COMPENDIUM OF SELECTED NORTH DAKOTA UNSATURATED FLOW DATA IN FUNCTIONAL FORMAT

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SYMBOLS AND ABBREVIATIONS

a	Coefficient for Eq. 15 (van Genuchten)
A	Coefficient for ln S vs. θ (Eq. 2)
AA	Coefficient for ln K vs. θ (Eq. 1)
b	Exponent for Brooks and Corey Equation (Eq. 9)
B	Intercept for ln S vs. θ
BB	Intercept for ln K vs. θ
C	Intercept for ln K vs. ln S
Cl	Percent clay
ρ	Density of water
D_i	Particle class boundary diameter (Bloemen)
Dm	Mean particle diameter for a given size class
$D(\theta)$	Soil water diffusivity as a function of θ (cm^2/hr)
f	Gravimetric fraction belonging to a given particle class
F	Grain size distribution Index of Bloemen
g	Acceleration due to gravity
G	Grain size index of Gosh for predicting 'b'
Gd	Standard deviation from the weighted geometric mean particle diameter (Gm)
Gm	Sample weighted geometric mean particle diameter
K	Soil water hydraulic conductivity (cm/hr)
K_i	K corresponding to inflection moisture θ_i
Km	Experimental K value, used to match theoretical models for determining the $K(\theta/S)$ function curve

Kr	'Relative K', determined from theortetical models, and matched to an experimental value (Km) for determining the K(θ/S) function curve (Eq. 4)
Ks	K value corresponding to saturation
K(θ/S)	K as a function of moisture or suction
m	Exponent for van Genuchten S vs. θ function (Eq. 15)
M	Empirical factor for parabolic S vs. θ function from θ_i to saturation (Eq. 13)
n	Exponent for van Genuchten S vs. θ function (eq. 15)
N	Coefficient for Log K vs. Log S (Eq. 3)
N'	Empirical variable for parabolic S vs. θ function from θ_c to saturation (Eq. 13)
Nb	Brooks and Corey estimate for N
Nc	Campbell estimate for N
Nm	Muelem estimate for N
p	Stochastic pore interaction factor for theoretical K models
P_i	Gravimetric percentage of particles belonging to a given size class
Por	Soil porosity estimated from bulk density (Eq. 32)
R_i	Capillary pore radius (cm)
Sasi	Sand to silt ratio
Sa	Percent sand
S	Soil water suction (cm, or as noted)
Se	S corresponding to air entry moisture

Si	S corresponding to θ/S curve inflection moisture, θi
Sil	Percent silt
Sm	S corresponding to experimentally determined matching K and θ values
τ	Surface tension of water
Z	Particle size index calculated from Gm/Gd
θ	Soil moisture content
θi	θ value at θ/S curve inflection, near air entry moisture
θm	θ corresponding to experimental matching K value
θr	Residual moisture
θs	Saturated moisture content
Θ	Effective saturation $(\theta - \theta r)/(\theta - \theta_s)$

INTRODUCTION

Materials presented in this report were compiled as part of a study, assessing recharge of shallow ground-water aquifers in southeast North Dakota. One aspect of the larger study involved an inventory of soil hydraulic properties, with the objective of classifying them for use in estimating recharge quantities. The data presented here are not new. Rather, they were measured under the supervision of D. K. Cassel from 1972 to 1973, and were presented by Cassel (8), and Cassel and Sweeney (9), and Carvallo (10). The purpose of this representation is outlined in the following introductory paragraphs. However, the report authors ask that where use of this data is acknowledged, the original workers be appropriately cited. It is further suggested that where precision of the data presented is critical, as in research or in design applications, that the original data be rechecked. Although the data presented have been carefully extracted, errors may exist.

The purpose of this report is threefold. First, it is intended to help extend the moisture range of Cassel's data. Original in situ measurements were made over a limited moisture range. Model applications often require that data be extended to drier or wetter ranges than those presented. This is done using established models (3, 21, 32) for predicting K as a function of soil water content or soil water suction (designated $K(\theta/S)$) using soil pore distribution estimates from moisture desorption data, and in situ K matching values to scale the curves.

The second purpose of this report is interpretive. Many models require that hydraulic data be presented in functional form. This removes the necessity for interpolation, where arrays of discrete points are used. Some functional relationships, such as those of Brooks and Corey (3), Mualem (21), and Campbell (6) define a relationship between unsaturated hydraulic conductivity, $K(\theta/S)$, volumetric water content (θ), and soil-water suction (S). An additional benefit of the functional form is that equations are often easily integrable and differentiable, where necessary, for the solution of ground-water flow problems (34).

Finally, this report is presented to save time for users of Cassel's data. The original data were presented in graphic format which, although space efficient, requires reextraction of data for application in modeling and research endeavors. This process is time consuming, involving photo-enlargement and tedius extraction of data points. It is hoped that representation in tabular and functional form in this report may facilitate the use of Cassel's data by other parties.

The intention of this report is practical. Its scope is to explain what the parameters are, present them, and show how to use them. Although theoretical bases are presented briefly, they are not treated in detail. Rather, the reader is referred to foundation literature for more complete discussion. Methods of data extraction and calculation of functional relationships are explained, so that the user is not blind to their potential limitations. It is hoped that in presenting the data, work will be saved for other potential users.

Symbols and abbreviations most commonly used are summarized in a preface to the main report. A few are defined only in the text. For convenience, the characters ln/ln are used to indicate a natural log vs. natural log functional relationship between two variables.

DATA EXTRACTION AND USE

Original Methods and Procedures

The original authors (7, 8, 9) determined K(θ) using an in situ procedure called the Instantaneous Profile Method (IPM). Calculations were made from neutron moisture and tensiometric readings on a draining field soil, protected from evapotranspiration and precipitation. Soil moisture characteristic curves were measured using undisturbed 7.62 x 7.62 cm core samples taken from pits excavated in the in situ measurement area. Single cell pressure plate extractors were used. Details of field and laboratory methods and data are presented by Cassel (8). Soil profile descriptions, 15 bar moisture data, and in situ field capacity values are in Cassel and Sweeney (9).

Data Extraction Procedures

Cassel's K(θ) data were originally presented on graphs. Data for θ vs S were presented on tables (8). To allow for numerical presentation of K vs θ and S, it was assumed that the relationship between K and

θ could be adequately described by linear segments of the form:

$$\ln K = AA[\theta] + BB \qquad [1a]$$

$$K = e^{BB}e^{AA[\theta]} \qquad [1b]$$

and inversely,

$$\theta = (\ln K - BB)/AA \qquad [1c].$$

Line segments for the data were provided by Cassel (8), who used a maximum of two line segments to represent each data set. Graphs were enlarged with a photocopier, and endpoints for Eq. [1] segments were measured using a transparent semi-log grid. Values for AA and BB were calculated from endpoints for each interval.

Data for θ vs S was assumed to be related such that θ and S could be accurately described by line segments of the form

$$\ln S = A[\theta] + B \qquad [2a]$$

or

$$S = e^{B}e^{A\theta} \qquad [2b].$$

Inversely,

$$\theta = (\ln S - B)/A \qquad [2c].$$

Table data were plotted, and divided into three to six segments of Equation [2] form, depending on requirements of the individual data set. A and B were determined for each segment using regression. Equations were forced through independent and dependent variable means, rather than through either endpoint, with the result of slight overlap of predicted values at curve segment intersections. However, coefficient of determination values (R^2) exceeded .99, and overlap was very slight. Manipulation of [1] and [2] give

$$\ln K = N \ln S + C \qquad [3a]$$

or

$$K = e^{C}S^{N} \qquad [3b]$$

where $N = AA/A$ and $C = (BB-(AA\ [B])/A)$. The inverse function

$$S = (K/e^{C})^{1/N} \qquad [3c]$$

enables calculation of suction from K. Thus, a three way relationship between K, θ, and S was established for each combination of $K(\theta)$ and $\theta(S)$ curve segments.

Use of Data Tables

Coefficient (A,AA,N) and intercept (B,BB,C) values for Equations [1], [2], and [3] are presented for each depth increment of each site in Appendix A. Estimates of discrete $K(\theta/S)$ values are also presented. Values not listed can be interpolated using the coefficients. Two examples are given to illustrate the use of the coefficients.

Example 1: for Site 1 (lacustrine material), 8 cm depth, K(S) and $\theta(S)$ are desired for 90 cm suction. Using data from Table A.1, Eq. [3b] is applied

$$K = e^{11.33}(90^{-3.78}) = 0.003416 \text{ cm/hr}$$

and from Equation [2c]

$$\theta = (\ln (90) - 9.34)/-14.69 = 0.3295 \text{ cm}^3/\text{cm}^3$$

Example 2: For Site 2 (Embden fsl), 8 cm depth, $K(\theta)$ and $S(\theta)$

are desired at .2100 cm^3/cm^3 moisture. From Equation [1b]

$$K = e^{-22.41}(e^{76.75\ [0.2100]}) = .00185\ cm/hr$$

and from Equation [2a]

$$S = e^{9.82}(e^{-25.35\ (.21)}) = 89.7\ cm$$

The original data were carefully extracted and checked, so that expected deviation should be small. Nonetheless, it is stressed that they have been retaken from graphs, and are subject to accuracy limitations of such interpretation. Upper and lower limits of the data presented in the interpretive tables correspond approximately to the endpoints of Cassel's graphic $K(\theta)$ data. Equations [1], [2], and [3] were derived for extraction and presentation of data within their original limits. Extensions of their use far beyond those upper or lower limits may or may not be valid, and are risky.

EXTENDING FIELD DATA CURVES

One of the major limitations in using in situ procedures involving free drainage of water, is that the soil profile seldom achieves large hydraulic gradients. This puts an effective lower limit on the soil moistures at which K can be measured, because of extremely slow drainage as the soil profile approaches 'field capacity'.

IPM procedure on coarse textured soil requires almost constant measurement during the early phase of drainage. Sometimes vital early information can be missed, due to insufficient time to monitor a quickly draining profile. Fine textured soils may have extremely slow drainage rates from the start requiring months of measurements, and yielding limited curves. Also, layered soils often prohibit full wetting of deeper soil horizons. These limitations exist, to some degree, in all field methods. Unfortunately, such truncated data are not often sufficient in themselves for modeling soil water phenomena. Recharge phenomena require hydraulic parameters to saturation, and crop and soil water interactions are most important between 'field capacity' and 'wilting point'. It is necessary to provide means of extending data into the necessary ranges.

Models for extending K curves using in situ matching values and 'relative K' calculated from soil pore distributions have been developed and tested (3, 5, 6, 19, 20, 21). 'Relative K' is described as

$$Kr(\theta/S) = K(\theta/S) / Km \qquad [4]$$

where the matching K value, Km, is usually saturated (Ks). These models assume that soil water flow is laminar, and that the soil can be viewed as an assemblage of capillary tubes of varying radii. Although such assumptions are only met in limited degrees, they provide a theoretical basis for predictive equations, which can be further empirically adjusted to meet more realistic conditions. Pore distribution can be estimated using soil moisture characteristic curves, since θ is a measure of water filled porosity, and suction is interconvertable with pore radius, using the capillary rise equation.

$$S = 2 \tau / (R\rho g) \qquad [5]$$

where τ is surface tension of water, R is pore radius, ρ is density of water, and g is the gravitational constant.

Two different but related theoretical bases are used to predict Kr. The first, is based on Poiseiulle flow, which considers soil water velocity as a function of pore radius squared. Viewing the soil as an assemblage of capillary tubes of varying radii, Kr is predicted from

$$Kr =(\theta/\theta m)^{p} \quad (\int_{0}^{\theta} S^{-2} \, d\theta / \int_{0}^{\theta m} S^{-2} d\theta) \qquad [6]$$

where θm is soil moisture corresponding to the matching K value, and 'p' is a stochastic factor accounting for 'pore interaction' (19, 20), ie., non-continuity of pores of a given radius over the length of the sample. This model is generally attributed to Burdine (5), with 'p' being equal to 2. Modifications were presented by Marshall (19) and Millington and Quirk (20), Green and Corey (13), Kunze et al. (18) and Jackson et al. (16). Main difference between authors was the estimate of the stochastic factor, 'p'. Some values given for 'p' are 2 [Burdine (5) and Marshall (19)], 1 [Kunze (18)], and 1.33 [Millington and Quirk (20)].

Mualem (21) proposed a second theoretical expression which is based on Eq. [6], but is modified to account for tortuosity. Mualem's model is

$$Kr = (\theta/\theta m)^{p} \ (\int_{0}^{\theta} \ S^{-1} d\theta \ / \int_{0}^{\theta m} \ S^{-1} d\theta)^{2} \qquad [7]$$

where p is .5. For both Equations [6] and [7], many applications use 'effective moisture content', substituting $(\theta - \theta r)$ and $(\theta m - \theta r)$ for θ and matching θm values. 'Residual moisture', θr, is subtracted considering that a fraction of soil water is bound and immobile and that at some moisture, often greater than 0, $d\theta/ds$ is effectively 0. In most treatments, θm is θs, and Ks is considered as the matching value. However, this is not necessary to be consistent with theory, and other matching values may be used. Carvallo reported better results using unsaturated K matching values for the Green and Corey model (7). Van Genuchten and Nielsen (34) discussed the problem of using Ks matching values, and pointed out that influence of a few very large pores on K near saturation often limit the usefulness of completely saturated values for matching Kr.

In the literature, many authors use 'effective saturation', Θ, in place of θ, or effective moisture, $(\theta - \theta r)$, values. 'Effective saturation' is described by

$$\Theta = (\theta - \theta r) \ / \ (\theta s - \theta r) \qquad [8]$$

This simplifies manipulation of some equations, since at saturation Θ is 1. Use of Θ changes specific functional solutions but does not change the meaning of the theoretical equations (Equations 6 and 7).

Various solutions for Equations [6] and [7] have been presented. Early applications for Eq. [6] employed a power series solutions (19, 20, 13, 18). Mualem proposed an integration of the S^{-1} term over the moisture characteristic range using a succession of linear segments for the moisture characteristic curve (21). Some easily differentiable and integrable functions for θ vs S. have been used to simplify calculation. The parameters presented for this report are for functions proposed by Brooks and Corey (3), Campbell (6), and van Genuchten (32, 33).

FUNCTIONAL SOLUTIONS FOR RELATIVE K

Several equations have been proposed for representation of soil moisture characteristic curves. This report is concerned with two, for which mathematic parameters are presented. Both equations are commonly used, and have been tested in field application. Both can also represent theoretical bases for either Eq. [6] or Eq. [7] above. Since theoretical basis for Eq. [6] is often attributed to Burdine (5), and Eq. [7] to Mualem (21), they will be referred hereafter by the names of their authors.

Brooks and Corey / Campbell

Both Brooks and Corey (3) and Campbell (6) observed that a large part of the moisture characteristic curve, to near saturation, can usually be described linearly using a ln θ vs. ln S function. Figure 1 illustrates a typical θ vs. ln S curve. It can be seen that curvature closely approximates an expected ln/ln form from driest measured moisture state, to near saturation. Brooks and Corey proposed the equation

$$(\theta-\theta r)/(\theta_i-\theta r) = (S/S_i)^{-b} \qquad [9]$$

for characterizing Figure 1, where θ_i and S_i represent the curve inflection point (see Figure 1) which comprises the "wettest" suction at which the curve can be properly matched to the data using a ln θ vs. ln S function. Equation [9] is often presented as

$$\Theta = (\theta-\theta r)/(\theta s-\theta r) = (S/Se)^{-b} \qquad [9a]$$

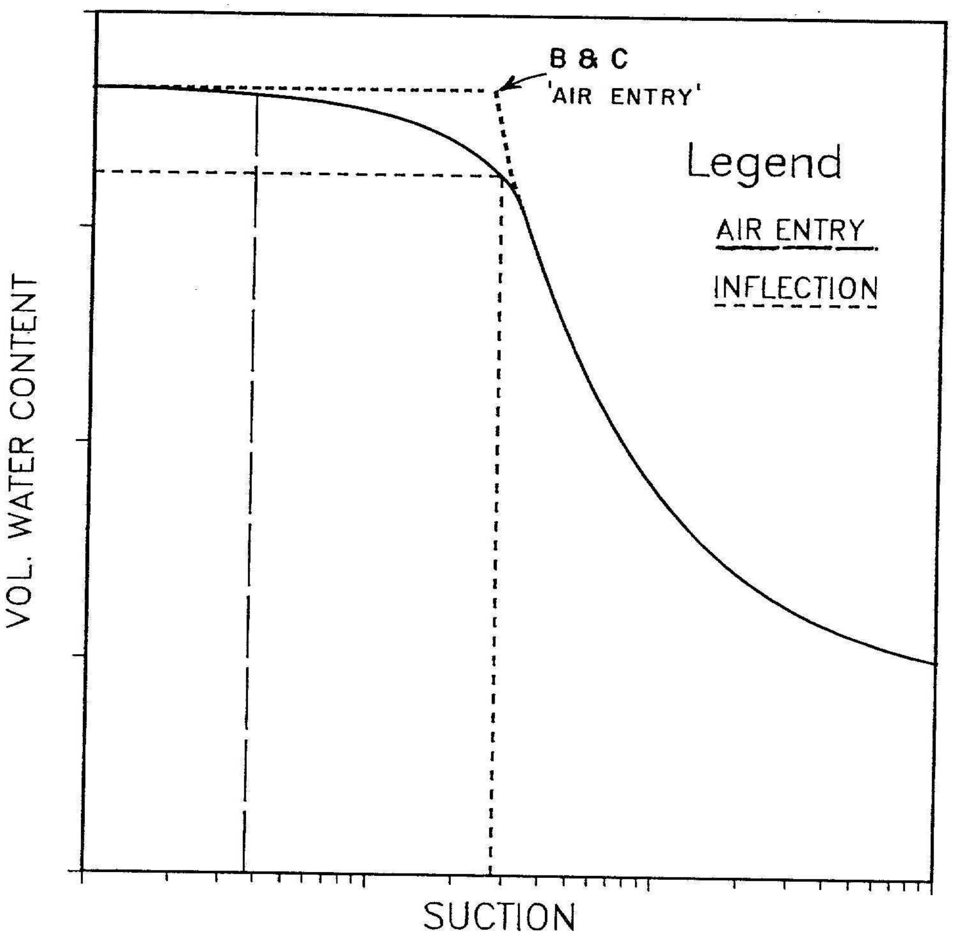

Figure 1. Illustration of 'air entry' and 'inflection' points on soil moisture characteristic curve.

Where θs is saturated water content, and Se is the 'air entry suction'; or, the suction at which water first begins to drain, when pressure is applied to the soil. This supposition is often not perfectly met, but is usually close enough to make its application practical.

Practical considerations make inclusion of a residual moisture content term desirable. Each soil has a moisture below which $d\theta/dS$ is negligible and below which contribution to capillary flow must be negligably small. From a curve fitting standpoint, coarse textured soils, such as the Embden soil (Figure 2) are not accurately fit by the ln/ln curve due to too great a curvature between wet and dry range. Both considerations are met by subtraction of a residual moisture term (θr).

Calculating Residual Moisture

In practice, determination of θr is an empirical procedure used for linearizing the ln/ln function (Equation [9]). Values for θr may vary with function, or calculation method. Thus, caution should be exercised when extending physical interpretation. Brooks and Corey (3) determined θr by plotting suction vs percent saturation, and noting the value of percent saturation asymptotically approached at high suctions. Percent effective saturation was then calculated using the corresponding θ value for θr, and was replotted vs. suction on a ln/ln scale. A straight line was extrapolated from inflection suction through the plotted points. Final adjustment was made by subtracting the deviation of the percent saturation for the highest suction from the linearly

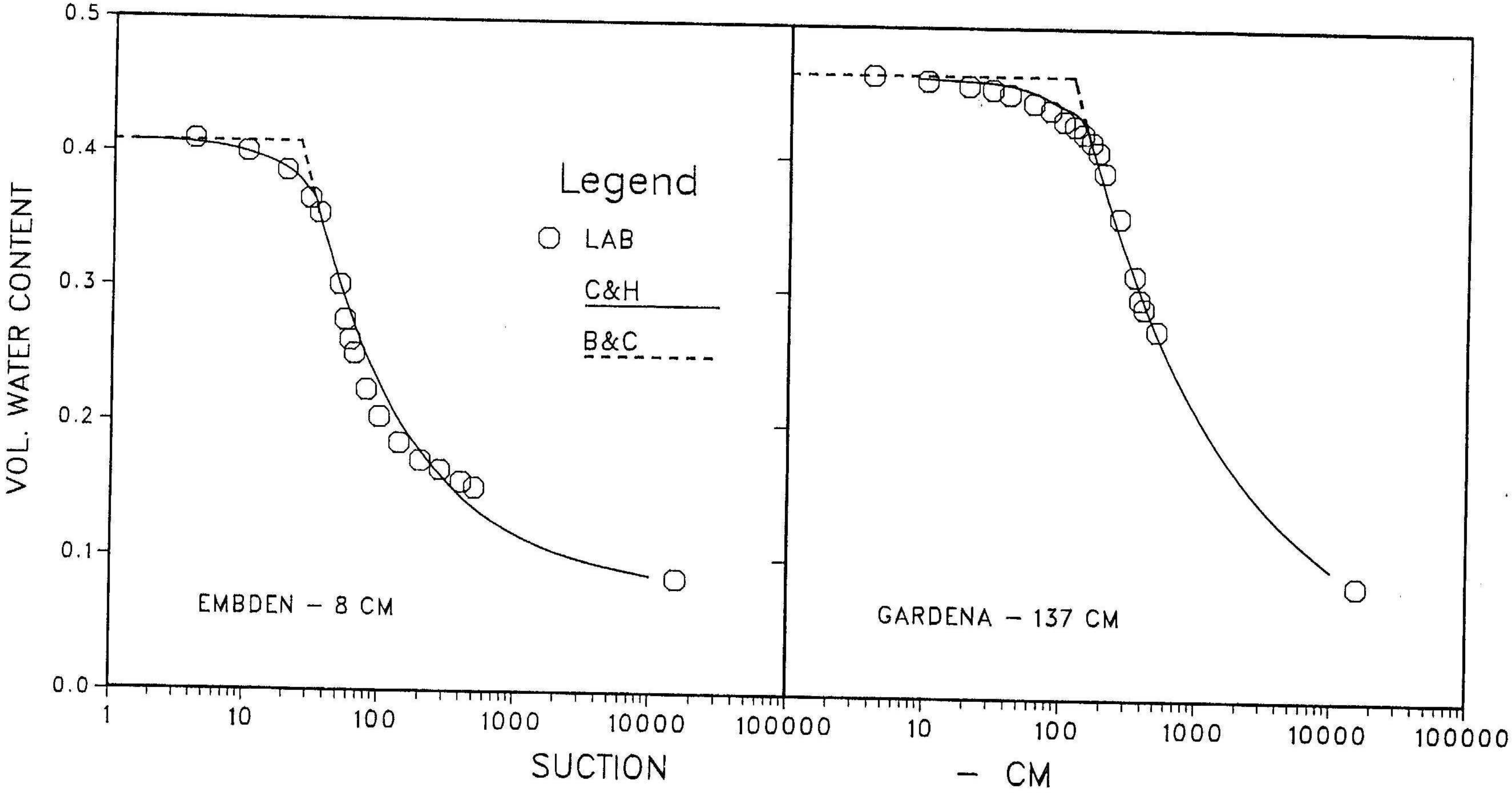

Figure 2. Brooks and Corey (B&C) and Clapp and Hornberger (C&H) moisture characteristic estimates.

predicted percent saturation at that suction. This process is time consuming and can take several successive approximations before an adequate θr value estimate is reached.

Mualem (21) suggested a numerical procedure for determining θr using an iterative least squares approximation. Mualem's method involves regression solution of the ln/ln form of Equation [9] for a stepped succession of θr values beginning with 0, and increasing in stepped increments. Our experience has indicated that increments of .001 work well. Each solution yields a coefficient, 'b' corresponding to the set θr value. Sum of square of deviations of the estimate from the true value (SSD) is used as criterion of goodness of fit. Values of θr and b are chosen for minimal SSD. Advantages of this procedure are 1) estimates for many samples can be quickly performed using a computer program, and 2) repetitive graphing is eliminated. An additional benefit is stability of a non-biased numerical standard. A FORTRAN computer program (RES5) for calculating Eq. [9] parameters using Mualem's iterative scheme is included in Appendix D.

Determination of K(θ/S) function

Solving the integrals of Eqs. [6] and [7] using Eq. [9] to describe S in terms of θ results in an equation of the form

$$Kr = (S/S_i)^{-n} \qquad [10]$$

where

$$n = 2 + (1+p)\ b \qquad [10a]$$

for Burdine theory; and for Muelem theory

$$n = 2+(2+p)b. \qquad [10b]$$

'Kr' is 'relative' K (Eq. [4]), and Km is usually considered to be identical to Ks. For moisture functions,

$$Kr = (\theta-\theta r)/(\theta_i-\theta r)^{n/b} \qquad [10b]$$

Brooks and Corey (3) uses Burdine's estimate for p = 2; thus n = 2 + 3b. Mualem (21) empirically estimated the optimal 'p' value to be .5 for most cases. The result is that n = 2 + 2.5 b.

In many cases, use of diffusivity ($D(\theta)$) is desirable, as it is less hysteritic than K(S). Hanks et al. (15) also observed that diffusivity was less prone to round-off errors in numerical flow models, than was hydraulic conductivity. Diffusivity is defined in terms of K as

$$D(\theta) = K(\theta) / (d\theta/dS) \qquad [11]$$

where $d\theta/dS$ is 'specific moisture capacity'.

Differentiation of Equation [9] gives

$$d\theta/dS = (\theta_i - \theta r)\, S_i^{b}\, (-b)\, S^{-b-1} \qquad [12]$$

Curve Fitting Procedures

Moisture characteristic curves are usually approximately sigmoid (Fig. 1). The Brooks and Corey function is properly fit to such data from the inflection moisture (Fig. 1) to residual moisture. Between inflection moisture and saturation a different representation must be used. Brooks and Corey (3) determined the exponent, b, by plotting ln ($\theta/\theta s$) vs. ln S. Inflection moisture, θi, was thus visually determined, and the slope (b) was calculated using moisture values less than or equal to θi. Equation [9] was then used to extrapolate the relationship through θi to saturation moisture ($\theta/\theta s = 1$). Suction corresponding to saturation water content was called the 'bubbling pressure' (3), or variously, the 'air entry' value.

Because 'air entry' has a physical definition, use of Equation [9a] for the Brooks and Corey function might cause some confusion. 'Air entry' suction represents the pressure at which the largest soil press first allow passage of air through a saturated sample. This corresponds to initiation of drainage. Often 'air entry' value initiates a slowly developing convex curve portion near saturation, rather than the abrupt change from horizontal line to the ln ($\theta/\theta s$) vs. ln S function (Fig. 1). Attempts to include, or match the moisture characteristic function to 'air entry' values thus interpreted, will result in decreased accuracy of fit for curve parameters. It is important to remember that the Brooks and Corey functions are fitted to and through curve inflection values, and that the 'bubbling' or 'air entry' suctions are determined from extrapolation of those curves to saturation moisture.

Using extrapolated 'air entry' values, and assuming identical moisture from those projected values to saturation can result in poor fits with actual wet range data (Figures 1 and 2). An alternative approach for representation of θ vs. S between inflection and saturation was proposed by Clapp and Hornberger (10). Their method is to match curves at the inflection value, and to represent the portion of the curve between inflection moisture and saturation using as parabolic function. Clapp and Hornberger proposed

$$S = -M\,(\theta/\theta s - N')\,(\theta/\theta s - 1) \qquad [13]$$

to describe the moisture characteristic at wetness exceeding inflection value. Differentiation of [13] gives 'specific moisture capacity'

$$d\theta/dS = \left|\theta s \,/\, M(1+N'-2[\theta/\theta s])\right| \qquad [13a].$$

Absolute value is used because 'specific moisture' does not have a directional component.

In this report, all values are forced through the inflection moisture and suction, and parabolic functions are fitted from inflection to saturation. This method was chosen, because accuracy of the K function equations (Eq. 10) depend on the precision of curve fitting functions. Moreover, few of the in situ K values available for matching values in this report are close to saturation. Most are well below the curve inflection value.

Using the Brooks and Corey and Mualem Functions

Exponent (b), residual moisture (RES-MOIS), and Root MSE values for each curve fit are provided by soil profile in Appendix B. Parameters for Eq. [13] are also provided in Appendix B (C&H M and C&H N'). Saturation moisture (W-SAT), inflection moisture (W-INF), inflection suction (S-INF) and air entry suction (S-AE) are included for each soil horizon. Air entry values presented are visually estimated from the moisture characteristic curve near saturation. They are not the Brooks and Corey estimates. Brooks and Corey - or Mualem parameters for $K(S/\theta)$ can be calculated using Eq. [10] with 'b' values provided. They are also provided for each horizon on the in situ data tables (Appendix A), (N-B&C and N-MUAL) respectively. An additional parameter estimate (N-CAMP) is for the Campbell relationship for N. Difference between Campbell and B&C n values is that Campbell always estimates residual moisture to be 0. This assumption tends to decrease accuracy of parameters, in terms of the theoretical bases for their derivation, since many moisture characteristic curves do not conform to the ln/ln fit without θr.

In using the information provided to extend the K function curves using matching in situ data provided (Appendix A), inflection hydraulic conductivities are not available in most cases. However, there is no reason why other matching K values cannot be used provided curve functions are accurate over the entire range of the moisture characteristic curve. In fact, Carvallo (7) found that fits in the unsaturated range often worked better than saturated matching values using the Green and Corey model. Thus, designating the desired matching K value as Km, with corresponding θm and Sm values, Equations [9] and [9a] become

$$K = Km(S/Sm)^{-n} \qquad [14]$$

and

$$K = Km(\theta/\theta m)^{n/b} \qquad [14a]$$

Some examples are as follows.

Example 3: For Site 1, 8 cm depth, hydraulic conductivity, diffusivity, moisture, and specific moisture values are to be estimated for 25 cm and 250 cm suctions respectively. Use Brooks and Corey function (3), Burdine (5) theory. The curve will be matched in the 60 cm suction range.

From Table A.1 For Sm = 67 cm suction, Km = .0109 cm/hr, and θm = .3500. From Table B.1, b=.227, and residual moisture is .033.

At 250 cm suction K is calculated using Eq. [10], assuming from Burdine (5) and Brooks and Corey (3) that 'p' = 2,

$$K(250) = .0109\ [250/67]^{-(2+\ (2+1).227)} = .000319 \text{ cm/hr}$$

Substituting Sm for Si in Equation [9], and subtracting residual moisture,

$$\theta(250) = (.3500 - .033)\ (250/67)^{-.227} + .033 = .268 \text{ cm}^3/\text{cm}^3$$

Applying Sm and m to Equation [12], specific moisture is calculated

$$d\theta/dS = (.3500 - .033)\ (67^{.227})\ (250^{(-.227\ -\ 1)} = .000214 \text{ cm}^3/\text{cm}$$

and dividing K by $d\theta/dS$ gives

$$D = .000319\ /\ .000214 = 1.49 \text{ cm}^2/\text{hr}.$$

At 25 cm suction, moisture is above inflection water content. Although the parabolic function (Eq. [13]) can be integrated using Eqs. [6]

and [7], the resulting equation is cumbersome. Instead, we will use the Brooks and Corey assumption of identity for K(S) from 'air entry' to saturation (3). First, Equation [9] is used to estimate air entry suction.

$$Se = 30\ [(.414 - .033) / (.404 - .033)]^{(-1/.227)} = 27 \text{ cm}$$

Since K(S) is assumed to be identical from air entry to saturation, S = 27 is used to estimate K(25) using Eq. [10].

$$K(25) = .0109\ (27/67)^{-(2+(2+1)\ .227)} = .125 \text{ cm/hr}$$

Because suction is below air entry value, Eq. [9] is not used to calculate θ. Either the saturation value (.414) is used, or successive trials using the parabolic function (Eq. [13]) can be used. For $\theta = .4068$,

$$S = -45821.44\ (.4068/.414 - .9487)\ (.4068/.414 - 1) = 24.96$$

which is close to the desired value of 25 cm.

Specific moisture is calculated from the parabolic function using Eq. [13a]. From Appendix Table B.1, we obtain M[45821] and N' [.9487].

$$d\theta/dS = .414 / 45821\ (1 + .9487 - 2[.4068/.414]) = .000547$$

From Eq. [11], diffusivity is estimated to be

$$D = .125 / .000547 = 228.5 \text{ cm}^2\text{/hr}.$$

although it must be recognized that the accuracy of this estimate is limited by the accuracy of the assumption that K(S) is identical from the estimated air entry suction to saturation.

Example 4. Calculate the same parameters at 250 cm using Muelem theory. Moisture contents are the same for Muelem, as for Brooks and Corey.

$$K = .0109\ (250/67)^{-(2 + (2+.5)b)} = .000371$$

Specific moisture is also identical for Brooks and Corey and Mualem.

Thus,

$$D = .000371 / .000214 = 1.73 \text{ cm}^2/\text{hr}$$

Van Genuchten Equation

A closed form equation

$$\Theta = (\theta-\theta r)/(\theta s-\theta r) = [\ 1/(1+(aS)^{n})]^{m} \qquad [15]$$

was used by van Genuchten (32, 33) to describe the moisture characteristic curve. Curves of this form are sigmoid, and therefore capable of fitting the entire range of values without truncating at the air entry value, or inflection value (see Figure 1). They are also integrable for solution of Equations [6] and [7], with certain simplifying assumptions explained by van Genuchten (32).

Burdine Theory:

Integration of Eq. [6], using Eq. 15 for calculating Kr using Burdine theory results in

$$Kr(\Theta) = \Theta^{2}[1-(1-\Theta^{1/m})^{m}] \qquad [16]$$

for expression in terms of Θ, or

$$Kr(S) = [1-(aS)^{n-2}(1+(aS)^{n})]^{-m} \ /\ [1 + (aS)^{n}]^{2m} \qquad [17]$$

in terms of suction. Diffusivity is given by

$$D = A[(1-\Theta^{1/m})^{-(m+1)/2} - (1-\Theta^{1/m})^{(m-1)/2}] \qquad [18]$$

where

$$A = [(1-m)Ks\ /\ 2am(\theta s-\theta r)\ ]\ \Theta^{(3-1/m)/2} \qquad [17a]$$

For Burdine theory, the simplification

$$m = 1-2/n \qquad [18]$$

is used.

Mualem Theory:

For Mualem theory, Eq. 6, van Genuchten's integration results are

$$Kr = \Theta^{.5}[1-(1-\Theta^{1/m})^{m}]^{2} \qquad [19]$$

for Θ, and for S

$$Kr = [(1-(ah)^{n-1}(1+(aS)^{n})^{-m}]^{2} \,/\, [1+(aS)^{n}]^{m/2} \qquad [20]$$

Diffusivity is calculated from

$$D = A[(1-\Theta^{1/m})^{-m} + (1-\Theta^{1/m})^{m}-2] \qquad [21]$$

where

$$A = \Theta^{.5-1/m}(1-m)\ Ks \,/\, [am\ (\theta s-\theta r)\ ] \qquad [21a]$$

For Mualem theory, the simplification

$$m = 1-1/n \qquad [22]$$

is used (32).

Calculating Equation Parameters

Van Genuchten considers θs, θr, m, n, and a to be empirical parameters, all of which are determined in optimizing the fit of the equation to the data. 'θs' is considered to be empirical because in his view the dominance of a few large pores at physical saturation, make its relationship to the expected sigmoid characteristic curve unreliable [van Genuchten and Nielsen (34)]. Residual moisture is also considered an empirical value, related to optimizing fit of the moisture retention function. Comparison of residual moisture values calculated for Equation [16] with those of the Brooks and Corey method matched through the curve inflection value indicate considerable variability (R^2=.66 Root MSE = .03, DF = 50), particularly close to θr = 0 for the Brooks and Corey estimate. Residual moisture is quite dependent upon the method of calculation, in using numerical models.

Parameters for Equation [14] are provided in Appendix B. Only Mualem theory parameters are provided. Graphical methods for estimating optimal θs, θr, M, N, and a values were outlined by van Genuchten (32, 33). These methods are somewhat entailed. A Fortran Computer program [SOHYP] written by van Genuchten (33), was used for calculations made for this report. The program is included in Appendix D with permission from its author.

Using the Van Genuchten Function

Since only Mualem theory data is provided in this report, examples are confined to that method. Equations for Kr assume that the matching K value is Ks. However, other K values can be used to calculate Ks from

$$Km/Kr(m) = Km/(Km\ /Ks) = Ks \qquad [23]$$

where Kr(m) is relative K at the matching suction or moisture.

It is cautioned that Ks determined from Eq. [23] is not necessarily identical with saturated K as physically determined for saturated samples, or from steady state infiltration on an homogeneous soil. Due to influence of a few very large pores at full saturation, true saturated K values may be somewhat higher than those predicted from the continuous K(S) function.

Example 5:

Calculate K, D, and θ at 250 and 25 cm suctions for Site 1 at 8 cm depth. As in Example 1, match at around 60 cm suction. Values for K and θ at 67 cm suction were given in Ex. 1 above, and were taken from Appendix Table A.1. First, relative K is calculated for the matching suction value (67 cm).

For Equation [20],

$$a(S) = .01278\ (67) = .856$$

Thus

$$Kr(67) = [1-.856)^{1.618-1}(1+.856^{1.618})^{-.382}]^{2}\ /\ (1+.856^{1.618})^{.382/2} = .066$$

Ks is calculated from Kr(67), and K(67). Thus, using Eq. [23],

$$Ks = .0109/.066 = .165 \text{ cm/hr}$$

for 250 cm suction

$$a(S) = .01278\ (250) = 3.195$$

and

$$Kr(250) = [(1-3.2^{1.618-1}(1+3.2^{1.618})^{-.382}]^{2} \ / \ (1+3.2^{1.618})^{.382/2} = .00189$$

So, using Eq. [4], with Ks = Km

$$K(250) = .001897\ (.165 \text{ cm/hr}) = .000313 \text{ cm/hr}$$

In this equation, saturation moisture, rather than inflection moisture, is used (Appendix Table B.2). Manipulation of Eq. [15] to solve for θ gives

$$\theta(250)=(413 - .115)\ [1/1+(3.2)^{1.618})]^{.382} + .115 = .253 \text{ cm}^3/\text{cm}^3$$

For diffusivity, using the calculated moisture at 250 cm in Eq. [21a]

$$A = [(1-.382).165 \ / \ (.01278(.38193)(.413-.115)][(.253-.115)/(.413-.115)]$$

$$= 358.19$$

and from Eq. [21]

$$D = 358.19\ [(1-.463^{(1/.382)})^{-.382} + (1-.463^{(1/.382)})^{.382} - 2]$$

$$= 1.075 \text{ cm}^2/\text{hr}$$

For the 25 cm suction, no truncation at inflection or air entry, value is necessary, as the function extends to saturation. The product, a(S), is .32. From this, relative K is calculated to be .211, and

$$K(25) = .211(.165) = .035 \text{ cm/hr}$$

similarly, θ is calculated using the same function (Eq. [15]).

$$\theta(25) = (.413-.115)\ [\ 1/(1+(.32)^{1.62})]^{.382} + .115 = .397 \text{ cm}^3/\text{cm}$$

Selecting Method and Function

Assumptions in theoretical development of pore interaction models require that soil can be modeled as an assemblage of capillary flow elements. They also do not account for shrink and swell phenomena, and therefore are not likely to have high levels of accuracy on swelling soils. Nyhan et al. (23) have observed that swelling indications (as evidenced by visual cracking) are first noticed at about 14% smectite content. In soils of grey Wisconsin glacial till origin, clay portion is often about 65% smectite (24); thus, use of pore interaction models above 20% clay would likely pose difficulties for northern plains soils. This is supported by the observations of Nielsen et al. (22) who observed a poor fit for the Marshall model on a Webster clay loam soil, and also by the work of Bouma and Anderson (2) and Ehlers (12) who noted poor fit on soils with structure types corresponding to high clay content. Generally, the models have fitted best on sandy soil, and loess (4, 27, 2, 12).

For the models here discussed, accuracy should be a function of two factors. First, the goodness of fit of functions to actual data is important, since the accuracy of integration of pore radius functions over the range of moistures is dependent upon them. The main advantage of the Brooks and Corey equation is its simplicity. With only two empirical parameters to derive, a simple least squares procedure can be used to calculate parameters. The equations, themselves, are also less entailed and easier to use. The main disadvantage is the truncation of the function at inflection value, and therefore a tendency toward inaccuracy in the wet range. The closed form equation is more mathematically entailed, but adequately fits data to saturation. For this reason, it has been suggested by some workers that the ln/ln (Brooks and Corey) equation be used for applications requiring dry range calculations (such as in crop water use modeling, which stress water use and movement below "field capacity", and that the closed form model be used when water dynamics near saturation are of most concern.

The second consideration, is the adequacy of the model itself. Mualem's tests, using 40 diverse soils (21), and later tests by van Genuchten (32) indicated that overall, the Muelem model provided the best fits. However, in the individual case, Burdine assumptions sometimes fit best. There is no single model that provides best results for all soils. In the example calculations above, it can be noted that K and θ predictions vary between models, and between functions. However, compared with field variability the differences observed are not large.

Figure 3 illustrates the fits of closed form predictions of K (Mualem theory only), and Brooks and Corey predictions of K (Mualem and Burdine theory) as functions of suction. Data were for Sites 2, 4, and 7 from Cassel. All were matched at around 60 cm suction, or below inflection value, if inflection suction was below 60 cm. For the Brooks and Corey functions, K estimates were extended to air entry values, which were visually estimated from moisture retention curves.

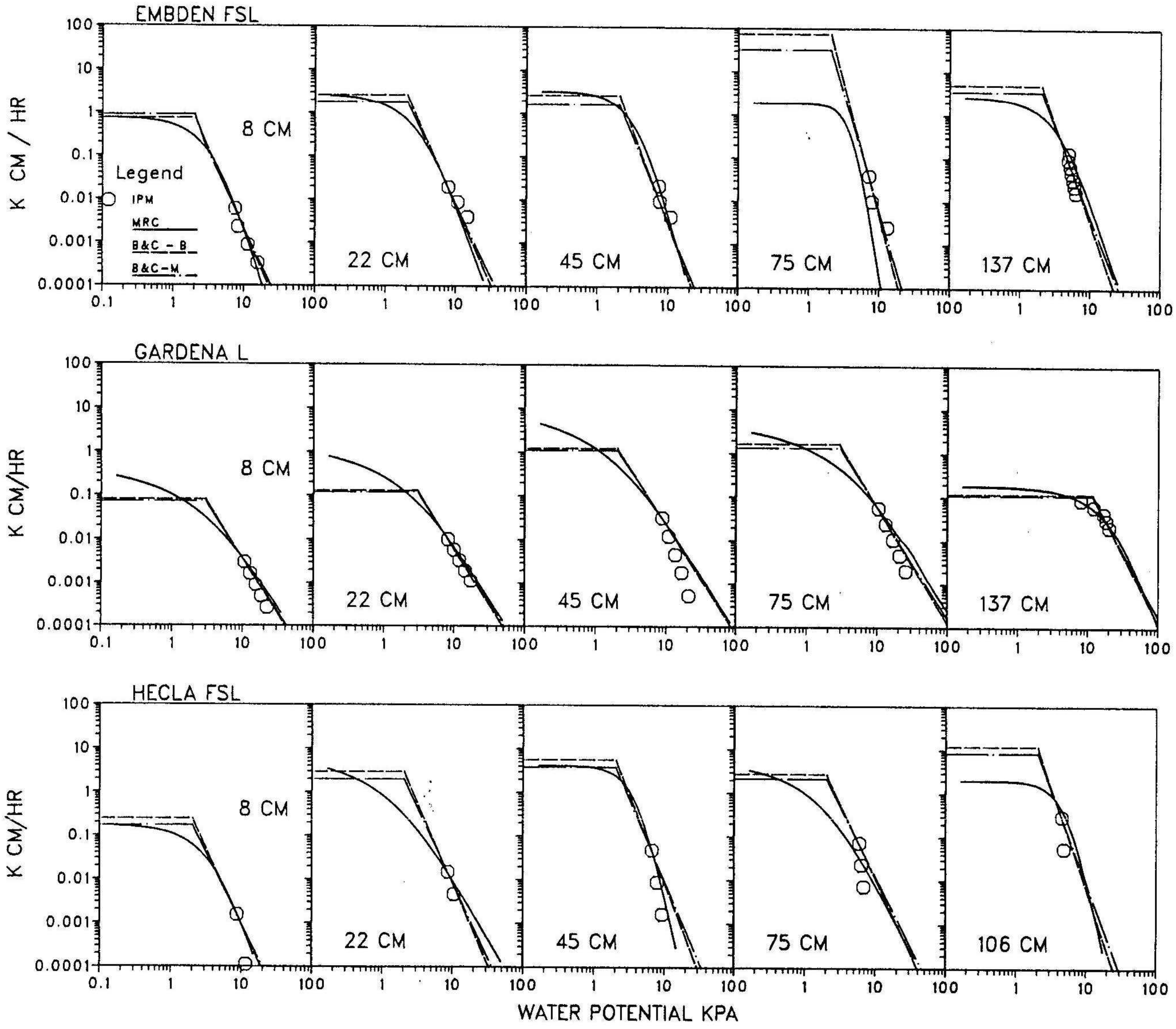

Figure 3. Comparison of K(S) predicted using Brooks and Corey, (ln/ln function), Muelem (ln/ln function, and Muelem (Van Genuchten function), with in situ determined K(S) values.

Above air entry suction, values were considered constant to saturation. Over the limited range of the data, all models fit reasonably well with in situ values. On these data, there was little difference between Burdine and Muelem theory values using the Brooks and Corey (3) function.

Greatest difference was between the Brooks and Corey (3) and van Genuchten (31) functions, and that occurred mostly near saturation. The sensitivity of the closed form equation to changes in porosity is demonstrated at the 137 cm depth of the Gardena profile, where it matched the change in curvature of the in situ K data with excellent precision. Other in situ data, extending to air entry value (not shown here), have indicated that prediction of Ke (and Ks), using the closed form equation matched at 60-70 cm suctions, is usually accurate. From this, it can be seen that the closed form equation of Van Genuchten is probably the best choice for wet range estimates, as no visual estimate of air entry suction is necessary, and a single function can be used over the entire range of water contents. However, in drier ranges, Brooks and Corey (3) estimates worked as well.

EXTENDING DATA INTERPRETATIONS FOR APPLICATION

Discussion thus far has focused on extending ranges of in situ and laboratory determined hydraulic data. In order to use these data for simulation of field problem situations, they must be interpreted spatially. Given a limited data base, the problem becomes one of using existing information to characterize more extensive hydrologic units: or, classification. Various classification criteria, including geographic, geologic, pedologic, and physical criteria are commonly used. Within any classification scheme, field variability of soil hydraulic properties is extensive and poses a problem of considerable magnitude. The problem of spatial variability is beyond the capability and scope of this report. It has been the focus of many workers; but to date, data for simulating hydrologic events is not extensive, and detailed maps of hydrologic properties are, for the most part, prohibitively expensive. Despite limitations, workers must still attempt to use existing information to best advantage in reaching decisions on use and allocation of water resources. This report will outline two possible classification schemes for Cassel's data. It is important to realize that none of the approaches discussed adequately deal with the problem of spatial variability. They do, however, offer rational bases for extending hydrologic interpretations from limited data bases.

Pedologic Classification

Within a given geographic area, soil mapping units are designated, based on physical, chemical, morphologic, and developmental criteria.

Since agricultural value is an important criteria in these classifications, they may, or may not be strongly related to hydrologic characteristics. Usually, however, similarity of parent materials, developmental processes, and the strong dependence of crop growth on water relations insure that classification units correlate reasonably well with hydraulic properties.

One possible method for extending data interpretation is to consider the data from a single, or limited number of soil profiles as representative of an entire classification unit. The unit most commonly used for such classification is the soil series. Where data is lacking for a desired series, broader classifications, called 'associations' which group series in a given landscape, might be used. Broader classification still, according to geomorphic units, or geographic criteria might also be used. In selecting classification schemes it is important to be aware of the hydrologic relevence of the classification criteria. It is also clear that the broader the classification used, the more severe will be the problem of variability, and the greater will be the likelihood of poor representation of the classification unit.

The above approach ignores the problem of spatial variability. Using Coefficient of Variation criteria, spatial variability of a log normal distribution of K(S) for a single soil series was estimated by Rogowski to be about 15% (26) but may be larger or smaller elsewhere. Sharma and Luxmoore (29) used the same criteria to estimate the log normal variability of infiltration on a watershed to be 50%. Using the data in this report, i.e., the three Maddock determinations by Carvallo et al.(7), we calculated a log normal C.V. value of about 10% within the field area in which they were measured. While it may not always be possible to characterize variability, it is important to be aware of its significance when deriving conclusions from limited data.

Series names are included, where classified, for information used in this report. More detailed classification information, with corresponding site locations, soil profile descriptions, and photos can be found in Cassel and Sweeney (9) and Cassel (8).

Material Classification

An alternative approach is to ignore pedalogic classification, and group according to material properties. This approach was suggested by Clapp and Hornberger (10) who classified Brooks and Corey and Campbell (6) parameters according to textural class. Rawls et al. (25) also used this approach to classify hydraulic parameters according to texture units for different parts of the United States. The data of Cassel (8) was included in his report for North Dakota. One advantage of this approach is that it allows assessment of variability of parameters without replication within a given mapping unit. Thus, means and standard deviations of parameters can be obtained and used to derive confidence intervals. One disadvantage is that hydrologically significant structural characteristics, similar within series, cannot be accounted for. Since Cassel's data was used in the classification of Rawls et al. (25), it is not included here. Further discussion can be found in Rawls et al. (25).

A different technique was used by De Jong (11) who used multiple regression equations to predict hydraulic parameters for % sand, % silt, % clay, bulk density, and organic matter variables, for Canadian soils. As with classification according to texture class, this method allows for assessment of variability for parameters, using regression statistics. It offers the further advantages of allowing for inclusion of non-textural physical data, and of estimation of parameters as a function of a continuum of physical properties, rather than viewing them as grouped into larger discrete units.

Many workers have developed texturally based indices for predicting Campbell and Brooks and Corey /S curve parameters (1, 14, 31). In some cases, these indices have proven to be better predictors of n than the commonly used % sand, % silt, and % clay (28). Although these indices do not always exhibit identical relationships to different data sets (28), they often correlate highly. In this report, we use them as indices for predicting Brooks and Corey (3) and Van Genuchten (32) curve parameters, rather than as predictions in themselves. In the following paragraphs, the indices used will be briefly described and documented. Predictive regression equations will then be presented.

Bloemen Index:

Bloemen (1) presented an index (here labeled F) for prediction of the Brooks and Corey and Campbell K vs. S parameters. The index was calculated as

$$F = \sum_{i=1}^{n} F_i \Big/ \sum_{i=1}^{n} (P_{i+1} - P_i) \qquad [24]$$

where

$$F_i = (P_{i+1} - P_i)\, tg_i \qquad [25]$$

and

$$tg_i = \ln(P_{i+1} / P_i) / \ln(D_{i+1} / D_i) \qquad [26]$$

P_i is the cumulative percentage by weight, from 0 to a given particle diameter D_i. Bloemen reported that the coefficient of the ln K vs ln S relationship (Equation [10] above) could be calculated from

$$n = 1.4 + 4.536(e^{.3F}-1) \qquad [27]$$

Although the specific relationship in Eq. [24] has not always been upheld, the Campbell moisture retention determined exponent (6) usually correlates significantly (Fig. 5) with F (28). F values for all data are presented in Appendix C, along with other textural data.

Gosh Index:

Gosh (14) predicted the slope of the ln θ vs. ln S curve (as bc = G), using the index

$$G = 2.619(\mathrm{Sil/Sa})^{0.2822} \, (X + 0.7)^{0.0625} \, X^{0.125} \, (5.91\ \mathrm{Cl}/[\mathrm{Sa} + \mathrm{Cl}] + 1.1)^{0.0625} \qquad [28]$$

Where

$$X = 6.2\ (\mathrm{Sil/Sa})^{.5} - 5.91\ (\mathrm{Cl}/(\mathrm{Sa} + \mathrm{Cl}) \qquad [29]$$

Although G was intended to estimate bc directly, it is here used as an index.

Sand to Silt Ratio:

The ratio of sand to silt percentages has been found to be strongly correlated in some instances with in situ N [slope of ln K vs. ln S] (28). It is used here as an index.

Geometric Mean Particle Statistics (GM, GD, Z):

Shirazi and Boersma (31) published a revised textural triangle in which a weighted Geometric Mean particle diameter (Gm), standard deviation (Gd) were presented. They suggested that many soil mechanical properties, were highly correlated with the Gm. Other workers have found them to be strongly correlated with soil hydraulic properties (28);

$$Gm = \exp\left(.01 \sum_{i=1}^{n} [f_i \ln M_i]\right) \qquad [30]$$

where f_i = gravimetric percentage corresponding to a particle size class with mean diameter M_i.

$$Gd = \exp\left[0.01 \left(\sum_{i=1}^{n} f_i \ln^2 M_i \right) - \left(0.01 \sum_{i=1}^{n} f_i \ln M_i\right)^2\right]^{.5} \qquad [31]$$

Another index is formed using

$$Z = Gm/Gd \times 100 \qquad [32]$$

Particle Index Values:

Values for the above indices are presented for each of the data sets of Cassel (8), Cassel and Sweeney (9) and Carvallo et al (7) in Appendix C. A Fortran computer program for calculating these indices (GCALC) is included in Appendix D.

Predicting Soil Hydraulic Parameters Using Textural Indices

Properties and indices used in regression modeling are summarized on Tables 1 and 2. In modeling, both dependent and independent variables were transformed, as necessary, to linearize the relationship. Most common relationships were combinations of linear, and ln transformed variables. Correlation matrices were then calculated to determine the best predictive variables. Variables with the significant r values (P:.05) were used to predict the best predictive model using 1, 2, 3, and 4 variables.

Tables 1 and 2 show the R^2 values for variables significantly related to the Brooks and Corey and van Genuchten properties respectively. It is noted that residual moisture values for both Brooks and Corey and van Genuchten curve formats are not strongly correlated with textural data. Rather, they are most strongly related to other curve parameters. This reconfirms the earlier observation that residual moisture is an empirical, rather than physical property. For Brooks and Corey, it is most strongly correlated with b. For van Genuchten, it is most strongly correlated with the product 'mn'. Table 3 shows the correlation between the particle variables and in situ ln K vs ln S values (N). Although significant, they are not predictive. No models for this relationship are presented.

Brooks and Corey Parameters:

Best fit models for the exponent value 'b', are on Table 4a, and is illustrated on Figure 4.

Best fit models for r are on Table 4.b. All predictive models required inclusion of 'b'. Textural variables alone could not provide a predictive model.

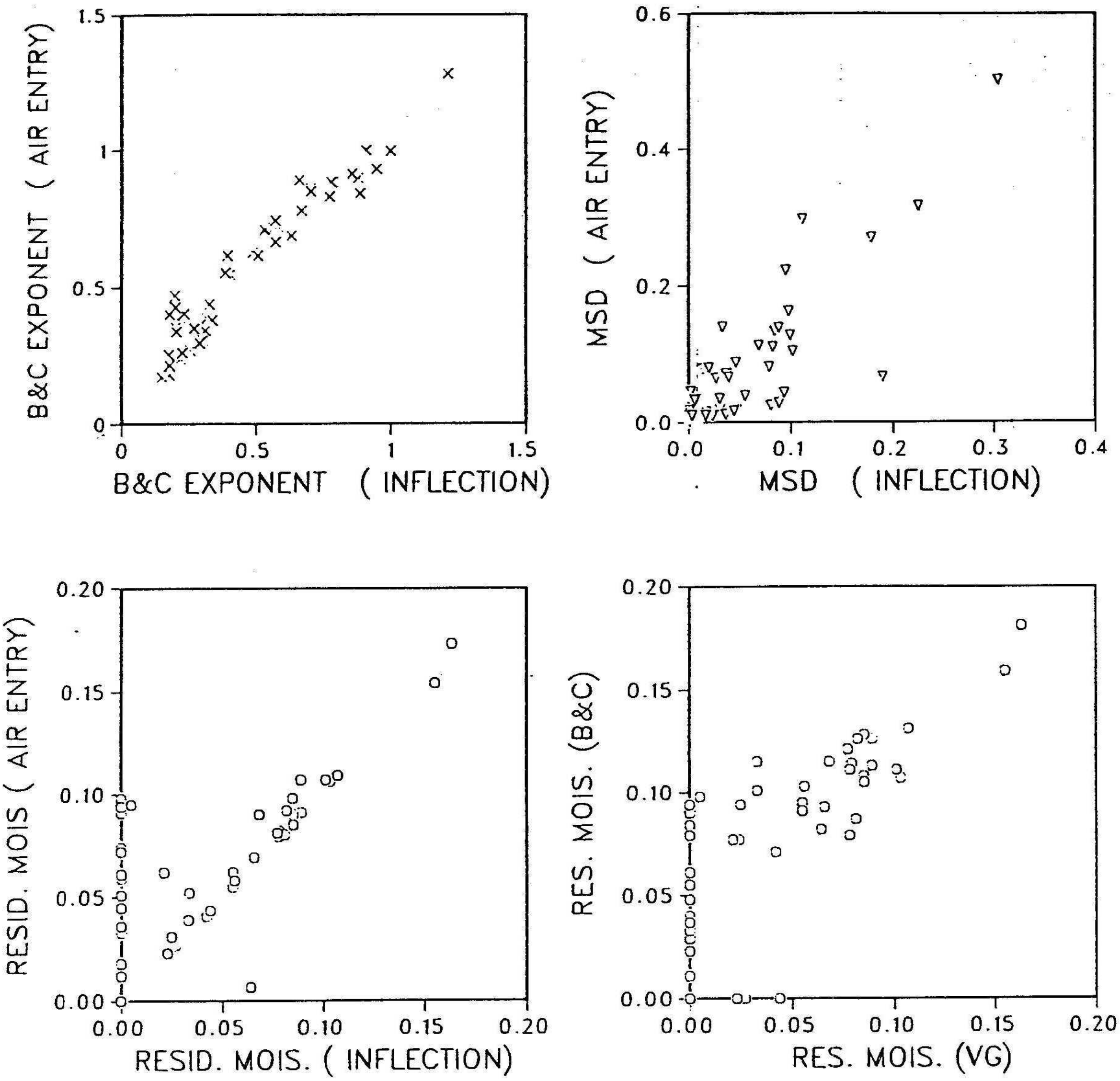

Figure 4. Illustration of relationships between Brooks and Corey parameters, and best fitting single predictive variable.

Saturated moisture content and inflection moisture content were most strongly related to porosity (Por), estimated from bulk density (Bd) and particle density (Pd);

$$\text{Por} = (1 - \text{Bd}/\text{Pd}) \qquad [33]$$

using the approximation 2.65 for Pd. 'θs' vs. Por and θi vs. Por are illustrated on Figure 4. Best fit models using Por and textural data are on Tables 4c and 4d.

Air Entry Suction, Se, was best predicted using Si and G index. Models are presented on Table 4.e. Inflection suction, Si, was best predicted by Sa and Si variables (Table 4.f).

Each of the models presented for Brooks and Corey data could account for between 60 and 70% of variability in parameter values. Standard error values for the estimates are included with descriptive equations.

One example of the use of these equations is given. Laboratory moisture characteristic and physical properties were determined for the 38 cm depth of a Hecla fine loamy sand soil, not included in determination of the regression models. Samples were taken from a soil profile at least 100 miles from the area where the samples used in model formation were taken, and hydraulic measurements were made in a different laboratory using pressure pot extractors. Variable values were Sa[92.4], Sil[3.2], Cl[4.4], Sasi [28.875], Gm [.6717], Gd [4.7], Z [.1442], F [.681], G [1.048], Bd [1.56].

Estimate of 'b' was made from Eq. [36].

$$b = .061(92.4) - 1.67(\ln 4.7) - 0.98(\ln .1442) - 3.28 = 1.67$$

Residual moisture was then calculated using Eq. [40].

$\theta r = 0.061\ (\ln 1.66) - 0.014\ (\ln 28.88) - 0.0024\ (\ln .6717) + 0.130 = 0.1152$

Since inflection moisture and suction were used in calculating b values used in forming the regression equations, they are calculated from Equation [48]

$\theta i = 0.505(1-1.56/2.65) + 0.236(0.681) - 0.237(0.672) + 0.085 = .294$

and Equation [56].

$Si = \exp[0.044(3.2) + 0.025(92.4) - 0.171(\ln 28.875) + 1.304] = 24.05$ cm

These four terms were included in Equation [9] to calculate the moisture characteristic at various suctions. A comparison of the above estimated values, and laboratory determined values is illustrated on Figure 6. Predicted values also included θs (calculated from Eq. [44]) matched vs. Se (calculated from Equation [52]).

Van Genuchten Parameters:

Van Genuchten and Nielsen (34) reported that of the parameters for Eq. [15], the product of m and n (mn) should be most strongly texturally correlated. The coefficient, a, was reported to approximate 1/Se for small m/n and 1/Si for large m/n. For these data mn did prove to be most strongly texturally correlated. Best predictive variable was the sand to silt ratio (Sasi). Best fit regression equations for mn are on Table 5.c. Relationship between a, and reciprocals of inflection and air entry suctions are shown on Fig. 5. For these data, 1/Si was most strongly correlated, with a approximately equal to .87 times 1/Si. Best fit regression equations for a are on Table 5.b.

1/ Data range limitations confine validity to sand, sandy loam, loamy sand, and coarse loam fractions. Specific equations may be limited to locale.

As with the Brooks and Corey model, residual moisture was best correlated with other curve parameters. In this case, 'mn' proved to be most strongly related to θr. Relationship between 'mn' and θr, however, was not monotonic. Rather, θr increased with 'mn' to an optimum near mn=1 and then slowly decreased (Fig. 5). Best fit predictive equations were formed from combined polynomial functions of 'mn', and textural indices (Table 5a). Natural log transform was used to dampen oscillation of the predicted curves.

Using the same example presented for the Brooks and Corey parameters, the moisture characteristic predicted using regression estimates of parameters for the closed form equation are as follows.

From Eq. [68],

$mn = .0664(28.875) + 1.35(1.56) + .0069(92.4) - 1.67$

$= 2.991$

and since $m = 1-1/n$, $n = 1+2.991 = 3.991$, and $m = .749$. 'a' is then calculated using the curve inflection value already estimated using Eq. [56] (24.05). Inserting estimated inflection suction in Eq. [64]

$a = -.832(1/24.05) + .00009(92.4) - .0166(1.56) + .015 = .032$

and using Eq. [60],

$\theta r = -.032(\ln 2.991)^2 + 0.031(\ln 2.991) - .017(\ln .6717) + .0693 = .072$

Saturated moisture is estimated using Equation 44 ($\Theta s = .359$). Predicted moisture characteristic is shown on Figure 6.[1/]

Jaynes and Tyler Approach

Another approach, useful only for sandy soils, was proposed by

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[1/] See Footnote 1. Page 43

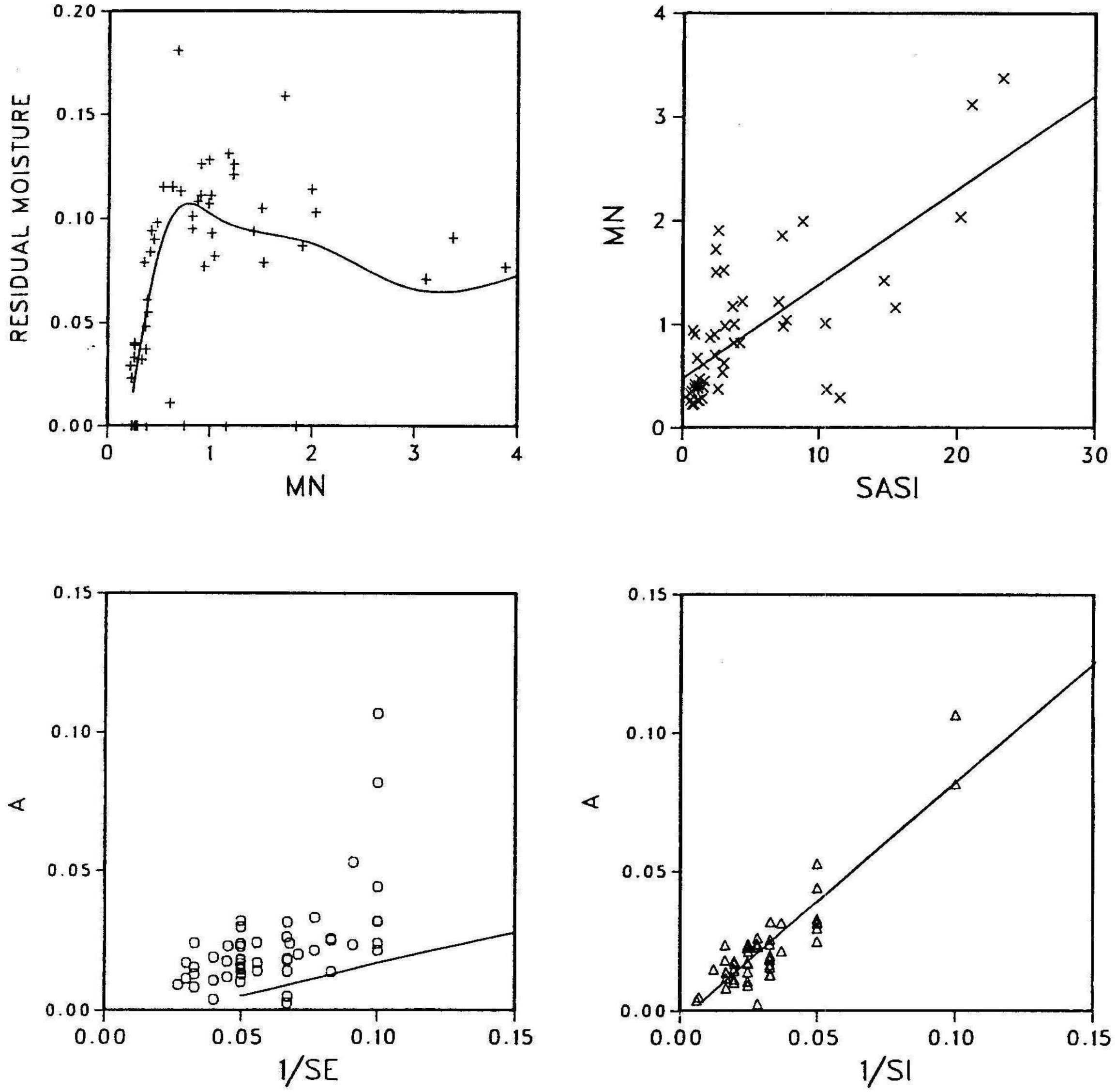

Figure 5. Illustration of relationships between van Genuchten parameters, and best fitting single predictive variable.

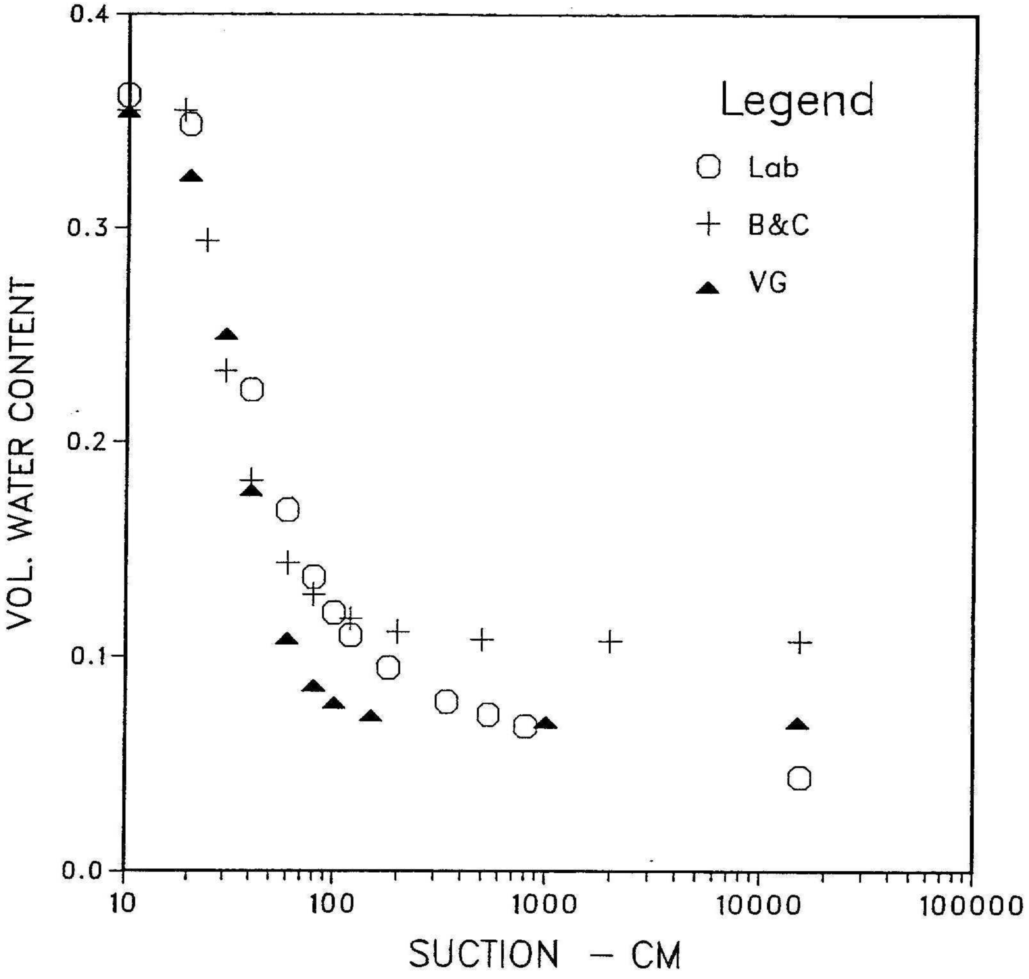

Figure 6. Example of moisture characteristic predicted using parameters estimated from regression equations.

Jaynes and Tyler (7). They used the functional relationship

$$\text{Log } K = b' S^{.5} + a' \quad [58]$$

and used textural data to predict b' and a'. Jaynes and Tyler (17) were able to account for 84% of variability in K values using % sand and % silt values. Their method is only applicable for sandy soils, and was only tested for the range of 1 - 100 cm suction.

Jaynes and Tyler equations are on Table 6. Their equations require Kilopascals (kPa=cm/10.2) rather than cm suction units. Units for calculated K values are cm/day. a' and b' values for calculating K(cm/day) from suction (kPa) are included on particle index tables (Appendix C) for each data set. The Jaynes and Tyler method was tested by Schuh and Sweeney (29) using sandy soil profiles included in this report. Overall, slope and intercept values did not differ significantly from the originally proposed values. However, only 60% of variability was accounted for. Some soils included in the test were as high as 18% clay, so test data may have overextended the limits of validity for the approach.

It was found that 'a' and 'b' value predictions could often be improved using local calibration for individual profiles, or for series. Generally, a' and b' were similar within profile, and within series. In this way, about 80% of variability could be accounted for in the predictive models. It is suggested that those wishing to use this approach to extend use of Cassel's data should use known in situ K vs. S values for the desired soil series to determine a', and b', and then extend those parameters to other profiles or sites, based on textures found on those sites.

Table 1.a. Significant (P:95) Textural Variables for Predicting Brooks and Corey (3) Exponent, Residual Moisture, Saturated Moisture, and Inflection Moisture

Brooks and Corey							
b		θr		θs		θi	
df = 69		df = 69		df = 69		df = 69	
Variable	R^2	Variable	R^2	Variable	R^2	Variable	R^2
Sa	.69	(ln) 'b'	.35	Por	.53	Por	.41
(ln) Sil	.74	Sa	.21	Sa	.12	Sa	.26
(ln) Cl	.59	(ln)Sil	.14	Sil	.25	Si	.29
(ln) Gm	.64	(ln) Gm	.16	Gm	.09	(ln) Cl	.16
(ln) Gd	.62	(ln) Sasi	.17	(ln) Gd	.02	Gm	.23
(ln) Z	.69	(ln) G	.23	(ln) z	.06	(ln) Gd	.15
F	.72	OM	.06	F	.03	(ln) Z	.22
(ln) G	.72			(ln) Sasi	.13	F	.16
(ln)Sasi	.74					Gosh	.25

Table 1.b. Significant (P:95) Textural Variables for Prediction of Brooks and Corey (3) Air Entry and Inflection Suctions

Brooks and Corey			
Se		Si	
df = 48		df=48	
Variable	R^2	Variable	R^2
Sil	.19	Sa	.18
(ln) Cl	.071	Sil	.36
Gd	.042	Gm	.13
G	.075	(ln) Z	.09
(ln) Sasi	.059	F	.08
Ws	.13	(ln) G	.29
		(ln) Sasi	.28

TABLE 2. Significant (P:95) Variables for Predicting van Genuchten Curve Parameters

van Genuchten

a		mn		θr	
df = 51		df = 51		df = 51	
Variable	R^2	Variable	R^2	Variable	R^2
* 1/Se	.22	Cl	.25	ln mn	.25
1/Si	.81	Sa	.45	$(\ln mn)^2$	.41
* Sa	.08	ln Sil	.57	$(\ln mn)^3$	.33
ln Sil	.18	Sasi	.65	ln Sa	.14
ln G	.17	Gm	.45	Sil	.15
ln Sasi	.15	ln Gd	.24	ln 2	.08
		ln Z	.40	ln Sasi	.10
		ln G	.54	ln Gm	.11
		Bd	.13	G	.15
		F	.42		

TABLE 3. Significant (P:95) Textural Variables for Predicting the ln K vs. ln Slope Directly

'N'

df = 67 Variable	R^2
Sa	.16
Sil	.13
(ln) Cl	.15
Gm	.17
(ln) Gd	.15
(ln) Z	.17
(ln) F	.14
G	.11
(ln) Sasi	.10

Table 4a. Best Fit Textural Variable Predictive Equations for Brooks and Corey (3) Exponent ,b.

Eq.No.	No. of Eq.	Equation	R2*	SE	DF
[34]	1	$b = 2.24(GM) + .19$	.77	.29	69
[35]	2	$b = 1.37(GM) - .253(\ln Si) + 1.08$	.81	.27	68
[36]	3	$b = .061(Sa) - 1.67(\ln Gd) - .98(\ln Z) - 3.28$	.82	.26	67
[37]	4	$b = .062(Sa) - 1.70(\ln Gd) - 1.01(\ln Z) - .118(Bd) - 3.21$	.82	.26	66

*Adjusted for degrees of freedom

Table 4b. Best Fit Textural Variable Predictive Equations for Brooks and Corey (3) Residual Moisture (θr)

Eq.No.	No. of Eq.	Equation	R2*	SE	DF
[38]	1	$\theta r = .041(\ln b) + .101$	.34	.048	69
[39]	2	$\theta r = .054(\ln b) - .013(\ln Gm) + .086$	.35	.048	68
[40]	3	$\theta r = .061(\ln b) - .0023(\ln Gm) - .014(\ln SaSi) + .130$	.35	.48	67
[41]	4	$\theta r = .063(\ln b) - .0127(\ln Gm) - .068(\ln SaSi) - .077(G) + .37$	.45	.044	66

*Adjusted for degrees of freedom

1/ Data range limitations confine validity to sand, sandy loam, loamy sand, and coarse loam fractions. Specific equations may be limited to locale.

Table 4c. Best Fit Textural Variable Predictive Equations for Brooks and Corey (3) Saturated Moisture (θ s)

Eq.No.	No. of Var.	Equation	R^{2*}	SE	DF
[42]	1	$\theta s = .598(\text{Por}) + .111$	.52	.023	69
[43]	2	$\theta s = .522(\text{Por}) + .0008(\text{Sil}) + .131$	.61	.021	68
[44]	3	$\theta s = .502(\text{Por}) + .003(\text{Sil}) + .025(\ln \text{Sasi}) + .059$	.71	.018	67
[45]	4	$\theta s = .498(\text{Por}) + .0032(\text{Sil}) + .0003(\text{Sa}) + .021(\ln \text{Sasi}) + .0446$	.71	.018	66

*Adjusted for degrees of freedom.

Table 4d. Best Fit Textural Variable Predictive Equations for Brooks and Corey (3) Inflection Moisture (θi)

Eq.No.	No. of Var.	Equation	R^{2*}	SE	DF
[46]	1	$\theta i = .621(\text{Por}) + .053$	.41	.029	69
[47]	2	$\theta i = .537(\text{Por}) - .000689(\text{Sa}) + .136$	.55	.026	68
[48]	3	$\theta i = .505(\text{Por}) + .236(\text{F}) - .237(\text{Gm}) + .085$	.59	.025	67
[49]	4	$\theta i = .534(\text{Por}) + .272(\text{F}) - .161(\text{Gm}) - .0161(\ln Z) - .030$	.60	.024	66

*Adjusted for degrees of freedom

1/ Data range limitations confine validity to sand, sandy loam, loamy sand, and coarse loam fractions. Specific equations may be limited to locale.

Table 4e. Best Fit Textural Variable Equations for Brooks and Corey (3) Air Entry Suction (Se) 1/

Eq.No.	No. of Var.	Equation	R^{2*}	SE	DF
[50]	1	$Se = .78(Sil) + 4.41$	.18	21	48
[51]	2	$Se = 5.49(Sil) - 62.05(G) + 61.1$	.60	14.7	47
[52]	3	$Se = 4.71(Sil) - 8.9\ (\ln Cl) - 48.3(G) + 67.5$	.64	13.8	46
[53]	4	$Se = 4.98(Sil) - 8.34(\ln Cl) - 51.5\ (\ln G) + 26.4(Bd) + 31.25$	.65	13.6	45

*Adjusted for degrees of freedom

Table 4f. Best Fit Textural Variable Predictive Equations for Brooks and Corey (3) Inflection Suction (Si) 1/

Eq.No.	No. of Var.	Equation	R^{2*}	SE	DF
[54]	1	$\ln Si = .022(Sil) + 3.04$	.36	.40	69
[55]	2	$\ln Si = .052(Sil) + .0195(Sa) + 1.235$	.45	.37	68
[56]	3	$\ln Si = .044(Sil) + .025(Sa) - .171(\ln Sasi) + 1.304$	.46	.37	67
[57]	4	$\ln Si = .046(Si) + .025(Sa) - .17(\ln Sasi) + .416\ (Bd) + .6526$	.46	.37	66

*Adjusted for degrees of freedom

1/ Data range limitations confine validity to sand, sandy loam, loamy sand, and coarse loam fractions. Specific equations may be limited to locale.

Table 5a. Best Fit Regression Equations for Predicting Residual Moisture for the Closed Form Equation of van Genuchten (32).[1/]

Eq.No.	No. of Var.	Equation	R2*	SE	DF
[58]	1	$\theta r = -.041(\ln mn)^2 + .104$	.40	.035	49
[59]	2	$\theta r = -.030(\ln mn)^2\ 3$ $+ .0106(\ln mn)^3 + .102$	.44	.034	48
[60]	3	$\theta r = -.032(\ln mn)^2$ $+ .031\ (\ln mn)$ $- .017(\ln Gm) + .0693$	.52	.032	47
[61]	4	$\theta r = -.0305(\ln mn)^2 +$ $.038(\ln mn) - .072(Bd)$ $- .195(\ln Gm) + .166$	.54	.031	46

*Adjusted for degrees of freedom

Table 5b. Best Fit Regression Equations for Predicting the Coefficient (a) for the Closed Form Equation of van Genuchten [1/]

Eq.No.	No. of Var.	Equation	R2*	SE	DF
[62]	1	$a = .859\ (1/Si) - .004$	.80	.002	49
[63]	2	$a = .857(1/Si) - .014(Bd)$ $+ .015$	.81	.007	48
[64]	3	$a = .832(1/Si) + .00009(Sa)$ $-.0166(Bd) + .015$	.82	.007	47
[65]	4	$a = .801(1/Si) + .00013(Sa)$ $-.0169(Bd) - .054(mn)$ $+ .0256$	.82	.007	46

*Adjusted for degrees of freedom

[1/] Data range limitations confine validity to sand, sandy loam, loamy sand, and coarse loam fractions. Specific equations may be limited to locale.

Table 5c. Best Fit Regression Equations for Predicting the Exponent Product (mn) for the Closed Form Equation of van Genuchten (32).[1/]

Eq.No.	No. of Var.	Equation	R^{2*}	SE	DF
[66]	1	mn = .0842(Sasi) + .50	.64	.486	49
[67]	2	mn = .0799(Sasi) +.37(Bd) - 1.38	.67	.465	48
[68]	3	mn = .0664(Sasi) + 1.35(Bd) + .0069(Sa) - 1.67	.68	.459	47
[69]	4	mn = .0853(Sasi) + 1.46(Bd) + .0139(Sa) + .372(ln Sil) - 3.409	.68	.457	46

*Adjusted for degrees of freedom

[1/] Data range limitations confine validity to sand, sandy loam, loamy sand, and coarse loam fractions. Specific equations may be limited to locale.

Table 6. Jaynes and Tyler Equations (17) for Predicting [a'] and [b'] Using % Sand (Sa), Silt (Sil) and Bulk Density (Bd) Data

Eq.	b'	a'	s*	R^2**
[70]	-0.012 (Sa)	0.029(Sa)	0.41	0.83
[71]	-0.04(Sa) + 0.0063(Sil)	0.029(Sa)	0.40	0.84
[72]	-0.016(Sa) + 0.013(Sil)	0.044(Sa) - 0.61 (Bd)	0.39	0.85

*Standard error of the estimate

**Coefficient of determination adjusted for degrees of freedom

CONCLUSION

This report has represented the in situ and laboratory data of Cassel (8), Cassel and Sweeney (9), and Carvallo (7) in functional form, and has discussed methods for extending the utility of these limited in situ hydraulic data for modeling soil hydrologic events. Methods for extending data curve ranges for $K(\theta/S)$ and $\theta(S)$ relations using theoretical 'pore interaction' models of Burdine (5) and Mualem (21) were reviewed, using the functional formats of Brooks and Corey (3), and van Genuchten (32, 33, 34). Methods for classifying and extending interpretations beyond the measured sites were also briefly reviewed.

Both Brooks and Corey and Van Genuchten functions adequately described the moisture retention function above air entry suction, but the van Genuchten closed form function provided better results near saturation. On three soil profiles tested, $K(S)$ predictions using Burdine and Mualem theory were comparable.

Residual moisture values were more strongly related to other curve parameters than to soil textural indices for both Brooks and Corey, and van Genuchten functions. They are, therefore, viewed as empirical parameters, determined in optimizing curve fits to data, rather than as physical properties. Residual moisture values are quite sensitive to the method of calculation, and are not transferable from one function to another.

Attempts to classify functional parameters using textural indices for interpretation of data beyond the measured sites were made. Brooks and Corey parameters could be predicted reasonably well (R^2 = .60 - .70) using textural indices. Van Genuchten functions were slightly less predictable (R^2 = .45 - .80). The main texturally dependent variable was the product 'mn'. Predictive models required estimates of S_i or Se. Residual moisture was principally a function of 'mn'.

Functional parameters for equations proposed by Brooks and Corey (3) and van Genuchten (33) were presented for each site and profile. Physical data corresponding to the hydraulic data were used to form predictive indices for classification of properties. All indices calculated were presented for future reference.

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APPENDIX A

In Situ Hydraulic Conductivity, Moisture, and Suction Data and Functions.

APPENDIX A SYMBOLS AND ABBREVIATIONS

DPTH	Depth of soil (cm)
N-CAMP, N-B&C,N-MUAL	Slopes of ln K vs. ln S curves using moisture retention data; Campbell, Brooks and Corey, and Mualem models respectively.
SI-CAMP, SI-BC	Moisture retention curve inflection value (identical and repetitive).
IN SUCT, DEX	Internal indices for program used to print Appendix A tables. Meaningless for readers of table data.
A, B	Parameters for text Eq. [2].
AA, BB	Parameters for text Eq. [1].
N, C	Parameters for text Eq. [3].
MOIST	Volumetric moisture content (θ).
SUC	Soil water suction, cm.
CON	Hydraulic conductivity [K(θ/S], cm/hr.

TABLE A.1

LACUSTRINE MATERIAL SITE 1 (CASSEL)
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION
PARAMETERS

```
 DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
   8.    2.39   30.00     2.68  30.00   .0330       2.57

 IN SUCT   A          B
    9.   -154.33       66.04

 DEX      AA         BB          N         C       MOIST    SUC     CON
  0.       0.00       0.00      0.00      0.00   .4125     11.   0.000E+00

 IN SUCT   A          B
   29.     -14.69       9.34

 DEX      AA         BB          N         C       MOIST    SUC     CON
  0.       0.00       0.00      0.00      0.00   .4000     32.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .3875     38.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .3750     46.   0.000E+00
  0.      55.48     -23.94     -3.78     11.33   .3625     55.   0.217E-01
  0.      55.48     -23.94     -3.78     11.33   .3500     67.   0.109E-01
  0.      55.48     -23.94     -3.78     11.33   .3375     80.   0.543E-02
  0.      55.48     -23.94     -3.78     11.33   .3250     96.   0.271E-02
  0.      55.48     -23.94     -3.78     11.33   .3125    116.   0.136E-02
  0.       0.00       0.00      0.00      0.00   .3000    139.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .2875    167.   0.000E+00

 IN SUCT   A          B
  209.     -15.69       9.69

 DEX      AA         BB          N         C       MOIST    SUC     CON
  0.       0.00       0.00      0.00      0.00   .2750    216.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .2625    263.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .2500    320.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .2375    389.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .2250    473.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .2125    576.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .2000    701.   0.000E+00
  0.       0.00       0.00      0.00      0.00   .1875    852.   0.000E+00
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APPENDIX A.1 CONT.

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DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 22.   2.38   27.00     2.81  27.00   .0680        2.68

IN SUCT   A          B
  4.   -1832.60     729.80
DEX      AA          BB         N        C       THETA    SUC      CON
 0.        0.00       0.00     0.00     0.00    .3975      4.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3974      5.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3973      6.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3972      7.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3971      8.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3970      9.   0.000E+00

IN SUCT   A          B
 10.     -41.91      18.97
DEX      AA          BB         N        C       THETA    SUC      CON
 0.        0.00       0.00     0.00     0.00    .3948     11.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3926     12.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3905     14.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3883     15.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3861     16.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3839     18.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3817     20.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3795     21.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3774     23.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3752     26.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .3730     28.   0.000E+00

IN SUCT   A          B
 25.     -16.28       9.28
DEX      AA          BB         N        C       THETA    SUC      CON
 0.        0.00       0.00     0.00     0.00    .3523     35.   0.000E+00
 0.      104.66     -35.79    -6.43    23.87    .3315     49.   0.336E+00
 0.      104.66     -35.79    -6.43    23.87    .3108     68.   0.384E-01
 0.      104.66     -35.79    -6.43    23.87    .2901     95.   0.439E-02
 0.        0.00       0.00     0.00     0.00    .2694    134.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .2486    187.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .2279    262.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .2072    368.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .1865    515.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .1657    722.   0.000E+00
 0.        0.00       0.00     0.00     0.00    .1450   1012.   0.000E+00
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TABLE     A.1 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 45.   2.12   27.00     4.01  27.00   .1070       3.67

IN SUCT  A          B
   4.   -610.86      225.88

DEX     AA          BB          N          C        MOIST    SUC     CON


IN SUCT  A          B
  10.    -22.94      10.70

DEX     AA          BB          N          C        MOIST    SUC     CON
 0.        0.00       0.00      0.00       0.00    .3625     11.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .3500     14.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .3375     19.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .3250     26.   0.000E+00

IN SUCT  A          B
 56.     -14.16       8.60

DEX     AA          BB          N          C        MOIST    SUC     CON
 0.        0.00       0.00      0.00       0.00    .3125     65.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .3000     78.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .2875     93.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .2750    111.   0.000E+00
 0.       85.76     -23.67     -6.06      28.42    .2625    132.   0.314E+00
 0.       85.76     -23.67     -6.06      28.42    .2500    158.   0.108E+00
 0.       85.76     -23.67     -6.06      28.42    .2375    188.   0.368E-01
 0.        0.00       0.00      0.00       0.00    .2250    225.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .2125    268.   0.000E+00

IN SUCT  A          B
 68.     -28.54      10.10

DEX     AA          BB          N          C        MOIST    SUC     CON
 0.        0.00       0.00      0.00       0.00    .2000     81.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .1875    115.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .1750    165.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .1625    236.   0.000E+00

IN SUCT  A          B
502.      -9.11       7.63

DEX     AA          BB          N          C        MOIST    SUC     CON
 0.        0.00       0.00      0.00       0.00    .1500    525.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .1375    588.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .1250    659.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .1125    739.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .1000    828.   0.000E+00
 0.        0.00       0.00      0.00       0.00    .0875    928.   0.000E+00
```

TABLE A.1 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
75.	2.78	4.00	3.01	4.00	.0660	2.84

IN SUCT	A	B
4.	-166.60	62.50

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3625	8.	0.000E+00

IN SUCT	A	B
12.	-8.38	5.49

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3500	13.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	14.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	16.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	18.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	20.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	22.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	24.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	27.	0.000E+00
0.	48.73	-12.48	-5.82	19.44	.2500	30.	0.743E+00
0.	48.73	-12.48	-5.82	19.44	.2375	33.	0.404E+00
0.	48.73	-12.48	-5.82	19.44	.2250	37.	0.220E+00
0.	48.73	-12.48	-5.82	19.44	.2125	41.	0.119E+00

IN SUCT	A	B
40.	-16.94	7.20

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.2000	45.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1875	56.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1750	69.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1625	85.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1500	106.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1375	130.	0.000E+00

IN SUCT	A	B
157.	-55.91	12.69

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1250	299.	0.000E+00

IN SUCT	A	B
499.	-17.98	8.29

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1125	527.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1000	660.	0.000E+00
0.	0.00	0.00	0.00	0.00	.0875	826.	0.000E+00

APPENDIX A.1 CONT.

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DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
137.   2.78   10.00     2.91  10.00  .0000       2.75

IN SUCT  A        B
  4.   -152.72     68.12
DEX      AA         BB        N       C      THETA   SUC    CON
 0.       0.00      0.00     0.00    0.00   .4370     4.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .4359     5.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .4348     6.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .4337     7.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .4326     8.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .4310    10.   0.000E+00

IN SUCT  A        B
  9.     -7.99      5.68
DEX      AA         BB        N       C      THETA   SUC    CON
 0.       0.00      0.00     0.00    0.00   .3945    13.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .3762    15.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .3579    17.   0.000E+00
 0.     100.11    -34.44   -12.53   36.73   .3396    19.   0.645E+00
 0.     100.11    -34.44   -12.53   36.73   .3214    22.   0.103E+00
 0.       0.00      0.00     0.00    0.00   .3031    26.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2848    30.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2665    35.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2483    40.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2300    47.   0.000E+00

IN SUCT  A        B
 51.    -59.60     17.63
DEX      AA         BB        N       C      THETA   SUC    CON
 0.       0.00      0.00     0.00    0.00   .2300    51.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2262    63.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2224    80.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2185   100.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2109   158.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .2090   177.   0.000E+00

IN SUCT  A        B
 201.   -11.90      7.79
DEX      AA         BB        N       C      THETA   SUC    CON
 0.       0.00      0.00     0.00    0.00   .2090   201.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .1740   305.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .1390   462.   0.000E+00

IN SUCT  A        B
 500.   -60.19     14.16
DEX      AA         BB        N       C      THETA   SUC    CON
 0.       0.00      0.00     0.00    0.00   .1320   500.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .1247   777.   0.000E+00
 0.       0.00      0.00     0.00    0.00   .1205   999.   0.000E+00
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TABLE    A.2

EMBDEN FINE SANDY LOAM     (CASSEL)       SITE 2
 CAMPBELL,BROOKS&COREY, K*THETA, SUCTION*THETA, K*SUCTION
 PARAMETERS


 DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST   N-MUAL
   8.   3.11   35.00     3.74  35.00  .0770          3.45

 IN SUCT  A         B
   4.     -68.20     29.39

 DEX     AA          BB          N          C        MOIST      SUC     CON
  0.       0.00        0.00      0.00       0.00    .4000        8.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .3875       19.   0.000E+00

 IN SUCT  A         B
  20.     -17.73       9.85

 DEX     AA          BB          N          C        MOIST      SUC     CON
  0.       0.00        0.00      0.00       0.00    .3750       25.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .3625       31.   0.000E+00

 IN SUCT  A         B
  35.      -6.06       5.70

 DEX     AA          BB          N          C        MOIST      SUC     CON
  0.       0.00        0.00      0.00       0.00    .3500       36.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .3375       39.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .3250       42.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .3125       45.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .3000       48.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .2875       52.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .2750       56.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .2625       61.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .2500       66.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .2375       71.   0.000E+00
  0.      76.75      -22.41    -12.66      49.73    .2250       76.   0.585E-02

 IN SUCT  A         B
  65.     -25.35       9.82

 DEX     AA          BB          N          C        MOIST      SUC     CON
  0.      76.75      -22.41     -3.03       7.32    .2125       84.   0.224E-02
  0.      76.75      -22.41     -3.03       7.32    .2000      116.   0.859E-03
  0.      76.75      -22.41     -3.03       7.32    .1875      159.   0.329E-03
  0.       0.00        0.00      0.00       0.00    .1750      218.   0.000E+00
  0.       0.00        0.00      0.00       0.00    .1625      299.   0.000E+00
```

TABLE A.2 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
22.	2.99	35.00	3.70	35.00	.0780	3.41

IN SUCT	A	B
5.	-73.89	30.56

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3875	7.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	17.	0.000E+00

IN SUCT	A	B
20.	-12.89	7.79

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3625	23.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	27.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	31.	0.000E+00

IN SUCT	A	B
35.	-7.04	5.91

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3250	37.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	41.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	45.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	49.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	53.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	58.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2500	63.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2375	69.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2250	76.	0.000E+00

IN SUCT	A	B
66.	-25.49	9.78

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	63.52	-17.45	-2.49	6.92	.2125	79.	0.192E-01
0.	63.52	-17.45	-2.49	6.92	.2000	108.	0.869E-02
0.	63.52	-17.45	-2.49	6.92	.1875	149.	0.393E-02
0.	0.00	0.00	0.00	0.00	.1750	204.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1625	281.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1500	386.	0.000E+00

```
TABLE    A.2 CONT.

DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST    N-MUAL
 45.    3.18    35.00      2.56   35.00   .0850          2.47

IN SUCT   A          B
   5.    -69.21       26.98

DEX      AA          BB          N          C        MOIST     SUC      CON
 0.        0.00        0.00      0.00       0.00    .3625      7.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .3500     16.   0.000E+00

IN SUCT   A          B
  20.    -11.34        6.91

DEX      AA          BB          N          C        MOIST     SUC      CON
 0.        0.00        0.00      0.00       0.00    .3375     22.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .3250     25.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .3125     29.   0.000E+00

IN SUCT   A          B
  35.      -6.77       5.59

DEX      AA          BB          N          C        MOIST     SUC      CON
 0.        0.00        0.00      0.00       0.00    .3000     35.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .2875     38.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .2750     42.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .2625     45.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .2500     49.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .2375     54.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .2250     58.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .2125     64.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .2000     69.   0.000E+00
 0.       65.79      -16.18     -9.72      38.14    .1875     75.   0.214E-01

IN SUCT   A          B
  64.    -28.08        9.26

DEX      AA          BB          N          C        MOIST     SUC      CON
 0.       65.79      -16.18     -2.34       5.52    .1750     77.   0.940E-02
 0.       65.79      -16.18     -2.34       5.52    .1625    110.   0.413E-02
 0.        0.00        0.00      0.00       0.00    .1500    156.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .1375    221.   0.000E+00
 0.        0.00        0.00      0.00       0.00    .1250    314.   0.000E+00
```

TABLE A.2 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 75.   4.42    35.00    6.12   35.00   .0620      5.43

IN SUCT   A        B
   5.   -86.43    32.84

DEX    AA       BB       N       C     MOIST   SUC    CON
 0.     0.00     0.00    0.00    0.00  .3500   13.  0.000E+00

IN SUCT   A        B
  20.   -15.59     8.37

DEX    AA       BB       N       C     MOIST   SUC    CON
 0.     0.00     0.00    0.00    0.00  .3375   22.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .3250   27.  0.000E+00

IN SUCT   A        B
  30.    -4.26     4.76

DEX    AA       BB       N       C     MOIST   SUC    CON
 0.     0.00     0.00    0.00    0.00  .3125   31.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .3000   33.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .2875   34.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .2750   36.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .2625   38.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .2500   40.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .2375   42.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .2250   45.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .2125   47.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .2000   50.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .1875   53.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .1750   55.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .1625   58.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .1500   62.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .1375   65.  0.000E+00
 0.     0.00     0.00    0.00    0.00  .1250   69.  0.000E+00
 0.   109.65   -15.57  -25.74  106.95  .1125   72.  0.394E-01

IN SUCT   A        B
  61.   -41.14     8.49

DEX    AA       BB       N       C     MOIST   SUC    CON
 0.   109.65   -15.57   -2.67    7.06  .1000   80.  0.100E-01
 0.   109.65   -15.57   -2.67    7.06  .0875  133.  0.254E-02
 0.     0.00     0.00    0.00    0.00  .0750  222.  0.000E+00
```

```
TABLE     A.2 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
106.   4.91   35.00     5.64  35.00  .0440       5.03

IN SUCT  A          B
   6.   -143.47      54.04

DEX      AA         BB          N          C       MOIST    SUC     CON
 0.        0.00       0.00      0.00       0.00   .3625      8.   0.000E+00

IN SUCT  A          B
  20.     -16.89      9.00

DEX      AA         BB          N          C       MOIST    SUC     CON
 0.        0.00       0.00      0.00       0.00   .3500     22.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .3375     27.   0.000E+00

IN SUCT  A          B
  30.      -3.71      4.62

DEX      AA         BB          N          C       MOIST    SUC     CON
 0.        0.00       0.00      0.00       0.00   .3250     30.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .3125     32.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .3000     33.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .2875     35.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .2750     37.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .2625     38.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .2500     40.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .2375     42.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .2250     44.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .2125     46.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .2000     48.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .1875     51.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .1750     53.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .1625     56.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .1500     58.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .1375     61.   0.000E+00
 0.       67.72     -10.43    -18.25      73.90   .1250     64.   0.140E+00
 0.       67.72     -10.43    -18.25      73.90   .1125     67.   0.601E-01
 0.       67.72     -10.43    -18.25      73.90   .1000     70.   0.258E-01

IN SUCT  A          B
  61.     -50.04      8.52

DEX      AA         BB          N          C       MOIST    SUC     CON
 0.       67.72     -10.43     -1.35       1.10   .0875     63.   0.111E-01
 0.        0.00       0.00      0.00       0.00   .0750    118.   0.000E+00
 0.        0.00       0.00      0.00       0.00   .0625    220.   0.000E+00
```

TABLE A.2 cont.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
137.	4.18	35.00	4.58	35.00	.0230	4.15

IN SUCT	A	B
6.	-192.08	74.39

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	11.	0.000E+00

IN SUCT	A	B
20.	-24.57	12.12

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3625	25.	0.000E+00

IN SUCT	A	B
31.	-4.08	4.88

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3500	32.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	33.	0.000
0.	0.00	0.00	0.00	0.00	.3250	35.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	37.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	39.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	41.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	43.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	45.	0.000E+00
0.	28.08	-9.01	-6.88	24.58	.2500	47.	0.137E+00
0.	28.08	-9.01	-6.88	24.58	.2375	50.	0.962E-01
0.	28.08	-9.01	-6.88	24.58	.2250	53.	0.677E-01
0.	28.08	-9.01	-6.88	24.58	.2125	55.	0.477E-01
0.	28.08	-9.01	-6.88	24.58	.2000	58.	0.336E-01
0.	28.08	-9.01	-6.88	24.58	.1875	61.	0.236E-01
0.	28.08	-9.01	-6.88	24.58	.1750	64.	0.166E-01
0.	0.00	0.00	0.00	0.00	.1625	68.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1500	71.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1375	75.	0.000E+00

IN SUCT	A	B
62.	-32.35	8.23

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1250	66.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1125	99.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1000	148.	0.000E+00
0.	0.00	0.00	0.00	0.00	.0875	221.	0.000E+00

TABLE A.3

EMRICK CLAY LOAM SITE 3 (CASSEL)
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION PARAMETERS

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
8.	2.41	50.00	2.62	50.00	.0000	2.52

IN SUCT	A	B
4.	-2643.00	1167.14

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	0.00	0.00	0.00	0.00	.4375	11.	0.000E+00

IN SUCT	A	B
0.	-38.80	19.85

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4250	29.	0.000E+00
0.	0.00	0.00	0.00	0.00	.4125	47.	0.000E+00

IN SUCT	A	B
0.	-13.50	9.47

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4000	58.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3875	69.	0.000E+00
0.	57.56	-24.87	-4.26	15.50	.3750	82.	0.374E-01
0.	57.56	-24.87	-4.26	15.50	.3625	97.	0.182E-01
0.	57.56	-24.87	-4.26	15.50	.3500	115.	0.888E-02
0.	57.56	-24.87	-4.26	15.50	.3375	136.	0.432E-02
0.	57.56	-24.87	-4.26	15.50	.3250	161.	0.211E-02
0.	57.56	-24.87	-4.26	15.50	.3125	190.	0.103E-02

APPENDIX A.3 CONT.

```
DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST   N-MUAL
 22.    2.40    50.00      2.61   50.00    .0050        2.61

IN SUCT   A          B
   4.   -1333.00     579.33
DEX      AA         BB         N          C        THETA     SUC      CON
 1.        0.00       0.00       0.00       0.00    .4315      4.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4304      6.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4293      7.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4282      9.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4271     10.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4260     11.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4250     13.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4239     14.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4228     16.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4217     17.   0.000E+00
 1.        0.00       0.00       0.00       0.00    .4206     19.   0.000E+00

IN SUCT   A          B
   0.     -28.20      14.84
DEX      AA         BB         N          C        THETA     SUC      CON
 0.        0.00       0.00       0.00       0.00    .4195     20.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .4165     22.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .4077     28.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .4047     31.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .3959     40.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .3929     43.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .3870     51.   0.000E+00

IN SUCT   A          B
   0.     -14.60       9.55
DEX      AA         BB         N          C        THETA     SUC      CON
 0.        0.00       0.00       0.00       0.00    .3696     63.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .3610     72.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .3523     82.   0.000E+00
 0.        0.00       0.00       0.00       0.00    .3436     93.   0.000E+00
 0.      100.11     -35.44     -6.86      30.01     .3349    105.   0.148E+00
 0.      100.11     -35.44     -6.86      30.01     .3262    119.   0.620E-01
 0.      100.11     -35.44     -6.86      30.01     .3175    135.   0.260E-01
 0.      100.11     -35.44     -6.86      30.01     .3089    154.   0.109E-01
 0.      100.11     -35.44     -6.86      30.01     .3002    175.   0.457E-02
 0.      100.11     -35.44     -6.86      30.01     .2915    198.   0.192E-02
```

```
TABLE    A.3 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 45.   2.36   40.00      2.54  40.00  .0000       2.45

IN SUCT  A         B
   4.   -818.00   349.35

DEX     AA          BB          N         C      MOIST    SUC     CON
 1.       0.00        0.00      0.00      0.00   .4125    12.   0.000E+00

IN SUCT  A         B
   0.    -18.10     10.36
 DEX     AA          BB          N         C      MOIST    SUC     CON
 0.       0.00        0.00      0.00      0.00   .4000    23.   0.000E+00
 0.       0.00        0.00      0.00      0.00   .3875    28.   0.000E+00
 0.       0.00        0.00      0.00      0.00   .3750    36.   0.000E+00
 0.       0.00        0.00      0.00      0.00   .3625    45.   0.000E+00
 0.       0.00        0.00      0.00      0.00   .3500    56.   0.000E+00
 0.       0.00        0.00      0.00      0.00   .3375    70.   0.000E+00
 0.      46.99      -17.95     -2.60      8.95   .3250    88.   0.687E-01
 0.      46.99      -17.95     -2.60      8.95   .3125   110.   0.382E-01
 0.      46.99      -17.95     -2.60      8.95   .3000   138.   0.212E-01
 0.      46.99      -17.95     -2.60      8.95   .2875   174.   0.118E-01
```

```
TABLE    A.3 CONT.

DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST   N-MUAL
 75.    2.48    40.00      3.60   44.00    .1010         3.33

IN SUCT  A           B
  3.   -1147.80    443.06
DEX     AA          BB         N         C       MOIST    SUC     CON
 1.       0.00       0.00     0.00      0.00    .3750     13.   0.000E+00

IN SUCT  A           B
  0.     -23.50      11.70
DEX     AA          BB         N         C       MOIST    SUC     CON
 0.       0.00       0.00     0.00      0.00    .3625     24.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3500     32.   0.000E+00

IN SUCT  A           B
  0.     -11.17       7.46
DEX     AA          BB         N         C       MOIST    SUC     CON
 0.       0.00       0.00     0.00      0.00    .3375     40.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3250     46.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3125     53.   0.000E+00
 0.      40.39     -12.52    -3.62     14.45    .3000     61.   0.668E+00
 0.      40.39     -12.52    -3.62     14.45    .2875     70.   0.403E+00
 0.      40.39     -12.52    -3.62     14.45    .2750     81.   0.243E+00
 0.      40.39     -12.52    -3.62     14.45    .2625     93.   0.147E+00
 0.      40.39     -12.52    -3.62     14.45    .2500    106.   0.887E-01
 0.      40.39     -12.52    -3.62     14.45    .2375    122.   0.535E-01
 0.      40.39     -12.52    -3.62     14.45    .2250    141.   0.323E-01
 0.      40.39     -12.52    -3.62     14.45    .2125    162.   0.195E-01
```

TABLE A.3 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
106.	2.83	50.00	5.00	50.00	.0810	4.50

IN SUCT	A	B
3.	-1606.20	565.20

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	0.00	0.00	0.00	0.00	.3500	3.	0.000E+00

IN SUCT	A	B
0.	-29.00	12.94

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3375	23.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	34.	0.000E+00

IN SUCT	A	B
0.	-6.67	5.85

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3125	43.	0.000E+00
0.	21.72	-6.47	-3.26	12.58	.3000	47.	0.105E+01
0.	21.72	-6.47	-3.26	12.58	.2875	51.	0.798E+00
0.	21.72	-6.47	-3.26	12.58	.2750	55.	0.608E+00
0.	21.72	-6.47	-3.26	12.58	.2625	60.	0.464E+00
0.	21.72	-6.47	-3.26	12.58	.2500	66.	0.353E+00
0.	21.72	-6.47	-3.26	12.58	.2375	71.	0.269E+00
0.	21.72	-6.47	-3.26	12.58	.2250	77.	0.205E+00
0.	21.72	-6.47	-3.26	12.58	.2125	84.	0.157E+00
0.	21.72	-6.47	-3.26	12.58	.2000	91.	0.119E+00
0.	21.72	-6.47	-3.26	12.58	.1875	99.	0.909E-01
0.	21.72	-6.47	-3.26	12.58	.1750	108.	0.693E-01
0.	102.33	-19.90	-15.34	69.85	.1625	117.	0.379E-01
0.	102.33	-19.90	-15.34	69.85	.1500	128.	0.106E-01

IN SUCT	A	B
0.	-17.80	7.48

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	102.33	-19.90	-5.75	23.10	.1375	153.	0.294E-02
0.	102.33	-19.90	-5.75	23.10	.1250	192.	0.818E-03

TABLE A.3 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
137.   2.69   50.00     4.36  50.00   .0780        3.97

IN SUCT   A          B
  3.   -1509.70   583.76
DEX     AA          BB         N        C      MOIST    SUC    CON
 1.      0.00        0.00     0.00     0.00   .3750    18.   0.000E+00
 1.      0.00        0.00     0.00     0.00   .3625    36.   0.000E+00

IN SUCT   A          B
  0.     -12.30       8.15

DEX     AA          BB         N        C      MOIST    SUC    CON
 0.     21.12       -9.03    -1.72     4.97   .3500    47.   0.194E+00
 0.     21.12       -9.03    -1.72     4.97   .3375    55.   0.149E+00

IN SUCT   A          B
  0.      -6.79       6.37

DEX     AA          BB         N        C      MOIST    SUC    CON
 0.     21.12       -9.03    -3.11    10.78   .3250    64.   0.115E+00
 0.     21.12       -9.03    -3.11    10.78   .3125    70.   0.880E-01
 0.     21.12       -9.03    -3.11    10.78   .3000    76.   0.676E-01
 0.     21.12       -9.03    -3.11    10.78   .2875    83.   0.519E-01
 0.     21.12       -9.03    -3.11    10.78   .2750    90.   0.399E-01
 0.     21.12       -9.03    -3.11    10.78   .2625    98.   0.306E-01
 0.     21.12       -9.03    -3.11    10.78   .2500   107.   0.235E-01
 0.     21.12       -9.03    -3.11    10.78   .2375   116.   0.181E-01
 0.     21.12       -9.03    -3.11    10.78   .2250   127.   0.139E-01
 0.     21.12       -9.03    -3.11    10.78   .2125   138.   0.107E-01
 0.     21.12       -9.03    -3.11    10.78   .2000   150.   0.818E-02
 0.     21.12       -9.03    -3.11    10.78   .1875   163.   0.628E-02
 0.     21.12       -9.03    -3.11    10.78   .1750   178.   0.482E-02
 0.     21.12       -9.03    -3.11    10.78   .1625   194.   0.371E-02
```

TABLE A.4

LACUSTRINE MATERIAL SITE 4 (CASSEL)
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION PARAMETERS

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
15.	2.43	40.00	3.01	40.00	.0820	2.85

IN SUCT	A	B
5.	-173.90	77.88

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4375	6.	0.000E+00

IN SUCT	A	B
41.	-10.41	8.16

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4250	42.	0.000E+00
0.	0.00	0.00	0.00	0.00	.4125	48.	0.000E+00
0.	40.04	-18.32	-3.85	13.07	.4000	54.	0.999E-01
0.	40.04	-18.32	-3.85	13.07	.3875	62.	0.605E-01
0.	40.04	-18.32	-3.85	13.07	.3750	71.	0.367E-01
0.	40.04	-18.32	-3.85	13.07	.3625	80.	0.222E-01
0.	40.04	-18.32	-3.85	13.07	.3500	92.	0.135E-01
0.	40.04	-18.32	-3.85	13.07	.3375	104.	0.818E-02
0.	40.04	-18.32	-3.85	13.07	.3250	119.	0.496E-02
0.	40.04	-18.32	-3.85	13.07	.3125	135.	0.300E-02
0.	40.04	-18.32	-3.85	13.07	.3000	154.	0.182E-02
0.	40.04	-18.32	-3.85	13.07	.2875	175.	0.110E-02

TABLE A.4 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
22.	2.44	40.00	3.16	40.00	.0890	2.97

IN SUCT	A	B
6.	-746.50	328.10

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	0.00	0.00	0.00	0.00	.4250	11.	0.000E+00
1.	0.00	0.00	0.00	0.00	.4125	20.	0.000E+00
1.	0.00	0.00	0.00	0.00	.4000	30.	0.000E+00

IN SUCT	A	B
0.	-11.12	7.99

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3875	40.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	46.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	52.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	60.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	69.	0.000E+00
0.	33.37	-13.38	-3.00	10.60	.3250	80.	0.793E-01
0.	33.37	-13.38	-3.00	10.60	.3125	91.	0.522E-01
0.	33.37	-13.38	-3.00	10.60	.3000	105.	0.344E-01
0.	33.37	-13.38	-3.00	10.60	.2875	121.	0.227E-01
0.	33.37	-13.38	-3.00	10.60	.2750	139.	0.149E-01
0.	33.37	-13.38	-3.00	10.60	.2625	159.	0.985E-02
0.	0.00	0.00	0.00	0.00	.2500	183.	0.000E+00

TABLE A.4 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
45.	2.49	50.00	3.99	50.00	.1030	3.66

IN SUCT	A	B
10.	-563.04	236.77

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	0.00	0.00	0.00	0.00	.4000	12.	0.000E+00
1.	0.00	0.00	0.00	0.00	.3875	19.	0.000E+00
1.	0.00	0.00	0.00	0.00	.3750	26.	0.000E+00

IN SUCT	A	B
0.	-10.00	7.16

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3625	34.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	39.	0.000E+00
0.	26.47	-9.53	-2.65	9.42	.3375	44.	0.551E+00
0.	26.47	-9.53	-2.65	9.42	.3250	50.	0.396E+00
0.	26.47	-9.53	-2.65	9.42	.3125	57.	0.284E+00
0.	26.47	-9.53	-2.65	9.42	.3000	64.	0.204E+00
0.	26.47	-9.53	-2.65	9.42	.2875	73.	0.147E+00
0.	26.47	-9.53	-2.65	9.42	.2750	82.	0.105E+00
0.	26.47	-9.53	-2.65	9.42	.2625	93.	0.756E-01
0.	26.47	-9.53	-2.65	9.42	.2500	106.	0.543E-01
0.	26.47	-9.53	-2.65	9.42	.2375	120.	0.390E-01
0.	0.00	0.00	0.00	0.00	.2250	136.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2125	154.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2000	174.	0.000E+00

TABLE A.4 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
75.	2.44	40.00	3.21	40.00	.0850	3.01

IN SUCT	A	B
6.	-164.75	65.05

DEX	AA	BB	N	C	MOIST	SUC	CON

IN SUCT	A	B
21.	-25.12	12.50

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	22.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	30.	0.000E+00
0.	44.71	-16.27	-1.78	5.98	.3500	41.	0.537E+00

IN SUCT	A	B
42.	-11.57	7.78

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	44.71	-16.27	-3.86	13.79	.3375	48.	0.307E+00
0.	44.71	-16.27	-3.86	13.79	.3250	56.	0.176E+00
0.	44.71	-16.27	-3.86	13.79	.3125	64.	0.100E+00
0.	44.71	-16.27	-3.86	13.79	.3000	74.	0.574E-01
0.	44.71	-16.27	-3.86	13.79	.2875	86.	0.328E-01
0.	44.71	-16.27	-3.86	13.79	.2750	99.	0.188E-01
0.	44.71	-16.27	-3.86	13.79	.2625	115.	0.107E-01
0.	0.00	0.00	0.00	0.00	.2500	133.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2375	153.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2250	177.	0.000E+00

```
TABLE     A.4 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
106.   2.22   30.00     2.98  30.00   .1630       2.82

IN SUCT  A         B
  6.       0.00      6.32

DEX     AA         BB          N        C       MOIST    SUC     CON


IN SUCT  A         B
  0.     -60.04     23.02

DEX     AA         BB          N        C       MOIST    SUC     CON
 0.      59.81    -20.63     -1.00     2.30   .3375     16.   0.641E+00

IN SUCT  A         B
  0.     -23.70     11.12

DEX     AA         BB          N        C       MOIST    SUC     CON
 0.      59.81    -20.63     -2.52     7.43   .3250     30.   0.304E+00
 0.      59.81    -20.63     -2.52     7.43   .3125     41.   0.144E+00
 0.      59.81    -20.63     -2.52     7.43   .3000     55.   0.681E-01
 0.      59.81    -20.63     -2.52     7.43   .2875     74.   0.322E-01
 0.      59.81    -20.63     -2.52     7.43   .2750    100.   0.153E-01
 0.       0.00      0.00      0.00     0.00   .2625    134.   0.000E+00
```

TABLE A.4 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
137.   2.66   30.00     4.64  30.00  .1550        4.20

IN SUCT  A          B
   6.       0.00        6.32

DEX      AA          BB          N         C       MOIST    SUC     CON


IN SUCT  A          B
   0.    -34.20       13.20

DEX      AA          BB          N         C       MOIST    SUC     CON
 0.        0.00        0.00      0.00      0.00   .3125     12.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .3000     19.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .2875     29.   0.000E+00

IN SUCT  A          B
   0.    -12.58        6.96

DEX      AA          BB          N         C       MOIST    SUC     CON
 0.        0.00        0.00      0.00      0.00   .2750     33.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .2625     39.   0.000E+00
 0.       46.52      -14.35     -3.70     11.39   .2500     45.   0.659E-01
 0.       46.52      -14.35     -3.70     11.39   .2375     53.   0.368E-01
 0.       46.52      -14.35     -3.70     11.39   .2250     62.   0.206E-01
 0.       46.52      -14.35     -3.70     11.39   .2125     73.   0.115E-01
 0.        0.00        0.00      0.00      0.00   .2000     85.   0.000E+00

IN SUCT  A          B
   0.    -32.47       10.78

DEX      AA          BB          N         C       MOIST    SUC     CON
 0.        0.00        0.00      0.00      0.00   .1875    109.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .1750    164.   0.000E+00
```

TABLE A.5

GARDENA LOAM (CASSEL) SITE 5
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION
PARAMETERS

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 DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST   N-MUAL
   8.    2.39    60.00      2.61   60.00    .0000        2.51

 IN SUCT   A          B
    4.    -72.97      34.87

 DEX      AA          BB          N          C        MOIST    SUC     CON
  0.       0.00        0.00       0.00       0.00    .4500      8.   0.000E+00
  0.       0.00        0.00       0.00       0.00    .4375     19.   0.000E+00

 IN SUCT   A          B
  21.     -34.34      18.04

 DEX      AA          BB          N          C        MOIST    SUC     CON
  0.       0.00        0.00       0.00       0.00    .4250     31.   0.000E+00
  0.       0.00        0.00       0.00       0.00    .4125     48.   0.000E+00

 IN SUCT   A          B
  59.     -14.33       9.89

 DEX      AA          BB          N          C        MOIST    SUC     CON
  0.       0.00        0.00       0.00       0.00    .4000     64.   0.000E+00
  0.       0.00        0.00       0.00       0.00    .3875     76.   0.000E+00
  0.       0.00        0.00       0.00       0.00    .3750     91.   0.000E+00
  0.      48.48      -23.39      -3.38      10.07    .3625    109.   0.298E-02
  0.      48.48      -23.39      -3.38      10.07    .3500    131.   0.163E-02
  0.      48.48      -23.39      -3.38      10.07    .3375    157.   0.887E-03
  0.      48.48      -23.39      -3.38      10.07    .3250    187.   0.484E-03
  0.      48.48      -23.39      -3.38      10.07    .3125    224.   0.264E-03

 IN SUCT   A          B
 261.     -19.69      11.59

 DEX      AA          BB          N          C        MOIST    SUC     CON
  0.       0.00        0.00       0.00       0.00    .3000    294.   0.000E+00
  0.       0.00        0.00       0.00       0.00    .2875    376.   0.000E+00
  0.       0.00        0.00       0.00       0.00    .2750    481.   0.000E+00
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TABLE A.5 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 22.   2.39    60.00    2.59   60.00   .0000      2.49

IN SUCT   A        B
  4.    -62.98    28.93

DEX    AA       BB       N       C      MOIST    SUC     CON
 0.    0.00     0.00     0.00    0.00   .4375     4.    0.000E+00
 0.    0.00     0.00     0.00    0.00   .4250     9.    0.000E+00
 0.    0.00     0.00     0.00    0.00   .4125    19.    0.000E+00

IN SUCT   A        B
 21.    -26.91    14.13

DEX    AA       BB       N       C      MOIST    SUC     CON
 0.    0.00     0.00     0.00    0.00   .4000    29.    0.000E+00
 0.    0.00     0.00     0.00    0.00   .3875    41.    0.000E+00
 0.    0.00     0.00     0.00    0.00   .3750    57.    0.000E+00

IN SUCT   A        B
 60.    -14.99     9.67

DEX    AA       BB       N       C      MOIST    SUC     CON
 0.    0.00     0.00     0.00    0.00   .3625    69.    0.000E+00
 0.   43.86   -19.96    -2.93    8.33   .3500    83.    0.996E-02
 0.   43.86   -19.96    -2.93    8.33   .3375   101.    0.576E-02
 0.   43.86   -19.96    -2.93    8.33   .3250   121.    0.333E-02
 0.   43.86   -19.96    -2.93    8.33   .3125   146.    0.192E-02
 0.   43.86   -19.96    -2.93    8.33   .3000   176.    0.111E-02

IN SUCT   A        B
177.    -21.19    11.52

DEX    AA       BB       N       C      MOIST    SUC     CON
 0.    0.00     0.00     0.00    0.00   .2875   228.    0.000E+00
 0.    0.00     0.00     0.00    0.00   .2750   297.    0.000E+00
 0.    0.00     0.00     0.00    0.00   .2625   387.    0.000E+00
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APPENDIX A.5 CONT.

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DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 45.   2.33   30.00     2.53  30.00    .0000     2.46

IN SUCT  A          B
  4.    -59.44      26.88
DEX      AA         BB        N        C      THETA    SUC     CON
 0.       0.00       0.00     0.00     0.00  .4290      4.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .4216      6.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .4192      7.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .4143     10.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .4118     11.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .4069     15.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .4045     17.   0.000E+00
IN SUCT  A          B
 20.    -20.20      11.13
DEX      AA         BB        N        C      THETA    SUC     CON
 0.       0.00       0.00     0.00     0.00  .4020     20.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .3921     25.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .3723     37.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .3624     45.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .3525     55.   0.000E+00

IN SUCT  A          B
 60.    -17.16      10.06
DEX      AA         BB        N        C      THETA    SUC     CON
 0.       0.00       0.00     0.00     0.00  .3475     60.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .3349     75.   0.000E+00
 0.      57.33     -22.40    -3.34    11.21  .3285     83.   0.283E-01
 0.      57.33     -22.40    -3.34    11.21  .3222     93.   0.197E-01
 0.      57.33     -22.40    -3.34    11.21  .3159    103.   0.137E-01
 0.      57.33     -22.40    -3.34    11.21  .3096    115.   0.955E-02
 0.      57.33     -22.40    -3.34    11.21  .3033    128.   0.665E-02
 0.      57.33     -22.40    -3.34    11.21  .2970    143.   0.463E-02
 0.      57.33     -22.40    -3.34    11.21  .2906    160.   0.322E-02
 0.      57.33     -22.40    -3.34    11.21  .2843    178.   0.224E-02
 0.     150.50     -48.45    -8.77    39.78  .2780    198.   0.135E-02

IN SUCT  A          B
196.    -24.71      12.15
DEX      AA         BB        N        C      THETA    SUC     CON
 0.     150.50     -48.45    -6.09    25.55  .2780    196.   0.135E-02
 0.     150.50     -48.45    -6.09    25.55  .2747    213.   0.817E-03
 0.     150.50     -48.45    -6.09    25.55  .2714    232.   0.496E-03
 0.     150.50     -48.45    -6.09    25.55  .2680    251.   0.301E-03
 0.       0.00       0.00     0.00     0.00  .2647    273.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .2481    411.   0.000E+00
 0.       0.00       0.00     0.00     0.00  .2415    484.   0.000E+00
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TABLE    A.5 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 75.   2.47    80.00    2.70   80.00   .0000      2.59

IN SUCT  A          B
  4.    -92.11      41.70

DEX      AA          BB          N         C       MOIST    SUC    CON
 0.        0.00        0.00      0.00      0.00   .4375      4.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .4250     13.   0.000E+00

IN SUCT  A          B
 20.    -26.34      14.07

DEX      AA          BB          N         C       MOIST    SUC    CON
 0.        0.00        0.00      0.00      0.00   .4125     25.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .4000     34.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .3875     48.   0.000E+00

IN SUCT  A          B
 62.    -19.24      11.40

DEX      AA          BB          N         C       MOIST    SUC    CON
 0.        0.00        0.00      0.00      0.00   .3750     66.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .3625     84.   0.000E+00
 0.       65.79      -25.92     -3.42     13.06   .3500    106.   0.554E-01
 0.       65.79      -25.92     -3.42     13.06   .3375    135.   0.243E-01
 0.       65.79      -25.92     -3.42     13.06   .3250    172.   0.107E-01

IN SUCT  A          B
201.    -15.69      10.26

DEX      AA          BB          N         C       MOIST    SUC    CON
 0.       65.79      -25.92     -4.19     17.10   .3125    212.   0.470E-02
 0.       65.79      -25.92     -4.19     17.10   .3000    258.   0.206E-02
 0.        0.00        0.00      0.00      0.00   .2875    314.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .2750    382.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .2625    465.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .2500    565.   0.000E+00
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TABLE A.5 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
106.   2.64   140.0     2.95  140.0   .0000        2.79

IN SUCT   A          B
   5.   -139.75     64.64

DEX      AA         BB         N        C      MOIST    SUC      CON
 0.       0.00       0.00      0.00     0.00   .4500      6.  0.000E+00
 0.       0.00       0.00      0.00     0.00   .4375     33.  0.000E+00

IN SUCT   A          B
  33.    -36.04     19.25

DEX      AA         BB         N        C      MOIST    SUC      CON
 0.       0.00       0.00      0.00     0.00   .4250     51.  0.000E+00
 0.       0.00       0.00      0.00     0.00   .4125     80.  0.000E+00
 0.      40.04     -18.32     -1.11     3.07   .4000    126.  0.999E-01

IN SUCT   A          B
 141.    -20.54     13.07

DEX      AA         BB         N        C      MOIST    SUC      CON
 0.      40.04     -18.32     -1.95     7.16   .3875    166.  0.605E-01
 0.      40.04     -18.32     -1.95     7.16   .3750    214.  0.367E-01
 0.      40.04     -18.32     -1.95     7.16   .3625    277.  0.222E-01

IN SUCT   A          B
 277.     -8.18      8.57

DEX      AA         BB         N        C      MOIST    SUC      CON
 0.       0.00       0.00      0.00     0.00   .3500    301.  0.000E+00
 0.       0.00       0.00      0.00     0.00   .3375    333.  0.000E+00
 0.       0.00       0.00      0.00     0.00   .3250    369.  0.000E+00
 0.       0.00       0.00      0.00     0.00   .3125    409.  0.000E+00
 0.       0.00       0.00      0.00     0.00   .3000    453.  0.000E+00
 0.       0.00       0.00      0.00     0.00   .2875    502.  0.000E+00
```

TABLE A.5 CONT.

```
DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST   N-MUAL
137.    2.70    160.00     3.18   160.00   .0210        2.99

IN SUCT    A           B
   4.    -211.87        99.67

DEX       AA          BB          N          C        MOIST     SUC      CON
 0.        0.00        0.00       0.00       0.00     .4625      5.    0.000E+00

IN SUCT    A           B
  31.     -68.44        34.50

DEX       AA          BB          N          C        MOIST     SUC      CON
 0.        0.00        0.00       0.00       0.00     .4500     41.    0.000E+00

IN SUCT    A           B
  64.     -33.95        19.24

DEX       AA          BB          N          C        MOIST     SUC      CON
 0.       28.43      -14.87      -0.84       1.24     .4375     80.    0.879E-01
 0.       28.43      -14.87      -0.84       1.24     .4250    123.    0.616E-01

IN SUCT    A           B
 166.      -7.33         8.16

DEX       AA          BB          N          C        MOIST     SUC      CON
 0.       28.43      -14.87      -3.88      16.78     .4125    170.    0.432E-01
 0.       28.43      -14.87      -3.88      16.78     .4000    186.    0.303E-01
 0.       28.43      -14.87      -3.88      16.78     .3875    204.    0.212E-01
 0.        0.00        0.00       0.00       0.00     .3750    224.    0.000E+00
 0.        0.00        0.00       0.00       0.00     .3625    245.    0.000E+00
 0.        0.00        0.00       0.00       0.00     .3500    269.    0.000E+00
 0.        0.00        0.00       0.00       0.00     .3375    295.    0.000E+00
 0.        0.00        0.00       0.00       0.00     .3250    323.    0.000E+00
 0.        0.00        0.00       0.00       0.00     .3125    354.    0.000E+00
 0.        0.00        0.00       0.00       0.00     .3000    388.    0.000E+00
 0.        0.00        0.00       0.00       0.00     .2875    425.    0.000E+00
```

TABLE A.6

HECLA FINE SANDY LOAM SITE 7 (CASSEL)
CAMPBELL,BROOKS AND COREY, K*THETA, SUCTION*THETA, K*SUCTION
PARAMETERS

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST   N-MUAL
  8.   3.05   40.00     3.52  40.00   .0850        3.27

IN SUCT  A          B
   5.   -181.47      73.83

DEX     AA          BB          N          C       MOIST    SUC     CON


IN SUCT  A          B
  20.    -31.19      15.16

DEX     AA          BB          N          C       MOIST    SUC     CON
 0.       0.00        0.00      0.00       0.00    .3875    22.   0.000E+00

IN SUCT  A          B
  31.     -6.88       6.04

DEX     AA          BB          N          C       MOIST    SUC     CON
 0.       0.00        0.00      0.00       0.00    .3750    32.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .3625    35.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .3500    38.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .3375    41.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .3250    45.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .3125    49.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .3000    53.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .2875    58.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .2750    63.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .2625    69.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .2500    75.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .2375    82.   0.000E+00
 0.     209.32      -53.58    -30.42     130.18    .2250    89.   0.153E-02

IN SUCT  A          B
  97.    -23.52       9.77

DEX     AA          BB          N          C       MOIST    SUC     CON
 0.     209.32      -53.58     -8.90      33.37    .2125   118.   0.112E-03
 0.       0.00        0.00      0.00       0.00    .2000   159.   0.000E+00

IN SUCT  A          B
 187.    -42.94      13.65

DEX     AA          BB          N          C       MOIST    SUC     CON
 0.       0.00        0.00      0.00       0.00    .1875   270.   0.000E+00
 0.       0.00        0.00      0.00       0.00    .1750   462.   0.000E+00
```

TABLE A.6 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
22.	3.07	40.00	3.72	40.00	.0890	3.43

IN SUCT	A	B
6.	-190.01	71.65

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3625	16.	0.000E+00

IN SUCT	A	B
20.	-33.79	15.19

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3500	29.	0.000E+00

IN SUCT	A	B
32.	-6.92	5.88

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3375	35.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	38.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	41.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	45.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	49.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	53.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	58.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2500	63.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2375	69.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2250	75.	0.000E+00

IN SUCT	A	B
78.	-15.62	7.79

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	93.98	-24.20	-6.02	22.67	.2125	87.	0.146E-01
0.	93.98	-24.20	-6.02	22.67	.2000	106.	0.450E-02
0.	0.00	0.00	0.00	0.00	.1875	129.	0.000E+00

IN SUCT	A	B
135.	-41.33	12.53

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1750	200.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1625	335.	0.000E+00

TABLE A.6 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
45.	3.48	40.00	4.11	40.00	.0790	3.76

IN SUCT	A	B
6.	-115.13	42.83

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3500	13.	0.000E+00

IN SUCT	A	B
20.	-18.86	9.52

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3375	23.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	30.	0.000E+00

IN SUCT	A	B
31.	-5.68	5.27

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3125	33.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	35.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	38.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	41.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	44.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2500	47.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2375	50.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2250	54.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2125	58.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2000	62.	0.000E+00
0.	135.44	-28.44	-23.85	97.22	.1875	67.	0.476E-01

IN SUCT	A	B
68.	-14.37	6.88

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	135.44	-28.44	-9.43	36.41	.1750	79.	0.875E-02
0.	135.44	-28.44	-9.43	36.41	.1625	94.	0.161E-02
0.	0.00	0.00	0.00	0.00	.1500	113.	0.000E+00

IN SUCT	A	B
110.	-50.35	12.15

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1375	186.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1250	349.	0.000E+00

TABLE A.6 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
75.	3.43	40.00	3.46	40.00	.0250	3.22

IN SUCT	A	B
6.	-115.13	43.00

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3500	15.	0.000E+00

IN SUCT	A	B
20.	-20.27	10.04

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3375	25.	0.000E+00

IN SUCT	A	B
31.	-5.66	5.29

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3250	32.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	34.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	36.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	39.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	42.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	45.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2500	48.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2375	52.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2250	56.	0.000E+00
0.	92.10	-22.20	-16.27	63.89	.2125	60.	0.724E-01
0.	92.10	-22.20	-16.27	63.89	.2000	64.	0.229E-01
0.	92.10	-22.20	-16.27	63.89	.1875	69.	0.724E-02

IN SUCT	A	B
68.	-13.33	6.70

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1750	79.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1625	93.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1500	110.	0.000E+00

IN SUCT	A	B
108.	-57.95	13.14

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1375	176.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1250	364.	0.000E+00

TABLE A.6 cont.

```
DPTH   N-CAMP  SI-CAMP   N-B&C   SI-B&C  RES MOIST   N-MUAL
106.    3.53   50.00      4.11   50.00   .0560        3.76

IN SUCT   A           B
   7.   -134.77     49.17

DEX      AA          BB          N        C       MOIST     SUC      CON
 0.        0.00        0.00     0.00     0.00    .3500      7.   0.000E+00

IN SUCT   A           B
  30.     -19.84     10.12

DEX      AA          BB          N        C       MOIST     SUC      CON
 0.        0.00        0.00     0.00     0.00    .3375     31.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .3250     39.   0.000E+00

IN SUCT   A           B
  40.      -5.27       5.40

DEX      AA          BB          N        C       MOIST     SUC      CON
 0.        0.00        0.00     0.00     0.00    .3125     43.   0.000E+00
 0.      135.45      -41.85   -25.70    96.94    .3000     46.   0.296E+00
 0.      135.45      -41.85   -25.70    96.94    .2875     49.   0.545E-01
 0.        0.00        0.00     0.00     0.00    .2750     52.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .2625     56.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .2500     59.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .2375     63.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .2250     68.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .2125     72.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .2000     77.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .1875     82.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .1750     88.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .1625     94.   0.000E+00

IN SUCT   A           B
  97.     -23.90      8.42

DEX      AA          BB          N        C       MOIST     SUC      CON
 0.        0.00        0.00     0.00     0.00    .1500    126.   0.000E+00
 0.        0.00        0.00     0.00     0.00    .1375    170.   0.000E+00

IN SUCT   A           B
 172.     -64.68     14.01

DEX      AA          BB          N        C       MOIST     SUC      CON
 0.        0.00        0.00     0.00     0.00    .1250    374.   0.000E+0D
```

TABLE A.7

HEIMDAL LOAM (CASSEL) SITE 8
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION PARAMETERS

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
8.	2.36	30.00	2.54	30.00	.0000	2.45

IN SUCT	A	B
6.	-1005.29	447.27

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	0.00	0.00	0.00	0.00	.4375	7.	0.000E+00
1.	0.00	0.00	0.00	0.00	.4250	20.	0.000E+00

IN SUCT	A	B
0.	-16.48	10.27

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4125	32.	0.000E+00
0.	62.33	-26.39	-3.78	12.45	.4000	40.	0.233E+00
0.	62.33	-26.39	-3.78	12.45	.3875	49.	0.107E+00
0.	62.33	-26.39	-3.78	12.45	.3750	60.	0.490E-01
0.	62.33	-26.39	-3.78	12.45	.3625	73.	0.225E-01
0.	62.33	-26.39	-3.78	12.45	.3500	90.	0.103E-01
0.	62.33	-26.39	-3.78	12.45	.3375	111.	0.473E-02
0.	62.33	-26.39	-3.78	12.45	.3250	136.	0.217E-02
0.	62.33	-26.39	-3.78	12.45	.3125	167.	0.996E-03

APPENDIX A.7 CONT.

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DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 22.   2.36   30.00     2.54  30.00   .0000      2.45

IN SUCT  A         B
   6.    -62.80     29.03
DEX     AA          BB          N          C       THETA     SUC      CON
 0.        0.00        0.00      0.00      0.00   .4330       6.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .4279       9.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .4228      12.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .4177      16.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .4126      23.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .4075      31.   0.000E+00

IN SUCT  A         B
  31.    -17.38     10.46
DEX     AA          BB          N          C       THETA     SUC      CON
 0.        0.00        0.00      0.00      0.00   .3950      36.   0.000E+00
 0.       44.28      -18.95     -2.55      7.70   .3849      43.   0.149E+00
 0.       44.28      -18.95     -2.55      7.70   .3749      52.   0.953E-01
 0.       44.28      -18.95     -2.55      7.70   .3648      62.   0.611E-01
 0.       44.28      -18.95     -2.55      7.70   .3548      73.   0.391E-01
 0.       44.28      -18.95     -2.55      7.70   .3447      87.   0.251E-01
 0.       44.28      -18.95     -2.55      7.70   .3347     104.   0.161E-01
 0.       44.28      -18.95     -2.55      7.70   .3246     124.   0.103E-01
 0.       44.28      -18.95     -2.55      7.70   .3146     147.   0.661E-02
 0.       44.28      -18.95     -2.55      7.70   .3045     175.   0.423E-02
 0.       44.28      -18.95     -2.55      7.70   .2945     209.   0.271E-02
```

TABLE A.7 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
45.	2.33	20.00	2.50	20.00	.0000	2.42

IN SUCT	A	B
6.	-49.60	21.99

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4000	9.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3875	16.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	30.	0.000E+00

IN SUCT	A	B
30.	-20.89	11.14

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	60.59	-22.06	-2.90	10.25	.3625	35.	0.908E+00
0.	60.59	-22.06	-2.90	10.25	.3500	46.	0.426E+00
0.	60.59	-22.06	-2.90	10.25	.3375	60.	0.200E+00
0.	60.59	-22.06	-2.90	10.25	.3250	78.	0.936E-01
0.	60.59	-22.06	-2.90	10.25	.3125	101.	0.439E-01
0.	60.59	-22.06	-2.90	10.25	.3000	131.	0.206E-01
0.	60.59	-22.06	-2.90	10.25	.2875	170.	0.965E-02

```
TABLE    A.7 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 75.   2.30   20.00     2.45  20.00   .0000      2.38

IN SUCT  A        B
   4.   -654.29   247.97

DEX     AA        BB       N       C      MOIST   SUC     CON
 1.      0.00      0.00    0.00    0.00   .3625   11.   0.000E+00
 1.      0.00      0.00    0.00    0.00   .3500   19.   0.000E+00

IN SUCT  A        B
   0.    -24.82    11.69

DEX     AA        BB       N       C      MOIST   SUC     CON
 0.     56.16    -19.38   -2.26    7.07   .3375   27.   0.653E+00
 0.     56.16    -19.38   -2.26    7.07   .3250   37.   0.324E+00
 0.     56.16    -19.38   -2.26    7.07   .3125   51.   0.160E+00
 0.     56.16    -19.38   -2.26    7.07   .3000   70.   0.795E-01
 0.     56.16    -19.38   -2.26    7.07   .2875   95.   0.394E-01
 0.     56.16    -19.38   -2.26    7.07   .2750  130.   0.195E-01
 0.      0.00      0.00    0.00    0.00   .2625  177.   0.000E+00
```

TABLE A.7 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
106.	2.44	30.00	2.66	30.00	.0000	2.55

IN SUCT	A	B
3.	-971.84	329.45

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	66.74	-22.22	-0.07	0.40	.3250	14.	0.589E+00

IN SUCT	A	B
0.	-25.00	11.17

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	66.74	-22.22	-2.67	7.60	.3125	29.	0.256E+00
0.	66.74	-22.22	-2.67	7.60	.3000	39.	0.111E+00
0.	66.74	-22.22	-2.67	7.60	.2875	54.	0.482E-01
0.	66.74	-22.22	-2.67	7.60	.2750	73.	0.209E-01
0.	66.74	-22.22	-2.67	7.60	.2625	100.	0.909E-02
0.	0.00	0.00	0.00	0.00	.2500	137.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2375	187.	0.000E+00

```
TABLE    A.7 CONT.

DPTH  N-CAMP  SI-CAMP   N-B&C  SI-B&C  RES MOIST  N-MUAL
137.   2.41   30.00      2.62  30.00   .0000       2.52

IN SUCT  A          B
   4.   -709.50    239.50

DEX      AA         BB          N        C      MOIST    SUC     CON
 1.      39.70     -13.42     -0.06    -0.02   .3250      9.   0.596E+00
 1.      39.70     -13.42     -0.06    -0.02   .3125     18.   0.363E+00
 1.      39.70     -13.42     -0.06    -0.02   .3000     27.   0.221E+00

IN SUCT  A          B
  0.     -19.90        9.28

DEX      AA         BB          N        C      MOIST    SUC     CON
 0.      39.70     -13.42     -1.99     5.09   .2875     35.   0.134E+00
 0.      39.70     -13.42     -1.99     5.09   .2750     45.   0.819E-01
 0.      39.70     -13.42     -1.99     5.09   .2625     58.   0.498E-01
 0.      39.70     -13.42     -1.99     5.09   .2500     74.   0.303E-01
 0.      39.70     -13.42     -1.99     5.09   .2375     95.   0.185E-01
 0.      39.70     -13.42     -1.99     5.09   .2250    122.   0.112E-01
 0.       0.00       0.00      0.00     0.00   .2125    156.   0.000E+00
```

TABLE A.8

HEIMDAL LOAM: (CASSEL) SITE 9
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA,K*SUCTION PARAMETERS

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
8.	2.39	60.00	2.58	60.00	.0000	2.48

IN SUCT	A	B
4.	-1902.38	789.55

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	0.00	0.00	0.00	0.00	.4125	5.	0.000E+00
1.	0.00	0.00	0.00	0.00	.4000	29.	0.000E+00
1.	0.00	0.00	0.00	0.00	.3875	52.	0.000E+00

IN SUCT	A	B
0.	-17.44	10.90

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	60.59	-26.66	-3.47	11.21	.3750	78.	0.195E-01
0.	60.59	-26.66	-3.47	11.21	.3625	97.	0.913E-02
0.	60.59	-26.66	-3.47	11.21	.3500	121.	0.428E-02
0.	60.59	-26.66	-3.47	11.21	.3375	151.	0.201E-02
0.	0.00	0.00	0.00	0.00	.3250	187.	0.000E+00

TABLE A.8 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
22.	2.40	60.00	2.60	60.00	.0000	2.50

IN SUCT	A	B
5.	-1225.05	526.88

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	0.00	0.00	0.00	0.00	.4250	6.	0.000E+00

IN SUCT	A	B
0.	-26.08	13.81

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4125	21.	0.000E+00
0.	0.00	0.00	0.00	0.00	.4000	29.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3875	41.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	56.	0.000E+00

IN SUCT	A	B
0.	-15.14	9.79

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	85.30	-33.60	-5.63	21.56	.3625	74.	0.686E-01
0.	85.30	-33.60	-5.63	21.56	.3500	89.	0.236E-01
0.	0.00	0.00	0.00	0.00	.3375	108.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	130.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	157.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	190.	0.000E+00

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APPENDIX A.8  CONT.

DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST
 45.    2.50    10.00      2.50   10.00    .0000

IN SUCT   A          B
  5.    -899.68    395.50
DEX     AA          BB         N         C      THETA     SUC      CON
 1.       0.00       0.00      0.00      0.00   .4335      5.   0.000E+00
 1.       0.00       0.00      0.00      0.00   .4320      7.   0.000E+00
 1.       0.00       0.00      0.00      0.00   .4305      8.   0.000E+00
 1.       0.00       0.00      0.00      0.00   .4275     11.   0.000E+00
 1.       0.00       0.00      0.00      0.00   .4245     14.   0.000E+00
 1.       0.00       0.00      0.00      0.00   .4215     16.   0.000E+00
 1.       0.00       0.00      0.00      0.00   .4185     19.   0.000E+00

IN SUCT   A          B
  0.     -19.33      11.06
DEX     AA          BB         N         C      THETA     SUC      CON
 0.       0.00       0.00      0.00      0.00   .4170     20.   0.000E+00
 0.       0.00       0.00      0.00      0.00   .4068     24.   0.000E+00
 0.       0.00       0.00      0.00      0.00   .3865     36.   0.000E+00
 0.       0.00       0.00      0.00      0.00   .3661     54.   0.000E+00

IN SUCT   A          B
  0.     -14.38       9.23
DEX     AA          BB         N         C      THETA     SUC      CON
 0.      38.37     -15.37     -2.67      9.26   .3535     63.   0.164E+00
 0.      38.37     -15.37     -2.67      9.26   .3460     70.   0.123E+00
 0.      38.37     -15.37     -2.67      9.26   .3385     78.   0.924E-01
 0.      38.37     -15.37     -2.67      9.26   .3310     87.   0.693E-01
 0.      38.37     -15.37     -2.67      9.26   .3235     97.   0.520E-01
 0.      38.37     -15.37     -2.67      9.26   .3160    108.   0.390E-01
 0.      38.37     -15.37     -2.67      9.26   .3085    121.   0.292E-01
 0.      38.37     -15.37     -2.67      9.26   .3010    134.   0.219E-01
 0.      38.37     -15.37     -2.67      9.26   .2935    150.   0.164E-01
 0.      38.37     -15.37     -2.67      9.26   .2860    167.   0.123E-01
 0.     255.84     -76.24    -17.79     87.96   .2785    186.   0.681E-02
```

TABLE A.8 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
75.	2.46	60.00	2.69	60.00	.0000	2.57

IN SUCT	A	B
6.	-908.31	389.31

DEX	AA	BB	N	C	MOIST	SUC	CON
1.	0.00	0.00	0.00	0.00	.4125	15.	0.000E+00
1.	0.00	0.00	0.00	0.00	.4000	26.	0.000E+00

IN SUCT	A	B
0.	-26.45	13.85

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3875	37.	0.000E+00
0.	31.12	-12.88	-1.18	3.42	.3750	51.	0.298E+00
0.	31.12	-12.88	-1.18	3.42	.3625	71.	0.202E+00

IN SUCT	A	B
0.	-14.60	9.63

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	31.12	-12.88	-2.13	7.65	.3500	92.	0.137E+00
0.	31.12	-12.88	-2.13	7.65	.3375	110.	0.928E-01
0.	31.12	-12.88	-2.13	7.65	.3250	132.	0.629E-01
0.	31.12	-12.88	-2.13	7.65	.3125	159.	0.426E-01
0.	0.00	0.00	0.00	0.00	.3000	191.	0.000E+00

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TABLE     A.8 CONT.

DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST   N-MUAL
106.    2.44    60.00      2.66   60.00    .0000         2.55

IN SUCT   A           B
   4.   -1456.51    540.50

DEX      AA          BB          N        C       MOIST     SUC      CON
 1.        0.00        0.00     0.00     0.00    .3625      13.   0.000E+00

IN SUCT   A           B
   0.     -32.83      14.92

DEX      AA          BB          N        C       MOIST     SUC      CON
 0.       57.56      -21.53    -1.75     4.63    .3500      31.   0.251E+00
 0.       57.56      -21.53    -1.75     4.63    .3375      46.   0.122E+00

IN SUCT   A           B
   0.     -17.56       9.93

DEX      AA          BB          N        C       MOIST     SUC      CON
 0.       57.56      -21.53    -3.28    11.02    .3250      68.   0.594E-01
 0.       57.56      -21.53    -3.28    11.02    .3125      85.   0.289E-01
 0.       57.56      -21.53    -3.28    11.02    .3000     106.   0.141E-01
 0.       57.56      -21.53    -3.28    11.02    .2875     132.   0.686E-02
 0.       57.56      -21.53    -3.28    11.02    .2750     164.   0.334E-02
1
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TABLE A.9

LACUSTRINE SED. SITE 10 (CASSEL)
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION PARAMETERS

```
 DPTH  N-CAMP   SI-CAMP   N-B&C  SI-B&C  RES MOIST   N-MUAL
   8.    2.43    40.00     2.76   40.00   .0330       2.64

 IN SUCT  A          B
    7.  18000.00  -6581.00

DEX      AA          BB          N         C       MOIST    SUC      CON


 IN SUCT  A          B
    0.    -71.92      29.80

DEX      AA          BB          N         C       MOIST    SUC      CON


 IN SUCT  A          B
    0.    -14.50       8.90

DEX      AA          BB          N         C       MOIST    SUC      CON
 0.        0.00        0.00      0.00      0.00   .3625     38.   0.000E+00
 0.       46.99      -19.92     -3.24      8.92   .3500     46.   0.309E-01
 0.       46.99      -19.92     -3.24      8.92   .3375     55.   0.172E-01
 0.       46.99      -19.92     -3.24      8.92   .3250     66.   0.954E-02
 0.       46.99      -19.92     -3.24      8.92   .3125     79.   0.530E-02
 0.       46.99      -19.92     -3.24      8.92   .3000     95.   0.295E-02
 0.       46.99      -19.92     -3.24      8.92   .2875    113.   0.164E-02
 0.       46.99      -19.92     -3.24      8.92   .2750    136.   0.910E-03
 0.        0.00        0.00      0.00      0.00   .2625    163.   0.000E+00
 0.        0.00        0.00      0.00      0.00   .2500    195.   0.000E+00
```

TABLE A.9 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 22.   2.44   30.00     2.94  30.00   .0550       2.78

IN SUCT  A          B
   8.  -2718.55   981.42

DEX     AA        BB        N       C      MOIST    SUC     CON
 1.      0.00      0.00    0.00    0.00   .3500    30.   0.000E+00

IN SUCT  A          B
   0.     -22.13     11.14

DEX     AA        BB        N       C      MOIST    SUC     CON
 0.      0.00      0.00    0.00    0.00   .3375    39.   0.000E+00

IN SUCT  A          B
   0.     -12.94      8.02

DEX     AA        BB        N       C      MOIST    SUC     CON
 0.      46.99    -16.45   -3.63   12.67  .3250    45.   0.308E+00
 0.      46.99    -16.45   -3.63   12.67  .3125    53.   0.171E+00
 0.      46.99    -16.45   -3.63   12.67  .3000    63.   0.951E-01
 0.      46.99    -16.45   -3.63   12.67  .2875    74.   0.528E-01
 0.      46.99    -16.45   -3.63   12.67  .2750    87.   0.294E-01
 0.      46.99    -16.45   -3.63   12.67  .2625   102.   0.163E-01
 0.      46.99    -16.45   -3.63   12.67  .2500   120.   0.907E-02
 0.      46.99    -16.45   -3.63   12.67  .2375   141.   0.504E-02
 0.       0.00      0.00    0.00    0.00  .2250   165.   0.000E+00
```

```
TABLE    A.9  CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 45.   2.98   20.00     3.90  20.00   .0640       3.58

IN SUCT  A          B
   7.       0.00      7.00

DEX     AA         BB         N        C       MOIST    SUC     CON


IN SUCT  A          B
   0.    -30.14     12.90

DEX     AA         BB         N        C       MOIST    SUC     CON
 0.       0.00       0.00     0.00     0.00   .3500    10.   0.000E+00
 0.       0.00       0.00     0.00     0.00   .3375    15.   0.000E+00

IN SUCT  A          B
   0.      -6.87      5.27

DEX     AA         BB         N        C       MOIST    SUC     CON
 0.       0.00       0.00     0.00     0.00   .3250    21.   0.000E+00
 0.       0.00       0.00     0.00     0.00   .3125    23.   0.000E+00
 0.       0.00       0.00     0.00     0.00   .3000    25.   0.000E+00
 0.       0.00       0.00     0.00     0.00   .2875    27.   0.000E+00
 0.       0.00       0.00     0.00     0.00   .2750    29.   0.000E+00
 0.       0.00       0.00     0.00     0.00   .2625    32.   0.000E+00
 0.       0.00       0.00     0.00     0.00   .2500    35.   0.000E+00
 0.       0.00       0.00     0.00     0.00   .2375    38.   0.000E+00

IN SUCT  A          B
   0.    -12.24      6.45

DEX     AA         BB         N        C       MOIST    SUC     CON
 0.      59.04     -14.23    -4.82    16.88   .2250    40.   0.388E+00
 0.      59.04     -14.23    -4.82    16.88   .2125    47.   0.186E+00
 0.      59.04     -14.23    -4.82    16.88   .2000    55.   0.887E-01
 0.      59.04     -14.23    -4.82    16.88   .1875    64.   0.424E-01
 0.      59.04     -14.23    -4.82    16.88   .1750    74.   0.203E-01

IN SUCT  A          B
   0.    -21.74      8.03

DEX     AA         BB         N        C       MOIST    SUC     CON
 0.      59.04     -14.23    -2.72     7.58   .1625    90.   0.970E-02
 0.      59.04     -14.23    -2.72     7.58   .1500   118.   0.464E-02
 0.       0.00       0.00     0.00     0.00   .1375   155.   0.000E+00
```

TABLE A.9 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST   N-MUAL
 75.   3.87   20.00     4.84  20.00  .0420         4.37

IN SUCT  A         B
   4.  ********  4228.00

DEX     AA        BB         N        C      MOIST    SUC     CON


IN SUCT  A         B
  10     -27.18     11.86

DEX     AA        BB         N        C      MOIST    SUC     CON
 0.       0.00      0.00     0.00     0.00   .3500    10.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .3375    15.   0.000E+00

IN SUCT  A         B
   0.     -4.03      4.36
DEX     AA        BB         N        C      MOIST    SUC     CON
 0.       0.00      0.00     0.00     0.00   .3250    21.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .3125    22.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .3000    23.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .2875    25.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .2750    26.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .2625    27.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .2500    29.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .2375    30.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .2250    32.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .2125    33.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .2000    35.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .1875    37.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .1750    39.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .1625    41.   0.000E+00

IN SUCT  A         B
   0.     -9.08      5.13

DEX     AA        BB         N        C      MOIST    SUC     CON
 0.      53.55    -10.12    -5.90    20.14   .1500    43.   0.124E+00
 0.      53.55    -10.12    -5.90    20.14   .1375    49.   0.635E-01
 0.      53.55    -10.12    -5.90    20.14   .1250    54.   0.325E-01

IN SUCT  A         B
   0.    -28.51      7.22

DEX     AA        BB         N        C      MOIST    SUC     CON
 0.      53.55    -10.12    -1.88     3.44   .1125    55.   0.166E-01
 0.      53.55    -10.12    -1.88     3.44   .1000    79.   0.852E-02
 0.       0.00      0.00     0.00     0.00   .0875   113.   0.000E+00
 0.       0.00      0.00     0.00     0.00   .0750   161.   0.000E+00
```

TABLE A.9 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
106.   3.88   20.00     4.66  20.00   .0240       4.22

IN SUCT  A          B
   6.    -92.22      35.99

DEX     AA          BB         N        C       MOIST    SUC     CON


IN SUCT  A          B
  18.     -6.65       5.37

DEX     AA          BB         N        C       MOIST    SUC     CON
 0.        0.00        0.00     0.00     0.00   .3625     19.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .3500     21.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .3375     23.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .3250     25.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .3125     27.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .3000     29.   0.000E+00

IN SUCT  A          B
  30.     -2.20       4.05

DEX     AA          BB         N        C       MOIST    SUC     CON
 0.        0.00        0.00     0.00     0.00   .2875     31.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .2750     31.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .2625     32.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .2500     33.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .2375     34.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .2250     35.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .2125     36.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .2000     37.   0.000E+00
 0.        0.00        0.00     0.00     0.00   .1875     38.   0.000E+00
 0.       56.16      -10.84   -25.57    92.73   .1750     39.   0.363E+00

IN SUCT  A          B
  40.     -8.53       5.10

DEX     AA          BB         N        C       MOIST    SUC     CON
 0.       56.16      -10.84    -6.58    22.74   .1625     41.   0.180E+00
 0.       56.16      -10.84    -6.58    22.74   .1500     46.   0.893E-01
 0.       56.16      -10.84    -6.58    22.74   .1375     51.   0.442E-01
 0.       56.16      -10.84    -6.58    22.74   .1250     56.   0.219E-01

IN SUCT  A          B
  52.    -31.37       7.65

DEX     AA          BB         N        C       MOIST    SUC     CON
 0.       56.16      -10.84    -1.79     2.86   .1125     62.   0.109E-01
 0.       56.16      -10.84    -1.79     2.86   .1000     91.   0.539E-02
 0.        0.00        0.00     0.00     0.00   .0875    135.   0.000E+00
```

```
TABLE     A.9 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
137.   4.06   20.00     4.32  20.00   .0270        3.94


IN SUCT   A          B
  0.     -13.08        7.70

DEX     AA         BB        N        C      MOIST    SUC     CON
 0.       0.00       0.00    0.00     0.00  .4125     10.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .4000     12.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .3875     14.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .3750     16.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .3625     19.   0.000E+00

IN SUCT   A          B
  0.      -3.37        4.22

DEX     AA         BB        N        C      MOIST    SUC     CON
 0.       0.00       0.00    0.00     0.00  .3500     21.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .3375     22.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .3250     23.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .3125     24.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .3000     25.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .2875     26.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .2750     27.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .2625     28.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .2500     29.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .2375     31.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .2250     32.   0.000E+00
 0.       0.00       0.00    0.00     0.00  .2125     33.   0.000E+00
 0.      56.16     -11.85  -16.66    58.47  .2000     35.   0.539E+00
 0.      56.16     -11.85  -16.66    58.47  .1875     36.   0.267E+00
 0.      56.16     -11.85  -16.66    58.47  .1750     38.   0.132E+00
 0.      56.16     -11.85  -16.66    58.47  .1625     39.   0.656E-01

IN SUCT   A          B
  0.     -16.11        6.16

DEX     AA         BB        N        C      MOIST    SUC     CON
 0.      56.16     -11.85   -3.49     9.62  .1500     42.   0.325E-01
 0.      56.16     -11.85   -3.49     9.62  .1375     52.   0.161E-01

IN SUCT   A          B
  0.     -54.10       10.95

DEX     AA         BB        N        C      MOIST    SUC     CON
 0.      56.16     -11.85   -1.04    -0.48  .1250     66.   0.799E-02
 0.      56.16     -11.85   -1.04    -0.48  .1125    130.   0.396E-02
1
```

TABLE A.10

```
MADDOCK SANDY LOAM          (CARVALLO)          PLOT1
 CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION
 PARAMETERS


 DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST   N-MUAL
   8.    2.32    40.00      3.16   40.00    .1910        3.00

 IN SUCT   A          B
    1.    -73.07      30.54

 DEX      AA          BB          N          C       MOIST     SUC     CON
  0.        0.00        0.00      0.00       0.00    .4125      1.   0.000E+00
  0.        0.00        0.00      0.00       0.00    .4000      4.   0.000E+00
  0.        0.00        0.00      0.00       0.00    .3875      9.   0.000E+00

 IN SUCT   A          B
  20.     -36.48      16.74

 DEX      AA          BB          N          C       MOIST     SUC     CON
  0.        0.00        0.00      0.00       0.00    .3750     21.   0.000E+00
  0.        0.00        0.00      0.00       0.00    .3625     34.   0.000E+00

 IN SUCT   A          B
  41.     -18.52      10.34

 DEX      AA          BB          N          C       MOIST     SUC     CON
  0.       42.64      -19.68     -2.30       4.13    .3500     47.   0.860E-02
  0.       42.64      -19.68     -2.30       4.13    .3375     60.   0.505E-02
  0.       42.64      -19.68     -2.30       4.13    .3250     75.   0.296E-02
  0.       42.64      -19.68     -2.30       4.13    .3125     95.   0.174E-02
  0.      164.47      -57.23     -8.88      34.60    .3000    120.   0.375E-03

 IN SUCT   A          B
 134.     -34.08      14.85

 DEX      AA          BB          N          C       MOIST     SUC     CON
  0.        0.00        0.00      0.00       0.00    .2875    156.   0.000E+00
  0.        0.00        0.00      0.00       0.00    .2750    239.   0.000E+00
  0.        0.00        0.00      0.00       0.00    .2625    367.   0.000E+00
```

APPENDIX A.10 CONT.

```
DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST  N-MUAL
 22.   2.35   20.00     2.68  20.00   .700       2.57

IN SUCT  A          B
  1.    -63.07      26.36
DEX     AA         BB         N        C        THETA    SUC     CON
 0.      0.00       0.00      0.00     0.00    .4137      1.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .4094      2.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .4007      3.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3964      4.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3921      5.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3878      7.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3835      9.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3791     12.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3748     15.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3705     20.    0.000E+00

IN SUCT  A          B
  21.   -16.94       9.30
DEX     AA         BB         N        C        THETA    SUC     CON
 0.      0.00       0.00      0.00     0.00    .3619     24.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3533     28.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3447     32.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3361     37.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .3275     43.    0.000E+00
 0.     61.89     -23.47     -3.65    10.51    .3190     49.    0.240E-01
 0.     61.89     -23.47     -3.65    10.51    .3104     57.    0.141E-01
 0.     61.89     -23.47     -3.65    10.51    .3018     66.    0.829E-02
 0.     61.89     -23.47     -3.65    10.51    .2932     76.    0.487E-02
 0.     61.89     -23.47     -3.65    10.51    .2846     88.    0.286E-02

IN SUCT  A          B
 100.   -25.95      11.77
DEX     AA         BB         N        C        THETA    SUC     CON
 0.     61.89     -23.47     -2.38     4.60    .2760    100.    0.168E-02
 0.     61.89     -23.47     -2.38     4.60    .2706    115.    0.120E-02
 0.     61.89     -23.47     -2.38     4.60    .2652    133.    0.861E-03
 0.      0.00       0.00      0.00     0.00    .2598    153.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .2544    176.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .2490    202.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .2435    233.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .2381    268.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .2327    308.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .2273    355.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .2219    408.    0.000E+00
 0.      0.00       0.00      0.00     0.00    .2165    470.    0.000E+00
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APPENDIX A.10 CONT.

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DPTH  N-CAMP  SI-CAMP   N-B&C  SI-B&C  RES MOIST  N-MUAL
 37.   2.46   20.00     3.04   20.00   .0900      2.87

IN SUCT  A         B
   1.    -52.10     21.28
DEX     AA        BB        N        C       THETA    SUC    CON
 O.      0.00      0.00     0.00     0.00   .4033     1.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3928     2.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3876     3.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3824     4.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3771     5.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3719     7.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3667     9.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3615    12.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3562    15.   0.000E+00

IN SUCT  A         B
  20.    -14.15     7.95
DEX     AA        BB        N        C       THETA    SUC    CON
 O.      0.00      0.00     0.00     0.00   .3510    20.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3408    23.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3305    26.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3203    30.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .3101    35.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .2999    41.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .2896    47.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .2794    54.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .2692    63.   0.000E+00
 O.     75.74    -24.90    -5.35    17.65   .2590    73.   0.506E-02
 O.     75.74    -24.90    -5.35    17.65   .2487    84.   0.233E-02

IN SUCT  A         B
  97.    -25.14    10.57
DEX     AA        BB        N        C       THETA    SUC    CON
 O.     75.74    -24.90    -3.01     6.94   .2385    97.   0.107E-02
 O.    261.66    -69.08   -10.41    40.94   .2329   112.   0.293E-03
 O.    261.66    -69.08   -10.41    40.94   .2273   128.   0.679E-04
 O.    261.66    -69.08   -10.41    40.94   .2217   148.   0.157E-04
 O.      0.00      0.00     0.00     0.00   .2161   170.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .2105   196.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .2050   225.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .1994   259.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .1938   298.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .1882   343.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .1826   395.   0.000E+00
 O.      0.00      0.00     0.00     0.00   .1770   455.   0.000E+00
```

TABLE A.10 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
53.	2.60	20.00	3.88	20.00	.123	3.56

IN SUCT	A	B
1.	-38.41	15.15

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3875	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	3.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	6.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	9.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	14.	0.000E+00

IN SUCT	A	B
19.	-13.65	7.26

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3125	20.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	24.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	28.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	33.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	40.	0.000E+00
0.	58.15	-18.19	-4.26	12.74	.2500	47.	0.259E-01
0.	58.15	-18.19	-4.26	12.74	.2375	56.	0.125E-01
0.	58.15	-18.19	-4.26	12.74	.2250	66.	0.606E-02
0.	58.15	-18.19	-4.26	12.74	.2125	78.	0.293E-02
0.	117.48	-30.59	-8.61	31.89	.2000	93.	0.830E-03
0.	117.48	-30.59	-8.61	31.89	.1875	110.	0.191E-03

IN SUCT	A	B
130.	-46.34	13.09

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	117.48	-30.59	-2.54	2.60	.1750	146.	0.440E-04
0.	117.48	-30.59	-2.54	2.60	.1625	260.	0.101E-04
0.	117.48	-30.59	-2.54	2.60	.1500	464.	0.233E-05

TABLE A.10 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
76.	3.19	20.00	6.12	1.00	.0950	5.43

IN SUCT	A	B
1.	-40.48	15.32

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	3.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	5.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	9.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	14.	0.000E+00

IN SUCT	A	B
20.	-6.67	5.01

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3000	20.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	22.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	24.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	26.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2500	28.	0.000E+00
0.	21.93	-7.48	-3.29	8.99	.2375	31.	0.103E+00
0.	21.93	-7.48	-3.29	8.99	.2250	33.	0.784E-01
0.	21.93	-7.48	-3.29	8.99	.2125	36.	0.596E-01
0.	21.93	-7.48	-3.29	8.99	.2000	39.	0.453E-01
0.	21.93	-7.48	-3.29	8.99	.1875	43.	0.345E-01
0.	21.93	-7.48	-3.29	8.99	.1750	47.	0.262E-01
0.	21.93	-7.48	-3.29	8.99	.1625	51.	0.199E-01
0.	82.24	-17.10	-12.33	44.67	.1500	55.	0.853E-02

IN SUCT	A	B
60.	-19.40	6.89

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	82.24	-17.10	-4.24	12.11	.1375	68.	0.305E-02
0.	82.24	-17.10	-4.24	12.11	.1250	87.	0.109E-02

IN SUCT	A	B
82.	-74.08	13.18

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1125	127.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1000	321.	0.000E+00

TABLE A.10 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
106.	3.42	20.00	6.72	20.00	.0960	5.93

IN SUCT	A	B
1.	-56.52	21.85

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	4.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	8.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	16.	0.000E+00

IN SUCT	A	B
19.	-5.10	4.67

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3250	20.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	22.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	23.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	25.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	26.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	28.	0.000E+00
0.	14.39	-5.35	-2.82	7.83	.2500	30.	0.173E+00
0.	14.39	-5.35	-2.82	7.83	.2375	32.	0.145E+00
0.	14.39	-5.35	-2.82	7.83	.2250	34.	0.121E+00
0.	14.39	-5.35	-2.82	7.83	.2125	36.	0.101E+00
0.	14.39	-5.35	-2.82	7.83	.2000	38.	0.844E-01
0.	14.39	-5.35	-2.82	7.83	.1875	41.	0.705E-01
0.	41.71	-10.44	-8.18	27.75	.1750	44.	0.432E-01
0.	41.71	-10.44	-8.18	27.75	.1625	47.	0.257E-01
0.	41.71	-10.44	-8.18	27.75	.1500	50.	0.152E-01
0.	0.00	0.00	0.00	0.00	.1375	53.	0.000E+00

IN SUCT	A	B
57.	-32.95	8.33

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1250	67.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1125	102.	0.000E+00

IN SUCT	A	B
121.	-185.44	24.27

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1000	307.	0.000E+00

TABLE A.10 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
137.	3.70	20.00	6.67	20.00	.1150	5.88

IN SUCT	A	B
1.	-33.66	14.17

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4125	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.4000	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3875	3.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	5.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	7.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	11.	0.000E+00
0.	16.21	-6.70	-0.48	0.12	.3375	17.	0.293E+00

IN SUCT	A	B
20.	-4.23	4.40

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	16.21	-6.70	-3.83	10.16	.3250	21.	0.239E+00
0.	16.21	-6.70	-3.83	10.16	.3125	22.	0.195E+00
0.	16.21	-6.70	-3.83	10.16	.3000	23.	0.159E+00
0.	16.21	-6.70	-3.83	10.16	.2875	24.	0.130E+00
0.	16.21	-6.70	-3.83	10.16	.2750	25.	0.106E+00
0.	16.21	-6.70	-3.83	10.16	.2625	27.	0.867E-01
0.	16.21	-6.70	-3.83	10.16	.2500	28.	0.708E-01
0.	16.21	-6.70	-3.83	10.16	.2375	30.	0.578E-01
0.	16.21	-6.70	-3.83	10.16	.2250	31.	0.472E-01
0.	16.21	-6.70	-3.83	10.16	.2125	33.	0.386E-01
0.	16.21	-6.70	-3.83	10.16	.2000	35.	0.315E-01
0.	16.21	-6.70	-3.83	10.16	.1875	37.	0.257E-01
0.	58.74	-14.36	-13.89	46.74	.1750	39.	0.169E-01

IN SUCT	A	B
36.	-25.54	7.88

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	58.74	-14.36	-2.30	3.76	.1625	42.	0.811E-02
0.	58.74	-14.36	-2.30	3.76	.1500	57.	0.389E-02
0.	0.00	0.00	0.00	0.00	.1375	79.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1250	109.	0.000E+00

TABLE A.11

MADDOCK SANDY LOAM (CARVALLO) PLOT 2
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION
PARAMETERS

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
8.	2.37	40.00	3.55	40.00	.1910	3.25

IN SUCT	A	B
1.	-73.07	29.81

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4000	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3875	4.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	11.	0.000E+00

IN SUCT	A	B
21.	-18.55	9.85

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3625	23.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	29.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	36.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	46.	0.000E+00
0.	69.35	-26.47	-3.74	10.35	.3125	58.	0.824E-02
0.	69.35	-26.47	-3.74	10.35	.3000	73.	0.346E-02
0.	69.35	-26.47	-3.74	10.35	.2875	92.	0.146E-02
0.	69.35	-26.47	-3.74	10.35	.2750	115.	0.612E-03

IN SUCT	A	B
141.	-38.33	15.07

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.2625	150.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2500	242.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2375	390.	0.000E+00

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TABLE    A.11 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST   N-MUAL
 22.   2.39   20.00     2.95  20.00  .1190         2.79

IN SUCT  A          B
   1.    -73.07      29.19

DEX      AA         BB          N        C      MOIST     SUC     CON
 0.       0.00       0.00     0.00     0.00    .3875       2.   0.000E+00
 0.       0.00       0.00     0.00     0.00    .3750       6.   0.000E+00
 0.       0.00       0.00     0.00     0.00    .3625      15.   0.000E+00

IN SUCT  A          B
  20.    -16.72       9.00

DEX      AA         BB          N        C      MOIST     SUC     CON
 0.       0.00       0.00     0.00     0.00    .3500      23.   0.000E+00
 0.       0.00       0.00     0.00     0.00    .3375      29.   0.000E+00
 0.       0.00       0.00     0.00     0.00    .3250      35.   0.000E+00
 0.       0.00       0.00     0.00     0.00    .3125      44.   0.000E+00
 0.       0.00       0.00     0.00     0.00    .3000      54.   0.000E+00
 0.      88.56     -30.29    -5.30    17.38    .2875      66.   0.799E-02
 0.      88.56     -30.29    -5.30    17.38    .2750      82.   0.264E-02
 0.      88.56     -30.29    -5.30    17.38    .2625     101.   0.873E-03
 0.       0.00       0.00     0.00     0.00    .2500     124.   0.000E+00

IN SUCT  A          B
 137.    -34.53      13.33

DEX      AA         BB          N        C      MOIST     SUC     CON
 0.       0.00       0.00     0.00     0.00    .2375     169.   0.000E+00
 0.       0.00       0.00     0.00     0.00    .2250     260.   0.000E+00
 0.       0.00       0.00     0.00     0.00    .2125     400.   0.000E+00
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TABLE A.11 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
37.	2.51	40.00	3.59	40.00	.0000	3.33

IN SUCT	A	B
1.	-78.84	29.88

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	4.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	10.	0.000E+00

IN SUCT	A	B
20.	-15.46	8.27

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3375	21.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	26.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	31.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	38.	0.000E+00
0.	59.34	-21.03	-3.84	10.71	.2875	46.	0.189E-01
0.	59.34	-21.03	-3.84	10.71	.2750	56.	0.899E-02
0.	59.34	-21.03	-3.84	10.71	.2625	67.	0.428E-02
0.	59.34	-21.03	-3.84	10.71	.2500	82.	0.204E-02
0.	59.34	-21.03	-3.84	10.71	.2375	99.	0.971E-03
0.	0.00	0.00	0.00	0.00	.2250	120.	0.000E+00

IN SUCT	A	B
133.	-32.38	11.90

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.2125	151.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2000	227.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1875	340.	0.000E+00

TABLE A.11 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
53.	2.61	20.00	3.73	20.00	.1070	3.44

IN SUCT	A	B
1.	-50.78	18.53

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3625	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	4.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	8.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	14.	0.000E+00

IN SUCT	A	B
19.	-13.88	7.20

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3000	21.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	25.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	29.	0.000E+00
0.	47.57	-16.04	-3.43	8.64	.2625	35.	0.286E-01
0.	47.57	-16.04	-3.43	8.64	.2500	42.	0.158E-01
0.	47.57	-16.04	-3.43	8.64	.2375	50.	0.872E-02
0.	47.57	-16.04	-3.43	8.64	.2250	59.	0.481E-02
0.	47.57	-16.04	-3.43	8.64	.2125	70.	0.265E-02
0.	47.57	-16.04	-3.43	8.64	.2000	83.	0.146E-02
0.	0.00	0.00	0.00	0.00	.1875	99.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1750	118.	0.000E+00

IN SUCT	A	B
131.	-43.83	12.26

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1625	170.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1500	295.	0.000E+00

TABLE A.11 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
76.	3.19	20.00	5.84	20.00	.0920	5.20

IN SUCT	A	B
1.	-49.11	18.02

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3625	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	4.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	8.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	14.	0.000E+00

IN SUCT	A	B
20.	-6.69	5.03

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3000	20.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	22.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	24.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	26.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2500	29.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2375	31.	0.000E+00
0.	15.77	-6.50	-2.36	5.35	.2250	34.	0.522E-01
0.	15.77	-6.50	-2.36	5.35	.2125	37.	0.429E-01
0.	15.77	-6.50	-2.36	5.35	.2000	40.	0.352E-01
0.	15.77	-6.50	-2.36	5.35	.1875	43.	0.289E-01
0.	52.33	-12.98	-7.82	26.33	.1750	47.	0.219E-01
0.	52.33	-12.98	-7.82	26.33	.1625	51.	0.114E-01
0.	52.33	-12.98	-7.82	26.33	.1500	56.	0.591E-02

IN SUCT	A	B
57.	-21.84	7.24

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	52.33	-12.98	-2.40	4.37	.1375	69.	0.307E-02
0.	0.00	0.00	0.00	0.00	.1250	91.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1125	119.	0.000E+00

IN SUCT	A	B
132.	-99.39	15.62

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1000	293.	0.000E+00

TABLE A.11 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
106.	3.85	20.00	7.22	20.00	.0850	6.35

IN SUCT	A	B
1.	-54.97	21.03

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	3.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	6.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	12.	0.000E+00

IN SUCT	A	B
20.	-4.09	4.34

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3250	20.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	21.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	22.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	24.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	25.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	26.	0.000E+00
0.	15.39	-6.06	-3.76	10.27	.2500	28.	0.109E+00
0.	15.39	-6.06	-3.76	10.27	.2375	29.	0.903E-01
0.	15.39	-6.06	-3.76	10.27	.2250	31.	0.745E-01
0.	15.39	-6.06	-3.76	10.27	.2125	32.	0.614E-01
0.	15.39	-6.06	-3.76	10.27	.2000	34.	0.507E-01
0.	15.39	-6.06	-3.76	10.27	.1875	36.	0.418E-01
0.	15.39	-6.06	-3.76	10.27	.1750	37.	0.345E-01
0.	42.96	-10.60	-10.50	34.99	.1625	39.	0.268E-01

IN SUCT	A	B
39.	-11.08	5.43

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	42.96	-10.60	-3.88	10.45	.1500	43.	0.157E-01
0.	42.96	-10.60	-3.88	10.45	.1375	50.	0.916E-02
0.	42.96	-10.60	-3.88	10.45	.1250	57.	0.535E-02
0.	42.96	-10.60	-3.88	10.45	.1125	66.	0.313E-02

IN SUCT	A	B
63.	-121.23	16.32

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1000	67.	0.000E+00
0.	0.00	0.00	0.00	0.00	.0875	303.	0.000E+00

TABLE A.11 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
137.	3.73	20.00	7.00	20.000	.1070	6.16

IN SUCT	A	B
1.	-26.75	11.37

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4250	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.4125	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.4000	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3875	3.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	4.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	5.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	7.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	10.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	15.	0.000E+00

IN SUCT	A	B
20.	-4.49	4.40

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3125	20.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	21.	0.000E+00
0.	15.35	-5.83	-3.42	9.21	.2875	22.	0.242E+00
0.	15.35	-5.83	-3.42	9.21	.2750	24.	0.200E+00
0.	15.35	-5.83	-3.42	9.21	.2625	25.	0.165E+00
0.	15.35	-5.83	-3.42	9.21	.2500	27.	0.136E+00
0.	15.35	-5.83	-3.42	9.21	.2375	28.	0.113E+00
0.	15.35	-5.83	-3.42	9.21	.2250	30.	0.929E-01
0.	15.35	-5.83	-3.42	9.21	.2125	31.	0.767E-01
0.	15.35	-5.83	-3.42	9.21	.2000	33.	0.633E-01
0.	52.33	-13.03	-11.65	38.25	.1875	35.	0.400E-01
0.	52.33	-13.03	-11.65	38.25	.1750	37.	0.208E-01
0.	0.00	0.00	0.00	0.00	.1625	39.	0.000E+00

IN SUCT	A	B
39.	-17.32	6.42

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1500	46.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1375	57.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1250	70.	0.000E+00

IN SUCT	A	B
64.	-131.90	20.19

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1125	211.	0.000E+00

TABLE A.12

MADDOCK SANDY LOAM (CARVALLO) PLOT 4
CAMPBELL, BROOKS & COREY, K*THETA, SUCTION*THETA, K*SUCTION PARAMETERS

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
8.	2.46	40.00	3.67	40.00	.1650	3.39

IN SUCT	A	B
1.	-47.55	19.88

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4125	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.4000	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3875	4.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	8.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	14.	0.000E+00

IN SUCT	A	B
20.	-16.11	8.72

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3500	22.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	27.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	33.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	40.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	49.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	60.	0.000E+00
0.	57.56	-21.18	-3.57	9.98	.2750	73.	0.474E-02
0.	57.56	-21.18	-3.57	9.98	.2625	89.	0.231E-02
0.	57.56	-21.18	-3.57	9.98	.2500	109.	0.112E-02

IN SUCT	A	B
138.	-34.54	13.15

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	191.88	-54.49	-5.56	18.56	.2375	141.	0.134E-03
0.	0.00	0.00	0.00	0.00	.2250	217.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2125	334.	0.000E+00

TABLE A.12 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
22.	2.52	40.00	3.67	40.00	.1450	3.39

IN SUCT	A	B
1.	-62.41	25.00

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.4000	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3875	2.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3750	5.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	11.	0.000E+00

IN SUCT	A	B
20.	-14.97	8.29

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3500	21.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3375	25.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	31.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	37.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	45.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	54.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	65.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	78.	0.000E+00
0.	93.60	-28.72	-6.25	23.11	.2500	94.	0.489E-02
0.	93.60	-28.72	-6.25	23.11	.2375	114.	0.152E-02

IN SUCT	A	B
135.	-31.54	12.03

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	93.60	-28.72	-2.97	6.98	.2250	139.	0.471E-03
0.	0.00	0.00	0.00	0.00	.2125	206.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2000	306.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1875	453.	0.000E+00

TABLE A.12 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
37.	2.63	40.00	3.99	40.00	.1270	3.66

IN SUCT	A	B
1.	-80.97	30.52

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	3.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	9.	0.000E+00

IN SUCT	A	B
21.	-13.45	7.60

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3375	21.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	25.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	30.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	35.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	42.	0.000E+00
0.	81.65	-25.67	-6.07	20.47	.2750	49.	0.401E-01
0.	81.65	-25.67	-6.07	20.47	.2625	59.	0.145E-01
0.	81.65	-25.67	-6.07	20.47	.2500	69.	0.521E-02
0.	81.65	-25.67	-6.07	20.47	.2375	82.	0.188E-02
0.	77.27	-24.66	-5.74	19.00	.2250	97.	0.693E-03
0.	77.27	-24.66	-5.74	19.00	.2125	115.	0.264E-03
0.	77.27	-24.66	-5.74	19.00	.2000	136.	0.100E-03

IN SUCT	A	B
129.	-31.58	11.16

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	77.27	-24.66	-2.45	2.65	.1875	188.	0.382E-04
0.	0.00	0.00	0.00	0.00	.1750	280.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1625	415.	0.000E+00

TABLE A.12 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
53.	3.52	40.00	6.74	40.00	.1260	5.95

IN SUCT	A	B
1.	-80.97	30.44

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	3.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3500	8.	0.000E+00

IN SUCT	A	B
20.	-9.73	6.31

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3375	21.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3250	23.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3125	26.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3000	30.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2875	34.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2750	38.	0.000E+00
0.	0.00	0.00	0.00	0.00	.2625	43.	0.000E+00
0.	57.56	-17.61	-5.92	19.72	.2500	48.	0.400E-01
0.	57.56	-17.61	-5.92	19.72	.2375	55.	0.195E-01
0.	57.56	-17.61	-5.92	19.72	.2250	62.	0.948E-02
0.	57.56	-17.61	-5.92	19.72	.2125	70.	0.461E-02
0.	57.56	-17.61	-5.92	19.72	.2000	79.	0.225E-02
0.	95.94	-25.14	-9.86	37.08	.1875	89.	0.786E-03
0.	95.94	-25.14	-9.86	37.08	.1750	100.	0.237E-03
0.	0.00	0.00	0.00	0.00	.1625	113.	0.000E+00

IN SUCT	A	B
126.	-50.96	12.71

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.1500	159.	0.000E+00
0.	0.00	0.00	0.00	0.00	.1375	300.	0.000E+00

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APPENDIX A.12 CONT.

DPTH  N-CAMP  SI-CAMP  N-B&C  SI-B&C  RES MOIST   N-MUAL
 76.   3.40   20.00     6.65  20.00   .0960       5.87

IN SUCT  A         B
  1.    -73.07      28.02
DEX      AA         BB        N         C       THETA    SUC     CON
 0.       0.00       0.00     0.00      0.00    .3798     1.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3723     2.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3686     3.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3649     4.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3611     5.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3574     7.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3537     9.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3500    12.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3462    15.   0.000E+00

IN SUCT  A         B
 19.     -6.17      5.08
DEX      AA         BB        N         C       THETA    SUC     CON
 0.       0.00       0.00     0.00      0.00    .3425    19.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3228    22.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .3031    25.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .2835    28.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .2638    32.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .2441    36.   0.000E+00
 0.      35.42     -10.91    -5.74     18.25    .2244    40.   0.517E-01
 0.      35.42     -10.91    -5.74     18.25    .2047    45.   0.258E-01
 0.      35.42     -10.91    -5.74     18.25    .1850    51.   0.128E-01
 0.      35.42     -10.91    -5.74     18.25    .1654    58.   0.639E-02
 0.      76.75     -17.12   -12.44     46.07    .1457    65.   0.263E-02

IN SUCT  A         B
 76.    -34.40      8.66
DEX      AA         BB        N         C       THETA    SUC     CON
 0.       0.00       0.00     0.00      0.00    .1260    76.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .1117   124.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .1055   153.   0.000E+00

IN SUCT  A         B
166.   -176.98     23.43
DEX      AA         BB        N         C       THETA    SUC     CON
 0.       0.00       0.00     0.00      0.00    .1030   183.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .1002   296.   0.000E+00
 0.       0.00       0.00     0.00      0.00    .0975   480.   0.000E+00
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TABLE     A.12   CONT.

DPTH   N-CAMP   SI-CAMP   N-B&C   SI-B&C   RES MOIST   N-MUAL
106.    4.02    20.00      7.25   20.00    .0075         6.38

IN SUCT   A           B
   1.     -48.32       18.68

DEX      AA          BB          N          C        MOIST    SUC     CON
 0.        0.00        0.00      0.00       0.00     .3750     2.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .3625     3.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .3500     6.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .3375    11.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .3250    20.    0.000E+00

IN SUCT   A           B
  20.      -3.93        4.27

DEX      AA          BB          N          C        MOIST    SUC     CON
 0.        0.00        0.00      0.00       0.00     .3125    21.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .3000    22.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .2875    23.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .2750    24.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .2625    25.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .2500    27.    0.000E+00
 0.       24.50       -8.28     -6.23      18.34     .2375    28.    0.853E-01
 0.       24.50       -8.28     -6.23      18.34     .2250    30.    0.628E-01
 0.       24.50       -8.28     -6.23      18.34     .2125    31.    0.462E-01
 0.       24.50       -8.28     -6.23      18.34     .2000    33.    0.340E-01
 0.       24.50       -8.28     -6.23      18.34     .1875    34.    0.251E-01
 0.       24.50       -8.28     -6.23      18.34     .1750    36.    0.185E-01
 0.       24.50       -8.28     -6.23      18.34     .1625    38.    0.136E-01
 0.       24.50       -8.28     -6.23      18.34     .1500    40.    0.100E-01

IN SUCT   A           B
  39.     -10.72        5.26

DEX      AA          BB          N          C        MOIST    SUC     CON
 0.       52.33      -11.93     -4.88      13.75     .1375    44.    0.878E-02
 0.       52.33      -11.93     -4.88      13.75     .1250    50.    0.457E-02
 0.       52.33      -11.93     -4.88      13.75     .1125    58.    0.237E-02
 0.        0.00        0.00      0.00       0.00     .1000    66.    0.000E+00
 0.        0.00        0.00      0.00       0.00     .0875    75.    0.000E+00

IN SUCT   A           B
  80.    -229.07       23.74

DEX      AA          BB          N          C        MOIST    SUC     CON
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TABLE A.12 CONT.

DPTH	N-CAMP	SI-CAMP	N-B&C	SI-B&C	RES MOIST	N-MUAL
137.	4.33	20.00	7.14	20.00	.0570	6.28

IN SUCT	A	B
1.	-41.32	15.81

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.3750	1.	0.000E+00
0.	0.00	0.00	0.00	0.00	.3625	2.	0.000E+00
0.	11.41	-6.42	-0.28	-2.05	.3500	4.	0.883E-01
0.	11.41	-6.42	-0.28	-2.05	.3375	6.	0.766E-01
0.	11.41	-6.42	-0.28	-2.05	.3250	11.	0.664E-01
0.	11.41	-6.42	-0.28	-2.05	.3125	18.	0.576E-01

IN SUCT	A	B
20.	-3.69	4.14

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	11.41	-6.42	-3.09	6.38	.3000	21.	0.499E-01
0.	11.41	-6.42	-3.09	6.38	.2875	22.	0.433E-01
0.	11.41	-6.42	-3.09	6.38	.2750	23.	0.375E-01
0.	11.41	-6.42	-3.09	6.38	.2625	24.	0.326E-01
0.	11.41	-6.42	-3.09	6.38	.2500	25.	0.282E-01
0.	11.41	-6.42	-3.09	6.38	.2375	26.	0.245E-01
0.	11.41	-6.42	-3.09	6.38	.2250	27.	0.212E-01
0.	11.41	-6.42	-3.09	6.38	.2125	29.	0.184E-01
0.	11.41	-6.42	-3.09	6.38	.2000	30.	0.160E-01
0.	11.41	-6.42	-3.09	6.38	.1875	31.	0.138E-01
0.	11.41	-6.42	-3.09	6.38	.1750	33.	0.120E-01
0.	11.41	-6.42	-3.09	6.38	.1625	34.	0.104E-01
0.	19.68	-7.73	-5.33	14.35	.1500	36.	0.841E-02
0.	19.68	-7.73	-5.33	14.35	.1375	38.	0.658E-02
0.	19.68	-7.73	-5.33	14.35	.1250	40.	0.514E-02

IN SUCT	A	B
39.	-12.36	5.18

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	19.68	-7.73	-1.59	0.52	.1125	44.	0.402E-02
0.	0.00	0.00	0.00	0.00	.1000	52.	0.000E+00
0.	0.00	0.00	0.00	0.00	.0875	60.	0.000E+00
0.	0.00	0.00	0.00	0.00	.0750	70.	0.000E+00

IN SUCT	A	B
80.	-215.60	18.83

DEX	AA	BB	N	C	MOIST	SUC	CON
0.	0.00	0.00	0.00	0.00	.0625	212.	0.000E+00

APPENDIX B

θ vs. S Curve Fit Parameters for Brooks and Corey and van Genuchten Functions

APPENDIX B SYMBOLS AND ABBREVIATIONS

DEPTH	Depth of soil horizon (cm)
W-SAT	Saturated water content (θ_s)
W-INF	Inflection water content (θ_i)
S-AE	Air entry suction (Se)(REVISED ON MARCH 13, 2012)
S-INF	Inflection suction (Si)
S-SEG, W-SEG	Boundary suction and moisture for moisture characteristic expressed as two ln/ln functions, and without residual moisture. These parameters are nonessential and may be ignored by users.
MSD	Mean square deviation of predicted from true value of the dependent variable.
RES-MOIS	Residual moisture (θ_r) for Brooks and Corey function.
B&C EXP	Brooks and Corey exponent (b)
C&H M	Clapp and Hornberger function parameter Eq. [13].
C&H N	Clapp and Hornberger function parameter Eq. [13].
RES-MOI	Residual moisture for van Genuchten function.
ALPHA	van Genuchten a (Eq. [15].
Mualem M	van Genuchten m (Eq. [15]), Mualem theory.
N	van Genuchten n (Eq. [15]), Mualem theory.

TABLE B.1

SITE 1 LACUSTRINE MAT. (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.4140	.4040	.1239	27.	30.	15499.
22.	.3975	.3730	.1230	20.	27.	15499.
45.	.3675	.3225	.2060	20.	27.	70.
75.	.3670	.2980	.1365	14.	20.	140.
106.	.4090	.4035	.2365	10.	10.	40.
137.	.4370	.4310	.2300	10.	10.	55.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.015	.03300	-0.227	45821.58	0.9487
22.	0.002	.06800	-0.270	5378.28	0.8569
45.	0.038	.10700	-0.669	1425.00	0.7228
75.	0.013	.10200	-0.837	409.27	0.5521
106.	0.023	.12900	-0.568	53972.11	0.9728
137.	0.008	.20000	-1.116	52385.12	0.9724

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.11518	0.01278	1.61771	0.38184
22.	0.11487	0.02138	1.52934	0.34612
45.	0.13123	0.03168	2.17325	0.53986
75.	0.09279	0.04418	2.01455	0.50361
106.	0.00000	0.09292	1.29723	0.22912
137.	0.00000	0.10656	1.28894	0.22417

TABLE B.2

EMBDEN FLS SITE 2 (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	0.4090	0.3540	0.2230	28.4	35.	80.
22.	0.3925	0.3335	0.2195	24.2	35.	80.
45.	0.3660	0.3000	0.1815	24.8	35.	80.
75.	0.3605	0.2870	0.1065	29.8	35.	80.
106.	0.3645	0.2915	0.0880	30.5	35.	80.
137.	0.3780	0.3320	0.1270	32.2	35.	80.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.002	.14000	-1.101	1662.32	0.7090
22.	0.026	.07800	-0.565	1063.59	0.6308
45.	0.019	.08500	-0.780	772.75	0.5685
75.	0.007	.06200	-1.769	720.09	0.5577
106.	0.013	.05200	-1.943	760.11	0.5698
137.	0.007	.07400	-1.957	2196.07	0.7473

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.12078	0.02420	2.22064	0.54968
22.	0.11075	0.02620	2.00066	0.50017
45.	0.10548	0.02520	2.50447	0.60071
75.	0.00000	0.02663	2.20311	0.54610
106.	0.00000	0.02376	2.84711	0.64877
137.	0.00000	0.02290	2.16057	0.53716

TABLE B.3

SITE 3 EMRICK CL (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.4400	.4100	.1248	35.5	50.	15499.
22.	.4315	.3870	.1240	29.1	50.	15499.
45.	.4220	.3685	.1240	18.8	40.	15499.
75.	.3830	.3395	.1110	29.2	40.	15499.
106.	.3500	.3020	.0820	41.1	50.	15499.
137.	.3845	.3500	.0810	43.0	50.	15499.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.001	.00000	-0.206	6941.63	0.8262
22.	0.001	.00500	-0.203	2042.70	0.6595
45.	0.006	.00000	-0.180	480.86	0.2171
75.	0.002	.10100	-0.533	2354.83	0.7369
106.	0.033	.08100	-1.000	2235.94	0.6998
137.	0.014	.07800	-0.786	5431.57	0.8077

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.10965	0.01010	1.60481	0.37687
22.	0.09753	0.01437	1.46714	0.31840
45.	0.07918	0.02269	1.34576	0.25693
75.	0.11067	0.01740	1.89818	0.47318
106.	0.08652	0.01532	2.90075	0.65526
137.	0.07888	0.01128	2.52107	0.60334

TABLE B.4

SITE 4 LACUSTRINE MAT. (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.4390	.4280	.1279	36.5	40.	15499.
22.	.4320	.3885	.1190	28.1	40.	15499.
45.	.4040	.3280	.1080	32.2	50.	15499.
75.	.3840	.3495	.1090	29.5	40.	15499.
106.	.3430	.3255	.1840	22.0	30.	15499.
137.	.3140	.2845	.1910	23.8	30.	100.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.001	.08200	-0.339	58878.74	0.9478
22.	0.001	.08900	-0.386	2800.58	0.7575
45.	0.003	.10300	-0.662	918.11	0.5224
75.	0.005	.08500	-0.403	3742.38	0.7912
106.	0.003	.16300	-0.328	9634.31	0.8879
137.	0.002	.13300	-0.763	2936.93	0.7973

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.12642	0.01056	1089956	1.47356
22.	0.11330	0.01691	1.69761	0.41094
45.	0.10679	0.01776	1.98269	0.49563
75.	0.10781	0.01404	1.87435	0.46648
106.	0.18148	0.01891	1.66887	0.40079
137.	0.15877	0.02414	2.71268	0.63136

TABLE B.5

SITE 5 GARDENA L (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.4590	.4060	.3060	32.7	60.	260.
22.	.4375	.3720	.2995	26.2	60.	180.
45.	.4290	.3830	.2780	15.1	30.	200.
75.	.4375	.3655	.0970	30.6	80.	15499.
106.	.4510	.3955	.0830	76.0	140.	15499.
137.	.4635	.4155	.0860	119.6	160.	15499.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.007	.00000	-0.202	1586.38	0.5570
22.	0.002	.00000	-0.196	266.28	-.6548
45.	0.003	.00000	-0.165	712.16	0.4999
75.	0.014	.00000	-0.187	-150.30	4.0697
106.	0.013	.00000	-0.215	3223.27	0.5240
137.	0.001	.02100	-0.394	10549.08	0.7500

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.03257	0.01820	1.26405	0.20889
22.	0.04026	0.02371	1.26268	0.20803
45.	0.02324	0.03203	1.23367	0.18941
75.	0.00000	0.01489	1.26463	0.20926
106.	0.00000	0.00494	1.38271	0.27679
137.	0.07728	0.00376	1.93964	0.48444

TABLE B.6

SITE 7 HECLA FLS (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
15.	.3980	.3530	.2100	33.4	40.	120.
22.	.3680	.3265	.1910	33.5	40.	120.
45.	.3560	.2880	.1575	31.4	40.	100.
75.	.3575	.2935	.1460	32.7	40.	120.
106.	.3505	.2870	.1434	41.7	50.	140.
137.	.3565	.2985	.1220	42.8	50.	120.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
15.	0.007	.16500	-1.196	2795.34	0.7604
22.	0.004	.14500	-1.167	2802.72	0.7607
45.	0.006	.11400	-1.359	905.90	0.5778
75.	0.005	.11800	-1.542	1071.61	0.6125
106.	0.003	.11900	-1.757	1331.55	0.6116
137.	0.032	.08300	-1.535	1649.96	0.6510

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
15.	0.12784	0.02286	1.97836	0.49453
22.	0.12588	0.02135	2.22007	0.54956
45.	0.11370	0.02340	2.99181	0.66575
75.	0.09364	0.02398	2.41967	0.58672
106.	0.10254	0.01769	3.03067	0.67004
137.	0.09069	0.01692	4.37460	0.77141

TABLE B.7

SITE 8 HEIMDAL CL (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.4390	.4140	.1286	21.7	30.	15499.
22.	.4330	.4050	.1260	19.7	30.	15499.
45.	.4080	.3885	.1180	14.1	20.	15499.
75.	.3730	.3485	.1180	14.0	20.	15499.
106.	.3355	.3115	.0696	18.1	30.	15499.
137.	.3320	.2950	.0790	17.0	30.	15499.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.023	.00000	-0.180	6152.75	0.8574
22.	0.076	.00000	-0.159	4047.23	0.8207
45.	0.003	.00000	-0.139	5591.38	0.8774
75.	0.007	.20400	-0.438	3891.37	0.8561
106.	0.007	.00000	-0.147	2779.36	0.7776
137.	0.006	.00000	-0.207	951.74	0.6057

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.09404	0.01559	1.41657	0.29407
22.	0.00000	0.02004	1.23067	0.18744
45.	0.03932	0.02502	1.25779	0.20496
75.	0.02918	0.03166	1.21755	0.17868
106.	0.00000	0.01658	1.27919	0.21826
137.	0.04847	0.02566	1.36996	0.27005

TABLE B.8

SITE 9 HEIMDAL CL (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
15.	.4130	.3840	.1278	41.1	60.	15499.
22.	.4260	.3725	.1220	30.6	60.	15499.
45.	.4335	.3970	.1040	18.1	30.	15499.
75.	.4220	.3700	.1000	33.8	60.	15499.
106.	.3690	.3295	.0950	35.8	60.	15499.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
15.	0.036	.00000	-0.192	7389.15	0.8141
22.	0.005	.00000	-0.199	1053.48	0.4209
45.	0.009	.00000	-0.174	1994.91	0.7372
75.	0.030	.00000	-0.229	1524.58	0.5574
106.	0.017	.00000	-0.219	2457.29	0.6635

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
15.	0.09045	0.00817	1.44587	0.30837
22.	0.08364	0.01393	1.40715	0.28934
45.	0.06095	0.01835	1.38082	0.27580
75.	0.03180	0.01368	1.32573	0.24570
106.	0.05471	0.01176	1.39481	0.28305

TABLE B.9

SITE 10 LACUSTRINE MAT. (CASSEL)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.3660	.3630	.1053	38.6	40.	15499.
22.	.3580	.3495	.0970	27.3	30.	15499.
45.	.3515	.3285	.1705	17.8	20.	80.
75.	.3520	.3260	.0940	18.8	20.	80.
106.	.3710	.3575	.0915	19.5	20.	100.
137.	.4135	.3600	.1290	18.4	20.	60.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.002	.00000	-0.228	573806.81	0.9833
22.	0.006	.00000	-0.251	48058.29	0.9500
45.	0.001	.08700	-0.770	4246.25	0.8626
75.	0.006	.06600	-1.551	3477.30	0.8483
106.	0.008	.07500	-1.708	14770.75	0.9264
137.	0.028	.10500	-2.260	1116.17	0.7321

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.10128	0.00906	1.81608	0.44936
22.	0.09540	0.01285	1.81824	0.45002
45.	0.08179	0.03328	2.03596	0.50883
75.	0.07141	0.03163	4.10898	0.75663
106.	0.07732	0.02975	4.87992	0.79508
137.	0.00000	0.05287	1.75233	0.42933

TABLE B.10

PLOT 1 MADDOCK SL (CARVALLO)

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.4180	.3580	.2530	18.6	40.	140.
22.	.4180	.3705	.2480	10.3	20.	180.
37.	.4085	.3510	.1915	11.1	20.	300.
53.	.3945	.3165	.1775	11.6	20.	140.
76.	.3785	.3045	.1090	16.0	20.	140.
106.	.3865	.3335	.1050	17.7	20.	140.
137.	.4210	.3320	.1400	16.3	20.	60.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.002	.20100	-0.422	1171.22	0.6185
22.	0.006	.05300	-0.211	605.60	0.5957
37.	0.003	.08300	-0.332	511.15	0.5813
53.	0.005	.12100	-0.612	305.53	0.4712
76.	0.003	.09500	-1.372	430.58	0.5669
106.	0.005	.09700	-1.691	963.62	0.7115
137.	0.023	.11600	-1.667	375.55	0.5367

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.00000	0.05980	1.15278	0.13253
22.	0.00000	0.06857	1.19362	0.16221
37.	0.00000	0.07535	1.24344	0.19578
53.	0.00000	0.11256	1.26621	0.21024
76.	0.00000	0.09452	1.44284	0.30692
106.	0.00000	0.08546	1.48707	0.32754
137.	0.00000	0.15267	1.37615	0.27334

TABLE B.11

PLOT 2 MADDOCK SL (CARVALLO)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.4080	.3340	.2640	17.6	40.	140.
22.	.3995	.3585	.2435	12.0	20.	140.
37.	.3790	.2980	.2165	18.5	40.	140.
53.	.3650	.3060	.1685	12.6	20.	140.
76.	.3670	.3060	.1080	16.4	20.	140.
106.	.3825	.3280	.1005	17.8	20.	80.
137.	.4250	.3130	.1290	15.5	20.	60.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.002	.19400	-0.517	694.88	0.5012
22.	0.006	.10400	-0.291	1153.32	0.7284
37.	0.001	.13000	-0.511	410.09	0.3299
53.	0.005	.10200	-0.548	496.12	0.5890
76.	0.003	.09200	-1.280	611.21	0.6369
106.	0.017	.08500	-1.777	893.05	0.7003
137.	0.021	.10700	-1.699	227.32	0.4026

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.00000	0.08223	1.19916	0.16609
22.	0.00000	0.06453	1.23779	0.19211
37.	0.00000	0.05393	1.30203	0.23197
53.	0.00000	0.08193	1.39261	0.28193
76.	0.00000	0.08278	1.53723	0.34948
106.	0.00000	0.07705	1.65496	0.39576
137.	0.00000	0.16980	1.85386	0.46059

TABLE B.12

PLOT 4 MADDOCK SL (CARVALLO)

CURVE INFLECTION POINTS

DEPTH	W-SAT	W-INF	W-SEG	S-AE	S-INF	S-SEG
8.	.4180	.3150	.2380	16.5	40.	140.
22.	.4005	.3105	.2260	18.1	40.	140.
37.	.3770	.2960	.1995	20.8	40.	140.
53.	.3760	.3390	.1545	36.6	40.	140.
76.	.3835	.3425	.1155	18.0	20.	100.
106.	.3865	.3245	.0845	17.7	20.	80.
137.	.3825	.3100	.0670	17.5	20.	80.

BROOKS AND CORY PARAMETERS

DEPTH	MSD	RES-MOIS	B&C EXP	C&H M	C&H N
8.	0.000	.17500	-0.621	311.68	0.2328
22.	0.000	.14000	-0.533	361.52	0.2829
37.	0.001	.10100	-0.531	420.13	0.3420
53.	0.007	.13200	-1.828	3884.14	0.7969
76.	0.010	.09300	-1.439	1604.22	0.7765
106.	0.043	.07400	-1.849	696.90	0.6607
137.	0.040	.05700	-1.879	487.42	0.5940

CLOSED FORM EQUATIONS - VAN GENUCHTEN

MUELEM THEORY PARAMETERS

DEPTH	RES-MOI	ALPHA	N	MUELEM-M
8.	0.00000	0.09775	1.19916	0.16609
22.	0.00000	0.06385	1.23779	0.19211
37.	0.00000	0.04621	1.30203	0.23197
53.	0.00000	0.05080	1.39261	0.28193
76.	0.00000	0.06029	1.53723	0.34948
106.	0.00000	0.07103	1.65496	0.39576
137.	0.00000	0.06161	1.85386	0.46059

APPENDIX C

Soil Particle Indices

TABLE C.1

LACUSTRINE MATERIAL SITE 1 (CASSEL)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON)					
	2.	50.	2000.	SAND	SILT	CLAY
8.	23.0	19.0	58.0	58.0	19.0	23.0
22.	23.5	19.5	57.0	57.0	19.5	23.5
45.	25.0	16.0	59.0	59.0	16.0	25.0
75.	20.0	7.0	73.0	73.0	7.0	20.0
106.	19.0	7.0	74.0	74.0	7.0	19.0
137.	18.5	6.5	75.0	75.0	6.5	18.5

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	3.053	0.1035	18.0	0.0057	0.223	1.18	0.00
22.	2.923	0.0982	18.2	0.0054	0.218	1.31	0.00
45.	3.688	0.1006	19.4	0.0052	0.223	1.42	0.00
75.	10.429	0.1981	16.5	0.0120	0.332	1.38	0.00
106.	10.571	0.2123	15.7	0.0135	0.342	1.30	0.00
137.	11.538	0.2239	15.3	0.0146	0.353	1.24	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE GOSH	ln K/ ln S SLOPE BLOEMEN	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA	
			b'	a'
8.	2.337	1.714	-0.6923	1.6820
22.	2.375	1.707	-0.6751	1.6530
45.	2.131	1.714	-0.7252	1.7110
75.	1.377	1.875	-0.9779	2.1170
106.	1.385	1.890	-0.9919	2.1460
137.	1.337	1.907	-1.0090	2.1750

TABLE C.2

EMBDEN FINE SANDY LOAM SITE 2 (CASSEL)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON) 2.	50.	2000.	SAND	SILT	CLAY
8.	8.0	17.0	75.0	75.0	17.0	8.0
22.	9.0	19.0	72.0	72.0	19.0	9.0
45.	12.0	25.5	62.5	62.5	25.5	12.0
75.	10.5	23.0	66.5	66.5	23.0	10.5
106.	4.0	11.0	85.0	85.0	11.0	4.0
137.	1.0	6.0	93.0	93.0	6.0	1.0

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	4.412	0.3152	8.8	0.0357	0.372	1.33	0.00
22.	3.789	0.2733	9.7	0.0283	0.347	1.39	0.00
45.	2.451	0.1748	11.8	0.0148	0.291	1.44	0.00
75.	2.891	0.2126	10.8	0.0196	0.313	1.46	0.00
106.	7.727	0.5185	5.6	0.0933	0.502	1.47	0.00
137.	15.500	0.7671	3.0	0.2557	0.714	1.46	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE GOSH	ln K/ ln S SLOPE BLOEMEN	JAYNES & TYLER K-PARAMETERS CM/DAY-KPA b'	a'
8.	2.127	1.936	-0.9429	2.1750
22.	2.251	1.898	-0.8883	2.0880
45.	2.649	1.814	-0.7143	1.8125
75.	2.492	1.847	-0.7861	1.9285
106.	1.735	2.137	-1.1207	2.4650
137.	1.350	2.484	-1.2642	2.6970

TABLE C.3

EMRICK CLAY LOAM SITE 3 (CASSEL)

DEPTH (CM)			PARTICLE SIZE CLASSES (MICRON)			
2.	50.	2000.	SAND	SILT	CLAY	
8.	31.0	27.0	42.0	42.0	27.0	31.0
22.	32.0	30.0	37.0	37.0	30.0	32.0
45.	34.0	39.0	26.0	26.0	39.0	34.0
75.	31.5	36.5	32.0	32.0	36.5	31.5
106.	25.5	20.5	54.0	54.0	20.5	25.5
137.	25.5	18.5	56.0	56.0	18.5	25.5

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	1.556	0.0443	19.0	0.0023	0.166	1.30	0.00
22.	1.233	0.0370	18.1	0.0020	0.162	1.30	0.00
45.	0.667	0.0232	14.7	0.0016	0.175	1.31	0.00
75.	0.877	0.0302	15.9	0.0019	0.176	1.43	0.00
106.	2.634	0.0824	19.0	0.0043	0.203	1.53	0.00
137.	3.027	0.0887	19.3	0.0046	0.209	1.51	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE	ln K/ ln S SLOPE	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA	
	GOSH	BLOEMEN	K-SLOPE	K-INT
8.	3.013	1.632	-0.4179	1.2180
22.	3.311	1.626	-0.3290	1.0730
45.	4.268	1.645	-0.1183	0.7540
75.	3.829	1.646	-0.2181	0.9280
106.	2.460	1.685	-0.6269	1.5660
137.	2.317	1.694	-0.6674	1.6240

TABLE C.4

LACUSTRINE MATERIAL SITE 4 (CASSEL)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON)					
	2.	50.	2000.	SAND	SILT	CLAY
8.	23.0	23.0	54.0	54.0	23.0	23.0
22.	23.0	23.0	54.0	54.0	23.0	23.0
45.	22.0	19.0	59.0	59.0	19.0	22.0
75.	26.5	24.5	49.0	49.0	24.5	26.5
106.	39.5	29.5	31.0	31.0	29.5	39.5
137.	36.5	18.5	45.0	45.0	18.5	36.5

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	2.348	0.0894	17.5	0.0051	0.212	1.23	0.00
22.	2.348	0.0894	17.5	0.0051	0.212	1.21	0.00
45.	3.105	0.1110	17.5	0.0063	0.230	1.29	0.00
75.	2.000	0.0664	18.6	0.0036	0.189	1.39	0.00
106.	1.051	0.0224	18.0	0.0012	0.136	1.42	0.00
137.	2.432	0.0414	22.6	0.0018	0.152	1.50	0.00

DEPTH (CM)	ln MOIS/ LN S SLOPE	ln K/ ln S SLOPE	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA	
	GOSH	BLOEMEN	K-SLOPE	K-INT
8.	2.609	1.698	-0.6111	1.5660
22.	2.609	1.698	-0.6111	1.5660
45.	2.331	1.724	-0.7063	1.7110
75.	2.754	1.665	-0.5317	1.4210
106.	3.471	1.589	-0.2482	0.8990
137.	2.397	1.612	-0.5134	1.3050

TABLE C.5

GARDENA LOAM SITE 5 (CASSEL)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRONS)					
	2.	50.	2000.	SAND	SILT	CLAY
8.	16.0	38.0	46.0	46.0	38.0	16.0
22.	16.5	39.0	44.5	44.5	39.0	16.5
45.	21.0	43.0	36.0	36.0	43.0	21.0
75.	18.0	39.0	43.0	43.0	39.0	18.0
106.	8.0	43.5	48.5	48.5	43.5	8.0
137.	5.0	55.0	40.0	40.0	55.0	5.0

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	1.211	0.0837	12.9	0.0065	0.262	1.08	0.00
22.	1.141	0.0779	12.9	0.0060	0.261	1.16	0.00
45.	0.837	0.0492	13.3	0.0037	0.244	1.28	0.00
75.	1.103	0.0702	13.4	0.0052	0.250	1.31	0.00
106.	1.115	0.1190	9.5	0.0125	0.368	1.36	0.00
137.	0.727	0.0961	7.8	0.0123	0.505	1.41	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE GOSH	ln K/ ln S SLOPE BLOEMEN	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA	
			K-SLOPE	K-INT
8.	3.470	1.771	-0.4046	1.3340
22.	3.549	1.769	-0.3773	1.2905
45.	3.983	1.744	-0.2331	1.0440
75.	3.588	1.753	-0.3563	1.2470
106.	3.613	1.929	-0.4049	1.4065
137.	4.256	2.142	-0.2135	1.1600

TABLE C.6

HECLA FINE SANDY LOAM SITE 7 (CASSEL)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON)					
	2.	50.	2000.	SAND	SILT	CLAY
8.	8.0	11.0	81.0	81.0	11.0	8.0
22.	8.0	11.5	80.5	80.5	11.5	8.0
45.	7.0	9.5	83.5	83.5	9.5	7.0
75.	6.0	6.0	88.0	88.0	6.0	6.0
106.	4.5	4.5	91.0	91.0	4.5	4.5
137.	3.0	4.0	93.0	93.0	4.0	3.0

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	7.364	0.3929	8.2	0.0481	0.429	1.47	0.00
22.	7.000	0.3858	8.2	0.0469	0.422	1.47	0.00
45.	8.789	0.4450	7.3	0.0610	0.466	1.44	0.00
75.	14.667	0.5424	6.1	0.0885	0.552	1.42	0.00
106.	20.222	0.6360	4.9	0.1291	0.632	1.45	0.00
137.	23.250	0.7187	3.9	0.1841	0.702	1.46	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE GOSH	ln K/ ln S SLOPE BLOEMEN	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA	
			K-SLOPE	K-INT
8.	1.744	2.023	-1.0647	2.3490
22.	1.779	2.012	-1.0545	2.3345
45.	1.635	2.081	-1.1091	2.4215
75.	1.347	2.217	-1.1942	2.5520
106.	1.201	2.347	-1.2456	2.6390
137.	1.150	2.463	-1.2768	2.6970

TABLE C.7

HEIMDAL LOAM SITE 8 (CASSEL)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON)					
	2.	50.	2000.	SAND	SILT	CLAY
8.	31.0	37.0	32.0	32.0	37.0	31.0
33.	32.5	40.0	27.5	27.5	40.0	32.5
45.	38.0	40.0	22.0	22.0	40.0	38.0
75.	38.0	36.0	26.0	26.0	36.0	38.0
106.	29.0	29.0	42.0	42.0	29.0	38.0
137.	24.0	21.0	55.0	55.0	21.0	29.0

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	0.865	0.0307	15.7	0.0020	0.179	1.34	0.00
33.	0.688	0.0248	14.5	0.0017	0.183	1.34	0.00
45.	0.550	0.0169	13.6	0.0012	0.168	1.40	0.00
75.	0.722	0.0196	15.4	0.0013	0.154	1.52	0.00
106.	1.448	0.0473	18.1	0.0026	0.175	1.66	0.00
137.	2.619	0.0898	18.3	0.0049	0.211	1.65	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE GOSH	ln K/ ln S SLOPE BLOEMEN	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA K-SLOPE	K-INT
8.	3.855	1.651	-0.2149	0.9280
33.	4.228	1.656	-0.1330	0.7975
45.	4.599	1.634	-0.0560	0.6380
75.	4.097	1.614	-0.1372	0.7540
106.	3.126	1.645	-0.4053	1.2180
137.	2.483	1.696	-0.6377	1.5950

TABLE C.8

HEIMDAL LOAM SITE 9 (CASSEL)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON)					
	2.	50.	2000.	SAND	SILT	CLAY
8.	30.0	27.0	43.0	43.0	27.0	30.0
22.	31.0	32.0	37.0	37.0	32.0	31.0
45.	32.5	36.5	31.0	31.0	36.5	32.5
75.	35.5	42.0	23.0	23.0	42.0	35.5
106.	30.0	28.0	42.5	42.5	28.0	30.0

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	1.593	0.0475	18.9	0.0025	0.171	1.42	0.00
22.	1.156	0.0369	17.4	0.0021	0.169	1.39	0.00
45.	0.849	0.0282	15.8	0.0018	0.173	1.35	0.00
75.	0.548	0.0187	13.3	0.0014	0.182	1.41	0.00
106.	1.518	0.0458	18.6	0.0025	0.171	1.58	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE GOSH	ln K/ ln S SLOPE BLOEMEN	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA	
			K-SLOPE	K-INT
8.	2.993	2.243	-0.4319	1.2470
22.	3.416	2.237	-0.3164	1.0730
45.	3.872	2.255	-0.2041	0.8990
75.	4.626	2.304	-0.0574	0.6670
106.	3.057	2.247	-0.4186	1.2325

TABLE C.9

LACUSTRINE MATERIAL SITE 10 CASSEL

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON)					
	2.	50.	2000.	SAND	SILT	CLAY
8.	9.0	17.0	64.0	64.0	17.0	9.0
22.	12.0	16.0	67.0	67.0	16.0	12.0
45.	14.0	10.0	76.0	76.0	10.0	14.0
75.	12.0	4.0	84.0	84.0	4.0	12.0
106.	11.0	2.0	87.0	87.0	2.0	11.0
137.	11.0	1.0	88.0	88.0	1.0	11.0

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	3.765	0.2934	9.5	0.0310	0.335	1.30	0.00
22.	4.188	0.2475	11.4	0.0218	0.318	1.39	0.00
45.	7.600	0.2689	12.3	0.0219	0.361	1.48	0.00
75.	21.000	0.3851	10.1	0.0381	0.478	1.51	0.00
106.	43.500	0.4443	9.1	0.0490	0.542	1.47	0.00
137.	88.000	0.4609	8.9	0.0517	0.569	1.34	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE GOSH	ln K/ ln S SLOPE BLOEMEN	JAYNES AND TYLER K PARAMETERS K-SLOPE	K-INT
8.	2.251	1.880	-0.7889	1.8560
22.	2.142	1.854	-0.8372	1.9430
45.	1.672	1.919	-1.0010	2.2040
75.	1.103	2.099	-1.1508	2.4360
106.	0.796	2.201	-1.2054	2.5230
137.	0.379	2.244	-1.2257	2.5520

TABLE C.10

MADDOCK SANDY LOAM PLOT 1 (CARVALLO)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON) 2.	50.	2000.	SAND	SILT	CLAY
8.	12.2	22.7	65.1	65.1	22.7	12.2
22.	14.8	23.2	62.0	62.0	23.2	14.8
37.	16.4	19.8	63.8	63.8	19.8	16.4
53.	12.6	3.6	83.8	83.8	3.6	12.6
75.	4.0	3.2	92.8	92.8	3.2	4.0
106.	4.9	5.0	90.1	90.1	5.0	4.9
137.	3.4	2.4	94.2	94.2	2.4	3.4

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	2.868	0.1911	11.8	0.0161	0.296	1.41	0.00
22.	2.672	0.1566	13.4	0.0117	0.271	1.36	0.00
37.	3.222	0.1589	14.3	0.0111	0.268	1.44	0.00
53.	23.278	0.3749	10.5	0.0357	0.476	1.53	0.00
75.	29.000	0.6906	4.4	0.1568	0.696	1.51	0.00
106.	18.020	0.6073	5.3	0.1155	0.605	1.44	0.00
137.	39.250	0.7414	3.9	0.1900	0.757	1.32	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE GOSH	ln K/ ln S SLOPE BLOEMEN	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA K-SLOPE	K-INT
8.	2.490	1.821	-0.7684	1.8879
22.	2.543	1.784	-0.7218	1.7980
37.	2.348	1.780	-0.7685	1.8502
53.	1.043	2.096	-1.1505	2.4302
75.	1.050	2.453	-1.2790	2.6912
106.	1.252	2.303	-1.2299	2.6129
137.	0.940	2.556	-1.3037	2.7318

TABLE C.11

MADDOCK SANDY LOAM PLOT 2 (CARVALLO)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON) 2.	50.	2000.	SAND	SILT	CLAY
8.	12.1	19.3	68.0	68.0	19.3	12.1
22.	15.5	22.0	62.5	62.5	22.0	15.5
37.	15.0	19.4	65.6	65.6	19.4	15.0
53.	9.2	6.8	84.0	84.0	6.8	9.2
75.	5.2	3.5	91.3	91.3	3.5	5.2
106.	3.9	3.7	92.4	92.4	3.7	3.9
137.	5.6	7.7	86.7	86.7	7.7	5.6

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	3.523	0.2180	11.6	0.0187	0.309	1.37	0.00
22.	2.841	0.1560	13.8	0.0113	0.268	1.39	0.00
37.	3.381	0.1776	13.5	0.0132	0.282	1.49	0.00
53.	12.353	0.4219	8.4	0.0500	0.472	1.51	0.00
75.	26.086	0.6285	5.2	0.1203	0.643	1.47	0.00
106.	24.973	0.6828	4.4	0.1545	0.680	1.42	0.00
137.	11.260	0.5239	6.1	0.0856	0.524	1.26	0.00

DEPTH (CM)	ln MOIS/ ln S SUCTION GOSH	ln K/ ln S SUCTION BLOEMEN	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA K-SLOPE	K-INT
8.	2.296	1.841	-0.8304	1.9720
22.	2.477	1.780	-0.7364	1.8125
37.	2.314	1.800	-0.7962	1.9024
53.	1.414	2.090	-1.1332	2.4360
75.	1.083	2.365	-1.2561	2.6477
106.	1.112	2.426	-1.2703	2.6796
137.	1.495	2.172	-1.1653	2.5143

TABLE C.12

MADDOCK SANDY LOAM PLOT 4 (CARVALLO)

DEPTH (CM)	PARTICLE SIZE CLASSES (MICRON)					
	2.	50.	2000.	SAND	SILT	CLAY
8.	11.2	22.2	66.6	66.6	22.2	11.2
22.	14.4	22.8	62.8	62.8	22.8	14.4
37.	13.7	16.5	69.8	69.8	16.5	13.7
53.	7.4	4.0	88.6	88.6	4.0	7.4
75.	3.4	3.0	93.6	93.6	3.0	3.4
106.	2.8	2.2	95.0	95.0	2.2	2.8
137.	2.5	2.7	94.8	94.8	2.7	2.5

DEPTH (CM)	SA/SI	GMEAN	GDEV	Z	F-INDEX	BD	OM
8.	3.000	0.2086	11.2	0.0186	0.308	1.34	0.00
22.	2.754	0.1634	13.1	0.0125	0.275	1.42	0.00
37.	4.230	0.2163	12.5	0.0173	0.309	1.51	0.00
53.	22.150	0.5298	6.8	0.0782	0.569	1.46	0.00
75.	31.200	0.7252	4.0	0.1815	0.728	1.50	0.00
106.	43.182	0.7786	3.5	0.2227	0.798	1.50	0.00
137.	35.111	0.7805	3.4	0.2301	0.786	1.46	0.00

DEPTH (CM)	ln MOIS/ ln S SLOPE	ln K/ ln S SLOPE	JAYNES AND TYLER K PARAMETERS CM/DAY-KPA	
	GOSH	BLOEMEN	K-SLOPE	K-INT
8.	2.452	1.839	-0.7925	1.9314
22.	2.516	1.790	-0.7356	1.8212
37.	2.125	1.841	-0.8732	2.0242
53.	1.134	2.244	-1.2152	2.5694
75.	1.026	2.507	-1.2915	2.7144
106.	0.912	2.627	-1.3161	2.7550
137.	0.988	2.606	-1.3102	2.7492

APPENDIX D

Fortran Computer Programs for Calculation of θ/S Function Parameters and Grain Indices

APPENDIX D.1 PROGRAM RES5

Program (RES5) calculated curve parameters for Brooks and Corey and Campbell for θ vs. S. FORTRAN code uses some of the options of FORTRAN 77.

Brooks and Corey:

Brooks and Corey (residual moisture) *r* and (exponent) b are calculated for

$$(\theta - \theta r)/(\theta i - \theta r) = (S/Si)^{-b} \qquad [D.1]$$

where matching moisture, θi, and suction, Si, are the θ vs. S curve inflection values (report Figure 1). Program may be easily modified to provide parameters for b and θr matched through air entry suction and θs, or through the geometric mean effective saturation and corresponding geometric mean suction values. Modifications to change curve matching values are documented within the program code. 'θr' is determined by calculating b using ln/ln regression, with progressively larger values for θr (beginning with 0) until sum of squares deviation of predicted dependent values from true values are minimized, as suggested by Mualem (21).

From inflection to saturation, curves are fitted using the parabolic function proposed by Clapp and Hornberger (10).

$$S = -M\ (\theta/\theta s - N)(\theta/\theta s - 1) \qquad [D.1.2]$$

This function is matched from curve inflection to saturation.

Campbell:

Campbell exponent, bc, is calculated for

$$(\theta/\theta i)^{bc} = (S/Si) \qquad [D.3]$$

Residual saturation is not used with this function. Because poor fits sometimes result, when residual moisture is ignored, the program allows for two sets of curve parameters to be calculated. By splitting the curve into two ln S vs. ln θ segments, fits can be improved. This is done by entering the boundary moisture (W2) and suction (S2) value at the intersection of two linear segments on a ln θ vs. ln S plot. Calculation of K functions based on such segmented curves is of questionable validity, however. Where only one curve is desired, the values of the highest data suction (and lowest moisture) are entered for W2 and S2. On the example given, only one curve is calculated.

Campbell function curves were matched through the inflection mean moisture and suction values for each curve segment. Data used for first (nearest saturation) curve includes data to inflection suction. Program may be modified, as documented in the code, to include data to air entry suction.

Input parameters (saturation and inflection moistures and suctions) outlined below must be obtained from examination of graphs of ln S vs. θ.

INPUT DEFINITIONS

Variable	Definition
L, N	No. of soil units, and no. of θ vs. S data pairs for each unit.
DPTH(I)	Depth (or ID No.) corresponding to each soil sample. Must be numeric.
PS(I), P1(I), P2(I)	Air entry suction, curve inflection suction, and 'curve break' suctions respectively. Where a single Campbell curve function is desired, P2 is the highest suction of the data set.
WS(I), W1(I), W2(I)	Saturated moisture, curve inflection moisture, and 'curve break' moisture respectively. Where a single Campbell curve function is desired, W2 is the lowest moisture of the data set.
THETA(I,K)	Soil moisture data for each soil unit (I) from highest to lowest.
SUC(I,K)	Soil water suction data for each soil unit (I) from lowest to highest (corresponding to THETA values).

INPUT DATA FORMAT

```
TITLE
L,N
DPTH(I),PS(I),P1(I),P2(I),WS(I),W1(I),W2(I)
THETA(1,1),THETA(1,2)...THETA(1,N)
SUC(1,1),SUC(1,2)...SUC(1,N)

DPTH(I),PS(I),P1(I),P2(I),WS(I),W1(I),W2(I)
THETA(2,1),THETA(2,2)...THETA(2,N)
SUC(2,1),SUC(2,2)...SUC(2,N)

DPTH(I),PS(I),P1(I),P2(I),WS(I),W1(I),W2(I)
THETA(L,1),THETA(L,2)...THETA(L,N)
SUC(L,1),SUC(L,2)...SUC(L,N)
```

EXAMPLE INPUT FILE

```
      SITE 1      LACUSTRINE MAT.     (CASSEL)
    6,18,
    8,20,30,15499,.414,.404,.1239
    .414,.414,.413,.406,.404,.390,.364,.347,.336,.334,.321,.308,
    .297,.289,.283,.277,.212,.1239

4,15,20,27,30,40,55,70,80,85,100,120,140,160,180,200,500,15499,
    22,10,27,15499,.3975,.373,.123

.3975,.397,.383,.373,.3655,.347,.3225,.306,.298,.296,.2875,.269,
        ,.2615,.2545,.249,.2435,.207,.123

4,10,20,27,30,40,55,70,80,85,100,120,140,160,180,200,500,15499,
```

NOTE: [for use of program res5]

The values of Brooks and Corey parameters (Particularly residual moisture) are often dependent on the range of data used to calculate them. The residual moisture value resulting in best fit for wet range data is greater than 15 or even 5 bar moisture on many sandy soils. In fact, it may be greater than the moisture corresponding to 500 cm suction on some very coarse soils. In program RES5, the iterative least squares procedure is determined from 0 residual moisture to the moisture corresponding to the highest data suction (lowest potential). If the lowest data moisture is below the best fit residual moisture, poor wet range representatioin will result for the calculated function parameters. This will usually occur as a tightening of the curve, underestimating the concavity of the true moisture characteristic function.

To avoid this problem, best results are most often achieved for data sets to 1,000 to 2,000 maximum suctions. Sometimes lower maximum suctions are required. Best wet range fit can be achieved by observing the mean square deviation (MSD) output. If it is large (greater than about .01 for the data we used), curve fits can often be improved by shaving the driest data points from the data set. Specific MSD values will also vary with the random variability of the data set used.

```
C      (WM SCHUH :  North Dakota State Water Commission: 1984)
C          RES5  CALCULATES THE CURVE SLOPE PARAMETERS FOR CAMPBELL
C      AND BROOKS AND COREY UNSATURATED K METHODS.  BOTH BROOKS
C      AND COREY AND CAMPBELL METHODS ARE FITTED FROM CURVE INFLECTION
C      VALUE.
C          SATURATED SIDE OF INFLECTION POINT USES CLAPP AND HORNBERGER
C      (WRR;I978) PARABOLIC FUNCTION TO DESCRIBE THETA VS S.
C                 S = -M (W-N) (W-1)
C      WHERE W = THETA/THETA(SAT). VALUE CLOSEST TO SATURATION
C      ABOVE AIR ENTRY VALUE IS USED TO REPRESENT THETA(SAT).
C          BROOKS AND COREY IS A SINGLE VALUED FUNCTION FOR
C      THE ENTIRE CURVE LENGTH ABOVE INFLECTION POINT.  RESIDUAL
C      SATURATION IS DETERMINED USING A MOVING LEAST SQUARES
C      PROCEDURE DESCRIBED BY MUALEM (WRR;1976) .  CURVE IS MATCHED
C      THROUGH CURVE INFLECTION.  MAY BE MODIFIED TO FORCE CURVE THROUGH
C      AIR ENTRY VALUE, OR THROUGH GEOMETRIC MEAN DATA VALUES.
C          CAMPBELL FUNCTIONS ARE SEGMENTED , WHERE LN/LN
C      FIT IS POOR OVER ENTIRE CURVE LENGTH.  TWO SLOPES ARE
C      PRESENTED-1ST MATCHED AT THETA AIR ENT AND 2ND AT THETA SEG.
C      APPROPRIATE C&H FUNCTIONS ARE USED BETWEEN INFL AND SAT.
C      LEAST SQUARES ARE REFERENCED
C      THROUGH INFLECTION VALUES.
C
C      INPUT:  L = NUMBER OF SOIL UNITS
C              N = NUMBER OF THETA/S UNITS PER SOIL HORIZON
C              PS,P1,= AIR ENTRY , INFLECTION, AND CURVE BREAK SUCTIONS
C               P2     RESPECTIVELY: FROM PERCENT SAT. VS LN SUCTION
C                      CURVE.
C              WS,W1,W2 = SATURATED,INFLECTION,AND CURVE BREAK MOISTURES.
C                         CORRESPOND TO P1 AND P2.
C              THETA    = MOISTURE FROM CHARACTERISTIC CURVE-WET TO DRY
C              SUC      = SUCTION FROM CHARACTERISTIC CURVE-WET TO DRY
C
C      OUTPUT: -SATURATED,INFLECTION, AND CURVE BREAK MOISTURES
C              -INFLECTION AND CURVE BREAK SUCTIONS
C              - BROOKS AND COREY - MEAN  SQUARE DEVIATION ,
C                    RESIDUAL SATURATION, EXPONENT, AND C&H PARAMETERS.
C              - CAMPBELL - EXPONENTS FOR TWO CURVE RANGES (ABOVE AND
C                BELOW BREAKING POINT) AND C&H PARAMETERS.
C
       character*15  infile,outfile
       CHARACTER*80        HEAD
       DIMENSION DPTH(10),THETA(10,40),SUC(10,40),
      X B(0:10,200),X(0:10,200),D(0:10,200),RES(10),BCB(10),
      X A(10),C(10),DD(10),P1(10),P2(10),W1(10),W2(10),CB1(10),
      X CB2(10),WS(10),BA(10),BC(10),CA(10),CC(10),PS(10)
C
C      The following lines establish screen prompts for reading
C      input and output files on an IBM PC using IBM PROFESSIONAL
C      FORTRAN and must be modified for batch environment.
C
```

```
            Write (*,*) 'enter input file '
            read (*,'(a15)')  infile
            open (15,file=infile)
            Write (*,*) 'enter output file'
            read (*,'(a15)')  outfile
            open (16,file=outfile)
C
C
            READ (15,'(A80)')   HEAD
            WRITE(16,'(A80)')   HEAD
            READ (15,*) L,N
         DO 100 I=1,L
            READ (15,*) DPTH(I),PS(I),P1(I),P2(I),WS(I),W1(I),W2(I)
            READ (15,*) (THETA(I,K),K=1,N)
            READ (15,*) (SUC(I,K),K=1,N)
100      CONTINUE
C
         DO 600 I=1,L

            M=THETA(I,N)/.001-1
          DO 500 J=0,M
             X(I,J)=.001*J
             SUM1=0.00
             SUM2=0.00
             SUM3=0.00
             SUM4=0.00
             SUMC1=0.0
             SUMC2=0.0
             SS=0.0
             WW=0.0
             NN=0.0
C       determine mean values
C
           DO 400 K=1,N
C
C       Following line eliminates data below inflection suction.
C       For air entry value match, replace P1(I) with PS(I).
C
C
             IF (SUC(I,K) .LT. P1(I)) GO TO 400
                SS = SS+ALOG(SUC(I,K))
                WW = WW + ALOG (THETA(I,K)-X(I,J))
                NN = NN + 1
400          CONTINUE
                SS=EXP(SS/NN)
                WW = EXP(WW/NN)
C
C    End mean determinations
C
           DO 450 K=1,N
```

```
C
C   Next line screens data.  As written, eliminates all
C   data of lower suction (higher moisture) than the curve
C   inflection value (P1).  Can be modified to eliminate
C   suctions lower than air entry suction (PS) by substituting
C   PS(I) for P1(I).
C
             IF (SUC(I,K) .LT. P1(I)) GO TO 450
C
C      BROOKS AND COREY ROUTINE PARAMETERS- wet range bias
C   These least square determinations are forced through
C   curve inflection points (W1, P1).  Can be modified
C   to force curve through the mean values (WW, SS) - ( standard
C   regression equation , or through air entry value (PS, WS) by
C   making substitutions noted.
C
C   Substitute WW (force through mean) or WS(I) (force through
C   air entry value) for (W1(I)-X(I,J)) in right hand term.
C
             T=(THETA(I,K)-X(I,J))/(W1(I) - X(I,J))
C
             TL=ALOG(T)
             SQTL=TL**2
C
C   Substitute SS (force through mean) or PS(I) (force through
C   air entry value) for P1(I) in right hand term.
C
             S=SUC(I,K)/P1(I)
C
C
             SL=ALOG(S)
             SQSL=SL**2
             DEM=TL*SL
             SUM1=SQTL+SUM1
             SUM2=DEM+SUM2
             SUM3=TL+SUM3
             SUM4=SQSL+SUM4

450        CONTINUE
              B(I,J)=SUM1/SUM2
              D(I,J)=SUM4-(2/B(I,J))*SUM2+SUM1/(B(I,J)**2)
              IF ((D(I,J) .GT. D(I,J-1)) .AND.(J .GT.0)) GO TO 501
500        CONTINUE
501        CONTINUE
              KKK = K-1
C
C       CAMPBELL ROUTINE PARAMETERS - SEGMENTED-NON BIASED
C
             SS=0.0
             WW=0.0
             NN=0.0
             SSS = ALOG(P2(I))
             WWW = ALOG(W2(I))
             NNN = 1
           DO 525 K=1,N
```

```
C
C    Following line eliminates data below inflection suction.
C    For air entry value match, replace P1(I) with PS(I)
C
             IF (SUC(I,K) .LT. P1(I)) GO TO 525
             IF  (SUC(I,K) .LE. P2(I) )  THEN
                SS =SUMS1+ALOG(SUC(I,K))
                WW = SUMS2 + ALOG (THETA(I,K))
                NN = SUMS3 + 1
             ELSE
                SSS =  SUMX1 + ALOG(SUC(I,K))
                WWW =  SUMX2 + ALOG(THETA(I,K))
                NNN = (SUMX3 + 1)
             ENDIF
525          CONTINUE
                IF (NNN .EQ. 0) THEN
                   NNN = 1
                ELSE
                   NNN = NNN
                ENDIF
                SS=EXP(SS/NN)
                WW = EXP(WW/NN)
                SSS = EXP(SSS/NNN)
                WWW = EXP(WWW/NNN)
         DO 550 K=1,N
C
C    Following line eliminates data below inflection suction.
C    For air entry value match, replace P1(I) with PS(I)
C
           IF (SUC(I,K) .LT. PS(I)) GO TO 550
           IF (SUC(I,K).LE. P2(I)) THEN
             TF=WW
             TS=SS
           ELSE
             TF = WWW
             TS= SSS
           ENDIF
             TC=THETA(I,K)/TF
             TCL=ALOG(TC)
             SQTCL=TCL**2
             SC=SUC(I,K)/TS
             SCL=ALOG(SC)
             DEMC=TCL*SCL
             SUMC1=SUMC1+SQTCL
             SUMC2=SUMC2+DEMC
          IF (SUC(I,K) .EQ.P2(I)) THEN
              CB1(I)=SUMC2/SUMC1
              SUMC1=(ALOG(THETA(I,K)/WWW))**2
              SUMC2=ALOG(THETA(I,K)/WWW)*ALOG(SUC(I,K)/SSS)
          ENDIF
550       CONTINUE
               RES(I)=X(I,J-1)
               DD(I)=D(I,J-1)/(KKK-2)
               BCB(I)=B(I,J-1)
               CB2(I)=SUMC2/SUMC1
```

```
C
C         CLAPP AND HORNBERGER FUNCTIONS - S/W NEAR SATURATION
C
              WF=W1(I)/THETA(I,1)
              DUM1=P1(I)/(1-WF)**2
              DUM2=P1(I)/(WF*(1-WF))
              DUM3=2*WF-1
              BA(I)=DUM1+DUM2/BCB(I)
              BC(I)=DUM3+P1(I)/(BA(I)*BCB(I)*WF)
              CA(I)=DUM1+DUM2*CB1(I)
              CC(I)=DUM3+P1(I)*CB1(I)/(CA(I)*WF)
600       CONTINUE
C
C         BEGIN WRITE ROUTINE
C
          WRITE (16,'(1X/)')
          WRITE (16,900)
          WRITE (16,'(/)')
          WRITE (16,925)
          WRITE (16,930) (DPTH(I),WS(I),W1(I),W2(I),PS(I),P1(I),P2(I),
     2                   I=1,L)
          WRITE (16,'(1X/)')
          WRITE (16,935)
          WRITE (16,'(/)')
            WRITE (16,940)
          WRITE (16,945) (DPTH(I),DD(I),RES(I),BCB(I),BA(I),BC(I),
     X                     I=1,L)
          WRITE (16,'(1X/)')
          WRITE (16,950)
          WRITE (16,'(/)')
          WRITE (16,955)
          WRITE (16,960) (DPTH(I),CB1(I),CB2(I),CA(I),CC(I),I=1,L)
          WRITE (16,'(1X/)')
          WRITE (16, 970)
          WRITE (16, 975)
900       FORMAT (1X,'CURVE INFLECTION POINTS')
925       FORMAT (1X,'DEPTH',3X,'W-SAT',2X,'W-INF',2X,'W-SEG',
     X               4X,'S-AE',2X, 'S-INF',3X,'S-SEG')
930     FORMAT(1X,F6.0,2X,F5.4,2X,F5.4,2X,F5.4,2X,F6.0,2X,F6.0,2X,F6.0)
935       FORMAT (1X,'BROOKS AND COREY PARAMETERS')
940       FORMAT (1X,'DEPTH',3X,'MSD',4X,'RES-MOIS',1X,'B&C - b',4X,
     X                 'C&H M',6X,'C&H N')
945       FORMAT (1X,F6.0,2X,F6.3,2X,F6.5,2X,F7.3,2X,F10.2,2X,F6.4)
950       FORMAT (1X,'SEGMENTED CAMPBELL PARAMETERS')
955       FORMAT (1X,'DEPTH',3X,'CA -bc1',3X,'CA -bc2',5X,'C&H M',5X,
     X                'C&H N')
960       FORMAT (1X,F6.0,2X,F8.3,2X,F8.3,2X,F10.2,2X,F6.4)
970       FORMAT (5X,'* NOTE:  B&C AND FIRST CAMPBELL CURVES ARE MATCHE
     XD')
975       FORMAT (14X, 'AT INFLECTION SUCTION')
          STOP
          END
```

```
SITE 1      LACUSTRINE MAT.     (CASSEL)

CURVE INFLECTION POINTS

DEPTH    W-SAT   W-INF   W-SEG       S-AE   S-INF    S-SEG
   8.    .4140   .4040   .1239        20.     30.   15499.
  22.    .3975   .3730   .1230        10.     27.   15499.

BROOKS AND COREY PARAMETERS

DEPTH     MSD     RES-MOIS  B&C - b     C&H M        C&H N
   8.    0.015    .03300    -0.227    45821.58     0.9487
  22.    0.002    .06800    -0.270     5378.28     0.8569

SEGMENTED CAMPBELL PARAMETERS

DEPTH    CA -bc1    CA -bc2      C&H M       C&H N
   8.     -5.086   ????????    44945.55    0.9482
  22.     -5.242   ????????     4660.15    0.8444

    * NOTE:  B&C AND FIRST CAMPBELL CURVES ARE MATCHED
             AT INFLECTION SUCTION
```

APPENDIX D.2 **PROGRAM GCALC3**

Program GCALC3 calculates indices based on particle size class. Included are the grain size indices of Gosh (14), and Bloemen (1), sand to silt ratio, geometric mean particle diameter, standard deviation from the geometric mean, and an index calculated from ratio of geometric mean/standard deviation x 100. Also included are coefficients for predicting K(S), from percent sand and percent silt data, as described by Jaynes and Tyler (17). Each of these indices is described in the report section "EXTENDING DATA INTERPRETATION FOR APPLICATION".

GCALC3 will perform calculations on either three, or eight particle class fractions, as specified in the input data.

INPUT DEFINITIONS

Variable	Definition
M,N	Number of particle size classes (3 or 8), and number of soil samples (12 maximum) respectively.
PS(I)	Upper particle class boundaries (microns) from smallest to largest for M particle classes.
DEPTH(J)	Depth (or index number). Numeric required.
BD(J), PD(J), OM(J)	Bulk density, particle density, and organic matter, respectively. Use 2.65 for particle density if specific data not available.
DIS(I,J)	Percentage of each particle class (I) for soil (J). Smallest to largest.

INPUT DATA FORMAT

Data format is list directed- data values seperated by space or comma - specific columns are not important.

Sample Input Format:

```
'NAME DESIGNATED FOR GROUP OF SOILS' (alpha-numeric)
 M,N
 PS(1), PS(2), ... PS(M)
 DEPTH(1),BD(1),PD(1),OM(1)
 DIS(1,1),DIS(2,1),...DIS(M,1)
 DEPTH(2),BD(2),PD(2),OM(2)
 DIS(1,2),DIS(2,2),...DIS(M,2)

           .
           .
           .

 DEPTH(N),BD(N),PD(N),OM(N)
 DIS(1,N),DIS(2,N),...DIS(M,N)
```

Sample Input Data File:

```
   GTEST EXAMPLE  FILE
 3,2
2,50,2000
6,1.58,2.65,.64
4.8,6,89.2
12,1.58,2.65,.31
3.3,5.1,91.6
```

Sample Output File:

```
  GTEST EXAMPLE  FILE


 DEPTH                          PARTICLE SIZE CLASSES
             2.       50.    2000.     SAND    SILT   CLAY
    6.      4.8       6.0    89.2      89.2     6.0     4.8
   12.      3.3       5.1    91.6      91.6     5.1     3.3


 DEPTH     SA/SI   GMEAN    GDEV      Z       F-INDEX   BD     OM
    6.    14.867  0.5895    5.3    0.1102    0.581   1.58   0.64
   12.    17.961  0.6761    4.3    0.1587    0.651   1.58   0.31


 DEPTH  CAMPBELL-b   ln K vs ln S GARDNER K-PARAMETERS (JAYNES & TYLER)
                      SLOPE
                                  CM/DAY-KPA          CM/HR-BAR
            GOSH        BLOEMEN   K-SLOPE  K-INT       K-SLOPE  K-INT
    6.      1.349       2.404     -1.2110   2.5868      -12.11     1.21
   12.      1.265       2.821     -1.2503   2.6564      -12.50     1.28
```

```
C (WM SCHUH:1984 North Dakota State Water Commission)
C GCALC CALCULATES SEVERAL SOIL INDICES FROM SOIL TEXTURE DATA.
C REQUIRED INPUT IS 1) DEPTH (SOIL IDENTIFIER), 2) M=NO.OF GRAIN SIZES,
C N= NUMBER OF SOIL MATERIALS . 3) BD ( BULK DENSITY), PD (PARTICLE
C DENSITY ) AND OM (ORGANIC MATTER) FOR EACH SOIL MATERIAL. WHERE PD IS
C NOT MEASURED, SUBSTITUTE 2.65 . 4) PS DESIGNATES PARTICLE SIZE CLASS-
C STARTING WITH FINEST, AND ENDING WITH COARSEST BOUNDARY.  DO NOT
C INCLUDE THE 0 BOUNDARY  - PROGRAM ASSUMES 0 BOUNDARY ON FINE END.
C PROGRAM ASSUMES ENTRIES ARE IN MICRONS.  EITHER 3 OR 8 CLASSES CAN
C USED WITH THE PROGRAM.
C 5) DIS DESIGNATES THE PERCENT (%) BELONGING TO EACH CORRESPONDING
C SIZE INTERVAL.
C     OUTPUT INCLUDES 1)PARTICLE STATISTICS,  - GEOMETRIC MEAN,
C GEOMETRIC MEAN STANDARD DEVIATION, GM/GMDx100, F-INDEX (BLOEMEN),
C SAND TO SILT RATIO.  2) THE CAMPBELL 'b' VALUE AS ESTIMETED BY
C GOSH FROM PARTICLE INFORMATION.  3) THE LN K VS LN S SLOPE
C AS ESTIMATED BY BLOEMAN FROM THE F-INDEX. 4)THE SLOPE AND INTERCEPT
C FOR GARDNER EQUATION FOR K(S) (LOG K = A*SQRT S +B)AS DETERMINED
C BY JAYNES AND TYLER FROM GRAIN SIZE.
      character*15  infile,outfile
      CHARACTER*80 HEAD
      CHARACTER*45 IFMT1,IFMT2,IFMT3,IFMT4,IFMT5,IFMT6,IFMT7
      DIMENSION PS(0:12),DIS(12,25),DISUM(0:12),PSUM(12),TG(12),F(12),
     A    ADDF(12),GINDEX(25),PSLOP(12),DISLOP(12),AM(12),WLM(12),
     A    WLS(0:12),SSQLM(0:12),GMEAN(25),GDEV(25),SA(25),SI(25),
     A    SASI(25),SQLM(12),DEPTH(25),CL(25),Z(25),BD(25),PD(25),OM(25)
      DIMENSION WATA(15,25),THETA(0:15,25),A2(25),B2(25),
     1           WA(0:15,25),VR(25),W(15),V(15),PRA(15),PART(15),
     2           POR(15,25),SUC(15,25),GB(25),BN(25),A1(25),B1(25)
      DIMENSION A(12),B(12),C(12),D(12),E(12),AA(12)
c
c     Following lines establish screen promts for reading input and
c     output files on IBM PC using IBM PROFESSIONAL FORTRAN .
c     Modification may be necessary for batch, or other JCL environments
c
       write (*,*) 'enter input data file'
       read (*,'(a15)') INFILE
       OPEN (15,FILE=INFILE)
       WRITE (*,*) 'ENTER OUTPUT DATA FILE'
       READ (*,'(A15)') OUTFILE
       OPEN (16,FILE=OUTFILE)
c
c
      READ (15,'(A80)') HEAD
      WRITE (16,'(A80)') HEAD
      WRITE (16,'(1X/)')
      READ(15,*) M,N
      READ(15,*) (PS(I),I=1,M)
      DO 10, J=1,N
         READ(15,*) DEPTH(J),BD(J),PD(J),OM(J)
         READ(15,*) (DIS(I,J), I=1,M)
```

```
 10     CONTINUE
       DO 50 J=1,N
          DO 25 I=1,M
C
C       INITIATE STATISTICAL FUNCTIONS
C
            SSQLM(0)=0
            WLS(0)=0
            PS(0)=0
            AM(I)=(PS(I)+PS(I-1))/2000
            WLM(I)=.01*DIS(I,J)*ALOG(AM(I))
            SQLM(I)=WLM(I)*ALOG(AM(I))
            WLS(I)=WLM(I)+WLS(I-1)
            SSQLM(I)=SQLM(I)+SSQLM(I-1)
C
C       INITIATE INDEX FUNCTIONS
C
            DISUM(0)=0
            DISUM(I)=DISUM(I-1)+DIS(I,J)
           IF (I .LT. 2) GO TO 25
           PSLOP(I)=ALOG10(PS(I)/PS(I-1))
           DISLOP(I)=ALOG10(DISUM(I)/DISUM(I-1))
            TG(I)=DISLOP(I)/PSLOP(I)
            F(I)=TG(I)*DIS(I,J)
            ADDF(1)=0
            ADDF(I)=F(I)+ADDF(I-1)
25         CONTINUE
            GINDEX(J)=ADDF(I-1)/(DISUM(I-1)-DISUM(1))
C
C       RESUME STATISTICAL FUNCTIONS
C
           XA=WLS(I-1)
           XB2=SSQLM(I-1)-XA**2
           XB=SQRT(XB2)
            GMEAN(J)=EXP(XA)
            GDEV(J)=EXP(XB)
            Z(J)=GMEAN(J)/GDEV(J)
C
C       INITIATE SASI RATIO FUNCTIONS
C
        IF (M .EQ. 8)  THEN
            SA(J)=DIS(4,J)+DIS(5,J)+DIS(6,J)+DIS(7,J)+DIS(8,J)
            SI(J)=DIS(2,J)+DIS(3,J)
        ELSE
            SA(J)=DIS(3,J)
            SI(J)=DIS(2,J)
        ENDIF
            CL(J)=DIS(1,J)
            SASI(J)=SA(J)/SI(J)
50       CONTINUE
C
```

```
C       ALL FUNCTIONS COMPLETED
C
C      GPRINT READS THE STORED OUTPUT FILES FROM PROGRAM 'GCALC'
C      AND FORMATS THEM FOR PRINTED PRESENTATION.
C
         IFMT7='(10X,8(F5.0,3X),''SAND'',3X,''SILT'',3X,''CLAY'')'
             WRITE (IFMT7 (6:6),'(I1)')M
      WRITE (16,55)
 55      FORMAT (1X,'DEPTH',21X,'PARTICLE SIZE CLASSES')
         WRITE (16,IFMT7) (PS(I),I=1,M)
         DO 75,J=1,N
            WRITE (16,70) DEPTH(J),(DIS(I,J),I=1,M),SA(J),SI(J),CL(J)
 70           FORMAT (1X,F5.0,3X,8(F5.1,3X),3(F5.1,2X))
 75      CONTINUE
         WRITE (16,'(/)')
         WRITE (16,76)
 76     FORMAT('DEPTH',4X,'SA/SI',2X,'GMEAN',3X,'GDEV',5X,'Z',5X,
     1        'F-INDEX',3X,'BD',4X,'OM')
         DO 80 ,J=1,N
          WRITE(16,85)DEPTH(J),SASI(J),GMEAN(J),GDEV(J),Z(J),GINDEX(J),
     1          BD(J),OM(J)
 80       CONTINUE
 85     FORMAT(F5.0,2X,F7.3,2X, F6.4,2X,F4.1,2X,F7.4,2X,F6.3,2X,F4.2,
     1         2X,F5.2)
C
C          CALCULATE  THETA/SUCTION CURVE SLOPE
C
          DO 2000,J=1,N
C             CALCULATE GOSH ESTIMATES
                XX=5.91*(CL(J)/(SA(J)+ CL(J)))
                VAR4=6.2*SQRT(SI(J)/SA(J))-XX
               GB(J)=2.619*(SI(J)/SA(J))**.2822*(VAR4+.7)**.0625
     1                *VAR4**.125*(XX+1.1)**.0625
C             CALCULATE BLOEMEN SLOPES
          IF (OM(J).EQ.0) THEN

               BN(J)=1.4+4.536*(EXP(.3*GINDEX(J))-1)
          ELSE
               BN(J)=1.4+4.536*(EXP(.3*GINDEX(J))-1)-.75*GINDEX(J)**1.6
     1           *ALOG(OM(J))
          ENDIF
C             CALCULATE GARDNER SLOPES
           A1(J)=-.014*SA(J)+.0063*SI(J)
           B1(J)=.029*SA(J)
           A2(J)= A1(J)*10
           B2(J)=B1(J)-1.3802
2000      CONTINUE
```

```
          WRITE (16,'(1X/)')
          WRITE (16,2100)
          WRITE (16,2110)
          WRITE (16,2150)
          WRITE (16,2200)
          DO 2050  J=1,N
          WRITE (16,2300)  DEPTH(J),GB(J),BN(J),A1(J),B1(J),A2(J),B2(J)
2050       CONTINUE
          WRITE (16,2350)
2100      FORMAT (1X,'DEPTH', 2X,'CAMPBELL-b  ln K vs ln S',1X,'GARDNER
     1 K-PARAMETERS (JAYNE & TYLER)')
2110      FORMAT (21x,'SLOPE')
2150      FORMAT(36X,'CM/DAY-KPA',10X,'CM/HR-BAR')
2200      FORMAT (10X,'GOSH',8X,'BLOEMEN',4X,'K-SLOPE',2X,'K-INT',
     1          7X,'K-SLOPE',2X,'K-INT')
2300   FORMAT (1X,F5.0,2X,F7.3,5X,F7.3,6X,F7.4,2X,F7.4,5X,F7.2,2X,F7.2)
2350      FORMAT ('1')
       STOP
       END
```

APPENDIX D.3 SOHYP: A Computer Model for Calculating the Soil Hydraulic Properties from Soil Moisture Retention Data

Program SOHYP was written by Rien van Genuchten (32) and is presented in this report with permission of its author. The program, as presented, was transcribed from printed form. It was carefully reproduced and has compiled and functioned satisfactorily on an IBM PC XT, using IBM PROFESSIONAL FORTRAN. All data used in this report were processed using this version. Although the program is, to the best of our knowledge, faithful to the original version, users should be aware of the transcription. Problems encountered in its use may be due to transcription errors, rather than to the original text.

A few minor changes in documentation, format, and code, were made in the version presented. They are as follows.

1. The program was modified for interactive specification of input and output files. The input file is assigned to unit number 15 and the output to unit number 16. If the FORTRAN 77 OPEN statement is not supported or the program is to be run in a batch environment, then the file assignments must be made through the operating system commands.

2. In the original program, the code term ARCOS was used in several lines, and did not link (IBM PROFESSIONAL FORTRAN). This was interpreted to designate the 'arcosine' function, and ACOS was substituted in this version.

Other documentation, and the example output file were reproduced or copied directly from the text of van Genuchten (32).

This Appendix gives a brief description and listing of SOHYP, a computer program for calculation of the soil hydraulic properties from observed soil moisture retention data. The program does this by means of a non-linear least-squares fit of the following equation to the observed data.

$$\theta = \theta_r + \frac{(\theta_s - \theta_r)}{[1+(aS)^n]^m} \qquad [D.3.1]$$

where for the Mualem theory,

$$m=1-1/n, \qquad [D.3.2]$$

and for the Burdine theory

$$m=1-2/n. \qquad [D.3.3]$$

The computer program provides for three options, controlled by the variable MODE. If MODE equals one, the program optimizes the three parameters θ_r, a, and n by means of a least-squares fit of equations [D.1.1] and [D.1.2] to the observed data. The soil hydraulic properties are then calculated in accordance with the Mualem theory. If MODE equals two, the program only calculates best-fit values of a and n, and assumes that θ_r is known beforehand. The value of θ_r is now given as an input variable. Values of a and n are still calculated by means of Eq. [D.1.1] and [D.1.2] (i.e. the Mualem theory still applied). If MODE equals three, the computer model again calculates best-fit values of the three parameters (θ_r, a, and n) but it is now assumed that the Burdine theory applies. Hence Eq. [D.1.1] and [D.1.3] are now used in the program. In each case the computer program provides for a table of the hydraulic properties of the soil consistent with the value of MODE selected.

SIGNIFICANT VARIABLES IN SOHYP

Variable	Definition
AK	Hydraulic conductivity (K).
ALPHA	Coefficient a in Eq. (A1).
B(I)	Array containing initial estimates of coefficients.
BI(I)	Array of coefficient names.
DIFFUS	Soil moisture diffusivity (D).
MIT	Maximum number of iterations.
MODE	Designates model type to be used in program: =1: three-parameter fit (θ_r, a, and n)(Mualem theory) =2: two-parameter fit (a, n)(Mualem theory) =3: three-parameter fit (θ_r, a, n)(Burdine theory).
MODEL	Subroutine to calculate soil moisture content ( ) from pressure head (Eq. [D.3.1].
NC	Number of cases considered.
NDATA	Input data code: =0: new data are read in =1: data from previous case are used.
NIT	Iteration number during program execution.
NOB	Number of observed data points (must not exceed 40).
RK	Relative hydraulic conductivity (K_r).
RM	Equals 1-1/n for Mualem theory, 1-2/n for Burdine theory.
RN	Coefficient n in Eq. [D.3.1].
RWC	Dimensionless moisture content (θ).
SATK	Hydraulic conductivity at saturation (K_s).
SSQ, SUMB	Residual sum of squares.

STOPCR	Stop Criterion. Iteration process stops when the relative change in each coefficient becomes less than STOPCR.
TITLE (I)	Array containing information of title cards.
WC	Volumetric moisture content (θ).
WCR	Residual moisture content (θ_r).
WCS	Saturated moisture content (θ_s).
X(I)	Array of observed pressure heads (values are assumed to be positive).
Y(I)	Array of observed moisture contents.

INPUT DEFINITIONS

Card	Columns	Format	Variable	Comment
1	1-5	15	NC	Number of cases considered.
				The following cards are repeated NC times. However, skip cards 6, etc., if NDATA = 1 on third data card.
2	1-80	20(A4)	TITLE	
3	1-5	I5	MODE	Defines model number (1, 2, or 3).
	6-10	I5	NP	Number of coefficients (2 or 3).
	11-15	I5	NOB	Number of observations.
	16-20	I5	NDATA	Data input code.
	21-30	F10.0	WCR	Residual moisture content. This information is only necessary when MODE = 2.
	31-40	F10.0	WCS	Saturated moisture content.
	41-50	F10.0	SATK	Saturated hydraulic conductivity.
4	1-10	F10.0	B(1)	Initial value of θ_r if NP = 3; Initial value of a if NP = 2.
	11-20	F10.0	B(2)	Initial value of a if NP = 3; Initial value of n if NP = 2.
	21-30	F10.0	B(3)	Initial value of n if NP = 3.
5	1-6	A4,A2	BI(1)	Coefficient name of B(1).
	11-16	A4, A2	BI(2)	Coefficient name of B(2).
	21-26	A4,A2	BI(3)	Coefficient name of B(3) (only if NP = 3).
6, etc.	1-10	F10.0	X(I)	Value of observed pressure head (assumed to be positive).
	11-20	F10.0	Y(I)	Value of observed moisture content.

Example Input File:

```
1           2           3            4            5            6
1234567890123456789012345678901234567890123456789012345678901
     1
           SILT LOAM G.E.3
     1     3    13     0        .018       0.396        4.96
   0.018      0.002       2.3
WCR        ALPHA          N
   10.0     0.396
   20.0     0.394
   43.0     0.390
   60.0     0.3855
   80.0     0.379
  111.0     0.370
  190.0     0.340
  285.0     0.300
  400.0     0.260
  600.0     0.220
  800.0     0.200
  900.0     0.194
 1000.0     0.190
```

EXAMPLE OUTPUT FILE:

```
********************************************************************************
*                                                                              *
*         NON-LINEAR     LEAST SQUARES ANALYSIS                                    *
*                                                                              *
*         SILT LOAM G.E.3                                                      *
*                                                                              *
********************************************************************************

INPUT PARAMETERS
================
MODEL NUMBER.................................  1
NUMBER OF COEFFICIENTS.......................  3
NUMBER OF OBSERVATIONS....................... 13
RESIDUAL MOISTURE CONTENT (FOR MODEL2).......    0.0180
SATURATED MOISTURE CONTENT...................    0.3960
SATURATED HYDRAULIC CONDUCTIVITY.............    4.9600

OBSERVED DATA
=============
OBS. NO.     PRESSURE  HEAD  MOISTURE CONTENT
    1            10.00          0.3960
    2            20.00          0.3940
    3            43.00          0.3900
    4            60.00          0.3855
    5            80.00          0.3790
    6           111.00          0.3700
    7           190.00          0.3400
    8           285.00          0.3000
    9           400.00          0.2600
   10           600.00          0.2200
   11           800.00          0.2000
   12           900.00          0.1940
   13          1000.00          0.1900
ITERATION NO        WCR        ALPHA          N           SSQ          MODEL
     0            0.1800     0.002000      2.3000      0.0391384         1
     1            0.1309     0.003176      2.1707      0.0027122         1
     2            0.1306     0.004033      2.0353      0.0002563         1
     3            0.1321     0.004236      2.0629      0.0000667         1
     4            0.1313     0.004233      2.0596      0.0000665         1
     5            0.1313     0.004233      2.0594      0.0000665         1

CORRELATION MATRIX
==================
         1          2          3
  1   1.0000
  2   0.3542     1.0000
  3   0.9466     0.0829     1.0000
```

0.891E+02	1.950	0.3794	0.430E+00	-0.367	0.213E+01	0.329	0.611E+04	3.786
0.106E+03	2.025	0.3732	0.355E+00	-0.450	0.176E+01	0.246	0.453E+04	3.656
0.126E+03	2.100	0.3650	0.281E+00	-0.551	0.139E+01	0.144	0.330E+04	3.518
0.150E+03	2.175	0.3547	0.211E+00	-0.675	0.105E+01	0.021	0.236E+04	3.373
0.178E+03	2.250	0.3421	0.151E+00	-0.822	0.747E+00	-0.127	0.166E+04	3.221
0.211E+03	2.325	0.3272	0.101E+00	-0.997	0.500E+00	-0.301	0.115E+04	3.061
0.251E+03	2.400	0.3105	0.634E-01	-1.198	0.314E+00	-0.502	0.783E+03	2.894
0.299E+03	2.475	0.2926	0.375E-01	-1.426	0.186E+00	-0.730	0.526E+03	2.721
0.355E+03	2.550	0.2743	0.210E-01	-1.678	0.104E+00	-0.983	0.349E+03	2.543
0.422E+03	2.625	0.2563	0.112E-01	-1.953	0.553E-01	-1.257	0.230E+03	2.361
0.501E+03	2.700	0.2394	0.569E-02	-2.245	0.282E-01	-1.549	0.150E+03	2.176
0.596E+03	2.775	0.2238	0.281E-02	-2.551	0.139E-01	-1.856	0.973E+02	1.988
0.708E+03	2.850	0.2100	0.135E-02	-2.869	0.670E-02	-2.174	0.629E+02	1.798
0.841E+03	2.925	0.1978	0.637E-03	-3.196	0.316E-02	-2.500	0.405E+02	1.608
0.100E+04	3.000	0.1873	0.296E-03	-3.529	0.147E-02	-2.833	0.261E+02	1.416
0.119E+04	3.075	0.1783	0.136E-03	-3.866	0.676E-03	-3.170	0.167E+02	1.223
0.141E+04	3.150	0.1706	0.622E-04	-4.206	0.308E-03	-3.511	0.107E+02	1.030
0.168E+04	3.225	0.1642	0.282E-04	-4.549	0.140E-03	-3.854	0.687E+01	0.837
0.200E+04	3.300	0.1588	0.128E-04	-4.894	0.633E-04	-4.198	0.440E+01	0.643
0.237E+04	3.375	0.1542	0.576E-05	-5.240	0.286E-04	-4.544	0.282E+01	0.450
0.282E+04	3.450	0.1504	0.259E-05	-5.586	0.129E-04	-4.891	0.180E+01	0.256
0.335E+04	3.525	0.1472	0.117E-05	-5.934	0.578E-05	-5.238	0.115E+01	0.062
0.398E+04	3.600	0.1446	0.522E-06	-6.282	0.259E-05	-5.586	0.736E+00	-0.133
0.473E+04	3.675	0.1424	0.235E-06	-6.630	0.116E-05	-5.934	0.471E+00	-0.327
0.562E+04	3.750	0.1405	0.105E-06	-6.978	0.522E-06	-6.282	0.301E+00	-0.521
0.668E+04	3.825	0.1390	0.472E-07	-7.326	0.234E-06	-6.630	0.193E+00	-0.715
0.794E+04	3.900	0.1377	0.212E-07	-7.674	0.105E-06	-6.979	0.123E+00	-0.909
0.944E+04	3.975	0.1366	0.949E-08	-8.023	0.471E-07	-7.327	0.789E-01	-1.103
0.112E+05	4.050	0.1357	0.425E-08	-8.371	0.211E-07	-7.676	0.504E-01	-1.297
0.133E+05	4.125	0.1350	0.191E-08	-8.720	0.946E-08	-8.024	0.323E-01	-1.491
0.158E+05	4.200	0.1344	0.855E-09	-9.068	0.424E-08	-8.373	0.206E-01	-1.685
0.188E+05	4.275	0.1339	0.383E-09	-9.417	0.190E-08	-8.721	0.132E-01	-1.880
0.224E+05	4.350	0.1334	0.172E-09	-9.765	0.851E-09	-9.070	0.844E-02	-2.074
0.266E+05	4.425	0.1331	0.769E-10	-10.114	0.381E-09	-9.419	0.540E-02	-2.268
0.316E+05	4.500	0.1328	0.345E-10	-10.463	0.171E-09	-9.767	0.345E-02	-2.462
0.376E+05	4.575	0.1325	0.154E-10	-10.811	0.766E-10	-10.116	0.221E-02	-2.656
0.447E+05	4.650	0.1323	0.692E-11	-11.160	0.343E-10	-10.464	0.141E-02	-2.850
0.531E+05	4.725	0.1322	0.310E-11	-11.508	0.154E-10	-10.813	0.902E-03	-3.045
0.631E+05	4.800	0.1320	0.139E-11	-11.857	0.689E-11	-11.162	0.577E-03	-3.239
0.750E+05	4.875	0.1319	0.623E-12	-12.206	0.309E-11	-11.510	0.369E-03	-3.433
0.891E+05	4.950	0.1318	0.279E-12	-12.554	0.138E-11	-11.859	0.236E-03	-3.627
0.106E+06	5.025	0.1317	0.125E-12	-12.903	0.620E-12	-12.208	0.151E-03	-3.821
0.126E+06	5.100	0.1317	0.560E-13	-13.252	0.278E-12	-12.556	0.965E-04	-4.016
0.150E+06	5.175	0.1316	0.251E-13	-13.600	0.125E-12	-12.905	0.617E-04	-4.210
0.178E+06	5.250	0.1315	0.112E-13	-13.949	0.558E-13	-13.253	0.395E-04	-4.404
0.211E+06	5.325	0.1315	0.504E-14	-14.298	0.250E-13	-13.602	0.252E-04	-4.598
0.251E+06	5.400	0.1315	0.226E-14	-14.646	0.112E-13	-13.951	0.161E-04	-4.792
0.298E+06	5.475	0.1314	0.101E-14	-14.995	0.502E-14	-14.299	0.103E-04	-4.986
0.355E+06	5.550	0.1314	0.454E-15	-15.343	0.225E-14	-14.648	0.660E-05	-5.181
0.422E+06	5.625	0.1314	0.203E-15	-15.692	0.101E-14	-14.997	0.422E-05	-5.375
0.501E+06	5.700	0.1314	0.911E-16	-16.041	0.452E-15	-15.345	0.270E-05	-5.569

```
NON-LINEAR LEAST-SQUARES ANALYSIS: FINAL RESULTS
++++++++++++++++++++++++++++++++++++++++++++++++

                                                         95% PERCENT CONFIDENCE LIMITS
VARIABLE         VALUE        S.E.COEFF.    T-VALUE        LOWER          UPPER
  WCR           0.13131         0.0096       13.67         0.1099         0.1527
 ALPHA          0.00423         0.0001       44.40         0.0040         0.0044
   N            2.05938         0.0804       25.61         1.8802         2.2386

--------ORDERED BY COMPUTER INPUT--------         ----------ORDERED BY RESIDUALS----------
                  MOISTURE CONTENT   RESI                             MOISTURE CONTENT    RESI-
NO   PRESSURE       OBS     FITTED   DUAL          NO   PRESSURE        OBS     FITTED     DUAL
 1      10.00     0.3960   0.3958   0.0002          7     190.00      0.3400   0.3366    0.0034
 2      20.00     0.3940   0.3952  -0.0012         13    1000.00      0.1900   0.1873    0.0027
 3      43.00     0.3900   0.3920  -0.0020          8     285.00      0.3000   0.2975    0.0025
 4      60.00     0.3855   0.3883  -0.0028         12     900.00      0.1940   0.1935    0.0005
 5      80.00     0.3790   0.3825  -0.0035          1      10.00      0.3960   0.3958    0.0002
 6     111.00     0.3700   0.3712  -0.0012         11     800.00      0.2000   0.2012   -0.0012
 7     190.00     0.3400   0.3366   0.0034          2      20.00      0.3940   0.3952   -0.0012
 8     285.00     0.3000   0.2975   0.0025          6     111.00      0.3700   0.3712   -0.0012
 9     400.00     0.2600   0.2618  -0.0018          9     400.00      0.2600   0.2618   -0.0018
10     600.00     0.2200   0.2232  -0.0032          3      43.00      0.3900   0.3920   -0.0020
11     800.00     0.2000   0.2012  -0.0012          4      60.00      0.3855   0.3883   -0.0028
12     900.00     0.1940   0.1935   0.0005         10     600.00      0.2200   0.2232   -0.0032
13    1000.00     0.1900   0.1873   0.0027          5      80.00      0.3790   0.3825   -0.0035
 PRESSURE     LOG P       WC         REL K      LOG RK       ABS K     LOG KA      DIFFUS      LOG D
 0.000E+00              0.3960    0.100E+01               0.496E+01
 0.141E+01    0.150     0.3960    0.991E+00    -0.004     0.492E+01    0.692    0.939E+06    5.973
 0.168E+01    0.225     0.3960    0.989E+00    -0.005     0.491E+01    0.691    0.781E+06    5.892
 0.200E+01    0.300     0.3960    0.987E+00    -0.006     0.490E+01    0.690    0.649E+06    5.812
 0.237E+01    0.375     0.3960    0.985E+00    -0.007     0.488E+01    0.689    0.539E+06    5.732
 0.282E+01    0.450     0.3960    0.982E+00    -0.008     0.487E+01    0.687    0.447E+06    5.651
 0.335E+01    0.525     0.3960    0.978E+00    -0.010     0.485E+01    0.686    0.371E+06    5.570
 0.398E+01    0.600     0.3960    0.974E+00    -0.012     0.483E+01    0.684    0.308E+06    5.488
 0.473E+01    0.675     0.3960    0.968E+00    -0.014     0.480E+01    0.682    0.255E+06    5.407
 0.562E+01    0.750     0.3959    0.962E+00    -0.017     0.477E+01    0.679    0.211E+06    5.324
 0.668E+01    0.825     0.3959    0.955E+00    -0.020     0.473E+01    0.675    0.174E+06    5.242
 0.794E+01    0.900     0.3959    0.946E+00    -0.024     0.469E+01    0.671    0.144E+06    5.158
 0.944E+01    0.975     0.3958    0.935E+00    -0.029     0.464E+01    0.666    0.119E+06    5.074
 0.112E+02    1.050     0.3957    0.922E+00    -0.035     0.457E+01    0.660    0.975E+05    4.989
 0.133E+02    1.125     0.3956    0.907E+00    -0.043     0.450E+01    0.653    0.799E+05    4.903
 0.158E+02    1.200     0.3955    0.888E+00    -0.051     0.441E+01    0.644    0.654E+05    4.815
 0.188E+02    1.275     0.3953    0.867E+00    -0.062     0.430E+01    0.633    0.532E+05    4.726
 0.224E+02    1.350     0.3949    0.841E+00    -0.075     0.417E+01    0.620    0.432E+05    4.635
 0.266E+02    1.425     0.3945    0.811E+00    -0.091     0.402E+01    0.604    0.348E+05    4.542
 0.316E+02    1.500     0.3939    0.775E+00    -0.111     0.384E+01    0.585    0.279E+05    4.446
 0.376E+02    1.575     0.3930    0.734E+00    -0.135     0.364E+01    0.561    0.222E+05    4.347
 0.447E+02    1.650     0.3917    0.686E+00    -0.164     0.340E+01    0.532    0.176E+05    4.245
 0.531E+02    1.725     0.3899    0.631E+00    -0.200     0.313E+01    0.496    0.137E+05    4.138
 0.631E+02    1.800     0.3874    0.570E+00    -0.244     0.283E+01    0.451    0.106E+05    4.026
 0.750E+02    1.875     0.3840    0.502E+00    -0.299     0.249E+01    0.396    0.811E+04    3.909
```

```
C        **************************************************************
C      *                                                               *
C      *        NON-LINEAR LEAST-SQUARES ANALYSIS OF         SOHYP     *
C      *        SOIL HYDRAULIC PROPERTIES                  APRIL 1980  *
C      *                                                               *
C       ***************************************************************
C
C
        CHARACTER*15     INFILE,OUTFILE
      DIMENSION X(40),Y(40),R(40),F(40),DELZ(40,4),LSORT(40),B(3),BI(6),
     1   E(3),P(3),PHI(3),Q(3),TB(3),A(3,3),D(3,3),TITLE(20),TH(3)
        DATA STOPCR/.0010/,MIT/20/
C
C      The following lines establish screen prompts for entering
C      input file (tape = 15) and output file (tape=16) on an
C      IBM PC using IBM PROFESSIONAL FORTRAN .  Modification may
C      be necessary for different JCL or batch environments.
C
        WRITE(*,*) 'ENTER INPUT DATA FILE'
        READ(*,'(A15)')  INFILE
        OPEN (15,FILE=INFILE)
        WRITE(*,*) 'ENTER OUTPUT DATA FILE'
        READ(*,'(A15)')  OUTFILE
        OPEN  (16,FILE=OUTFILE)
C
C      -------READ NUMBER OF CASES CONSIDERED-------------------
        READ(15,1000) NC
        DO 144 IC=1,NC
        READ (15,1002)  TITLE
        WRITE(16,1004)  TITLE
        WRITE(*,1004) TITLE
C
C      -------READ INPUT PARAMETERS-----------------------------
        READ (15,1000) MODE,NP,NOB,NDATA,WCR,WCS,SATK
        WRITE(16,1005)  MODE,NP,NOB,WCR,WCS,SATK
C
C      -------READ INITIAL ESTIMATES----------------------------
        READ(15,1006) (B(I),I=1,NP)
C
C      -------READ COEFFICIENTS NAMES---------------------------
         NBI=2*NP
         READ(15,1007)  (BI(I),I=1,NBI)
C
C       ------READ AND WRITE EXPERIMENTAL DATA------------------
        WRITE(16,1008)
        IF (NDATA.GT.0) GO TO 8
        DO 4  I=1,NOB
    4   READ(15,1006) X(I),Y(I)
    8   DO 10 I=1,NOB
   10   WRITE(16,1011)  I,X(I),Y(I)
C
```

```
C      ----------------------------------------------------------
         DO 12  I=1,NP
  12       TH(I) = B(I)
           IF((NP-2)*(NP-3)) 14,16,14
  14       WRITE (16,1016)
           GO TO 142
  16       GA=0.02
          CALL MODEL(TH,F,NOB,X,WCS,MODE,NP,WCR)
          SSQ=0.
          DO 32 I=1,NOB
          R(I)=Y(I)-F(I)
  32      SSQ=SSQ+R(I)*R(I)
         NIT=0
          WRITE(16,1030)
          IF(MODE.EQ.2) WRITE(16,1026) NIT,WCR,B(1),B(2),SSQ,MODE
          IF (MODE.NE.2) WRITE(16,1026) NIT,B(1),B(2),B(3),SSQ,MODE
C
C      -------BEGIN OF ITERATION---------------------------------
 34         NIT=NIT+1
            GA=0.1*GA
            DO 38  J=1,NP
            TEMP=TH(J)
            TH(J)=1.01*TH(J)
             Q(J)=0
             CALL MODEL (TH,DELZ(1,J),NOB,X,WCS,MODE,NP,WCR)
            DO 36 I=1,NOB
            DELZ(I,J)=DELZ(I,J)-F(I)
 36         Q(J) = Q(J) + DELZ(I,J)*R(I)
            Q(J)=100.*Q(J)/TH(J)
C
C       -----STEEPEST DESCENT------------------------------------
 38          TH(J)=TEMP
             DO 44 I=1,NP
             DO 42 J=1,I
             SUM=0
             DO 40 K=1,NOB
 40          SUM=SUM+DELZ(K,I)*DELZ(K,J)
             D(I,J)=10000.*SUM/(TH(I)*TH(J))
 42          D(J,I)=D(I,J)

C       -----D = MOMENT MATRIX-----------------------------------
 44          E(I) = SQRT(D(I,I))
 50          DO 52  I=1,NP
             DO 52  J=1,NP
 52          A(I,J)=D(I,J)/(E(I)*E(J))
C
C       -----A IS THE SCALED MOMENT MATRIX----------------------
             DO 54 I=1,NP
             P(I)=Q(I)/E(I)
             PHI(I)=P(I)
 54          A(I,I) = A(I,I) + GA
```

```
             CALL MATINV(A,NP,P)
C
C         ----P/E IS THE CORRECTION FACTOR----------------------
            STEP = 1.0
 56         DO 58 I=1,NP
 58          TB(I) = P(I)*STEP/E(I) + TH(I)
             DO 62   I=1,NP
             IF (TH(I)*TB(I)) 66,66,62
 62         CONTINUE
            SUMB = 0.0
            CALL MODEL (TB,F,NOB,X,WCS,MODE,NP,WCR)
            DO 64  I=1,NOB
            R(I) = Y(I) - F(I)
 64         SUMB = SUMB + R(I)*R(I)
 66         SUM1 = 0.0
            SUM2 = 0.0
            SUM3 = 0.0
             DO 68  I=1,NP
            SUM1 = SUM1+P(I)*PHI(I)
            SUM2 = SUM2 +P(I)*P(I)
 68        SUM3 =SUM3 +PHI(I)*PHI(I)
C
C ****  NOTE:  ACOS was ARCOS in original program.  Did not link PF;
C       Any special meaning unclear - interpreted to be ARCOSINE .
C ****  (WMS 1985).
C
           ANGLE = 57.29578*ACOS(SUM1/SQRT(SUM2*SUM3))
C
C        -------------------------------------------------------
           DO 72  I=1,NP
           IF (TH(I)*TB(I)) 74,74,72
 72        CONTINUE
          IF (SUMB/SSQ-1.0)80,80,74
 74       IF (ANGLE - 30.0) 76,76,78
 76        STEP=STEP/2.0
          GO TO 56
 78       GA = 10.*GA
          GO TO 50
C
C        -----PRINT COEFFICIENTS AFTER EACH ITERATION------------
 80       CONTINUE
          DO 82 I=1,NP
82        TH(I) = TB(I)
         IF (MODE.EQ.2) WRITE(6,1026) NIT,WCR,TH(1),TH(2),SUMB,MODE
         IF (MODE.NE.2) WRITE(16,1026) NIT,TH(1),TH(2),TH(3),SUMB,MODE
          IF (MODE.EQ.2) GO TO 90
          IF (TH(1).GT.0.005) GO TO 90
          WRITE(16,1028)
          GO TO 144
 90       DO 92  I=1,NP
          IF(ABS(P(I)*STEP/E(I))/(1.0E-20+ABS(TH(I)))-STOPCR) 92,92,94
```

```
 92         CONTINUE
            GO TO 96
 94         SSQ=SUMB
            IF (NIT.LE.MIT) GO TO 34
C
C        -----END OF ITERATION LOOP-----------------------------
 96           CONTINUE
            CALL  MATINV(D,NP,P)
C
C        -----WRITE CORRELATION MATRIX--------------------------
           DO 98  I=1,NP
 98          E(I) = SQRT (D(I,I))
             WRITE(16,1044) (I,I=1,NP)
             DO 102    I=1,NP
             DO 100 J=1,I
 100         A(J,I) = D(J,I)/(E(I)*E(J))
 102         WRITE(16,1048)  I,(A(J,I),J=1,I)
C
C        -----CALCULATE 95% CONFIDENCE INTERVAL----------------
           Z=1./FLOAT(NOB-NP)
           SDEV = SQRT(Z*SUMB)
           WRITE(16,1052)
       TVAR=1.96 + Z*(2.3779 + Z*(2.7135+Z*(3.187936+2.466666*Z**2)))
           DO 108   I=1,NP
           SECOEF = E(I)*SDEV
           TVALUE = TH(I)/SECOEF
           TSEC = TVAR*SECOEF
           TMCOE = TH(I) - TSEC
           TPCOE = TH(I) + TSEC
           K=2*I
           J=K-1
 108    WRITE(16,1058)  BI(J),BI(K),TH(I),SECOEF,TVALUE,TMCOE,TPCOE
C
C      -------PREPARE FINAL OUTPUT ------------------------------
           LSORT(1) = 1
           DO 116  J=2,NOB
           TEMP=R(J)
           K=J-1
           DO 111 L=1,K
           LL=LSORT(L)
           IF(TEMP-R(LL)) 112,112,111
 111       CONTINUE
            LSORT(J) = J
            GO TO 116
 112        KK=J
 113        KK=KK-1
            LSORT(KK+1)=LSORT(KK)
            IF(KK-L) 115,115,113
 115        LSORT(L)=J
 116        CONTINUE
            WRITE(16,1066)
```

```
      DO 118 I=1,NOB
      J=LSORT(NOB+1-I)
  118 WRITE(16,1068) I,X(I),Y(I),F(I),R(I),J,X(J),Y(J),F(J),R(J)
C
C    -------WRITE HYDRAULIC PROPERTIES--------------
      WRITE(16,1069)
      PRESS =1.18850
      RN1=0.0
      RKLN=1.0
      WRITE(16,1072) RN1,WCS,RKLN,SATK
      DO 140  I=1,75
      IF(RKLN.LT.(-16.)) GO TO 142
      PRESS = 1.18850*PRESS
      IF (MODE-2) 120,122,120
  120 WCR=TH(1)
      ALPHA = TH(2)
      RN=TH(3)
      GO TO 124
  122 ALPHA=TH(1)
      RN=TH(2)
  124 RM=1.-1./RN
      IF(MODE.EQ.3)  RM=1.-2./RN
      RN1=RM*RN
      RWC=1./(1.+(ALPHA*PRESS)**RN)**RM
      WC=WCR+(WCS-WCR)*RWC
      TERM=1.-RWC*(ALPHA*PRESS)**RN1
    IF((TERM.LT.5.E-05).OR.(RWC.LT.0.06)) TERM=RM*RWC**(1./RM)
      IF (MODE.EQ.3) RK=RWC*RWC*TERM
      IF(MODE.NE.3) RK=SQRT(RWC)*TERM*TERM
  TERM=ALPHA*RN1*(WCS-WCR)*RWC*RWC**(1./RM)*(ALPHA*PRESS)**(RN-1.)
      AK=SATK*RK
      DIFFUS=AK/TERM
      PRLN=ALOG10(PRESS)
      AKLN=ALOG10(AK)
      RKLN=ALOG10(RK)
      DIFLN=ALOG10(DIFFUS)
  140 WRITE(16,1070) PRESS,PRLN,WC,RK,RKLN,AK,AKLN,DIFFUS,DIFLN
  142 CONTINUE
  144 CONTINUE
C
C      ----END OF PROBLEM--------------------------------------
 1000 FORMAT(4I5,5F10.0)
 1002 FORMAT(20A4)
 1004 FORMAT(1H1,10X,82(1H*)/11X,1H*,80X,1H*/11X,1H*,9X,'NON-LINEAR
     1LEAST SQUARES ANALYSIS',38X,1H*/11X,1H*,80X,1H*/11X,1H*,20A4,
     2 1H*/11X,1H*,80X,1H*/11X,82(1H*))
 1005 FORMAT(//11X,'INPUT PARAMETERS'/11X,16(1H=)/
     2 11X,'MODEL NUMBER.................................',I3/
     3 11X,'NUMBER OF COEFFICIENTS.......................',I3/
     4 11X,'NUMBER OF OBSERVATIONS.......................',I3/
     5 11X,'RESIDUAL MOISTURE CONTENT (FOR MODEL2).......',F10.4/
```

```
    6     11X,'SATURATED MOISTURE CONTENT...................',F10.4/
    7     11X,'SATURATED HYDRAULIC CONDUCTIVITY.............',F10.4)
 1006     FORMAT(4F10.0)
 1007     FORMAT(4(A4,A2,4X))
 1008   FORMAT(//11X,'OBSERVED DATA',/11X,13(1H=)/11X,'OBS. NO.',4X,
    2   'PRESSURE  HEAD',2X,'MOISTURE CONTENT')
 1011     FORMAT(11X,I5,5X,F12.2,4X,F12.4)
 1016    FORMAT(//5X,10(1H*),'ERROR:INCORRECT NUMBER OF COEFFICIENTS')
 1026     FORMAT(15X,I2,10X,F8.4,3X,F10.6,2X,F10.4,5X,F12.7,4X,I4)
 1028 FORMAT(//11X,'WCR IS LESS THAN 0.005, USE TWO-PARAMETER MODEL WITH
    2     WCR=0.0'  )
 1030  FORMAT(1H1,10X,'ITERATION NO',8X,'WCR',8X,'ALPHA',10X,'N', 13X,
    2       'SSQ',8X,'MODEL')
 1044  FORMAT(//11X,'CORRELATION MATRIX'/11X,18(1H=)/14X,10(4X,I2,5X))
 1048  FORMAT (11X,I3,10(2X,F7.4,2X))
 1052  FORMAT(//11X,'NON-LINEAR LEAST-SQUARES ANALYSIS: FINAL RESULTS'/
    1 11X,48(1H+)/64X,'95% PERCENT CONFIDENCE LIMITS'/11X,'VARIABLE',
    2 8X,'VALUE',7X,'S.E.COEFF.',3X,'T-VALUE',6X,'LOWER',10X,'UPPER')
 1058    FORMAT(13X,A4,A2,4X,F10.5,5X,F9.4,5X,F6.2,4X,F9.4,5X,F9.4)
 1066 FORMAT(//10X,8(1H-),'ORDERED BY COMPUTER INPUT',8(1H-),7X,10(1H-),
    1'ORDERED BY RESIDUALS',10(1H-)/26X,'MOISTURE CONTENT',3X,'RESI',
    124X,'MOISTURE CONTENT',3X,'RESI-'/10X,'NO',3X,'PRESSURE',5X,'OBS',
    2 4X,'FITTED',4X,'DUAL',9X,'NO',3X,'PRESSURE',5X,'OBS',4X,'FITTED',
    3     4X,'DUAL')
 1068     FORMAT(10X,I2,F10.2,1X,3F9.4,8X,I2,F10.2,1X,3F9.4)
 1069 FORMAT(1H1,10X,'PRESSURE',4X, 'LOG P',6X,'WC',7X,'REL K',5X,
    1  'LOG RK',    6X,'ABS K',4X,'LOG KA',5X,'DIFFUS',5X,'LOG D')
 1070     FORMAT(10X,E10.3,F8.3,F10.4,3(E13.3,F8.3))
 1072     FORMAT(10X,E10.3,8X,F10.4,E13.3,8X,E13.3)
          STOP
          END
          SUBROUTINE MATINV(A,NP,B)
          DIMENSION A(3,3),B(3),INDEX(3,2)
          DO 2 J=1,4
 2        INDEX(J,1)=0
          I=0
 4        AMAX=-1.0
          DO 11 J=1,NP
          IF(INDEX(J,1)) 11,6,11
 6        DO 10 K=1,NP
          IF(INDEX(K,1)) 10,8,10
 8        P= ABS(A(J,K))
          IF(P.LE.AMAX) GO TO 10
          IR=J
          IC=K
          AMAX=P
 10       CONTINUE
11        CONTINUE
          IF(AMAX) 30,30,14
 14       INDEX(IC,1)=IR
          IF(IR.EQ.IC) GO TO 18
```

```
      DO 16 L=1,NP
      P=A(IR,L)
      A(IR,L)=A(IC,L)
16    A(IC,L)=P
      P=B(IR)
      B(IR)=B(IC)
      B(IC)=P
      I=I+1
      INDEX(I,2)=IC
18    P=1./A(IC,IC)
      A(IC,IC)=1.0
      DO 20 L=1,NP
20    A(IC,L)=A(IC,L)*P
      B(IC)=B(IC)*P
      DO 24 K=1,NP
      IF(K.EQ.IC) GO TO 24
      P=A(K,IC)
      A(K,IC)=0.0
      DO 22 L=1,NP
22    A(K,L)=A(K,L)-A(IC,L)*P
      B(K)=B(K)-B(IC)*P
24    CONTINUE
      GO TO 4
26    IC=INDEX(I,2)
      IR=INDEX(IC,1)
      DO 28 K=1,NP
      P=A(K,IR)
      A(K,IR)=A(K,IC)
28    A(K,IC)=P
      I=I-1
30    IF(I) 26,32,26
32    RETURN
      END
      SUBROUTINE MODEL (B,FY,NOB,X,WCS,MODE,NP,WCR)
      DIMENSION B(3),FY(40),X(40)
C
C     MODE=1  :MUELEM THEORY WITH THREE COEFFICIENTS
C     MODE=2  :MUELEM THEORY WITH TWO COEFFRICIENTS
C     MODE=3  :BURDINE THEORY WITH THREE COEFFICIENTS
C
      IF (MODE-2) 10,20,30
10    CONTINUE
      DO 12 J=1,NOB
12    FY(J)=B(1)+(WCS-B(1))/(1.+(B(2)*X(J))**B(3))**(1.-1./B(3))
      RETURN
20    CONTINUE
      DO 22 J=1,NOB
22    FY(J)=WCR+(WCS-WCR)/(1.+(B(1)*X(J))**B(2))**(1.-1./B(2))
      RETURN
30    CONTINUE
      DO 32 J= 1,NOB
```

```
32          FY(J)=B(1)+(WCS-B(1))/(1.+(B(2)*X(J))**B(3))**(1.-2./B(3))
            RETURN
            END
```