Soil Hydraulic Conductivity Data (FIFE)

Summary:

The Soil Hydraulic Conductivity Data Set contains soil hydraulic conductivity, matric flux potential, and soil depth data collected during the 1989 FIFE soil properties investigation. The purpose of the 1989 FIFE soil properties investigation was to obtain more points on the soil moisture release curves for the soils at the FIFE stations, and provide values for the saturated hydraulic conductivity for the long-term water balance studies.

In-situ measurements of field-saturated hydraulic conductivity were made using the constant well head permeameter method. These measurements were made at five sites, each representing a different soil series. The constant well head method for hydraulic conductivity involves augering a hole to the desired depth and measuring the steady state flow rate of water into the hole while maintaining a constant head of water inside the hole. Six measurements were made at each of the two soil depths at each site. The hydraulic conductivity measurements were made at the same depths and close to (< 1 m away from) the location where samples for moisture release measurements were taken.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Soil Hydraulic Conductivity Data (FIFE).

Data Set Introduction:

The Soil Hydraulic Conductivity Data Set contains soil hydraulic conductivity, matric flux potential, and soil depth data collected during the 1989 FIFE soil properties investigation.

Objective/Purpose:

The purpose of the 1989 FIFE soil properties investigation was to obtain more points on the soil moisture release curves for the soils at the FIFE stations, and provide values for the saturated hydraulic conductivity for the long-term water balance studies.

Summary of Parameters:

Soil hydraulic conductivity, matric flux potential, and soil depth.

Discussion:

In-situ measurements of field-saturated hydraulic conductivity were made using the constant well head permeameter method. The method is also known as the dry auger hole method. These measurements were made at five sites, each representing a different soil series.

Related Data Sets:

- Soil Moisture Release.
- Neutron Probe Soil Moisture.
- Gravimetric Soil Moisture.
- Soil Properties Reference Information.

FIS Data Base Table Name:

SOIL_HYDRAULIC_CONDUCT_REF.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Edward T. Kanemasu, Leader
Kansas State University

Title of Investigation:

Soil Properties Measurements for FIFE.

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Requested Form of Acknowledgment.

The Soil Hydraulic Conductivity data were collected for FIFE by the staff of the Evapotranspiration Laboratory at Kansas State University.

3. Theory of Measurements:

The constant well head method for hydraulic conductivity involves augering a hole to the desired depth and measuring the steady state flow rate of water into the hole while maintaining a constant head of water inside the hole. Six measurements were made at each of the two soil depths at each site. The hydraulic conductivity measurements were made at the same depths and close to (< 1 m away from) the location where samples for moisture release measurements were taken.

4. Equipment:

Sensor/Instrument Description:

Auger, Guelph permeameter, and brush.

Collection Environment:

Ground.

Source/Platform:

Ground.

Source/Platform Mission Objectives:

The goal was to determine the soil hydraulic conductivity by the shallow well pump-in technique, also referred to as constant head well permeameter or dry auger hole method.

Key Variables:

Field-saturated hydraulic conductivity, and matric flux potential.

Principles of Operation:

A hole is bored to the desired depth in the soil, and a constant head of water is maintained in the hole. When the water flow into the soil reaches a constant value, i.e., a steady-state condition, the flow is measured while the level is kept constant.

Sensor/Instrument Measurement Geometry:

A cylindrical hole 6 cm in diameter and 7-10 cm deep for the shallow depth measurements, and 30 cm or more for greater depths.

Manufacturer of Sensor/Instrument:

Guelph Permeameter:
Soil Moisture Equipment Corp.
P.O. Box 30025
Santa Barbara, CA 93105.

Calibration:

Unknown at this date.

Specifications:

Not available.

Tolerance:

Not available.

Frequency of Calibration:

Not available.

Other Calibration Information:

Not available.

5. Data Acquisition Methods:

The hydraulic conductivity measurements were done at two depths for each of five stations (see the *Spatial Coverage Section*). One set of measurements were made at 5-10 cm depth, and another set at a greater depth where a significant change in soil texture or structure was observed.

A 6 cm diameter hole was augered out to the desired depth. This was usually 7-10 cm for the shallower depth and 30 cm or more for the lower depth. The hole was brushed with a stiff cylindrical brush to try to remove any smearing of the hole walls caused by the auger. For setting up a constant head of water in the hole and for monitoring the rate of flow of water into the hole, the Guelph Permeameter was used. This apparatus employs the Mariotte principle to maintain a constant head of water. The rate of discharge of water from the apparatus into the hole was read at regular time intervals, until at least three consecutive readings gave the same rate of discharge (this usually took between 1 to 2 hours). This was assumed to be the steady-state flow rate into the hole. Hydraulic conductivity was calculated as described in the *Derivation Techniques and Algorithms Section*.

6. Observations:

Data Notes:

Not available.

Field Notes:

Six replicate measurements were made in the WAB of each site. See the *Spatial Coverage Section* for location of replicates.

The maximum value for saturated hydraulic conductivity ([cm][sec^-1]) is calculated by setting alpha to infinity, so that all flow is attributed to saturated terms.

The maximum matric flux potential ([cm^2][sec^-1]) is calculated by setting alpha = 0 in the calculation of phi.

7. Data Description:

Spatial Characteristics:

The FIFE study area, with areal extent of 15 km by 15 km, is located south of the Tuttle Reservoir and Kansas River, and about 10 km from Manhattan, Kansas, USA. The northwest corner of the area has UTM coordinates of 4,334,000 Northing and 705,000 Easting in UTM Zone 14.

Spatial Coverage:

The soil hydraulic conductivity and moisture release measurements were made at the following five locations on different soil series:

SITEGRID	STN	SOIL SERIES	NORTHING	EASTING	LATITUDE	LONGITUDE
2915-BRK	12	Benfield	4328167	708028	39 04 47	-96 35 42
2133-ECA	906	Clime	4329726	711604	39 05 34	-96 33 12
4439-ECV	916	Dwight	4325193	712773	39 03 06	-96 32 28
4168-SAM	925	Florence	4325704	718646	39 03 18	-96 28 24
2655-BRL	936	Tully	4328787	716070	39 05 00	-96 30 07

SITEGRID	ELEV	SLOPE	ASPECT
2915-BRK	415		
2133-ECA	443	1	TOP
4439-ECV	443	2	N
4168-SAM	438	1	TOP
2655-BRL	367	4	E

Except for Sitegrid 2915-SHC, the measurements were made inside the permanent WAB (Wind Aligned Blobs), i.e., between 140 and 240 degrees of the compass and about 50 to 60 m from where the flux stations were located. At Sitegrid 2915-SHC, there was a rapid change of soil type when moving along the slope away from the location of the station. At this site, the measurements were made along a line perpendicularly across the slope and within 5 to 20 m of the location of the flux station.

Spatial Coverage Map:

Not available.

Spatial Resolution:

These are point data. The hydraulic conductivity measurements were made at the same depths and close to (< 1 m away from) the location where samples for moisture release measurements were taken (see Soil Moisture Release document on FIFE CD-ROM Volume 1).

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

These data were collected during the 1989 Intensive Field Campaign, July 24 through August 12, 1989.

Temporal Coverage Map:

Not available.

Temporal Resolution:

One to 2 hours per measurement.

Data Characteristics:

The SQL definition for this table is found in the SOILHYDC.TDF file located on FIFE CD-ROM Volume 1.

Parameter/Variable Name

Parameter/Variable Description	Range	Units	Source
SITEGRID_ID This is a FIS grid location code. Site grid codes (SSEE-III) give the south (SS) and east (EE) cell number in a 100 x 100 array of 200 m square cells. The last 3 characters (III) are an instrument identifier.			
STATION_ID The station ID designating the location of the observations.			
PLOT_NUM The plot number, six measurements were taken in the WAB at each site.			
DEPTH The greatest depth of the auger hole.		[cm]	
HYDRO_CONDCTVTY The best estimate of the field-saturated hydraulic conductivity.		[cm] [sec^-1]	

MAX_HYDRO_CONDCTVTY
The maximum value for saturated hydraulic conductivity, i.e. all flow is attributed to saturated terms. [cm] [sec^-1]

MATRIC_FLUX_POTNTL
The best estimate of matric flux potential. [cm^2] [sec^-1]

MAX_MATRIC_FLUX_POTNTL
The maximum matric flux potential. [cm^2] [sec^-1]

FIFE_DATA_CRTFCN_CODE *
The FIFE Certification Code for the data, in the following format: CPI (Certified by PI), CPI-??? (CPI - questionable data).

LAST_REVISION_DATE
data, in the format (DD-MMM-YY).

Footnote:

Decode the FIFE_DATA_CRTFCN_CODE field as follows:

The primary certification codes are: EXM Example or Test data (not for release). PRE Preliminary (unchecked, use at your own risk). CPI Checked by Principal Investigator (reviewed for quality). CGR Checked by a group and reconciled (data comparisons and cross-checks).

The certification code modifiers are: PRE-NFP Preliminary - Not for publication, at the request of investigator. CPI-MRG PAMS data that are "merged" from two separate receiving stations to eliminate transmission errors. CPI-??? Investigator thinks data item may be questionable.

Sample Data Record:

SITEGRID_ID	STATION_ID	PLOT_NUM	DEPTH	HYDRO_CONDCTVTY	MAX_HYDRO_CONDCTVTY
2133-SHC	906	1	7	.00071000	.00190000
2133-SHC	906	2	7	.00045000	.00120000
2133-SHC	906	3	7	.00032000	.00088000
2133-SHC	906	4	7	.00039000	.00110000

MATRIC_FLUX_POTNTL	MAX_MATRIC_FLUX_POTNTL	FIFE_DATA_CRTFCN_CODE
.00590000	.00930000	CPI
.00380000	.00590000	CPI
.00270000	.00420000	CPI
.00320000	.00510000	CPI

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     LAST_REVISION_DATE
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04-MAR-92
04-MAR-92
04-MAR-92
04-MAR-92
```

8. Data Organization:

Data Granularity:

These are point data made at the five locations with the FIFE study area. The hydraulic conductivity measurements were made at the same depths and close to (< 1 m away from) the location where samples for moisture release measurements were taken (see Soil Moisture Release document on FIFE CD-ROM Volume 1).

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary.

Data Format:

The CD-ROM file format consists of numerical and character fields of varying length separated by commas. The character fields are enclosed with a single apostrophe. There are no spaces between the fields. Each file begins with five header records. Header records contain the following information: Record 1 Name of this file, its table name, number of records in this file, path and name of the document that describes the data in this file, and name of principal investigator for these data. Record 2 Path and filename of the previous data set, and path and filename of the next data set. (Path and filenames for files that contain another set of data taken at the same site on the same day.) Record 3 Path and filename of the previous site, and path and filename of the next site. (Path and filenames for files of the same data set taken on the same day for the previous and next sites (sequentially numbered by SITEGRID_ID)). Record 4 Path and filename of the previous date, and path and filename of the next date. (Path and filenames for files of the same data set taken at the same site for the previous and next date.) Record 5 Column names for the data within the file, delimited by commas. Record 6 Data records begin.

Each field represents one of the attributes listed in the chart in the *Data Characteristics Section* and described in detail in the TDF file. These fields are in the same order as in the chart.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

Several formulae have been developed for estimating the saturated hydraulic conductivity (K(0)) (units [cm][sec^-1]) from the steady-state flow rate of water into the hole and the head of water

in the hole (e.g., Zangar 1953; Stephens and Neuman 1982; Philip 1985). The approximate analytic solution of Reynolds et al. (1985) were used, where:

Q = [(2 * pi * H^2 / C) + pi * a^2] K(0) + (2 * pi *H / C) phi = AK(0) + Bphi

where:

A = (2 * pi * H^2 / C) + pi * a^2
B = 2 * pi * H / C

Q is the steady state flow rate of water into the well hole [cm^3][sec^-1], **H** is the depth of water in the hole [cm], **a** is the radius of the auger hole [cm] and **C** is a dimensionless shape parameter that depends mainly on the **H/a** ratio and to a lesser extent on the **K(0)/phi** ratio (see Reynolds et al., 1985). **phi** is the matric flux potential [cm^2][sec^-1] and is given by:

phi = Integral of [K(psi) dpsi] from **psii**, the starting soil water potential to **psi0**, soil water potential of zero.

K(0) and **phi** are then given by:

K(0) = Q / (A + B / alpha)
phi = Q / (A * alpha + B)

where:

alpha = K(0) / phi

Data Processing Sequence:

Processing Steps:

Not applicable.

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

The main problem, however, is that we do not know the value of alpha (see the *Derivation Techniques and Algorithms Section*). Elrick and Reynold (1989) showed that the calculation of **K(0)** is not strongly influenced by the value of **alpha**, which varies from .01 to 1.0 [cm^-1], and that for most soils a value of about 0.12 [cm^-1] can be assumed (Dave Elrick, personal communication).

Calculated Variables:

- Saturated hydraulic conductivity, and
- Matric flux potential.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

The lower depth measurements of saturated hydraulic conductivity were problematic. Because of the high clay content (see Soil Properties Reference Information document on FIFE CD-ROM Volume 1), it was difficult to auger out a hole without smearing the walls. Even brushing with a stiff brush was not very effective at eliminating the smearing effect. The two alternative values are probably more reliable than our measured values at the lower depth.

Quality Assessment:

Data Validation by Source:

Not available at this revision.

Confidence Level/Accuracy Judgment:

No information on this was provided by the investigators.

Measurement Error for Parameters:

No quantitative assessment was made, see the *Confidence Level/Accuracy Judgment Section*.

Additional Quality Assessments:

FIS staff applied a general Quality Assessment (QA) procedure to these data to identify inconsistencies and problems for potential users. As a general procedure, the FIS QA consisted of examining the maximum, minimum, average, and standard deviation for each numerical field in the data table. An attempt was made to find an explanation for unexpected high or low values, values outside of the normal physical range for a variable, or standard deviations that appeared inconsistent with the mean. In some cases, histograms were examined to determine whether outliers were consistent with the shape of the data distribution.

The discrepancies, that were identified, are reported as problems in the *Known Problems with the Data Section*.

Data Verification by Data Center:

The data verification performed by the ORNL DAAC deals with the quality of the data format, media, and readability. The ORNL DAAC does not make an assessment of the quality of the data itself except during the course of performing other QA procedures as described below.

The FIFE data were transferred to the ORNL DAAC via CD-ROM. These CD-ROMs are distributed by the ORNL DAAC unmodified as a set or in individual volumes, as requested. In addition, the DAAC has incorporated each of the 98 FIFE tabular datasets from the CD-ROMs into its online data holdings. Incorporation of these data involved the following steps:

- Copying the entire FIFE Volume 1, maintaining the directory structure on the CD-ROM;
- Using data files, documentation, and SQL code provided on the CD-ROM to create a database in Statistical Analysis System (SAS); and
- Creating transfer files to transfer the SAS metadata database to Sybase tables.

Each distinct type of data (i.e. "data set" on the CD-ROM), is accompanied by a documentation file (i.e., .doc file) and a data format/structure definition file (i.e., .tdf file). The data format files on the CD-ROM are Oracle SQL commands (e.g., "create table") that can be used to set up a relational database table structure. This file provides column/variable names, character/numeric type, length, and format, and labels/comments. These SQL commands were converted to SAS code and were used to create SAS data sets and subsequently to input data files directly from the CD-ROM into a SAS dataset. During this process, file names and directory paths were captured and metadata was extracted to the extent possible electronically. No files were found to be corrupted or unreadable during the conversion process.

Additional Quality Assurance procedures were performed as follows:

- Statistical operations were performed to calculate minimum and maximum values for all numeric fields and to create a listing of all values of the character fields. During this process, it was determined that various conventions were used to represent missing values. (Note: no modifications were made to any data by the DAAC). In most cases, missing value identification conventions were discussed in the accompanying .doc file. Based on a visual check of the minimum and maximum values, no glaring errors or holes were identified that might indicate errors introduced during CD-ROM mastering by the FIFE project or data ingest by the DAAC.
- Some minor inconsistencies and typographical errors were identified in some of the character fields and column labels, however, no modifications were made to the data by the DAAC.
- Some conversions of ASCII data were necessary to move the data from a DOS platform to a UNIX platform. Standard operating system conversion utilities were used (e.g., dos2unix).
- Much of the metadata required for archival is imbedded in the narrative documentation accompanying the data sets and extracted manually by DAAC staff who have read the .doc files provided on the CD-ROM and have hand entered this information into the metadata database maintained by the DAAC. QA procedures have been performed on

these metadata to identify and eliminate typographical errors and inconsistencies in naming conventions, to ensure that all required metadata is present, and to ensure the accuracy of file names and paths for retrieval.
- Data requested for distribution to users are checked to verify that files copied from disk to other media remain uncorrupted.

As errors are discovered in the online tabular data by investigators, users, or DAAC staff, corrections are made in cooperation with the principal investigators. These corrections are then distributed to users. CD-ROM data are corrected when re-mastering occurs for replenishment of CD-ROM stock.

11. Notes:

Limitations of the Data:

Not available.

Known Problems with the Data:

None.

Usage Guidance:

This data set can be used in conjunction with the soil water release and soil thermal conductivity data to describe heat and moisture transfer for the soil types at the FIFE study area. Some of these calculations have been done and appear in the Soil Water Properties data set. The Soil Properties Reference Information documents and data sets survey has descriptions of soil properties.

Any Other Relevant Information about the Study:

It should be noted that Bill Wehmueller (USDA, SCS) and Micky Ransom (Agronomy Dept., KSU), who are familiar with the soils of Riley county and surrounding areas, warn that the soils on the Konza Prairie Natural Research Area are very heterogeneous. A change of soil-type can frequently be observed along a transect of 20 meters or so. With the exception of site 712, all of our measurements were taken within the WAB zone and about 50-60 m from the WAB apex (see above), thus it is possible that parts of the WAB area not sampled by us were of a different soil type.

12. Application of the Data Set:

This data set can be used in conjunction with the soil water release and soil thermal conductivity data to describe heat and moisture transfer for the soil types at the FIFE study area.

13. Future Modifications and Plans:

The FIFE field campaigns were held in 1987 and 1989 and there are no plans for new data collection. Field work continues near the FIFE site at the Long-Term Ecological Research (LTER) Network Konza research site (i.e., LTER continues to monitor the site). The FIFE investigators are continuing to analyze and model the data from the field campaigns to produce new data products.

14. Software:

Software to access the data set is available on the all volumes of the FIFE CD-ROM set. For a detailed description of the available software see the *Software Description Document*.

15. Data Access:

Contact Information:

ORNL DAAC User Services
Oak Ridge National Laboratory

Telephone: (865) 241-3952
FAX: (865) 574-4665

Email: ornldaac@ornl.gov

Data Center Identification:

ORNL Distributed Active Archive Center
Oak Ridge National Laboratory
USA

Telephone: (865) 241-3952
FAX: (865) 574-4665

Email: ornldaac@ornl.gov

Procedures for Obtaining Data:

Users may place requests by telephone, electronic mail, or FAX. Data is also available via the World Wide Web at http://daac.ornl.gov.

Data Center Status/Plans:

FIFE data are available from the ORNL DAAC. Please contact the ORNL DAAC User Services Office for the most current information about these data.

16. Output Products and Availability:

The Soil Hydraulic Conductivity data are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

\DATA\SOILPROP\SOILHYDC\1987MULT.SHC

17. References:

Satellite/Instrument/Data Processing Documentation.

Amoozegar, A., and A.W. Warrick. 1986. Hydraulic conductivity of saturated soils: Field methods. In: Methods of Soil Analysis Part 1 Physical and Mineralogical Methods. Agronomy Monograph No. 9 (2nd Edition) pp. 735-770. Amer. Soc. Agron. Madison.

Journal Articles and Study Reports.

Elrick, D.E. and Reynolds, W.D. 1989. Water Flux Components and their measurements. Proc. App. Soil Physics in Stress Environments. Jan 22-26 NARC. Islamabad, Pakistan.

Philip, J.R. 1985. Approximate analysis of the borehole permeameter in unsaturated soil. Water Resources Res. 21:1025-1033.

Reynolds, W.D., D.E. Elrick, and B.E. Clothier. 1985. The constant head well permeameter: Effect on unsaturated flow. Soil Sci.139:172-180.

Stephens, D.B. and S.P. Neuman. 1982. Vadose zone permeability tests: Summary. J Hydraul. Div. Amer. Soc. Civ. Eng. 108:623-639.

Zangar, C.N. 1953. Theory and problems of water percolation. U.S. Dept. Interior. Bureau of Reclamation. Eng. Monogr. 8. Denver, Colorado.

Archive/DBMS Usage Documentation.

Contact the EOS Distributed Active Archive Center (DAAC) at Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee (see the *Data Center Identification Section*). Documentation about using the archive and/or online access to the data at the ORNL DAAC is not available at this revision.

18. Glossary of Terms:

A general glossary for the DAAC is located at Glossary.

19. List of Acronyms:

CD-ROM Compact Disk-Read Only Memory DAAC Distributed Active Archive Center EOSDIS Earth Observing System Data and Information System FIFE First ISLSCP Field Experiment FIS FIFE Information System ISLSCP International Satellite Land Surface Climatology Project ORNL Oak Ridge National Laboratory URL Uniform Resource Locator UTM Universal Transverse Mercator WAB Wind Aligned Blobs

A general list of acronyms for the DAAC is available at Acronyms.

20. Document Information:

May 4, 1994 (citation revised on October 15, 2002).

Warning: This document has not been checked for technical or editorial accuracy by the FIFE Information Scientist. There may be inconsistencies with other documents, technical or editorial errors that were inadvertently introduced when the document was compiled or references to preliminary data that were not included on the final CD-ROM.

Previous versions of this document have been reviewed by the Principal Investigator, the person who transmitted the data to FIS, a FIS staff member, or a FIFE scientist generally familiar with the data.

Document Review Date:

June 27, 1996.

Document ID:

ORNL-FIFE_SOILHYDC.

Citation:

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National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, U.S.A. (available from http://www.daac.ornl.gov).

Document Curator:

DAAC Staff

Document URL:

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