230E+00	.8095E-02	.1425E+02
21.751100	.6356E-04	.1207E+00	.7669E-02	.1448E+02
21.759400	.4750E-04	.1323E+00	.6286E-02	.1467E+02
21.767800	.4559E-04	.1442E+00	.6572E-02	.1487E+02
21.776100	.4371E-04	.1558E+00	.6812E-02	.1507E+02
21.784400	.2797E-04	.1654E+00	.4626E-02	.1521E+02
21.792800	.2649E-04	.1606E+00	.4256E-02	.1534E+02
21.801100	.2506E-04	.1559E+00	.3908E-02	.1546E+02
21.809400	.2366E-04	.1512E+00	.3579E-02	.1556E+02
21.817800	.2231E-04	.1465E+00	.3268E-02	.1566E+02
21.826100	.1991E-04	.1418E+00	.2823E-02	.1575E+02
21.834400	.1867E-04	.1371E+00	.2558E-02	.1582E+02
21.842800	.1746E-04	.1323E+00	.2310E-02	.1589E+02
21.851100	.1629E-04	.1276E+00	.2079E-02	.1596E+02
21.859400	.1517E-04	.1229E+00	.1864E-02	.1601E+02
21.867800	.1408E-04	.1181E+00	.1663E-02	.1606E+02
21.876100	.1303E-04	.1134E+00	.1478E-02	.1611E+02
21.884400	.1202E-04	.1087E+00	.1307E-02	.1615E+02
21.892800	.1105E-04	.1039E+00	.1149E-02	.1618E+02
21.901100	.1012E-04	.9924E-01	.1005E-02	.1621E+02
21.909400	.9234E-05	.9453E-01	.8729E-03	.1624E+02
21.917800	.8384E-05	.8977E-01	.7526E-03	.1626E+02
21.926100	.7574E-05	.8506E-01	.6443E-03	.1628E+02
21.934400	.6188E-05	.8035E-01	.4972E-03	.1629E+02
21.942800	.5492E-05	.7559E-01	.4151E-03	.1631E+02
21.951100	.4837E-05	.7088E-01	.3429E-03	.1632E+02
21.959400	.4222E-05	.6618E-01	.2794E-03	.1632E+02
21.967800	.3648E-05	.6141E-01	.2241E-03	.1633E+02
21.976100	.3115E-05	.5671E-01	.1767E-03	.1634E+02
21.984400	.2623E-05	.5200E-01	.1364E-03	.1634E+02
21.992800	.2173E-05	.4724E-01	.1026E-03	.1634E+02
22.001100	.1763E-05	.4253E-01	.7499E-04	.1635E+02
22.009400	.1396E-05	.3782E-01	.5279E-04	.1635E+02
22.017800	.1070E-05	.3306E-01	.3537E-04	.1635E+02
22.026100	.7865E-06	.2835E-01	.2230E-04	.1635E+02
22.034400	.5456E-06	.2365E-01	.1290E-04	.1635E+02
22.042800	.3476E-06	.1888E-01	.6565E-05	.1635E+02
22.051100	.1932E-06	.1418E-01	.2740E-05	.1635E+02
22.059400	.8304E-07	.9470E-02	.7864E-06	.1635E+02
22.067800	.0000E+00	.4707E-02	.0000E+00	.1635E+02
22.076100	.0000E+00	.0000E+00	.0000E+00	.1635E+02

Total runoff volume going through collector rip_1 = .112865665 m^3
Total sediment going through collector rip_1 = 16.349859599 g

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 21.249688889 h

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.2534E+00	695.	1175.	.3543E-03	2915.
field_2	.2795E+00	695.	965.	.4598E-03	2945.
g4_1	.1973E+00	695.	1265.	.4096E-03	2945.
g4_2	.1773E+00	785.	1415.	.3531E-03	2915.
g8_1	.5502E-01	755.	1625.	.6492E-04	2945.
g8_2	.6905E-01	1445.	1805.	.1087E-03	2945.
rip_1	.1129E+00	815.	1355.	.2624E-03	2945.
rip_2	.2332E-03	695.	1295.	.3665E-06	2945.
field_avg	.2665E+00	695.	965.	.4030E-03	2945.
g4_avg	.1873E+00	695.	1295.	.3461E-03	2945.
g8_avg	.6204E-01	755.	1625.	.8552E-04	2945.

RAINFALL DATA FOR EVENT u112-92

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 21.249688889 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.8467E-06
.3002E+03	.5927E-05
.6001E+03	.1609E-04
.9000E+03	.8467E-05
.1200E+04	.2540E-05
.1500E+04	.1693E-05
.1800E+04	.8467E-06
.2100E+04	.8467E-06
.2400E+04	.1693E-05
.2701E+04	.0000E+00
.3000E+04	.8467E-06
.3301E+04	.0000E+00
.3903E+04	.0000E+00

Total rainfall volume= 1.194 cm

Table 5. Summary of field data for event on (05/30/92b)

TABLE OF SEDIMENT AND RUNOFF DATA

Files used= u151b-92.q u151b-92.sedin
Collector= g4_1
Number of field samples= 5

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
18.134400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.142800	.0000E+00	.1346E-01	.0000E+00	.0000E+00
18.151100	.0000E+00	.2675E-01	.0000E+00	.0000E+00
18.159400	.0000E+00	.4005E-01	.0000E+00	.0000E+00
18.167800	.0000E+00	.5350E-01	.0000E+00	.0000E+00
18.176100	.0000E+00	.6680E-01	.0000E+00	.0000E+00
18.184400	.0000E+00	.8009E-01	.0000E+00	.0000E+00
18.192800	.0000E+00	.9355E-01	.0000E+00	.0000E+00
18.201100	.0000E+00	.1068E+00	.0000E+00	.0000E+00
18.209400	.0000E+00	.1201E+00	.0000E+00	.0000E+00
18.217800	.0000E+00	.1336E+00	.0000E+00	.0000E+00
18.226100	.0000E+00	.1469E+00	.0000E+00	.0000E+00
18.234400	.0000E+00	.1602E+00	.0000E+00	.0000E+00
18.384400	.0000E+00	.4005E+00	.0000E+00	.0000E+00
18.392800	.0000E+00	.4139E+00	.0000E+00	.0000E+00
18.401100	.0000E+00	.4272E+00	.0000E+00	.0000E+00
18.409400	.0000E+00	.4405E+00	.0000E+00	.0000E+00
18.417800	.0000E+00	.4540E+00	.0000E+00	.0000E+00
18.426100	.0000E+00	.4673E+00	.0000E+00	.0000E+00
18.434400	.0000E+00	.4806E+00	.0000E+00	.0000E+00
18.442800	.0000E+00	.4940E+00	.0000E+00	.0000E+00
18.451100	.0000E+00	.5073E+00	.0000E+00	.0000E+00
18.459400	.0000E+00	.5206E+00	.0000E+00	.0000E+00
18.467800	.0000E+00	.5341E+00	.0000E+00	.0000E+00
18.476100	.0000E+00	.5474E+00	.0000E+00	.0000E+00
18.484400	.7017E-07	.5607E+00	.3934E-04	.1176E-02
18.492800	.0000E+00	.5741E+00	.0000E+00	.1176E-02
18.501100	.6342E-05	.5874E+00	.3725E-02	.1125E+00
18.509400	.1591E-04	.6007E+00	.9559E-02	.3981E+00
18.517800	.1591E-04	.5846E+00	.9303E-02	.6794E+00
18.526100	.1591E-04	.3812E+00	.6067E-02	.8607E+00
18.534400	.1591E-04	.2034E+00	.3237E-02	.9575E+00
18.542800	.1591E-04	.1987E+00	.3161E-02	.1053E+01
18.551100	.1591E-04	.1939E+00	.3086E-02	.1145E+01
18.559400	.1591E-04	.1892E+00	.3011E-02	.1235E+01
18.567800	.1591E-04	.1845E+00	.2935E-02	.1324E+01
18.576100	.1706E-04	.1798E+00	.3067E-02	.1416E+01
18.584400	.1946E-04	.1750E+00	.3406E-02	.1517E+01
18.592800	.2329E-04	.1703E+00	.3966E-02	.1637E+01
18.601100	.2329E-04	.1656E+00	.3856E-02	.1753E+01
18.609400	.3179E-04	.1608E+00	.5114E-02	.1905E+01
18.617800	.5760E-04	.1561E+00	.8990E-02	.2177E+01
18.626100	.7818E-04	.1514E+00	.1183E-01	.2531E+01
18.634400	.1013E-03	.1474E+00	.1493E-01	.2977E+01
18.642800	.1013E-03	.1486E+00	.1506E-01	.3432E+01
18.651100	.1013E-03	.1509E+00	.1529E-01	.3889E+01
18.659400	.1013E-03	.1603E+00	.1623E-01	.4374E+01
18.667800	.1013E-03	.1681E+00	.1703E-01	.4889E+01
18.676100	.1013E-03	.1661E+00	.1682E-01	.5392E+01
18.684400	.1013E-03	.1640E+00	.1661E-01	.5888E+01
18.692800	.1013E-03	.1618E+00	.1639E-01	.6384E+01
18.701100	.1013E-03	.1597E+00	.1618E-01	.6868E+01
18.709400	.1037E-03	.1577E+00	.1636E-01	.7356E+01
18.717800	.1037E-03	.1555E+00	.1614E-01	.7844E+01
18.726100	.1037E-03	.1534E+00	.1592E-01	.8320E+01
18.734400	.1037E-03	.1513E+00	.1570E-01	.8789E+01
18.742800	.1037E-03	.1492E+00	.1548E-01	.9257E+01

18.751100	.1037E-03	.1471E+00	.1526E-01	.9713E+01
18.759400	.1037E-03	.1450E+00	.1505E-01	.1016E+02
18.767800	.1037E-03	.1429E+00	.1483E-01	.1061E+02
18.776100	.1037E-03	.1408E+00	.1461E-01	.1105E+02
18.784400	.1037E-03	.1387E+00	.1439E-01	.1148E+02
18.792800	.1037E-03	.1366E+00	.1417E-01	.1191E+02
18.801100	.1037E-03	.1345E+00	.1396E-01	.1232E+02
18.809400	.1037E-03	.1324E+00	.1374E-01	.1273E+02
18.817800	.1037E-03	.1303E+00	.1352E-01	.1314E+02
18.826100	.1037E-03	.1282E+00	.1330E-01	.1354E+02
18.834400	.1037E-03	.1261E+00	.1308E-01	.1393E+02
18.842800	.1037E-03	.1240E+00	.1286E-01	.1432E+02
18.851100	.1037E-03	.1219E+00	.1265E-01	.1470E+02
18.859400	.9631E-04	.1198E+00	.1154E-01	.1504E+02
18.867800	.9377E-04	.1177E+00	.1104E-01	.1538E+02
18.876100	.9126E-04	.1156E+00	.1055E-01	.1569E+02
18.884400	.8878E-04	.1135E+00	.1008E-01	.1599E+02
18.892800	.8633E-04	.1114E+00	.9616E-02	.1628E+02
18.901100	.8391E-04	.1093E+00	.9171E-02	.1656E+02
18.909400	.8151E-04	.1072E+00	.8738E-02	.1682E+02
18.917800	.7914E-04	.1051E+00	.8317E-02	.1707E+02
18.926100	.7681E-04	.1030E+00	.7910E-02	.1731E+02
18.934400	.7450E-04	.1009E+00	.7517E-02	.1753E+02
18.942800	.6598E-04	.9878E-01	.6518E-02	.1773E+02
18.951100	.6382E-04	.9669E-01	.6170E-02	.1791E+02
18.959400	.6168E-04	.9459E-01	.5835E-02	.1809E+02
18.967800	.5958E-04	.9247E-01	.5509E-02	.1825E+02
18.976100	.5750E-04	.9038E-01	.5197E-02	.1841E+02
18.984400	.5545E-04	.8829E-01	.4896E-02	.1856E+02
18.992800	.5344E-04	.8617E-01	.4605E-02	.1869E+02
19.001100	.5146E-04	.8407E-01	.4326E-02	.1882E+02
19.009400	.4950E-04	.8198E-01	.4058E-02	.1895E+02
19.017800	.4758E-04	.7986E-01	.3800E-02	.1906E+02
19.026100	.4056E-04	.7777E-01	.3155E-02	.1915E+02
19.034400	.3880E-04	.7567E-01	.2936E-02	.1924E+02
19.042800	.3706E-04	.7355E-01	.2726E-02	.1932E+02
19.051100	.3536E-04	.7146E-01	.2527E-02	.1940E+02
19.059400	.3369E-04	.6937E-01	.2337E-02	.1947E+02
19.067800	.3206E-04	.6725E-01	.2156E-02	.1954E+02
19.076100	.3046E-04	.6515E-01	.1984E-02	.1959E+02
19.084400	.2889E-04	.6306E-01	.1822E-02	.1965E+02
19.092800	.2736E-04	.6094E-01	.1667E-02	.1970E+02
19.101100	.2586E-04	.5885E-01	.1522E-02	.1974E+02
19.109400	.2440E-04	.5676E-01	.1385E-02	.1979E+02
19.117800	.2167E-04	.5464E-01	.1184E-02	.1982E+02
19.126100	.2031E-04	.5254E-01	.1067E-02	.1985E+02
19.134400	.1899E-04	.5045E-01	.9579E-03	.1988E+02
19.142800	.1770E-04	.4833E-01	.8556E-03	.1991E+02
19.151100	.1646E-04	.4624E-01	.7609E-03	.1993E+02
19.159400	.1525E-04	.4414E-01	.6731E-03	.1995E+02
19.167800	.1408E-04	.4202E-01	.5916E-03	.1997E+02
19.176100	.1295E-04	.3993E-01	.5170E-03	.1998E+02
19.184400	.1186E-04	.3784E-01	.4486E-03	.2000E+02
19.192800	.1080E-04	.3572E-01	.3859E-03	.2001E+02
19.201100	.9793E-05	.3362E-01	.3293E-03	.2002E+02
19.209400	.7955E-05	.3153E-01	.2508E-03	.2003E+02
19.217800	.7067E-05	.2941E-01	.2079E-03	.2003E+02
19.226100	.6224E-05	.2732E-01	.1700E-03	.2004E+02
19.234400	.5426E-05	.2522E-01	.1369E-03	.2004E+02
19.242800	.4673E-05	.2311E-01	.1080E-03	.2005E+02
19.251100	.3968E-05	.2101E-01	.8337E-04	.2005E+02
19.259400	.3311E-05	.1892E-01	.6264E-04	.2005E+02
19.267800	.2704E-05	.1680E-01	.4543E-04	.2005E+02
19.276100	.2149E-05	.1471E-01	.3160E-04	.2005E+02
19.284400	.1647E-05	.1261E-01	.2078E-04	.2005E+02
19.292800	.1203E-05	.1049E-01	.1262E-04	.2005E+02
19.301100	.8172E-06	.8400E-02	.6864E-05	.2005E+02
19.309400	.4955E-06	.6306E-02	.3125E-05	.2005E+02
19.317800	.2434E-06	.4187E-02	.1019E-05	.2005E+02
19.326100	.0000E+00	.2094E-02	.0000E+00	.2005E+02
19.334400	.0000E+00	.0000E+00	.0000E+00	.2005E+02

Total runoff volume going through collector g4_1 = .154620742 m^3
Total sediment going through collector g4_1 = 20.053544339 g

Collector= field_1
Number of field samples= 8

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
18.134400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.142800	.9207E-05	.1020E+01	.9390E-02	.2839E+00
18.151100	.2348E-04	.1896E+01	.4451E-01	.1614E+01
18.159400	.2348E-04	.1908E+01	.4479E-01	.2952E+01
18.167800	.2348E-04	.1914E+01	.4494E-01	.4311E+01
18.176100	.2348E-04	.1883E+01	.4420E-01	.5632E+01
18.184400	.3090E-04	.1851E+01	.5721E-01	.7341E+01
18.192800	.3090E-04	.1820E+01	.5623E-01	.9042E+01
18.201100	.3090E-04	.1788E+01	.5526E-01	.1069E+02
18.209400	.3090E-04	.1757E+01	.5430E-01	.1232E+02
18.217800	.9695E-05	.1726E+01	.1673E-01	.1282E+02
18.226100	.0000E+00	.1694E+01	.0000E+00	.1282E+02
18.234400	.0000E+00	.1663E+01	.0000E+00	.1282E+02
18.384400	.0000E+00	.1098E+01	.0000E+00	.1282E+02
18.392800	.5697E-05	.1066E+01	.6073E-02	.1301E+02
18.401100	.2348E-04	.1136E+01	.2667E-01	.1380E+02

18.409400	.3912E-04	.1869E+01	.7312E-01	.1599E+02
18.417800	.5985E-04	.2391E+01	.1431E+00	.2031E+02
18.426100	.8164E-04	.1515E+01	.1237E+00	.2401E+02
18.434400	.8164E-04	.7594E+00	.6200E-01	.2586E+02
18.442800	.8164E-04	.8261E+00	.6744E-01	.2790E+02
18.451100	.8164E-04	.8920E+00	.7282E-01	.3008E+02
18.459400	.8164E-04	.9578E+00	.7820E-01	.3241E+02
18.467800	.8164E-04	.1024E+01	.8364E-01	.3494E+02
18.476100	.8164E-04	.1090E+01	.8902E-01	.3760E+02
18.484400	.8397E-04	.1156E+01	.9708E-01	.4050E+02
18.492800	.7707E-04	.1223E+01	.9424E-01	.4335E+02
18.501100	.7040E-04	.1289E+01	.9073E-01	.4606E+02
18.509400	.6610E-04	.1355E+01	.8953E-01	.4874E+02
18.517800	.6610E-04	.1421E+01	.9394E-01	.5158E+02
18.526100	.6610E-04	.1487E+01	.9829E-01	.5452E+02
18.534400	.6610E-04	.1553E+01	.1026E+00	.5758E+02
18.542800	.6610E-04	.1620E+01	.1070E+00	.6082E+02
18.551100	.6610E-04	.1685E+01	.1114E+00	.6415E+02
18.559400	.6610E-04	.1751E+01	.1158E+00	.6761E+02
18.567800	.6610E-04	.1818E+01	.1202E+00	.7124E+02
18.576100	.8632E-04	.1884E+01	.1626E+00	.7610E+02
18.584400	.1416E-03	.2251E+01	.3187E+00	.8563E+02
18.592800	.1907E-03	.4694E+01	.8951E+00	.1127E+03
18.601100	.1907E-03	.6750E+01	.1287E+01	.1512E+03
18.609400	.1940E-03	.6474E+01	.1256E+01	.1887E+03
18.617800	.1973E-03	.6195E+01	.1222E+01	.2256E+03
18.626100	.1940E-03	.5918E+01	.1148E+01	.2599E+03
18.634400	.1940E-03	.5642E+01	.1094E+01	.2926E+03
18.642800	.1940E-03	.5363E+01	.1040E+01	.3241E+03
18.651100	.1940E-03	.5086E+01	.9866E+00	.3536E+03
18.659400	.1940E-03	.4810E+01	.9330E+00	.3814E+03
18.667800	.1940E-03	.4531E+01	.8788E+00	.4080E+03
18.676100	.1940E-03	.4254E+01	.8252E+00	.4327E+03
18.684400	.1940E-03	.3978E+01	.7716E+00	.4557E+03
18.692800	.1940E-03	.3699E+01	.7174E+00	.4774E+03
18.701100	.1940E-03	.3422E+01	.6638E+00	.4973E+03
18.709400	.2039E-03	.3146E+01	.6415E+00	.5164E+03
18.717800	.2313E-03	.2866E+01	.6631E+00	.5365E+03
18.726100	.2313E-03	.2590E+01	.5992E+00	.5544E+03
18.734400	.2313E-03	.2345E+01	.5426E+00	.5706E+03
18.742800	.2313E-03	.2313E+01	.5350E+00	.5868E+03
18.751100	.2313E-03	.2280E+01	.5275E+00	.6025E+03
18.759400	.2313E-03	.2248E+01	.5200E+00	.6181E+03
18.767800	.2313E-03	.2215E+01	.5124E+00	.6336E+03
18.776100	.2313E-03	.2182E+01	.5049E+00	.6487E+03
18.784400	.2313E-03	.2150E+01	.4973E+00	.6635E+03
18.792800	.2313E-03	.2117E+01	.4898E+00	.6783E+03
18.801100	.2313E-03	.2085E+01	.4822E+00	.6927E+03
18.809400	.2313E-03	.2052E+01	.4747E+00	.7069E+03
18.817800	.2313E-03	.2019E+01	.4671E+00	.7210E+03
18.826100	.2313E-03	.1987E+01	.4596E+00	.7348E+03
18.834400	.2313E-03	.1954E+01	.4521E+00	.7483E+03
18.842800	.2313E-03	.1922E+01	.4445E+00	.7617E+03
18.851100	.2313E-03	.1889E+01	.4370E+00	.7748E+03
18.859400	.2150E-03	.1857E+01	.3992E+00	.7867E+03
18.867800	.2091E-03	.1824E+01	.3815E+00	.7983E+03
18.876100	.2034E-03	.1791E+01	.3643E+00	.8091E+03
18.884400	.1977E-03	.1759E+01	.3477E+00	.8195E+03
18.892800	.1920E-03	.1726E+01	.3315E+00	.8295E+03
18.901100	.1864E-03	.1694E+01	.3158E+00	.8390E+03
18.909400	.1809E-03	.1661E+01	.3006E+00	.8480E+03
18.917800	.1755E-03	.1628E+01	.2858E+00	.8566E+03
18.926100	.1701E-03	.1596E+01	.2715E+00	.8647E+03
18.934400	.1648E-03	.1564E+01	.2577E+00	.8724E+03
18.942800	.1565E-03	.1531E+01	.2396E+00	.8797E+03
18.951100	.1514E-03	.1498E+01	.2269E+00	.8864E+03
18.959400	.1463E-03	.1466E+01	.2145E+00	.8929E+03
18.967800	.1413E-03	.1433E+01	.2026E+00	.8990E+03
18.976100	.1364E-03	.1401E+01	.1911E+00	.9047E+03
18.984400	.1316E-03	.1368E+01	.1800E+00	.9101E+03
18.992800	.1268E-03	.1335E+01	.1693E+00	.9152E+03
19.001100	.1221E-03	.1303E+01	.1590E+00	.9199E+03
19.009400	.1174E-03	.1270E+01	.1492E+00	.9244E+03
19.017800	.1129E-03	.1238E+01	.1397E+00	.9286E+03
19.026100	.1032E-03	.1205E+01	.1244E+00	.9323E+03
19.034400	.9890E-04	.1173E+01	.1160E+00	.9358E+03
19.042800	.9465E-04	.1140E+01	.1079E+00	.9391E+03
19.051100	.9046E-04	.1107E+01	.1002E+00	.9421E+03
19.059400	.8636E-04	.1075E+01	.9283E-01	.9448E+03
19.067800	.8233E-04	.1042E+01	.8579E-01	.9474E+03
19.076100	.7837E-04	.1010E+01	.7913E-01	.9498E+03
19.084400	.7450E-04	.9772E+00	.7281E-01	.9520E+03
19.092800	.7071E-04	.9444E+00	.6678E-01	.9540E+03
19.101100	.6699E-04	.9120E+00	.6109E-01	.9558E+03
19.109400	.6336E-04	.8795E+00	.5573E-01	.9575E+03
19.117800	.5578E-04	.8467E+00	.4723E-01	.9589E+03
19.126100	.5241E-04	.8142E+00	.4267E-01	.9602E+03
19.134400	.4912E-04	.7818E+00	.3840E-01	.9613E+03
19.142800	.4592E-04	.7490E+00	.3439E-01	.9624E+03
19.151100	.4281E-04	.7165E+00	.3067E-01	.9633E+03
19.159400	.3979E-04	.6841E+00	.2722E-01	.9641E+03
19.167800	.3685E-04	.6512E+00	.2400E-01	.9648E+03
19.176100	.3401E-04	.6188E+00	.2104E-01	.9655E+03
19.184400	.3126E-04	.5863E+00	.1833E-01	.9660E+03
19.192800	.2860E-04	.5535E+00	.1583E-01	.9665E+03
19.201100	.2604E-04	.5211E+00	.1357E-01	.9669E+03
19.209400	.2083E-04	.4886E+00	.1018E-01	.9672E+03
19.217800	.1859E-04	.4558E+00	.8472E-02	.9674E+03

19.226100	.1645E-04	.4233E+00	.6962E-02	.9677E+03
19.234400	.1441E-04	.3909E+00	.5633E-02	.9678E+03
19.242800	.1249E-04	.3581E+00	.4471E-02	.9680E+03
19.251100	.1067E-04	.3256E+00	.3475E-02	.9681E+03
19.259400	.8975E-05	.2932E+00	.2631E-02	.9681E+03
19.267800	.7398E-05	.2603E+00	.1926E-02	.9682E+03
19.276100	.5946E-05	.2279E+00	.1355E-02	.9682E+03
19.284400	.4625E-05	.1954E+00	.9039E-03	.9683E+03
19.292800	.3440E-05	.1626E+00	.5593E-03	.9683E+03
19.301100	.2400E-05	.1302E+00	.3124E-03	.9683E+03
19.309400	.1516E-05	.9772E-01	.1482E-03	.9683E+03
19.317800	.8033E-06	.6489E-01	.5213E-04	.9683E+03
19.326100	.0000E+00	.3244E-01	.0000E+00	.9683E+03
19.334400	.0000E+00	.0000E+00	.0000E+00	.9683E+03

Total runoff volume going through collector field_1 =   .404756093 m^3
Total sediment going through collector field_1 =   968.296881106 g

Collector= g4_2
Number of field samples= 8

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
18.134400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.142800	.0000E+00	.1537E+00	.0000E+00	.0000E+00
18.151100	.1152E-06	.3056E+00	.3522E-04	.1052E-02
18.159400	.1152E-06	.4575E+00	.5272E-04	.2628E-02
18.167800	.1152E-06	.6112E+00	.7044E-04	.4758E-02
18.176100	.1152E-06	.7631E+00	.8794E-04	.7386E-02
18.184400	.3565E-06	.9150E+00	.3262E-03	.1713E-01
18.192800	.8027E-07	.1069E+01	.8578E-04	.1973E-01
18.201100	.5038E-07	.1221E+01	.6150E-04	.2156E-01
18.209400	.2618E-07	.1372E+01	.3594E-04	.2264E-01
18.217800	.8308E-08	.1526E+01	.1268E-04	.2302E-01
18.226100	.0000E+00	.1678E+01	.0000E+00	.2302E-01
18.234400	.0000E+00	.1830E+01	.0000E+00	.2302E-01
18.384400	.0000E+00	.4575E+01	.0000E+00	.2302E-01
18.392800	.0000E+00	.4729E+01	.0000E+00	.2302E-01
18.401100	.0000E+00	.4881E+01	.0000E+00	.2302E-01
18.409400	.0000E+00	.5032E+01	.0000E+00	.2302E-01
18.417800	.0000E+00	.5186E+01	.0000E+00	.2302E-01
18.426100	.0000E+00	.5338E+01	.0000E+00	.2302E-01
18.434400	.0000E+00	.5490E+01	.0000E+00	.2302E-01
18.442800	.0000E+00	.5644E+01	.0000E+00	.2302E-01
18.451100	.0000E+00	.5796E+01	.0000E+00	.2302E-01
18.459400	.0000E+00	.5947E+01	.0000E+00	.2302E-01
18.467800	.0000E+00	.6101E+01	.0000E+00	.2302E-01
18.476100	.0000E+00	.6253E+01	.0000E+00	.2302E-01
18.484400	.8482E-05	.6405E+01	.5432E-01	.1646E+01
18.492800	.3099E-04	.6559E+01	.2032E+00	.7792E+01
18.501100	.5686E-04	.6486E+01	.3688E+00	.1881E+02
18.509400	.5482E-04	.4944E+01	.2710E+00	.2691E+02
18.517800	.5482E-04	.3383E+01	.1854E+00	.3252E+02
18.526100	.5482E-04	.1840E+01	.1009E+00	.3553E+02
18.534400	.5482E-04	.4946E+00	.2711E-01	.3634E+02
18.542800	.5482E-04	.4811E+00	.2637E-01	.3714E+02
18.551100	.5482E-04	.4677E+00	.2564E-01	.3790E+02
18.559400	.5482E-04	.4543E+00	.2490E-01	.3865E+02
18.567800	.5482E-04	.4407E+00	.2416E-01	.3938E+02
18.576100	.5482E-04	.4273E+00	.2342E-01	.4008E+02
18.584400	.5686E-04	.4139E+00	.2354E-01	.4078E+02
18.592800	.5686E-04	.4004E+00	.2276E-01	.4147E+02
18.601100	.5686E-04	.3870E+00	.2200E-01	.4213E+02
18.609400	.6533E-04	.3736E+00	.2440E-01	.4286E+02
18.617800	.6973E-04	.3600E+00	.2510E-01	.4362E+02
18.626100	.6751E-04	.3466E+00	.2340E-01	.4432E+02
18.634400	.6751E-04	.3332E+00	.2250E-01	.4499E+02
18.642800	.6751E-04	.3196E+00	.2158E-01	.4564E+02
18.651100	.6751E-04	.3062E+00	.2067E-01	.4626E+02
18.659400	.6751E-04	.2928E+00	.1977E-01	.4685E+02
18.667800	.6751E-04	.2793E+00	.1885E-01	.4742E+02
18.676100	.6751E-04	.2659E+00	.1795E-01	.4796E+02
18.684400	.6751E-04	.2525E+00	.1704E-01	.4847E+02
18.692800	.6751E-04	.2389E+00	.1613E-01	.4895E+02
18.701100	.6751E-04	.2255E+00	.1522E-01	.4941E+02
18.709400	.9841E-04	.2121E+00	.2087E-01	.5003E+02
18.717800	.1452E-03	.1985E+00	.2884E-01	.5090E+02
18.726100	.1452E-03	.1851E+00	.2689E-01	.5171E+02
18.734400	.1452E-03	.1720E+00	.2498E-01	.5245E+02
18.742800	.1452E-03	.1605E+00	.2331E-01	.5316E+02
18.751100	.1452E-03	.1601E+00	.2326E-01	.5385E+02
18.759400	.1452E-03	.2319E+00	.3368E-01	.5486E+02
18.767800	.1452E-03	.3045E+00	.4423E-01	.5620E+02
18.776100	.1452E-03	.3763E+00	.5465E-01	.5783E+02
18.784400	.1452E-03	.4480E+00	.6507E-01	.5977E+02
18.792800	.1452E-03	.5206E+00	.7562E-01	.6206E+02
18.801100	.1452E-03	.5924E+00	.8604E-01	.6463E+02
18.809400	.1452E-03	.6642E+00	.9647E-01	.6751E+02
18.817800	.1452E-03	.7368E+00	.1070E+00	.7075E+02
18.826100	.1452E-03	.8085E+00	.1174E+00	.7426E+02
18.834400	.1452E-03	.8803E+00	.1279E+00	.7808E+02
18.842800	.1452E-03	.9529E+00	.1384E+00	.8227E+02
18.851100	.1452E-03	.1025E+01	.1488E+00	.8671E+02
18.859400	.1414E-03	.1096E+01	.1550E+00	.9134E+02
18.867800	.1405E-03	.1169E+01	.1642E+00	.9631E+02
18.876100	.1395E-03	.1241E+01	.1731E+00	.1015E+03

18.884400	.1386E-03	.1313E+01	.1820E+00	.1069E+03
18.892800	.1377E-03	.1385E+01	.1908E+00	.1127E+03
18.901100	.1368E-03	.1457E+01	.1993E+00	.1186E+03
18.909400	.1359E-03	.1529E+01	.2077E+00	.1249E+03
18.917800	.1350E-03	.1601E+01	.2161E+00	.1314E+03
18.926100	.1341E-03	.1673E+01	.2243E+00	.1381E+03
18.934400	.1332E-03	.1745E+01	.2324E+00	.1450E+03
18.942800	.1023E-03	.1817E+01	.1860E+00	.1507E+03
18.951100	.1015E-03	.1889E+01	.1918E+00	.1564E+03
18.959400	.1007E-03	.1961E+01	.1975E+00	.1623E+03
18.967800	.9990E-04	.2026E+01	.2024E+00	.1684E+03
18.976100	.9910E-04	.2043E+01	.2024E+00	.1745E+03
18.984400	.9830E-04	.2060E+01	.2025E+00	.1805E+03
18.992800	.9750E-04	.2077E+01	.2025E+00	.1866E+03
19.001100	.9670E-04	.2093E+01	.2024E+00	.1927E+03
19.009400	.9590E-04	.2110E+01	.2024E+00	.1987E+03
19.017800	.9511E-04	.2127E+01	.2023E+00	.2048E+03
19.026100	.6398E-04	.2144E+01	.1372E+00	.2089E+03
19.034400	.6330E-04	.2161E+01	.1368E+00	.2130E+03
19.042800	.6263E-04	.2178E+01	.1364E+00	.2172E+03
19.051100	.6196E-04	.2170E+01	.1344E+00	.2212E+03
19.059400	.6129E-04	.2000E+01	.1226E+00	.2248E+03
19.067800	.6062E-04	.1827E+01	.1108E+00	.2282E+03
19.076100	.5996E-04	.1657E+01	.9937E-01	.2312E+03
19.084400	.5930E-04	.1487E+01	.8819E-01	.2338E+03
19.092800	.5864E-04	.1315E+01	.7711E-01	.2361E+03
19.101100	.5798E-04	.1145E+01	.6639E-01	.2381E+03
19.109400	.5733E-04	.9749E+00	.5589E-01	.2398E+03
19.117800	.3246E-04	.8027E+00	.2606E-01	.2406E+03
19.126100	.3194E-04	.6326E+00	.2021E-01	.2412E+03
19.134400	.3142E-04	.4865E+00	.1529E-01	.2416E+03
19.142800	.3091E-04	.5034E+00	.1556E-01	.2421E+03
19.151100	.3040E-04	.5201E+00	.1581E-01	.2426E+03
19.159400	.2989E-04	.5368E+00	.1604E-01	.2430E+03
19.167800	.2938E-04	.5537E+00	.1627E-01	.2435E+03
19.176100	.2888E-04	.5704E+00	.1647E-01	.2440E+03
19.184400	.2839E-04	.5871E+00	.1666E-01	.2445E+03
19.192800	.2789E-04	.6040E+00	.1685E-01	.2450E+03
19.201100	.2740E-04	.6207E+00	.1701E-01	.2455E+03
19.209400	.9931E-05	.6374E+00	.6330E-02	.2457E+03
19.217800	.9603E-05	.6543E+00	.6283E-02	.2459E+03
19.226100	.9278E-05	.6710E+00	.6225E-02	.2461E+03
19.234400	.8958E-05	.6783E+00	.6076E-02	.2463E+03
19.242800	.8643E-05	.6213E+00	.5370E-02	.2465E+03
19.251100	.8331E-05	.5650E+00	.4707E-02	.2466E+03
19.259400	.8025E-05	.5087E+00	.4082E-02	.2467E+03
19.267800	.7722E-05	.4517E+00	.3488E-02	.2468E+03
19.276100	.7424E-05	.3954E+00	.2936E-02	.2469E+03
19.284400	.7131E-05	.3391E+00	.2418E-02	.2470E+03
19.292800	.6842E-05	.2822E+00	.1931E-02	.2470E+03
19.301100	.6558E-05	.2259E+00	.1481E-02	.2471E+03
19.309400	.6279E-05	.1696E+00	.1065E-02	.2471E+03
19.317800	.6004E-05	.1126E+00	.6760E-03	.2471E+03
19.326100	.0000E+00	.5630E-01	.0000E+00	.2471E+03
19.334400	.0000E+00	.0000E+00	.0000E+00	.2471E+03

Total runoff volume going through collector g4_2 = .228165414 m^3
Total sediment going through collector g4_2 = 247.137160824 g

Collector= field_2
Number of field samples= 7

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
18.134400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.142800	.1928E-06	.1414E+00	.2726E-04	.8244E-03
18.151100	.9568E-06	.2811E+00	.2690E-03	.8862E-02
18.159400	.9568E-06	.4208E+00	.4027E-03	.2089E-01
18.167800	.9568E-06	.5622E+00	.5380E-03	.3716E-01
18.176100	.9568E-06	.7020E+00	.6716E-03	.5723E-01
18.184400	.5084E-05	.8417E+00	.4279E-02	.1851E+00
18.192800	.1176E-04	.9831E+00	.1156E-01	.5346E+00
18.201100	.1176E-04	.1132E+01	.1331E-01	.9323E+00
18.209400	.1176E-04	.1340E+01	.1575E-01	.1403E+01
18.217800	.2067E-04	.1550E+01	.3204E-01	.2372E+01
18.226100	.3164E-04	.1758E+01	.5564E-01	.4034E+01
18.234400	.0000E+00	.1840E+01	.0000E+00	.4034E+01
18.384400	.0000E+00	.1441E+01	.0000E+00	.4034E+01
18.392800	.3917E-06	.1476E+01	.5784E-03	.4052E+01
18.401100	.1928E-06	.1512E+01	.2914E-03	.4061E+01
18.409400	.3914E-06	.1547E+01	.6053E-03	.4079E+01
18.417800	.2175E-05	.1582E+01	.3441E-02	.4183E+01
18.426100	.3795E-05	.1617E+01	.6138E-02	.4366E+01
18.434400	.3795E-05	.1652E+01	.6271E-02	.4554E+01
18.442800	.3795E-05	.1688E+01	.6405E-02	.4747E+01
18.451100	.3795E-05	.1723E+01	.6539E-02	.4943E+01
18.459400	.3795E-05	.1758E+01	.6672E-02	.5142E+01
18.467800	.3795E-05	.1793E+01	.6806E-02	.5348E+01
18.476100	.3795E-05	.1828E+01	.6939E-02	.5555E+01
18.484400	.4419E-05	.1863E+01	.8235E-02	.5801E+01
18.492800	.3795E-05	.1899E+01	.7207E-02	.6019E+01
18.501100	.3795E-05	.1934E+01	.7340E-02	.6238E+01
18.509400	.3213E-05	.1969E+01	.6326E-02	.6427E+01
18.517800	.3213E-05	.2004E+01	.6440E-02	.6622E+01
18.526100	.3213E-05	.2040E+01	.6552E-02	.6818E+01
18.534400	.3213E-05	.2075E+01	.6665E-02	.7017E+01

18.542800	.3213E-05	.2110E+01	.6779E-02	.7222E+01
18.551100	.3213E-05	.2145E+01	.6892E-02	.7428E+01
18.559400	.3213E-05	.2180E+01	.7004E-02	.7637E+01
18.567800	.3213E-05	.2216E+01	.7118E-02	.7853E+01
18.576100	.9869E-05	.2251E+01	.2221E-01	.8516E+01
18.584400	.3948E-04	.2286E+01	.9025E-01	.1121E+02
18.592800	.7367E-04	.2321E+01	.1710E+00	.1638E+02
18.601100	.7367E-04	.2356E+01	.1736E+00	.2157E+02
18.609400	.9406E-04	.2391E+01	.2249E+00	.2829E+02
18.617800	.9646E-04	.2404E+01	.2319E+00	.3531E+02
18.626100	.9406E-04	.2275E+01	.2140E+00	.4170E+02
18.634400	.8702E-04	.2154E+01	.1875E+00	.4730E+02
18.642800	.8702E-04	.2091E+01	.1820E+00	.5280E+02
18.651100	.8702E-04	.2029E+01	.1766E+00	.5808E+02
18.659400	.8702E-04	.1967E+01	.1712E+00	.6319E+02
18.667800	.8702E-04	.1904E+01	.1657E+00	.6820E+02
18.676100	.8702E-04	.1842E+01	.1603E+00	.7299E+02
18.684400	.8702E-04	.1779E+01	.1548E+00	.7762E+02
18.692800	.8702E-04	.1716E+01	.1494E+00	.8214E+02
18.701100	.8702E-04	.1654E+01	.1440E+00	.8644E+02
18.709400	.9887E-04	.1592E+01	.1574E+00	.9114E+02
18.717800	.1114E-03	.1529E+01	.1703E+00	.9629E+02
18.726100	.1114E-03	.1467E+01	.1633E+00	.1012E+03
18.734400	.1114E-03	.1405E+01	.1564E+00	.1058E+03
18.742800	.1114E-03	.1342E+01	.1494E+00	.1104E+03
18.751100	.1114E-03	.1279E+01	.1425E+00	.1146E+03
18.759400	.1114E-03	.1217E+01	.1355E+00	.1187E+03
18.767800	.1114E-03	.1154E+01	.1285E+00	.1226E+03
18.776100	.1114E-03	.1092E+01	.1216E+00	.1262E+03
18.784400	.1114E-03	.1030E+01	.1147E+00	.1296E+03
18.792800	.1114E-03	.9667E+00	.1077E+00	.1329E+03
18.801100	.1114E-03	.9045E+00	.1007E+00	.1359E+03
18.809400	.1114E-03	.8422E+00	.9380E-01	.1387E+03
18.817800	.1114E-03	.7793E+00	.8678E-01	.1413E+03
18.826100	.1114E-03	.7170E+00	.7985E-01	.1437E+03
18.834400	.1114E-03	.6548E+00	.7292E-01	.1459E+03
18.842800	.1114E-03	.5918E+00	.6591E-01	.1479E+03
18.851100	.1114E-03	.5296E+00	.5898E-01	.1496E+03
18.859400	.8690E-04	.4674E+00	.4062E-01	.1508E+03
18.867800	.8449E-04	.4044E+00	.3417E-01	.1519E+03
18.876100	.8211E-04	.3422E+00	.2810E-01	.1527E+03
18.884400	.7976E-04	.2873E+00	.2291E-01	.1534E+03
18.892800	.7743E-04	.2819E+00	.2183E-01	.1541E+03
18.901100	.7514E-04	.2766E+00	.2078E-01	.1547E+03
18.909400	.7288E-04	.2713E+00	.1977E-01	.1553E+03
18.917800	.7064E-04	.2660E+00	.1879E-01	.1558E+03
18.926100	.6844E-04	.2607E+00	.1784E-01	.1564E+03
18.934400	.6626E-04	.2554E+00	.1692E-01	.1569E+03
18.942800	.6013E-04	.2500E+00	.1503E-01	.1573E+03
18.951100	.5807E-04	.2447E+00	.1421E-01	.1578E+03
18.959400	.5605E-04	.2394E+00	.1342E-01	.1582E+03
18.967800	.5405E-04	.2340E+00	.1265E-01	.1585E+03
18.976100	.5209E-04	.2287E+00	.1191E-01	.1589E+03
18.984400	.5016E-04	.2234E+00	.1121E-01	.1592E+03
18.992800	.4826E-04	.2181E+00	.1052E-01	.1595E+03
19.001100	.4639E-04	.2128E+00	.9870E-02	.1598E+03
19.009400	.4455E-04	.2075E+00	.9243E-02	.1601E+03
19.017800	.4274E-04	.2021E+00	.8639E-02	.1604E+03
19.026100	.3609E-04	.1968E+00	.7103E-02	.1606E+03
19.034400	.3444E-04	.1915E+00	.6596E-02	.1608E+03
19.042800	.3283E-04	.1862E+00	.6111E-02	.1610E+03
19.051100	.3124E-04	.1809E+00	.5651E-02	.1611E+03
19.059400	.2970E-04	.1756E+00	.5213E-02	.1613E+03
19.067800	.2818E-04	.1702E+00	.4796E-02	.1614E+03
19.076100	.2670E-04	.1649E+00	.4403E-02	.1616E+03
19.084400	.2526E-04	.1596E+00	.4031E-02	.1617E+03
19.092800	.2384E-04	.1542E+00	.3678E-02	.1618E+03
19.101100	.2247E-04	.1489E+00	.3346E-02	.1619E+03
19.109400	.2113E-04	.1436E+00	.3034E-02	.1620E+03
19.117800	.1861E-04	.1383E+00	.2574E-02	.1621E+03
19.126100	.1738E-04	.1330E+00	.2311E-02	.1621E+03
19.134400	.1618E-04	.1277E+00	.2065E-02	.1622E+03
19.142800	.1501E-04	.1223E+00	.1837E-02	.1623E+03
19.151100	.1389E-04	.1170E+00	.1625E-02	.1623E+03
19.159400	.1280E-04	.1117E+00	.1430E-02	.1624E+03
19.167800	.1175E-04	.1064E+00	.1250E-02	.1624E+03
19.176100	.1074E-04	.1011E+00	.1086E-02	.1624E+03
19.184400	.9771E-05	.9576E-01	.9357E-03	.1625E+03
19.192800	.8840E-05	.9040E-01	.7991E-03	.1625E+03
19.201100	.7948E-05	.8510E-01	.6764E-03	.1625E+03
19.209400	.7097E-05	.7980E-01	.5664E-03	.1625E+03
19.217800	.6288E-05	.7444E-01	.4681E-03	.1625E+03
19.226100	.5522E-05	.6914E-01	.3817E-03	.1625E+03
19.234400	.4798E-05	.6384E-01	.3063E-03	.1625E+03
19.242800	.4118E-05	.5848E-01	.2408E-03	.1626E+03
19.251100	.3483E-05	.5318E-01	.1852E-03	.1626E+03
19.259400	.2894E-05	.4788E-01	.1386E-03	.1626E+03
19.267800	.2353E-05	.4252E-01	.1000E-03	.1626E+03
19.276100	.1860E-05	.3722E-01	.6923E-04	.1626E+03
19.284400	.1418E-05	.3192E-01	.4526E-04	.1626E+03
19.292800	.1028E-05	.2656E-01	.2730E-04	.1626E+03
19.301100	.6928E-06	.2126E-01	.1473E-04	.1626E+03
19.309400	.4159E-06	.1596E-01	.6638E-05	.1626E+03
19.317800	.2017E-06	.1060E-01	.2138E-05	.1626E+03
19.326100	.0000E+00	.5299E-02	.0000E+00	.1626E+03
19.334400	.0000E+00	.0000E+00	.0000E+00	.1626E+03

Total runoff volume going through collector field_2 = .155831159 m^3

Total sediment going through collector field_2 = 162.573597542 g

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.
Time for beginning event (0 s) = 18.333088889 h

Event on u151b-92

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.3977E+00	215.	1865.	.2313E-03	3575.
field_2	.1530E+00	215.	1865.	.1114E-03	3575.
g4_1	.1546E+00	605.	1865.	.1037E-03	3575.
g4_2	.2281E+00	545.	1865.	.1452E-03	3575.
g8_1	.9914E-03	935.	1865.	.9454E-06	3575.
g8_2	.8954E-03	305.	1025.	.8860E-06	3575.
rip_1	.2318E-04	2495.	3575.	.6957E-07	3605.
rip_2	.2707E-05	575.	275.	.2733E-07	905.
field_avg	.2753E+00	215.	1865.	.1713E-03	3575.
g4_avg	.1914E+00	545.	1865.	.1245E-03	3575.
g8_avg	.9434E-03	305.	1385.	.7517E-06	3575.

RAINFALL DATA FOR EVENT u168a-92

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 18.333088889 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.2540E-05
.2999E+03	.8467E-06
.5998E+03	.1693E-05
.9000E+03	.1693E-05
.1200E+04	.1693E-05
.1500E+04	.8467E-06
.1801E+04	.0000E+00
.2400E+04	.8467E-06
.2701E+04	.0000E+00
.3303E+04	.0000E+00

Total rainfall volume= 0.305 cm

Table 6. Summary of field data for event on (06/16/92 a)

TABLE OF SEDIMENT AND RUNOFF DATA

Files used= u168a-92.q u168a-92.sedin
Collector= g4_1
Number of field samples= 4

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
-.040600	.0000E+00	.0000E+00	.0000E+00	.0000E+00
-.032200	.7036E-07	.5529E-01	.3890E-05	.1176E-03
-.023900	.7036E-07	.1099E+00	.7734E-05	.3487E-03
-.015600	.2296E-06	.1646E+00	.3778E-04	.1478E-02
-.007200	.2296E-06	.2199E+00	.5047E-04	.3004E-02
.001100	.7036E-07	.2745E+00	.1931E-04	.3581E-02
.009400	.2299E-06	.3291E+00	.7566E-04	.5841E-02
.017800	.2299E-06	.3844E+00	.8837E-04	.8514E-02
.026100	.4589E-06	.4391E+00	.2015E-03	.1453E-01
.034400	.2299E-06	.4937E+00	.1135E-03	.1792E-01
.042800	.2299E-06	.5490E+00	.1262E-03	.2174E-01
.051100	.2299E-06	.6036E+00	.1388E-03	.2589E-01
.059400	.2299E-06	.6583E+00	.1513E-03	.3041E-01
.067800	.2299E-06	.7135E+00	.1640E-03	.3537E-01
.076100	.2299E-06	.7682E+00	.1766E-03	.4064E-01
.084400	.2299E-06	.8228E+00	.1891E-03	.4630E-01
.092800	.2299E-06	.8781E+00	.2018E-03	.5240E-01
.101100	.2299E-06	.9327E+00	.2144E-03	.5881E-01
.109400	.2299E-06	.9874E+00	.2270E-03	.6559E-01
.117800	.4589E-06	.1043E+01	.4785E-03	.8006E-01
.126100	.3180E-04	.1097E+01	.3490E-01	.1123E+01
.134400	.6967E-04	.1152E+01	.8025E-01	.3521E+01
.142800	.8264E-04	.1207E+01	.9977E-01	.6538E+01
.151100	.8264E-04	.1200E+01	.9915E-01	.9500E+01
.159400	.8264E-04	.7856E+00	.6492E-01	.1144E+02
.167800	.8264E-04	.4432E+00	.3662E-01	.1255E+02
.176100	.8947E-04	.5910E+00	.5288E-01	.1413E+02
.184400	.9891E-04	.7388E+00	.7308E-01	.1631E+02
.192800	.1063E-03	.8884E+00	.9440E-01	.1917E+02
.201100	.1164E-03	.1036E+01	.1206E+00	.2277E+02

.209400	.1323E-03	.1184E+01	.1567E+00	.2745E+02
.217800	.1323E-03	.1334E+01	.1764E+00	.3279E+02
.226100	.1406E-03	.1481E+01	.2082E+00	.3901E+02
.234400	.1406E-03	.1629E+01	.2290E+00	.4585E+02
.242800	.1696E-03	.1779E+01	.3017E+00	.5497E+02
.251100	.1976E-03	.1927E+01	.3807E+00	.6635E+02
.259400	.1976E-03	.2075E+01	.4100E+00	.7860E+02
.267800	.1976E-03	.2081E+01	.4113E+00	.9104E+02
.276100	.1976E-03	.1183E+01	.2339E+00	.9803E+02
.284400	.1976E-03	.3992E+00	.7888E-01	.1004E+03
.292800	.1838E-03	.3857E+00	.7089E-01	.1025E+03
.301100	.1763E-03	.3725E+00	.6566E-01	.1045E+03
.309400	.1660E-03	.3592E+00	.5965E-01	.1063E+03
.317800	.1561E-03	.3458E+00	.5398E-01	.1079E+03
.326100	.1464E-03	.3326E+00	.4868E-01	.1094E+03
.334400	.1369E-03	.3193E+00	.4372E-01	.1107E+03
.342800	.1277E-03	.3059E+00	.3908E-01	.1118E+03
.351100	.1188E-03	.2927E+00	.3477E-01	.1129E+03
.359400	.1102E-03	.2794E+00	.3078E-01	.1138E+03
.367800	.1018E-03	.2660E+00	.2708E-01	.1146E+03
.376100	.9369E-04	.2527E+00	.2368E-01	.1153E+03
.384400	.8586E-04	.2395E+00	.2056E-01	.1159E+03
.392800	.7833E-04	.2261E+00	.1771E-01	.1165E+03
.401100	.7108E-04	.2128E+00	.1513E-01	.1169E+03
.409400	.6412E-04	.1996E+00	.1280E-01	.1173E+03
.417800	.5746E-04	.1862E+00	.1070E-01	.1176E+03
.426100	.4399E-04	.1729E+00	.7607E-02	.1179E+03
.434400	.3833E-04	.1597E+00	.6120E-02	.1180E+03
.442800	.3299E-04	.1463E+00	.4825E-02	.1182E+03
.451100	.2799E-04	.1330E+00	.3723E-02	.1183E+03
.459400	.2334E-04	.1197E+00	.2795E-02	.1184E+03
.467800	.1904E-04	.1063E+00	.2024E-02	.1185E+03
.476100	.1511E-04	.9308E-01	.1406E-02	.1185E+03
.484400	.1156E-04	.7983E-01	.9228E-03	.1185E+03
.492800	.8414E-05	.6642E-01	.5589E-03	.1185E+03
.501100	.5694E-05	.5317E-01	.3027E-03	.1185E+03
.509400	.3429E-05	.3992E-01	.1369E-03	.1186E+03
.517800	.1660E-05	.2650E-01	.4401E-04	.1186E+03
.526100	.0000E+00	.1325E-01	.0000E+00	.1186E+03
.534400	.0000E+00	.0000E+00	.0000E+00	.1186E+03

Total runoff volume going through collector g4_1 = .139702572 m^3
Total sediment going through collector g4_1 = 118.552360914 g

Collector= field_1
Number of field samples= 8

time	q	Sed. conc.	Sed. load	Cumulative
(h)	(m3/s)	(g/l)	(g/s)	(g)
-.040600	.0000E+00	.0000E+00	.0000E+00	.0000E+00
-.032200	.2890E-05	.1758E+00	.5080E-03	.1536E-01
-.023900	.2890E-05	.3495E+00	.1010E-02	.4554E-01
-.015600	.1814E-04	.8782E+00	.1593E-01	.5215E+00
-.007200	.3742E-04	.3849E+01	.1440E+00	.4877E+01
.001100	.7040E-04	.6440E+01	.4534E+00	.1842E+02
.009400	.1302E-03	.6776E+01	.8821E+00	.4478E+02
.017800	.2348E-03	.7280E+01	.1709E+01	.9647E+02
.026100	.3019E-03	.8825E+01	.2664E+01	.1761E+03
.034400	.3379E-03	.1037E+02	.3504E+01	.2808E+03
.042800	.3379E-03	.1193E+02	.4033E+01	.4028E+03
.051100	.3379E-03	.1307E+02	.4417E+01	.5347E+03
.059400	.3379E-03	.1152E+02	.3893E+01	.6511E+03
.067800	.3379E-03	.9955E+01	.3364E+01	.7528E+03
.076100	.3379E-03	.8407E+01	.2841E+01	.8377E+03
.084400	.3379E-03	.7011E+01	.2369E+01	.9085E+03
.092800	.3379E-03	.6638E+01	.2243E+01	.9763E+03
.101100	.3379E-03	.6269E+01	.2119E+01	.1040E+04
.109400	.3379E-03	.5901E+01	.1994E+01	.1099E+04
.117800	.2980E-03	.5528E+01	.1647E+01	.1149E+04
.126100	.2713E-03	.5159E+01	.1399E+01	.1191E+04
.134400	.2601E-03	.4790E+01	.1246E+01	.1228E+04
.142800	.2419E-03	.4417E+01	.1069E+01	.1260E+04
.151100	.2419E-03	.4136E+01	.1001E+01	.1290E+04
.159400	.2419E-03	.4422E+01	.1070E+01	.1322E+04
.167800	.2419E-03	.4712E+01	.1140E+01	.1357E+04
.176100	.2788E-03	.4998E+01	.1393E+01	.1398E+04
.184400	.3298E-03	.5284E+01	.1743E+01	.1450E+04
.192800	.3629E-03	.5574E+01	.2023E+01	.1512E+04
.201100	.3714E-03	.5860E+01	.2177E+01	.1577E+04
.209400	.3757E-03	.6147E+01	.2309E+01	.1646E+04
.217800	.3757E-03	.6437E+01	.2418E+01	.1719E+04
.226100	.3527E-03	.6730E+01	.2374E+01	.1790E+04
.234400	.3386E-03	.6960E+01	.2356E+01	.1860E+04
.242800	.3087E-03	.6765E+01	.2088E+01	.1923E+04
.251100	.2837E-03	.6572E+01	.1865E+01	.1979E+04
.259400	.2707E-03	.6380E+01	.1727E+01	.2031E+04
.267800	.2580E-03	.6185E+01	.1596E+01	.2079E+04
.276100	.2455E-03	.5992E+01	.1471E+01	.2123E+04
.284400	.2333E-03	.5800E+01	.1353E+01	.2163E+04
.292800	.2077E-03	.5605E+01	.1164E+01	.2198E+04
.301100	.1896E-03	.5412E+01	.1026E+01	.2229E+04
.309400	.1786E-03	.5220E+01	.9321E+00	.2257E+04
.317800	.1678E-03	.5025E+01	.8433E+00	.2282E+04
.326100	.1574E-03	.4832E+01	.7604E+00	.2305E+04
.334400	.1472E-03	.4640E+01	.6828E+00	.2326E+04
.342800	.1372E-03	.4445E+01	.6100E+00	.2344E+04

.351100	.1276E-03	.4252E+01	.5426E+00	.2360E+04
.359400	.1182E-03	.4060E+01	.4800E+00	.2375E+04
.367800	.1092E-03	.3865E+01	.4219E+00	.2387E+04
.376100	.1004E-03	.3672E+01	.3687E+00	.2398E+04
.384400	.9192E-04	.3480E+01	.3198E+00	.2408E+04
.392800	.8374E-04	.3285E+01	.2751E+00	.2416E+04
.401100	.7588E-04	.3092E+01	.2346E+00	.2423E+04
.409400	.6833E-04	.2900E+01	.1981E+00	.2429E+04
.417800	.6110E-04	.2705E+01	.1653E+00	.2434E+04
.426100	.4658E-04	.2512E+01	.1170E+00	.2438E+04
.434400	.4042E-04	.2320E+01	.9376E-01	.2440E+04
.442800	.3461E-04	.2125E+01	.7355E-01	.2443E+04
.451100	.2917E-04	.1932E+01	.5638E-01	.2444E+04
.459400	.2412E-04	.1740E+01	.4196E-01	.2446E+04
.467800	.1945E-04	.1545E+01	.3005E-01	.2446E+04
.476100	.1520E-04	.1352E+01	.2056E-01	.2447E+04
.484400	.1138E-04	.1160E+01	.1320E-01	.2447E+04
.492800	.8018E-05	.9651E+00	.7737E-02	.2448E+04
.501100	.5145E-05	.7725E+00	.3975E-02	.2448E+04
.509400	.2808E-05	.5800E+00	.1629E-02	.2448E+04
.517800	.1077E-05	.3851E+00	.4146E-03	.2448E+04
.526100	.0000E+00	.1925E+00	.0000E+00	.2448E+04
.534400	.0000E+00	.4337E-18	.0000E+00	.2448E+04

Total runoff volume going through collector field_1 = .378614156 m^3
Total sediment going through collector field_1 = 2447.887572836 g

Collector= g4_2
Number of field samples= 6

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
-.040600	.0000E+00	.0000E+00	.0000E+00	.0000E+00
-.032200	.1152E-06	.1048E+00	.1208E-04	.3654E-03
-.023900	.1152E-06	.2085E+00	.2402E-04	.1083E-02
-.015600	.3565E-06	.3121E+00	.1113E-03	.4408E-02
-.007200	.1152E-06	.4169E+00	.4805E-04	.5860E-02
.001100	.1152E-06	.5205E+00	.5999E-04	.7653E-02
.009400	.3570E-06	.6241E+00	.2228E-03	.1431E-01
.017800	.3570E-06	.7290E+00	.2602E-03	.2218E-01
.026100	.3570E-06	.8326E+00	.2972E-03	.3106E-01
.034400	.1155E-06	.9362E+00	.1082E-03	.3429E-01
.042800	.1155E-06	.1041E+01	.1203E-03	.3793E-01
.051100	.1155E-06	.1145E+01	.1322E-03	.4188E-01
.059400	.1155E-06	.1248E+01	.1442E-03	.4619E-01
.067800	.1155E-06	.1353E+01	.1563E-03	.5091E-01
.076100	.1155E-06	.1457E+01	.1683E-03	.5594E-01
.084400	.1155E-06	.1560E+01	.1803E-03	.6133E-01
.092800	.1155E-06	.1665E+01	.1924E-03	.6715E-01
.101100	.1155E-06	.1769E+01	.2043E-03	.7325E-01
.109400	.1155E-06	.1872E+01	.2163E-03	.7972E-01
.117800	.3570E-06	.1977E+01	.7058E-03	.1011E+00
.126100	.1155E-06	.2081E+01	.2404E-03	.1082E+00
.134400	.1155E-06	.2184E+01	.2524E-03	.1158E+00
.142800	.1155E-06	.2289E+01	.2645E-03	.1238E+00
.151100	.1155E-06	.2393E+01	.2764E-03	.1320E+00
.159400	.1155E-06	.2496E+01	.2884E-03	.1407E+00
.167800	.1155E-06	.2601E+01	.3005E-03	.1497E+00
.176100	.1155E-06	.2705E+01	.3125E-03	.1591E+00
.184400	.1907E-04	.2808E+01	.5357E-01	.1760E+01
.192800	.5087E-04	.2913E+01	.1482E+00	.6241E+01
.201100	.7894E-04	.3017E+01	.2382E+00	.1336E+02
.209400	.9849E-04	.3121E+01	.3073E+00	.2254E+02
.217800	.9849E-04	.3022E+01	.2976E+00	.3154E+02
.226100	.1280E-03	.1636E+01	.2094E+00	.3780E+02
.234400	.1280E-03	.4125E+00	.5281E-01	.3938E+02
.242800	.1308E-03	.2949E+00	.3859E-01	.4054E+02
.251100	.1337E-03	.1991E+00	.2662E-01	.4134E+02
.259400	.1337E-03	.2363E+00	.3160E-01	.4228E+02
.267800	.1337E-03	.2821E+00	.3773E-01	.4342E+02
.276100	.1337E-03	.3794E+00	.5074E-01	.4494E+02
.284400	.1337E-03	.4767E+00	.6375E-01	.4684E+02
.292800	.1266E-03	.5752E+00	.7280E-01	.4904E+02
.301100	.1222E-03	.6724E+00	.8218E-01	.5150E+02
.309400	.1180E-03	.7697E+00	.9086E-01	.5422E+02
.317800	.1139E-03	.8682E+00	.9891E-01	.5721E+02
.326100	.1099E-03	.9654E+00	.1061E+00	.6038E+02
.334400	.1059E-03	.1063E+01	.1125E+00	.6374E+02
.342800	.1019E-03	.1161E+01	.1184E+00	.6732E+02
.351100	.9805E-04	.1258E+01	.1234E+00	.7100E+02
.359400	.9422E-04	.1356E+01	.1277E+00	.7482E+02
.367800	.9045E-04	.1454E+01	.1315E+00	.7880E+02
.376100	.8675E-04	.1551E+01	.1346E+00	.8282E+02
.384400	.8310E-04	.1649E+01	.1370E+00	.8691E+02
.392800	.7951E-04	.1747E+01	.1389E+00	.9111E+02
.401100	.7599E-04	.1844E+01	.1402E+00	.9530E+02
.409400	.7252E-04	.1942E+01	.1408E+00	.9951E+02
.417800	.6912E-04	.2040E+01	.1410E+00	.1038E+03
.426100	.3638E-04	.2137E+01	.7776E-01	.1061E+03
.434400	.3379E-04	.2235E+01	.7551E-01	.1084E+03
.442800	.3127E-04	.2333E+01	.7296E-01	.1106E+03
.451100	.2883E-04	.2408E+01	.6941E-01	.1126E+03
.459400	.2647E-04	.2333E+01	.6173E-01	.1145E+03
.467800	.2418E-04	.2257E+01	.5457E-01	.1161E+03
.476100	.2198E-04	.2182E+01	.4794E-01	.1176E+03
.484400	.1985E-04	.2107E+01	.4182E-01	.1188E+03

.492800	.1781E-04	.2031E+01	.3618E-01	.1199E+03
.501100	.1586E-04	.1956E+01	.3102E-01	.1208E+03
.509400	.1400E-04	.1881E+01	.2633E-01	.1216E+03
.517800	.1223E-04	.1805E+01	.2207E-01	.1223E+03
.526100	.0000E+00	.1730E+01	.0000E+00	.1223E+03
.534400	.0000E+00	.1655E+01	.0000E+00	.1223E+03

Total runoff volume going through collector g4_2 = .097092402 m^3
Total sediment going through collector g4_2 = 122.287111911 g

Collector= field_2
Number of field samples= 4

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
-.040600	.0000E+00	.0000E+00	.0000E+00	.0000E+00
-.032200	.0000E+00	.1852E+01	.0000E+00	.0000E+00
-.023900	.0000E+00	.3681E+01	.0000E+00	.0000E+00
-.015600	.5739E-07	.5510E+01	.3162E-03	.9450E-02
-.007200	.1315E-05	.7362E+01	.9684E-02	.3023E+00
.001100	.6528E-05	.9191E+01	.6000E-01	.2095E+01
.009400	.4807E-04	.1102E+02	.5298E+00	.1792E+02
.017800	.1706E-03	.1210E+02	.2064E+01	.8034E+02
.026100	.2547E-03	.8251E+01	.2102E+01	.1431E+03
.034400	.2847E-03	.4884E+01	.1390E+01	.1847E+03
.042800	.2847E-03	.4761E+01	.1355E+01	.2257E+03
.051100	.2847E-03	.4639E+01	.1321E+01	.2651E+03
.059400	.2847E-03	.4508E+01	.1283E+01	.3035E+03
.067800	.2847E-03	.4376E+01	.1246E+01	.3411E+03
.076100	.2847E-03	.4245E+01	.1208E+01	.3773E+03
.084400	.2847E-03	.4114E+01	.1171E+01	.4122E+03
.092800	.2847E-03	.3982E+01	.1133E+01	.4465E+03
.101100	.2847E-03	.3851E+01	.1096E+01	.4793E+03
.109400	.2847E-03	.3720E+01	.1059E+01	.5109E+03
.117800	.2695E-03	.3588E+01	.9670E+00	.5402E+03
.126100	.2511E-03	.3457E+01	.8681E+00	.5661E+03
.134400	.2439E-03	.3326E+01	.8112E+00	.5903E+03
.142800	.2403E-03	.3194E+01	.7675E+00	.6136E+03
.151100	.2403E-03	.3063E+01	.7361E+00	.6355E+03
.159400	.2403E-03	.2932E+01	.7047E+00	.6566E+03
.167800	.2403E-03	.2800E+01	.6729E+00	.6770E+03
.176100	.2658E-03	.2669E+01	.7094E+00	.6981E+03
.184400	.3041E-03	.2538E+01	.7719E+00	.7212E+03
.192800	.3200E-03	.2406E+01	.7699E+00	.7445E+03
.201100	.3322E-03	.2285E+01	.7591E+00	.7672E+03
.209400	.3404E-03	.2228E+01	.7585E+00	.7898E+03
.217800	.3404E-03	.2170E+01	.7389E+00	.8122E+03
.226100	.3219E-03	.2114E+01	.6803E+00	.8325E+03
.234400	.3078E-03	.2057E+01	.6329E+00	.8514E+03
.242800	.2939E-03	.1999E+01	.5875E+00	.8692E+03
.251100	.2803E-03	.1942E+01	.5444E+00	.8855E+03
.259400	.2670E-03	.1885E+01	.5033E+00	.9005E+03
.267800	.2539E-03	.1828E+01	.4641E+00	.9145E+03
.276100	.2412E-03	.1771E+01	.4270E+00	.9273E+03
.284400	.2287E-03	.1714E+01	.3919E+00	.9390E+03
.292800	.2064E-03	.1656E+01	.3418E+00	.9493E+03
.301100	.1786E-03	.1599E+01	.2857E+00	.9579E+03
.309400	.1677E-03	.1542E+01	.2586E+00	.9656E+03
.317800	.1570E-03	.1485E+01	.2331E+00	.9726E+03
.326100	.1467E-03	.1428E+01	.2094E+00	.9789E+03
.334400	.1366E-03	.1371E+01	.1873E+00	.9845E+03
.342800	.1269E-03	.1313E+01	.1666E+00	.9895E+03
.351100	.1174E-03	.1257E+01	.1476E+00	.9940E+03
.359400	.1083E-03	.1200E+01	.1299E+00	.9978E+03
.367800	.9951E-04	.1142E+01	.1136E+00	.1001E+04
.376100	.9103E-04	.1085E+01	.9878E-01	.1004E+04
.384400	.8287E-04	.1028E+01	.8522E-01	.1007E+04
.392800	.7505E-04	.9707E+00	.7285E-01	.1009E+04
.401100	.6755E-04	.9138E+00	.6173E-01	.1011E+04
.409400	.6040E-04	.8569E+00	.5176E-01	.1012E+04
.417800	.5360E-04	.7993E+00	.4284E-01	.1014E+04
.426100	.4365E-04	.7424E+00	.3241E-01	.1015E+04
.434400	.3776E-04	.6855E+00	.2589E-01	.1015E+04
.442800	.3224E-04	.6280E+00	.2024E-01	.1016E+04
.451100	.2709E-04	.5711E+00	.1547E-01	.1016E+04
.459400	.2234E-04	.5142E+00	.1149E-01	.1017E+04
.467800	.1798E-04	.4566E+00	.8209E-02	.1017E+04
.476100	.1403E-04	.3997E+00	.5608E-02	.1017E+04
.484400	.1051E-04	.3428E+00	.3603E-02	.1017E+04
.492800	.7435E-05	.2852E+00	.2120E-02	.1017E+04
.501100	.4826E-05	.2283E+00	.1102E-02	.1017E+04
.509400	.2714E-05	.1714E+00	.4652E-03	.1017E+04
.517800	.1144E-05	.1138E+00	.1302E-03	.1017E+04
.526100	.0000E+00	.5690E-01	.0000E+00	.1017E+04
.534400	.0000E+00	.0000E+00	.0000E+00	.1017E+04

Total runoff volume going through collector field_2 = .337462799 m^3
Total sediment going through collector field_2 = 1017.455971245 g

Collector= rip_1
Number of field samples= 2

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)

-.040600	.0000E+00	.0000E+00	.0000E+00	.0000E+00
-.032200	.0000E+00	.1750E+00	.0000E+00	.0000E+00
-.023900	.0000E+00	.3478E+00	.0000E+00	.0000E+00
-.015600	.0000E+00	.5207E+00	.0000E+00	.0000E+00
-.007200	.0000E+00	.6957E+00	.0000E+00	.0000E+00
.001100	.0000E+00	.8685E+00	.0000E+00	.0000E+00
.009400	.0000E+00	.1041E+01	.0000E+00	.0000E+00
.017800	.0000E+00	.1216E+01	.0000E+00	.0000E+00
.026100	.0000E+00	.1389E+01	.0000E+00	.0000E+00
.034400	.0000E+00	.1562E+01	.0000E+00	.0000E+00
.042800	.0000E+00	.1737E+01	.0000E+00	.0000E+00
.051100	.0000E+00	.1910E+01	.0000E+00	.0000E+00
.059400	.0000E+00	.2083E+01	.0000E+00	.0000E+00
.067800	.0000E+00	.2258E+01	.0000E+00	.0000E+00
.076100	.0000E+00	.2431E+01	.0000E+00	.0000E+00
.084400	.0000E+00	.2604E+01	.0000E+00	.0000E+00
.092800	.0000E+00	.2778E+01	.0000E+00	.0000E+00
.101100	.0000E+00	.2951E+01	.0000E+00	.0000E+00
.109400	.0000E+00	.3124E+01	.0000E+00	.0000E+00
.117800	.4145E-06	.3299E+01	.1367E-02	.4135E-01
.126100	.7985E-06	.3472E+01	.2773E-02	.1242E+00
.134400	.1303E-05	.3645E+01	.4750E-02	.2661E+00
.142800	.5029E-05	.3820E+01	.1921E-01	.8471E+00
.151100	.5029E-05	.3993E+01	.2008E-01	.1447E+01
.159400	.5029E-05	.4166E+01	.2095E-01	.2073E+01
.167800	.5029E-05	.4266E+01	.2145E-01	.2722E+01
.176100	.6792E-05	.3891E+01	.2643E-01	.3512E+01
.184400	.6176E-05	.3517E+01	.2172E-01	.4160E+01
.192800	.6792E-05	.3138E+01	.2131E-01	.4805E+01
.201100	.6787E-05	.2763E+01	.1875E-01	.5365E+01
.209400	.7431E-05	.2388E+01	.1775E-01	.5895E+01
.217800	.7431E-05	.2009E+01	.1493E-01	.6347E+01
.226100	.1638E-04	.1635E+01	.2678E-01	.7147E+01
.234400	.1638E-04	.1260E+01	.2064E-01	.7764E+01
.242800	.1736E-04	.8810E+00	.1530E-01	.8226E+01
.251100	.1940E-04	.5540E+00	.1075E-01	.8548E+01
.259400	.1940E-04	.5377E+00	.1043E-01	.8859E+01
.267800	.1940E-04	.5213E+00	.1011E-01	.9165E+01
.276100	.1940E-04	.5051E+00	.9799E-02	.9458E+01
.284400	.1940E-04	.4888E+00	.9484E-02	.9741E+01
.292800	.2047E-04	.4724E+00	.9668E-02	.1003E+02
.301100	.2050E-04	.4562E+00	.9354E-02	.1031E+02
.309400	.2050E-04	.4400E+00	.9021E-02	.1058E+02
.317800	.2050E-04	.4235E+00	.8684E-02	.1085E+02
.326100	.2050E-04	.4073E+00	.8352E-02	.1109E+02
.334400	.2050E-04	.3911E+00	.8019E-02	.1133E+02
.342800	.2050E-04	.3746E+00	.7682E-02	.1157E+02
.351100	.2050E-04	.3584E+00	.7349E-02	.1179E+02
.359400	.2050E-04	.3422E+00	.7016E-02	.1200E+02
.367800	.2050E-04	.3258E+00	.6680E-02	.1220E+02
.376100	.2050E-04	.3095E+00	.6347E-02	.1239E+02
.384400	.2050E-04	.2933E+00	.6014E-02	.1257E+02
.392800	.2050E-04	.2769E+00	.5677E-02	.1274E+02
.401100	.2050E-04	.2606E+00	.5345E-02	.1290E+02
.409400	.2050E-04	.2444E+00	.5012E-02	.1305E+02
.417800	.2050E-04	.2280E+00	.4675E-02	.1319E+02
.426100	.2160E-04	.2118E+00	.4574E-02	.1333E+02
.434400	.2160E-04	.1955E+00	.4223E-02	.1345E+02
.442800	.2160E-04	.1791E+00	.3868E-02	.1357E+02
.451100	.2160E-04	.1629E+00	.3518E-02	.1367E+02
.459400	.2160E-04	.1467E+00	.3167E-02	.1377E+02
.467800	.2160E-04	.1302E+00	.2813E-02	.1385E+02
.476100	.2160E-04	.1140E+00	.2462E-02	.1393E+02
.484400	.2160E-04	.9777E-01	.2112E-02	.1399E+02
.492800	.2160E-04	.8134E-01	.1757E-02	.1404E+02
.501100	.2160E-04	.6511E-01	.1406E-02	.1409E+02
.509400	.2160E-04	.4888E-01	.1056E-02	.1412E+02
.517800	.2160E-04	.3246E-01	.7010E-03	.1414E+02
.526100	.2160E-04	.1623E-01	.3505E-03	.1415E+02
.534400	.0000E+00	.0000E+00	.0000E+00	.1415E+02

Total runoff volume going through collector rip_1 = .024598319 m^3
Total sediment going through collector rip_1 = 14.149467578 g

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.

Time for beginning event (0 s) = -.000311111 h
Event on u168a-92

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.3749E+00	35.	785.	.3757E-03	1895.
field_2	.3373E+00	35.	785.	.3404E-03	1895.
g4_1	.1397E+00	35.	1025.	.1976E-03	1895.
g4_2	.9705E-01	35.	1025.	.1337E-03	1895.
g8_1	.1543E-03	35.	1025.	.1929E-06	1895.
g8_2	.4688E-01	1055.	1505.	.7922E-04	1895.
rip_1	.2460E-01	425.	1895.	.2160E-04	1925.
rip_2	.2729E-03	695.	1895.	.5531E-06	1925.
field_avg	.3561E+00	35.	785.	.3581E-03	1895.
g4_avg	.1184E+00	35.	1025.	.1657E-03	1895.

g8_avg	.2352E-01	35.	1505.	.3967E-04	1895.

RAINFALL DATA FOR EVENT u168a-92

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = -.000311111 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.8467E-06
.3010E+03	.0000E+00
.6001E+03	.8467E-06
.9011E+03	.0000E+00
.1200E+04	.8467E-06
.1500E+04	.8467E-06
.1800E+04	.5927E-05
.2100E+04	.3387E-05
.2400E+04	.8467E-06
.2700E+04	.8467E-06
.3000E+04	.8467E-06
.3301E+04	.0000E+00
.3903E+04	.0000E+00

Total rainfall volume= 0.457 cm

Table 7. Summary of field data for event on (06/26/92 a)

TABLE OF SEDIMENT AND RUNOFF DATA

Files used= u178a-92.q u178a-92.sedin
Collector= g4_1
Number of field samples= 13

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
11.526100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11.534400	.7036E-07	.8174E-02	.5751E-06	.1718E-04
11.542800	.6783E-07	.1645E-01	.1115E-05	.5091E-04
11.551100	.7423E-06	.2462E-01	.1828E-04	.5970E-03
11.559400	.7423E-06	.3279E-01	.2434E-04	.1324E-02
11.567800	.1088E-05	.4107E-01	.4469E-04	.2676E-02
11.576100	.1088E-05	.4924E-01	.5358E-04	.4277E-02
11.584400	.1487E-05	.5741E-01	.8538E-04	.6828E-02
11.592800	.1956E-05	.6569E-01	.1285E-03	.1071E-01
11.601100	.3000E-05	.7386E-01	.2216E-03	.1733E-01
11.609400	.7160E-05	.8203E-01	.5873E-03	.3488E-01
11.617800	.2889E-04	.9030E-01	.2608E-02	.1138E+00
11.626100	.1164E-03	.9848E-01	.1147E-01	.4564E+00
11.634400	.7310E-03	.1067E+00	.7796E-01	.2786E+01
11.642800	.1152E-02	.1149E+00	.1324E+00	.6788E+01
11.651100	.1750E-02	.2551E+00	.4463E+00	.2013E+02
11.659500	.2304E-02	.1271E+01	.2929E+01	.1087E+03
11.667800	.2503E-02	.2275E+01	.5694E+01	.2788E+03
11.676100	.2503E-02	.3279E+01	.8206E+01	.5240E+03
11.684400	.2428E-02	.4266E+01	.1036E+02	.8335E+03
11.692800	.2390E-02	.5145E+01	.1229E+02	.1205E+04
11.701100	.2369E-02	.5840E+01	.1384E+02	.1619E+04
11.709500	.2208E-02	.5389E+01	.1190E+02	.1978E+04
11.717800	.2060E-02	.4943E+01	.1018E+02	.2283E+04
11.726100	.2008E-02	.4497E+01	.9029E+01	.2553E+04
11.734400	.1964E-02	.4091E+01	.8034E+01	.2793E+04
11.742800	.1904E-02	.3949E+01	.7519E+01	.3020E+04
11.751100	.1861E-02	.3791E+01	.7056E+01	.3231E+04
11.759400	.1779E-02	.3514E+01	.6251E+01	.3418E+04
11.767800	.1730E-02	.3233E+01	.5592E+01	.3587E+04
11.776100	.1696E-02	.2956E+01	.5015E+01	.3737E+04
11.784400	.1687E-02	.2717E+01	.4583E+01	.3873E+04
11.792800	.1646E-02	.2737E+01	.4506E+01	.4010E+04
11.801100	.1545E-02	.2757E+01	.4261E+01	.4137E+04
11.809500	.1418E-02	.2778E+01	.3939E+01	.4256E+04
11.817800	.1281E-02	.2798E+01	.3585E+01	.4363E+04
11.826100	.1150E-02	.2818E+01	.3241E+01	.4460E+04
11.834500	.1063E-02	.2831E+01	.3011E+01	.4551E+04
11.842800	.1043E-02	.2799E+01	.2919E+01	.4638E+04
11.851100	.9351E-03	.2744E+01	.2566E+01	.4715E+04
11.859500	.8149E-03	.2531E+01	.2063E+01	.4777E+04
11.867800	.7125E-03	.2326E+01	.1657E+01	.4827E+04
11.876100	.6366E-03	.2150E+01	.1369E+01	.4868E+04
11.884400	.5642E-03	.1969E+01	.1111E+01	.4901E+04
11.892800	.4955E-03	.1753E+01	.8685E+00	.4927E+04
11.901100	.4306E-03	.1539E+01	.6627E+00	.4947E+04
11.909500	.3653E-03	.1323E+01	.4833E+00	.4962E+04
11.917800	.3161E-03	.1116E+01	.3528E+00	.4972E+04
11.926100	.2773E-03	.9513E+00	.2638E+00	.4980E+04
11.934400	.2405E-03	.7866E+00	.1892E+00	.4986E+04

11.942800	.2060E-03	.6200E+00	.1277E+00	.4990E+04
11.951100	.1798E-03	.4795E+00	.8623E-01	.4992E+04
11.959400	.1552E-03	.4970E+00	.7711E-01	.4994E+04
11.967800	.1266E-03	.5146E+00	.6517E-01	.4996E+04
11.976100	.1055E-03	.5321E+00	.5611E-01	.4998E+04
11.984400	.1024E-03	.5496E+00	.5628E-01	.5000E+04
11.992800	.8537E-04	.5672E+00	.4842E-01	.5001E+04
12.001100	.7172E-04	.5798E+00	.4159E-01	.5003E+04
12.009400	.6914E-04	.5606E+00	.3876E-01	.5004E+04
12.017800	.6660E-04	.5411E+00	.3604E-01	.5005E+04
12.026100	.5436E-04	.5218E+00	.2837E-01	.5006E+04
12.034400	.4313E-04	.5026E+00	.2168E-01	.5006E+04
12.042800	.4104E-04	.4831E+00	.1983E-01	.5007E+04
12.051100	.3900E-04	.4639E+00	.1809E-01	.5007E+04
12.059400	.3081E-04	.4446E+00	.1370E-01	.5008E+04
12.067800	.2900E-04	.4251E+00	.1233E-01	.5008E+04
12.076100	.2724E-04	.4059E+00	.1106E-01	.5009E+04
12.084400	.2153E-04	.3866E+00	.8325E-02	.5009E+04
12.092800	.1998E-04	.3671E+00	.7334E-02	.5009E+04
12.101100	.1847E-04	.3479E+00	.6425E-02	.5009E+04
12.109400	.1701E-04	.3286E+00	.5590E-02	.5009E+04
12.117800	.1560E-04	.3092E+00	.4823E-02	.5009E+04
12.126100	.1424E-04	.2899E+00	.4130E-02	.5010E+04
12.134400	.9979E-05	.2707E+00	.2701E-02	.5010E+04
12.142800	.8857E-05	.2512E+00	.2225E-02	.5010E+04
12.151100	.7791E-05	.2319E+00	.1807E-02	.5010E+04
12.159400	.6782E-05	.2127E+00	.1442E-02	.5010E+04
12.167800	.5832E-05	.1932E+00	.1127E-02	.5010E+04
12.176100	.4942E-05	.1739E+00	.8597E-03	.5010E+04
12.184400	.4114E-05	.1547E+00	.6364E-03	.5010E+04
12.192800	.3350E-05	.1352E+00	.4529E-03	.5010E+04
12.201100	.2135E-05	.1160E+00	.2476E-03	.5010E+04
12.209400	.1565E-05	.9672E-01	.1513E-03	.5010E+04
12.217800	.1069E-05	.7723E-01	.8257E-04	.5010E+04
12.226100	.6544E-06	.5798E-01	.3795E-04	.5010E+04
12.234400	.3277E-06	.3873E-01	.1269E-04	.5010E+04
12.242800	.1004E-06	.1925E-01	.1933E-05	.5010E+04
12.251100	.0000E+00	.0000E+00	.0000E+00	.5010E+04

Total runoff volume going through collector g4_1 = 1.611720129 m^3
Total sediment going through collector g4_1 = 5009.973905406 g

Collector= g8_1
Number of field samples= 20

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
11.526100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11.534400	.1903E-06	.1094E-01	.2082E-05	.6221E-04
11.542800	.5492E-07	.2201E-01	.1209E-05	.9876E-04
11.551100	.6357E-06	.3295E-01	.2095E-04	.7246E-03
11.559400	.9409E-06	.4389E-01	.4130E-04	.1959E-02
11.567800	.6357E-06	.5496E-01	.3494E-04	.3015E-02
11.576100	.3833E-06	.6590E-01	.2526E-04	.3770E-02
11.584400	.9409E-06	.7684E-01	.7230E-04	.5930E-02
11.592800	.9520E-06	.8791E-01	.8369E-04	.8461E-02
11.601100	.6451E-06	.9885E-01	.6376E-04	.1037E-01
11.609400	.9520E-06	.1098E+00	.1045E-03	.1349E-01
11.617800	.8079E-05	.1209E+00	.9764E-03	.4302E-01
11.626100	.2180E-04	.1318E+00	.2874E-02	.1289E+00
11.634400	.1793E-03	.1395E+00	.2500E-01	.8760E+00
11.642800	.3950E-03	.1247E+00	.4926E-01	.2366E+01
11.651100	.7242E-03	.1090E+00	.7890E-01	.4723E+01
11.659500	.1606E-02	.8486E-01	.1363E+00	.8845E+01
11.667800	.2303E-02	.1968E+00	.4531E+00	.2239E+02
11.676100	.2523E-02	.1167E+01	.2945E+01	.1104E+03
11.684400	.2523E-02	.2089E+01	.5272E+01	.2679E+03
11.692800	.2446E-02	.2693E+01	.6589E+01	.4671E+03
11.701100	.2352E-02	.3210E+01	.7548E+01	.6927E+03
11.709500	.2249E-02	.3197E+01	.7190E+01	.9101E+03
11.717800	.2222E-02	.3122E+01	.6937E+01	.1117E+04
11.726100	.2113E-02	.2652E+01	.5605E+01	.1285E+04
11.734400	.1989E-02	.2211E+01	.4398E+01	.1416E+04
11.742800	.1946E-02	.1961E+01	.3816E+01	.1532E+04
11.751100	.1894E-02	.1718E+01	.3254E+01	.1629E+04
11.759400	.1869E-02	.1498E+01	.2801E+01	.1713E+04
11.767800	.1793E-02	.1308E+01	.2346E+01	.1784E+04
11.776100	.1769E-02	.1324E+01	.2342E+01	.1853E+04
11.784400	.1761E-02	.1331E+01	.2344E+01	.1924E+04
11.792800	.1687E-02	.1280E+01	.2160E+01	.1989E+04
11.801100	.1606E-02	.1230E+01	.1976E+01	.2048E+04
11.809500	.1512E-02	.1180E+01	.1783E+01	.2102E+04
11.817800	.1374E-02	.1163E+01	.1599E+01	.2150E+04
11.826100	.1360E-02	.1362E+01	.1851E+01	.2205E+04
11.834500	.1193E-02	.1521E+01	.1814E+01	.2260E+04
11.842800	.1016E-02	.1426E+01	.1448E+01	.2303E+04
11.851100	.8325E-03	.1296E+01	.1079E+01	.2335E+04
11.859500	.6707E-03	.9339E+00	.6264E+00	.2354E+04
11.867800	.5391E-03	.6196E+00	.3340E+00	.2364E+04
11.876100	.4246E-03	.5777E+00	.2453E+00	.2372E+04
11.884400	.3382E-03	.5319E+00	.1799E+00	.2377E+04
11.892800	.2754E-03	.4579E+00	.1261E+00	.2381E+04
11.901100	.2182E-03	.3989E+00	.8704E-01	.2383E+04
11.909500	.1729E-03	.4331E+00	.7487E-01	.2386E+04
11.917800	.1463E-03	.4502E+00	.6584E-01	.2388E+04
11.926100	.1243E-03	.3622E+00	.4500E-01	.2389E+04

11.934400	.1013E-03	.2871E+00	.2908E-01	.2390E+04
11.942800	.8950E-04	.2998E+00	.2683E-01	.2391E+04
11.951100	.7616E-04	.3092E+00	.2355E-01	.2391E+04
11.959400	.6783E-04	.2985E+00	.2025E-01	.2392E+04
11.967800	.5605E-04	.2880E+00	.1614E-01	.2392E+04
11.976100	.4701E-04	.2795E+00	.1314E-01	.2393E+04
11.984400	.4538E-04	.2711E+00	.1230E-01	.2393E+04
11.992800	.4041E-04	.2626E+00	.1061E-01	.2393E+04
12.001100	.3569E-04	.2541E+00	.9070E-02	.2394E+04
12.009400	.3425E-04	.2457E+00	.8415E-02	.2394E+04
12.017800	.3284E-04	.2372E+00	.7787E-02	.2394E+04
12.026100	.2712E-04	.2287E+00	.6203E-02	.2394E+04
12.034400	.2186E-04	.2203E+00	.4815E-02	.2395E+04
12.042800	.2069E-04	.2117E+00	.4382E-02	.2395E+04
12.051100	.1956E-04	.2033E+00	.3976E-02	.2395E+04
12.059400	.1728E-04	.1949E+00	.3367E-02	.2395E+04
12.067800	.1623E-04	.1863E+00	.3024E-02	.2395E+04
12.076100	.1521E-04	.1779E+00	.2705E-02	.2395E+04
12.084400	.1317E-04	.1695E+00	.2232E-02	.2395E+04
12.092800	.1224E-04	.1609E+00	.1969E-02	.2395E+04
12.101100	.1133E-04	.1525E+00	.1728E-02	.2395E+04
12.109400	.1046E-04	.1440E+00	.1507E-02	.2395E+04
12.117800	.9617E-05	.1355E+00	.1303E-02	.2395E+04
12.126100	.8804E-05	.1271E+00	.1119E-02	.2395E+04
12.134400	.6439E-05	.1186E+00	.7639E-03	.2395E+04
12.142800	.5758E-05	.1101E+00	.6339E-03	.2395E+04
12.151100	.5110E-05	.1017E+00	.5194E-03	.2395E+04
12.159400	.4495E-05	.9321E-01	.4190E-03	.2395E+04
12.167800	.3914E-05	.8468E-01	.3314E-03	.2395E+04
12.176100	.3368E-05	.7624E-01	.2568E-03	.2395E+04
12.184400	.2858E-05	.6780E-01	.1938E-03	.2395E+04
12.192800	.2384E-05	.5926E-01	.1413E-03	.2395E+04
12.201100	.1136E-05	.5083E-01	.5775E-04	.2395E+04
12.209400	.8258E-06	.4239E-01	.3501E-04	.2395E+04
12.217800	.5588E-06	.3385E-01	.1891E-04	.2395E+04
12.226100	.3377E-06	.2541E-01	.8582E-05	.2395E+04
12.234400	.1661E-06	.1698E-01	.2819E-05	.2395E+04
12.242800	.4936E-07	.8437E-02	.4164E-06	.2395E+04
12.251100	.0000E+00	.0000E+00	.0000E+00	.2395E+04

Total runoff volume going through collector g8_1 = 1.471476311 m^3
Total sediment going through collector g8_1 = 2395.468063932 g

Collector= field_1
Number of field samples= 23

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
11.526100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11.534400	.1121E-04	.1811E+02	.2031E+00	.6068E+01
11.542800	.5776E-04	.3643E+02	.2105E+01	.6971E+02
11.551100	.1165E-03	.5147E+02	.5995E+01	.2488E+03
11.559400	.2072E-03	.4643E+02	.9618E+01	.5362E+03
11.567800	.2208E-03	.4005E+02	.8842E+01	.8036E+03
11.576100	.2038E-03	.2564E+02	.5226E+01	.9598E+03
11.584400	.1746E-03	.1288E+02	.2249E+01	.1027E+04
11.592800	.1474E-03	.1123E+02	.1655E+01	.1077E+04
11.601100	.1387E-03	.9662E+01	.1340E+01	.1117E+04
11.609400	.3842E-03	.8473E+01	.3256E+01	.1214E+04
11.617800	.1336E-02	.9145E+01	.1222E+02	.1584E+04
11.626100	.1838E-02	.2169E+02	.3987E+02	.2775E+04
11.634400	.2888E-02	.3343E+02	.9657E+02	.5660E+04
11.642800	.3145E-02	.3983E+02	.1253E+03	.9448E+04
11.651100	.3234E-02	.4448E+02	.1439E+03	.1375E+05
11.659500	.3082E-02	.3815E+02	.1176E+03	.1730E+05
11.667800	.2865E-02	.3237E+02	.9276E+02	.2007E+05
11.676100	.2692E-02	.2958E+02	.7965E+02	.2245E+05
11.684400	.2654E-02	.2695E+02	.7151E+02	.2459E+05
11.692800	.2606E-02	.2534E+02	.6605E+02	.2659E+05
11.701100	.2422E-02	.2367E+02	.5733E+02	.2830E+05
11.709500	.2252E-02	.2142E+02	.4824E+02	.2976E+05
11.717800	.2286E-02	.1949E+02	.4455E+02	.3109E+05
11.726100	.2258E-02	.1940E+02	.4382E+02	.3240E+05
11.734400	.2275E-02	.1955E+02	.4447E+02	.3373E+05
11.742800	.2265E-02	.2130E+02	.4824E+02	.3519E+05
11.751100	.2186E-02	.2302E+02	.5032E+02	.3669E+05
11.759400	.2220E-02	.2475E+02	.5493E+02	.3833E+05
11.767800	.2227E-02	.2653E+02	.5909E+02	.4012E+05
11.776100	.2306E-02	.2851E+02	.6572E+02	.4208E+05
11.784400	.2296E-02	.3048E+02	.6998E+02	.4418E+05
11.792800	.2087E-02	.3248E+02	.6778E+02	.4623E+05
11.801100	.1701E-02	.3345E+02	.5690E+02	.4793E+05
11.809500	.1363E-02	.2769E+02	.3773E+02	.4907E+05
11.817800	.1319E-02	.2231E+02	.2943E+02	.4995E+05
11.826100	.1048E-02	.1888E+02	.1979E+02	.5054E+05
11.834500	.8726E-03	.1606E+02	.1402E+02	.5096E+05
11.842800	.7725E-03	.1721E+02	.1330E+02	.5136E+05
11.851100	.6720E-03	.1903E+02	.1279E+02	.5174E+05
11.859500	.6079E-03	.2530E+02	.1538E+02	.5220E+05
11.867800	.5218E-03	.3015E+02	.1573E+02	.5267E+05
11.876100	.4641E-03	.2649E+02	.1230E+02	.5304E+05
11.884400	.3787E-03	.2386E+02	.9036E+01	.5331E+05
11.892800	.3162E-03	.2824E+02	.8927E+01	.5358E+05
11.901100	.2296E-03	.3144E+02	.7219E+01	.5380E+05
11.909500	.2222E-03	.2730E+02	.6067E+01	.5398E+05
11.917800	.1949E-03	.2412E+02	.4702E+01	.5412E+05

11.926100	.1509E-03	.2675E+02	.4036E+01	.5424E+05
11.934400	.1447E-03	.2854E+02	.4129E+01	.5437E+05
11.942800	.1218E-03	.2461E+02	.2999E+01	.5446E+05
11.951100	.1032E-03	.2117E+02	.2184E+01	.5452E+05
11.959400	.8811E-04	.2059E+02	.1814E+01	.5458E+05
11.967800	.6325E-04	.1999E+02	.1265E+01	.5461E+05
11.976100	.4913E-04	.1941E+02	.9534E+00	.5464E+05
11.984400	.4706E-04	.1882E+02	.8856E+00	.5467E+05
11.992800	.3629E-04	.1823E+02	.6615E+00	.5469E+05
12.001100	.3284E-04	.1764E+02	.5794E+00	.5471E+05
12.009400	.3108E-04	.1706E+02	.5302E+00	.5472E+05
12.017800	.2937E-04	.1646E+02	.4835E+00	.5474E+05
12.026100	.2621E-04	.1588E+02	.4161E+00	.5475E+05
12.034400	.2458E-04	.1529E+02	.3759E+00	.5476E+05
12.042800	.2302E-04	.1470E+02	.3384E+00	.5477E+05
12.051100	.2150E-04	.1411E+02	.3035E+00	.5478E+05
12.059400	.2003E-04	.1353E+02	.2709E+00	.5479E+05
12.067800	.1859E-04	.1294E+02	.2405E+00	.5480E+05
12.076100	.1720E-04	.1235E+02	.2124E+00	.5480E+05
12.084400	.1707E-04	.1176E+02	.2008E+00	.5481E+05
12.092800	.1572E-04	.1117E+02	.1757E+00	.5481E+05
12.101100	.1443E-04	.1059E+02	.1527E+00	.5482E+05
12.109400	.1317E-04	.1000E+02	.1317E+00	.5482E+05
12.117800	.1197E-04	.9407E+01	.1126E+00	.5482E+05
12.126100	.1081E-04	.8821E+01	.9532E-01	.5483E+05
12.134400	.8731E-05	.8235E+01	.7191E-01	.5483E+05
12.142800	.7714E-05	.7643E+01	.5895E-01	.5483E+05
12.151100	.6748E-05	.7057E+01	.4762E-01	.5483E+05
12.159400	.5834E-05	.6471E+01	.3775E-01	.5483E+05
12.167800	.4975E-05	.5878E+01	.2924E-01	.5484E+05
12.176100	.4171E-05	.5293E+01	.2208E-01	.5484E+05
12.184400	.3425E-05	.4707E+01	.1612E-01	.5484E+05
12.192800	.2740E-05	.4114E+01	.1127E-01	.5484E+05
12.201100	.1612E-05	.3528E+01	.5687E-02	.5484E+05
12.209400	.1119E-05	.2943E+01	.3292E-02	.5484E+05
12.217800	.7006E-06	.2350E+01	.1646E-02	.5484E+05
12.226100	.3650E-06	.1764E+01	.6439E-03	.5484E+05
12.234400	.1235E-06	.1179E+01	.1455E-03	.5484E+05
12.242800	.2125E-08	.5857E+00	.1244E-05	.5484E+05
12.251100	.0000E+00	.0000E+00	.0000E+00	.5484E+05

Total runoff volume going through collector field_1 = 2.008656097 m^3
Total sediment going through collector field_1 = 54836.871136474 g

Collector= g4_2
Number of field samples= 21

time	q	Sed. conc.	Sed. load	Cumulative
(h)	(m3/s)	(g/l)	(g/s)	(g)
11.526100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11.534400	.0000E+00	.2401E+00	.0000E+00	.0000E+00
11.542800	.0000E+00	.4830E+00	.0000E+00	.0000E+00
11.551100	.0000E+00	.7231E+00	.0000E+00	.0000E+00
11.559400	.0000E+00	.9632E+00	.0000E+00	.0000E+00
11.567800	.0000E+00	.1206E+01	.0000E+00	.0000E+00
11.576100	.0000E+00	.1446E+01	.0000E+00	.0000E+00
11.584400	.0000E+00	.1686E+01	.0000E+00	.0000E+00
11.592800	.1253E-09	.1929E+01	.2418E-06	.7312E-05
11.601100	.1253E-09	.2169E+01	.2719E-06	.1544E-04
11.609400	.0000E+00	.2409E+01	.0000E+00	.1544E-04
11.617800	.1253E-09	.2652E+01	.3324E-06	.2549E-04
11.626100	.1253E-09	.2892E+01	.3625E-06	.3632E-04
11.634400	.1253E-09	.3132E+01	.3926E-06	.4805E-04
11.642800	.1605E-03	.3375E+01	.5417E+00	.1638E+02
11.651100	.3744E-03	.3615E+01	.1354E+01	.5683E+02
11.659500	.4588E-03	.3858E+01	.1770E+01	.1104E+03
11.667800	.5010E-03	.4209E+01	.2109E+01	.1734E+03
11.676100	.5049E-03	.5262E+01	.2657E+01	.2528E+03
11.684400	.5041E-03	.6169E+01	.3110E+01	.3457E+03
11.692800	.4657E-03	.6087E+01	.2835E+01	.4314E+03
11.701100	.4603E-03	.6005E+01	.2764E+01	.5140E+03
11.709500	.4055E-03	.5922E+01	.2402E+01	.5866E+03
11.717800	.4003E-03	.4490E+01	.1798E+01	.6403E+03
11.726100	.3779E-03	.4490E+01	.1697E+01	.6911E+03
11.734400	.4031E-03	.4490E+01	.1810E+01	.7451E+03
11.742800	.4425E-03	.4487E+01	.1985E+01	.8052E+03
11.751100	.4834E-03	.4467E+01	.2159E+01	.8697E+03
11.759400	.5403E-03	.4337E+01	.2343E+01	.9397E+03
11.767800	.5592E-03	.4206E+01	.2352E+01	.1011E+04
11.776100	.5987E-03	.4077E+01	.2441E+01	.1084E+04
11.784400	.6184E-03	.4011E+01	.2480E+01	.1158E+04
11.792800	.6489E-03	.4380E+01	.2842E+01	.1244E+04
11.801100	.6271E-03	.4745E+01	.2975E+01	.1333E+04
11.809500	.5207E-03	.5114E+01	.2663E+01	.1413E+04
11.817800	.4447E-03	.5479E+01	.2436E+01	.1486E+04
11.826100	.3733E-03	.5843E+01	.2182E+01	.1551E+04
11.834500	.2646E-03	.6107E+01	.1616E+01	.1600E+04
11.842800	.1969E-03	.5724E+01	.1127E+01	.1634E+04
11.851100	.2098E-03	.3642E+01	.7642E+00	.1657E+04
11.859500	.2196E-03	.3455E+01	.7586E+00	.1680E+04
11.867800	.1789E-03	.3248E+01	.5812E+00	.1697E+04
11.876100	.1387E-03	.2903E+01	.4025E+00	.1709E+04
11.884400	.1381E-03	.2557E+01	.3530E+00	.1719E+04
11.892800	.1020E-03	.2207E+01	.2251E+00	.1726E+04
11.901100	.9894E-04	.1860E+01	.1840E+00	.1732E+04
11.909500	.6764E-04	.1495E+01	.1011E+00	.1735E+04

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
11.526100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11.534400	.1727E-06	.1562E+00	.2698E-04	.8063E-03
11.542800	.4824E-07	.3143E+00	.1516E-04	.1265E-02
11.551100	.1695E-06	.4706E+00	.7974E-04	.3647E-02
11.559400	.1695E-06	.6268E+00	.1062E-03	.6821E-02
11.567800	.1695E-06	.7849E+00	.1330E-03	.1084E-01
11.576100	.4824E-07	.9411E+00	.4540E-04	.1220E-01
11.584400	.1695E-06	.1097E+01	.1860E-03	.1776E-01
11.592800	.1760E-06	.1255E+01	.2210E-03	.2444E-01
11.601100	.1760E-06	.1412E+01	.2485E-03	.3186E-01
11.609400	.5204E-07	.1568E+01	.8159E-04	.3430E-01
11.617800	.3607E-06	.1726E+01	.6226E-03	.5313E-01
11.626100	.3607E-06	.1882E+01	.6789E-03	.7341E-01
11.634400	.1624E-05	.2038E+01	.3311E-02	.1724E+00
11.642800	.9013E-03	.2197E+01	.1980E+01	.6004E+02
11.651100	.2684E-02	.2388E+01	.6412E+01	.2516E+03
11.659500	.3187E-02	.2819E+01	.8984E+01	.5233E+03
11.667800	.3245E-02	.3180E+01	.1032E+02	.8316E+03
11.676100	.3190E-02	.3133E+01	.9993E+01	.1130E+04
11.684400	.3123E-02	.3085E+01	.9637E+01	.1418E+04
11.692800	.3058E-02	.3038E+01	.9288E+01	.1699E+04
11.701100	.2870E-02	.2990E+01	.8582E+01	.1955E+04
11.709500	.2676E-02	.2943E+01	.7875E+01	.2194E+04
11.717800	.2562E-02	.2861E+01	.7331E+01	.2413E+04
11.726100	.2429E-02	.2566E+01	.6234E+01	.2599E+04
11.734400	.2269E-02	.2322E+01	.5271E+01	.2756E+04
11.742800	.2153E-02	.2430E+01	.5232E+01	.2915E+04
11.751100	.2040E-02	.2456E+01	.5010E+01	.3064E+04
11.759400	.1995E-02	.1956E+01	.3903E+01	.3181E+04
11.767800	.1960E-02	.1506E+01	.2951E+01	.3270E+04
11.776100	.1906E-02	.1408E+01	.2683E+01	.3350E+04
11.784400	.1899E-02	.1309E+01	.2487E+01	.3425E+04
11.792800	.1783E-02	.1210E+01	.2158E+01	.3490E+04
11.801100	.1662E-02	.1125E+01	.1869E+01	.3546E+04
11.809500	.1620E-02	.1127E+01	.1826E+01	.3601E+04
11.817800	.1622E-02	.1129E+01	.1832E+01	.3656E+04
11.826100	.1448E-02	.1131E+01	.1638E+01	.3705E+04
11.834500	.1267E-02	.1128E+01	.1429E+01	.3748E+04
11.842800	.1111E-02	.1037E+01	.1152E+01	.3782E+04
11.851100	.9574E-03	.9430E+00	.9028E+00	.3809E+04
11.859500	.8395E-03	.8292E+00	.6961E+00	.3830E+04
11.867800	.7346E-03	.7293E+00	.5358E+00	.3846E+04
11.876100	.6246E-03	.7090E+00	.4428E+00	.3860E+04
11.884400	.5224E-03	.6732E+00	.3517E+00	.3870E+04
11.892800	.4380E-03	.5309E+00	.2325E+00	.3877E+04
11.901100	.3737E-03	.4241E+00	.1585E+00	.3882E+04
11.917800	.4483E-04	.1164E+01	.5216E-01	.1736E+04
11.926100	.4262E-04	.9726E+00	.4145E-01	.1738E+04
11.934400	.2256E-04	.8014E+00	.1808E-01	.1738E+04
11.942800	.9852E-05	.7638E+00	.7526E-02	.1738E+04
11.951100	.7684E-05	.7267E+00	.5584E-02	.1739E+04
11.959400	.1098E-05	.6896E+00	.7574E-03	.1739E+04
11.967800	.3055E-06	.3795E+00	.1159E-03	.1739E+04
11.976100	.0000E+00	.4412E+00	.0000E+00	.1739E+04
11.984400	.0000E+00	.4865E+00	.0000E+00	.1739E+04
11.992800	.0000E+00	.4197E+00	.0000E+00	.1739E+04
12.001100	.0000E+00	.3666E+00	.0000E+00	.1739E+04
12.009400	.0000E+00	.3987E+00	.0000E+00	.1739E+04
12.017800	.0000E+00	.4311E+00	.0000E+00	.1739E+04
12.026100	.0000E+00	.4631E+00	.0000E+00	.1739E+04
12.034400	.0000E+00	.4883E+00	.0000E+00	.1739E+04
12.042800	.0000E+00	.4670E+00	.0000E+00	.1739E+04
12.051100	.0000E+00	.4460E+00	.0000E+00	.1739E+04
12.059400	.0000E+00	.4249E+00	.0000E+00	.1739E+04
12.067800	.0000E+00	.4037E+00	.0000E+00	.1739E+04
12.076100	.0000E+00	.3826E+00	.0000E+00	.1739E+04
12.084400	.0000E+00	.3616E+00	.0000E+00	.1739E+04
12.092800	.0000E+00	.3403E+00	.0000E+00	.1739E+04
12.101100	.0000E+00	.3193E+00	.0000E+00	.1739E+04
12.109400	.0000E+00	.2983E+00	.0000E+00	.1739E+04
12.117800	.0000E+00	.2770E+00	.0000E+00	.1739E+04
12.126100	.0000E+00	.2560E+00	.0000E+00	.1739E+04
12.134400	.0000E+00	.2350E+00	.0000E+00	.1739E+04
12.142800	.0000E+00	.2137E+00	.0000E+00	.1739E+04
12.151100	.0000E+00	.1927E+00	.0000E+00	.1739E+04
12.159400	.0000E+00	.1716E+00	.0000E+00	.1739E+04
12.167800	.0000E+00	.1503E+00	.0000E+00	.1739E+04
12.176100	.0000E+00	.1293E+00	.0000E+00	.1739E+04
12.184400	.1908E-06	.1092E+00	.2085E-04	.1739E+04
12.192800	.1686E-05	.9549E-01	.1610E-03	.1739E+04
12.201100	.0000E+00	.8190E-01	.0000E+00	.1739E+04
12.209400	.0000E+00	.6830E-01	.0000E+00	.1739E+04
12.217800	.0000E+00	.5454E-01	.0000E+00	.1739E+04
12.226100	.8906E-06	.4095E-01	.3647E-04	.1739E+04
12.234400	.2963E-05	.2735E-01	.8105E-04	.1739E+04
12.242800	.5873E-05	.1359E-01	.7984E-04	.1739E+04
12.251100	.0000E+00	.0000E+00	.0000E+00	.1739E+04

Total runoff volume going through collector g4_2 = .378935202 m^3
Total sediment going through collector g4_2 = 1738.625602587 g

Collector= g8_2
Number of field samples= 16

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
11.526100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11.534400	.5739E-07	.4418E+01	.2535E-03	.7576E-02
11.542800	.7293E-05	.8889E+01	.6482E-01	.1968E+01
11.551100	.3163E-04	.1331E+02	.4208E+00	.1454E+02
11.559400	.5170E-04	.1772E+02	.9163E+00	.4192E+02
11.567800	.1299E-03	.2057E+02	.2673E+01	.1227E+03
11.576100	.1768E-03	.1310E+02	.2317E+01	.1920E+03
11.584400	.1706E-03	.6496E+01	.1108E+01	.2251E+03
11.592800	.1646E-03	.5708E+01	.9395E+00	.2535E+03
11.601100	.2659E-03	.5198E+01	.1382E+01	.2948E+03
11.609400	.7779E-03	.6447E+01	.5015E+01	.4446E+03
11.617800	.1764E-02	.8273E+01	.1459E+02	.8859E+03
11.626100	.1772E-02	.1365E+02	.2419E+02	.1609E+04
11.634400	.1781E-02	.1946E+02	.3465E+02	.2644E+04
11.642800	.1772E-02	.2834E+02	.5024E+02	.4163E+04
11.651100	.1781E-02	.3610E+02	.6429E+02	.6084E+04
11.659500	.1781E-02	.3719E+02	.6623E+02	.8087E+04
11.667800	.1781E-02	.3827E+02	.6814E+02	.1012E+05
11.676100	.1772E-02	.3934E+02	.6973E+02	.1221E+05
11.684400	.1781E-02	.4042E+02	.7197E+02	.1436E+05
11.692800	.1781E-02	.4150E+02	.7391E+02	.1659E+05
11.701100	.1781E-02	.4258E+02	.7583E+02	.1886E+05
11.709500	.1772E-02	.4367E+02	.7740E+02	.2120E+05
11.717800	.1781E-02	.4474E+02	.7968E+02	.2358E+05
11.726100	.1781E-02	.4581E+02	.8159E+02	.2602E+05
11.734400	.1746E-02	.4689E+02	.8189E+02	.2846E+05
11.742800	.1704E-02	.4798E+02	.8176E+02	.3094E+05
11.751100	.1679E-02	.4905E+02	.8233E+02	.3340E+05
11.759400	.1645E-02	.5013E+02	.8246E+02	.3586E+05
11.767800	.1612E-02	.5121E+02	.8255E+02	.3836E+05
11.776100	.1571E-02	.5229E+02	.8214E+02	.4081E+05
11.784400	.1538E-02	.5336E+02	.8210E+02	.4326E+05
11.792800	.1506E-02	.5445E+02	.8201E+02	.4574E+05
11.801100	.1474E-02	.5553E+02	.8185E+02	.4819E+05
11.809500	.1435E-02	.5661E+02	.8123E+02	.5065E+05
11.817800	.1419E-02	.5769E+02	.8184E+02	.5309E+05
11.826100	.1380E-02	.5876E+02	.8109E+02	.5551E+05
11.834500	.1349E-02	.5985E+02	.8074E+02	.5796E+05
11.842800	.1210E-02	.6092E+02	.7372E+02	.6016E+05
11.851100	.1017E-02	.6200E+02	.6307E+02	.6204E+05
11.859500	.9707E-03	.6309E+02	.6124E+02	.6389E+05
11.867800	.7666E-03	.6317E+02	.4842E+02	.6534E+05
11.876100	.6420E-03	.5695E+02	.3656E+02	.6643E+05
11.884400	.5882E-03	.5088E+02	.2993E+02	.6733E+05
11.892800	.5464E-03	.4575E+02	.2500E+02	.6808E+05
11.909500	.3351E-03	.5403E+00	.1810E+00	.3887E+04
11.917800	.2782E-03	.6563E+00	.1826E+00	.3893E+04
11.926100	.2407E-03	.7802E+00	.1878E+00	.3898E+04
11.934400	.2233E-03	.9429E+00	.2105E+00	.3905E+04
11.942800	.1603E-03	.1373E+01	.2201E+00	.3911E+04
11.951100	.1518E-03	.1798E+01	.2730E+00	.3920E+04
11.959400	.1348E-03	.2223E+01	.2997E+00	.3929E+04
11.967800	.1214E-03	.2585E+01	.3138E+00	.3938E+04
11.976100	.1086E-03	.2509E+01	.2726E+00	.3946E+04
11.984400	.1066E-03	.2434E+01	.2595E+00	.3954E+04
11.992800	.9708E-04	.2357E+01	.2288E+00	.3961E+04
12.001100	.8554E-04	.2281E+01	.1951E+00	.3967E+04
12.009400	.8376E-04	.2206E+01	.1847E+00	.3972E+04
12.017800	.8200E-04	.2129E+01	.1746E+00	.3977E+04
12.026100	.3534E-04	.2053E+01	.7256E-01	.3980E+04
12.034400	.2255E-04	.1977E+01	.4458E-01	.3981E+04
12.042800	.2156E-04	.1901E+01	.4099E-01	.3982E+04
12.051100	.2060E-04	.1825E+01	.3760E-01	.3983E+04
12.059400	.1725E-04	.1749E+01	.3018E-01	.3984E+04
12.067800	.1638E-04	.1673E+01	.2740E-01	.3985E+04
12.076100	.1553E-04	.1597E+01	.2480E-01	.3986E+04
12.084400	.1259E-04	.1521E+01	.1915E-01	.3986E+04
12.092800	.1183E-04	.1444E+01	.1709E-01	.3987E+04
12.101100	.1110E-04	.1369E+01	.1519E-01	.3987E+04
12.109400	.1038E-04	.1293E+01	.1342E-01	.3988E+04
12.117800	.9685E-05	.1216E+01	.1178E-01	.3988E+04
12.126100	.9012E-05	.1141E+01	.1028E-01	.3988E+04
12.134400	.5273E-05	.1065E+01	.5615E-02	.3989E+04
12.142800	.4761E-05	.9882E+00	.4705E-02	.3989E+04
12.151100	.4272E-05	.9125E+00	.3898E-02	.3989E+04
12.159400	.3806E-05	.8368E+00	.3185E-02	.3989E+04
12.167800	.3364E-05	.7601E+00	.2557E-02	.3989E+04
12.176100	.2947E-05	.6844E+00	.2017E-02	.3989E+04
12.184400	.2553E-05	.6086E+00	.1554E-02	.3989E+04
12.192800	.2185E-05	.5320E+00	.1163E-02	.3989E+04
12.201100	.7441E-06	.4562E+00	.3395E-03	.3989E+04
12.209400	.5374E-06	.3805E+00	.2045E-03	.3989E+04
12.217800	.3609E-06	.3039E+00	.1097E-03	.3989E+04
12.226100	.2159E-06	.2281E+00	.4926E-04	.3989E+04
12.234400	.1047E-06	.1524E+00	.1596E-04	.3989E+04
12.242800	.3039E-07	.7574E-01	.2302E-05	.3989E+04
12.251100	.0000E+00	.0000E+00	.0000E+00	.3989E+04

Total runoff volume going through collector g8_2 = 1.848386562 m^3
Total sediment going through collector g8_2 = 3989.154940945 g

Collector= field_2
Number of field samples= 11

11.901100	.4867E-03	.4097E+02	.1994E+02	.6868E+05
11.909500	.4622E-03	.3802E+02	.1757E+02	.6921E+05
11.917800	.4430E-03	.3552E+02	.1574E+02	.6968E+05
11.926100	.4243E-03	.3563E+02	.1512E+02	.7013E+05
11.934400	.4013E-03	.3561E+02	.1429E+02	.7056E+05
11.942800	.3789E-03	.3467E+02	.1314E+02	.7096E+05
11.951100	.3656E-03	.3373E+02	.1233E+02	.7133E+05
11.959400	.3482E-03	.3280E+02	.1142E+02	.7167E+05
11.967800	.3272E-03	.3186E+02	.1042E+02	.7198E+05
11.976100	.3067E-03	.3092E+02	.9484E+01	.7227E+05
11.984400	.2906E-03	.2999E+02	.8716E+01	.7253E+05
11.992800	.2749E-03	.2904E+02	.7986E+01	.7277E+05
12.001100	.2596E-03	.2811E+02	.7298E+01	.7299E+05
12.009400	.2447E-03	.2718E+02	.6650E+01	.7318E+05
12.017800	.2301E-03	.2623E+02	.6037E+01	.7337E+05
12.026100	.2160E-03	.2530E+02	.5464E+01	.7353E+05
12.034400	.2021E-03	.2437E+02	.4925E+01	.7368E+05
12.042800	.1887E-03	.2342E+02	.4420E+01	.7381E+05
12.051100	.1757E-03	.2249E+02	.3952E+01	.7393E+05
12.059400	.1631E-03	.2156E+02	.3516E+01	.7403E+05
12.067800	.1509E-03	.2061E+02	.3111E+01	.7413E+05
12.076100	.1391E-03	.1968E+02	.2738E+01	.7421E+05
12.084400	.1305E-03	.1874E+02	.2446E+01	.7428E+05
12.092800	.1194E-03	.1780E+02	.2126E+01	.7435E+05
12.101100	.1088E-03	.1687E+02	.1835E+01	.7440E+05
12.109400	.9858E-04	.1593E+02	.1571E+01	.7445E+05
12.117800	.8881E-04	.1499E+02	.1331E+01	.7449E+05
12.126100	.7947E-04	.1406E+02	.1117E+01	.7452E+05
12.134400	.6849E-04	.1312E+02	.8987E+00	.7455E+05
12.142800	.6016E-04	.1218E+02	.7327E+00	.7457E+05
12.151100	.5231E-04	.1124E+02	.5882E+00	.7459E+05
12.159400	.4493E-04	.1031E+02	.4632E+00	.7460E+05
12.167800	.3803E-04	.9367E+01	.3562E+00	.7461E+05
12.176100	.3163E-04	.8433E+01	.2668E+00	.7462E+05
12.184400	.2575E-04	.7500E+01	.1931E+00	.7463E+05
12.192800	.2039E-04	.6556E+01	.1336E+00	.7463E+05
12.201100	.1448E-04	.5622E+01	.8142E-01	.7463E+05
12.209400	.1037E-04	.4689E+01	.4865E-01	.7464E+05
12.217800	.6867E-05	.3744E+01	.2571E-01	.7464E+05
12.226100	.3998E-05	.2811E+01	.1124E-01	.7464E+05
12.234400	.1818E-05	.1878E+01	.3415E-02	.7464E+05
12.242800	.4171E-06	.9333E+00	.3893E-03	.7464E+05
12.251100	.0000E+00	.0000E+00	.0000E+00	.7464E+05

Total runoff volume going through collector field_2 = 1.798463716 m^3
Total sediment going through collector field_2 = 74636.949403573 g

Collector= rip_1

Number of field samples= 16

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
11.526100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11.534400	.0000E+00	.1069E+00	.0000E+00	.0000E+00
11.542800	.7050E-07	.2150E+00	.1516E-04	.4583E-03
11.551100	.1851E-07	.3219E+00	.5957E-05	.6363E-03
11.559400	.7050E-07	.4287E+00	.3022E-04	.1539E-02
11.567800	.7050E-07	.5369E+00	.3785E-04	.2684E-02
11.576100	.7050E-07	.6437E+00	.4538E-04	.4040E-02
11.584400	.7050E-07	.7506E+00	.5291E-04	.5621E-02
11.592800	.6854E-07	.8587E+00	.5886E-04	.7401E-02
11.601100	.6854E-07	.9656E+00	.6618E-04	.9378E-02
11.609400	.5579E-05	.1072E+01	.5983E-02	.1881E+00
11.617800	.4750E-04	.1181E+01	.5608E-01	.1884E+01
11.626100	.1083E-03	.1287E+01	.1394E+00	.6049E+01
11.634400	.1200E-02	.1394E+01	.1674E+01	.5606E+02
11.642800	.1818E-02	.1502E+01	.2731E+01	.1387E+03
11.651100	.3154E-02	.2389E+01	.7536E+01	.3638E+03
11.659500	.3397E-02	.8452E+01	.2871E+02	.1232E+04
11.667800	.3661E-02	.1364E+02	.4995E+02	.2724E+04
11.676100	.3699E-02	.1377E+02	.5094E+02	.4247E+04
11.684400	.3684E-02	.1366E+02	.5031E+02	.5750E+04
11.692800	.3601E-02	.1186E+02	.4269E+02	.7041E+04
11.701100	.3441E-02	.1020E+02	.3509E+02	.8089E+04
11.709500	.3336E-02	.9342E+01	.3116E+02	.9032E+04
11.717800	.3095E-02	.8516E+01	.2635E+02	.9819E+04
11.726100	.3056E-02	.7811E+01	.2387E+02	.1053E+05
11.734400	.2982E-02	.7173E+01	.2139E+02	.1117E+05
11.742800	.2968E-02	.6979E+01	.2071E+02	.1180E+05
11.751100	.2942E-02	.6873E+01	.2022E+02	.1240E+05
11.759400	.2869E-02	.7325E+01	.2102E+02	.1303E+05
11.767800	.2856E-02	.7783E+01	.2223E+02	.1370E+05
11.776100	.2890E-02	.8236E+01	.2380E+02	.1441E+05
11.784400	.2889E-02	.8688E+01	.2510E+02	.1516E+05
11.792800	.2804E-02	.9146E+01	.2565E+02	.1594E+05
11.801100	.2393E-02	.9598E+01	.2297E+02	.1663E+05
11.809500	.2178E-02	.1006E+02	.2190E+02	.1729E+05
11.817800	.1903E-02	.1051E+02	.2000E+02	.1789E+05
11.826100	.1629E-02	.1096E+02	.1785E+02	.1842E+05
11.834500	.1477E-02	.1098E+02	.1622E+02	.1891E+05
11.842800	.1220E-02	.8307E+01	.1013E+02	.1921E+05
11.851100	.1008E-02	.5872E+01	.5920E+01	.1939E+05
11.859500	.8821E-03	.4980E+01	.4392E+01	.1952E+05
11.867800	.7455E-03	.4114E+01	.3067E+01	.1961E+05
11.876100	.6373E-03	.3353E+01	.2137E+01	.1968E+05
11.884400	.5165E-03	.2642E+01	.1365E+01	.1972E+05

11.892800	.3630E-03	.2266E+01	.8226E+00	.1974E+05
11.901100	.2764E-03	.1927E+01	.5326E+00	.1976E+05
11.909500	.2080E-03	.1796E+01	.3736E+00	.1977E+05
11.917800	.1695E-03	.1668E+01	.2827E+00	.1978E+05
11.926100	.1459E-03	.1539E+01	.2245E+00	.1979E+05
11.934400	.9947E-04	.1455E+01	.1447E+00	.1979E+05
11.942800	.7123E-04	.1677E+01	.1195E+00	.1979E+05
11.951100	.4759E-04	.1855E+01	.8828E-01	.1980E+05
11.959400	.3816E-04	.1760E+01	.6714E-01	.1980E+05
11.967800	.2974E-04	.1663E+01	.4948E-01	.1980E+05
11.976100	.1707E-04	.1573E+01	.2684E-01	.1980E+05
11.984400	.1696E-04	.1488E+01	.2523E-01	.1980E+05
11.992800	.7750E-05	.1441E+01	.1117E-01	.1980E+05
12.001100	.5227E-05	.1395E+01	.7290E-02	.1980E+05
12.009400	.5165E-05	.1348E+01	.6964E-02	.1980E+05
12.017800	.5103E-05	.1302E+01	.6642E-02	.1980E+05
12.026100	.1310E-05	.1255E+01	.1644E-02	.1980E+05
12.034400	.5773E-06	.1209E+01	.6980E-03	.1980E+05
12.042800	.5562E-06	.1162E+01	.6463E-03	.1980E+05
12.051100	.5354E-06	.1116E+01	.5974E-03	.1980E+05
12.059400	.3507E-06	.1069E+01	.3751E-03	.1980E+05
12.067800	.3341E-06	.1023E+01	.3417E-03	.1980E+05
12.076100	.3180E-06	.9763E+00	.3104E-03	.1980E+05
12.084400	.8753E-07	.9300E+00	.8140E-04	.1980E+05
12.092800	.7921E-07	.8831E+00	.6995E-04	.1980E+05
12.101100	.7129E-07	.8368E+00	.5965E-04	.1980E+05
12.109400	.6378E-07	.7905E+00	.5041E-04	.1980E+05
12.117800	.5667E-07	.7436E+00	.4214E-04	.1980E+05
12.126100	.4997E-07	.6973E+00	.3485E-04	.1980E+05
12.134400	.1138E-06	.6510E+00	.7411E-04	.1980E+05
12.142800	.1044E-06	.6042E+00	.6305E-04	.1980E+05
12.151100	.9526E-07	.5579E+00	.5314E-04	.1980E+05
12.159400	.8658E-07	.5116E+00	.4429E-04	.1980E+05
12.167800	.7830E-07	.4647E+00	.3639E-04	.1980E+05
12.176100	.7043E-07	.4184E+00	.2947E-04	.1980E+05
12.184400	.6296E-07	.3721E+00	.2343E-04	.1980E+05
12.192800	.5590E-07	.3252E+00	.1818E-04	.1980E+05
12.201100	.4925E-07	.2789E+00	.1374E-04	.1980E+05
12.209400	.4301E-07	.2326E+00	.1001E-04	.1980E+05
12.217800	.3718E-07	.1858E+00	.6907E-05	.1980E+05
12.226100	.3177E-07	.1395E+00	.4431E-05	.1980E+05
12.234400	.2677E-07	.9316E-01	.2494E-05	.1980E+05
12.242800	.2219E-07	.4630E-01	.1027E-05	.1980E+05
12.251100	.0000E+00	.0000E+00	.0000E+00	.1980E+05

Total runoff volume going through collector rip_1 = 2.298301559 m^3

Total sediment going through collector rip_1 = 19801.79716965 g

Collector= rip_2

Number of field samples= 11

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
11.526100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
11.534400	.2725E-07	.1006E+01	.2740E-04	.8187E-03
11.542800	.2135E-06	.2023E+01	.4321E-03	.1388E-01
11.551100	.1008E-06	.3029E+01	.3053E-03	.2301E-01
11.559400	.1008E-06	.4034E+01	.4066E-03	.3515E-01
11.567800	.1008E-06	.5052E+01	.5092E-03	.5055E-01
11.576100	.2135E-06	.6058E+01	.1294E-02	.8921E-01
11.584400	.1008E-06	.7063E+01	.7119E-03	.1105E+00
11.592800	.9783E-07	.8081E+01	.7906E-03	.1344E+00
11.601100	.9783E-07	.9087E+01	.8890E-03	.1609E+00
11.609400	.2094E-06	.1009E+02	.2113E-02	.2241E+00
11.617800	.9783E-07	.1111E+02	.1087E-02	.2569E+00
11.626100	.9783E-07	.1212E+02	.1185E-02	.2924E+00
11.634400	.1846E-04	.1312E+02	.2422E+00	.7528E+01
11.642800	.1198E-03	.1414E+02	.1694E+01	.5877E+02
11.651100	.1174E-03	.1514E+02	.1777E+01	.1119E+03
11.659500	.3169E-02	.1616E+02	.5122E+02	.1661E+04
11.667800	.3305E-02	.1631E+02	.5390E+02	.3271E+04
11.676100	.3206E-02	.1102E+02	.3533E+02	.4327E+04
11.684400	.3052E-02	.6385E+01	.1949E+02	.4909E+04
11.692800	.2772E-02	.6162E+01	.1708E+02	.5426E+04
11.701100	.2670E-02	.5941E+01	.1587E+02	.5900E+04
11.709500	.2458E-02	.5718E+01	.1405E+02	.6325E+04
11.717800	.2313E-02	.5461E+01	.1263E+02	.6702E+04
11.726100	.2200E-02	.4972E+01	.1094E+02	.7029E+04
11.734400	.2118E-02	.4515E+01	.9563E+01	.7315E+04
11.742800	.2103E-02	.4278E+01	.8994E+01	.7587E+04
11.751100	.2069E-02	.4115E+01	.8513E+01	.7841E+04
11.759400	.1952E-02	.4428E+01	.8645E+01	.8099E+04
11.767800	.1974E-02	.4660E+01	.9198E+01	.8378E+04
11.776100	.1950E-02	.4360E+01	.8501E+01	.8632E+04
11.784400	.1908E-02	.4073E+01	.7772E+01	.8864E+04
11.792800	.1858E-02	.3877E+01	.7203E+01	.9082E+04
11.801100	.1730E-02	.3684E+01	.6373E+01	.9272E+04
11.809500	.1477E-02	.3488E+01	.5151E+01	.9428E+04
11.817800	.1242E-02	.3294E+01	.4092E+01	.9550E+04
11.826100	.9474E-03	.3100E+01	.2937E+01	.9638E+04
11.834500	.8548E-03	.2905E+01	.2484E+01	.9713E+04
11.842800	.7962E-03	.2718E+01	.2164E+01	.9778E+04
11.851100	.6996E-03	.2511E+01	.1757E+01	.9830E+04
11.859500	.6463E-03	.2171E+01	.1403E+01	.9873E+04
11.867800	.6160E-03	.2719E+01	.1675E+01	.9923E+04
11.876100	.5916E-03	.8862E+01	.5243E+01	.1008E+05

11.884400	.5526E-03	.1418E+02	.7834E+01	.1031E+05
11.892800	.5293E-03	.1385E+02	.7331E+01	.1054E+05
11.901100	.5067E-03	.1353E+02	.6855E+01	.1074E+05
11.909500	.4843E-03	.1320E+02	.6396E+01	.1093E+05
11.917800	.4579E-03	.1288E+02	.5900E+01	.1111E+05
11.926100	.4368E-03	.1256E+02	.5487E+01	.1127E+05
11.934400	.4161E-03	.1224E+02	.5093E+01	.1143E+05
11.942800	.4001E-03	.1192E+02	.4768E+01	.1157E+05
11.951100	.3759E-03	.1160E+02	.4360E+01	.1170E+05
11.959400	.3566E-03	.1128E+02	.4021E+01	.1182E+05
11.967800	.3377E-03	.1095E+02	.3698E+01	.1193E+05
11.976100	.3232E-03	.1063E+02	.3436E+01	.1203E+05
11.984400	.3052E-03	.1031E+02	.3146E+01	.1213E+05
11.992800	.2876E-03	.9985E+01	.2872E+01	.1222E+05
12.001100	.2706E-03	.9664E+01	.2615E+01	.1229E+05
12.009400	.2540E-03	.9343E+01	.2373E+01	.1236E+05
12.017800	.2379E-03	.9018E+01	.2146E+01	.1243E+05
12.026100	.2223E-03	.8698E+01	.1934E+01	.1249E+05
12.034400	.2073E-03	.8377E+01	.1736E+01	.1254E+05
12.042800	.1927E-03	.8052E+01	.1551E+01	.1259E+05
12.051100	.1785E-03	.7731E+01	.1380E+01	.1263E+05
12.059400	.1649E-03	.7410E+01	.1222E+01	.1266E+05
12.067800	.1518E-03	.7086E+01	.1076E+01	.1270E+05
12.076100	.1392E-03	.6765E+01	.9416E+00	.1272E+05
12.084400	.1245E-03	.6444E+01	.8025E+00	.1275E+05
12.092800	.1131E-03	.6119E+01	.6918E+00	.1277E+05
12.101100	.1021E-03	.5798E+01	.5920E+00	.1279E+05
12.109400	.9165E-04	.5478E+01	.5020E+00	.1280E+05
12.117800	.8173E-04	.5153E+01	.4212E+00	.1281E+05
12.126100	.7234E-04	.4832E+01	.3496E+00	.1283E+05
12.134400	.6535E-04	.4511E+01	.2948E+00	.1283E+05
12.142800	.5692E-04	.4186E+01	.2383E+00	.1284E+05
12.151100	.4902E-04	.3866E+01	.1895E+00	.1285E+05
12.159400	.4168E-04	.3545E+01	.1478E+00	.1285E+05
12.167800	.3490E-04	.3220E+01	.1124E+00	.1285E+05
12.176100	.2867E-04	.2899E+01	.8312E-01	.1286E+05
12.184400	.2302E-04	.2578E+01	.5935E-01	.1286E+05
12.192800	.1794E-04	.2254E+01	.4044E-01	.1286E+05
12.201100	.1438E-04	.1933E+01	.2779E-01	.1286E+05
12.209400	.1037E-04	.1612E+01	.1671E-01	.1286E+05
12.217800	.6970E-05	.1287E+01	.8973E-02	.1286E+05
12.226100	.4207E-05	.9664E+00	.4066E-02	.1286E+05
12.234400	.2101E-05	.6456E+00	.1356E-02	.1286E+05
12.242800	.6859E-06	.3208E+00	.2201E-03	.1286E+05
12.251100	.0000E+00	.0000E+00	.0000E+00	.1286E+05

Total runoff volume going through collector rip_2 = 1.790130113 m^3
Total sediment going through collector rip_2 = 12862.08463961 g

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 11.416388889 h
Event on u178a-92

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.2009E+01	425.	845.	.3234E-02	3005.
field_2	.1798E+01	425.	1115.	.1781E-02	3005.
g4_1	.1612E+01	425.	935.	.2503E-02	3005.
g4_2	.3789E+00	2915.	1355.	.6489E-03	3005.
g8_1	.1471E+01	425.	965.	.2523E-02	3005.
g8_2	.1848E+01	425.	905.	.3245E-02	3005.
rip_1	.2298E+01	455.	935.	.3699E-02	3005.
rip_2	.1790E+01	425.	905.	.3305E-02	3005.
field_avg	.1903E+01	425.	845.	.2507E-02	3005.
g4_avg	.9952E+00	425.	935.	.1504E-02	3005.
g8_avg	.1660E+01	425.	935.	.2856E-02	3005.

RAINFALL DATA FOR EVENT u178a-92

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 11.416388889 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.5080E-05
.2999E+03	.3133E-04
.6001E+03	.3810E-04
.9000E+03	.2710E-04
.1200E+04	.7620E-05
.1501E+04	.0000E+00
.1800E+04	.8467E-06
.2101E+04	.0000E+00
.2703E+04	.0000E+00

Total rainfall volume= 3.303 cm

Table 8. Summary of field data for event on (11/06/92)

TABLE OF SEDIMENT AND RUNOFF DATA(11/06/92)

Files used= u309-92.q u309-92.sedin
Collector= g4_1
Number of field samples= 7

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
18.226100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.234400	.7109E-11	.4773E+00	.3394E-08	.1014E-06
18.242800	.7090E-07	.9604E+00	.6810E-04	.2059E-02
18.251100	.2305E-06	.1438E+01	.3313E-03	.1196E-01
18.259400	.7090E-07	.1915E+01	.1358E-03	.1602E-01
18.267800	.7090E-07	.2398E+01	.1700E-03	.2116E-01
18.276100	.2305E-06	.2876E+01	.6627E-03	.4096E-01
18.284400	.2457E-04	.3353E+01	.8239E-01	.2503E+01
18.292800	.1112E-03	.3836E+01	.4264E+00	.1540E+02
18.301100	.3466E-03	.4313E+01	.1495E+01	.6007E+02
18.309500	.5385E-03	.4796E+01	.2583E+01	.1382E+03
18.317800	.8153E-03	.5274E+01	.4300E+01	.2666E+03
18.326100	.1066E-02	.5751E+01	.6131E+01	.4498E+03
18.334500	.1401E-02	.5926E+01	.8302E+01	.7009E+03
18.342800	.1655E-02	.4213E+01	.6974E+01	.9093E+03
18.351100	.1813E-02	.2598E+01	.4710E+01	.1050E+04
18.359400	.1837E-02	.1626E+01	.2988E+01	.1139E+04
18.367800	.1084E-02	.7897E+00	.8564E+00	.1165E+04
18.376100	.1013E-02	.8964E+00	.9081E+00	.1192E+04
18.384400	.9747E-03	.1001E+01	.9757E+00	.1221E+04
18.392800	.9492E-03	.1093E+01	.1038E+01	.1253E+04
18.401100	.9178E-03	.1107E+01	.1016E+01	.1283E+04
18.409400	.8750E-03	.6154E+00	.5385E+00	.1299E+04
18.417800	.8505E-03	.1849E+00	.1573E+00	.1304E+04
18.426100	.8264E-03	.1866E+00	.1542E+00	.1309E+04
18.434400	.8025E-03	.1882E+00	.1511E+00	.1313E+04
18.442800	.7790E-03	.1899E+00	.1479E+00	.1318E+04
18.451100	.7557E-03	.1916E+00	.1448E+00	.1322E+04
18.459400	.7327E-03	.1932E+00	.1416E+00	.1326E+04
18.467800	.6937E-03	.1949E+00	.1352E+00	.1330E+04
18.476100	.6715E-03	.1966E+00	.1320E+00	.1334E+04
18.484400	.6497E-03	.1982E+00	.1288E+00	.1338E+04
18.492800	.6281E-03	.1999E+00	.1255E+00	.1342E+04
18.501100	.6068E-03	.2015E+00	.1223E+00	.1346E+04
18.509400	.5858E-03	.2032E+00	.1190E+00	.1349E+04
18.517800	.5652E-03	.2049E+00	.1158E+00	.1353E+04
18.526100	.5064E-03	.2065E+00	.1046E+00	.1356E+04
18.534400	.4870E-03	.2082E+00	.1014E+00	.1359E+04
18.542800	.4496E-03	.2099E+00	.9437E-01	.1362E+04
18.551100	.4135E-03	.2115E+00	.8748E-01	.1364E+04
18.559400	.3787E-03	.2132E+00	.8074E-01	.1367E+04
18.567800	.3615E-03	.2149E+00	.7767E-01	.1369E+04
18.576100	.3446E-03	.2165E+00	.7462E-01	.1371E+04
18.584400	.3281E-03	.2171E+00	.7122E-01	.1373E+04
18.592800	.3119E-03	.2103E+00	.6557E-01	.1375E+04
18.601100	.2960E-03	.2035E+00	.6024E-01	.1377E+04
18.609400	.2805E-03	.1967E+00	.5518E-01	.1379E+04
18.617800	.2653E-03	.1899E+00	.5038E-01	.1380E+04
18.626100	.2505E-03	.1832E+00	.4588E-01	.1382E+04
18.634400	.2257E-03	.1764E+00	.3982E-01	.1383E+04
18.642800	.2119E-03	.1696E+00	.3593E-01	.1384E+04
18.651100	.1984E-03	.1628E+00	.3230E-01	.1385E+04
18.659400	.1760E-03	.1560E+00	.2746E-01	.1386E+04
18.667800	.1635E-03	.1492E+00	.2440E-01	.1386E+04
18.676100	.1514E-03	.1425E+00	.2157E-01	.1387E+04
18.684400	.1397E-03	.1357E+00	.1896E-01	.1388E+04
18.692800	.1284E-03	.1289E+00	.1655E-01	.1388E+04
18.701100	.1175E-03	.1221E+00	.1435E-01	.1389E+04
18.709400	.1021E-03	.1153E+00	.1178E-01	.1389E+04
18.717800	.9220E-04	.1085E+00	.1000E-01	.1389E+04
18.726100	.8272E-04	.1018E+00	.8417E-02	.1390E+04
18.734400	.7156E-04	.9500E-01	.6798E-02	.1390E+04
18.742800	.6306E-04	.8816E-01	.5559E-02	.1390E+04
18.751100	.5501E-04	.8140E-01	.4478E-02	.1390E+04
18.759400	.4742E-04	.7465E-01	.3540E-02	.1390E+04
18.767800	.4030E-04	.6781E-01	.2733E-02	.1390E+04
18.776100	.3367E-04	.6105E-01	.2056E-02	.1390E+04
18.784400	.2754E-04	.5430E-01	.1495E-02	.1390E+04
18.792800	.2193E-04	.4746E-01	.1041E-02	.1390E+04
18.801100	.1686E-04	.4070E-01	.6862E-03	.1390E+04
18.809400	.1235E-04	.3394E-01	.4193E-03	.1390E+04
18.817800	.8441E-05	.2711E-01	.2288E-03	.1390E+04
18.826100	.5167E-05	.2035E-01	.1052E-03	.1390E+04
18.834400	.2587E-05	.1359E-01	.3517E-04	.1390E+04
18.842800	.7931E-06	.6756E-02	.5358E-05	.1390E+04
18.851100	.0000E+00	.0000E+00	.0000E+00	.1390E+04

Total runoff volume going through collector g4_1 = .942962608 m^3
Total sediment going through collector g4_1 = 1390.387560437 g

Collector= g8_1
Number of field samples= 4

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
18.226100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.234400	.5686E-07	.9700E-01	.5516E-05	.1648E-03
18.242800	.5686E-07	.1952E+00	.1110E-04	.5004E-03
18.251100	.3877E-06	.2922E+00	.1133E-03	.3885E-02
18.259400	.1908E-06	.3892E+00	.7426E-04	.6104E-02
18.267800	.3877E-06	.4873E+00	.1889E-03	.1182E-01
18.276100	.9475E-06	.5843E+00	.5536E-03	.2836E-01
18.284400	.2135E-05	.6813E+00	.1455E-02	.7182E-01
18.292800	.1688E-05	.7795E+00	.1315E-02	.1116E+00
18.301100	.2135E-05	.8765E+00	.1871E-02	.1675E+00
18.309500	.2626E-05	.9747E+00	.2560E-02	.2449E+00
18.317800	.5894E-04	.1072E+01	.6317E-01	.2132E+01
18.326100	.1952E-03	.1169E+01	.2281E+00	.8948E+01
18.334500	.3351E-03	.1267E+01	.4245E+00	.2179E+02
18.342800	.4306E-03	.1364E+01	.5872E+00	.3933E+02
18.351100	.5063E-03	.1461E+01	.7396E+00	.6143E+02
18.359400	.4478E-03	.1558E+01	.6976E+00	.8228E+02
18.367800	.3371E-03	.1581E+01	.5329E+00	.9839E+02
18.376100	.3279E-03	.1125E+01	.3691E+00	.1094E+03
18.384400	.3270E-03	.7242E+00	.2368E+00	.1165E+03
18.392800	.3179E-03	.6886E+00	.2189E+00	.1231E+03
18.401100	.3169E-03	.6274E+00	.1988E+00	.1291E+03
18.409400	.3159E-03	.3961E+00	.1251E+00	.1328E+03
18.417800	.3070E-03	.1930E+00	.5923E-01	.1346E+03
18.426100	.2981E-03	.1893E+00	.5643E-01	.1363E+03
18.434400	.2894E-03	.1856E+00	.5370E-01	.1379E+03
18.442800	.2808E-03	.1818E+00	.5106E-01	.1394E+03
18.451100	.2723E-03	.1781E+00	.4850E-01	.1409E+03
18.459400	.2639E-03	.1744E+00	.4603E-01	.1422E+03
18.467800	.2484E-03	.1707E+00	.4239E-01	.1435E+03
18.476100	.2403E-03	.1670E+00	.4013E-01	.1447E+03
18.484400	.2324E-03	.1633E+00	.3794E-01	.1459E+03
18.492800	.2245E-03	.1596E+00	.3582E-01	.1469E+03
18.501100	.2168E-03	.1559E+00	.3379E-01	.1480E+03
18.509400	.2092E-03	.1522E+00	.3183E-01	.1489E+03
18.517800	.2017E-03	.1484E+00	.2994E-01	.1498E+03
18.526100	.1816E-03	.1447E+00	.2628E-01	.1506E+03
18.534400	.1746E-03	.1410E+00	.2462E-01	.1513E+03
18.542800	.1616E-03	.1373E+00	.2218E-01	.1520E+03
18.551100	.1462E-03	.1336E+00	.1953E-01	.1526E+03
18.559400	.1369E-03	.1299E+00	.1779E-01	.1531E+03
18.567800	.1307E-03	.1262E+00	.1649E-01	.1536E+03
18.576100	.1246E-03	.1225E+00	.1526E-01	.1541E+03
18.584400	.1186E-03	.1188E+00	.1409E-01	.1545E+03
18.592800	.1128E-03	.1150E+00	.1297E-01	.1549E+03
18.601100	.1071E-03	.1113E+00	.1192E-01	.1552E+03
18.609400	.1015E-03	.1076E+00	.1092E-01	.1556E+03
18.617800	.9599E-04	.1039E+00	.9973E-02	.1559E+03
18.626100	.9066E-04	.1002E+00	.9084E-02	.1561E+03
18.634400	.8318E-04	.9650E-01	.8027E-02	.1564E+03
18.642800	.7817E-04	.9276E-01	.7251E-02	.1566E+03
18.651100	.7329E-04	.8907E-01	.6528E-02	.1568E+03
18.659400	.6045E-04	.8537E-01	.5161E-02	.1569E+03
18.667800	.5609E-04	.8163E-01	.4579E-02	.1571E+03
18.676100	.5187E-04	.7793E-01	.4042E-02	.1572E+03
18.684400	.4779E-04	.7424E-01	.3548E-02	.1573E+03
18.692800	.4386E-04	.7050E-01	.3092E-02	.1574E+03
18.701100	.4007E-04	.6680E-01	.2677E-02	.1575E+03
18.709400	.3486E-04	.6310E-01	.2200E-02	.1576E+03
18.717800	.3144E-04	.5936E-01	.1866E-02	.1576E+03
18.726100	.2817E-04	.5567E-01	.1568E-02	.1577E+03
18.734400	.2372E-04	.5197E-01	.1233E-02	.1577E+03
18.742800	.2084E-04	.4823E-01	.1005E-02	.1577E+03
18.751100	.1811E-04	.4453E-01	.8066E-03	.1577E+03
18.759400	.1555E-04	.4084E-01	.6351E-03	.1578E+03
18.767800	.1316E-04	.3710E-01	.4883E-03	.1578E+03
18.776100	.1095E-04	.3340E-01	.3656E-03	.1578E+03
18.784400	.8907E-05	.2970E-01	.2646E-03	.1578E+03
18.792800	.7050E-05	.2596E-01	.1830E-03	.1578E+03
18.801100	.5383E-05	.2227E-01	.1199E-03	.1578E+03
18.809400	.3912E-05	.1857E-01	.7265E-04	.1578E+03
18.817800	.2647E-05	.1483E-01	.3925E-04	.1578E+03
18.826100	.1600E-05	.1113E-01	.1781E-04	.1578E+03
18.834400	.7868E-06	.7437E-02	.5851E-05	.1578E+03
18.842800	.2339E-06	.3696E-02	.8644E-06	.1578E+03
18.851100	.0000E+00	.0000E+00	.0000E+00	.1578E+03

Total runoff volume going through collector g8_1 = .289630476 m^3
Total sediment going through collector g8_1 = 157.813065853 g

Collector= field_1
Number of field samples= 5

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
18.226100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.234400	.1319E-05	.6833E+00	.9012E-03	.2693E-01
18.242800	.4926E-05	.1375E+01	.6773E-02	.2317E+00
18.251100	.1122E-04	.2058E+01	.2310E-01	.9218E+00
18.259400	.1815E-04	.2742E+01	.4976E-01	.2409E+01

18.267800	.3915E-04	.3433E+01	.1344E+00	.6473E+01
18.276100	.7485E-04	.4116E+01	.3081E+00	.1568E+02
18.284400	.2455E-03	.4800E+01	.1178E+01	.5088E+02
18.292800	.4931E-03	.5491E+01	.2708E+01	.1328E+03
18.301100	.9312E-03	.6266E+01	.5835E+01	.3071E+03
18.309500	.1224E-02	.7657E+01	.9376E+01	.5907E+03
18.317800	.1482E-02	.8610E+01	.1276E+02	.9719E+03
18.326100	.2148E-02	.6900E+01	.1482E+02	.1415E+04
18.334500	.7881E-03	.5263E+01	.4148E+01	.1540E+04
18.342800	.7312E-03	.4209E+01	.3078E+01	.1632E+04
18.351100	.6868E-03	.3256E+01	.2236E+01	.1699E+04
18.359400	.6649E-03	.2955E+01	.1965E+01	.1758E+04
18.367800	.6380E-03	.2685E+01	.1713E+01	.1809E+04
18.376100	.6167E-03	.2639E+01	.1628E+01	.1858E+04
18.384400	.6010E-03	.2593E+01	.1559E+01	.1905E+04
18.392800	.5854E-03	.2547E+01	.1491E+01	.1950E+04
18.401100	.5699E-03	.2500E+01	.1425E+01	.1992E+04
18.409400	.5496E-03	.2454E+01	.1349E+01	.2033E+04
18.417800	.5345E-03	.2408E+01	.1287E+01	.2071E+04
18.426100	.5195E-03	.2361E+01	.1227E+01	.2108E+04
18.434400	.5048E-03	.2315E+01	.1169E+01	.2143E+04
18.442800	.4902E-03	.2269E+01	.1112E+01	.2177E+04
18.451100	.4758E-03	.2223E+01	.1057E+01	.2208E+04
18.459400	.4616E-03	.2176E+01	.1005E+01	.2238E+04
18.467800	.4293E-03	.2130E+01	.9143E+00	.2266E+04
18.476100	.4157E-03	.2084E+01	.8661E+00	.2292E+04
18.484400	.4022E-03	.2038E+01	.8195E+00	.2316E+04
18.492800	.3889E-03	.1991E+01	.7742E+00	.2340E+04
18.501100	.3758E-03	.1945E+01	.7308E+00	.2362E+04
18.509400	.3628E-03	.1899E+01	.6889E+00	.2382E+04
18.517800	.3501E-03	.1852E+01	.6483E+00	.2402E+04
18.526100	.3254E-03	.1806E+01	.5876E+00	.2419E+04
18.534400	.3132E-03	.1760E+01	.5511E+00	.2436E+04
18.542800	.2895E-03	.1713E+01	.4960E+00	.2451E+04
18.551100	.2666E-03	.1667E+01	.4444E+00	.2464E+04
18.559400	.2409E-03	.1621E+01	.3905E+00	.2476E+04
18.567800	.2301E-03	.1574E+01	.3622E+00	.2487E+04
18.576100	.2195E-03	.1528E+01	.3354E+00	.2497E+04
18.584400	.2091E-03	.1482E+01	.3099E+00	.2506E+04
18.592800	.1989E-03	.1435E+01	.2855E+00	.2515E+04
18.601100	.1889E-03	.1389E+01	.2625E+00	.2522E+04
18.609400	.1792E-03	.1343E+01	.2406E+00	.2530E+04
18.617800	.1696E-03	.1296E+01	.2199E+00	.2536E+04
18.626100	.1602E-03	.1250E+01	.2003E+00	.2542E+04
18.634400	.1481E-03	.1204E+01	.1784E+00	.2548E+04
18.642800	.1393E-03	.1157E+01	.1612E+00	.2552E+04
18.651100	.1307E-03	.1111E+01	.1452E+00	.2557E+04
18.659400	.1169E-03	.1065E+01	.1245E+00	.2561E+04
18.667800	.1088E-03	.1018E+01	.1108E+00	.2564E+04
18.676100	.1010E-03	.9724E+00	.9823E-01	.2567E+04
18.684400	.9346E-04	.9263E+00	.8657E-01	.2569E+04
18.692800	.8613E-04	.8796E+00	.7576E-01	.2572E+04
18.701100	.7905E-04	.8335E+00	.6588E-01	.2574E+04
18.709400	.7002E-04	.7873E+00	.5513E-01	.2575E+04
18.717800	.6352E-04	.7407E+00	.4704E-01	.2577E+04
18.726100	.5727E-04	.6946E+00	.3978E-01	.2578E+04
18.734400	.4750E-04	.6484E+00	.3080E-01	.2579E+04
18.742800	.4197E-04	.6018E+00	.2526E-01	.2580E+04
18.751100	.3671E-04	.5556E+00	.2040E-01	.2580E+04
18.759400	.3174E-04	.5095E+00	.1617E-01	.2581E+04
18.767800	.2706E-04	.4629E+00	.1253E-01	.2581E+04
18.776100	.2269E-04	.4167E+00	.9457E-02	.2581E+04
18.784400	.1864E-04	.3706E+00	.6907E-02	.2582E+04
18.792800	.1491E-04	.3239E+00	.4829E-02	.2582E+04
18.801100	.1152E-04	.2778E+00	.3201E-02	.2582E+04
18.809400	.8494E-05	.2317E+00	.1968E-02	.2582E+04
18.817800	.5849E-05	.1850E+00	.1082E-02	.2582E+04
18.826100	.3616E-05	.1389E+00	.5022E-03	.2582E+04
18.834400	.1836E-05	.9279E-01	.1703E-03	.2582E+04
18.842800	.5761E-06	.4612E-01	.2657E-04	.2582E+04
18.851100	.0000E+00	.0000E+00	.0000E+00	.2582E+04

Total runoff volume going through collector field_1 = .69808769 m^3
Total sediment going through collector field_1 = 2581.91368049 g

Collector= g4_2
Number of field samples= 10

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
18.226100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.234400	.3579E-06	.9651E+00	.3454E-03	.1032E-01
18.242800	.4138E-05	.1942E+01	.8034E-02	.2533E+00
18.251100	.9507E-05	.2907E+01	.2764E-01	.1079E+01
18.259400	.1279E-04	.3872E+01	.4954E-01	.2559E+01
18.267800	.3103E-04	.4849E+01	.1504E+00	.7109E+01
18.276100	.8366E-04	.5814E+01	.4864E+00	.2164E+02
18.284400	.9331E-04	.6779E+01	.6325E+00	.4054E+02
18.292800	.1336E-03	.7756E+01	.1036E+01	.7187E+02
18.301100	.2262E-03	.8721E+01	.1973E+01	.1308E+03
18.309500	.3448E-03	.9698E+01	.3344E+01	.2319E+03
18.317800	.4178E-03	.1066E+02	.4455E+01	.3650E+03
18.326100	.5104E-03	.1163E+02	.5935E+01	.5424E+03
18.334500	.6358E-03	.1271E+02	.8084E+01	.7868E+03
18.342800	.8937E-03	.1446E+02	.1292E+02	.1173E+04
18.351100	.1118E-02	.1501E+02	.1679E+02	.1675E+04

18.359400	.1112E-02	.7739E+01	.8604E+01	.1932E+04
18.367800	.1131E-02	.1344E+01	.1521E+01	.1978E+04
18.376100	.1138E-02	.1146E+01	.1304E+01	.2017E+04
18.384400	.1145E-02	.1034E+01	.1183E+01	.2052E+04
18.392800	.1145E-02	.1509E+01	.1727E+01	.2104E+04
18.401100	.1224E-02	.1808E+01	.2214E+01	.2170E+04
18.409400	.1334E-02	.9954E+00	.1328E+01	.2210E+04
18.417800	.1334E-02	.2994E+00	.3994E+00	.2222E+04
18.426100	.1334E-02	.4152E+00	.5539E+00	.2239E+04
18.434400	.1334E-02	.5125E+00	.6838E+00	.2259E+04
18.442800	.1334E-02	.4843E+00	.6462E+00	.2279E+04
18.451100	.1334E-02	.4565E+00	.6090E+00	.2297E+04
18.459400	.1334E-02	.4287E+00	.5719E+00	.2314E+04
18.467800	.1275E-02	.3921E+00	.4999E+00	.2329E+04
18.476100	.1231E-02	.3025E+00	.3722E+00	.2340E+04
18.484400	.1187E-02	.2240E+00	.2657E+00	.2348E+04
18.492800	.1143E-02	.2207E+00	.2523E+00	.2356E+04
18.501100	.1101E-02	.2175E+00	.2393E+00	.2363E+04
18.509400	.1058E-02	.2142E+00	.2268E+00	.2370E+04
18.517800	.1017E-02	.2110E+00	.2145E+00	.2376E+04
18.526100	.9702E-03	.2077E+00	.2015E+00	.2382E+04
18.534400	.9301E-03	.2045E+00	.1902E+00	.2388E+04
18.542800	.8907E-03	.2012E+00	.1792E+00	.2393E+04
18.551100	.8520E-03	.1980E+00	.1687E+00	.2398E+04
18.559400	.8139E-03	.1948E+00	.1585E+00	.2403E+04
18.567800	.7766E-03	.1915E+00	.1487E+00	.2408E+04
18.576100	.7399E-03	.1883E+00	.1393E+00	.2412E+04
18.584400	.7038E-03	.1850E+00	.1302E+00	.2416E+04
18.592800	.6685E-03	.1818E+00	.1215E+00	.2419E+04
18.601100	.6339E-03	.1785E+00	.1132E+00	.2423E+04
18.609400	.6000E-03	.1753E+00	.1052E+00	.2426E+04
18.617800	.5669E-03	.1720E+00	.9752E-01	.2429E+04
18.626100	.5344E-03	.1688E+00	.9021E-01	.2431E+04
18.634400	.5027E-03	.1656E+00	.8323E-01	.2434E+04
18.642800	.4718E-03	.1623E+00	.7657E-01	.2436E+04
18.651100	.4416E-03	.1591E+00	.7024E-01	.2438E+04
18.659400	.4034E-03	.1558E+00	.6286E-01	.2440E+04
18.667800	.3750E-03	.1521E+00	.5703E-01	.2442E+04
18.676100	.3474E-03	.1452E+00	.5044E-01	.2443E+04
18.684400	.3207E-03	.1383E+00	.4435E-01	.2445E+04
18.692800	.2948E-03	.1313E+00	.3871E-01	.2446E+04
18.701100	.2697E-03	.1244E+00	.3357E-01	.2447E+04
18.709400	.2456E-03	.1176E+00	.2887E-01	.2448E+04
18.717800	.2223E-03	.1106E+00	.2458E-01	.2449E+04
18.726100	.1999E-03	.1037E+00	.2073E-01	.2449E+04
18.734400	.1784E-03	.9681E-01	.1727E-01	.2450E+04
18.742800	.1579E-03	.8985E-01	.1419E-01	.2450E+04
18.751100	.1384E-03	.8296E-01	.1148E-01	.2450E+04
18.759400	.1198E-03	.7607E-01	.9117E-02	.2451E+04
18.767800	.1024E-03	.6911E-01	.7075E-02	.2451E+04
18.776100	.8598E-04	.6222E-01	.5350E-02	.2451E+04
18.784400	.7072E-04	.5533E-01	.3913E-02	.2451E+04
18.792800	.5664E-04	.4837E-01	.2739E-02	.2451E+04
18.801100	.4379E-04	.4148E-01	.1816E-02	.2451E+04
18.809400	.3226E-04	.3459E-01	.1116E-02	.2451E+04
18.817800	.2214E-04	.2763E-01	.6117E-03	.2451E+04
18.826100	.1356E-04	.2074E-01	.2812E-03	.2451E+04
18.834400	.6701E-05	.1385E-01	.9283E-04	.2451E+04
18.842800	.1882E-05	.6886E-02	.1296E-04	.2451E+04
18.851100	.0000E+00	.0000E+00	.0000E+00	.2451E+04

Total runoff volume going through collector g4_2 = 1.306868564 m^3
Total sediment going through collector g4_2 = 2451.439160772 g

Collector= g8_2
Number of field samples= 13

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
18.226100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.234400	.3571E-06	.1813E+00	.6475E-04	.1935E-02
18.242800	.8879E-06	.3648E+00	.3239E-03	.1173E-01
18.251100	.2534E-05	.5461E+00	.1384E-02	.5307E-01
18.259400	.4883E-05	.7274E+00	.3552E-02	.1592E+00
18.267800	.7881E-05	.9109E+00	.7178E-02	.3763E+00
18.276100	.1458E-04	.1092E+01	.1593E-01	.8522E+00
18.284400	.1676E-04	.1273E+01	.2134E-01	.1490E+01
18.292800	.2295E-04	.1457E+01	.3344E-01	.2501E+01
18.301100	.5588E-04	.1638E+01	.9154E-01	.5236E+01
18.309500	.1221E-03	.1822E+01	.2224E+00	.1196E+02
18.317800	.1697E-03	.2003E+01	.3400E+00	.2212E+02
18.326100	.2277E-03	.2184E+01	.4974E+00	.3698E+02
18.334500	.2730E-03	.2244E+01	.6125E+00	.5551E+02
18.342800	.7417E-03	.1545E+01	.1146E+01	.8975E+02
18.351100	.6818E-03	.1046E+01	.7132E+00	.1111E+03
18.359400	.7787E-03	.1858E+01	.1447E+01	.1543E+03
18.367800	.9212E-03	.2417E+01	.2226E+01	.2216E+03
18.376100	.1140E-02	.1299E+01	.1481E+01	.2659E+03
18.384400	.1260E-02	.3207E+00	.4043E+00	.2779E+03
18.392800	.1260E-02	.2803E+00	.3533E+00	.2886E+03
18.401100	.1145E-02	.2412E+00	.2761E+00	.2969E+03
18.409400	.1128E-02	.2074E+00	.2339E+00	.3039E+03
18.417800	.1104E-02	.1719E+00	.1897E+00	.3096E+03
18.426100	.1080E-02	.1287E+00	.1391E+00	.3137E+03
18.434400	.1057E-02	.9151E-01	.9670E-01	.3166E+03
18.442800	.1033E-02	.9459E-01	.9775E-01	.3196E+03

18.451100	.1010E-02	.9763E-01	.9863E-01	.3225E+03
18.459400	.9873E-03	.1007E+00	.9940E-01	.3255E+03
18.467800	.9578E-03	.1038E+00	.9938E-01	.3285E+03
18.476100	.9355E-03	.1068E+00	.9990E-01	.3315E+03
18.484400	.9134E-03	.1098E+00	.1003E+00	.3345E+03
18.492800	.8915E-03	.1129E+00	.1007E+00	.3375E+03
18.501100	.8698E-03	.1160E+00	.1009E+00	.3406E+03
18.509400	.8484E-03	.1190E+00	.1010E+00	.3436E+03
18.517800	.8272E-03	.1221E+00	.1010E+00	.3466E+03
18.526100	.7750E-03	.1251E+00	.9697E-01	.3495E+03
18.534400	.7547E-03	.1282E+00	.9672E-01	.3524E+03
18.542800	.6866E-03	.1312E+00	.9011E-01	.3551E+03
18.551100	.6215E-03	.1343E+00	.8345E-01	.3576E+03
18.559400	.5591E-03	.1373E+00	.7678E-01	.3599E+03
18.567800	.5415E-03	.2051E+00	.1111E+00	.3633E+03
18.576100	.5242E-03	.6826E+00	.3578E+00	.3740E+03
18.584400	.5071E-03	.1036E+01	.5251E+00	.3897E+03
18.592800	.4902E-03	.5389E+00	.2642E+00	.3977E+03
18.601100	.4736E-03	.1132E+00	.5361E-01	.3993E+03
18.609400	.4572E-03	.1132E+00	.5176E-01	.4008E+03
18.617800	.4411E-03	.1132E+00	.4993E-01	.4023E+03
18.626100	.4253E-03	.1132E+00	.4813E-01	.4037E+03
18.634400	.3550E-03	.1132E+00	.4017E-01	.4049E+03
18.642800	.3406E-03	.1132E+00	.3854E-01	.4061E+03
18.651100	.3264E-03	.1132E+00	.3694E-01	.4072E+03
18.659400	.2682E-03	.1132E+00	.3034E-01	.4081E+03
18.667800	.2555E-03	.1136E+00	.2902E-01	.4090E+03
18.676100	.2430E-03	.1170E+00	.2844E-01	.4099E+03
18.684400	.2309E-03	.1200E+00	.2770E-01	.4107E+03
18.692800	.2190E-03	.1199E+00	.2626E-01	.4115E+03
18.701100	.2074E-03	.1199E+00	.2486E-01	.4122E+03
18.709400	.1893E-03	.1198E+00	.2268E-01	.4129E+03
18.717800	.1784E-03	.1198E+00	.2137E-01	.4135E+03
18.726100	.1678E-03	.1197E+00	.2009E-01	.4141E+03
18.734400	.1514E-03	.1196E+00	.1812E-01	.4147E+03
18.742800	.1416E-03	.1196E+00	.1693E-01	.4152E+03
18.751100	.1320E-03	.1195E+00	.1578E-01	.4157E+03
18.759400	.1228E-03	.1195E+00	.1467E-01	.4161E+03
18.767800	.1138E-03	.1194E+00	.1359E-01	.4165E+03
18.776100	.1052E-03	.1193E+00	.1255E-01	.4169E+03
18.784400	.9682E-04	.1193E+00	.1155E-01	.4172E+03
18.792800	.8877E-04	.1192E+00	.1058E-01	.4176E+03
18.801100	.8103E-04	.1192E+00	.9657E-02	.4178E+03
18.809400	.7361E-04	.1191E+00	.8768E-02	.4181E+03
18.817800	.6649E-04	.1191E+00	.7917E-02	.4183E+03
18.826100	.5970E-04	.1190E+00	.7105E-02	.4186E+03
18.834400	.5324E-04	.1189E+00	.6332E-02	.4187E+03
18.842800	.4710E-04	.1189E+00	.5599E-02	.4189E+03
18.851100	.0000E+00	.1188E+00	.0000E+00	.4189E+03

Total runoff volume going through collector g8_2 = 1.021797829 m^3
Total sediment going through collector g8_2 = 418.916933902 g

Collector= field_2
Number of field samples= 6

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
18.226100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.234400	.1176E-04	.2756E+00	.3242E-02	.9686E-01
18.242800	.2194E-04	.5545E+00	.1217E-01	.4648E+00
18.251100	.3952E-04	.8301E+00	.3280E-01	.1445E+01
18.259400	.5740E-04	.1106E+01	.6347E-01	.3342E+01
18.267800	.9651E-04	.1385E+01	.1336E+00	.7383E+01
18.276100	.9651E-04	.1660E+01	.1602E+00	.1217E+02
18.284400	.1496E-03	.1928E+01	.2885E+00	.2079E+02
18.292800	.1645E-03	.2147E+01	.3531E+00	.3147E+02
18.301100	.1117E-02	.2323E+01	.2594E+01	.1090E+03
18.309500	.1674E-02	.2228E+01	.3730E+01	.2218E+03
18.317800	.4200E-03	.2278E+01	.9567E+00	.2503E+03
18.326100	.4075E-03	.3236E+01	.1319E+01	.2898E+03
18.334500	.4040E-03	.4073E+01	.1645E+01	.3395E+03
18.342800	.3744E-03	.4088E+01	.1530E+01	.3852E+03
18.351100	.3374E-03	.4132E+01	.1394E+01	.4269E+03
18.359400	.3100E-03	.4364E+01	.1353E+01	.4673E+03
18.367800	.2913E-03	.4557E+01	.1328E+01	.5075E+03
18.376100	.2807E-03	.4479E+01	.1257E+01	.5450E+03
18.384400	.2628E-03	.4401E+01	.1157E+01	.5796E+03
18.392800	.2563E-03	.4321E+01	.1108E+01	.6131E+03
18.401100	.2499E-03	.4243E+01	.1060E+01	.6448E+03
18.409400	.2399E-03	.4165E+01	.9992E+00	.6746E+03
18.417800	.2336E-03	.4086E+01	.9546E+00	.7035E+03
18.426100	.2274E-03	.4007E+01	.9115E+00	.7307E+03
18.434400	.2213E-03	.3929E+01	.8696E+00	.7567E+03
18.442800	.2153E-03	.3850E+01	.8288E+00	.7818E+03
18.451100	.2093E-03	.3772E+01	.7894E+00	.8053E+03
18.459400	.2034E-03	.3693E+01	.7512E+00	.8278E+03
18.467800	.1878E-03	.3614E+01	.6788E+00	.8483E+03
18.476100	.1822E-03	.3536E+01	.6442E+00	.8676E+03
18.484400	.1766E-03	.3458E+01	.6107E+00	.8858E+03
18.492800	.1711E-03	.3379E+01	.5781E+00	.9033E+03
18.501100	.1657E-03	.3300E+01	.5469E+00	.9196E+03
18.509400	.1604E-03	.3222E+01	.5167E+00	.9351E+03
18.517800	.1551E-03	.3143E+01	.4874E+00	.9498E+03
18.526100	.1413E-03	.3065E+01	.4331E+00	.9628E+03
18.534400	.1363E-03	.2986E+01	.4072E+00	.9749E+03

18.542800	.1260E-03	.2907E+01	.3662E+00	.9860E+03
18.551100	.1108E-03	.2829E+01	.3134E+00	.9954E+03
18.559400	.9890E-04	.2751E+01	.2720E+00	.1003E+04
18.567800	.9462E-04	.2671E+01	.2528E+00	.1011E+04
18.576100	.9043E-04	.2593E+01	.2345E+00	.1018E+04
18.584400	.8632E-04	.2515E+01	.2171E+00	.1025E+04
18.592800	.8229E-04	.2436E+01	.2004E+00	.1031E+04
18.601100	.7835E-04	.2357E+01	.1847E+00	.1036E+04
18.609400	.7448E-04	.2279E+01	.1698E+00	.1041E+04
18.617800	.7070E-04	.2200E+01	.1555E+00	.1046E+04
18.626100	.6701E-04	.2122E+01	.1422E+00	.1050E+04
18.634400	.5748E-04	.2043E+01	.1175E+00	.1054E+04
18.642800	.5411E-04	.1964E+01	.1063E+00	.1057E+04
18.651100	.5082E-04	.1886E+01	.9584E-01	.1060E+04
18.659400	.4411E-04	.1808E+01	.7974E-01	.1062E+04
18.667800	.4111E-04	.1728E+01	.7105E-01	.1064E+04
18.676100	.3819E-04	.1650E+01	.6302E-01	.1066E+04
18.684400	.3537E-04	.1572E+01	.5559E-01	.1068E+04
18.692800	.3263E-04	.1493E+01	.4871E-01	.1069E+04
18.701100	.3000E-04	.1414E+01	.4243E-01	.1071E+04
18.709400	.2208E-04	.1336E+01	.2950E-01	.1072E+04
18.717800	.1986E-04	.1257E+01	.2496E-01	.1072E+04
18.726100	.1774E-04	.1179E+01	.2091E-01	.1073E+04
18.734400	.1572E-04	.1100E+01	.1730E-01	.1073E+04
18.742800	.1381E-04	.1021E+01	.1411E-01	.1074E+04
18.751100	.1201E-04	.9429E+00	.1132E-01	.1074E+04
18.759400	.1031E-04	.8647E+00	.8918E-02	.1074E+04
18.767800	.8731E-05	.7855E+00	.6858E-02	.1075E+04
18.776100	.7262E-05	.7072E+00	.5136E-02	.1075E+04
18.784400	.5911E-05	.6289E+00	.3718E-02	.1075E+04
18.792800	.4680E-05	.5497E+00	.2573E-02	.1075E+04
18.801100	.3575E-05	.4715E+00	.1685E-02	.1075E+04
18.809400	.2599E-05	.3932E+00	.1022E-02	.1075E+04
18.817800	.1760E-05	.3140E+00	.5525E-03	.1075E+04
18.826100	.1064E-05	.2357E+00	.2508E-03	.1075E+04
18.834400	.5238E-06	.1575E+00	.8248E-04	.1075E+04
18.842800	.1559E-06	.7826E-01	.1220E-04	.1075E+04
18.851100	.0000E+00	.0000E+00	.0000E+00	.1075E+04

Total runoff volume going through collector field_2 = .347039083 m^3
Total sediment going through collector field_2 = 1075.105858236 g

Collector= rip_2
Number of field samples= 1

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
18.226100	.0000E+00	.0000E+00	.0000E+00	.0000E+00
18.234400	.0000E+00	.2658E+00	.0000E+00	.0000E+00
18.242800	.0000E+00	.5347E+00	.0000E+00	.0000E+00
18.251100	.0000E+00	.8005E+00	.0000E+00	.0000E+00
18.259400	.9895E-07	.1066E+01	.1055E-03	.3153E-02
18.267800	.9895E-07	.1335E+01	.1321E-03	.7148E-02
18.276100	.5472E-06	.1601E+01	.8762E-03	.3333E-01
18.284400	.5563E-06	.1867E+01	.1038E-02	.6436E-01
18.292800	.1105E-04	.2136E+01	.2360E-01	.7780E+00
18.301100	.3033E-04	.2402E+01	.7284E-01	.2955E+01
18.309500	.5642E-04	.2671E+01	.1507E+00	.7511E+01
18.317800	.8553E-04	.2936E+01	.2511E+00	.1501E+02
18.326100	.1251E-03	.3202E+01	.4007E+00	.2699E+02
18.334500	.1929E-03	.3471E+01	.6696E+00	.4724E+02
18.342800	.2924E-03	.3737E+01	.1093E+01	.7988E+02
18.351100	.4019E-03	.4003E+01	.1609E+01	.1279E+03
18.359400	.4107E-03	.4268E+01	.1753E+01	.1803E+03
18.367800	.4420E-03	.4491E+01	.1985E+01	.2403E+03
18.376100	.5225E-03	.4413E+01	.2306E+01	.3092E+03
18.384400	.5273E-03	.4336E+01	.2287E+01	.3776E+03
18.392800	.5273E-03	.4258E+01	.2245E+01	.4455E+03
18.401100	.5624E-03	.4181E+01	.2351E+01	.5157E+03
18.409400	.5985E-03	.4104E+01	.2456E+01	.5891E+03
18.417800	.5985E-03	.4026E+01	.2410E+01	.6620E+03
18.426100	.5985E-03	.3949E+01	.2364E+01	.7326E+03
18.434400	.5985E-03	.3872E+01	.2317E+01	.8019E+03
18.442800	.5985E-03	.3794E+01	.2271E+01	.8705E+03
18.451100	.5985E-03	.3717E+01	.2225E+01	.9370E+03
18.459400	.5985E-03	.3639E+01	.2178E+01	.1002E+04
18.467800	.6466E-03	.3561E+01	.2303E+01	.1072E+04
18.476100	.6466E-03	.3484E+01	.2253E+01	.1139E+04
18.484400	.6466E-03	.3407E+01	.2203E+01	.1205E+04
18.492800	.6466E-03	.3329E+01	.2152E+01	.1270E+04
18.501100	.6466E-03	.3252E+01	.2103E+01	.1333E+04
18.509400	.6466E-03	.3175E+01	.2053E+01	.1394E+04
18.517800	.6466E-03	.3097E+01	.2002E+01	.1455E+04
18.526100	.6054E-03	.3020E+01	.1828E+01	.1509E+04
18.534400	.5810E-03	.2943E+01	.1710E+01	.1560E+04
18.542800	.5320E-03	.2865E+01	.1524E+01	.1606E+04
18.551100	.4850E-03	.2787E+01	.1352E+01	.1647E+04
18.559400	.4401E-03	.2710E+01	.1193E+01	.1682E+04
18.567800	.4191E-03	.2632E+01	.1103E+01	.1716E+04
18.576100	.3985E-03	.2555E+01	.1018E+01	.1746E+04
18.584400	.3785E-03	.2478E+01	.9379E+00	.1774E+04
18.592800	.3589E-03	.2400E+01	.8614E+00	.1800E+04
18.601100	.3398E-03	.2323E+01	.7894E+00	.1824E+04
18.609400	.3212E-03	.2246E+01	.7214E+00	.1845E+04
18.617800	.3031E-03	.2168E+01	.6571E+00	.1865E+04
18.626100	.2855E-03	.2091E+01	.5969E+00	.1883E+04

18.634400	.2576E-03	.2013E+01	.5188E+00	.1899E+04
18.642800	.2413E-03	.1935E+01	.4671E+00	.1913E+04
18.651100	.2255E-03	.1858E+01	.4190E+00	.1925E+04
18.659400	.2006E-03	.1781E+01	.3573E+00	.1936E+04
18.667800	.1861E-03	.1703E+01	.3169E+00	.1946E+04
18.676100	.1721E-03	.1626E+01	.2798E+00	.1954E+04
18.684400	.1586E-03	.1549E+01	.2457E+00	.1961E+04
18.692800	.1456E-03	.1471E+01	.2142E+00	.1968E+04
18.701100	.1332E-03	.1394E+01	.1856E+00	.1973E+04
18.709400	.1139E-03	.1317E+01	.1499E+00	.1978E+04
18.717800	.1028E-03	.1239E+01	.1273E+00	.1982E+04
18.726100	.9221E-04	.1161E+01	.1071E+00	.1985E+04
18.734400	.7604E-04	.1084E+01	.8245E-01	.1987E+04
18.742800	.6690E-04	.1006E+01	.6732E-01	.1989E+04
18.751100	.5831E-04	.9291E+00	.5418E-01	.1991E+04
18.759400	.5027E-04	.8520E+00	.4283E-01	.1992E+04
18.767800	.4278E-04	.7740E+00	.3311E-01	.1993E+04
18.776100	.3586E-04	.6969E+00	.2499E-01	.1994E+04
18.784400	.2950E-04	.6197E+00	.1828E-01	.1995E+04
18.792800	.2373E-04	.5417E+00	.1285E-01	.1995E+04
18.801100	.1854E-04	.4646E+00	.8614E-02	.1995E+04
18.809400	.1395E-04	.3875E+00	.5406E-02	.1995E+04
18.817800	.9974E-05	.3094E+00	.3086E-02	.1995E+04
18.826100	.6621E-05	.2323E+00	.1538E-02	.1995E+04
18.834400	.3913E-05	.1552E+00	.6072E-03	.1996E+04
18.842800	.1877E-05	.7712E-01	.1447E-03	.1996E+04
18.851100	.0000E+00	.0000E+00	.0000E+00	.1996E+04

Total runoff volume going through collector rip_2 = .624575656 m^3
Total sediment going through collector rip_2 = 1995.508795208 g

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 18.166388889 h
Event on u309-92

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.6983E+00	245.	575.	.2148E-02	2465.
field_2	.3469E+00	245.	515.	.1674E-02	2465.
g4_1	.9430E+00	245.	695.	.1837E-02	2465.
g4_2	.1307E+01	245.	1055.	.1334E-02	2465.
g8_1	.2896E+00	245.	665.	.5063E-03	2465.
g8_2	.1022E+01	245.	815.	.1260E-02	2465.
rip_1	.1120E+00	575.	635.	.1536E-03	2465.
rip_2	.6246E+00	335.	1265.	.6466E-03	2465.
field_avg	.5226E+00	245.	515.	.1449E-02	2465.
g4_avg	.1125E+01	245.	695.	.1475E-02	2465.
g8_avg	.6557E+00	245.	785.	.7937E-03	2465.

RAINFALL DATA FOR EVENT u309-92

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 18.166388889 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.5080E-05
.2999E+03	.1185E-04
.6001E+03	.4233E-05
.9000E+03	.8467E-06
.1200E+04	.8467E-06
.1501E+04	.0000E+00
.2103E+04	.0000E+00

Total rainfall volume= 0.686 cm

Table 9. Summary of field data for event on (11/30/92a)

TABLE OF SEDIMENT AND RUNOFF DATA(11/30/92a)

Files used= u331a-92.q u331a-92.sedin
Collector= g4_1
Number of field samples= 9

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
3.267800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
3.276100	.2281E-06	.2578E+00	.5879E-04	.1757E-02
3.284400	.6945E-07	.5155E+00	.3580E-04	.2826E-02

3.292800	.1943E-05	.7764E+00	.1508E-02	.4843E-01
3.301100	.1373E-04	.1034E+01	.1420E-01	.4727E+00
3.309500	.6393E-03	.1295E+01	.8279E+00	.2551E+02
3.317800	.2457E-02	.1553E+01	.3815E+01	.1395E+03
3.326100	.1609E-02	.1811E+01	.2913E+01	.2265E+03
3.334400	.1703E-02	.2068E+01	.3522E+01	.3318E+03
3.342800	.1703E-02	.2329E+01	.3967E+01	.4517E+03
3.351100	.1633E-02	.2555E+01	.4174E+01	.5764E+03
3.359400	.1520E-02	.2575E+01	.3914E+01	.6934E+03
3.367800	.1403E-02	.2595E+01	.3640E+01	.8035E+03
3.376100	.1275E-02	.2615E+01	.3335E+01	.9031E+03
3.384400	.1133E-02	.2634E+01	.2985E+01	.9923E+03
3.392800	.1004E-02	.2654E+01	.2666E+01	.1073E+04
3.401100	.8881E-03	.2674E+01	.2375E+01	.1144E+04
3.409400	.7777E-03	.2693E+01	.2095E+01	.1206E+04
3.417800	.6576E-03	.2646E+01	.1740E+01	.1259E+04
3.426100	.5510E-03	.2169E+01	.1195E+01	.1295E+04
3.434400	.4658E-03	.1710E+01	.7967E+00	.1319E+04
3.442800	.4211E-03	.1370E+01	.5770E+00	.1336E+04
3.451100	.3741E-03	.1079E+01	.4036E+00	.1348E+04
3.459400	.3335E-03	.1080E+01	.3602E+00	.1359E+04
3.467800	.2687E-03	.1039E+01	.2790E+00	.1367E+04
3.476100	.2033E-03	.7244E+00	.1473E+00	.1372E+04
3.484500	.1455E-03	.4579E+00	.6663E-01	.1374E+04
3.492800	.9845E-04	.5090E+00	.5011E-01	.1375E+04
3.501100	.6132E-04	.5482E+00	.3361E-01	.1376E+04
3.509400	.3021E-04	.5087E+00	.1537E-01	.1377E+04
3.517800	.8806E-05	.4687E+00	.4127E-02	.1377E+04
3.526100	.0000E+00	.4291E+00	.0000E+00	.1377E+04
3.526100	.0000E+00	.4291E+00	.0000E+00	.1377E+04
3.534400	.0000E+00	.3946E+00	.0000E+00	.1377E+04
3.734400	.0000E+00	.1714E-01	.0000E+00	.1377E+04
3.742800	.0000E+00	.0000E+00	.0000E+00	.1377E+04

Total runoff volume going through collector g4_1 = .64112639 m^3
Total sediment going through collector g4_1 = 1376.815122423 g

Collector= g8_1
Number of field samples= 11

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
3.267800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
3.276100	.6391E-06	.1685E-01	.1077E-04	.3218E-03
3.284400	.9449E-06	.3370E-01	.3184E-04	.1273E-02
3.292800	.9449E-06	.5075E-01	.4796E-04	.2723E-02
3.301100	.1704E-05	.6760E-01	.1152E-03	.6165E-02
3.309500	.1579E-03	.8465E-01	.1337E-01	.4105E+00
3.317800	.3950E-03	.1015E+00	.4009E-01	.1608E+01
3.326100	.4921E-03	.1183E+00	.5824E-01	.3349E+01
3.334400	.9360E-03	.1352E+00	.1266E+00	.7130E+01
3.342800	.1220E-02	.1522E+00	.1857E+00	.1275E+02
3.351100	.1234E-02	.1691E+00	.2087E+00	.1898E+02
3.359400	.1427E-02	.1859E+00	.2654E+00	.2691E+02
3.367800	.1442E-02	.1969E+00	.2841E+00	.3550E+02
3.376100	.1347E-02	.1694E+00	.2282E+00	.4232E+02
3.384400	.1198E-02	.1567E+00	.1876E+00	.4793E+02
3.392800	.1083E-02	.2453E+00	.2656E+00	.5596E+02
3.401100	.1018E-02	.3329E+00	.3390E+00	.6609E+02
3.409400	.9624E-03	.4205E+00	.4047E+00	.7818E+02
3.417800	.8396E-03	.5071E+00	.4258E+00	.9106E+02
3.426100	.7473E-03	.5801E+00	.4335E+00	.1040E+03
3.434400	.6377E-03	.6419E+00	.4093E+00	.1162E+03
3.442800	.5457E-03	.6278E+00	.3426E+00	.1266E+03
3.451100	.4599E-03	.5968E+00	.2745E+00	.1348E+03
3.459400	.3848E-03	.4542E+00	.1748E+00	.1400E+03
3.467800	.3075E-03	.3402E+00	.1046E+00	.1432E+03
3.476100	.2378E-03	.4192E+00	.9969E-01	.1462E+03
3.484500	.1727E-03	.4828E+00	.8340E-01	.1487E+03
3.492800	.1117E-03	.4456E+00	.4977E-01	.1502E+03
3.501100	.6652E-04	.4113E+00	.2736E-01	.1510E+03
3.509400	.3023E-04	.3958E+00	.1197E-01	.1513E+03
3.517800	.9421E-05	.3812E+00	.3591E-02	.1515E+03
3.526100	.0000E+00	.3732E+00	.0000E+00	.1515E+03
3.526100	.0000E+00	.3732E+00	.0000E+00	.1515E+03
3.534400	.0000E+00	.3625E+00	.0000E+00	.1515E+03
3.734400	.0000E+00	.1337E-01	.0000E+00	.1515E+03
3.742800	.0000E+00	.0000E+00	.0000E+00	.1515E+03

Total runoff volume going through collector g8_1 = .524028357 m^3
Total sediment going through collector g8_1 = 151.456940552 g

Collector= field_1
Number of field samples= 10

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
3.267800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
3.276100	.1061E-03	.3831E+01	.4064E+00	.1214E+02
3.284400	.9012E-03	.7662E+01	.6905E+01	.2185E+03
3.292800	.1137E-02	.1154E+02	.1312E+02	.6153E+03
3.301100	.1373E-02	.1537E+02	.2110E+02	.1246E+04
3.309500	.1550E-02	.1925E+02	.2983E+02	.2148E+04
3.317800	.1603E-02	.2219E+02	.3558E+02	.3211E+04

3.326100	.1634E-02	.1956E+02	.3196E+02	.4166E+04
3.334400	.1681E-02	.1702E+02	.2861E+02	.5021E+04
3.342800	.1712E-02	.1514E+02	.2593E+02	.5805E+04
3.351100	.1720E-02	.1341E+02	.2307E+02	.6494E+04
3.359400	.1720E-02	.1248E+02	.2147E+02	.7136E+04
3.367800	.1594E-02	.1148E+02	.1830E+02	.7689E+04
3.376100	.1399E-02	.1010E+02	.1413E+02	.8111E+04
3.384400	.1180E-02	.8725E+01	.1030E+02	.8419E+04
3.392800	.1002E-02	.7330E+01	.7343E+01	.8641E+04
3.401100	.8531E-03	.5951E+01	.5077E+01	.8793E+04
3.409400	.7197E-03	.4572E+01	.3291E+01	.8891E+04
3.417800	.6008E-03	.3276E+01	.1968E+01	.8951E+04
3.426100	.4626E-03	.2624E+01	.1214E+01	.8987E+04
3.434400	.3599E-03	.2100E+01	.7558E+00	.9009E+04
3.442800	.2829E-03	.2445E+01	.6917E+00	.9030E+04
3.451100	.2379E-03	.2697E+01	.6418E+00	.9050E+04
3.459400	.1929E-03	.2369E+01	.4569E+00	.9063E+04
3.467800	.1546E-03	.2048E+01	.3167E+00	.9073E+04
3.476100	.1067E-03	.1803E+01	.1924E+00	.9078E+04
3.484500	.6819E-04	.1582E+01	.1079E+00	.9082E+04
3.492800	.3212E-04	.1526E+01	.4901E-01	.9083E+04
3.501100	.1082E-04	.1470E+01	.1591E-01	.9084E+04
3.509400	.6947E-06	.1414E+01	.9826E-03	.9084E+04
3.517800	.4343E-05	.1358E+01	.5897E-02	.9084E+04
3.526100	.0000E+00	.1302E+01	.0000E+00	.9084E+04
3.526100	.0000E+00	.1302E+01	.0000E+00	.9084E+04
3.534400	.0000E+00	.1246E+01	.0000E+00	.9084E+04
3.734400	.0000E+00	.4972E-01	.0000E+00	.9084E+04
3.742800	.0000E+00	.0000E+00	.0000E+00	.9084E+04

Total runoff volume going through collector field_1 = .731956613 m^3
Total sediment going through collector field_1 = 9083.890737765 g

Collector= g4_2
Number of field samples= 6

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
3.267800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
3.276100	.1141E-06	.5113E+00	.5835E-04	.1743E-02
3.284400	.6880E-06	.1023E+01	.7036E-03	.2277E-01
3.292800	.2043E-04	.1540E+01	.3147E-01	.9743E+00
3.301100	.3288E-03	.2052E+01	.6745E+00	.2113E+02
3.309500	.8646E-03	.2569E+01	.2221E+01	.8830E+02
3.317800	.1212E-02	.3080E+01	.3732E+01	.1998E+03
3.326100	.1492E-02	.3592E+01	.5357E+01	.3599E+03
3.334400	.1739E-02	.4103E+01	.7136E+01	.5731E+03
3.342800	.1944E-02	.4621E+01	.8984E+01	.8448E+03
3.351100	.2026E-02	.5132E+01	.1040E+02	.1155E+04
3.359400	.2050E-02	.5643E+01	.1157E+02	.1501E+04
3.367800	.2058E-02	.6038E+01	.1243E+02	.1877E+04
3.376100	.2067E-02	.5648E+01	.1167E+02	.2226E+04
3.384400	.1878E-02	.5258E+01	.9874E+01	.2521E+04
3.392800	.1681E-02	.4863E+01	.8176E+01	.2768E+04
3.401100	.1522E-02	.4473E+01	.6808E+01	.2971E+04
3.409400	.1327E-02	.4083E+01	.5419E+01	.3133E+04
3.417800	.1162E-02	.3688E+01	.4288E+01	.3263E+04
3.426100	.9879E-03	.3298E+01	.3258E+01	.3360E+04
3.434400	.8243E-03	.2908E+01	.2397E+01	.3432E+04
3.442800	.7047E-03	.2514E+01	.1772E+01	.3486E+04
3.451100	.5573E-03	.2176E+01	.1213E+01	.3522E+04
3.459400	.4417E-03	.2185E+01	.9649E+00	.3551E+04
3.467800	.3532E-03	.2193E+01	.7745E+00	.3574E+04
3.476100	.2726E-03	.2201E+01	.6000E+00	.3592E+04
3.484500	.2034E-03	.2129E+01	.4330E+00	.3605E+04
3.492800	.1455E-03	.1564E+01	.2275E+00	.3612E+04
3.501100	.9556E-04	.1074E+01	.1026E+00	.3615E+04
3.509400	.5400E-04	.1073E+01	.5795E-01	.3617E+04
3.517800	.2224E-04	.1039E+01	.2311E-01	.3617E+04
3.526100	.0000E+00	.7911E+00	.0000E+00	.3617E+04
3.526100	.0000E+00	.7911E+00	.0000E+00	.3617E+04
3.534400	.0000E+00	.5724E+00	.0000E+00	.3617E+04
3.734400	.0000E+00	.2307E-01	.0000E+00	.3617E+04
3.742800	.0000E+00	.0000E+00	.0000E+00	.3617E+04

Total runoff volume going through collector g4_2 = .840948342 m^3
Total sediment going through collector g4_2 = 3617.347614392 g

Collector= g8_2
Number of field samples= 10

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
3.267800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
3.276100	.8846E-06	.2753E-01	.2436E-04	.7278E-03
3.284400	.1225E-05	.5507E-01	.6747E-04	.2744E-02
3.292800	.1614E-05	.8294E-01	.1338E-03	.6791E-02
3.301100	.1614E-05	.1105E+00	.1783E-03	.1212E-01
3.309500	.1614E-05	.1383E+00	.2232E-03	.1887E-01
3.317800	.4876E-05	.1659E+00	.8087E-03	.4303E-01
3.326100	.1195E-03	.1934E+00	.2311E-01	.7337E+00
3.334400	.4166E-03	.2209E+00	.9206E-01	.3484E+01
3.342800	.2805E-02	.2488E+00	.6980E+00	.2459E+02
3.351100	.2567E-02	.3341E+00	.8578E+00	.5022E+02

3.359400	.2431E-02	.7974E+00	.1938E+01	.1081E+03
3.367800	.2287E-02	.1246E+01	.2850E+01	.1943E+03
3.376100	.2138E-02	.1561E+01	.3337E+01	.2940E+03
3.384400	.2012E-02	.1801E+01	.3624E+01	.4023E+03
3.392800	.1744E-02	.1534E+01	.2675E+01	.4832E+03
3.401100	.1629E-02	.1270E+01	.2068E+01	.5450E+03
3.409400	.1468E-02	.1005E+01	.1476E+01	.5891E+03
3.417800	.1168E-02	.7659E+00	.8948E+00	.6161E+03
3.426100	.1044E-02	.7059E+00	.7369E+00	.6382E+03
3.434400	.9390E-03	.6458E+00	.6064E+00	.6563E+03
3.442800	.8454E-03	.5851E+00	.4946E+00	.6712E+03
3.451100	.7439E-03	.5356E+00	.3985E+00	.6831E+03
3.459400	.5167E-03	.5552E+00	.2869E+00	.6917E+03
3.467800	.3437E-03	.5751E+00	.1977E+00	.6977E+03
3.476100	.2572E-03	.5947E+00	.1530E+00	.7023E+03
3.484500	.1817E-03	.5768E+00	.1048E+00	.7054E+03
3.492800	.1181E-03	.3280E+00	.3876E-01	.7066E+03
3.501100	.6918E-04	.1121E+00	.7753E-02	.7068E+03
3.509400	.3049E-04	.1112E+00	.3391E-02	.7069E+03
3.517800	.7991E-05	.1106E+00	.8838E-03	.7070E+03
3.526100	.0000E+00	.1112E+00	.0000E+00	.7070E+03
3.526100	.0000E+00	.1112E+00	.0000E+00	.7070E+03
3.534400	.0000E+00	.1266E+00	.0000E+00	.7070E+03
3.734400	.0000E+00	.1495E-01	.0000E+00	.7070E+03
3.742800	.0000E+00	-.2711E-19	.0000E+00	.7070E+03

Total runoff volume going through collector g8_2 = .777099652 m^3
Total sediment going through collector g8_2 = 706.952781922 g

Collector= field_2
Number of field samples= 8

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
3.267800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
3.276100	.1961E-03	.3216E+00	.6307E-01	.1884E+01
3.284400	.8629E-03	.6432E+00	.5550E+00	.1847E+02
3.292800	.1317E-02	.9687E+00	.1275E+01	.5704E+02
3.301100	.1626E-02	.1290E+01	.2098E+01	.1197E+03
3.309500	.1890E-02	.1616E+01	.3054E+01	.2121E+03
3.317800	.1919E-02	.1937E+01	.3718E+01	.3232E+03
3.326100	.1928E-02	.2259E+01	.4355E+01	.4533E+03
3.334400	.1945E-02	.2872E+01	.5587E+01	.6203E+03
3.342800	.1954E-02	.5493E+01	.1073E+02	.9449E+03
3.351100	.7910E-03	.7962E+01	.6298E+01	.1133E+04
3.359400	.6652E-03	.9642E+01	.6414E+01	.1325E+04
3.367800	.6597E-03	.1094E+02	.7214E+01	.1543E+04
3.376100	.6596E-03	.9636E+01	.6356E+01	.1733E+04
3.384400	.6596E-03	.8336E+01	.5499E+01	.1897E+04
3.392800	.6542E-03	.7021E+01	.4593E+01	.2036E+04
3.401100	.6542E-03	.5721E+01	.3742E+01	.2148E+04
3.409400	.6596E-03	.4421E+01	.2916E+01	.2235E+04
3.417800	.6596E-03	.3254E+01	.2147E+01	.2300E+04
3.426100	.6598E-03	.3046E+01	.2010E+01	.2360E+04
3.434400	.6544E-03	.2837E+01	.1856E+01	.2415E+04
3.442800	.6544E-03	.2626E+01	.1718E+01	.2467E+04
3.451100	.8196E-03	.2417E+01	.1981E+01	.2527E+04
3.459400	.8574E-03	.2209E+01	.1894E+01	.2583E+04
3.467800	.5749E-03	.1997E+01	.1148E+01	.2618E+04
3.476100	.3803E-03	.1789E+01	.6803E+00	.2638E+04
3.484500	.2672E-03	.1578E+01	.4215E+00	.2651E+04
3.492800	.2074E-03	.1369E+01	.2839E+00	.2659E+04
3.501100	.1211E-03	.1131E+01	.1369E+00	.2663E+04
3.509400	.7328E-04	.7040E+00	.5159E-01	.2665E+04
3.517800	.2716E-04	.3257E+00	.8846E-02	.2665E+04
3.526100	.0000E+00	.2952E+00	.0000E+00	.2665E+04
3.526100	.0000E+00	.2952E+00	.0000E+00	.2665E+04
3.534400	.0000E+00	.2712E+00	.0000E+00	.2665E+04
3.734400	.0000E+00	.1349E-01	.0000E+00	.2665E+04
3.742800	.0000E+00	.0000E+00	.0000E+00	.2665E+04

Total runoff volume going through collector field_2 = .750033546 m^3
Total sediment going through collector field_2 = 2665.282314783 g

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 3.166388889 h
Event on u331a-92

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.7320E+00	395.	695.	.1720E-02	1295.
field_2	.7500E+00	395.	635.	.1954E-02	1295.
g4_1	.6411E+00	395.	545.	.2457E-02	1295.
g4_2	.8409E+00	395.	755.	.2067E-02	1295.
g8_1	.5240E+00	395.	725.	.1442E-02	1295.
g8_2	.7769E+00	395.	635.	.2805E-02	1295.
rip_1	.4105E-01	395.	515.	.1506E-03	1295.

rip_2	.7118E+00	395.	665.	.2598E-02	1295.
field_avg	.7409E+00	395.	635.	.1833E-02	1295.
g4_avg	.7410E+00	395.	545.	.1834E-02	1295.
g8_avg	.6505E+00	395.	635.	.2013E-02	1295.

RAINFALL DATA FOR EVENT u331a-92

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 3.166388889 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.5927E-05
.2999E+03	.3303E-04
.6001E+03	.3387E-05
.9000E+03	.8467E-06
.1201E+04	.0000E+00
.1803E+04	.0000E+00

Total rainfall volume= 1.296 cm

Table 10. Summary of field data for event on (11/30/92c)

TABLE OF SEDIMENT AND RUNOFF DATA(11/30/92c)

Files used= u331c-92.q u331c-92.sedin
Collector= g4_1
Number of field samples= 1

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
5.092800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
5.101100	.7491E-06	.1886E-01	.1413E-04	.4222E-03
5.109500	.1070E-04	.3795E-01	.4061E-03	.1270E-01
5.117800	.2604E-04	.5682E-01	.1479E-02	.5691E-01
5.126100	.4141E-04	.7568E-01	.3134E-02	.1505E+00
5.134400	.6155E-04	.9454E-01	.5819E-02	.3244E+00
5.142800	.9893E-04	.1136E+00	.1124E-01	.6644E+00
5.151100	.1577E-03	.1325E+00	.2090E-01	.1289E+01
5.159500	.2173E-03	.1516E+00	.3293E-01	.2285E+01
5.167800	.2845E-03	.1677E+00	.4769E-01	.3710E+01
5.176100	.3549E-03	.1661E+00	.5895E-01	.5471E+01
5.184500	.4054E-03	.1645E+00	.6668E-01	.7487E+01
5.192800	.4097E-03	.1629E+00	.6674E-01	.9482E+01
5.201100	.4184E-03	.1613E+00	.6751E-01	.1150E+02
5.209400	.4586E-03	.1598E+00	.7327E-01	.1369E+02
5.217800	.5050E-03	.1582E+00	.7988E-01	.1610E+02
5.226100	.5484E-03	.1566E+00	.8588E-01	.1867E+02
5.234400	.5934E-03	.1550E+00	.9200E-01	.2142E+02
5.242800	.6450E-03	.1534E+00	.9895E-01	.2441E+02
5.251100	.7091E-03	.1518E+00	.1077E+00	.2763E+02
5.259400	.7701E-03	.1503E+00	.1157E+00	.3109E+02
5.267800	.8449E-03	.1487E+00	.1256E+00	.3488E+02
5.276100	.9042E-03	.1471E+00	.1330E+00	.3886E+02
5.284400	.9840E-03	.1455E+00	.1432E+00	.4314E+02
5.292800	.1028E-02	.1439E+00	.1480E+00	.4761E+02
5.301100	.1047E-02	.1424E+00	.1491E+00	.5207E+02
5.309400	.1047E-02	.1408E+00	.1474E+00	.5647E+02
5.317800	.9888E-03	.1392E+00	.1376E+00	.6063E+02
5.326100	.9318E-03	.1376E+00	.1282E+00	.6447E+02
5.334400	.8643E-03	.1360E+00	.1176E+00	.6798E+02
5.342800	.8047E-03	.1344E+00	.1082E+00	.7125E+02
5.351100	.7637E-03	.1329E+00	.1015E+00	.7428E+02
5.359400	.7017E-03	.1313E+00	.9213E-01	.7703E+02
5.367800	.6897E-03	.1297E+00	.8945E-01	.7974E+02
5.376100	.6777E-03	.1281E+00	.8683E-01	.8233E+02
5.384400	.6659E-03	.1265E+00	.8426E-01	.8485E+02
5.392800	.6541E-03	.1250E+00	.8173E-01	.8732E+02
5.401100	.6424E-03	.1234E+00	.7926E-01	.8969E+02
5.409400	.6051E-03	.1218E+00	.7370E-01	.9189E+02
5.417800	.5938E-03	.1202E+00	.7138E-01	.9405E+02
5.426100	.5675E-03	.1186E+00	.6733E-01	.9606E+02
5.434400	.5565E-03	.1171E+00	.6515E-01	.9801E+02
5.442800	.5456E-03	.1155E+00	.6300E-01	.9992E+02
5.451100	.5348E-03	.1139E+00	.6091E-01	.1017E+03
5.459400	.5145E-03	.1123E+00	.5778E-01	.1035E+03
5.467800	.5039E-03	.1107E+00	.5579E-01	.1051E+03
5.476100	.4934E-03	.1091E+00	.5385E-01	.1068E+03
5.484400	.4830E-03	.1076E+00	.5196E-01	.1083E+03
5.492800	.4727E-03	.1060E+00	.5010E-01	.1098E+03
5.501100	.4625E-03	.1044E+00	.4829E-01	.1113E+03
5.509400	.4524E-03	.1028E+00	.4652E-01	.1127E+03
5.517800	.4424E-03	.1012E+00	.4478E-01	.1140E+03
5.526100	.4325E-03	.9965E-01	.4310E-01	.1153E+03
5.534400	.4227E-03	.9808E-01	.4145E-01	.1165E+03

5.542800	.4129E-03	.9648E-01	.3984E-01	.1177E+03
5.551100	.4033E-03	.9491E-01	.3827E-01	.1189E+03
5.559400	.3937E-03	.9333E-01	.3675E-01	.1200E+03
5.567800	.3843E-03	.9174E-01	.3525E-01	.1211E+03
5.576100	.3749E-03	.9016E-01	.3380E-01	.1221E+03
5.584400	.3656E-03	.8858E-01	.3239E-01	.1230E+03
5.592800	.3565E-03	.8699E-01	.3101E-01	.1240E+03
5.601100	.3474E-03	.8541E-01	.2967E-01	.1249E+03
5.609400	.3384E-03	.8384E-01	.2837E-01	.1257E+03
5.617800	.3296E-03	.8225E-01	.2710E-01	.1265E+03
5.626100	.3208E-03	.8067E-01	.2588E-01	.1273E+03
5.634400	.3121E-03	.7909E-01	.2469E-01	.1280E+03
5.642800	.3035E-03	.7750E-01	.2352E-01	.1287E+03
5.651100	.2950E-03	.7592E-01	.2240E-01	.1294E+03
5.659400	.2718E-03	.7435E-01	.2021E-01	.1300E+03
5.667800	.2529E-03	.7275E-01	.1840E-01	.1306E+03
5.676100	.2451E-03	.7118E-01	.1744E-01	.1311E+03
5.684400	.2373E-03	.6960E-01	.1652E-01	.1316E+03
5.692800	.2297E-03	.6801E-01	.1562E-01	.1321E+03
5.701100	.2221E-03	.6643E-01	.1476E-01	.1325E+03
5.709400	.2147E-03	.6486E-01	.1392E-01	.1329E+03
5.717800	.2073E-03	.6326E-01	.1312E-01	.1333E+03
5.726100	.1905E-03	.6169E-01	.1175E-01	.1337E+03
5.734400	.1835E-03	.6011E-01	.1103E-01	.1340E+03
5.742800	.1766E-03	.5852E-01	.1034E-01	.1343E+03
5.751100	.1699E-03	.5694E-01	.9674E-02	.1346E+03
5.759400	.1632E-03	.5537E-01	.9038E-02	.1349E+03
5.767800	.1567E-03	.5377E-01	.8425E-02	.1351E+03
5.776100	.1446E-03	.5220E-01	.7546E-02	.1353E+03
5.784400	.1383E-03	.5062E-01	.7003E-02	.1356E+03
5.792800	.1322E-03	.4903E-01	.6483E-02	.1358E+03
5.801100	.1262E-03	.4745E-01	.5991E-02	.1359E+03
5.809400	.1204E-03	.4588E-01	.5522E-02	.1361E+03
5.817800	.1070E-03	.4428E-01	.4739E-02	.1362E+03
5.826100	.1015E-03	.4271E-01	.4336E-02	.1364E+03
5.834400	.9145E-04	.4113E-01	.3761E-02	.1365E+03
5.842800	.8632E-04	.3954E-01	.3413E-02	.1366E+03
5.851100	.8131E-04	.3796E-01	.3087E-02	.1367E+03
5.859400	.7642E-04	.3639E-01	.2781E-02	.1368E+03
5.867800	.7167E-04	.3479E-01	.2493E-02	.1368E+03
5.876100	.6100E-04	.3322E-01	.2026E-02	.1369E+03
5.884400	.5667E-04	.3164E-01	.1793E-02	.1369E+03
5.892800	.5248E-04	.3005E-01	.1577E-02	.1370E+03
5.901100	.4842E-04	.2847E-01	.1379E-02	.1370E+03
5.909400	.4450E-04	.2690E-01	.1197E-02	.1371E+03
5.917800	.3742E-04	.2530E-01	.9468E-03	.1371E+03
5.926100	.3391E-04	.2373E-01	.8045E-03	.1371E+03
5.934400	.3053E-04	.2215E-01	.6764E-03	.1371E+03
5.942800	.2591E-04	.2056E-01	.5326E-03	.1372E+03
5.951100	.2291E-04	.1898E-01	.4348E-03	.1372E+03
5.959400	.2006E-04	.1741E-01	.3491E-03	.1372E+03
5.967800	.1737E-04	.1581E-01	.2746E-03	.1372E+03
5.976100	.1484E-04	.1424E-01	.2112E-03	.1372E+03
5.984400	.1247E-04	.1266E-01	.1579E-03	.1372E+03
5.992800	.1028E-04	.1107E-01	.1138E-03	.1372E+03
6.001100	.8273E-05	.9491E-02	.7852E-04	.1372E+03
6.009400	.6446E-05	.7915E-02	.5102E-04	.1372E+03
6.017800	.4811E-05	.6321E-02	.3041E-04	.1372E+03
6.026100	.3380E-05	.4745E-02	.1604E-04	.1372E+03
6.034400	.2164E-05	.3170E-02	.6860E-05	.1372E+03
6.042800	.1182E-05	.1575E-02	.1862E-05	.1372E+03
6.051100	.0000E+00	.0000E+00	.0000E+00	.1372E+03

Total runoff volume going through collector g4_1 = 1.160746767 m^3
Total sediment going through collector g4_1 = 137.215023031 g

Collector= g8_1
Number of field samples= 6

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
5.092800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
5.101100	.6404E-06	.2400E+00	.1537E-03	.4592E-02
5.109500	.8066E-05	.4829E+00	.3895E-02	.1224E+00
5.117800	.2854E-04	.7229E+00	.2063E-01	.7389E+00
5.126100	.5331E-04	.9629E+00	.5133E-01	.2273E+01
5.134400	.6703E-04	.1203E+01	.8063E-01	.4682E+01
5.142800	.9848E-04	.1446E+01	.1424E+00	.8987E+01
5.151100	.1240E-03	.1686E+01	.2091E+00	.1523E+02
5.159500	.1640E-03	.1929E+01	.3162E+00	.2480E+02
5.167800	.1954E-03	.1998E+01	.3902E+00	.3646E+02
5.176100	.2361E-03	.9845E+00	.2324E+00	.4340E+02
5.184500	.2614E-03	.1018E+00	.2662E-01	.4421E+02
5.192800	.2916E-03	.1033E+00	.3011E-01	.4511E+02
5.201100	.3355E-03	.1044E+00	.3501E-01	.4615E+02
5.209400	.3776E-03	.1033E+00	.3901E-01	.4732E+02
5.217800	.4264E-03	.1030E+00	.4391E-01	.4865E+02
5.226100	.5116E-03	.1070E+00	.5477E-01	.5028E+02
5.234400	.5827E-03	.1105E+00	.6440E-01	.5221E+02
5.242800	.6575E-03	.1099E+00	.7227E-01	.5439E+02
5.251100	.7419E-03	.1092E+00	.8105E-01	.5682E+02
5.259400	.7477E-03	.1081E+00	.8084E-01	.5923E+02
5.267800	.7535E-03	.1070E+00	.8060E-01	.6167E+02
5.276100	.8734E-03	.1058E+00	.9243E-01	.6443E+02
5.284400	.9749E-03	.1047E+00	.1021E+00	.6748E+02
5.292800	.1041E-02	.1036E+00	.1078E+00	.7074E+02

5.301100	.1061E-02	.1024E+00	.1086E+00	.7398E+02
5.309400	.1061E-02	.1013E+00	.1074E+00	.7719E+02
5.317800	.1013E-02	.1001E+00	.1015E+00	.8026E+02
5.326100	.9477E-03	.9900E-01	.9383E-01	.8307E+02
5.334400	.8902E-03	.9787E-01	.8712E-01	.8567E+02
5.342800	.7981E-03	.9672E-01	.7719E-01	.8800E+02
5.351100	.7331E-03	.9559E-01	.7008E-01	.9010E+02
5.359400	.6761E-03	.9446E-01	.6386E-01	.9201E+02
5.367800	.6645E-03	.9331E-01	.6201E-01	.9388E+02
5.376100	.6530E-03	.9218E-01	.6019E-01	.9568E+02
5.384400	.6416E-03	.9104E-01	.5841E-01	.9743E+02
5.392800	.6302E-03	.8989E-01	.5665E-01	.9914E+02
5.401100	.6189E-03	.8876E-01	.5494E-01	.1008E+03
5.409400	.5609E-03	.8763E-01	.4915E-01	.1022E+03
5.417800	.5502E-03	.8648E-01	.4758E-01	.1037E+03
5.426100	.5097E-03	.8535E-01	.4350E-01	.1050E+03
5.434400	.4994E-03	.8421E-01	.4206E-01	.1062E+03
5.442800	.4892E-03	.8307E-01	.4064E-01	.1075E+03
5.451100	.4791E-03	.8193E-01	.3926E-01	.1086E+03
5.459400	.4503E-03	.8080E-01	.3639E-01	.1097E+03
5.467800	.4406E-03	.7965E-01	.3509E-01	.1108E+03
5.476100	.4309E-03	.7852E-01	.3384E-01	.1118E+03
5.484400	.4214E-03	.7739E-01	.3261E-01	.1128E+03
5.492800	.4074E-03	.7624E-01	.3106E-01	.1137E+03
5.501100	.3849E-03	.7511E-01	.2891E-01	.1146E+03
5.509400	.3758E-03	.7397E-01	.2780E-01	.1154E+03
5.517800	.3583E-03	.7283E-01	.2609E-01	.1162E+03
5.526100	.3495E-03	.7169E-01	.2506E-01	.1170E+03
5.534400	.3408E-03	.7056E-01	.2404E-01	.1177E+03
5.542800	.3321E-03	.6941E-01	.2305E-01	.1184E+03
5.551100	.3236E-03	.6828E-01	.2209E-01	.1190E+03
5.559400	.3151E-03	.6714E-01	.2116E-01	.1197E+03
5.567800	.3068E-03	.6600E-01	.2025E-01	.1203E+03
5.576100	.2985E-03	.6486E-01	.1936E-01	.1208E+03
5.584400	.2904E-03	.6373E-01	.1850E-01	.1214E+03
5.592800	.2823E-03	.6258E-01	.1767E-01	.1219E+03
5.601100	.2743E-03	.6145E-01	.1686E-01	.1224E+03
5.609400	.2665E-03	.6032E-01	.1607E-01	.1229E+03
5.617800	.2587E-03	.5917E-01	.1531E-01	.1234E+03
5.626100	.2510E-03	.5804E-01	.1457E-01	.1238E+03
5.634400	.2435E-03	.5690E-01	.1385E-01	.1242E+03
5.642800	.2360E-03	.5576E-01	.1316E-01	.1246E+03
5.651100	.2286E-03	.5462E-01	.1249E-01	.1250E+03
5.659400	.2145E-03	.5349E-01	.1147E-01	.1253E+03
5.667800	.1975E-03	.5234E-01	.1034E-01	.1257E+03
5.676100	.1907E-03	.5121E-01	.9764E-02	.1260E+03
5.684400	.1839E-03	.5008E-01	.9211E-02	.1262E+03
5.692800	.1773E-03	.4893E-01	.8677E-02	.1265E+03
5.701100	.1708E-03	.4779E-01	.8164E-02	.1267E+03
5.709400	.1644E-03	.4666E-01	.7672E-02	.1270E+03
5.717800	.1581E-03	.4551E-01	.7196E-02	.1272E+03
5.726100	.1461E-03	.4438E-01	.6485E-02	.1274E+03
5.734400	.1401E-03	.4325E-01	.6060E-02	.1276E+03
5.742800	.1342E-03	.4210E-01	.5652E-02	.1277E+03
5.751100	.1285E-03	.4097E-01	.5263E-02	.1279E+03
5.759400	.1228E-03	.3983E-01	.4892E-02	.1280E+03
5.767800	.1173E-03	.3869E-01	.4536E-02	.1282E+03
5.776100	.1093E-03	.3755E-01	.4103E-02	.1283E+03
5.784400	.1040E-03	.3642E-01	.3787E-02	.1284E+03
5.792800	.9882E-04	.3527E-01	.3486E-02	.1285E+03
5.801100	.9377E-04	.3414E-01	.3201E-02	.1286E+03
5.809400	.8883E-04	.3301E-01	.2932E-02	.1287E+03
5.817800	.8174E-04	.3186E-01	.2604E-02	.1288E+03
5.826100	.7709E-04	.3073E-01	.2369E-02	.1288E+03
5.834400	.7255E-04	.2959E-01	.2147E-02	.1289E+03
5.842800	.6814E-04	.2844E-01	.1938E-02	.1290E+03
5.851100	.6384E-04	.2731E-01	.1744E-02	.1290E+03
5.859400	.5967E-04	.2618E-01	.1562E-02	.1291E+03
5.867800	.5561E-04	.2503E-01	.1392E-02	.1291E+03
5.876100	.4985E-04	.2390E-01	.1191E-02	.1291E+03
5.884400	.4611E-04	.2276E-01	.1050E-02	.1292E+03
5.892800	.4248E-04	.2162E-01	.9184E-03	.1292E+03
5.901100	.3899E-04	.2048E-01	.7987E-03	.1292E+03
5.909400	.3563E-04	.1935E-01	.6894E-03	.1292E+03
5.917800	.3090E-04	.1820E-01	.5624E-03	.1293E+03
5.926100	.2786E-04	.1707E-01	.4756E-03	.1293E+03
5.934400	.2496E-04	.1594E-01	.3978E-03	.1293E+03
5.942800	.1970E-04	.1479E-01	.2913E-03	.1293E+03
5.951100	.1721E-04	.1366E-01	.2350E-03	.1293E+03
5.959400	.1487E-04	.1252E-01	.1862E-03	.1293E+03
5.967800	.1268E-04	.1138E-01	.1442E-03	.1293E+03
5.976100	.1063E-04	.1024E-01	.1089E-03	.1293E+03
5.984400	.8748E-05	.9108E-02	.7968E-04	.1293E+03
5.992800	.7022E-05	.7961E-02	.5590E-04	.1293E+03
6.001100	.5461E-05	.6828E-02	.3729E-04	.1293E+03
6.009400	.4072E-05	.5694E-02	.2319E-04	.1293E+03
6.017800	.2861E-05	.4547E-02	.1301E-04	.1293E+03
6.026100	.1838E-05	.3414E-02	.6273E-05	.1293E+03
6.034400	.1015E-05	.2280E-02	.2314E-05	.1293E+03
6.042800	.4103E-06	.1133E-02	.4650E-06	.1293E+03
6.051100	.0000E+00	.0000E+00	.0000E+00	.1293E+03

Total runoff volume going through collector g8_1 = 1.035523327 m^3
Total sediment going through collector g8_1 = 129.32158689 g

Collector= field_1
Number of field samples= 1

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
5.092800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
5.101100	.0000E+00	.3961E+00	.0000E+00	.0000E+00
5.109500	.2892E-05	.7969E+00	.2305E-02	.6969E-01
5.117800	.1020E-04	.1193E+01	.1217E-01	.4332E+00
5.126100	.2349E-04	.1589E+01	.3733E-01	.1549E+01
5.134400	.2635E-04	.1985E+01	.5231E-01	.3111E+01
5.142800	.2935E-04	.2386E+01	.7003E-01	.5229E+01
5.151100	.1811E-03	.2782E+01	.5038E+00	.2028E+02
5.159500	.2420E-03	.3183E+01	.7703E+00	.4358E+02
5.167800	.2714E-03	.3520E+01	.9553E+00	.7212E+02
5.176100	.3020E-03	.3487E+01	.1053E+01	.1036E+03
5.184500	.3463E-03	.3454E+01	.1196E+01	.1398E+03
5.192800	.3800E-03	.3421E+01	.1300E+01	.1786E+03
5.201100	.4375E-03	.3388E+01	.1482E+01	.2229E+03
5.209400	.4934E-03	.3355E+01	.1655E+01	.2724E+03
5.217800	.5470E-03	.3321E+01	.1817E+01	.3273E+03
5.226100	.5670E-03	.3288E+01	.1864E+01	.3830E+03
5.234400	.6770E-03	.3255E+01	.2204E+01	.4488E+03
5.242800	.6933E-03	.3221E+01	.2233E+01	.5164E+03
5.251100	.7376E-03	.3188E+01	.2352E+01	.5866E+03
5.259400	.7945E-03	.3155E+01	.2507E+01	.6615E+03
5.267800	.8413E-03	.3122E+01	.2626E+01	.7410E+03
5.276100	.9011E-03	.3089E+01	.2783E+01	.8241E+03
5.284400	.9815E-03	.3056E+01	.2999E+01	.9137E+03
5.292800	.1191E-02	.3022E+01	.3599E+01	.1023E+04
5.301100	.1191E-02	.2989E+01	.3560E+01	.1129E+04
5.309400	.1191E-02	.2956E+01	.3520E+01	.1234E+04
5.317800	.1147E-02	.2923E+01	.3353E+01	.1336E+04
5.326100	.1098E-02	.2889E+01	.3173E+01	.1430E+04
5.334400	.1069E-02	.2856E+01	.3053E+01	.1522E+04
5.342800	.1047E-02	.2823E+01	.2955E+01	.1611E+04
5.351100	.9615E-03	.2790E+01	.2682E+01	.1691E+04
5.359400	.9278E-03	.2757E+01	.2558E+01	.1768E+04
5.367800	.9129E-03	.2723E+01	.2486E+01	.1843E+04
5.376100	.8980E-03	.2690E+01	.2416E+01	.1915E+04
5.384400	.8833E-03	.2657E+01	.2347E+01	.1985E+04
5.392800	.8687E-03	.2624E+01	.2279E+01	.2054E+04
5.401100	.8541E-03	.2591E+01	.2213E+01	.2120E+04
5.409400	.8220E-03	.2557E+01	.2102E+01	.2183E+04
5.417800	.8078E-03	.2524E+01	.2039E+01	.2244E+04
5.426100	.7707E-03	.2491E+01	.1920E+01	.2302E+04
5.434400	.7568E-03	.2458E+01	.1860E+01	.2357E+04
5.442800	.7431E-03	.2424E+01	.1801E+01	.2412E+04
5.451100	.7294E-03	.2391E+01	.1744E+01	.2464E+04
5.459400	.6993E-03	.2358E+01	.1649E+01	.2513E+04
5.467800	.6860E-03	.2325E+01	.1595E+01	.2562E+04
5.476100	.6728E-03	.2292E+01	.1542E+01	.2608E+04
5.484400	.6597E-03	.2259E+01	.1490E+01	.2652E+04
5.492800	.6466E-03	.2225E+01	.1439E+01	.2696E+04
5.501100	.6337E-03	.2192E+01	.1389E+01	.2737E+04
5.509400	.6209E-03	.2159E+01	.1341E+01	.2777E+04
5.517800	.5423E-03	.2125E+01	.1153E+01	.2812E+04
5.526100	.5303E-03	.2092E+01	.1110E+01	.2845E+04
5.534400	.5184E-03	.2059E+01	.1067E+01	.2877E+04
5.542800	.5066E-03	.2026E+01	.1026E+01	.2908E+04
5.551100	.4949E-03	.1993E+01	.9861E+00	.2938E+04
5.559400	.4833E-03	.1960E+01	.9470E+00	.2966E+04
5.567800	.4718E-03	.1926E+01	.9088E+00	.2993E+04
5.576100	.4604E-03	.1893E+01	.8716E+00	.3019E+04
5.584400	.4492E-03	.1860E+01	.8355E+00	.3044E+04
5.592800	.4380E-03	.1827E+01	.8001E+00	.3069E+04
5.601100	.4270E-03	.1793E+01	.7658E+00	.3091E+04
5.609400	.4161E-03	.1760E+01	.7325E+00	.3113E+04
5.617800	.4053E-03	.1727E+01	.6999E+00	.3135E+04
5.626100	.3946E-03	.1694E+01	.6684E+00	.3154E+04
5.634400	.3840E-03	.1661E+01	.6378E+00	.3174E+04
5.642800	.3736E-03	.1627E+01	.6079E+00	.3192E+04
5.651100	.3633E-03	.1594E+01	.5791E+00	.3209E+04
5.659400	.3365E-03	.1561E+01	.5253E+00	.3225E+04
5.667800	.3106E-03	.1528E+01	.4744E+00	.3239E+04
5.676100	.3010E-03	.1495E+01	.4498E+00	.3253E+04
5.684400	.2915E-03	.1461E+01	.4260E+00	.3265E+04
5.692800	.2822E-03	.1428E+01	.4029E+00	.3278E+04
5.701100	.2729E-03	.1395E+01	.3807E+00	.3289E+04
5.709400	.2638E-03	.1362E+01	.3593E+00	.3300E+04
5.717800	.2548E-03	.1328E+01	.3385E+00	.3310E+04
5.726100	.2388E-03	.1295E+01	.3093E+00	.3319E+04
5.734400	.2302E-03	.1262E+01	.2906E+00	.3328E+04
5.742800	.2217E-03	.1229E+01	.2724E+00	.3336E+04
5.751100	.2133E-03	.1196E+01	.2551E+00	.3344E+04
5.759400	.2051E-03	.1163E+01	.2385E+00	.3351E+04
5.767800	.1970E-03	.1129E+01	.2224E+00	.3358E+04
5.776100	.1858E-03	.1096E+01	.2036E+00	.3364E+04
5.784400	.1780E-03	.1063E+01	.1892E+00	.3369E+04
5.792800	.1704E-03	.1029E+01	.1754E+00	.3375E+04
5.801100	.1629E-03	.9964E+00	.1623E+00	.3379E+04
5.809400	.1555E-03	.9633E+00	.1498E+00	.3384E+04
5.817800	.1254E-03	.9298E+00	.1166E+00	.3387E+04
5.826100	.1188E-03	.8967E+00	.1065E+00	.3391E+04
5.834400	.1020E-03	.8636E+00	.8810E-01	.3393E+04
5.842800	.9591E-04	.8302E+00	.7962E-01	.3396E+04
5.851100	.8997E-04	.7971E+00	.7171E-01	.3398E+04
5.859400	.8418E-04	.7640E+00	.6431E-01	.3400E+04
5.867800	.7854E-04	.7305E+00	.5738E-01	.3402E+04

5.876100	.6870E-04	.6974E+00	.4791E-01	.3403E+04
5.884400	.6351E-04	.6644E+00	.4220E-01	.3404E+04
5.892800	.5850E-04	.6309E+00	.3691E-01	.3405E+04
5.901100	.5365E-04	.5978E+00	.3207E-01	.3406E+04
5.909400	.4897E-04	.5647E+00	.2765E-01	.3407E+04
5.917800	.4445E-04	.5313E+00	.2362E-01	.3408E+04
5.926100	.4012E-04	.4982E+00	.1999E-01	.3408E+04
5.934400	.3597E-04	.4651E+00	.1673E-01	.3409E+04
5.942800	.2890E-04	.4316E+00	.1247E-01	.3409E+04
5.951100	.2528E-04	.3985E+00	.1007E-01	.3410E+04
5.959400	.2185E-04	.3655E+00	.7987E-02	.3410E+04
5.967800	.1863E-04	.3320E+00	.6186E-02	.3410E+04
5.976100	.1562E-04	.2989E+00	.4670E-02	.3410E+04
5.984400	.1283E-04	.2658E+00	.3411E-02	.3410E+04
5.992800	.1026E-04	.2323E+00	.2385E-02	.3410E+04
6.001100	.7932E-05	.1993E+00	.1581E-02	.3410E+04
6.009400	.5848E-05	.1662E+00	.9718E-03	.3410E+04
6.017800	.4027E-05	.1327E+00	.5344E-03	.3410E+04
6.026100	.2489E-05	.9964E-01	.2480E-03	.3410E+04
6.034400	.1264E-05	.6656E-01	.8411E-04	.3410E+04
6.042800	.3966E-06	.3308E-01	.1312E-04	.3410E+04
6.051100	.0000E+00	.0000E+00	.0000E+00	.3410E+04

Total runoff volume going through collector field_1 = 1.391100443 m^3
Total sediment going through collector field_1 = 3410.441021709 g

Collector= field_2
Number of field samples= 3

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
5.092800	.0000E+00	.0000E+00	.0000E+00	.0000E+00
5.101100	.1276E-04	.4476E+00	.5713E-02	.1707E+00
5.109500	.3952E-04	.9007E+00	.3559E-01	.1247E+01
5.117800	.7588E-04	.1348E+01	.1023E+00	.4304E+01
5.126100	.9174E-04	.1796E+01	.1648E+00	.9227E+01
5.134400	.1114E-03	.2244E+01	.2500E+00	.1670E+02
5.142800	.1498E-03	.2697E+01	.4039E+00	.2891E+02
5.151100	.2127E-03	.3014E+01	.6411E+00	.4807E+02
5.159500	.2623E-03	.2474E+01	.6488E+00	.6769E+02
5.167800	.3448E-03	.2056E+01	.7087E+00	.8886E+02
5.176100	.4140E-03	.2370E+01	.9811E+00	.1182E+03
5.184500	.4790E-03	.2640E+01	.1264E+01	.1564E+03
5.192800	.5179E-03	.2614E+01	.1354E+01	.1969E+03
5.201100	.5736E-03	.2589E+01	.1485E+01	.2412E+03
5.209400	.5892E-03	.2564E+01	.1511E+01	.2864E+03
5.217800	.5892E-03	.2538E+01	.1495E+01	.3316E+03
5.226100	.5892E-03	.2513E+01	.1481E+01	.3758E+03
5.234400	.5893E-03	.2488E+01	.1466E+01	.4196E+03
5.242800	.6264E-03	.2462E+01	.1542E+01	.4663E+03
5.251100	.7035E-03	.2437E+01	.1714E+01	.5175E+03
5.259400	.8021E-03	.2412E+01	.1934E+01	.5753E+03
5.267800	.9062E-03	.2386E+01	.2162E+01	.6407E+03
5.276100	.9829E-03	.2361E+01	.2320E+01	.7100E+03
5.284400	.1009E-02	.2335E+01	.2357E+01	.7804E+03
5.292800	.9945E-03	.2310E+01	.2297E+01	.8499E+03
5.301100	.9800E-03	.2285E+01	.2239E+01	.9168E+03
5.309400	.9720E-03	.2259E+01	.2196E+01	.9824E+03
5.317800	.9770E-03	.2234E+01	.2182E+01	.1048E+04
5.326100	.9690E-03	.2208E+01	.2140E+01	.1112E+04
5.334400	.9354E-03	.2183E+01	.2042E+01	.1173E+04
5.342800	.9024E-03	.2158E+01	.1947E+01	.1232E+04
5.351100	.9135E-03	.2132E+01	.1948E+01	.1290E+04
5.359400	.8746E-03	.2107E+01	.1843E+01	.1346E+04
5.367800	.8670E-03	.2081E+01	.1805E+01	.1400E+04
5.376100	.8594E-03	.2056E+01	.1767E+01	.1453E+04
5.384400	.8519E-03	.2031E+01	.1730E+01	.1505E+04
5.392800	.8444E-03	.2005E+01	.1693E+01	.1556E+04
5.401100	.8369E-03	.1980E+01	.1657E+01	.1605E+04
5.409400	.7935E-03	.1955E+01	.1551E+01	.1652E+04
5.417800	.7862E-03	.1929E+01	.1517E+01	.1698E+04
5.426100	.7555E-03	.1904E+01	.1438E+01	.1740E+04
5.434400	.7484E-03	.1879E+01	.1406E+01	.1782E+04
5.442800	.7413E-03	.1853E+01	.1374E+01	.1824E+04
5.451100	.7342E-03	.1828E+01	.1342E+01	.1864E+04
5.459400	.6876E-03	.1802E+01	.1239E+01	.1901E+04
5.467800	.6808E-03	.1777E+01	.1210E+01	.1938E+04
5.476100	.6740E-03	.1752E+01	.1180E+01	.1973E+04
5.484400	.6672E-03	.1726E+01	.1152E+01	.2007E+04
5.492800	.6604E-03	.1701E+01	.1123E+01	.2041E+04
5.501100	.6537E-03	.1675E+01	.1095E+01	.2074E+04
5.509400	.6470E-03	.1650E+01	.1068E+01	.2106E+04
5.517800	.6135E-03	.1624E+01	.9966E+00	.2136E+04
5.526100	.6070E-03	.1599E+01	.9706E+00	.2165E+04
5.534400	.6005E-03	.1574E+01	.9451E+00	.2193E+04
5.542800	.5940E-03	.1548E+01	.9197E+00	.2221E+04
5.551100	.5876E-03	.1523E+01	.8949E+00	.2248E+04
5.559400	.5812E-03	.1498E+01	.8705E+00	.2274E+04
5.567800	.5748E-03	.1472E+01	.8462E+00	.2300E+04
5.576100	.5685E-03	.1447E+01	.8225E+00	.2324E+04
5.584400	.5622E-03	.1422E+01	.7992E+00	.2348E+04
5.592800	.5559E-03	.1396E+01	.7760E+00	.2371E+04
5.601100	.5496E-03	.1371E+01	.7534E+00	.2394E+04
5.609400	.5434E-03	.1345E+01	.7312E+00	.2416E+04
5.617800	.5372E-03	.1320E+01	.7091E+00	.2437E+04
5.626100	.5311E-03	.1295E+01	.6875E+00	.2458E+04

5.634400	.5250E-03	.1269E+01	.6663E+00	.2478E+04
5.642800	.5189E-03	.1244E+01	.6453E+00	.2497E+04
5.651100	.5128E-03	.1218E+01	.6248E+00	.2516E+04
5.659400	.4128E-03	.1193E+01	.4926E+00	.2531E+04
5.667800	.3940E-03	.1168E+01	.4600E+00	.2545E+04
5.676100	.3886E-03	.1142E+01	.4439E+00	.2558E+04
5.684400	.3832E-03	.1117E+01	.4281E+00	.2571E+04
5.692800	.3779E-03	.1091E+01	.4125E+00	.2583E+04
5.701100	.3726E-03	.1066E+01	.3973E+00	.2595E+04
5.709400	.3674E-03	.1041E+01	.3824E+00	.2606E+04
5.717800	.3621E-03	.1015E+01	.3677E+00	.2617E+04
5.726100	.3527E-03	.9900E+00	.3492E+00	.2628E+04
5.734400	.3476E-03	.9647E+00	.3353E+00	.2638E+04
5.742800	.3425E-03	.9391E+00	.3216E+00	.2648E+04
5.751100	.3374E-03	.9138E+00	.3083E+00	.2657E+04
5.759400	.3324E-03	.8885E+00	.2953E+00	.2666E+04
5.767800	.3274E-03	.8630E+00	.2825E+00	.2674E+04
5.776100	.3224E-03	.8377E+00	.2700E+00	.2682E+04
5.784400	.3174E-03	.8124E+00	.2579E+00	.2690E+04
5.792800	.3125E-03	.7868E+00	.2459E+00	.2697E+04
5.801100	.3076E-03	.7615E+00	.2343E+00	.2704E+04
5.809400	.3028E-03	.7362E+00	.2229E+00	.2711E+04
5.817800	.2980E-03	.7107E+00	.2117E+00	.2718E+04
5.826100	.2932E-03	.6854E+00	.2009E+00	.2724E+04
5.834400	.2884E-03	.6601E+00	.1904E+00	.2729E+04
5.842800	.2837E-03	.6345E+00	.1800E+00	.2735E+04
5.851100	.2790E-03	.6092E+00	.1700E+00	.2740E+04
5.859400	.2744E-03	.5839E+00	.1602E+00	.2745E+04
5.867800	.2698E-03	.5583E+00	.1506E+00	.2749E+04
5.876100	.2297E-04	.5331E+00	.1224E-01	.2749E+04
5.884400	.2139E-04	.5078E+00	.1086E-01	.2750E+04
5.892800	.1986E-04	.4822E+00	.9577E-02	.2750E+04
5.901100	.1838E-04	.4569E+00	.8398E-02	.2750E+04
5.909400	.1695E-04	.4316E+00	.7316E-02	.2751E+04
5.917800	.1448E-04	.4060E+00	.5879E-02	.2751E+04
5.926100	.1319E-04	.3808E+00	.5022E-02	.2751E+04
5.934400	.1195E-04	.3555E+00	.4249E-02	.2751E+04
5.942800	.8953E-05	.3299E+00	.2954E-02	.2751E+04
5.951100	.7911E-05	.3046E+00	.2410E-02	.2751E+04
5.959400	.6924E-05	.2793E+00	.1934E-02	.2751E+04
5.967800	.5994E-05	.2537E+00	.1521E-02	.2751E+04
5.976100	.5122E-05	.2285E+00	.1170E-02	.2751E+04
5.984400	.4309E-05	.2032E+00	.8756E-03	.2751E+04
5.992800	.3558E-05	.1776E+00	.6318E-03	.2751E+04
6.001100	.2868E-05	.1523E+00	.4369E-03	.2751E+04
6.009400	.2244E-05	.1270E+00	.2850E-03	.2751E+04
6.017800	.1686E-05	.1014E+00	.1710E-03	.2751E+04
6.026100	.1197E-05	.7615E-01	.9119E-04	.2751E+04
6.034400	.7825E-06	.5087E-01	.3980E-04	.2751E+04
6.042800	.4453E-06	.2528E-01	.1126E-04	.2751E+04
6.051100	.0000E+00	.0000E+00	.0000E+00	.2751E+04

Total runoff volume going through collector field_2 = 1.532426688 m^3
Total sediment going through collector field_2 = 2751.340466991 g

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 4.999688889 h
Event on u331c-92

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.1391E+01	395.	1115.	.1191E-02	3785.
field_2	.1532E+01	365.	1025.	.1009E-02	3785.
g4_1	.1161E+01	365.	1115.	.1047E-02	3785.
g4_2	.7396E+00	515.	1115.	.9005E-03	3785.
g8_1	.1035E+01	365.	1115.	.1061E-02	3785.
g8_2	.2093E+01	365.	1145.	.1604E-02	3785.
rip_1	.2245E-01	395.	545.	.1943E-04	3785.
rip_2	.5069E+00	365.	1055.	.5673E-03	3785.
field_avg	.1462E+01	365.	1055.	.1093E-02	3785.
g4_avg	.9501E+00	365.	1115.	.9739E-03	3785.
g8_avg	.1564E+01	365.	1115.	.1332E-02	3785.

RAINFALL DATA FOR EVENT u331c-92

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 4.999688889 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.8467E-06
.3002E+03	.1101E-04
.6001E+03	.1101E-04
.9000E+03	.7620E-05
.1200E+04	.8467E-06

.1501E+04	.0000E+00
.2103E+04	.0000E+00

Total rainfall volume= 0.940 cm

Table 11. Summary of field data for event on (01/24/93)

TABLE OF SEDIMENT AND RUNOFF DATA(01/24/93)

Files used= u024-93.q u024-93.sedin
Collector= g4_1
Number of field samples= 3

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
15.184400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
15.192800	.7036E-07	.1068E+00	.7517E-05	.2273E-03
15.201100	.7036E-07	.2124E+00	.1495E-04	.6739E-03
15.209400	.2296E-06	.3180E+00	.7300E-04	.2855E-02
15.217800	.2296E-06	.4249E+00	.9753E-04	.5805E-02
15.226100	.2296E-06	.5304E+00	.1218E-03	.9443E-02
15.234400	.2296E-06	.6360E+00	.1460E-03	.1381E-01
15.242800	.2296E-06	.7429E+00	.1705E-03	.1896E-01
15.251100	.7036E-07	.8484E+00	.5969E-04	.2075E-01
15.259400	.7036E-07	.9540E+00	.6712E-04	.2275E-01
15.267800	.2287E-06	.1061E+01	.2426E-03	.3009E-01
15.276100	.2287E-06	.1166E+01	.2667E-03	.3806E-01
15.284400	.1606E-03	.1272E+01	.2043E+00	.6144E+01
15.292800	.3073E-03	.1379E+01	.4237E+00	.1896E+02
15.301100	.3591E-03	.1484E+01	.5330E+00	.3488E+02
15.309400	.3632E-03	.1590E+01	.5775E+00	.5214E+02
15.317800	.4863E-03	.1697E+01	.8252E+00	.7709E+02
15.326100	.5290E-03	.1802E+01	.9536E+00	.1056E+03
15.334400	.5436E-03	.1908E+01	.1037E+01	.1366E+03
15.342800	.5534E-03	.2015E+01	.1115E+01	.1703E+03
15.351100	.5583E-03	.2120E+01	.1184E+01	.2057E+03
15.359400	.5583E-03	.2226E+01	.1243E+01	.2428E+03
15.367800	.5583E-03	.2300E+01	.1284E+01	.2816E+03
15.376100	.5583E-03	.2166E+01	.1209E+01	.3178E+03
15.384400	.5583E-03	.2031E+01	.1134E+01	.3517E+03
15.392800	.5633E-03	.1895E+01	.1068E+01	.3839E+03
15.401100	.5633E-03	.1763E+01	.9932E+00	.4136E+03
15.409400	.5682E-03	.1648E+01	.9363E+00	.4416E+03
15.417800	.5238E-03	.1531E+01	.8017E+00	.4658E+03
15.426100	.4855E-03	.1415E+01	.6870E+00	.4864E+03
15.434400	.4484E-03	.1313E+01	.5889E+00	.5040E+03
15.442800	.4126E-03	.1305E+01	.5382E+00	.5202E+03
15.451100	.3779E-03	.1296E+01	.4898E+00	.5349E+03
15.459400	.3446E-03	.1287E+01	.4437E+00	.5481E+03
15.467800	.3125E-03	.1279E+01	.3997E+00	.5602E+03
15.476100	.2818E-03	.1270E+01	.3580E+00	.5709E+03
15.484400	.2524E-03	.1262E+01	.3184E+00	.5804E+03
15.492800	.2243E-03	.1253E+01	.2811E+00	.5889E+03
15.501100	.1850E-03	.1245E+01	.2302E+00	.5958E+03
15.509400	.1517E-03	.1236E+01	.1875E+00	.6014E+03
15.517800	.1211E-03	.1227E+01	.1487E+00	.6059E+03
15.526100	.1007E-03	.1219E+01	.1227E+00	.6096E+03
15.534400	.8184E-04	.1210E+01	.9905E-01	.6125E+03
15.542800	.6464E-04	.1202E+01	.7767E-01	.6149E+03
15.551100	.4915E-04	.1193E+01	.5864E-01	.6166E+03
15.559400	.3546E-04	.1184E+01	.4200E-01	.6179E+03
15.567800	.2367E-04	.1176E+01	.2783E-01	.6187E+03
15.576100	.1393E-04	.1167E+01	.1625E-01	.6192E+03
15.584400	.4267E-05	.1159E+01	.4945E-02	.6194E+03
15.592800	.0000E+00	.1150E+01	.0000E+00	.6194E+03
15.601100	.0000E+00	.1142E+01	.0000E+00	.6194E+03
15.759400	.0000E+00	.9785E+00	.0000E+00	.6194E+03
15.767800	.0000E+00	.9698E+00	.0000E+00	.6194E+03
15.776100	.0000E+00	.9613E+00	.0000E+00	.6194E+03
16.009400	.0000E+00	.7210E+00	.0000E+00	.6194E+03
16.017800	.0000E+00	.7123E+00	.0000E+00	.6194E+03
16.026100	.0000E+00	.7038E+00	.0000E+00	.6194E+03
16.034400	.5240E-08	.6952E+00	.3643E-05	.6194E+03
16.042800	.3149E-07	.6866E+00	.2162E-04	.6194E+03
16.051100	.0000E+00	.6780E+00	.0000E+00	.6194E+03
16.059400	.0000E+00	.6695E+00	.0000E+00	.6194E+03
16.459400	.0000E+00	.2575E+00	.0000E+00	.6194E+03
16.467800	.0000E+00	.2488E+00	.0000E+00	.6194E+03
16.476100	.0000E+00	.2403E+00	.0000E+00	.6194E+03
16.484400	.0000E+00	.2317E+00	.0000E+00	.6194E+03
16.492800	.0000E+00	.2231E+00	.0000E+00	.6194E+03
16.501100	.0000E+00	.2145E+00	.0000E+00	.6194E+03
16.509400	.0000E+00	.2060E+00	.0000E+00	.6194E+03
16.517800	.0000E+00	.1973E+00	.0000E+00	.6194E+03
16.526100	.0000E+00	.1888E+00	.0000E+00	.6194E+03
16.534400	.0000E+00	.1802E+00	.0000E+00	.6194E+03
16.542800	.0000E+00	.1716E+00	.0000E+00	.6194E+03
16.551100	.0000E+00	.1630E+00	.0000E+00	.6194E+03
16.559400	.0000E+00	.1545E+00	.0000E+00	.6194E+03
16.567800	.0000E+00	.1458E+00	.0000E+00	.6194E+03

16.576100	.0000E+00	.1373E+00	.0000E+00	.6194E+03
16.584400	.0000E+00	.1287E+00	.0000E+00	.6194E+03
16.592800	.0000E+00	.1201E+00	.0000E+00	.6194E+03
16.601100	.0000E+00	.1115E+00	.0000E+00	.6194E+03
16.609400	.0000E+00	.1030E+00	.0000E+00	.6194E+03
16.617800	.0000E+00	.9435E-01	.0000E+00	.6194E+03
16.626100	.0000E+00	.8580E-01	.0000E+00	.6194E+03
16.634400	.0000E+00	.7725E-01	.0000E+00	.6194E+03
16.642800	.0000E+00	.6860E-01	.0000E+00	.6194E+03
16.651100	.0000E+00	.6005E-01	.0000E+00	.6194E+03
16.659400	.0000E+00	.5150E-01	.0000E+00	.6194E+03
16.667800	.0000E+00	.4285E-01	.0000E+00	.6194E+03
16.676100	.0000E+00	.3430E-01	.0000E+00	.6194E+03
16.684400	.0000E+00	.2575E-01	.0000E+00	.6194E+03
16.692800	.0000E+00	.1710E-01	.0000E+00	.6194E+03
16.701100	.0000E+00	.8549E-02	.0000E+00	.6194E+03
16.709400	.0000E+00	.0000E+00	.0000E+00	.6194E+03

Total runoff volume going through collector g4_1 = .368598618 m^3
Total sediment going through collector g4_1 = 619.355266601 g

Collector= g8_1
Number of field samples= 3

time (h)	q (m3/s)	Sed. conc. (g/1)	Sed. load (g/s)	Cumulative (g)
15.184400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
15.192800	.6404E-06	.1986E+00	.1272E-03	.3845E-02
15.201100	.6404E-06	.3948E+00	.2528E-03	.1140E-01
15.209400	.1302E-05	.5910E+00	.7696E-03	.3440E-01
15.217800	.1302E-05	.7896E+00	.1028E-02	.6549E-01
15.226100	.1302E-05	.9858E+00	.1284E-02	.1038E+00
15.234400	.1302E-05	.1182E+01	.1539E-02	.1498E+00
15.242800	.1302E-05	.1381E+01	.1798E-02	.2042E+00
15.251100	.1302E-05	.1577E+01	.2053E-02	.2656E+00
15.259400	.1302E-05	.1773E+01	.2309E-02	.3346E+00
15.267800	.1301E-05	.1972E+01	.2564E-02	.4121E+00
15.276100	.1301E-05	.2168E+01	.2819E-02	.4963E+00
15.284400	.1704E-05	.2364E+01	.4028E-02	.6167E+00
15.292800	.1301E-05	.2563E+01	.3333E-02	.7175E+00
15.301100	.9449E-06	.2759E+01	.2607E-02	.7953E+00
15.309400	.9449E-06	.2955E+01	.2792E-02	.8788E+00
15.317800	.9439E-06	.3153E+01	.2977E-02	.9688E+00
15.326100	.1299E-05	.3350E+01	.4353E-02	.1099E+01
15.334400	.9439E-06	.3546E+01	.3347E-02	.1199E+01
15.342800	.9439E-06	.3744E+01	.3535E-02	.1306E+01
15.351100	.1299E-05	.3941E+01	.5121E-02	.1459E+01
15.359400	.1299E-05	.4137E+01	.5376E-02	.1619E+01
15.367800	.1299E-05	.4335E+01	.5634E-02	.1790E+01
15.376100	.1299E-05	.4532E+01	.5889E-02	.1966E+01
15.384400	.1299E-05	.4728E+01	.6143E-02	.2149E+01
15.392800	.1299E-05	.4926E+01	.6401E-02	.2343E+01
15.401100	.1299E-05	.5123E+01	.6656E-02	.2542E+01
15.409400	.1299E-05	.5319E+01	.6911E-02	.2748E+01
15.417800	.1299E-05	.5517E+01	.7166E-02	.2965E+01
15.426100	.1299E-05	.5714E+01	.7421E-02	.3187E+01
15.434400	.1299E-05	.5910E+01	.7676E-02	.3416E+01
15.442800	.1299E-05	.6108E+01	.7934E-02	.3656E+01
15.451100	.1299E-05	.6305E+01	.8189E-02	.3901E+01
15.459400	.1299E-05	.6501E+01	.8443E-02	.4153E+01
15.467800	.1299E-05	.6699E+01	.8701E-02	.4416E+01
15.476100	.1299E-05	.6896E+01	.8956E-02	.4684E+01
15.484400	.1299E-05	.7092E+01	.9211E-02	.4959E+01
15.492800	.1299E-05	.7290E+01	.9469E-02	.5245E+01
15.501100	.8056E-05	.7487E+01	.6031E-01	.7047E+01
15.509400	.1583E-04	.7683E+01	.1216E+00	.1068E+02
15.517800	.2995E-04	.7881E+01	.2361E+00	.1782E+02
15.526100	.2995E-04	.8078E+01	.2420E+00	.2505E+02
15.534400	.2995E-04	.8274E+01	.2478E+00	.3245E+02
15.542800	.2995E-04	.8472E+01	.2538E+00	.4013E+02
15.551100	.2995E-04	.8283E+01	.2481E+00	.4754E+02
15.559400	.2995E-04	.5571E+01	.1669E+00	.5253E+02
15.567800	.2995E-04	.3244E+01	.9718E-01	.5547E+02
15.576100	.2995E-04	.3600E+01	.1078E+00	.5869E+02
15.584400	.3143E-04	.3907E+01	.1228E+00	.6236E+02
15.592800	.3143E-04	.3878E+01	.1219E+00	.6604E+02
15.601100	.0000E+00	.3849E+01	.0000E+00	.6604E+02
15.759400	.0000E+00	.3299E+01	.0000E+00	.6604E+02
15.767800	.0000E+00	.3270E+01	.0000E+00	.6604E+02
15.776100	.0000E+00	.3241E+01	.0000E+00	.6604E+02
16.009400	.0000E+00	.2431E+01	.0000E+00	.6604E+02
16.017800	.0000E+00	.2402E+01	.0000E+00	.6604E+02
16.026100	.0000E+00	.2373E+01	.0000E+00	.6604E+02
16.034400	.0000E+00	.2344E+01	.0000E+00	.6604E+02
16.042800	.0000E+00	.2315E+01	.0000E+00	.6604E+02
16.051100	.0000E+00	.2286E+01	.0000E+00	.6604E+02
16.059400	.0000E+00	.2257E+01	.0000E+00	.6604E+02
16.459400	.0000E+00	.8682E+00	.0000E+00	.6604E+02
16.467800	.0000E+00	.8390E+00	.0000E+00	.6604E+02
16.476100	.0000E+00	.8102E+00	.0000E+00	.6604E+02
16.484400	.0000E+00	.7814E+00	.0000E+00	.6604E+02
16.492800	.0000E+00	.7522E+00	.0000E+00	.6604E+02
16.501100	.0000E+00	.7234E+00	.0000E+00	.6604E+02
16.509400	.0000E+00	.6946E+00	.0000E+00	.6604E+02
16.517800	.0000E+00	.6654E+00	.0000E+00	.6604E+02
16.526100	.0000E+00	.6366E+00	.0000E+00	.6604E+02

16.534400	.0000E+00	.6077E+00	.0000E+00	.6604E+02
16.542800	.0000E+00	.5786E+00	.0000E+00	.6604E+02
16.551100	.0000E+00	.5498E+00	.0000E+00	.6604E+02
16.559400	.0000E+00	.5209E+00	.0000E+00	.6604E+02
16.567800	.0000E+00	.4918E+00	.0000E+00	.6604E+02
16.576100	.0000E+00	.4629E+00	.0000E+00	.6604E+02
16.584400	.0000E+00	.4341E+00	.0000E+00	.6604E+02
16.592800	.0000E+00	.4049E+00	.0000E+00	.6604E+02
16.601100	.0000E+00	.3761E+00	.0000E+00	.6604E+02
16.609400	.0000E+00	.3473E+00	.0000E+00	.6604E+02
16.617800	.0000E+00	.3181E+00	.0000E+00	.6604E+02
16.626100	.0000E+00	.2893E+00	.0000E+00	.6604E+02
16.634400	.0000E+00	.2605E+00	.0000E+00	.6604E+02
16.642800	.0000E+00	.2313E+00	.0000E+00	.6604E+02
16.651100	.0000E+00	.2025E+00	.0000E+00	.6604E+02
16.659400	.0000E+00	.1736E+00	.0000E+00	.6604E+02
16.667800	.0000E+00	.1445E+00	.0000E+00	.6604E+02
16.676100	.0000E+00	.1156E+00	.0000E+00	.6604E+02
16.684400	.0000E+00	.8682E-01	.0000E+00	.6604E+02
16.692800	.0000E+00	.5765E-01	.0000E+00	.6604E+02
16.701100	.0000E+00	.2882E-01	.0000E+00	.6604E+02
16.709400	.0000E+00	.2168E-18	.0000E+00	.6604E+02

Total runoff volume going through collector g8_1 = .011157835 m^3
Total sediment going through collector g8_1 = 66.043184725 g

Collector= field_1
Number of field samples= 3

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
15.184400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
15.192800	.6514E-05	.2956E+01	.1925E-01	.5823E+00
15.201100	.4511E-03	.5876E+01	.2651E+01	.7980E+02
15.209400	.6130E-03	.8797E+01	.5393E+01	.2409E+03
15.217800	.6130E-03	.1175E+02	.7205E+01	.4588E+03
15.226100	.6130E-03	.1467E+02	.8995E+01	.7276E+03
15.234400	.6130E-03	.1716E+02	.1052E+02	.1042E+04
15.242800	.6130E-03	.1665E+02	.1021E+02	.1351E+04
15.251100	.6130E-03	.1616E+02	.9906E+01	.1647E+04
15.259400	.6130E-03	.1566E+02	.9603E+01	.1933E+04
15.267800	.6130E-03	.1518E+02	.9304E+01	.2215E+04
15.276100	.6130E-03	.1478E+02	.9063E+01	.2486E+04
15.284400	.6182E-03	.1439E+02	.8897E+01	.2751E+04
15.292800	.6130E-03	.1399E+02	.8578E+01	.3011E+04
15.301100	.6130E-03	.1360E+02	.8337E+01	.3260E+04
15.309400	.6287E-03	.1321E+02	.8303E+01	.3508E+04
15.317800	.6605E-03	.1281E+02	.8461E+01	.3764E+04
15.326100	.6605E-03	.1242E+02	.8201E+01	.4009E+04
15.334400	.6659E-03	.1202E+02	.8006E+01	.4248E+04
15.342800	.6273E-03	.1163E+02	.7293E+01	.4469E+04
15.351100	.5948E-03	.1123E+02	.6681E+01	.4668E+04
15.359400	.5630E-03	.1084E+02	.6103E+01	.4851E+04
15.367800	.5319E-03	.1044E+02	.5554E+01	.5019E+04
15.376100	.5015E-03	.1005E+02	.5039E+01	.5169E+04
15.384400	.4718E-03	.9655E+01	.4556E+01	.5305E+04
15.392800	.4429E-03	.9258E+01	.4100E+01	.5429E+04
15.401100	.4147E-03	.8865E+01	.3676E+01	.5539E+04
15.409400	.3872E-03	.8472E+01	.3281E+01	.5637E+04
15.417800	.3605E-03	.8074E+01	.2911E+01	.5725E+04
15.426100	.3346E-03	.7681E+01	.2570E+01	.5802E+04
15.434400	.3095E-03	.7288E+01	.2256E+01	.5869E+04
15.442800	.2852E-03	.6890E+01	.1965E+01	.5929E+04
15.451100	.2616E-03	.6497E+01	.1700E+01	.5980E+04
15.459400	.2354E-03	.6104E+01	.1437E+01	.6023E+04
15.467800	.2136E-03	.5706E+01	.1219E+01	.6059E+04
15.476100	.1927E-03	.5313E+01	.1024E+01	.6090E+04
15.484400	.1727E-03	.4920E+01	.8498E+00	.6115E+04
15.492800	.1536E-03	.4522E+01	.6947E+00	.6136E+04
15.501100	.1135E-03	.4129E+01	.4686E+00	.6150E+04
15.509400	.9253E-04	.3736E+01	.3457E+00	.6161E+04
15.517800	.7331E-04	.3338E+01	.2447E+00	.6168E+04
15.526100	.5998E-04	.2945E+01	.1766E+00	.6173E+04
15.534400	.4774E-04	.2552E+01	.1218E+00	.6177E+04
15.542800	.3666E-04	.2154E+01	.7897E-01	.6179E+04
15.551100	.2678E-04	.1812E+01	.4851E-01	.6181E+04
15.559400	.1819E-04	.1799E+01	.3271E-01	.6182E+04
15.567800	.1098E-04	.1786E+01	.1961E-01	.6182E+04
15.576100	.5315E-05	.1773E+01	.9422E-02	.6183E+04
15.584400	.1433E-05	.1760E+01	.2521E-02	.6183E+04
15.592800	.0000E+00	.1746E+01	.0000E+00	.6183E+04
15.601100	.0000E+00	.1733E+01	.0000E+00	.6183E+04
15.759400	.0000E+00	.1486E+01	.0000E+00	.6183E+04
15.767800	.0000E+00	.1473E+01	.0000E+00	.6183E+04
15.776100	.0000E+00	.1460E+01	.0000E+00	.6183E+04
16.009400	.0000E+00	.1095E+01	.0000E+00	.6183E+04
16.017800	.0000E+00	.1082E+01	.0000E+00	.6183E+04
16.026100	.0000E+00	.1069E+01	.0000E+00	.6183E+04
16.034400	.2042E-07	.1056E+01	.2156E-04	.6183E+04
16.042800	.1243E-06	.1043E+01	.1296E-03	.6183E+04
16.051100	.0000E+00	.1030E+01	.0000E+00	.6183E+04
16.059400	.0000E+00	.1017E+01	.0000E+00	.6183E+04
16.459400	.0000E+00	.3910E+00	.0000E+00	.6183E+04
16.467800	.0000E+00	.3779E+00	.0000E+00	.6183E+04
16.476100	.0000E+00	.3649E+00	.0000E+00	.6183E+04
16.484400	.0000E+00	.3519E+00	.0000E+00	.6183E+04

16.492800	.0000E+00	.3388E+00	.0000E+00	.6183E+04
16.501100	.0000E+00	.3258E+00	.0000E+00	.6183E+04
16.509400	.0000E+00	.3128E+00	.0000E+00	.6183E+04
16.517800	.0000E+00	.2997E+00	.0000E+00	.6183E+04
16.526100	.0000E+00	.2867E+00	.0000E+00	.6183E+04
16.534400	.0000E+00	.2737E+00	.0000E+00	.6183E+04
16.542800	.0000E+00	.2606E+00	.0000E+00	.6183E+04
16.551100	.0000E+00	.2476E+00	.0000E+00	.6183E+04
16.559400	.0000E+00	.2346E+00	.0000E+00	.6183E+04
16.567800	.0000E+00	.2215E+00	.0000E+00	.6183E+04
16.576100	.0000E+00	.2085E+00	.0000E+00	.6183E+04
16.584400	.0000E+00	.1955E+00	.0000E+00	.6183E+04
16.592800	.0000E+00	.1824E+00	.0000E+00	.6183E+04
16.601100	.0000E+00	.1694E+00	.0000E+00	.6183E+04
16.609400	.0000E+00	.1564E+00	.0000E+00	.6183E+04
16.617800	.0000E+00	.1433E+00	.0000E+00	.6183E+04
16.626100	.0000E+00	.1303E+00	.0000E+00	.6183E+04
16.634400	.1786E-08	.1173E+00	.2096E-06	.6183E+04
16.642800	.5894E-08	.1042E+00	.6140E-06	.6183E+04
16.651100	.1174E-07	.9118E-01	.1071E-05	.6183E+04
16.659400	.1911E-07	.7820E-01	.1494E-05	.6183E+04
16.667800	.2784E-07	.6506E-01	.1812E-05	.6183E+04
16.676100	.3785E-07	.5208E-01	.1972E-05	.6183E+04
16.684400	.4906E-07	.3910E-01	.1918E-05	.6183E+04
16.692800	.6141E-07	.2596E-01	.1594E-05	.6183E+04
16.701100	.7485E-07	.1298E-01	.9717E-06	.6183E+04
16.709400	.0000E+00	.0000E+00	.0000E+00	.6183E+04

Total runoff volume going through collector field_1 = .53924086 m^3
Total sediment going through collector field_1 = 6182.844149125 g

Collector= g4_2
Number of field samples= 6

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
15.184400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
15.192800	.0000E+00	.7529E-01	.0000E+00	.0000E+00
15.201100	.0000E+00	.1497E+00	.0000E+00	.0000E+00
15.209400	.0000E+00	.2241E+00	.0000E+00	.0000E+00
15.217800	.0000E+00	.2994E+00	.0000E+00	.0000E+00
15.226100	.0000E+00	.3738E+00	.0000E+00	.0000E+00
15.234400	.0000E+00	.4481E+00	.0000E+00	.0000E+00
15.242800	.0000E+00	.5234E+00	.0000E+00	.0000E+00
15.251100	.0000E+00	.5978E+00	.0000E+00	.0000E+00
15.259400	.0000E+00	.6722E+00	.0000E+00	.0000E+00
15.267800	.0000E+00	.7475E+00	.0000E+00	.0000E+00
15.276100	.0000E+00	.8219E+00	.0000E+00	.0000E+00
15.284400	.1144E-06	.8963E+00	.1025E-03	.3064E-02
15.292800	.0000E+00	.9716E+00	.0000E+00	.3064E-02
15.301100	.1956E-03	.1046E+01	.2046E+00	.6115E+01
15.309400	.2700E-03	.1120E+01	.3024E+00	.1515E+02
15.317800	.3326E-03	.1196E+01	.3977E+00	.2718E+02
15.326100	.3701E-03	.1270E+01	.4700E+00	.4122E+02
15.334400	.3743E-03	.1344E+01	.5033E+00	.5626E+02
15.342800	.3786E-03	.1420E+01	.5375E+00	.7252E+02
15.351100	.3829E-03	.1494E+01	.5721E+00	.8961E+02
15.359400	.3829E-03	.1569E+01	.6006E+00	.1076E+03
15.367800	.3829E-03	.1644E+01	.6294E+00	.1266E+03
15.376100	.3829E-03	.1718E+01	.6579E+00	.1462E+03
15.384400	.3829E-03	.1740E+01	.6664E+00	.1662E+03
15.392800	.3829E-03	.1405E+01	.5379E+00	.1824E+03
15.401100	.3829E-03	.1109E+01	.4248E+00	.1951E+03
15.409400	.3829E-03	.1051E+01	.4025E+00	.2071E+03
15.417800	.3829E-03	.9920E+00	.3798E+00	.2186E+03
15.426100	.3829E-03	.9337E+00	.3575E+00	.2293E+03
15.434400	.3829E-03	.8819E+00	.3377E+00	.2394E+03
15.442800	.3829E-03	.8734E+00	.3344E+00	.2495E+03
15.451100	.3829E-03	.8651E+00	.3312E+00	.2594E+03
15.459400	.3829E-03	.8568E+00	.3280E+00	.2692E+03
15.467800	.3829E-03	.8483E+00	.3248E+00	.2790E+03
15.476100	.3829E-03	.8400E+00	.3216E+00	.2886E+03
15.484400	.3829E-03	.8317E+00	.3184E+00	.2982E+03
15.492800	.3829E-03	.8232E+00	.3152E+00	.3077E+03
15.501100	.3829E-03	.8149E+00	.3120E+00	.3170E+03
15.509400	.3829E-03	.8066E+00	.3088E+00	.3262E+03
15.517800	.3828E-03	.7981E+00	.3056E+00	.3355E+03
15.526100	.3828E-03	.7898E+00	.3024E+00	.3445E+03
15.534400	.3828E-03	.7815E+00	.2992E+00	.3535E+03
15.542800	.3828E-03	.7730E+00	.2960E+00	.3624E+03
15.551100	.3828E-03	.7647E+00	.2928E+00	.3712E+03
15.559400	.3828E-03	.7564E+00	.2896E+00	.3798E+03
15.567800	.3828E-03	.7480E+00	.2863E+00	.3885E+03
15.576100	.3828E-03	.7396E+00	.2832E+00	.3969E+03
15.584400	.3872E-03	.7313E+00	.2831E+00	.4054E+03
15.592800	.0000E+00	.7229E+00	.0000E+00	.4054E+03
15.601100	.0000E+00	.7145E+00	.0000E+00	.4054E+03
15.759400	.0000E+00	.5556E+00	.0000E+00	.4054E+03
15.767800	.0000E+00	.5472E+00	.0000E+00	.4054E+03
15.776100	.0000E+00	.5389E+00	.0000E+00	.4054E+03
16.009400	.0000E+00	.3047E+00	.0000E+00	.4054E+03
16.017800	.0000E+00	.2963E+00	.0000E+00	.4054E+03
16.026100	.0000E+00	.2879E+00	.0000E+00	.4054E+03
16.034400	.0000E+00	.2796E+00	.0000E+00	.4054E+03
16.042800	.0000E+00	.2712E+00	.0000E+00	.4054E+03
16.051100	.0000E+00	.2628E+00	.0000E+00	.4054E+03

16.059400	.0000E+00	.2545E+00	.0000E+00	.4054E+03
16.459400	.0000E+00	.1399E+00	.0000E+00	.4054E+03
16.467800	.0000E+00	.1389E+00	.0000E+00	.4054E+03
16.476100	.0000E+00	.1379E+00	.0000E+00	.4054E+03
16.484400	.0000E+00	.1368E+00	.0000E+00	.4054E+03
16.492800	.0000E+00	.1358E+00	.0000E+00	.4054E+03
16.501100	.0000E+00	.1348E+00	.0000E+00	.4054E+03
16.509400	.0000E+00	.1337E+00	.0000E+00	.4054E+03
16.517800	.0000E+00	.1327E+00	.0000E+00	.4054E+03
16.526100	.0000E+00	.1317E+00	.0000E+00	.4054E+03
16.534400	.0000E+00	.1306E+00	.0000E+00	.4054E+03
16.542800	.0000E+00	.1296E+00	.0000E+00	.4054E+03
16.551100	.0000E+00	.1293E+00	.0000E+00	.4054E+03
16.559400	.0000E+00	.1341E+00	.0000E+00	.4054E+03
16.567800	.0000E+00	.1389E+00	.0000E+00	.4054E+03
16.576100	.0000E+00	.1436E+00	.0000E+00	.4054E+03
16.584400	.0000E+00	.1484E+00	.0000E+00	.4054E+03
16.592800	.3257E-07	.1532E+00	.4990E-05	.4054E+03
16.601100	.2059E-06	.1579E+00	.3253E-04	.4054E+03
16.609400	.4784E-06	.1627E+00	.7783E-04	.4054E+03
16.617800	.8314E-06	.1675E+00	.1393E-03	.4054E+03
16.626100	.1255E-05	.1723E+00	.2162E-03	.4054E+03
16.634400	.1744E-05	.1770E+00	.3086E-03	.4054E+03
16.642800	.2292E-05	.1818E+00	.4166E-03	.4054E+03
16.651100	.2896E-05	.1866E+00	.5402E-03	.4054E+03
16.659400	.3553E-05	.1913E+00	.6797E-03	.4055E+03
16.667800	.4261E-05	.1961E+00	.8356E-03	.4055E+03
16.676100	.5017E-05	.2009E+00	.1008E-02	.4055E+03
16.684400	.5821E-05	.2056E+00	.1197E-02	.4056E+03
16.692800	.6670E-05	.2104E+00	.1404E-02	.4056E+03
16.701100	.7563E-05	.1894E+00	.1433E-02	.4056E+03
16.709400	.0000E+00	.1355E-19	.0000E+00	.4056E+03

Total runoff volume going through collector g4_2 = .392087309 m^3
Total sediment going through collector g4_2 = 405.639137957 g

Collector= g8_2
Number of field samples= 5

time (h)	q (m3/s)	Sed. conc. (g/l)	Sed. load (g/s)	Cumulative (g)
15.184400	.0000E+00	.0000E+00	.0000E+00	.0000E+00
15.192800	.0000E+00	.6574E-01	.0000E+00	.0000E+00
15.201100	.0000E+00	.1307E+00	.0000E+00	.0000E+00
15.209400	.0000E+00	.1956E+00	.0000E+00	.0000E+00
15.217800	.0000E+00	.2614E+00	.0000E+00	.0000E+00
15.226100	.0000E+00	.3263E+00	.0000E+00	.0000E+00
15.234400	.0000E+00	.3913E+00	.0000E+00	.0000E+00
15.242800	.0000E+00	.4570E+00	.0000E+00	.0000E+00
15.251100	.0000E+00	.5220E+00	.0000E+00	.0000E+00
15.259400	.0000E+00	.5869E+00	.0000E+00	.0000E+00
15.267800	.0000E+00	.6527E+00	.0000E+00	.0000E+00
15.276100	.0000E+00	.7176E+00	.0000E+00	.0000E+00
15.284400	.4958E-07	.7826E+00	.3880E-04	.1159E-02
15.292800	.0000E+00	.8483E+00	.0000E+00	.1159E-02
15.301100	.0000E+00	.9133E+00	.0000E+00	.1159E-02
15.309400	.0000E+00	.9782E+00	.0000E+00	.1159E-02
15.317800	.0000E+00	.1044E+01	.0000E+00	.1159E-02
15.326100	.0000E+00	.1109E+01	.0000E+00	.1159E-02
15.334400	.0000E+00	.1174E+01	.0000E+00	.1159E-02
15.342800	.0000E+00	.1240E+01	.0000E+00	.1159E-02
15.351100	.4917E-07	.1305E+01	.6415E-04	.3076E-02
15.359400	.4917E-07	.1370E+01	.6734E-04	.5088E-02
15.367800	.4917E-07	.1435E+01	.7058E-04	.7223E-02
15.376100	.4917E-07	.1500E+01	.7377E-04	.9427E-02
15.384400	.5994E-04	.1565E+01	.9382E-01	.2813E+01
15.392800	.1393E-03	.1631E+01	.2272E+00	.9683E+01
15.401100	.2316E-03	.1696E+01	.3927E+00	.2142E+02
15.409400	.3794E-03	.1761E+01	.6680E+00	.4138E+02
15.417800	.4260E-03	.1827E+01	.7781E+00	.6491E+02
15.426100	.4260E-03	.1892E+01	.8058E+00	.8899E+02
15.434400	.4260E-03	.7537E+00	.3211E+00	.9858E+02
15.442800	.4260E-03	.5727E+00	.2440E+00	.1060E+03
15.451100	.4260E-03	.3938E+00	.1678E+00	.1110E+03
15.459400	.4260E-03	.2150E+00	.9158E-01	.1137E+03
15.467800	.4260E-03	.6033E-01	.2570E-01	.1145E+03
15.476100	.4260E-03	.7461E-01	.3178E-01	.1154E+03
15.484400	.4260E-03	.8889E-01	.3787E-01	.1166E+03
15.492800	.4260E-03	.1033E+00	.4402E-01	.1179E+03
15.501100	.4260E-03	.1176E+00	.5011E-01	.1194E+03
15.509400	.4260E-03	.1319E+00	.5619E-01	.1211E+03
15.517800	.4260E-03	.1464E+00	.6234E-01	.1230E+03
15.526100	.4260E-03	.1606E+00	.6842E-01	.1250E+03
15.534400	.4260E-03	.1749E+00	.7450E-01	.1272E+03
15.542800	.4260E-03	.1894E+00	.8066E-01	.1297E+03
15.551100	.4260E-03	.2036E+00	.8674E-01	.1323E+03
15.559400	.4260E-03	.2179E+00	.9283E-01	.1350E+03
15.567800	.4260E-03	.2324E+00	.9898E-01	.1380E+03
15.576100	.4260E-03	.2467E+00	.1051E+00	.1412E+03
15.584400	.4851E-03	.2609E+00	.1266E+00	.1449E+03
15.592800	.5316E-03	.2754E+00	.1464E+00	.1494E+03
15.601100	.0000E+00	.2897E+00	.0000E+00	.1494E+03
15.759400	.0000E+00	.2264E+00	.0000E+00	.1494E+03
15.767800	.0000E+00	.2244E+00	.0000E+00	.1494E+03
15.776100	.0000E+00	.2224E+00	.0000E+00	.1494E+03
16.009400	.0000E+00	.1668E+00	.0000E+00	.1494E+03

16.017800	.0000E+00	.1648E+00	.0000E+00	.1494E+03
16.026100	.3148E-08	.1628E+00	.5126E-06	.1494E+03
16.034400	.3503E-07	.1609E+00	.5636E-05	.1494E+03
16.042800	.9423E-07	.1589E+00	.1497E-04	.1494E+03
16.051100	.0000E+00	.1569E+00	.0000E+00	.1494E+03
16.059400	.0000E+00	.1549E+00	.0000E+00	.1494E+03
16.459400	.0000E+00	.5958E-01	.0000E+00	.1494E+03
16.467800	.0000E+00	.5758E-01	.0000E+00	.1494E+03
16.476100	.0000E+00	.5560E-01	.0000E+00	.1494E+03
16.484400	.0000E+00	.5362E-01	.0000E+00	.1494E+03
16.492800	.0000E+00	.5162E-01	.0000E+00	.1494E+03
16.501100	.0000E+00	.4964E-01	.0000E+00	.1494E+03
16.509400	.0000E+00	.4766E-01	.0000E+00	.1494E+03
16.517800	.0000E+00	.4566E-01	.0000E+00	.1494E+03
16.526100	.0000E+00	.4368E-01	.0000E+00	.1494E+03
16.534400	.0000E+00	.4171E-01	.0000E+00	.1494E+03
16.542800	.0000E+00	.3970E-01	.0000E+00	.1494E+03
16.551100	.0000E+00	.3773E-01	.0000E+00	.1494E+03
16.559400	.0000E+00	.3575E-01	.0000E+00	.1494E+03
16.567800	.0000E+00	.3375E-01	.0000E+00	.1494E+03
16.576100	.0000E+00	.3177E-01	.0000E+00	.1494E+03
16.584400	.0000E+00	.2979E-01	.0000E+00	.1494E+03
16.592800	.0000E+00	.2779E-01	.0000E+00	.1494E+03
16.601100	.0000E+00	.2581E-01	.0000E+00	.1494E+03
16.609400	.0000E+00	.2383E-01	.0000E+00	.1494E+03
16.617800	.3405E-09	.2183E-01	.7434E-08	.1494E+03
16.626100	.6860E-08	.1985E-01	.1362E-06	.1494E+03
16.634400	.0000E+00	.1787E-01	.0000E+00	.1494E+03
16.642800	.0000E+00	.1587E-01	.0000E+00	.1494E+03
16.651100	.0000E+00	.1389E-01	.0000E+00	.1494E+03
16.659400	.0000E+00	.1192E-01	.0000E+00	.1494E+03
16.667800	.0000E+00	.9914E-02	.0000E+00	.1494E+03
16.676100	.0000E+00	.7936E-02	.0000E+00	.1494E+03
16.684400	.2794E-08	.5958E-02	.1665E-07	.1494E+03
16.692800	.1281E-07	.3956E-02	.5066E-07	.1494E+03
16.701100	.2877E-07	.1978E-02	.5691E-07	.1494E+03
16.709400	.0000E+00	.0000E+00	.0000E+00	.1494E+03

Total runoff volume going through collector g8_2 = .310486882 m^3
Total sediment going through collector g8_2 = 149.376165292 g

SUMMARY FOR FIELD HYDROGRAPHS

NOTE: The time scales have been shifted to absolute number of second from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 15.083088889 h

Event on u024-93

Filter	Vol(m3)	td(s)	tp(s)	Qp(m3/s)	tend(s)
field_1	.5393E+00	395.	905.	.6659E-03	1835.
field_2	.7126E-01	425.	575.	.1355E-03	1835.
g4_1	.3687E+00	395.	1175.	.5682E-03	1835.
g4_2	.3909E+00	785.	1805.	.3872E-03	1835.
g8_1	.1115E-01	395.	1835.	.3143E-04	1865.
g8_2	.3104E+00	965.	1835.	.5316E-03	1865.
rip_1	.2717E+00	605.	1475.	.3951E-03	1835.
rip_2	.1607E-01	665.	1805.	.2291E-04	1835.
field_avg	.3053E+00	395.	575.	.3743E-03	1835.
g4_avg	.3798E+00	395.	1175.	.4756E-03	1835.
g8_avg	.1608E+00	395.	1835.	.2815E-03	1865.

RAINFALL DATA FOR EVENT u024-93

NOTE: The time scales have been shifted to absolute number of seconds from the beginning of the rainfall for that event.

Time for beginning event (0 s) = 15.083088889 h

Time (s) (s from start)	R intensity (m/s)
.0000E+00	.3387E-05
.2999E+03	.1355E-04
.5998E+03	.1693E-05
.9000E+03	.2540E-05
.1200E+04	.1693E-05
.1500E+04	.8467E-06
.1801E+04	.0000E+00
.2403E+04	.0000E+00

Total rainfall volume= 0.711 cm

APPENDIX 5: COMPUTER PROGRAM

Sample Input Files

soil.in

```
2.08e-5       0.02   0.365  0.20   0.0    0.d0
-------------------------------------------------
Ks            Sav    Theta-s Theta-i Sm   schk
(m/s)         (m)                    (m)
```

kwga.in

```
Unit9, r-1, u024-93
1.27
4.31  29   0.5 0.8  250   0   3     1    1
7
5     0.30  0.129861
9     0.30  0.226389
13    0.30  0.1875
17    0.30  0.186111
21    0.30  0.3125
25    0.30  0.090278
29    0.30  0.148276
------------------------------------------------------------
label
filterwidth
vl   n   thetaw  cr  maxiter  out  npol   ielout      kpg
nprop
(nodep(iprop),rna(iprop),soa(iprop), iprop=1,nprop)
```

rain.in

```
 8        .1355E-04
.0000E+00   .3387E-05
.2999E+03   .1355E-04
.5998E+03   .1693E-05
.9000E+03   .2540E-05
.1200E+04   .1693E-05
.1500E+04   .8467E-06
.1801E+04   .0000E+00
```

```
.2403E+04   .0000E+00
----------------------------------
nrain, rpeak
(rain(i,j),j=1,2) i=1,nrain
```

roffkw.in

```
68      .2192E-02
.7816E+03   .0000E+00
.8115E+03   .0000E+00
.8417E+03   .0000E+00
.8716E+03   .5724E-07
.9018E+03   .5724E-07
.9317E+03   .5724E-07
.9616E+03   .3160E-05
.9915E+03   .8045E-05
.1022E+04   .2054E-04
.1052E+04   .1215E-03
   . . .
------------------------------------
nbcroff,bcropeak
(bcroff(i,j),j=1,2) i=1,nbcroff
```

grass.in

```
7      0      .0678   2.2    0.016  0.034   15.     425.    .434    .1      .04
.00034 2.60
------------------------------------------------------------------------------------------------
npart  coarse Sc      Ss     Vn      Ci      H       VL      por     Vn1     Vn2
                      (cm)   (s/cm1/3)(g/cm3)(cm)    (cm)            (s/m1/3)
```

```
      PROGRAM VFSMOD
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                        c
c     WRITTEN FOR: Final Ph.D.dissertation                              c
c     RE-WRITTEN : combined version, July 1993                          c
c     Last Updated:  July 6, 1993. Combination of hydrology and sediment c
c                    models.                                             c
c     Written by:    Rafael Munoz-Carpena                               c
c                    Bio & Ag. Engineering,                              c
c                    Weaver Labs, NCSU                                   c
c                    Raleigh, NC 27695-7625                              c
c                    Phone: (919) 515-6806                               c
c                    e-mail: carpena@nextl.bae.ncsu.edu                  c
c                                                                        c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                        c
c     THIS VERSION SOLVES THE OVERLAND FLOW PROBLEM FOR THE CASE OF     c
c     VARYING ROUGHNESS COEFFICIENT (Manning's n) AND SLOPE AT THE NODES c
c     AND INFILTRATION WITH GREEN-AMPT METHOD FOR THE DOMAIN.           c
c     ************** PETROV-GALERKIN FINITE METHOD ******************** c
c                                                                        c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                        c
c     This program solves the kinetic wave aproximation of the Saint-   c
c     Vennant's (1881) equations for overland flow (KW) for the 1-D case c
c     as presented by Lighthill and Whitham (1955) such as:             c
c                                                                        c
c            dh     dq                                                   c
c           ---- + ---- = r(t)           (Continuity equation)          c
c            dt     dx                                                   c
c                                                                        c
c           So = Sf                      (Momentum equation)            c
c                                                                        c
c     Then the momentum equation is used as a link between the two      c
c     variables since then we have (Manning's):                         c
c                          1/2    5/3                                    c
c           q = q(h) = (So  /n) h                                        c
c                                                                        c
c     Where h is depth of overland flow (L), q is the flow per unit width c
c     of the plane (L^2/T), So is the slope of the plane, Sf is the     c
c     hydraulic or friction slope, and n is Manning's roughness coficient c
c     (L^1/6). The initial and boundary conditions can be summarized as: c
c                                                                        c
c           h=0 ;  0 <=x<= L , t <=0                                     c
c           h=ho;   x = 0    ; t > 0                                     c
c                                                                        c
c     where ho can be 0, a constant or a time dependent function.       c
c                                                                        c
c     The numerical method is based on a N=2 upwinding Petrov-Galerkin  c
c     finite element method approximation  for the spacial derivatives c
c     and a time weighting finite difference approximation for the time c
c     derivatives.                                                      c
c                                                                        c
c     The non-linearity of the equation (q=q(h)) is taken care of using c
c     the Picard iterative scheme inside every time step lagging 2/3 of c
c     the power of h in q ,(5/3 = 2/3(m)+1 (m+1)) for the iteration level c
c     m, such as:                                                        c
c                              m+1      m                                c
c                         [A] {h} = {b(h)}                               c
c                                                                        c
c     In this program the core of the time step solution is taken care  c
c     of following this steps:                                           c
c                                                                        c
c     1- Form the system matrix [A] of constant coefficients            c
c     2- Perfom LUD decomposition over this matrix [A]                  c
c     3- Form the system matrix [BM] of constant coefficients           c
c     4- Form r.h.s of equation (vector {b}=[BM]{xo} for each time step) c
c     5- solve for [A].{b} to get a {x} for that time step              c
c     6- Repeat 4 & 5 until convergence of that time step               c
c     7- Repeat 3 & 6 until completion of desired number of time steps  c
c                                                                        c
c                                                                        c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                        c
c                SUBROUTINES BY ORDER OF APPEARANCE                     c
c                                                                        c
c     INI, INPUTS,QUAD,FORMF, FORMA,ELEM, SHAPE ASSM, BCA, FACTOR,      c
c     GASUB, SOLVE, CONVER, UPDATE, FLOW, WRITE.                        c
c                                                                        c
c                                                                        c
c          DEFINITION OF GLOBAL VARIABLES FOR KW SUBPROGRAM             c
c                                                                        c
c     A(I,J)= SYSTEM MATRIX, SQUARE OF DIMENSIONS NxN, ie  [A]          c
c     B(I)= RIGHT HAND SIDE VECTOR OF DIMENSIONS 1xN , ie  {b}          c
c     DPSI(L) = DERIVATIVE OF BASIS FUNCTIONS                           c
c     DR= DURATION OF THE RAINFALL (s)                                  c
c     DT = INCREMENT OF TIME (s)                                        c
c     DX= SPACE STEP (m)                                                c
c     MAXITER= MAXIMUM NUMBER OF ITERATIONS ALOWED                      c
c     MFLAG= CONVERGENCE FLAG (0. NO CONVERGENCE; 1. CONVERGENCE)       c
c     N=ACTUAL NUMBER OF NODES IN THE DOMAIN                            c
c     NDT = NUMBER OF TIME STEPS                                        c
c     NELEM= ACTUAL NUMBER OF ELEMENTS IN THE DOMAIN                    c
c     NL= ORDER OF THE INTEGRATION RULE OVER EACH ELEMENT               c
c     NMAX= MAXIMUM NUMBER OF EQUATIONS AND VARIABLES THAT CAN BE SOLVED c
c     NPOL=NUMBER OF NODAL POINTS OVER EACH ELEMENT (POLYNOMIAL DEG +1) c
c     OUT= 0, print values at the downstream end of the plane (hydrograph) c
c          1, Print values for all nodes at each time step              c
c     QK(MAXFON): NODAL ALPHA IN MANNING'S UNIFORM FLOW EQUATION        c
c     R= Lateral inflow (m/s)                                            c
c     RN = MANNING'S ROUGHNESS COEFFICIENT                              c
c     SO = SLOPE OF THE ELEMENT                                         c
c     SR= DURATION OF THE SIMULATION (s)                                c
c     THETAW= TIME-WEIGHT FACTOR                                        c
c     VL= LENGTH OF THE PLANE (m)                                       c
c     W(L) = GAUSS QUADRATURE WEIGHTS                                   c
c     X(I)= SOLUTION VECTOR, DIMENSION 1xN, AT TIME STEP L+1            c
c     XI(L)= GAUSS QUADRATURE POINT                                     c
c     XM(I)= SOLUTION VECTOR, DIMENSION 1xN, AT ITERATION M, L STEP L+1 c
c     XO(I)= SOLUTION VECTOR, DIMENSION 1xN, AT  TIME STEP L            c
c                                                                        c
c                                                                        c
c        DEFINITION OF GLOBAL VARIABLES FOR GASUB SUBPROGRAM            c
c                                                                        c
```

```
C       AGA = Green-Ampt's "A", saturated hydraulic conductivity, Ku (m/s)     C
C       NCROFF(200,2)= Boundary condition at the upstream node (inflow from    C
C            adjacent field                                                    C
C       BGA = Green-Ampt's "B" = Ks*Sav*M    (m2/s)                            C
C       CP= Chu's surface condition indicator for ponding at initial time      C
C       CU= Chu's surface condition indicator for no-ponding at initial time   C
C       F= Cumulative infiltration (m)                                         C
C       FPI= Cumulative infiltration when the end to poding in reached (m)     C
C       L= rainfall period                                                     C
C       LO = index to show if time step is in the same rainfall period (LO=L)  C
C       NPOND= shows ponded (=1) non-ponded (=0) surface conditions            C
C       NEND= Indicates that the end of runoff is reached                      C
C       PS= Cumulative recipitation in m.                                      C
C       PSOLD= Cumulative recipitation in m for last rainfall period.          C
C       PST= Total cumulative recipitation in m.                               C
C       PSI(L) = BASIS FUNCTIONS (QUADRATIC LAGRANGIAN POLYNOMIALS)            C
C       RAIN(50,2)= Times (s) and rainfall rates (m/s) over the VFS.           C
C       RO= Cumulative runoff rate at the node (without considering BCRO)      C
C       SM= Maximum surface storage (m)                                        C
C       STO= Cumulative surface storage (m)                                    C
C       TP, TPP= Chu's (1978) tp and tp' coefficients                          C
C       TI= time to infiltrate surface ponded water                            C
C                                                                              C
C               DEFINITION OF VARIABLES FOR SEDIMENT SUBPROGRAM                C
C                                                                              C
C       Ss: spacing of the filter media elments (cm)                           C
C       Sc: filter main slope                                                  C
C       n: Manning's n= 0.0072 for cilindrical media (s/cm^1/3)                C
C       q: overland flow (cm2/s)                                               C
C       df: depth of flow at D(t) (cm)                                         C
C       Vm: depth averaged velocity at D(t)(cm/s)                              C
C       Rs: hydraulic radius of the filter (cm)                                C
C       dp: particle size, diameter (cm)                                       C
C       gamma, gammas:  water and sediment weight density (g/cm3)              C
C       gs2=gsd: sediment load entering downstream section (g/s/cm)            C
C       Rss: hydraulic radius of the filter at B(t) (cm)                       C
C       dfs: depth of flow at B(t) (cm)                                        C
C       Vms: depth averaged velocity at B(t) (cm/s)                            C
C       So: equilibrium slope at B(t)                                          C
C       f: fraction trapped in the deposition wedge                            C
C                                                                              C
C       NOTE: all units in CGS system (cm,g,s), including Manning's n          C
C                                                                              C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
        PARAMETER (MAXEQN=1001,MAXBND=7)
        IMPLICIT DOUBLE PRECISION    (A-H,O-Z)


        COMMON/PAR/QK(200),R THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
        COMMON/CINT/XI(5,5),W(5,5)
        COMMON/GA1/PS,PSOLD,PST,F,RO,TP,TPP,TI,FPI,STO,CU,CP,AGA,BGA,SM
        COMMON/GA2/LO,NPOND
        COMMON/GRASSD/PART(3),SC,SS,VN,GSI,H,VLCM,POR,QSED(4),RS(3),DF(3),VM(3)
        COMMON/GRASSD2/GSIMASS,GSOMASS,TTE,DEP
        DIMENSION A(MAXEQN,MAXBND),B(MAXEQN),BS(MAXEQN)
        DIMENSION X(MAXEQN),X0(MAXEQN),XM(MAXEQN),Q0(MAXEQN),QM(MAXEQN)
        DIMENSION PGPAR(4)
        DIMENSION BCROFF(100,2),RAIN(50,2),NODEX(4)

        OPEN(1,FILE='kwga.in',STATUS='OLD')
        OPEN(2,FILE='rain.in',STATUS='OLD')
        OPEN(3,FILE='roffkw.in',STATUS='OLD')
c       OPEN(4,FILE='ga.out', STATUS= 'UNKNOWN')
        OPEN(7,FILE='soil.in',STATUS='OLD')
        OPEN(10,FILE='summary.out', STATUS= 'UNKNOWN')
        OPEN(11,FILE='hydrograph.out', STATUS= 'UNKNOWN')
        OPEN(12,FILE='grass.in',STATUS='OLD')
        OPEN(13, FILE='grass1.out',STATUS='UNKNOWN')
        OPEN(14, FILE='grass2.out',STATUS='UNKNOWN')

C-------Initialize matrices-------------------------

        CALL INI(A,B,X,XM,X0,Q0,QM,SSF)

C------------Read inputs for sediment problem-------------------------

        CALL GRASSIN(coarse,VN1,VN2)

C-------Get inputs and parameters for the problem-----

        CALL INPUTS(N,NBAND,NRAIN,RAIN,NBCROFF,BCROFF,TE,QMAX,VL,FWID,
     &  PGPAR,VKS,nchk)

C------Get the Gauss quadrature parameters-------

        CALL QUAD

C-------Assemble the system matrix A ------------

        CALL FORMA(A,NBAND,PGPAR)

C-------Perform LU decomposition over A ----------

        CALL FACTOR(A,N,NBAND)

C-------Numerical time dependent solution----------

        MAXIT=100
        TIME=0.D0
        RO=0.D0
        PS=0.D0
        STO= 0.D0
        F=0.000001D0
        NPOND=0
        pzero=1.0d-8
        NSTART=0
        NEND=0
        NWRITE=NDT/100
        VLCM=VL*100.D0
        DO 40 LCOUNT=1,NDT
               TIME=DT*LCOUNT

C-------Select the rainfall intensity --------------
```

```
      R=0.D0
      DO 10 I=1,NRAIN-1
         IF(TIME.GT.RAIN(I,1).AND.TIME.LE.RAIN(I+1,1)) L=I
10    CONTINUE

c------new 08/20/92------------------------
C     R=RAIN(L,2)
c     IFLAG=0
c     IF(L.EQ.LO)IFLAG=1
c     npond=0
c     IF(X(N).GT.0.D0.AND.BCRO.GT.D0.AND.IFLAG.EQ.0)THEN
c           NPOND=1
c           PRINT*,'dum!!',npond
c           QBC=QX(1)*BCRO**(5 d0/3 d0)
c           QMED=(QBC+QO(N))/2.D0
c           RMED=QMED/VL
c           RAIN(L,2)=RAIN(L,2)+RMED
c        ELSEIF (X(N).EQ.0.D0)THEN
c           NPOND=0
c     ENDIF
c------new 08/20/92------------------------

C-------Select the BC in upper node of system (incoming hydrograph)---

      BCRO=0.D0
      DO 15 I=1,NBCROFF-1
         IF(TIME.GT.BCROFF(I,1).AND.TIME.LE.BCROFF(I+1,1)) THEN
            BCRO=(TIME-BCROFF(I,1))/(BCROFF(I+1,1)-BCROFF(I,1))*
     &      (BCROFF(I+1,2)-BCROFF(I,2))+BCROFF(I,2)
         ENDIF
15    CONTINUE

C--------Get effective rainfall and control execution of overland flow----
C--------For an infiltrating surface call Green-Ampt subroutine----------
C--------The assumption here is that the surface will be flooded, and----
C--------thus will supply the maximum infiltration capacity as given by--
C--------the Green-Ampt model.
c
c-07/05/93-In this version we select the node to check (nchk) to ------
c----------evaluate sensitivity of the model to this assumption---------

c     IF(X(N).GT.0.D0)NPOND=1
      IF(X(NCHK).GT.PZERO)NPOND=1
c     IF(BCRO.EQ.0.D0.AND.X(N).EQ.0.D0.AND.NSTART.EQ.1)NEND=1
      IF(BCRO.EQ.0.D0.AND.X(NCHK).EQ.0.D0.AND.NSTART.EQ.1)NEND=1
      IF(VKS.GT.0.D0)THEN
         CALL GASUB(TIME,DT,L,R,RAIN,NEND,TRAI)
      ELSE
         R=RAIN(L,2)
         TRAI=TRAI+DT*(R+ROLD)*0.5D0
         ROLD=R
      ENDIF
C     IF(R.LE.0.D0.AND.BCRO.EQ.0.D0.AND.X(N).EQ.0.D0)NSTART=0
      IF(R.LE.0.D0.AND.BCRO.EQ.0.D0.AND.X(NCHK).EQ.0.D0)NSTART=0
      IF(R.GT.0.D0.OR.BCRO.GT.0.D0)NSTART=1

C--------------Form of r.h.s vector for that time step ------

      CALL FORMB(BO,XO,QO,N,BCRO,PGPAR)

C--------------Start Picard iteration----------------

      M=0
      MFLAG=0
      IF(NSTART.EQ.0)MFLAG=1
      DO 20 WHILE (M.LT.MAXITER.AND.MFLAG.EQ.0)
         M=M+1

C---------------------Update (b) + (bm) ------------------

         CALL UPDATE(N,BO,B)
         CALL MODIFY(QM,B,BCRO,PGPAR)

C---------------------Feed the vector to the solver-----------

         CALL SOLVE(A,B,X,N,NBAND)

C---------------------Check for convergence-----------------

         CALL CONVER(N,X,XM,MFLAG)

C---------------------Update Xm = X m+1 --------------------

         CALL UPDATE(N,X,XM)

C--------------Find flow component at iteration step---------

         CALL FLOW(N,X,QM)

20    CONTINUE

C-------------Update h and q for next time level--------------------

      CALL UPDATE(N,X,XO)
      CALL FLOW(N,X,QO)

C---------Call sediment transport subroutine-----------------

      DO 25 I=1,3
         ND=NODEX(I)
         QSED(I)=QO(ND)
         IF(QSED(I).LT.1E-99)QSED(I)=0.D0
25    CONTINUE
      IF(BCRO.NE.0.D0)CALL SUBGRASSED(TIME,N,BCRO,NODEX,FWID,VN1,VN2)

C--------------Write the solution for that time step-------

      DO 30 I=1,100
         IF(LCOUNT.EQ.I*NWRITE) THEN
            CALL XWRITE(N,LCOUNT,M,QO,X,BCRO,FWID)
         ENDIF
30    CONTINUE
40    CONTINUE
      TOTRAIN=TRAI*VL*FWID
```

```
      WRITE(11,300)TOTRAIN
      CLOSE(11)
      OPEN(11,FILE='hydrograph.out', STATUS= 'OLD')
      CALL OUTMASS(VL,FWID,QK(1))
      TTE=(GSIMASS-GSOMASS)/GSIMASS

      WRITE(*,*)'Sediment inflow = ',GSIMASS,' g/cm ;',GSIMASS*FWIDTH,' g'
      WRITE(*,*)'Sediment outflow= ',GSOMASS,' g/cm ;',GSOMASS*FWIDTH,' g'
      WRITE(*,201)' Total trapping efficiency (%) = ',TTE*100
      WRITE(*,201)' Sediment depth in low section = ',DEP,' cm'
      WRITE(*,*)'Finished'

300   FORMAT('Volume from rainfall= ', E14.4,' m3')

      CLOSE(1)
      CLOSE(2)
      CLOSE(3)
c      CLOSE(4)
      CLOSE(7)
      CLOSE(8)
      CLOSE(9)
      CLOSE(10)
      CLOSE(11)
      CLOSE(12)
      CLOSE(13)
      CLOSE(14)

      STOP
      END

      SUBROUTINE INI(A,B,X,XM,XO,QK,QO,SSE)
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                      c
c     SET ALL MATRICES=0 TO START PROGRAM                              c
c                                                                      c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc

      PARAMETER (MAXEQN=1001,MAXBND=7)
      IMPLICIT DOUBLE PRECISION   (A-H,O-Z)

      DIMENSION A(MAXEQN,MAXBND),B(MAXEQN)
      DIMENSION X(MAXEQN),XO(MAXEQN),XM(MAXEQN),QK(MAXEQN),QO(MAXEQN)

      DO 10 I=1,MAXEQN
            B(I)= 0.D0
            X(I)= 0.D0
            XO(I)=0.D0
            XM(I)=0.D0
            QK(I)= 0.D0
            QO(I)=0.D0
            DO 10 J=1,MAXBND
                  A(I,J)= 0.D0
10    CONTINUE
      SSE=0.D0

      RETURN
      END

      SUBROUTINE INPUTS(N,NBAND,NRATH,RAIN,NBCROFF,BCROFF,TE,QMAX,VL
     &  , FWIDTH, PCPAR,VKS,NCHK)
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                      c
c     Read data from input file inkw.dat in free format calculate the  c
c     following parameters:                                            c
c                                                                      c
c     1- N, NBAND,NELEM                                                c
c     2- Maximum flow rate and depth at steady-state condition (QMAX,HMAX) c
c     3- Celerity of the wave (C)                                      c
c     4- Courant time step (DTC)                                       c
c     5- Froude number (FR)                                            c
c     6- Kinematic flow number (FK)                                    c
c     7- Henderson's time to equilibrium (TE)                          c
c                                                                      c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc

      PARAMETER (MAXEQN=1001,MAXBND=7)
      IMPLICIT DOUBLE PRECISION   (A-H,O-Z)
      CHARACTER*50 PLABEL

      COMMON/GA1/PS,PSOLD,PST,F,RO,TP,TPP,TI,FTI,STO,CU,CP,AGA,BGA,SM
      COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,KL

      DIMENSION BCROFF(200,2),RAIN(50,2)
      DIMENSION NODEP(15),RNA(15),SOA(15)
      DIMENSION PCPAR(4)

C-------Read in main parameters of the program--------------

      READ(1,'(A50)')PLABEL
      READ(1,*)FWIDTH
      READ(1,*)VL,N,THETAW,CR,MAXITER,OUT,NPOL,IELOUT,KPG
      READ(1,*)NPROP
      DO 5 IPROP=1,NPROP
            READ(1,*)NODEP(IPROP),RNA(IPROP),SOA(IPROP)
5     CONTINUE
      SMALLQK=1000.D0
      BIGQK=0.D0
      DO 15 I=1,N
            DO 10 IPROP=1,NPROP
                  IF(I.LE.NODEP(IPROP))THEN
                        RN=RNA(IPROP)
                        SO=SOA(IPROP)
                        GOTO 12
                  ENDIF
10          CONTINUE
12          QK(I) = SO**0.5D0/RN
            BIGQK=DMAX1(BIGQK,QK(I))
            SMALLQK=DMIN1(SMALLQK,QK(I))
            IF (QK(I).eq.BIGQK)then
                  nbig=I
              ELSEIF(QK(I).eq.SMALLQK)then
                  nsmall=1
```

```
         endif
15    CONTINUE

C--------Check if N is compatible with type of shape function----

      NEVE=MOD(N-1,2)
      IF(NPOL.EQ.3.AND.NEVE.NE.0) THEN
         PRINT*,'                  ERROR IN NUMBER OF NODES-'
         PRINT*,'  '
         PRINT*,'For quadratic solutions an odd number of
     & nodes is needed.'
         PRINT*,'Please change the number of nodes to meet this
     & requirement.'
         PRINT*,'NOTE that for this batch form of the program
     &the number of'
         PRINT*,'nodes is automatically decreased  by 1 by changing'
         WRITE(10,200)'length of the plane (Lt)=',VL-DX
         WRITE(10,*)'    number of nodes       =',N
         VL=VL-DX
         N=VL/DX+1
         NELEM=N/(NPOL-1)
         PRINT*,' '
      ENDIF

C-------Read rainfall distribution ---------------------------------

      READ(2,*)NRAIN, RPEAK
      DO 20 I=1,NRAIN
         READ(2,*)(RAIN(I,J),J=1,2)
20    CONTINUE
      DR1=RAIN(NRAIN,1)

C-------Calculate Green-Ampt parameters--------------------------------

      READ(7,*)VKS, Sav, OS, OI, SM,SCHK
      DM=OS-OI
      SavM=Sav*DM
      AGA= VKS
      BGA= VKS*SAVM
c-07/05/93- get node downslope for flood checking---------------------
      nchk=idnint(schk*n)
      if(nchk.lt.1)nchk=1

C-------Read runoff inflow at upper side of strip (BC) in (m3/s) and transform
C------ into depth (m) at the first node----

      READ(3,*)NBCROFF,BCROPEAK
      DO 30 I=1,NBCROFF
         READ(3,*)(BCROFF(I,J),J=1,2)
         SCROFF(I,2)=BCROFF(I,2)/FWIDTH
         BCROFF(I,2)=(BCROFF(I,2)/CK(1))**(3.D0/5.D0)
30    CONTINUE
      DR2=BCROFF(NBCROFF,1)
      DR=DMAX1(DR1,DR2)

C-------Find the bandwidth for the matrix, #element, #nodes---

      NBAND=2*NPOL-1
      DX=VL/(N-1)
      NELEM=(N-1)/(NPOL-1)

C-------Calculate convergence and wave form parameters--------

C***** English Units
c        G=32.165D0
c        CMN=1.486D0
C***** Metric Units
      G=9.81D0
      CMN=1.D0

      VM=5.D0/3.D0
      PEAK=RPEAK+BCROPEAK
      QMAX= VL*PEAK
      HMAX= (QMAX/BIGCK)**(1.D0/VM)
      VMAX=QMAX/HMAX
      FR=VMAX/(G*HMAX)**.5D0
      FK=(VL*SO*G)/VMAX**2.D0
      C= VM*BIGCK*HMAX**(VM-1)
      DTC= DX/C
      DT=DTC*CR
      TE= HMAX/PEAK
      NDT=DR/DT
      CRR=(VM*qmax*dt/dx)/((QMAX/SMALLQK)**(1.D0/VM))

C-------Calculate the PC Parameters (in this case for n=5C)--------------

      IF(KPC.EQ.1)THEN
         PCPAR(1)=0.0215873 - 0.345217*CR + 1.33259*CR**2 -
     &               1.62016*CR**3 + 0.620333*CR**4
         PCPAR(2)= 0.0592655 - 0.107237*CR + 0.235216*CR**2 -
     &               0.426017*CR**3 + 0.222225*CR**4
         PCPAR(3)=0.0250422 + 0.175632*CR - 0.592941*CR**2 -
     &               0.149698*CR**3 - 0.0704731*CR**4
         PCPAR(4)= -0.0456247 +0.00117745*Cr +0.420433*Cr**2 -
     &               0.0935913*Cr**3 - 0.0764558*Cr**4
      ENDIF

C-------Set the order of the integration rule--------------------

      IF(KPC.EQ.0.OR.(PCPAR(4).EQ.0.D0.AND.PCPAR(3).EQ.0.D0))THEN
         NL=NPOL-1
      ELSE
         NL=5
      ENDIF

C-------Output all the parameters----------------------------------

      WRITE(11,*)'Storm parameters'
      WRITE(11,*)'-------- -------'
      WRITE(11,*)'Storm on: ',PLABEL
      WRITE(11,400)'Peak rainfall intensity(m/s)=',RPEAK
      WRITE(11,400)'Peak inflow rate BC (m3/s)=',BCROPEAK*FWIDTH
      WRITE(11,200)'Duration of the rain (s)=',DR
      WRITE(11,*)'Filter parameters'
```

```
      WRITE(11,*)'-----------------'
      WRITE(11,200)'Length of the strip (m)=',VL
      WRITE(11,200)'Width of the strip (m)=',FWIDTH
C-------Output nodal information if desired (ielout=1)----------------
      IF(IELOUT.EQ.1)THEN
         WRITE(11,*)
         WRITE(11,*)' Elemental information follows (IELOUT=1):'
         WRITE(11,*)'  Elem  node  local   alpha      x(m)'
         WRITE(11,*)
         DO 40 NEL=1,NELEM
               K=(NPOL-1)*NEL-NPOL+1
               DO 40 I=1 NPOL
                     K=K+1
                     WRITE(11,600)NEL,K,I,QX(K),(k-1)*dx
40       CONTINUE
         WRITE(11,*)
      ENDIF
      WRITE(11,*)'Soil parameters'
      WRITE(11,*)'--------------------'
      WRITE(11,200)'Saturated hydraulic cond (Ks)=',VKS
      WRITE(11,200)'Avg. suction at wet front(Sav)=',Sav
      WRITE(11,200)'Sat. soil-water content(Os)=',Os
      WRITE(11,200)'Initial soil-water content(Oi)=',Oi
      WRITE(11,200)'Initial soil-water deficit (M)=',DM
      WRITE(11,400)'Green-Ampt parameters (A,B)=',AGA,BGA
      WRITE(11,*)'Node number for flood checking=',NCHK
      WRITE(11,*)'Simulation parameters'
      WRITE(11,*)'---------------------'
      WRITE(11,*)' Order of the basis functions= ',NPOL-1
      WRITE(11,300)'Output option (0=q(t);1= h(x)-', OUT
      WRITE(11,700)'Petrov-Galerkin parameters=',(PGPAR(I),I= 1,4)
      WRITE(11,200)'Time weighting parameter=',THETAW
      WRITE(11,200)'Space step, dx(m) =',DX
      WRITE(11,200)'Time step, dt (s) =',DT
      WRITE(11,*)'Number of nodes in system     =',N
      WRITE(11,*)'Number of time steps          =',NDT
      WRITE(11,*)'Maximum number of iterations =',MAXITER
      WRITE(11,200)'Maximum flow rate and depth=',QMAX,HMAX
      WRITE(11,200)'Celerity of the wave=',C
c      WRITE(11,200)'Time to equilibrium (s)=',TE
      WRITE(11,200)'Courant time step=',DTC
      WRITE(11,200)'Froude number=',FR
      WRITE(11,200)'Kinematic flow number=',FK
      WRITE(11,200)'Courant number=',CR
      WRITE(11,*)

C-------Issue a warning if any of the criteria is not met-------

      IF(FK.LT.10.D0) THEN
           WRITE(*,*)'WARNING, Kinematic number smaller than 10'
        ELSE IF (FR.GT 1.5D0) THEN
           WRITE(*,*)'WARNING: Froude number greater than 2'
        ELSE IF (CR.GT.1.D0) THEN
           WRITE(*,*)'WARNING. Courant number greater than 1'
      ENDIF
      WRITE(11,*)

C-------Print header for output values-------------------------

      IF(OUT EQ.0.D0) THEN
            WRITE(11,*)'  TIME     OUTFLOW     CUM.FLOW    ie - r-f
     &     INFLOW      ITER'
            WRITE(11,*)'   (s)      (m3/s)         (m3)        (m/s)
C    &        (m3/s/m)'
     &       (m3/s)'
            WRITE(11,*)
            WRITE(11,500)0 d0,0.d0,BCROPF(1,2),0 d0.0 d0,0
         ELSE
            WRITE(11,*)'ITER      TIME        INFLOW      ie =r-f
     &    DEPTH (X=L/2)'
            WRITE(11,*)'            (s)          (m)         (m/s)
     &         (m)'
            WRITE(11,*)
      ENDIF
c           WRITE(4,*)'      TIME        Lp           Lpp        ie =r-f
c    &      FS          F           FL          STO         RO          R'
c           WRITE(4,*)'      (s)        (s)                  (s)        (m/s)
c    &    (m)         (m)         (m/s)         (m)         (m)         (m/s)'
c      WRITE(4,*)

200   FORMAT(A31,2F12.6)
300   FORMAT(A31,F4.0)
400   FORMAT(A31,2E12.4)
500   FORMAT(F8.2,4E12.4.I6)
600   FORMAT(3I6,2F10.4)
700   FORMAT(A31,4F6.3)
      RETURN
      END


      SUBROUTINE QUAD
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C     THE SUBROUTINE QUAD DEFINES THE VALUES OF THE PARAMETERS         C
C     REQUIRED FOR THE NUMERICAL INTEGRATION OF ELEMENT MATRICES       C
C     AND VECTORS.  THESE DATA ARE PROBLEM INDEPENT AND ARE GIVEN      C
C     OVER THE INTERVAL (-1,1).                                        C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON/CINT/XI(5,5),W(5,5)

C-------Gaussian Quadrature of order 1-----------

      XI(1,1) = 0.D0
      W(1,1)  = 2.D0

C-------Gaussian Quadrature of order 2-----------

      XI(1,2) = -1.D0/DSQRT(3.D0)
      XI(2,2) = -XI(1,2)
      W(1,2)  = 1.D0
      W(2,2)  = W(1,2)
```

```
C-------Gaussian Quadrature of order 3----------

        XI(1,3) = -DSQRT(3.D0/5.D0)
        XI(2,3) = 0.D0
        XI(3,3) = -XI(1,3)
        W(1,3)  = 5.D0/9.D0
        W(2,3)  = 8.D0/9.D0
        W(3,3)  = W(1,3)

C-------Gaussian Quadrature of order 4----------

        XI(1,4) = -0.8611363116D0
        XI(2,4) = -0.3399810436D0
        XI(3,4) = -XI(2,4)
        XI(4,4) = -XI(1,4)
        W(1,4)  = 0.3478548451D0
        W(2,4)  = 0.6521451549D0
        W(3,4)  = W(2,4)
        W(4,4)  = W(1,4)

C------Gaussian quadrature of order 5------------

         XI(1,5) = -0.9061798459386640D0
         XI(2,5) = -0.5384693101056831D0
         XI(3,5) = 0.D0
         XI(4,5) = -XI(2,5)
         XI(5,5) = -XI(1,5)
         W(1,5)  = 0.2369268850561891D0
         W(2,5)  = 0.4786286704993665D0
         W(3,5)  = 0.5688888888888889D0
         W(4,5)  = W(2,5)
         W(5,5)  = W(1,5)

        RETURN
        END


        SUBROUTINE FORMA(A,NBAND,PGPAR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                         C
C       This subroutine assembles the system matrix [A] as a banded matrix.  C
C       This procedure involves the calculation of element matrices EK and   C
C       their accumulation in the banded system matrix [A]. Finally we end   C
C       up plugging in the BC for the problem.                               C
C                                                                         C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

        PARAMETER (MAXEQN=1001,MAXBND=7)
        IMPLICIT DOUBLE PRECISION   (A-H,O-Z)

        COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT NELEM,MAXITER,NPOL,OUT,NL
        DIMENSION A(MAXEQN,MAXBND),EK(4,4),PGPAR(4)


        DO 10 NEL=1,NELEM
C---------------Form the element matrices EK----------------

                CALL ELEM(EK,PGPAR)

C---------------Assemble the matrix------------------

                CALL ASSM(A,EK,NBAND,NEL)
10      CONTINUE

C-------Apply boundary conditions over A----------

        CALL BCA(A,NBAND)

        RETURN
        END


        SUBROUTINE ELEM(EK,PGPAR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                        C
C       SUBROUTINE ELEM EVALUATE THE COMPONENTS                          C
C       FOR THE ELEMENT STIFFNESS MATRIX k.                              C
C                                                                        C
C       NPOL     - NUMBER OF NODAL POINTS IN THE ELEMENT                 C
C       THETAW   - TIME WEIGHTING FACTOR                                 C
C       EK(I,J)  - ENTRY IN ELEMENT STIFFNESS MATRIX                     C
C       NL       - ORDER OF THE INTEGRATION RULE                         C
C       XI(L)    - ci, THE LOCATION OF THE L-TH GAUSS ABSCISSA           C
C       W(L)     - wi, the l-th gauss quadrature  point                  C
C       DX1      - betwen nodes in element                               C
C       PSI(I)   - Weighting functions                                   C
C       PSI(I),DPSI(I) -Basis functions and derivatves                   C
C                                                                        C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

        PARAMETER (MAXEQN=1001,MAXBND=7)
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)

        COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
        COMMON/CINT/XI(5,5),W(5,5)
        DIMENSION PGPAR(4)
        DIMENSION EK(4,4),PSI(4),DPSI(4),WF(4)

C----------Initialize element arrays-----------

        DO 10 I=1,NPOL
                DO 10 J=1,NPOL
                        EK(I,J) = 0.D0
10      CONTINUE

C----------Begin integration point loop---------

        DX1=DX*(NPOL-1)
        DO 20 L=1,NL
                CALL SHAPE(XI(L,NL),PSI,DPSI,WF,PGPAR)
                DO 20 J=1,NPOL
```

```
             DO 20 I=1,NPOL
                  EK(I,J)=EK(I,J)+(DX1*.5D0*WF(I)*PSI(J)*W(L,NL)
20       CONTINUE

         RETURN
         END

      SUBROUTINE SHAPE(XI,PSI,DPSI,WF,PGPAR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                     C
C     SUBROUTINE SHAPE CALCULATES THE VALUES OF THE WEIGHTING AND BASIS  C
C     FUNCTIONS PSI AND THEIR DERIVATIVES DPSI WITH RESPECT TO  THE MASTER C
C     ELEMENT COORDINATES AT A SPECIFIED VALUE OF XI.                 C
C                                                                     C
C     ANY TYPICAL ELEMENT   = [X1,Xk+1] CONSISTING OF k+1 NODES        C
C     X1, ...., Xk+1 IS ALWAYS NORMALIZED INTO THE MASTER             C
C     ELEMENT   = [-1,1] BY THE TRANSFORMATION OVER A TYPICAL         C
C     ELEMENT  (X1,Xk+1) THERE EXIST k+1 ELEMENT SHAPE FUNCTIONS      C
C     PSI, EACH IS A POLYNOMIAL OF DEGREE k.                          C
C                                                                     C
C        XI      :  THE MASTER COORDINATE OF THE POINT AT WHICH       C
C                   VALUES OF PSI AND DPSI ARE DESIRED                C
C        NPOL    :  NUMBER OF NODES IN THE ELEMENT                    C
C                   (AND HENCE NUMBER OF SHAPE FUNCTIONS)             C
C        PSI(I)  :  THE I-TH SHAPE FUNCTION AT XI                     C
C        DPSI(I):   THE DERIVATIVE OF THE I-TH SHAPE FUNCTION         C
C                   AT XI                                             C
C        WF(I)   :  MODIFIED WEIGHTING FUNCTIONOS                     C
C        PGPAR(I).  PETROV-GALERKIN PARAMETERS (I-1,4)                C
C                                                                     C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

         IMPLICIT DOUBLE PRECISION (A-H,O-Z)

         COMMON/PAR/QK(200),R,THETAN,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
         DIMENSION PSI(4),DPSI(4),WF(4)
         DIMENSION PGPAR(4)

         IF (NPOL.LT.2.OR.NPOL.GT.4) GO TO 99
         GO TO (99,10,20,30) NPOL
C-------------------------------
C     LINEAR SHAPE FUNCTIONS
C-------------------------------
10       PSI(1) = .5D0*(1.D0-XI)
         PSI(2) = .5D0*(1.D0+XI)
         DPSI(1)= -.5D0
         DPSI(2)= .5D0
         GO TO 80
C-------------------------------
C     QUADRATIC SHAPE FUNCTION
C-------------------------------
20       PSI(1) = XI*(XI-1.D0)*0.5D0
         PSI(2) = 1.D0-XI**2.D0
         PSI(3) = XI*(XI+1.D0)*0.5D0
         DPSI(1)= XI-0.5D0
         DPSI(2)= -2.D0*XI
         DPSI(3)= XI+0.5D0

C------------Modified weighting functions------------

         FCU= 5.D0/8.D0*XI*(XI+1.D0)*(XI-2.D0)
         FQR= 21.D0/16.D0*(-XI**4+XI**2)
         WF(2)= PSI(1) - PGPAR(2)*FCU - PGPAR(3)*FQR
         WF(2)= PSI(2) + 4.D0*PGPAR(2)*FCU - 4.D0*PGPAR(4)*FQR
         WF(3)= PSI(3) - PGPAR(1)*FCU - PGPAR(3)*FQR
         GO TO 80
C-------------------------------
C     CUBIC SHAPE FUNCTION
C-------------------------------
30       PSI(1) = 9.D0/16.D0*(1.D0/9.D0-XI**2.D0)*(XI-1.D0)
         PSI(2) = 27.D0/16.D0*(1.D0-XI**2.D0)*(1.D0/3.D0-XI)
         PSI(3) = 27.D0/16.D0*(1.D0-XI**2.D0)*(1.D0/3.D0+XI)
         PSI(4) = -9.D0/16.D0*(1.D0/9.D0-XI**2.D0)*(1.D0+XI)
         DPSI(1)= -9.D0/16.D0*(3.D0*XI**2-2.D0*XI-1.D0/9.D0)
         DPSI(2)= 27.D0/16.D0*(3.D0*XI**2-2.D0/3.D0*XI-1.D0)
         DPSI(3)= 27.D0/16.D0*(-3.D0*XI**2-2.D0/3.D0*XI+1.D0)
         DPSI(4)= -9.D0/16.D0*(-3.D0*XI**2-2.D0*XI+1.D0/9.D0)
C
80       RETURN
99       WRITE(6,*)'ERROR IN CALLING TO SHAPE, NPOL= ', NPOL
         STOP
         END


         SUBROUTINE ASSM(A,EK,NBAND,NEL)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C        ASSM ADDS EK AND EF TO GK AND GF GLOBAL MATRIX AND VECTOR    C
C                                                                     C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

         PARAMETER (MAXEQN=1001,MAXBND=7)
         IMPLICIT DOUBLE PRECISION (A-H,O-Z)

         COMMON/PAR/QK(200),R,THETAN,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
         DIMENSION A(MAXEQN,MAXBND),EK(4,4)

         NDIAG = NBAND/2 + 1
         NRMAX=NEL+NPOL-1
         NCOL=NDIAG +1
         K=0
         I=(NPOL-1)*NEL-NPOL+1
         DO 10 L=NEL,NRMAX
               I=I+1
               M=0
               K=K+1
               NCOL=NCOL-1
               DO 10 J=NCOL,NCOL+NPOL-1
                     M=M+1
                     A(I,J) = A(I,J) + EK(K,M)
10       CONTINUE

         RETURN
```

```
      END

      SUBROUTINE BCA(A,NBAND)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C     The boundary conditions for this program are (problem set 2, part 1)  C
C            C (x=0,t>0) = 1                                           C
C            dC/dx (x=xL) = 0                                          C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      PARAMETER (MAXEQN=1001,MAXBND=7)
      IMPLICIT DOUBLE PRECISION   (A-H,O-Z)

      COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
      DIMENSION A(MAXEQN,MAXBND)


      NDIAG = NBAND/2 + 1

C-------Plug in first kind of BC (Dirichlet)------

      DO 10 I=1,NBAND
            A(1,I)=0.D0
10    CONTINUE
      A(1,NDIAG)=1.D0

      RETURN
      END



      SUBROUTINE FORMB(B0,X0,Q0,N,BCRO,PGPAR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C     In this subroutine the assembling of the right hand side part of the  C
C     equation (vector b).                                             C
C                                                                      C
C     Where HOLD = is the depth of water at the the last time step     C
C            = is a matrix of constant coefficients                    C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      PARAMETER (MAXEQN=1001,MAXBND=7)
      IMPLICIT DOUBLE PRECISION   (A-H,O-Z)

      COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
      COMMON/CINT/XI(5,5),W(5,5)
      DIMENSION PGPAR(4)
      DIMENSION PSI(4),DPSI(4),WF(4),BTO(4)
      DIMENSION X0(MAXEQN),Q0(MAXEQN),B0(MAXEQN)


C------Find dx1 for integration rule---------------------

      DX1=DX*(NPOL-1)

C-------Initialize vector {b}------------------------------------

      DO 10 I=1,N
            B0(I)=0.D0
10    CONTINUE

C-------Begin vector formation element by element----------

      VK=5.D0/3.D0
      DO 60 NEL=1,NELEM

C-------Initialize temporary vectors----------------------

            K1 =(NPOL-1)*NEL-NPOL+2
            K2 =K1+1
            K3= K1+2
            BTO(1)=0.D0
            BTO(2)=0.D0
            BTO(3)=0.D0

C-------Begin integration point-------------------------------

            DO 30 L=1,NL
               CALL SHAPE(XI(L,NL),PSI,DPSI,WF,PGPAR)
               HOLD = PSI(1)*X0(K1)+PSI(2)*X0(K2)+PSI(3)*X0(K3)
               DQOLD = DPSI(1)*Q0(K1)+DPSI(2)*Q0(K2)+DPSI(3)*Q0(K3)
               RAIN= (PSI(1)+PSI(2)+PSI(3))*R
               BTO(1)=BTO(1)+(DX1*.5D0*WF(1)*HOLD+WF(1)*RAIN*DX1
     &               *.5D0*DT - (1-THETAW)*DT*WF(1)*DQOLD)*W(L,NL)
               BTO(2)=BTO(2)+(DX1*.5D0*WF(2)*HOLD+WF(2)*RAIN*DX1
     &               *.5D0*DT - (1-THETAW)*DT*WF(2)*DQOLD)*W(L,NL)
               BTO(3)=BTO(3)+(DX1*.5D0*WF(3)*HOLD+WF(3)*RAIN*DX1
     &               *.5D0*DT - (1-THETAW)*DT*WF(3)*DQOLD)*W(L,NL)
30          CONTINUE

C-------Plug the element vector into the {b0} vector--------

            B0(K1)=B0(K1)+BTO(1)
            B0(K2)=B0(K2)+BTO(2)
            B0(K3)=B0(K3)+BTO(3)
60    CONTINUE

C------Plug in the boundary condition b(1)=0 -------------

      B0(1) = BCRO


      RETURN
      END


      SUBROUTINE MODIFY(QM,B,BCRO,PGPAR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C     In this subroutine the assembling of the right hand side part of the  C
```

```
C       equation (vector b) following the procedure discussed by Vieux et al  C
C       (1990)                                                                C
C                                                                             C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

        PARAMETER (MAXEQN=1001,MAXBND=7)
        IMPLICIT DOUBLE PRECISION    (A-H,O-Z)

        COMMON/PAR/QK(2001),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
        COMMON/CINT/XI(5,5),W(5,5)
        DIMENSION PGPAR(4)
        DIMENSION QN(MAXEQN),PSI(4),DPSI(4),WF(4),B(MAXEQN),BT(4)

C------Find dxl for integration rule----------------------

        DX1=DX*(NPOL-1)

C-------Begin vector formation element by element----------

        VH=5.D0/3.D0
        DO 60 NEL=1,NELEM
                K1  =(NPOL-1)*NEL-NPOL+2
                K2=K1+1
                K3=K1+2
                BT(1)=0.D0
                BT(2)=0.D0
                BT(3)=0.D0

C-------Begin integration point-------------------------------

                DO 30 L=1,NL
                    CALL SHAPE(XI(L,NL),PSI,DPSI,WF,PGPAR)
                    DQN=DPSI(1)*QN(K1)+DPSI(2)*QN(K2)+DPSI(3)*QN(K3)
                    BT(1)=BT(1)+WF(1)*DQN*W(L,NL)
                    BT(2)=BT(2)+WF(2)*DQN*W(L,NL)
                    BT(3)=BT(3)+WF(3)*DQN*W(L,NL)
30              CONTINUE

C-------Plug the element vector into the (b) vector--------


                B(K1)=B(K1)-THETAW*DT*BT(1)
                B(K2)=B(K2)-THETAW*DT*BT(2)
                B(K3)=B(K3)-THETAW*DT*BT(3)
60      CONTINUE

C------Plug in the boundary condition b(1)=0 -------------

        B(1) = ZERO


        RETURN
        END
```

```
        SUBROUTINE FACTOR (A,N,NBAND)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                             C
C       PERFORM THE LOWER AND UPPER DECOMPOSITON OVER SYSTEM MATRIX A   AND   C
C       AND STORE THE LOWER AND UPPER TRIANGULAR MATRICES ON THE OLD A MATRIX C
C                                                                             C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      PARAMETER (MAXEQN=1001,MAXBND=40)
      IMPLICIT DOUBLE PRECISION  (A-H, O-Z)

      DIMENSION A(MAXEQN,MAXBND)

      NMAX = NBAND/2
      NDIAG = NMAX + 1
      M = N -1
      DO 10 I = 1,M
         NA  = NMAX
         IF(N -I  .LT. NA) NA   = N -I
         DO 10 J = 1,NA
            NEQN  = I+J
            A(NEQN ,NDIAG-J) = -A(NEQN ,NDIAG-J)/A(I,NDIAG)
            NLOW = NDIAG-J+1
            NHIGH = NLOW+NA-1
            DO 10 K = NLOW,NHIGH
               A(NEQN,K) =A(NEQN,K)+A(NEQN,NDIAG-J)*A(I,NDIAG+1-NLOW+K)
   10 CONTINUE

      RETURN
      END



        SUBROUTINE SOLVE(A,B,X,N,NBAND)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                              C
C      SOLVE THE TRANSFORMA MATRIX A USING A BACKWARD AND FORWARD SUBSTITUTION C
C       SUCH:    [A] {x} = {b}                                                 C
C       Since    [A]= [L] [U] then  [L][U]{x}   [L]([U]{x})= [L]{y}= {b}       C
C       solving  [L]{y}=b     (forward substitution)                           C
C                [U]{x}=y     (backward substitution)                          C
C                                                                              C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      PARAMETER (MAXEQN 1001,MAXBND-40)
      IMPLICIT DOUBLE PRECISION  (A-H, O-Z)

      DIMENSION A(MAXEQN,MAXBND), B(MAXEQN), X(MAXEQN)

      NDIAG = (NBAND/2)+1
      NMAX = NBAND-NDIAG
      M = N  -1
      DO 10 I = 1,M
         NA = NMAX
         IF(NA .GT. N  -I) NA = N  -I
         DO 10 J = 1,NA
            B(I+J) = B(I+J)+A(I+J,NDIAG-J)*B(I)
```

```
10 CONTINUE
   X(N) = B(N)/A(N,NDIAG)
   DO 20 J = M,1,-1
      NA = NMAX
      IF(NA .GT. N  -J) NA= N  -J
      DO 30 K = 1,NA
         B(J) = B(J)-X(J+K)*A(J,NDIAG+K)
30    CONTINUE
      X(J) = B(J)/A(J,NDIAG)
20    CONTINUE

   RETURN
   END


      SUBROUTINE FLOW(N,XT,QT)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C      Calculate the flow vector at each iteration or time step        C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      PARAMETER (MAXEQN=1001,MAXBND=7)
      IMPLICIT DOUBLE PRECISION    (A-H,O-Z)

      COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
      DIMENSION XT(MAXEQN), QT(MAXEQN)

      DO 10 I=1,N
              QT(I)=QK(I)*XT(I)**(5.D0/3.D0)
10    CONTINUE

      RETURN
      END


      SUBROUTINE UPDATE(N,X,XO)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                     I    I-1         C
C      Refresh values of the X vector, this is X  = X                  C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      PARAMETER (MAXEQN=1001,MAXBND=7)
      IMPLICIT DOUBLE PRECISION    (A-H,O-Z)

      DIMENSION X(MAXEQN),XO(MAXEQN)

      DO 10 I=1,N
              XO(I)=X(I)
10    CONTINUE

      RETURN
      END
```

```
      SUBROUTINE CONVER(N,X,XM,MFLAG)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C             This subroutine checks for convergence as:               C
C                                          n+1                         C
C                    Max (deltaX)/Max (X ) <= eps                      C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      PARAMETER (MAXEQN=1001,MAXBND=7)
      IMPLICIT DOUBLE PRECISION    (A-H,O-Z)

      COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
      DIMENSION X(MAXEQN),XM(MAXEQN)

      EPS= 1.0E-8
      BIG1=0.D0
      BIG2=0.D0
      DO 10 I=1,N
              C1= ABS(X(I)-XM(I))
              IF(X(I).LT.0.D0) THEN
                      C1=0.D0
                      X(I)=0.D0
              ENDIF
              C2= ABS(XM(I))
              BIG1=MAX(BIG1,C1)
              BIG2=MAX(BIG2,C2)
10    CONTINUE
      IF(BIG2.EQ.0.D0)THEN
              TOL=1.1D0*EPS
           ELSE
              TOL=BIG1/BIG2
      ENDIF

C-------If there is convergence return MFLAG=1, otherwise 0----

      MFLAG= 0
      IF(TOL.LE.EPS) MFLAG=1

      RETURN
      END


      SUBROUTINE XWWRITE(N,L,M,QO,X,ECRO,FWID)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C      WRITE THE RESULT VECTOR FOR X=100 m IN FORMAT TO THE FILE OUTP.DAT C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      PARAMETER (MAXEQN=1001,MAXBND=7)
      IMPLICIT DOUBLE PRECISION    (A-H,O-Z)

      COMMON/GRASSD/PAKT(3),SC,SS,VN,CSI,H,VLCM,POR,QSED(4),RS(3),DP(3),VM(3)
      COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
      DIMENSION QO(MAXEQN),X(MAXEQN),NODEX(4)
```

```
      TIME=L*DT
      DMAX=R*TIME
      IF(OUT.EQ.1.D0) THEN

C-------Print values for nodes for each time step (OUT=1)-------

         MID=N/2+1
         VMID=(N-1)*DX/2
         DO 10 I=1,N
            VNODE=(I-1)*DX
            IF(VNODE.EQ.VMID)WRITE(11,200)TIME,VMID,X(MID),K
10       CONTINUE
      ELSE

C------Print values of flowrate at the downstream end of the plane(OUT<>0)
         TIMEINCR=TIME-TIMELAST
         FLOWRATE=FWID*Q0(N)
         SUMFLOW=SUMFLOW+0.5d0*(flowrate+flowlast)*timeincr
         VE=5.d0/3.d0
         QFIELD=qk(1)*(BCRO**ve)*FWID
         TIMELAST=TIME
         FLOWLAST=FLOWRATE
         QSED(1)=QSED(1)/1000.d0*FWID
         QSED(2)=QSED(2)/1000.d0*FWID
         QSED(3)=QSED(3)/1000.d0*FWID
         WRITE(11,400)TIME,FLOWRATE,sumflow,R,QFIELD,QSED(1),QSED(2)
     &   ,QSED(3),K
      ENDIF

C200  FORMAT(F8.2,4E12.4,I6)
C300  FORMAT(I4,2X,5E12.4)
400   FORMAT(F8.2,6E12.4,4F10.4,I6)

      RETURN
      END

      SUBROUTINE CASUB(TIME,DT,L,R,RAIN,NEND,TRAI)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                       C
C     WRITTEN BY : RAFAEL MUNOZ-CARPENA, PhD CANDIDATE, NCSU, RALEIGH, USA C
C     LAST UPDATED: 11-20-91                                            C
C                                                                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                       C
C     This program solves and infiltration problem for unsteady rainfall C
C     case using the Green-Ampt infiltration model. The program is based on C
C     Skaggs (1982) in Hydrologic modeling of small watersheds, edited by C
C     Haan, Johnson and Brakensiek, ASAE monograph no. 5, and Chu (1978) C
C     Water Resour. Res.                                                C
C                                                                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                       C
C  ***** SUBROUTINE FORM OF THE PROGRAM CA.F TO BE CALLED BY KWSTD F ****** C
C                                                                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                       C
C     THIS IS A MODIFIED VERSION OF THE ORIGINAL SUBROUTINE. IN THIS CASE C
C     THE INFLITRATION IS ALLOWED TO BE ITS MAXIMUM POTENTIAL AFTER THE C
C     FIRST PODING. THE IMPLICATION HERE IS THAT AFTER THE ORIGINAL     C
C     PONDING IS ACHIEVED, THE RUNOFF WATER MOVING AT THE SURFACE WILL  C
C     SUPPLY ENOUGH WATER TO SUSTENTAIN THE MAXIMUM POSSIBLE INFILTRATION C
C     FOR THAT TIME STEP. IN OTHER WORDS, THE EFFECTIVE RAILFALL FEEDED C
C     INTO THE MAIN FE-PROGRAM (R) WILL BE IN MOST CASES A NEGATIVE VALUE C
C                                                                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)

      COMMON/CA1/PS,PSOLD,PST,F,RO,TP,TPP,TI,FPI,STO,CU,CP,AGA,BGA,SM
      COMMON/CA2/LO,NPOND
      DIMENSION RAIN(50,2)

      MAXIT=100
      C2=BGA/AGA
      ICU=0
      IF(NEND.EQ.1)THEN
         NPOND=0
         ICU=1
         CU=-1.D0
      ENDIF

C------Surface ponding at beginning ? y(npond=1), n (npond=0) ---

      IF(L.NE.LO) THEN
         PSOLD=PS
         PST = PS + RAIN(L,2)*(RAIN(L+1,1)-RAIN(L,1))
      ENDIF

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     Case 1. Without surface ponding at the beginning of the period    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      IF(NPOND.EQ.0) THEN
         IF(L.NE.LO) THEN
            FP= BGA/(RAIN(L,2)-AGA)
            IF(FP.LT.0.D0) FP=F
            CU= PST - RO - FP
            IF(AGA.GE.RAIN(L,2).OR.ICU.EQ.1)CU=-1.D0
         ENDIF

C-----1-a) With ponding at the end of the period (Cu >0)-----------------------

         IF (CU.GT.0.D0) THEN
            IF(L.NE.LO) THEN
               TP=(FP-PS+RO)/RAIN(L,2)+RAIN(L,1)
               IF (TP.LT.RAIN(L,1))THEN
                  TP=RAIN(L,1)
                  FP=F
               ENDIF
               TPP=(FP-C2*DLOG(1.D0+FP/C2))/AGA
            ENDIF
            PS= PSOLD + RAIN(L,2)*(TIME-RAIN(L,1))
            IF(TIME.LT.TP)THEN
```

```
          F= PS -RO
          FI=RAIN(L,2)
        ELSE
          C1 = AGA*(TIME-TP+TPP)
          F=RNEWTON(C1,C2,F)
          FI=AGA+BOA/F
          EXCESS= PS -F - RO -STO
          STO =STO +EXCESS
          IF (STO.GT.SM) THEN
                ROI=STO-SM
                STO=SM
                RO =RO +ROI
          ENDIF
        ENDIF
        R=RAIN(L,2)-FI
c       WRITE(4,1000)TIME,TP,TPP,RAIN(L,2),PS,F,FI,STO,RO,R
        IF((TIME+DT).GT RAIN(L+1,1)) THEN
          C1=AGA*(RAIN(L+1,1)-TP+TPP)
          NPOND=1
          F=RNEWTON(C1,C2,F)
        ENDIF

C-----1-b) No ponding at the end of the period (Cu <0)------------------------

       ELSE
        PS= PSOLD + RAIN(L,2)*(TIME-RAIN(L,1))
        F= PS - RO
        FI=RAIN(L,2)
        R=RAIN(L,2)-FI
c       WRITE(4,1000)TIME,TP,TPP,RAIN(L,2),PS,F,FI,STO,RO,R
        IF((TIME+DT).GT.RAIN(L+1,1)) THEN
          F = PST -RO
        ENDIF
      ENDIF

C----------------Find values at the limit of this rainfall period----------
C----------------regardless of time step-----------------------------------

      IF((TIME+DT).GT RAIN(L+1,1)) THEN
        PS=PST
        EXCESS= PS -F - RO -STO
        STO =STO +EXCESS
        IF (STO.GT.SM) THEN
             ROI=STO-SM
             STO=SM
             RO =RO +ROI
        ENDIF
      ENDIF

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C       Case 2  With surface ponding at the beginning of the period        C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

    ELSE
      PS= PSOLD + RAIN(L,2)*(TIME-RAIN(L,1))
      C1= AGA*(TIME-TP+TPP)
      F=RNEWTON(C1,C2,F)
          FI=AGA+BOA/F
          EXCESS= PS -F - RO
          RO =RO +EXCESS
          R=RAIN(L,2)-FI
c         WRITE(4,1000)TIME,TP,TPP,RAIN(L,2),PS,F,FI,STO,RO,R
          IF((TIME+DT).GT RAIN(L+1,1))THEN
             F=PST-RO
             PS=PST
             EXCESS= PS -F - RO -STO
             RO =RO +EXCESS
          ENDIF
        ENDIF
        LO=L
        TRAI=PS
1000    FORMAT(10E11 4)

        RETURN
        END


        FUNCTION RNEWTON(C1,C2,F)
        IMPLICIT DOUBLE PRECISION(A-H, O-Z)

        VF=F
        MAXIT=100
        ERROR=1.D0
        NS=0.D0
        DO 120 WHILE(NS.LT.MAXIT.AND.ERROR.GT 1E-8)
              VFO=VF
              PHI=C1-VF+C2*DLOG(1 D0+VF/C2)
              DPHI=C2/(C2+VF)-1 D0
              VF=VFO-PHI/DPHI
              ERROR=DABS(VFO-VF)
              NS=NS+1
120     CONTINUE
        RNEWTON=VF

        return
        END

        SUBROUTINE OUTMASS(VL,WIDTH,ALPHA)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                            C
C       This subroutine processes the output hydrograph and find components  C
C       of the water balance and hydrograph. The results go "summary.out"    C
C                                                                            C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        CHARACTER*65 DUMMY

        WRITE(10,*)'INPUTS'
        WRITE(10,*)'------'
        SUM0=0.D0
        SUM1=0.D0
        SUM2=0.D0
        TIME0=0.D0
5       READ(11,'(A)')DUMMY
```

```
      IDX=INDEX(DUMMY,'ITER')
      IF(IDX.NE.0) GOTO 6
      WRITE(10,*)DUMMY
      GOTO 5
6     READ(11,'(A)')DUMMY
      READ(11,'(A)')DUMMY
      BIG1=0.D0
      NZERO=1
      INI=0
      DO 10 I=1,101
         READ(11,*,end=10)TIME1,OUTF1,CUMFLOW,RAIN_E1,UPIN1,NITER
         TIMEINCR=TIME1-TIME0
c        UPIN1=ALPHA*UPIN1**(5.d0/3.d0)
         AREA0=TIMEINCR*(UPIN1+UPIN0)/2.D0
         SUM0=SUM0 + AREA0
         AREA1=TIMEINCR*(OUTF1+OUTF0)/2.D0
         SUM1=SUM1 + AREA1
         AREA2=TIMEINCR*(RAIN_E1+RAIN_E0)/2.D0
         SUM2=SUM2 + AREA2
         UPIN0=UPIN1
         OUTF0=OUTF1
         RAIN_E0=RAIN_E1
         TIME0=TIME1
c        WRITE(10,500)TIME1,UPIN1,RAIN_E1,OUTF1,NITER
         C1= OUTF1
         BIG1=DMAX1(BIG1,C1)
         IF(C1.EQ.BIG1)THEN
               TBIG=TIME1
               QBIG=C1
         ENDIF
         IF(NZERO.EQ.1.AND.C1.GT.0.D0.AND.INI.EQ.0) THEN
               TINI=TIME1
               NZERO=0
               INI=1
           ELSEIF(NZERO.EQ.0.AND.C1.EQ.0.D0) THEN
               NZERO=1
               TEND=TIME1
         ENDIF
         IF(C1.GT.0.D0)TEND=TIME1
10    CONTINUE
      WRITE(10,*)'OUTPUTS'
      WRITE(10,*)'-------'
30    WRITE(10,*)'Water balance'
      WRITE(10,*)'-------------'
      READ(11,600)DUMMY,TRAI
      WRITE(10,600)DUMMY,TRAI
      Vout=SUM1
      Vie=SUM2*VL*width
      Vin=SUM0
      WRITE(10,300)Vin
      WRITE(10,100)Vout
      FLOW_IN=Vin+TRAI
      FLOW_OUT=Vout
      Vf=FLOW_IN - FLOW_OUT
      WRITE(10,400)Vf
      WRITE(10,*)'Hydrograph data'
      WRITE(10,*)'---------------'
c     BAL=TRAI-Vf
c     ERR=100*(Vie-BAL)/Vie
c     WRITE(10,*)bal
c     WRITE(10,200)Vie,ERR
      WRITE(10,700)TINI
      WRITE(10,800)TBIG,QBIG
      WRITE(10,900)TEND

100   FORMAT('Volume from outflow  = ', E14.4,' m3')
200   FORMAT('Volume from i_e      = ', E14.4,' m3',F14.2,'%')
300   FORMAT('Volume from up-field= ', E14.4,' m3')
400   FORMAT('Volume infiltrated   = ', E14.4,' m3')
500   FORMAT(F8.2,3E12.4,I6)
600   FORMAT(A22,E14.4,' m3')
700   FORMAT('Time to beginning    = ', E14.4,' s')
800   FORMAT('Time and q at peak   = ', E14.4,' s ',E14.4,' m3/s')
900   FORMAT('Time to end runoff   = ', E14.4,' s')

      RETURN
      END


      SUBROUTINE SUBGRASSED(TIME,N,BCRO,NODEX,FWID,VN1,VN2)
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                            c
c     WRITTEN FOR: Paper on sediment transport in VFS/ASAE Winter, 1992      c
c     Modified: 04-29-93                                                     c
c     Last version: v0.3 KWD.2: 05-14-93                                     c
c     Written by:      Rafael Munoz-Carpena                                  c
c                      Bio & Ag. Engineering,                                c
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c                      Phone: (919) 515-6806                                 c
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c                                                                            c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                            c
c     This program solves the sediment transport problem on a grass filter  c
c     It utilizes the method proposed by:                                    c
c                                                                            c
c  1. Tollner et al. (1976). "Suspended sediment filtration capacity of      c
c     simulated vegetation". Trans. ASAE. 19(4):678-682.                     c
c  2. Tollner et al. (1977). "Sediment deposition patterns in simulated      c
c     grass filters". Trans. ASAE. 20(5):940-944.                            c
c  3. Barfield et. al (1979)"Filtration of sediment by simulated vegetation c
c     I. Trans  ASAE, 22(3):540-548.                                         c
c  4. Hayes et. al (1979)"Filtration of sediment by simulated vegetation II c
c     Trans. ASAE, 22(5):1063-1067                                           c
c  5. Hayes et. al (1984)"Performance of grass filters under laboratory and c
c     field Conditions".Trans. ASAE, 27(5):1321-1331, to account for         c
c     triangular upslope deposition and particle and size distribution       c
c  6  Wilson et al (1981)"A Hydrology and sedimentology model: Part I.      c
c     Modeling techniques. U.of Kentucky. Lexington. This is a major        c
c     rewrite of the prodedures involved.                                    c
c                                                                            c
c     This is just the main unit calling the subroutines:                    c
c                      GRASSIN, OCF, EINSTEIN, STEP3                         c
```

```fortran
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON/GRASSD/PART(3),SC,SS,VN,CSI,H,VLCM,POR,QSED(4),RS(3),DF(3),VM(3)
      COMMON/GRASSD2/GSIMASS,GSOMASS,TTE,DEP
      COMMON/OLD/SEOLD,GSIOLD, FOLD,TOLD,XTOLD,YTOLD,DEP,CDEP,SK
      DIMENSION XPOINTS(3),NODEX(4)

C------Start time loop for the unsteady conditions------------------

      FWIDTH=FWID*100.D0
      QIN=100000.d0*QSED(2)
      GSI=QIN*CI
      QSED(1)=QSED(1)*1000000.D0/FWIDTH
      QSED(2)=QSED(2)*1000000.D0/FWIDTH
      QSED(3)=QSED(3)*1000000.D0/FWIDTH
      GSI=GSI/FWIDTH
      IF(QIN.LE.0.D0) THEN
         GS2=0.D0
         GOTO 120
      ENDIF

C-----------Solves hydraulic properties to be used later on-----------

      DO 10 NPLACE=2,3
         CALL OCF(NPLACE)
10    CONTINUE

C------------Solve Einstein's equation to find gs2 at the end of S(t)--

      CALL EINSTEIN(GS2,NTRCAP)
      if(coarse eq.0 d0)ntrcap=1

C----------This program finds d/o, Rew, and Se at B(t) and finishes up--

      CALL STEP3(GS2,TIME,NTRCAP,GSIMASS,GSOMASS)

C----------Get xk values for extracting info from KWGA-----------------

      CALL POINTS(N,XT,YT,SE,XPOINTS,NODEX,vbt,VN1,VN2)

120   WRITE(14,200)TIME,QIN,(QSED(J),RS(J),VM(J),DF(J),J=1,3),COUT

      CLOSE(1)
      CLOSE(2)
      CLOSE(3)
      CLOSE(4)
200   FORMAT(F7.0,14E10.3)
201   FORMAT(A32,F9.4,a4)

      RETURN
      END

      SUBROUTINE GRASSIN(coarse,VN1,VN2)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C     Get hydraulic properties to be used in later from file grass.in  C
C                                                                      C
C     NOTE: all units in CGS system (cm,g,s), including Manning's n    C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON/GRASSD/PART(3),SC,SS,VN,GSI,H,VLCM,POR,QSED(4),RS(3),DF(3),VM(3)
      DIMENSION PARTC(6,3)
      CHARACTER*14 PARTLBL(6),PARTLB
      DATA (PARTC(I,1), I=1,6),(PARTC(I,2), I=1,6),(PARTC(I,3), I=1,6)
c-----particle diameters (cm)---------------
     & /.0002D0, .001D0, .003D0, .03D0, .02D0, .0029D0,
c-----fall velocities (cm/s)----------------
     & .0004D0, .0094D0, .0408D0 ,3.0625D0, 3.7431D0, .076D0,
c-----particle densities (g/cm3)------------
     & 2.6D0, 2.65D0, 1.80D0, 1.60D0, 2.65D0, 2.65D0/
      DATA (PARTLBL(I), I=1,6)/'     Clay','     Silt',' Sm.Aggregate',
     & ' Lg.Aggregate','     Sand',' Silt (USDA)'/

      READ(12,*)NPART,COARSE,SC, SS, VN, CI, H, VLCM,POR,VN1,VN2

C--if the particle class is other than those defined above, calculate values--

      IF(NPART.LE.6)THEN
            DO 10 I=1,3
                  PART(I)=PARTC(NPART,I)
10          CONTINUE
            PARTLB=PARTLBL(NPART)
         ELSE
            READ(12,*)DP,SC
            PART(1)=DP
            PART(3)=SC
c----Barfield et al. (1981) to calculate fall velocity in GRASSF----------
c----note: dp in mm-------------------------------------------------------
C           VC1=-.34246727D0
C           VC2=0.98912195D0
C           VC3=1.14617800D0
C           CDP=DLOG(DP/10 D0)
C           PART(2)=10.D0**(VC1*CDP*CDP+VC2*CDP+VC3)
c----Fair and Geyer method (1954), based on Stokes----------------------
c----note: all units in SI-----------------------------------------------
            AGRAV=9.8066352
            VISCOS=0.000001003352832
            MAXITER=100
            DIA=PART(1)/100.D0
            FV=AGRAV*(SG-1.D0)*DIA**2/(18.D0*VISCOS)
            C1=DIA*VISCOS
            REYN=FV*C1
            IF(REYN.LE.0.1D0) GO TO 70
            C2=SQRT(4.D0*AGRAV*(SG-1.)*DIA/3.D0)
            ITER=0
            DO 69 WHILE(EPS.GT..00001D0.AND.ITER.LT.MAXITER)
               ITER=ITER+1
               CD=24.D0/REYN+3.D0/SQRT(REYN)+.34D0
               FV=C2/SQRT(CD)
               REYN=FV*C1
               EPS=DABS(FV-FVOLD)
               FVOLD=FV
```

```
69          CONTINUE
70          PART(2)=FV*100
            PARTLB='    coarse'
            IF(DP.LT.0.0037d0)PARTLB='     fine'
      ENDIF

c-------If particle is fine(<37 microns) don't run the wedge part (coarse=0)-

c     COARSE=1
      IF(PART(1).LE.0.0037D0)COARSE=0

c-- ----Output all input values---------------------------------------------

      WRITE(*,*)
      WRITE(*,*)'Input (Sc, Ss, n, Ci, H, L, Porosity)=',SC,SS, VN, CI, H,
     &   VLCM,POR
      WRITE(*,*)
      WRITE(*,*)'      Particle        dp         Vs      gamma-s'
      WRITE(*,*)'        class         (cm)      (cm/s)  '
      WRITE(*,*)'-----------------------------------------------'
      WRITE(*,100)NPART,PARTLB,(PART(J),J=1,3)
      WRITE(*,*)
      WRITE(14,101)
      WRITE(14,102)
      WRITE(14,107)
      WRITE(14,*)'    0         0         0         0
     &       0         0         0         0         0         0
     & 0        0         0         0         0'
      WRITE(13,*)
      WRITE(13,*)'Input (Sc, Ss, n, Ci, H, L, Porosity)=',SC,SS, VN, CI, H,
     &   VLCM,POR
      WRITE(13,*)
      WRITE(13,*)'      Particle        dp         Vs      gamma-s'
      WRITE(13,*)'        class         (cm)      (cm/s)       '
      WRITE(13,*)'--------------------------------------------------'
      WRITE(13,100)NPART,PARTLBL(NPART),(PART(J),J=1,3)
      WRITE(13,*)
      WRITE(13,105)
      WRITE(13,106)
      WRITE(13,107)
100   FORMAT(I3,a12,3F10.4)
101   FORMAT('  Time      qin       q1        Rs1       Vm1        d(1',
     & '       q2        Rs2       Vm2       d(2       q3        Rs3',
     & '       Vm3       d(3       cout')
102   FORMAT('   (s)   (cm3/s/cm)(cm3/s/cm)  (cm)     (cm/s)     (cm)',
     & '   (cm3/s/cm)   (cm)     (cm/s)     (cm)   (cm3/s/cm)  (cm)',
     & '   (cm/s)      (cm)  (cm3/s/cm)')
105   FORMAT('  Time      Y(t)      X1(t)     X2(t)      L(t)',
     & '      gsI        gs1       gs2       gso       Cum gsi   ',
     & 'Cum.gso      f        frac       TL')
105   FORMAT('   (s)        (cm)      (cm)      (cm)       (cm)',
     & '   (g/cm.s)  (g/cm.s)  (g/cm.s)  (g/cm.s)   (g/cm)    ',
     & '(g/cm)')
107   FORMAT('-------------------------------------------',
     & '------------------------------------------------------',
     & '------------------------------------------------------')
```

```
      RETURN
      END

      SUBROUTINE OCF(NPLACE)
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                      c
c     This program solves the hydraulic properties to be used in later c
c     steps of the problem by means of Manning's and Channel Flow      c
c     theory and a Newton-Raphson iterative method. It utilizes the method c
c      proposed by Barfield et. al (1979) "Filtration of sediment by   c
c     simulated vegetation I. Trans. ASAE, 22(5):540-548.              c
c                                                                      c
c     Known:                                                           c
c            Ss: spacing of the filter media elements (cm)             c
c            Sc: filter main slope                                     c
c            n: Manning's n= 0.0072 for cilindrical media (s/cm^1/3)   c
c            q: overland flow (cm2/s)                                  c
c     Unknown:                                                         c
c            df: depth of flow at D(t) (cm)                            c
c            Vm: depth averaged velocity at D(t)(cm/s)                 c
c            Rs: hydraulic radius of the filter (cm)                   c
c                                                                      c
c     NOTE  all units in CGS system (cm,g,s), including Manning's n    c
c                                                                      c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON/GRASSD/PART(3),SC,SS,VN,GSI,H,VLCM,POR,QSED(4),RS(3),DF(3),VM(3)

      ALPHA=DSQRT(SC)/VN
      Q=QSED(NPLACE)
      CO=(1.D0/ALPHA)**1.5D0
      C1= 2.D0*Q
      C2=SS
      C3=SS*Q

c------Newton-Raphson Method-------------------

      VMD=0.000001D0
      MAXIT=100
      ERROR=1.D0
      NS=0.D0
      DO 120 WHILE(NS.LT.MAXIT.AND.ERROR.GT.1E-8)
             VMDO=VMD
             PHI=CO*(VMD**1.5D0)*(C1+C2*VMD)-C3
             DPHI=1.5D0*CO*DSQRT(VMD)*(C1+C2*VMD)+CO*(VMD**1.5D0)*C2
             VMD=VMDO-PHI/DPHI
             ERROR=DABS(VMDO-VMD)
             NS=NS+1
120   CONTINUE
      VM(NPLACE)=VMD
      DF(NPLACE)=Q/VMD
      RS(NPLACE)=DF(NPLACE)*SS/(2*DF(NPLACE)+SS)
c     PRINT*,'INPUTS (SS,SC,VN,Q)=',SS,SC,VN,Q
c     PRINT*,'OUTPUTS (VM,DF,RS)=', VM(NPLACE),DF(NPLACE),RS(NPLACE)

      RETURN
```

```
      END

      SUBROUTINE EINSTEIN(GS2,NTRCAP)
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                      c
c     This program solves Einstein's equation to find g_sd at the end of c
c     C(t)  After  Barfield et  al (1979)"Filtration of sediment by    c
c     simulated vegetation I. Trans  ASAE, 22(5):540-548.              c
c                                                                      c
c     Known:                                                           c
c             dp: particle size, diameter (cm)                         c
c             Sc: filter main slope                                    c
c             Rs: hydraulic radius of the filter at B(t) (cm)          c
c             gamma, gammas.  water and sediment weight density (g/cm3) c
c             g_acc= acceleration due to gravity (980 cm/s2)           c
c     Unknown.                                                         c
c             gs2: sediment load entering downstream section (g/s/cm)  c
c                                                                      c
c     NOTE: all units in CGS system (cm,g,s), including Manning's n    c
c                                                                      c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON/GRASSD/PART(3),SC,SS,VN,GSI,H,VLCM,POR,QSED(4),RS(3),DF(3),VM(3)

      GAMMAW=1.D0
      GACC=980.D0
      CC0=(PART(3)-GAMMAW)/GAMMAW
      CC1= PART(3)*DSQRT(CC0*GACC*PART(1)**3.D0)
      CC2= CC0*PART(1)/1.08D0/SC/RS(2)
      GS2=CC1 * CC2**(-1.D0/.28D0)

c--------Check if the transport capacity is lower than concentration----
c--------is yes, proceed with step 3 if not update values and exit step)

      IF(GS2.GT.GSI)THEN
              GS2=GSI
              NTRCAP=1
          ELSE
              NTRCAP=0
      ENDIF

c     PRINT*,'Output (gs2)=',GS2,' g/s/cm'
c     PRINT*,''

      RETURN
      END

      SUBROUTINE STEP3(GS2,TIME,NTRCAP,GSIMASS,GSOMASS)
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                      c
c     This program solves step 3 to find dfs, SSs, and Se to go to step c
c     4. After  Barfield et. al (1979)"Filtration of sediment by simulated c
c     vegetation II. Trans. ASAE, 22(5).540 548. and Hayes et. al (1984) c
c     "Performance of Grass Filters under Laboratory and Field Conditions. c
c     Trans  ASAE, 27(5):1321-1331.                                    c
c                                                                      c
c     Known:                                                           c
c             dp: particle size, diameter (cm)                         c
c             Sc: filter main slope                                    c
c             gamma, gammas:  water and sediment weight density (g/cm3) c
c             g_acc= acceleration due to gravity (980 cm/s2)           c
c             gsd: sediment load entering downstream section (g/s/cm)  c
c     Unknown:                                                         c
c             Rss: hydraulic radius of the filter at B(t) (cm)         c
c             dfs: depth of flow at B(t) (cm)                          c
c             Vms: depth averaged velocity at B(t) (cm/s)              c
c             Se: equilibrium slope at B(t)                            c
c             f: fraction trapped in the deposition wedge              c
c                                                                      c
c     NOTE: all units in CGS system (cm,g,s), including Manning's n    c
c                                                                      c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON/GRASSD/PART(3),SC,SS,VN,GSI,H,VLCM,POR,QSED(4),RS(3),DF(3),VM(3)
      COMMON/OLD/SEOLD,GSIOLD, FOLD,TOLD,XTOLD,YTOLD,DEP,CDEP,SE

      DTG=TIME-TOLD
      GAMMASB=(1-POR)*PART(3)
      GAMMAW=1.D0
      GACC=981.D0
      IF(NTRCAP.EQ.1)THEN
              SE=SEOLD
              F=0.D0
              XT=XTOLD
              YT=YTOLD
              GSSI=GSI
              GS2=GSI
              GOTO 140
      ENDIF
      CCC1=(PART(3)-GAMMAW)/GAMMAW
      CCC2=PART(1)
      CCC3=PART(3)*DSQRT(CCC1*GACC*CCC2**3.D0)
      CCC7=2.D0*QSED(1)
      CCC8=QSED(1)*SS
      MAXITER=500
      TOL=1.0E-5
      EPS=1000.d0

C==> Modification for triangular upslope deposition (Wilson et al. 1981) <==

      M=0
      F=SE/(SE+SC)
      DO 20 WHILE (M.LT.MAXITER.AND.EPS.GT.TOL)
          M=M+1
C------Open channel flow and Einstein in B(t), find Rss, Se-----
          GSSI=GSI*(1-F)+F*GS2
          GS1=(GSSI+GS2)/2.D0
          CCC4=(CCC1*CCC2/1.08D0)*(GS1/CCC3)**.28D0
          CCC5=DSQRT(CCC4)/VN
          CCC6=CCC5*SS
c!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
c------Newton-Raphson Method--------------------
```

```
        RSS=0.000001D0
        MAXIT=100
        ERROR=1.D0
        NS=0.D0
        DO 120 WHILE(NS.LT.MAXIT.AND.ERROR.GT.1E-6)
                RSSO=RSS
                PHI=RSS*(CCC6*RSS**(1.D0/6.D0)+CCC7)-CCC8
                DPHI=7.D0/6.D0*CCC6*RSS**(1.D0/6.D0)+CCC7
                RSS=RSSO-PHI/DPHI
                ERROR=DABS(RSSO-RSS)
                NS=NS+1
120         CONTINUE
        SET=CCC4/RSS
        SE=dtan(datan(SET)-datan(SC))
        F=SE/(SE+SC)
        EPS=DABS(GSSI-GSSIOLD)
        GSSIOLD=GSSI
20      CONTINUE
        RS(1)=RSS
        DF(1)=SS*RSS/(SS-2.D0*RSS)
        VM(1)=QSED(2)/DF(1)

C------Find advancement of sediment front and outflow concentration--

        DVOL=(GSI-GS2)*DTG/GAMMASB
        YT=DSQRT(2.D0*DVOL*SE*SC/(SE+SC)+YTOLD*YTOLD)
        IF(YT.LE.H) THEN
            XT=DSQRT(2.D0*SC*DVOL/(SE*(SE+SC))+XTOLD*XTOLD)
            ELSE
            XT=DVOL/H+XTOL
            YT=H
            EPS=0.D0
        ENDIF
        X1=YT/SC
        IF(XT.GT.VLCM)THEN
                print*,'Strip Filled up!!',SE
                STOP
        ENDIF

C====> Tollner's (1977) Sediment Trapping Efficiency <=====================

140     VLT=VLCM-XT
        RATIO=VM(3)*RS(3)/0.01D0
        PNF=(VLT*PART(2))/(VM(3)*DF(3))
        FRAC=CDEP*DEXP(-.00105d0*(RATIO**.82D0)*PNF**(-.91D0))
        GSO=GS2*(1.D0-FRAC)
        CO=GSO/QSED(3)
        PPM1=1000000.D0*CO
        GSIMASS=GSIMASS+(GSI+GSIOLD)*.5D0*DTG
        GSOMASS=GSOMASS+(GSO+GSOOLD)*.5D0*DTG
        TOTRAP=(GSI-GSO)/GSI
        if(gsi.eq.0.d0)totrap=0.d0

C-----------------Write outputs------------------------------

c       WRITE(13,100)TIME/60.D0,YT,X1,XT,VLT,GSSI,GSI,GSO,CO,PPM1
        WRITE(13,100)TIME,YT,X1,XT,VLT,GSI,GSSI,GS2,GSO,GSIMASS,GSOMASS,f,
     &  FRAC,TOTRAP
c       write(*,*)TIME,GSI,GSO
c-------On the assumption that the trapped sediment is uniformly distributed on
c-------bed of channel, calculate DEP, depth of sediment deposited for that dt
c-------and CDEP as a multiplier to reruce the actual GSO.

        GTRAP= GS2*FRAC
        GTRAPMASS=GTRAP*DTG
        VOLTRAP=GTRAPMASS/GAMMASB
        DEP=DEP+VOLTRAP/VLT/2.54d0
        CDEP=0.5D0*(DEXP(-3.D0*DEP)+DEXP(15.D0*DEP*(0.2D0-DEP)))

c---------------Update values for next time step-------- ----

        SEOLD=SE
        FOLD=F
        GSIOLD=GSI
        GSOOLD=GSO
        TOLD=TIME
        XTOLD=XT
        YTOLD=YT

100     FORMAT(f7.0,4F10.3,11E10.3)

        RETURN
        END


        SUBROUTINE POINTS(N,XT,YT,SE,XPOINTS,NODEX,vbt,VN1,VN2)
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
c                                                                      c
c       This program finds qk, x1,x2,x3 to feed back to the KWGA program c
c                                                                      c
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
        IMPLICIT DOUBLE PRECISION(A-H,O-Z)
        PARAMETER (MAXEQN=1001,MAXBND=7)
        COMMON/PAR/QK(200),R,THETAW,DX,DT,NDT,NELEM,MAXITER,NPOL,OUT,NL
        COMMON/GRASSD/PART(3),SC,SS,VN,GSI,H,VLCM,POR,QSED(4),RS(3),DF(3),VM(3)
        COMMON/GRASSD2/GSIMASS,GSOMASS,TTE,DEP
        DIMENSION XPOINTS(3),NODEX(4)

C-------Find points for each of the areas in filter---------------

        SET=SC+SE
        VLT=VLCM-XT
        VBT=YT/SE
        IF(VBT.GT.XT)VBT=XT
        XPOINTS(1)=XT-.5D0*VBT
        XPOINTS(2)=XT
        XPOINTS(3)=VLCM-VLT*.5D0
        XPOINTBT=XT-VBT
        NODEX(1)=IDNINT(XPOINTS(1)/DX/100.d0)+1
        NODEX(2)=IDNINT(XPOINTS(2)/DX/100.d0)+1
        NODEX(3)=IDNINT(XPOINTS(3)/DX/100.d0)+1
        NODEX(4)=IDNINT(XPOINTBT/DX/100.d0)+1
```

```
C-------Reshape the surface topography of the filter-----------------

        ALPHA1=DSQRT(SC)/VN2
        ALPHA2=DSQRT(SET)/VN1
        ALPHA3=DSQRT(SC)/VN1
        DO 10 I=1,N
              IF(I.GT.NODEX(2))THEN
                   QK(I)=ALPHA3
                 ELSEIF(I.GT.NODEX(4))THEN
                   QK(I)=ALPHA2
                 ELSE
                   QK(I)=ALPHA1
              ENDIF
10      CONTINUE

        RETURN
        END
```