DOE/ID-22171

HYDROLOGIC AND METEOROLOGICAL DATA FOR AN UNSATURATED-ZONE STUDY AREA NEAR THE RADIOACTIVE WASTE MANAGEMENT COMPLEX, IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY, IDAHO 1997 TO 1999

U.S. GEOLOGICAL SURVEY
OPEN-FILE REPORT 00-248

Prepared in cooperation with the

U.S. DEPARTMENT OF ENERGY

USGS

science for a changing world

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By Kim S. Perkins

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Idaho Falls, Idaho
2000

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
CHARLES G. GROAT, Director

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Box 25286, Federal Center
Denver, CO 80225

CONTENTS

FIGURES

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED UNITS

Multiply	By	To obtain
Millimeter (mm)	0.03937	Inch
Centimeter (cm)	0.3937	Inch
Meter (m)	3.281	Foot
Square kilometer (km^2)	0.3861	Square mile
Cubic centimeter (cm^3)	0.06102	Cubic inch
Gram (g)	0.03527	Ounce
Kilogram (kg)	2.205	Pound
Gram per cubic centimeter (g/cm^3)	62.4220	Pound per cubic foot

For temperature, degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by using the equation:
°F = (1.8)(°C) + 32.

Abbreviated unit used in report:: mol/L (mole per liter)

FIGURES

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED [illegible]

[illegible]

Hydrologic and Meteorological Data for an Unsaturated-Zone Study Area near the Radioactive Waste Management Complex, Idaho National Engineering and Environmental Laboratory, Idaho, 1997 to 1999

By Kim S. Perkins

Abstract

The Radioactive Waste Management Complex (RWMC) Subsurface Disposal Area (SDA) at the Idaho National Engineering and Environmental Laboratory (INEEL) has been used for burial of radioactive waste since 1952. In 1985, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, began a multi-phase study of the geohydrology of the RWMC to provide a basis for estimating the extent of and the potential for migration of radionuclides in the unsaturated zone beneath the waste trenches and pits. This is the final phase in a study to provide hydrologic and meteorological data collected at a designated test trench area established by the U.S. Geological Survey in 1985 adjacent to the northern boundary of the RWMC SDA.

Soil-moisture content measurements were collected approximately monthly during the 1997–99 period from 13 neutron-probe access holes with a neutron moisture gage. A meteorological station inside the test trench area provides data for the determination of evapotranspiration rates. This station measures soil surface temperature, net radiation, air temperature, relative humidity, windspeed, wind direction, soil heat flux, and precipitation, and also calculates vapor pressure. Meteorological data for the test trench area are available for 1997 and part of 1998. The meteorological and soil-moisture data are contained in files on a compact disk included with this report. The data are presented in simple American Standard Code for Information Interchange (ASCII) format with tab-delimited fields.

INTRODUCTION

The Radioactive Waste Management Complex (RWMC), which is managed by the U.S. Department of Energy (DOE), occupies about 0.66 km^2 of the Idaho National Engineering and Environmental Laboratory (INEEL) in southeastern Idaho (fig. 1). From 1952 to 1970, chemical, low-level radioactive, and transuranic wastes were buried in trenches and pits excavated into the surficial sediments at the RWMC Subsurface Disposal Area (SDA). Since 1970, only low-level radioactive waste has been buried; transuranic waste has been stored on above-ground asphalt pads in retrievable containers. As of 1986, about 180,000 m^3 of radioactive wastes and an estimated 335 m^3 of organic wastes (Pittman, 1995) had been buried at the SDA.

Waste materials buried at the RWMC and waste water at INEEL have been principal sources of radioactive and chemical waste constituents in water from the Snake River Plain aquifer. Radionuclides have been detected in core and drill cuttings from several boreholes drilled into the surficial sediments and underlying rock units at the RWMC (Barraclough and others, 1976, Laney and others, 1988).

Purpose and Scope

The purpose of this report is to provide site-specific data needed to estimate recharge to the Snake River Plain aquifer. Recharge is one of the primary factors influencing the potential migration of radionuclides in the unsaturated zone. The quantity of water that moves through the buried waste depends on the timing and amount of inputs

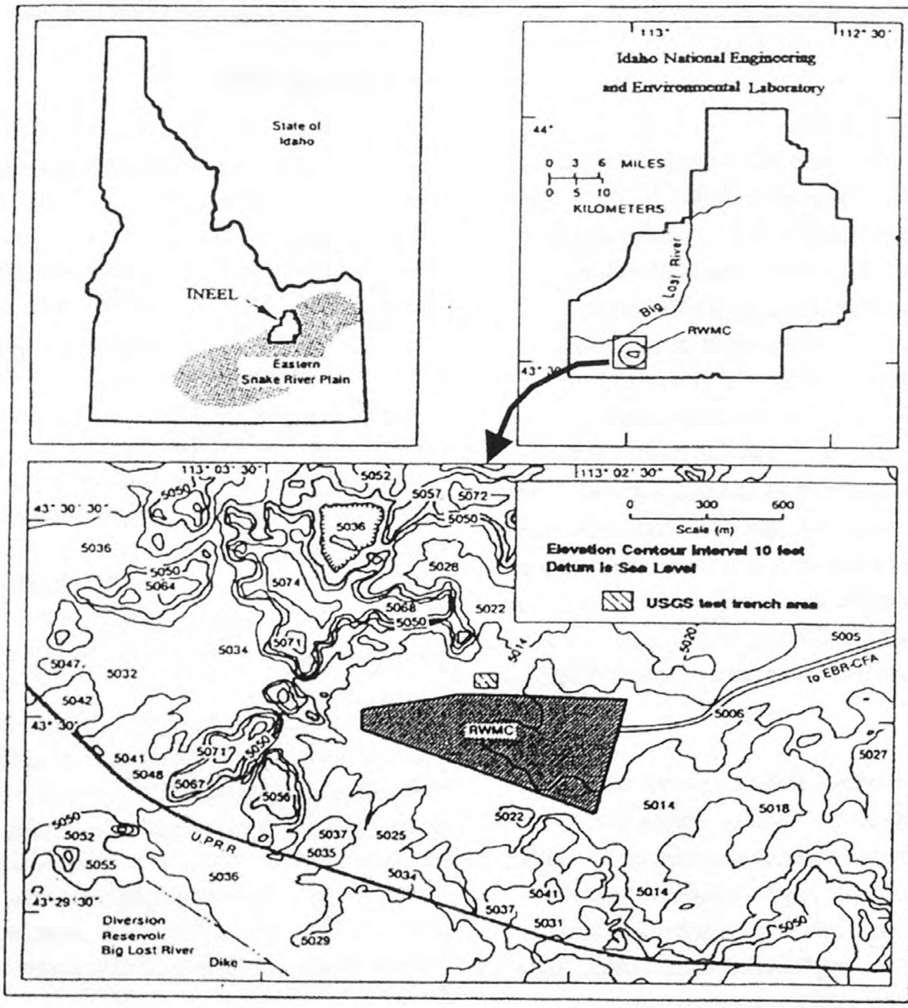

Figure 1. Location of the Idaho National Engineering and Environmental Laboratory (INEEL) Subsurface Disposal Area (SDA) of the Radioactive Waste Management Complex (RWMC), and the USGS test trench area.

such as rainfall and snowmelt, on meteorological variables, and on soil hydraulic properties. This report presents available hydrologic and meteorological data collected during 1997–99. Prior reports present data for 1985–86 (Pittman, 1989), 1987 (Davis and Pittman, 1990), 1988–89 (Pittman, 1995), and 1990–96 (Perkins and others, 1998).

Acknowledgments

Technical support in neutron moisture probe data logging during 1997–99 was provided by the following USGS Water Resources Division employees: Michael R. Greene, Brian V. Twining, Daniel J. Ackerman, and Stacy J. Learch.

PHYSICAL AND GEOLOGIC SETTING

The eastern Snake River Plain is a structural basin about 325 km long and 80 to 110 km wide, bounded by mountain ranges and high plateaus. Streams within alluvial valleys separating the mountain ranges to the north and northwest flow onto the plain and the INEEL in response to rainfall and snowmelt.

The eastern Snake River Plain is underlain by a sequence of basaltic lava flows interbedded with sedimentary deposits. The sediments consist of fluvial, lacustrine, and eolian deposits of clay, silt, sand, and gravel. Substantial sedimentary deposits occur at depths of about 9, 34, and 73 m below land surface. Rhyolitic lava flows and tuffs crop out locally at the surface and occur at depth below the basalt-sediment sequence (Mann, 1986). The INEEL occupies about 2,300 km^2 of semiarid sagebrush-covered terrain on the northwestern side of the plain.

The RWMC is in the southwestern part of the INEEL in a shallow topographic depression. The surficial sediments at the RWMC consist of about 0.6 to 7.0 m of clay, silt, sand, and gravel. The deposit at 73-m depth underlies all of the RWMC and may underlie a large part of the INEEL. The deposits at 9- and 34-m depth are discontinuous, although the deposit at 34-m depth underlies a large part of the RWMC. Other sedimentary deposits of lesser areal extent occur at depth at the RWMC.

USGS Test Trench Area

The study area for this project, designated the test trench area, is adjacent to the northern boundary of the RWMC SDA. The dominant vegetation in the test trench area consists of big sagebrush (*Artemisia tridentata ssp. wyomingenis*) and crested wheatgrass (*Agropyron cristatum*). The thickness of the surficial sediments in the test trench area ranges from about 3 to 6 m.

The test trench area was constructed in 1985 for use in unsaturated zone investigations. A 61- by 46-m area was fenced to preserve natural vegetation and to prevent vehicular traffic. The test trench area is modeled after those described by Morgan and Fischer (1984). Three distinct trenches in this area are designated as east, west, and simulated-waste trenches (fig. 2). Pittman (1989) describes the conceptual design and procedures used for construction of the test trenches. The area contains 13 numbered neutron-probe access holes which were used to measure soil moisture contents at various depths. Access holes 2 and 9 are located within the undisturbed restricted-foot-traffic areas adjacent to the east and west trenches. Holes 15, 17, 19, and 21 are located within the disturbed soil of the simulated-waste trench. Access holes 1, 4, 7, 10, 16, 18, and 20 are located outside the test trenches within the undisturbed area.

During August 1990, an infiltration test was performed in the undisturbed restricted-foot-traffic area near the west test trench. An area 2 by 4.4 m was ponded with 8 cm of water for 24 hours on August 16–17 followed by drainage and redistribution (Kaminsky, 1991). In August 1994 another infiltration test was conducted using the same techniques within the simulated-waste trench (Nimmo and others, 2000). These tests have likely had some effect on the hydraulic properties of the soil.

Hydrologic Data

The soil moisture content data presented here were obtained with a neutron moisture probe containing a source of fast high-energy neutrons and a slow (thermal) neutron detector. Hydrogen present in the soil water slows the movement of

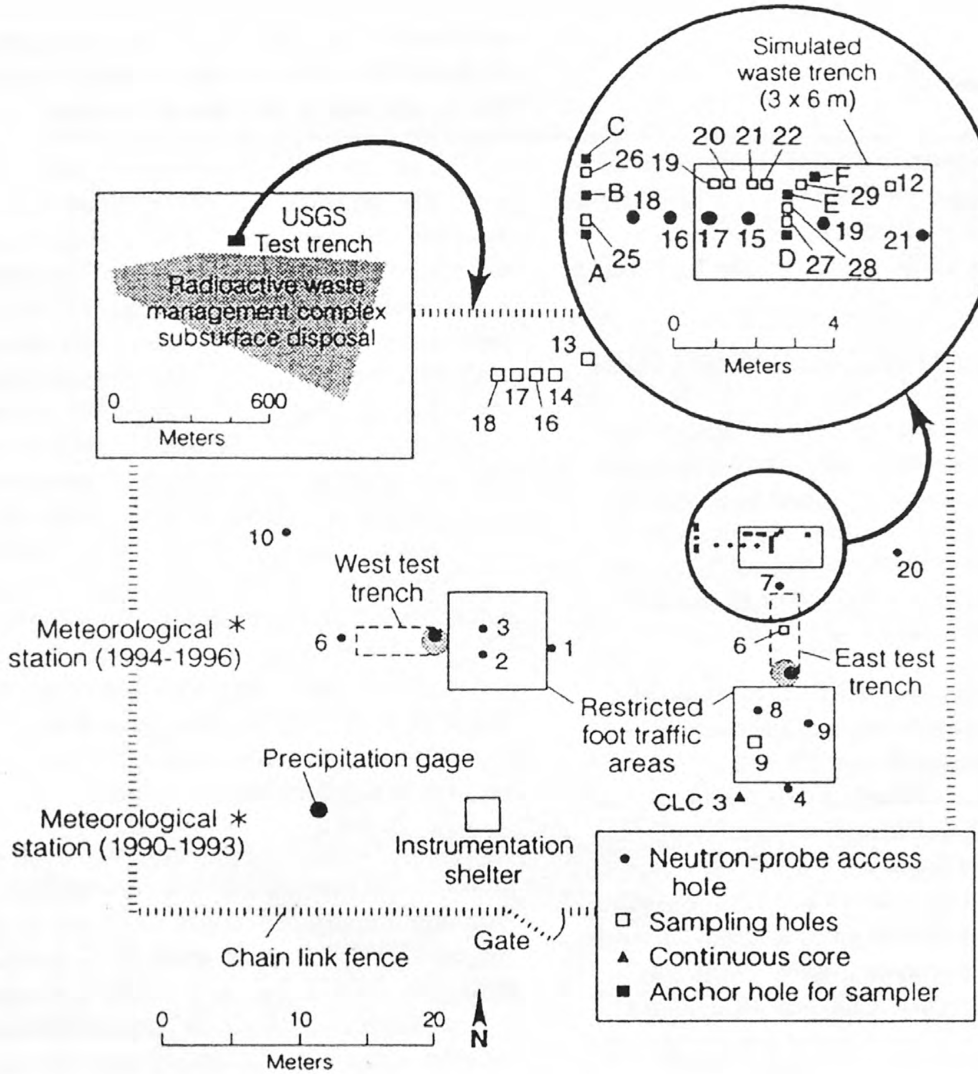

Figure 2. Location of the USGS Test Trench area (relative to the Radioactive Waste Management Complex (RWMC)), monitoring facilities, and soil sample collection sites.

neutrons for detection by the probe. The probe is lowered into an aluminum cased hole to a specified depth where slow neutrons are measured. Volumetric water content is then calculated from these raw neutron counts (Campbell Pacific Nuclear, 1984, p. 1).

Calibration equations based on linear regressions of the neutron-probe data were developed using the calculated volumetric water content of the soil cores and the ratio of the raw neutron count to the standard count computed by the neutron probe. A single calibration equation for undisturbed soil was developed for field data from the neutron probe (Pittman, 1989, p. 12) and was used in calculating moisture content in both the undisturbed and disturbed soil. The raw counts were converted to volumetric water contents using this calibration equation. The standard error of the volumetric water content, which was based on the calibration equation, was ±2.8 percent.

During 1997–99, soil-moisture content was measured approximately monthly in 13 neutron-probe access holes completed in disturbed and undisturbed soil. Moisture contents are presented as percent by volume at various depths in meters below the surface. Soil-moisture profiles generally were driest in September and wettest in April or May after infiltration from snowmelt or rainfall. Temporal variations in moisture content tended to decrease with increasing depth. Few temporal variations were observed in moisture content below 3 m. Soil-moisture content profiles for all holes are included in the Appendix.

METEOROLOGICAL DATA

Evapotranspiration, which can be calculated using various meteorological data, is one of the factors affecting the amount of water that infiltrates the surficial sediments and eventually recharges the aquifer. The meteorological instrumentation used during 1997–98 includes: (1) two sets of thermocouple probes and two heat flux plates to measure soil heat flux in watts per square meter; (2) a net radiometer to measure net radiation in watts per square meter; (3) two thin-film-capacitance-change probes and thermistors to measure relative humidity in kilopascals and air temperature in degrees Celsius at 1 and 2 m above land surface; (4) one anemometer to measure windspeed in meters per second; (5) a wind vane to measure wind direction in degrees; and 6) a heated rain gage to measure precipitation in millimeters.

Vapor pressure is calculated in kilopascals using temperature and relative humidity data (Fritchen and Gay, 1979). The sensors were scanned every 20 seconds with a 20 minute output interval. Data from these instruments were collected hourly. Meteorological data from the test trench area are available for January 1, 1997 through April 7, 1998, terminating due to mechanical malfunction. Construction of buildings to the east and south-east of the test trench area subsequent to the placement of this monitoring equipment may have some effect on the meteorological data presented here.

Description of Data Files

The data are located on a compact disk included with this report. All data are presented in American Standard Code for Information Interchange (ASCII) format as tab-delimited files. These files can be used by most software capable of importing tab-delimited ASCII data.

Hourly meteorological data for 1997 and part of 1998 are presented by year in two files. The data are arranged in rows by date and time. Columns are headed as follows: Up T and Low T are air temperatures in degrees Celsius at 1 and 2 m above land surface. Up VP and Low VP are vapor pressures in kilopascals at 1 and 2 m above land surface. RN is net radiation in watts per meter squared. Wind sp is wind speed in meters per second. Wind dir is wind direction in degrees. Precip is precipitation in millimeters. Flux 1 and Flux 2 are soil heat fluxes 8 cm below the surface under vegetation and bare soil. Soil T is surface temperature in degrees Celsius.

Soil moisture content data are in 13 separate files according to neutron access hole identification number. Data tables are arranged in rows by date of measurement. Columns are headed by depth of neutron probe reading in meters below land surface.

Any blanks within the files indicates a lack of data for that collection interval. The filenames and approximate disk space occupied (in kilobytes) are as follows:

1997met.txt	700
1998met.txt	200
%H2O-#.txt *	50 (total)

* The # represents the number of the neutron access hole of interest and includes holes 1, 2, 4, 7, 9, 10, 15, 16, 17, 18, 19, 20, and 21.

SUMMARY

Since 1985, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, has been investigating the potential for and extent of migration of radionuclides from waste pits and trenches at the RWMC through the unsaturated zone to the Snake River Plain aquifer, the surface of which is approximately 177 m below land surface at that location.

Two test trenches and a simulated-waste trench were installed in the surficial sediment adjacent to the RWMC SDA and were instrumented for collection of hydrologic data from undisturbed and disturbed soil. These data and data collected at a meteorological station may be used to quantify soil-moisture content (variability with depth and time), soil temperature, physical properties of the soil, hydraulic conductivities, and evapotranspiration. Quantification of these properties allows for the estimation and comparison of soil-moisture flux in two different subsurface environments: (1) undisturbed native surficial soil, and (2) disturbed soil in a simulated-waste trench.

During 1997–99, soil-moisture content was measured approximately monthly in 13 neutron-probe access holes using a neutron moisture gage. Meteorological data collected at the test trench area from 1997–98 includes air temperature, precipitation, net radiation, wind speed, wind direction, soil surface temperature, soil heat flux, and relative humidity.

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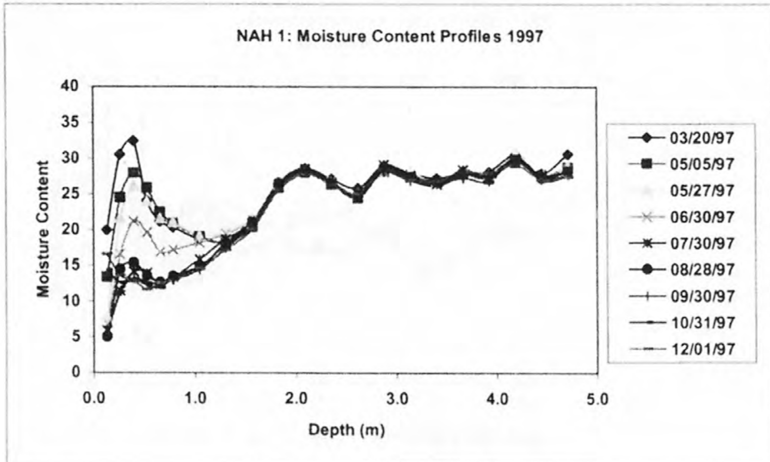
Appendix

Moisture profiles for neutron-probe access holes (NAH)
1, 2, 4, 7, 9, 10, 15, 16, 17, 18, 19, 20, and 21, 1997-1999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Depth (m)
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06/30/97
07/30/97
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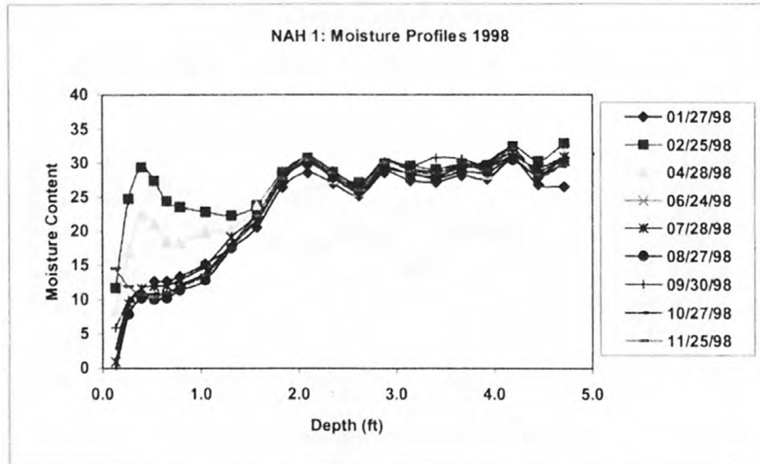
10/31/97
12/01/97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Depth (ft)
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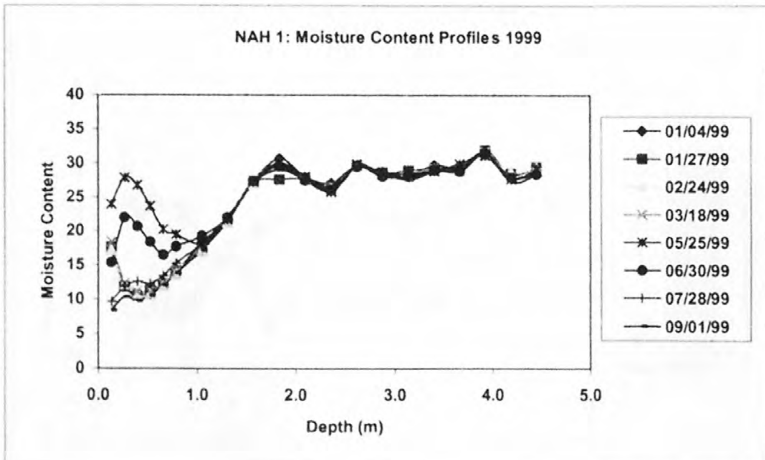
10/27/98
11/25/98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Moisture Content
Depth (m)
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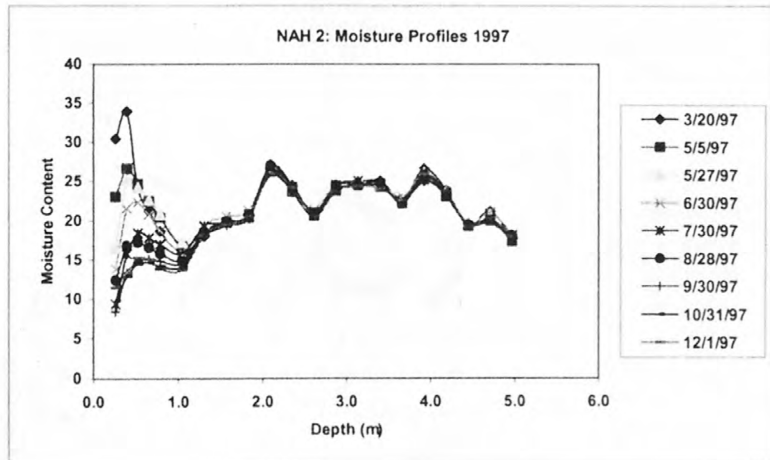
06/30/99
07/28/99
09/01/99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Depth (m)
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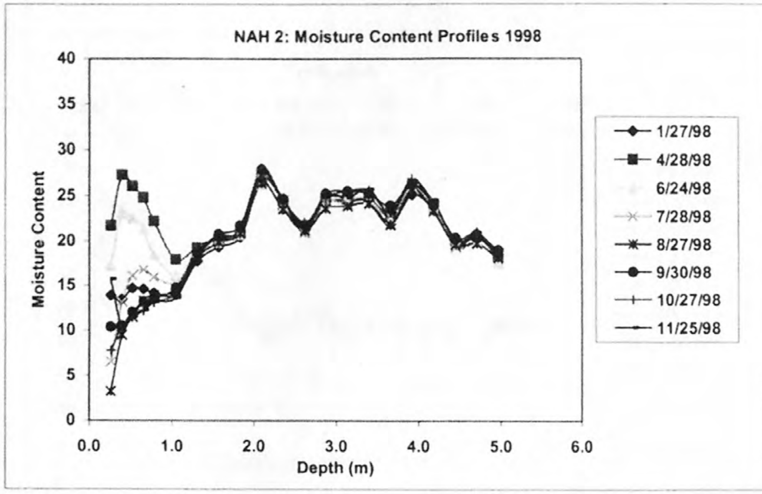
10/31/97
12/1/97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Moisture Content
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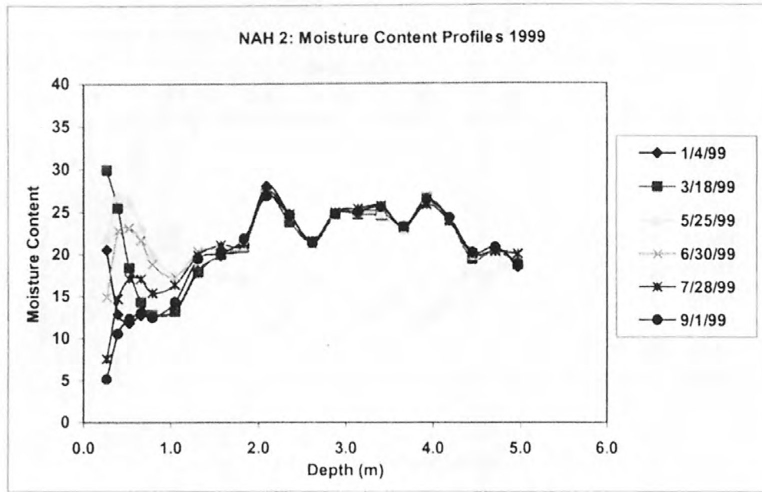
9/30/98
10/27/98
11/25/98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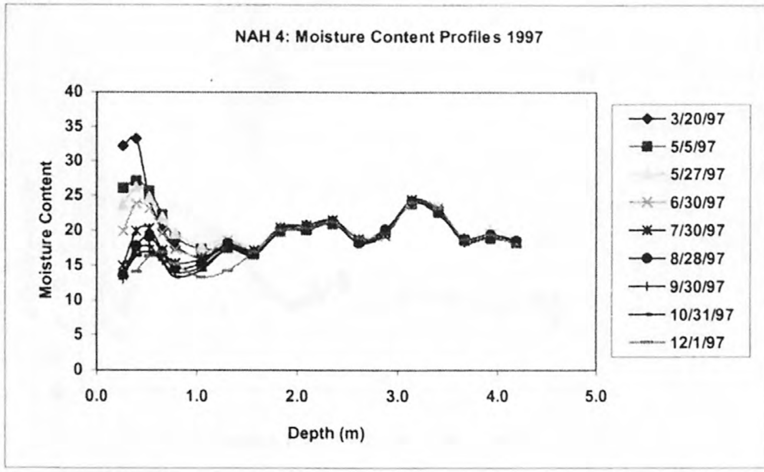
9/1/99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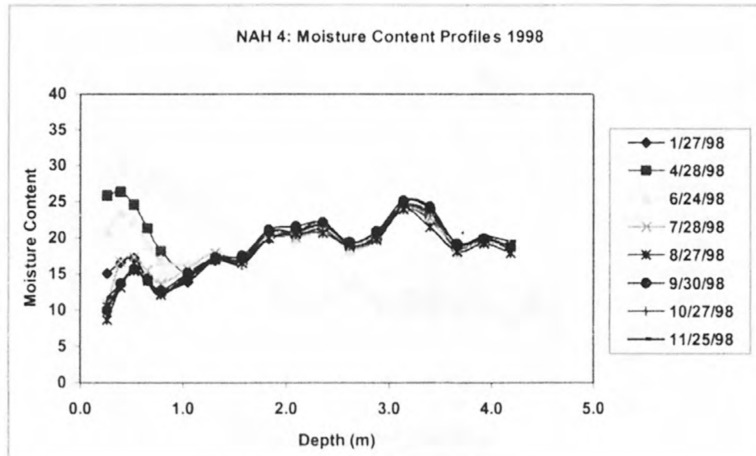
12/1/97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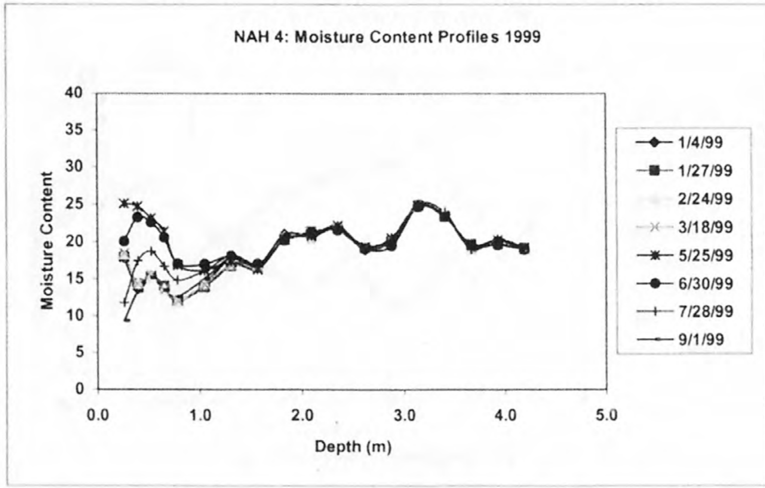
11/25/98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3.0
4.0
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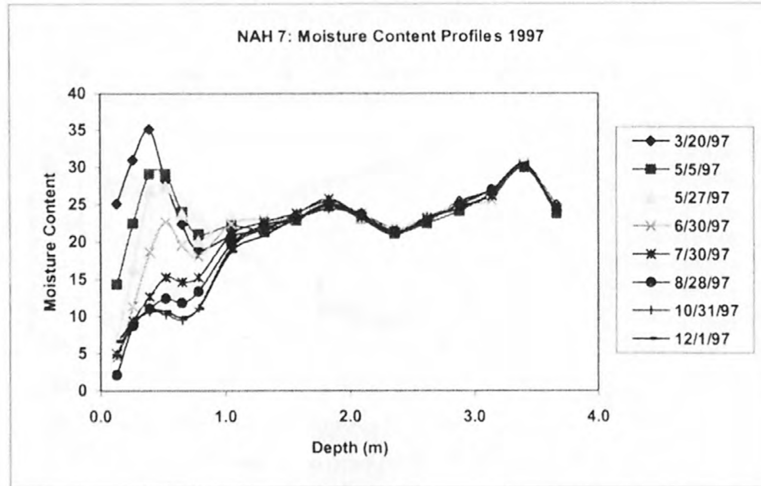
7/28/99
9/1/99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35
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3.0
4.0
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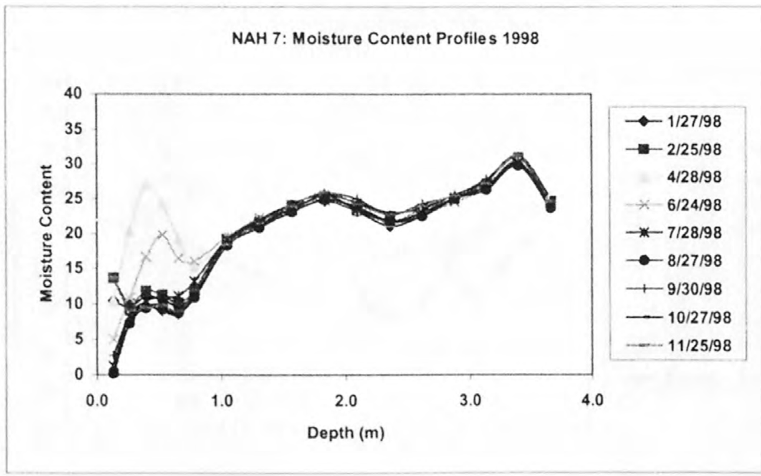
12/1/97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3.0
4.0
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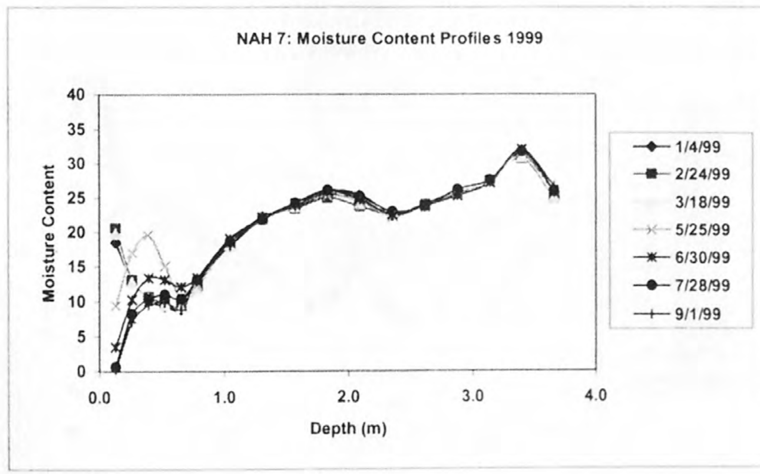
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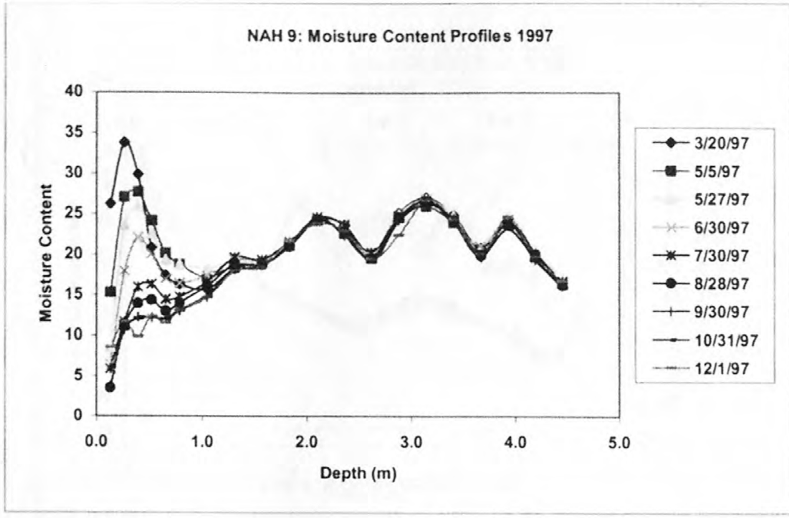
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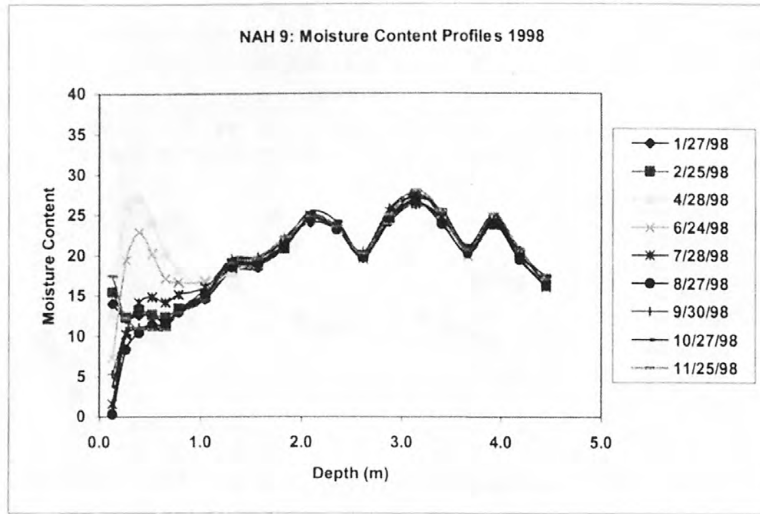
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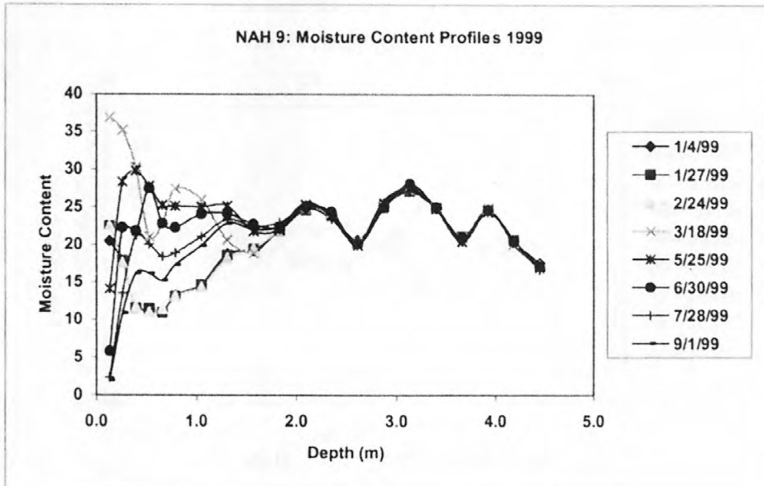
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Moisture Content
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4.0
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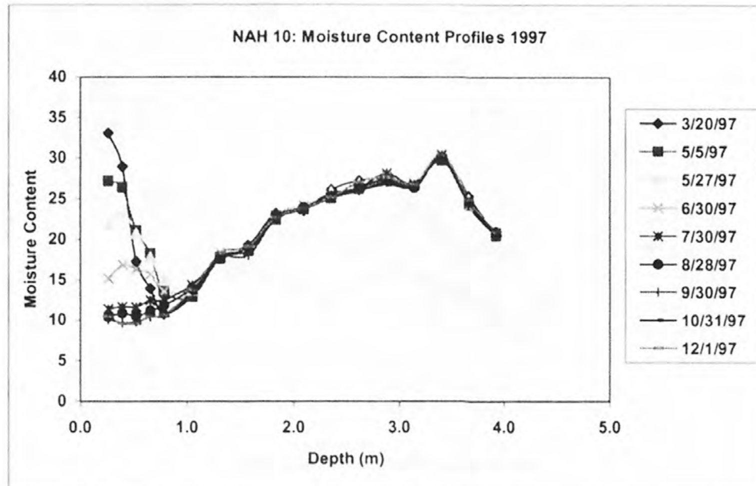
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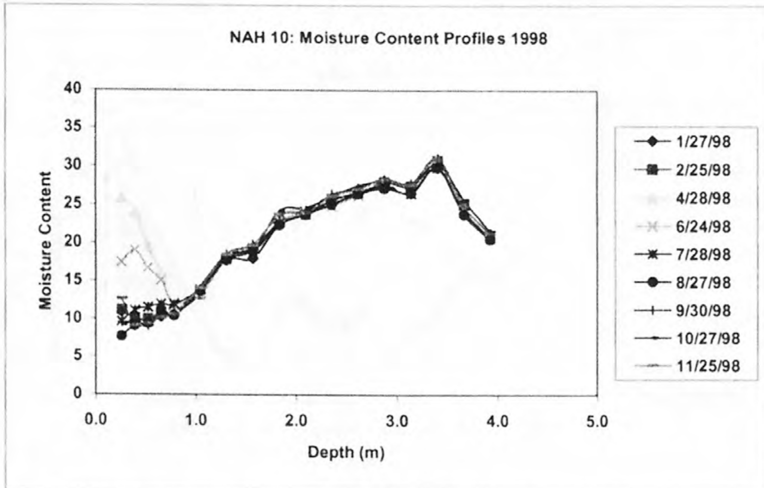
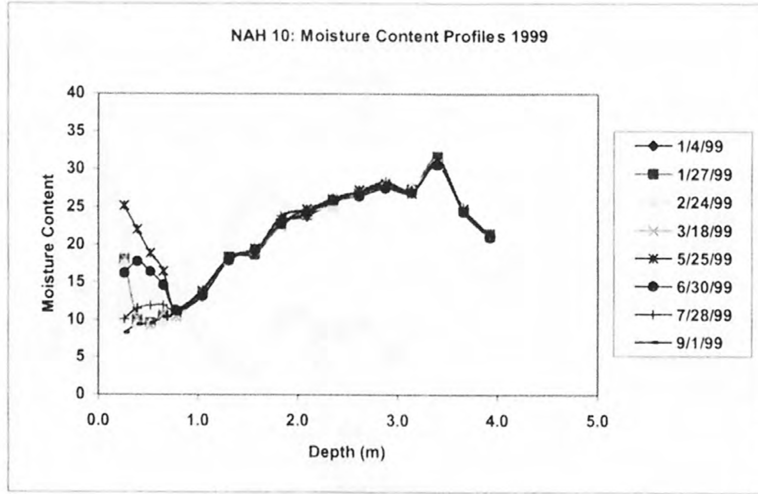
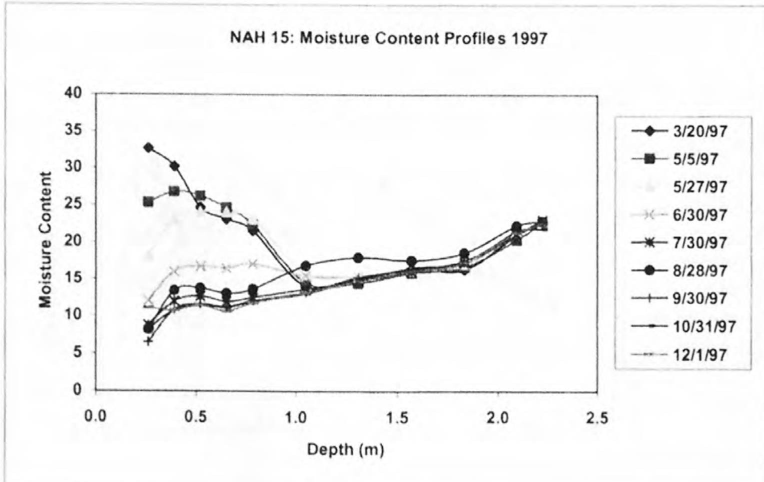
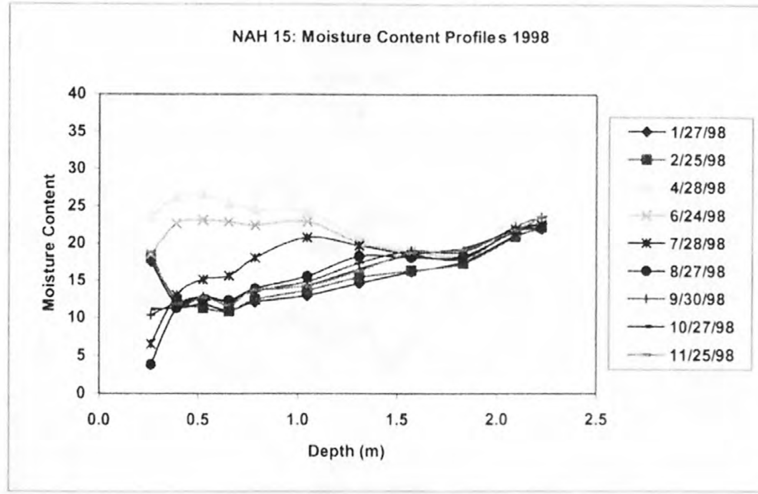
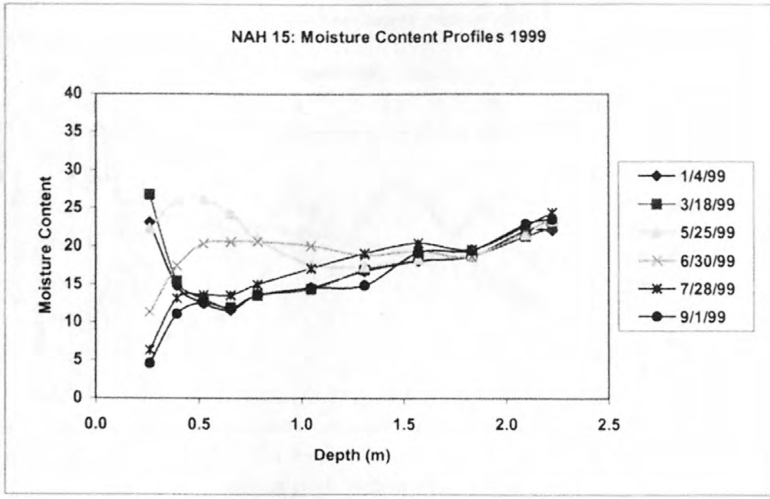
10
15
20
25
30
35
40
0.0
1.0
2.0
3.0
4.0
5.0
3/20/97
5/5/97
5/27/97
6/30/97
7/30/97
8/28/97
9/30/97
10/31/97
12/1/97

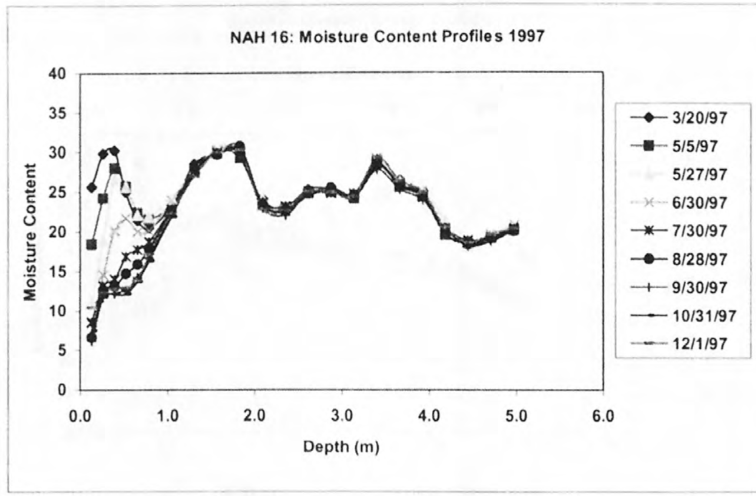

NAH 10: Moisture Content Profiles 1998
Moisture Content
Depth (m)
0.0 1.0 2.0 3.0 4.0 5.0
0 5 10 15 20 25 30 35 40
1/27/98
2/25/98
4/28/98
6/24/98
7/28/98
8/27/98
9/30/98
10/27/98
11/25/98

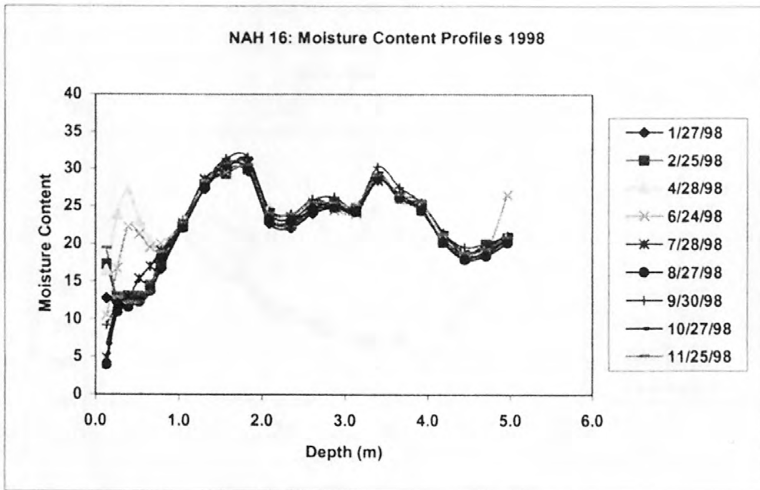

NAH 10: Moisture Content Profiles 1999
Moisture Content
Depth (m)
0.0 1.0 2.0 3.0 4.0 5.0
0 5 10 15 20 25 30 35 40
1/4/99
1/27/99
2/24/99
3/18/99
5/25/99
6/30/99
7/28/99
9/1/99

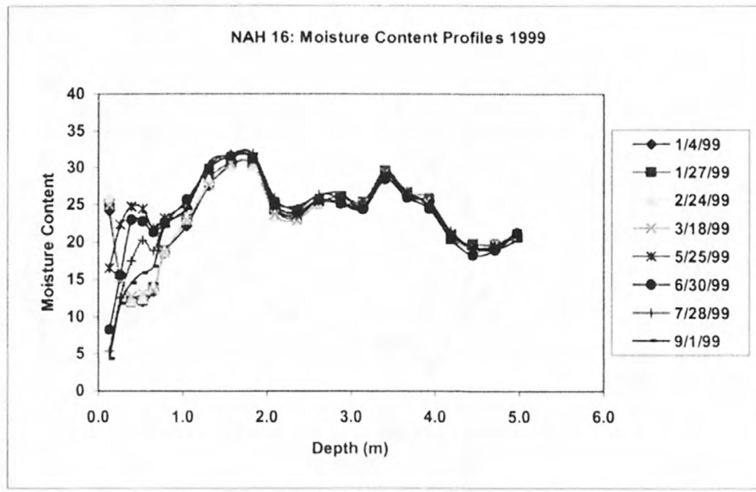

NAH 15: Moisture Content Profiles 1997
Moisture Content
Depth (m)
0.0 0.5 1.0 1.5 2.0 2.5
0 5 10 15 20 25 30 35 40
3/20/97
5/5/97
5/27/97
6/30/97
7/30/97
8/28/97
9/30/97
10/31/97
12/1/97

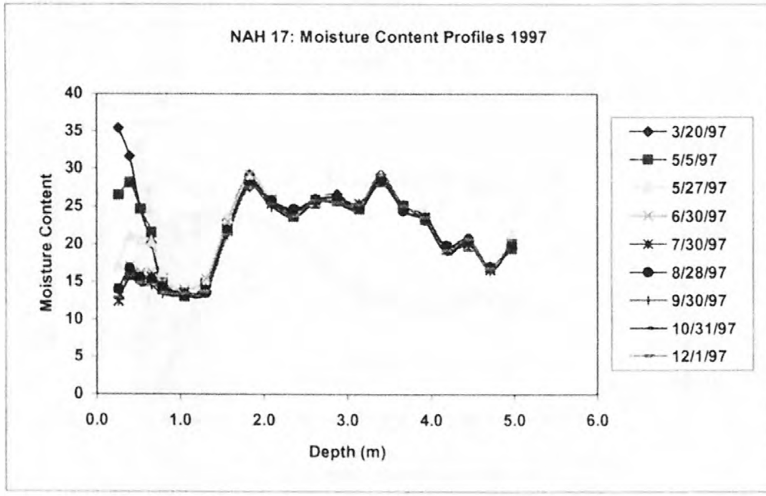

NAH 15: Moisture Content Profiles 1998
Moisture Content
Depth (m)
0.0 0.5 1.0 1.5 2.0 2.5
0 5 10 15 20 25 30 35 40
1/27/98
2/25/98
4/28/98
6/24/98
7/28/98
8/27/98
9/30/98
10/27/98
11/25/98

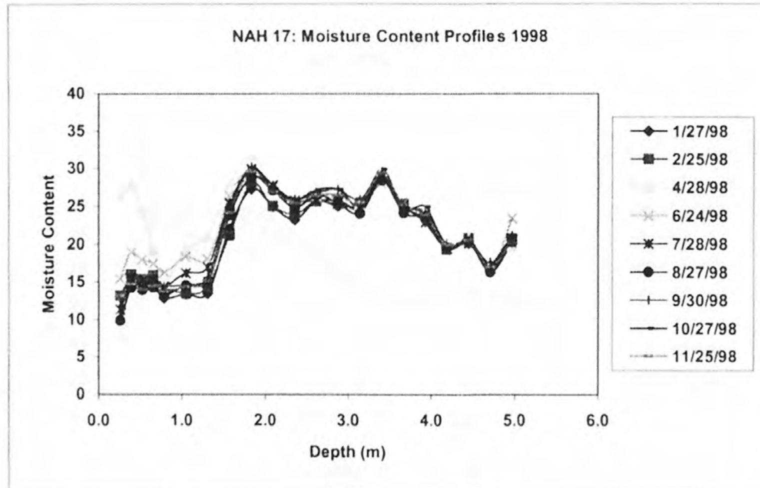

NAH 15: Moisture Content Profiles 1999
Moisture Content
Depth (m)
0
5
10
15
20
25
30
35
40
0.0
0.5
1.0
1.5
2.0
2.5
1/4/99
3/18/99
5/25/99
6/30/99
7/28/99
9/1/99

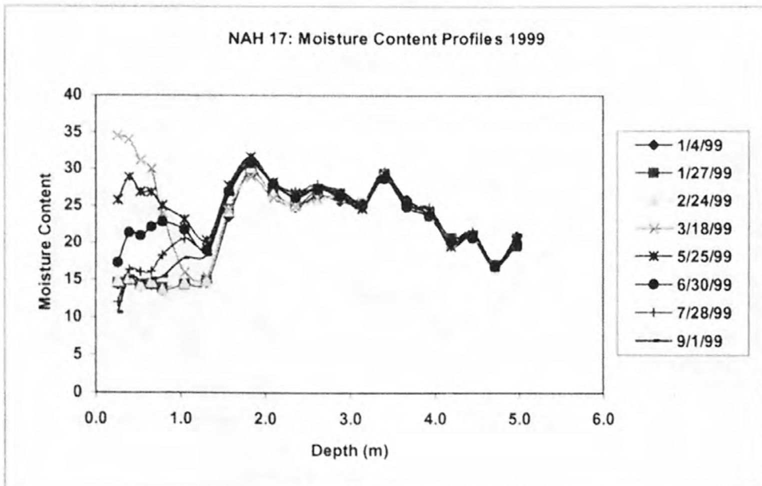

NAH 16: Moisture Content Profiles 1997
Moisture Content
Depth (m)
0
5
10
15
20
25
30
35
40
0.0
1.0
2.0
3.0
4.0
5.0
6.0
3/20/97
5/5/97
5/27/97
6/30/97
7/30/97
8/28/97
9/30/97
10/31/97
12/1/97

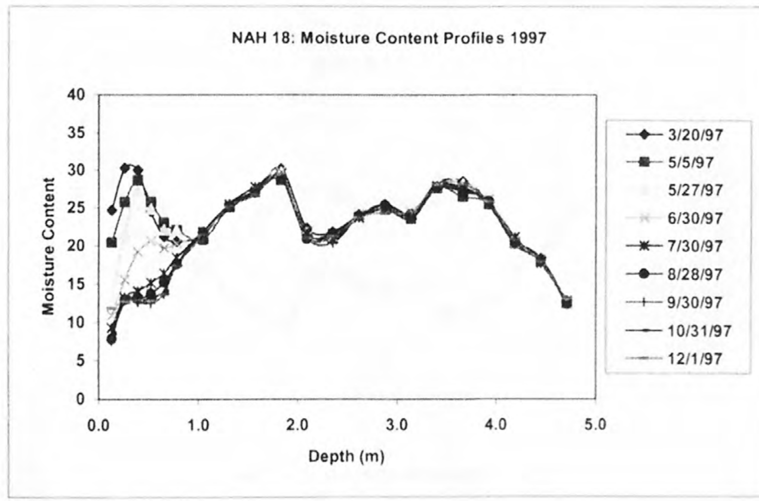

NAH 16: Moisture Content Profiles 1998
Moisture Content
Depth (m)
0
5
10
15
20
25
30
35
40
0.0
1.0
2.0
3.0
4.0
5.0
6.0
1/27/98
2/25/98
4/28/98
6/24/98
7/28/98
8/27/98
9/30/98
10/27/98
11/25/98

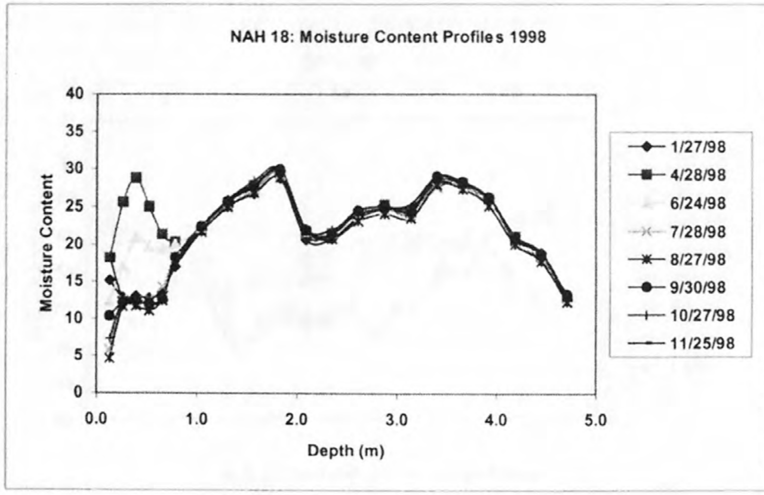

NAH 16: Moisture Content Profiles 1999
Moisture Content
Depth (m)
0
5
10
15
20
25
30
35
40
0.0
1.0
2.0
3.0
4.0
5.0
6.0
1/4/99
1/27/99
2/24/99
3/18/99
5/25/99
6/30/99
7/28/99
9/1/99

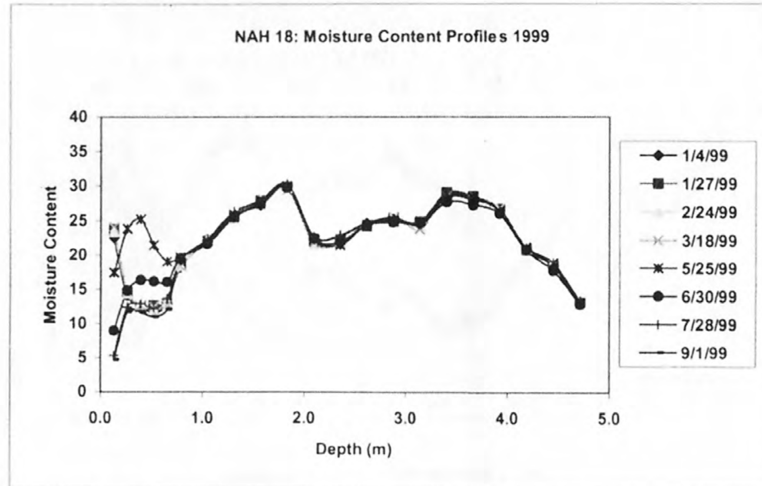

NAH 17: Moisture Content Profiles 1997
Moisture Content
Depth (m)
0 5 10 15 20 25 30 35 40
0.0 1.0 2.0 3.0 4.0 5.0 6.0
3/20/97
5/5/97
5/27/97
6/30/97
7/30/97
8/28/97
9/30/97
10/31/97
12/1/97

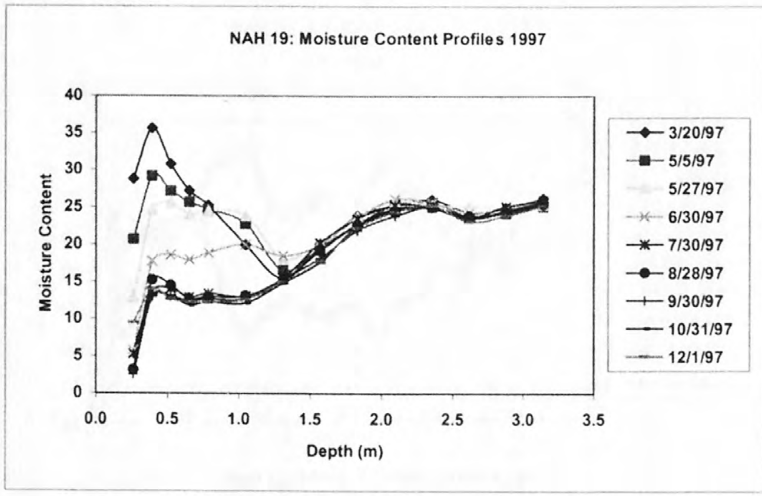

NAH 17: Moisture Content Profiles 1998
Moisture Content
Depth (m)
0 5 10 15 20 25 30 35 40
0.0 1.0 2.0 3.0 4.0 5.0 6.0
1/27/98
2/25/98
4/28/98
6/24/98
7/28/98
8/27/98
9/30/98
10/27/98
11/25/98

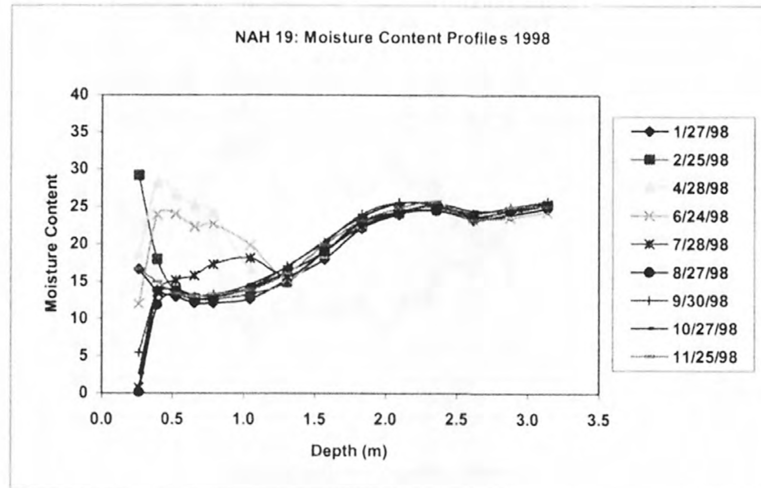

NAH 17: Moisture Content Profiles 1999
Moisture Content
Depth (m)
0 5 10 15 20 25 30 35 40
0.0 1.0 2.0 3.0 4.0 5.0 6.0
1/4/99
1/27/99
2/24/99
3/18/99
5/25/99
6/30/99
7/28/99
9/1/99

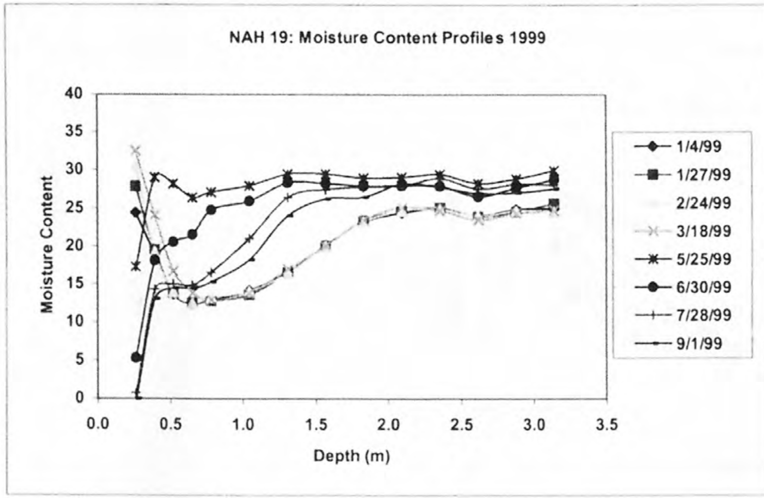

NAH 18: Moisture Content Profiles 1997
Moisture Content
Depth (m)
0 5 10 15 20 25 30 35 40
0.0 1.0 2.0 3.0 4.0 5.0
3/20/97
5/5/97
5/27/97
6/30/97
7/30/97
8/28/97
9/30/97
10/31/97
12/1/97

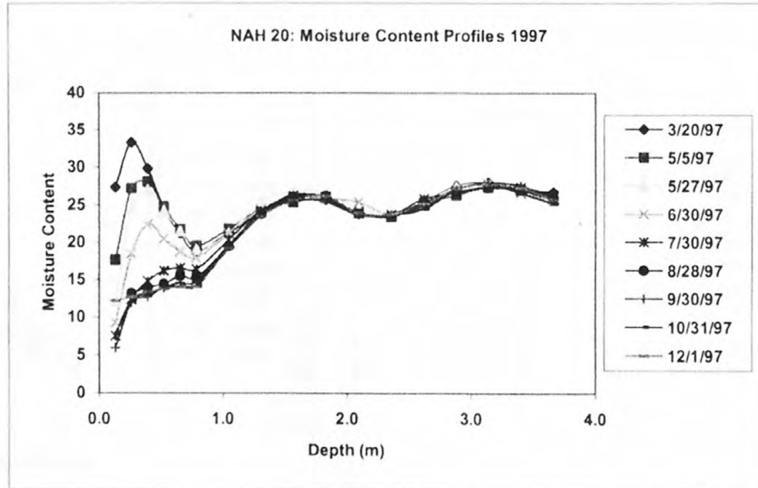

NAH 18: Moisture Content Profiles 1998
Moisture Content
Depth (m)
1/27/98
4/28/98
6/24/98
7/28/98
8/27/98
9/30/98
10/27/98
11/25/98

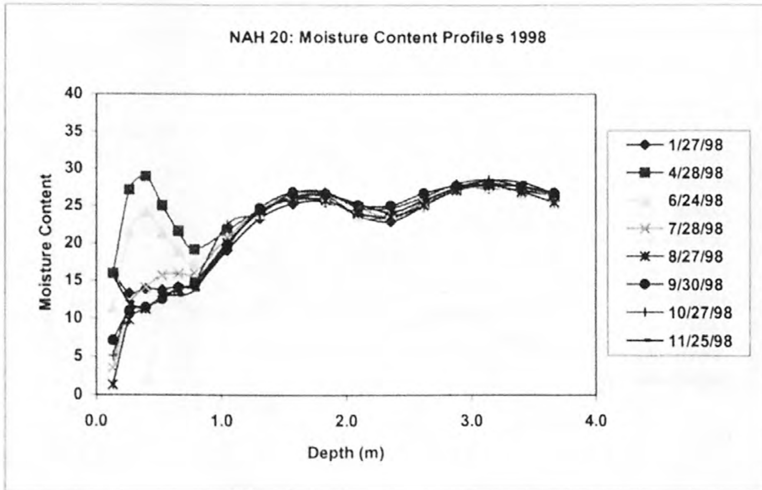

NAH 18: Moisture Content Profiles 1999
Moisture Content
Depth (m)
1/4/99
1/27/99
2/24/99
3/18/99
5/25/99
6/30/99
7/28/99
9/1/99

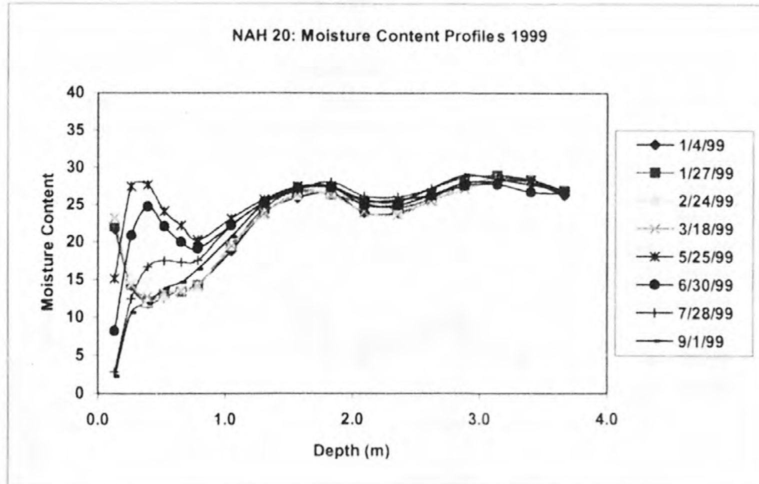

NAH 19: Moisture Content Profiles 1997
Moisture Content
Depth (m)
3/20/97
5/5/97
5/27/97
6/30/97
7/30/97
8/28/97
9/30/97
10/31/97
12/1/97

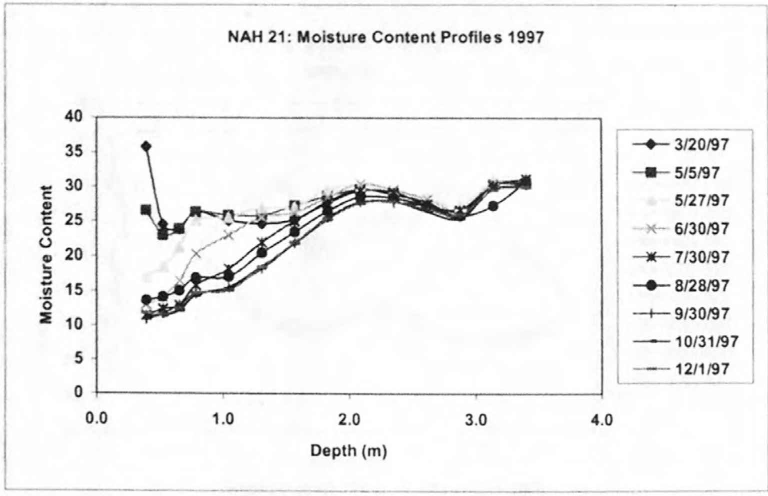

NAH 19: Moisture Content Profiles 1998
Moisture Content
Depth (m)
1/27/98
2/25/98
4/28/98
6/24/98
7/28/98
8/27/98
9/30/98
10/27/98
11/25/98

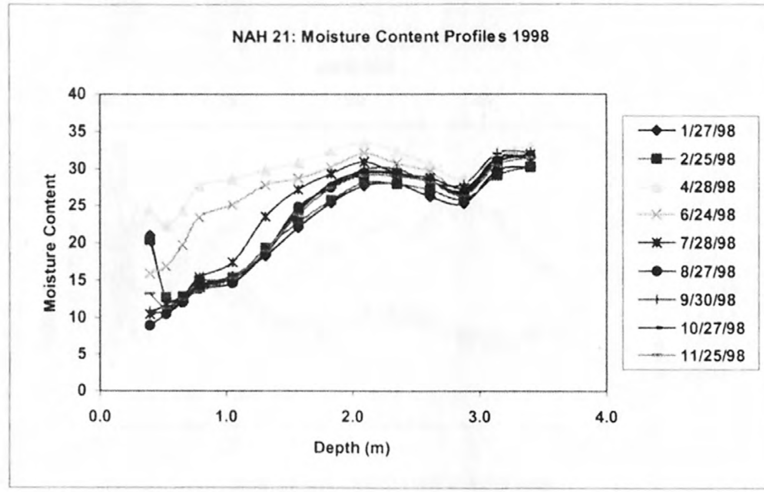

NAH 19: Moisture Content Profiles 1999
Moisture Content
Depth (m)
1/4/99
1/27/99
2/24/99
3/18/99
5/25/99
6/30/99
7/28/99
9/1/99

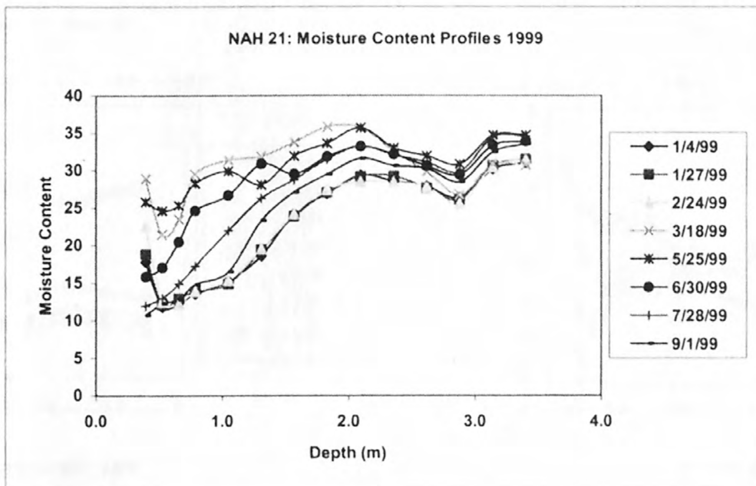

NAH 20: Moisture Content Profiles 1997
Moisture Content
Depth (m)
3/20/97
5/5/97
5/27/97
6/30/97
7/30/97
8/28/97
9/30/97
10/31/97
12/1/97


NAH 20: Moisture Content Profiles 1998
Moisture Content
Depth (m)
1/27/98
4/28/98
6/24/98
7/28/98
8/27/98
9/30/98
10/27/98
11/25/98


NAH 20: Moisture Content Profiles 1999
Moisture Content
Depth (m)
1/4/99
1/27/99
2/24/99
3/18/99
5/25/99
6/30/99
7/28/99
9/1/99


NAH 21: Moisture Content Profiles 1997
Moisture Content
Depth (m)
3/20/97
5/5/97
5/27/97
6/30/97
7/30/97
8/28/97
9/30/97
10/31/97
12/1/97


NAH 21: Moisture Content Profiles 1998
Moisture Content
Depth (m)
1/27/98
2/25/98
4/28/98
6/24/98
7/28/98
8/27/98
9/30/98
10/27/98
11/25/98


NAH 21: Moisture Content Profiles 1999
Moisture Content
Depth (m)
1/4/99
1/27/99
2/24/99
3/18/99
5/25/99
6/30/99
7/28/99
9/1/99