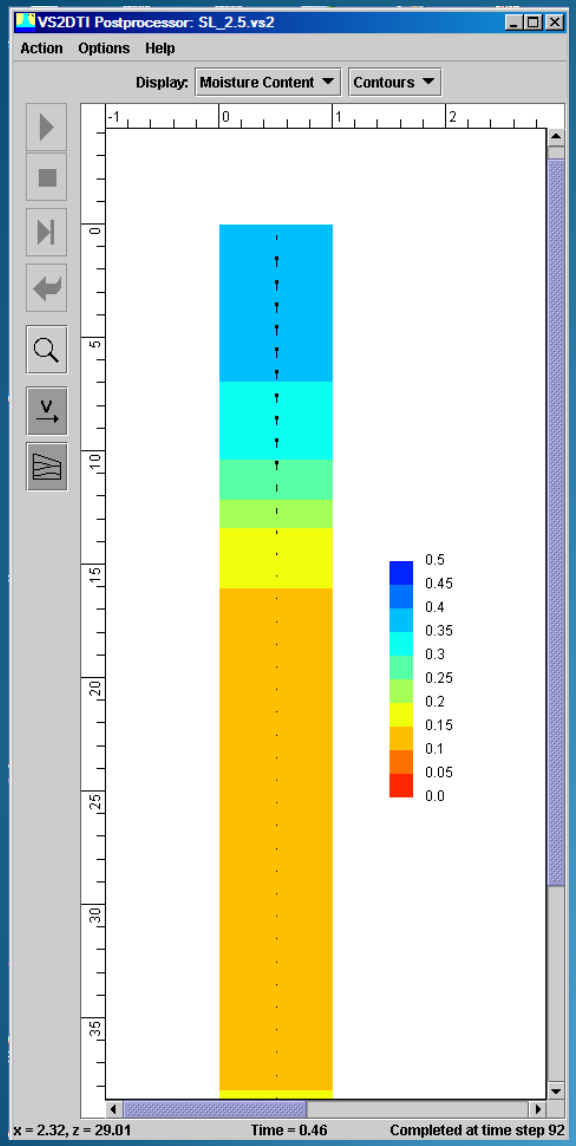



# Pedoclimates
# Simulating fluid flow (VS2D)

USGS Hsieh et.al, WRI report 99-4130, 2000

Douglas Merkler, Resource Soil Scientist

$$Kr = ( 1 - C * D^{(-gamma)} )^2 / D^{(gamma/2)}$$

# Soil Climate - SNPLMA

Through the Southern Nevada Public Lands Management Act round 6, a project is being conducted to characterize the local climate and soils within ecological zones of the Spring and Sheep Mountains.

This is a cooperative effort sponsored by the U.S. Forest Service. Other cooperators include U.S. Fish and Wildlife Service, U.S. Geological Survey, Natural Resource Conservation Service, and Bureau of Land Management.

# NSF EPSCoR

On September 1, 2008, NSHE received an award of $15 million from NSF EPSCoR (Cooperative Agreement No. EPS-0814372).

The five-year award funds science, education, and outreach infrastructure at UNR, UNLV, DRI, NSC, and NSHE's community colleges for the study of climate change and its effects on Nevada.

# NSF EPSCoR

On September 1, 2008, NSHE received an award of $15 million from NSF EPSCoR (Cooperative Agreement No. EPS-0814372).

The five-year award funds science, education, and outreach infrastructure at UNR, UNLV, DRI, NSC, and NSHE's community colleges for the study of climate change and its effects on Nevada.

# NSF EPSCoR

On September 1, 2008, NSHE received an award of $15 million from NSF EPSCoR (Cooperative Agreement No. EPS-0814372).

The five-year award funds science, education, and outreach infrastructure at UNR, UNLV, DRI, NSC, and NSHE's community colleges for the study of climate change and its effects on Nevada.

# Need

Soil moisture plays an important role in the dynamics of land–atmosphere interactions and many current and upcoming models and satellite sensors. In situ data will be required to provide calibration and validation datasets.

Therefore, there is a need for sensor networks at a variety of scales that provide near-real-time soil moisture and temperature data combined with other climate information for use in natural resource planning, drought assessment, water resource management, and resource inventory, such as the NCSS.

Porosity ($\phi$)

$$\phi = \frac{\text{volume of pores}}{\text{volume of soil}}$$

$$\phi = \left(1 - \frac{\rho_b}{\rho_p}\right)100\%$$

Typical values: 30 - 60%

# Volumetric water content ($\theta_v$)

$\theta_V$ = volumetric water content (fraction)
$V_w$ = volume of water
$V_b$ = volume of soil sample
At saturation, $\theta_V = \phi$
$\theta_V = As\ \theta_m$
As = apparent soil specific gravity = $\rho_b/\rho_w$
($\rho_w$ = density of water = 1 g/cm$^3$)
As = $\rho_b$ numerically when units of g/cm$^3$ are used

$$\theta_v = \frac{V_w}{V_b}$$

# Equivalent depth of water (d)

d = volume of water per unit land area = $(\theta_v\ A\ L)\ /\ A = \theta_v\ L$
d = equivalent depth of water in a soil layer
L = depth (thickness) of the soil layer

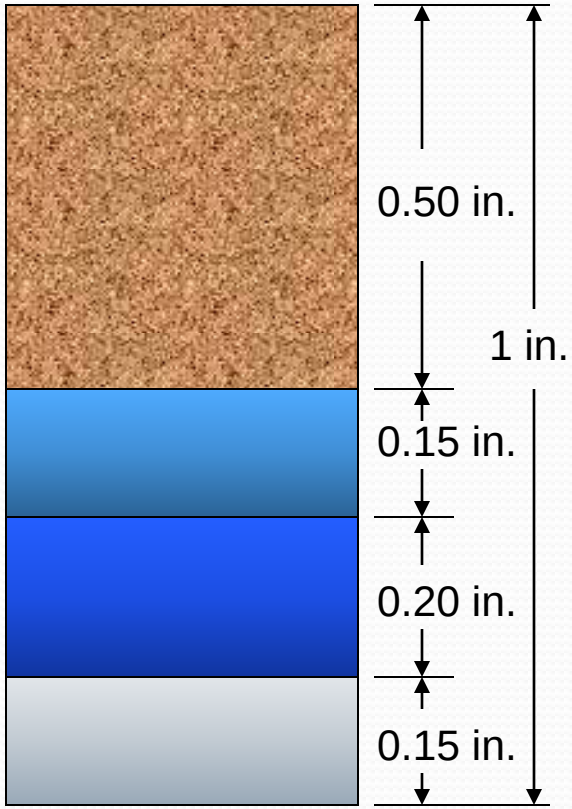
# Volumetric Water Content & Equivalent Depth

## Typical Values

Soil Solids (Particles): 50%

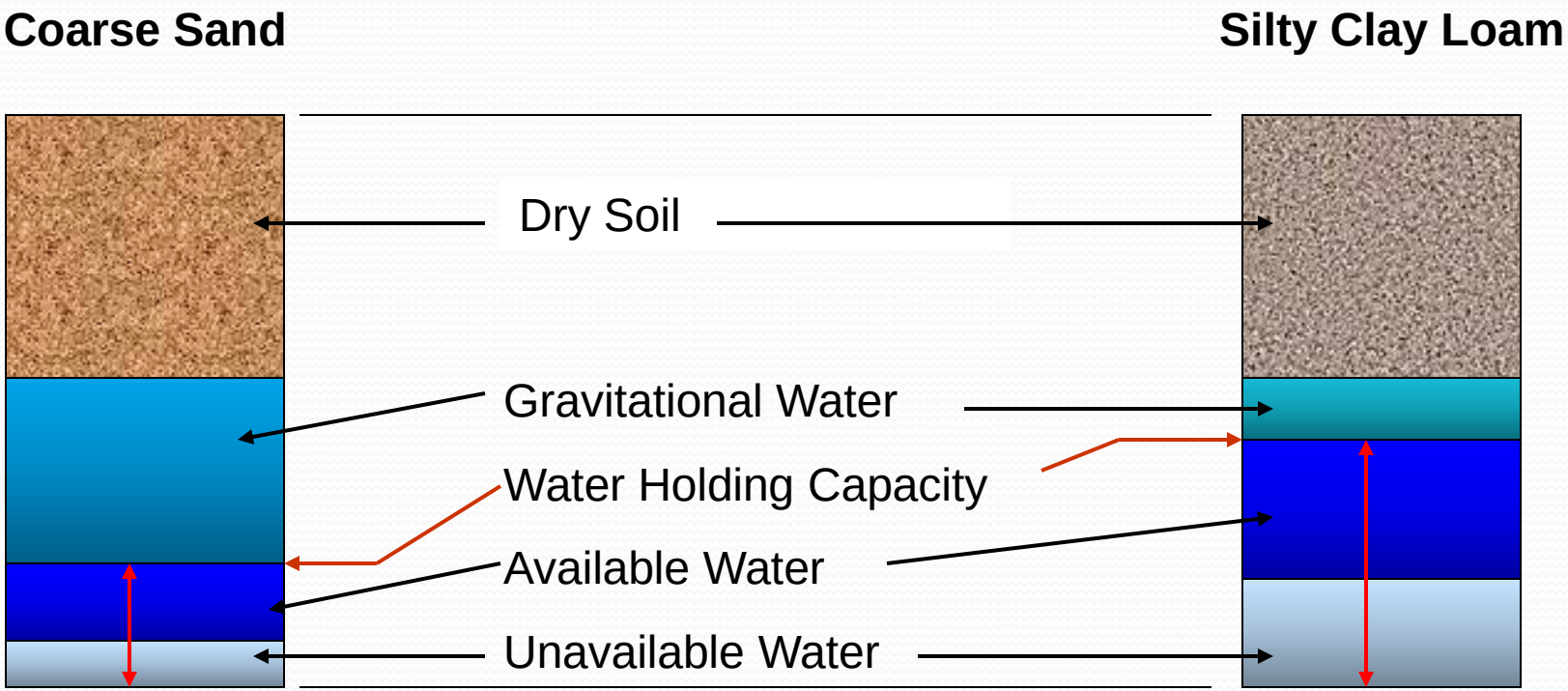
Total Pore Space: 50%

- Very Large Pores: 15% (Gravitational Water)
- Medium-sized Pores: 20% (Plant Available Water)
- Very Small Pores: 15% (Unavailable Water)



# Water-Holding Capacity of Soil

## Effect of Soil Texture



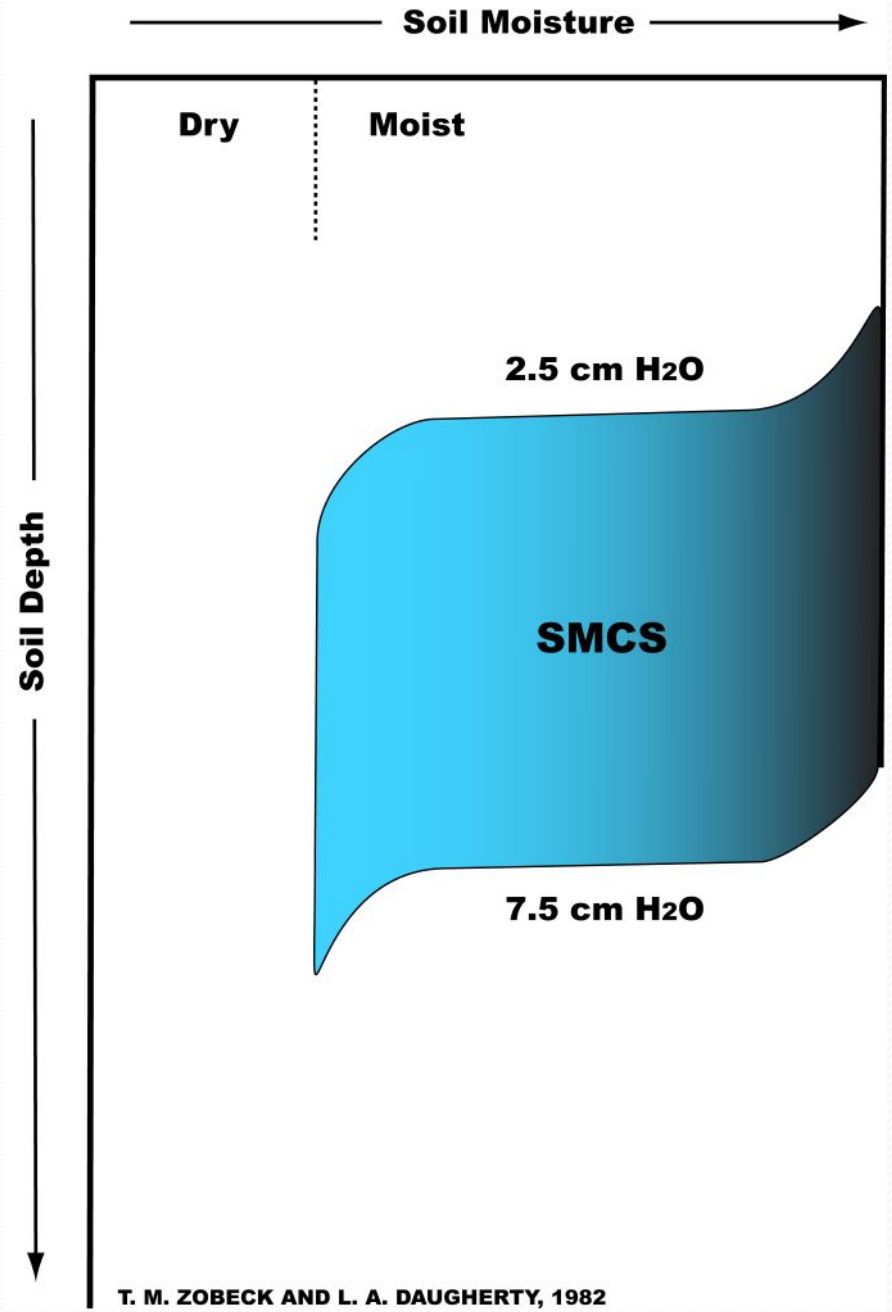
# Soil Moisture Control Section

- The intent in defining the soil moisture control section is to facilitate estimation of soil moisture regimes from climatic data.
- The upper boundary of this control section is the depth to which a dry (tension of more than 1500 kPa, but not airdry) soil will be moistened by 2.5 cm of water within 24 hours.
- The lower boundary is the depth to which a dry soil will be moistened by 7.5 cm of water within 48 hours.

**Schematic representation of a soil profile detailing the penetration of 2.5 and 7.5 cm of water.**

**The soil moisture control section is indicated by SMCS.**

**Measuring soil moisture control sections in the field is time consuming and presents many practical problems.**

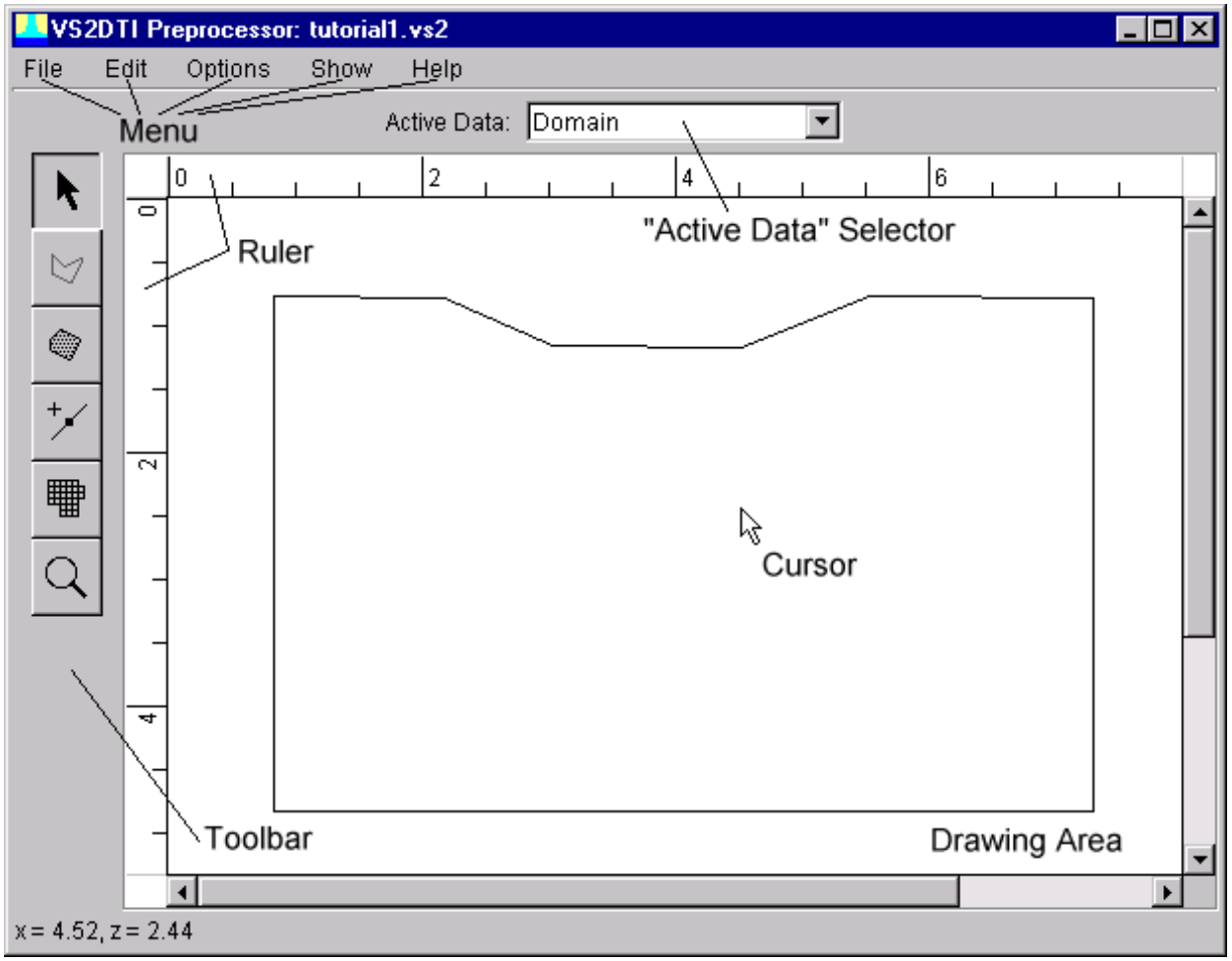


Examples are borrowed from USGS Water-Resources Investigations Report 90-4025 (p. 45). It involves one-dimensional infiltration of water with a solute concentration of 1. into column of dry sandy loam that initially contains solute free water.

The column is 40 cm in height. Uniform spacing (1 cm) and time step size (0.005 hr) are used.

Initial pressure heads are set to -120 cm.
Water is applied to the top of the column at the rate of 5.5 cm/hr for a period of 0.46 hr to deliver 2.54 cm of water. This defines the top of the moisture control section.

Then Water is applied to the top of the column at the rate of 5.5 cm/hr for a period of 1.36 hr to deliver 7.5 cm of water. This defines the bottom of the moisture control section.


VS2DTI Preprocessor: tutorial1.vs2
File
Edit
Options
Show
Help
Menu
Active Data:
Domain
Ruler
"Active Data" Selector
Cursor
Toolbar
Drawing Area
x = 4.52, z = 2.44

## *** Primary Characterization Data ***

Pedon ID: S08NV003003 ( Clark, Nevada ) Print Date: Jun 24 2012 12:20PM

Sampled as :
Revised to :

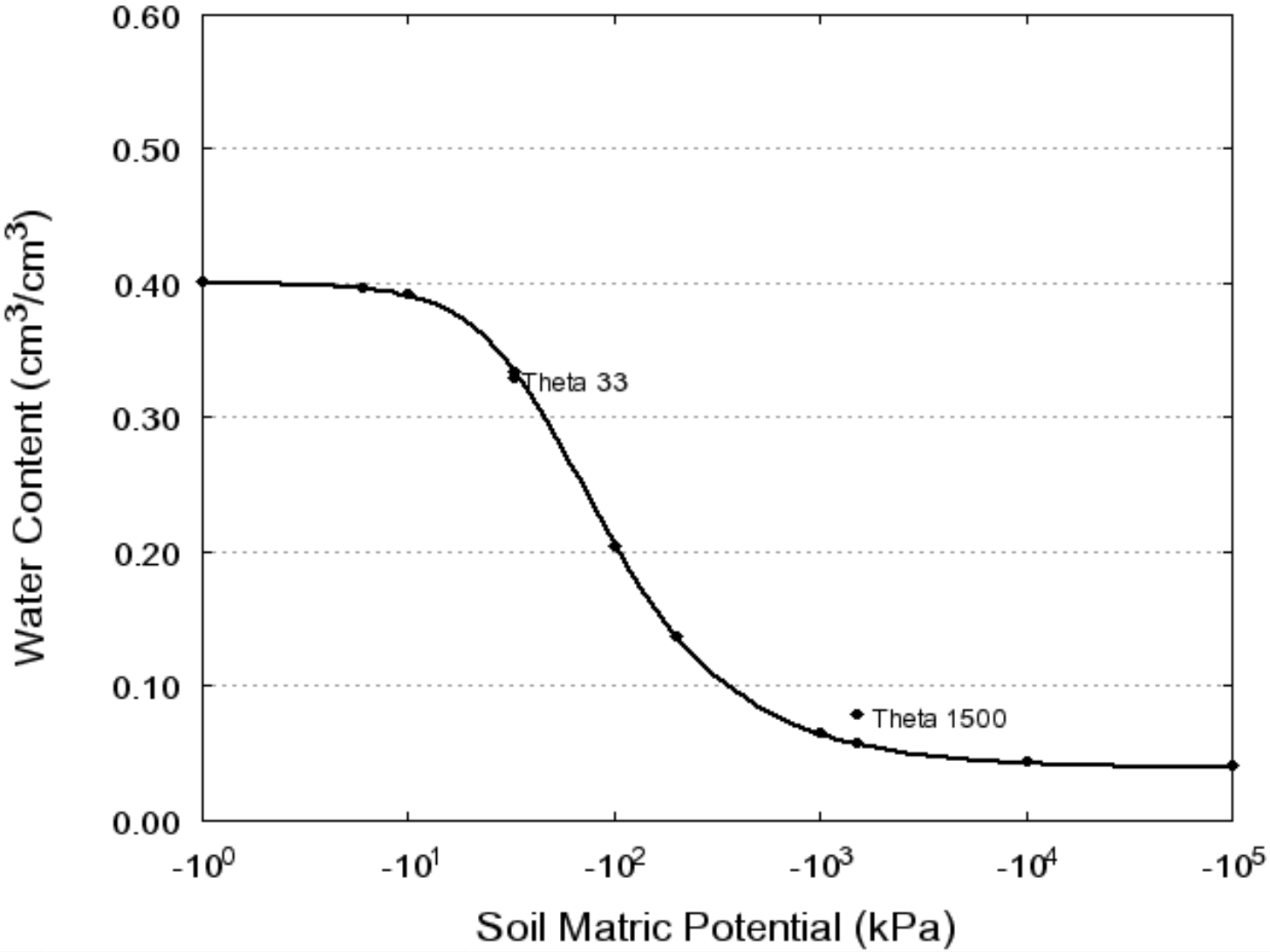
SSL - Project C2008USNV106 Climate Monitoring Station SNOTEL/SCAN
- Site ID Pine Nut northwest
- Pedon No. 08N0497
- General Methods 1B1A, 2A1, 2B

United States Department of Agriculture
Natural Resources Conservation Service
National Soil Survey Center
Kellogg Soil Survey Laboratory
Lincoln, Nebraska 68508-3866

| Layer | Horizon | Orig Hzn | Depth (cm) | Field Label 1 | Field Label 2 | Field Label 3 | Field Texture | Lab Texture |
|---|---|---|---|---|---|---|---|---|
| 08N03231 | A | | 0-9 | S08NV003-003-1 | | | | L |
| 08N03232 | ABk | | 9-31 | S08NV003-003-2 | | | | L |
| 08N03233 | Btk1 | | 31-48 | S08NV003-003-3 | | | | L |
| 08N03234 | Btk2 | | 48-83 | S08NV003-003-4 | | | | CL |
| 08N03235 | 2Bk | | 83-152 | S08NV003-003-5 | | | | FSL |

PSDA & Rock Fragments

| | | | | -1- | -2- | -3- | -4- | -5- | -6- | -7- | -8- | -9- | -10- | -11- | -12- | -13- | -14- | -15- | -16- | -17- |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (- - - - - Total - - - - - -) | | | (- - Clay - - -) | | (- - - - Silt - - - - -) | | (- - - - - - - - - - - - Sand - - - - - - - - - - - -) | | | | | ( Rock Fragments (mm) ) | | | | |
| | | | | Clay | Silt | Sand | Fine | $CO_3$ | Fine | Coarse | VF | F | M | C | VC | (- - - - - - - - Weight - - - - - - - -) | | | | >2 mm |
| | | | | < | .002 | .05 | < | < | .002 | .02 | .05 | .10 | .25 | .5 | 1 | 2 | 5 | 20 | .1- | wt % |
| | Depth | | | .002 | -.05 | -2 | .0002 | .002 | -.02 | -.05 | -.10 | -.25 | -.50 | -1 | -2 | -5 | -20 | -75 | 75 | whole |
| Layer | (cm) | Horz | Prep | (- - - - - - - - - - - - - - - - - - - - - - - - - - - - - % of <2mm Mineral Soil - - - - - - - - - - - - - - - - - - - - - - - - - - - - -) | | | | | | | | | | | | (- - - - - - - % of <75mm - - - - - -) | | | | soil |
| | | | | 3A1a1a | | | 3A1a1a | 3A1a1a | 3A1a1a | | 3A1a1a | 3A1a1a | 3A1a1a | 3A1a1a | 3A1a1a | | | | | |
| 08N03231 | 0-9 | A | S | 16.8 | 38.5 | 44.7 | 4.8 | 1.1 | 20.8 | 17.7 | 24.2 | 8.4 | 4.3 | 3.4 | 4.4 | 8 | 32 | 1 | 53 | 41 |
| 08N03232 | 9-31 | ABk | S | 20.3 | 41.2 | 38.5 | 6.4 | 0.8 | 18.5 | 22.7 | 19.9 | 8.4 | 3.4 | 3.2 | 3.6 | 12 | 23 | tr | 47 | 35 |
| 08N03233 | 31-48 | Btk1 | S | 23.9 | 38.3 | 37.8 | 7.5 | 4.3 | 19.0 | 19.3 | 15.0 | 10.6 | 4.5 | 4.1 | 3.6 | 8 | 21 | -- | 45 | 29 |
| 08N03234 | 48-83 | Btk2 | S | 29.6 | 28.4 | 42.0 | 9.9 | 2.7 | 14.3 | 14.1 | 12.2 | 16.7 | 6.6 | 2.7 | 3.8 | 9 | 25 | 1 | 54 | 35 |
| 08N03235 | 83-152 | 2Bk | S | 7.0 | 17.1 | 75.9 | 2.9 | 1.5 | 5.3 | 11.8 | 18.5 | 36.6 | 9.0 | 2.9 | 8.9 | 10 | 54 | tr | 85 | 64 |

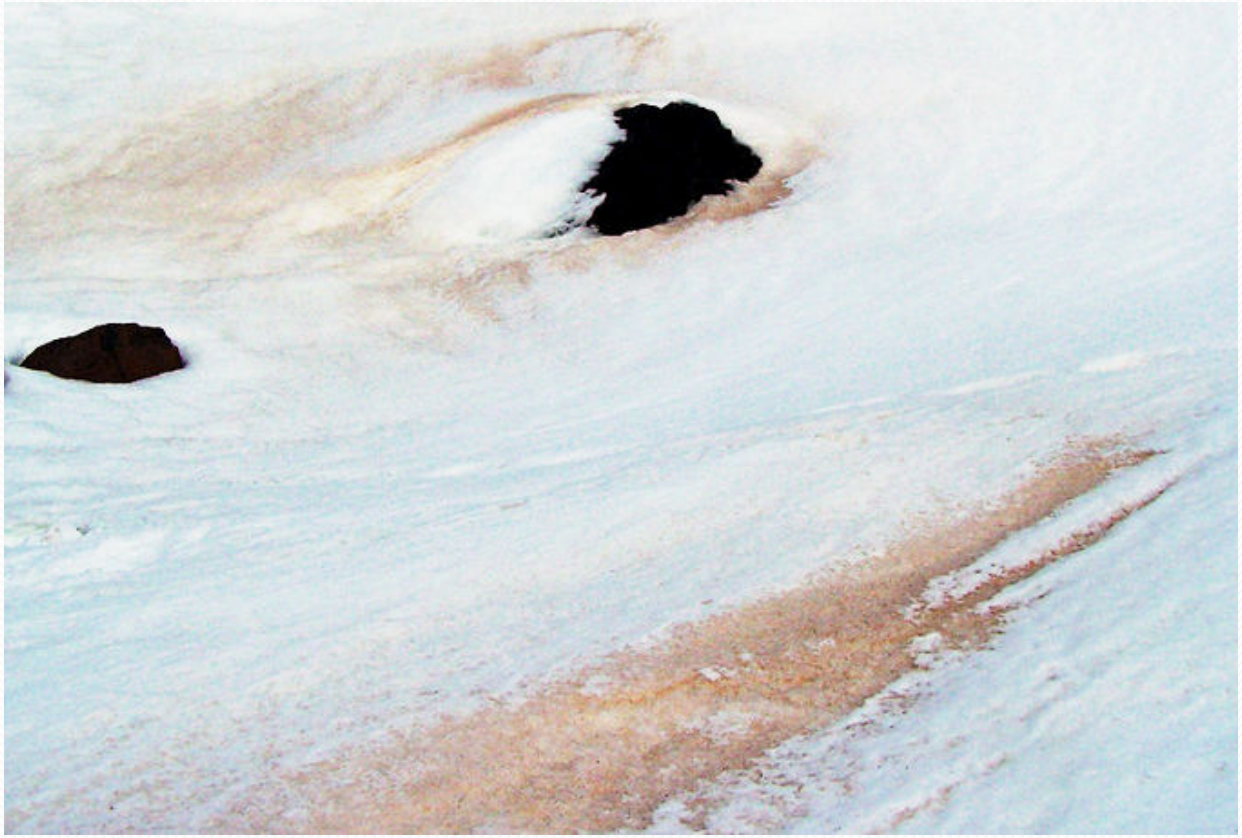

0.60
0.50
0.40
0.30
0.20
0.10
0.00
Water Content (cm3/cm3)
Theta 33
Theta 1500
-100
-101
-102
-103
-104
-105
Soil Matric Potential (kPa)

In shallow or moderately deep soils or in soils containing rock fragments the approximate depths for the SMCS given in Soil Taxonomy do not apply.

If the definition of the SMCS given in Soil Taxonomy is taken literally, the boundaries must be measured in the field.

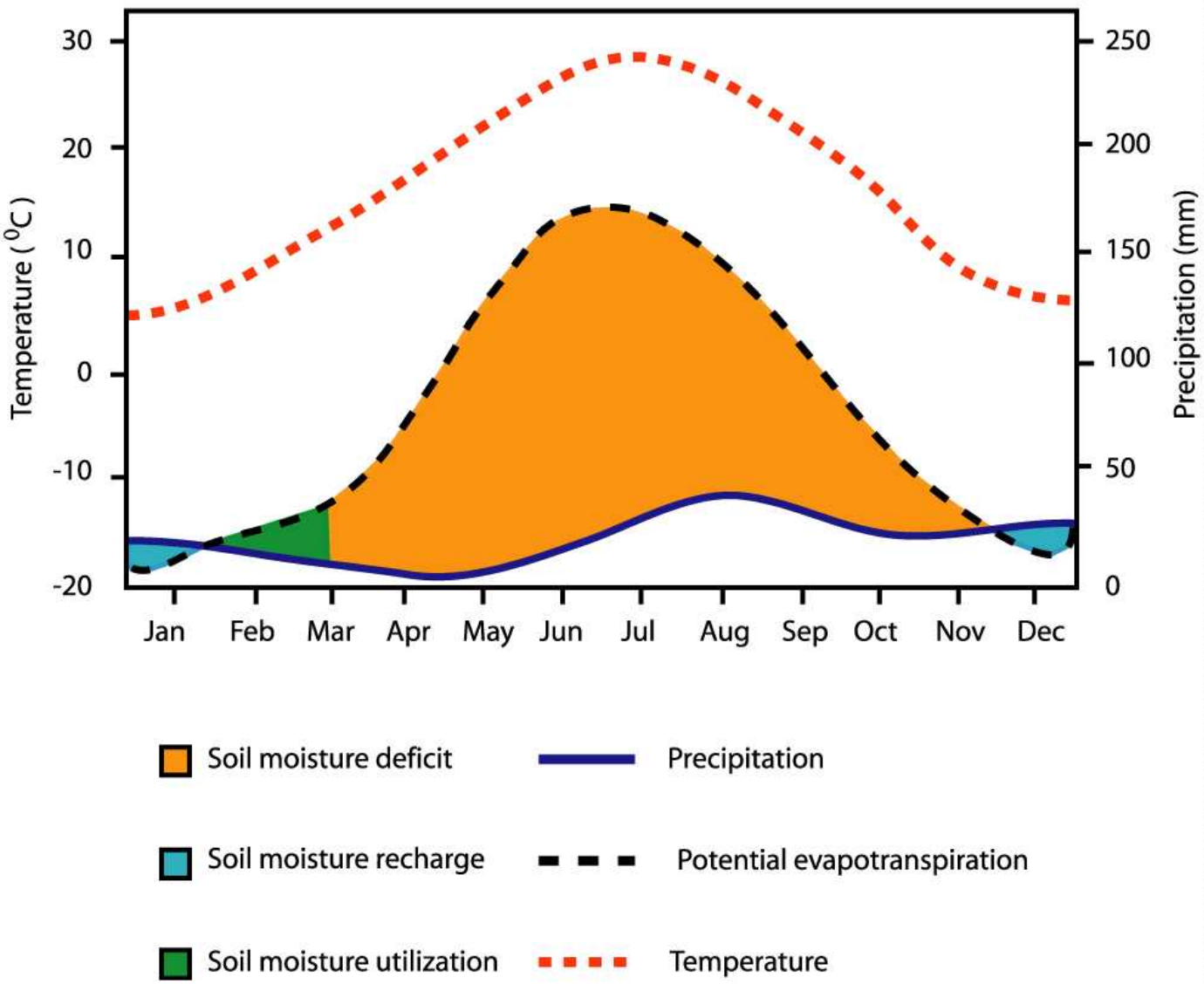
The magnitude of the difference in SMCS thickness and depth will vary as properties associated with soil moisture, such as texture and bulk density, vary.

## Impact of disturbed desert soils on duration of mountain snow cover



It is likely that the current duration of snow cover and surface radiation budget represent a dramatic change from those before the widespread soil disturbance of the western US in the late 1800s that resulted in enhanced dust emission.

# Arid Moisture Regime



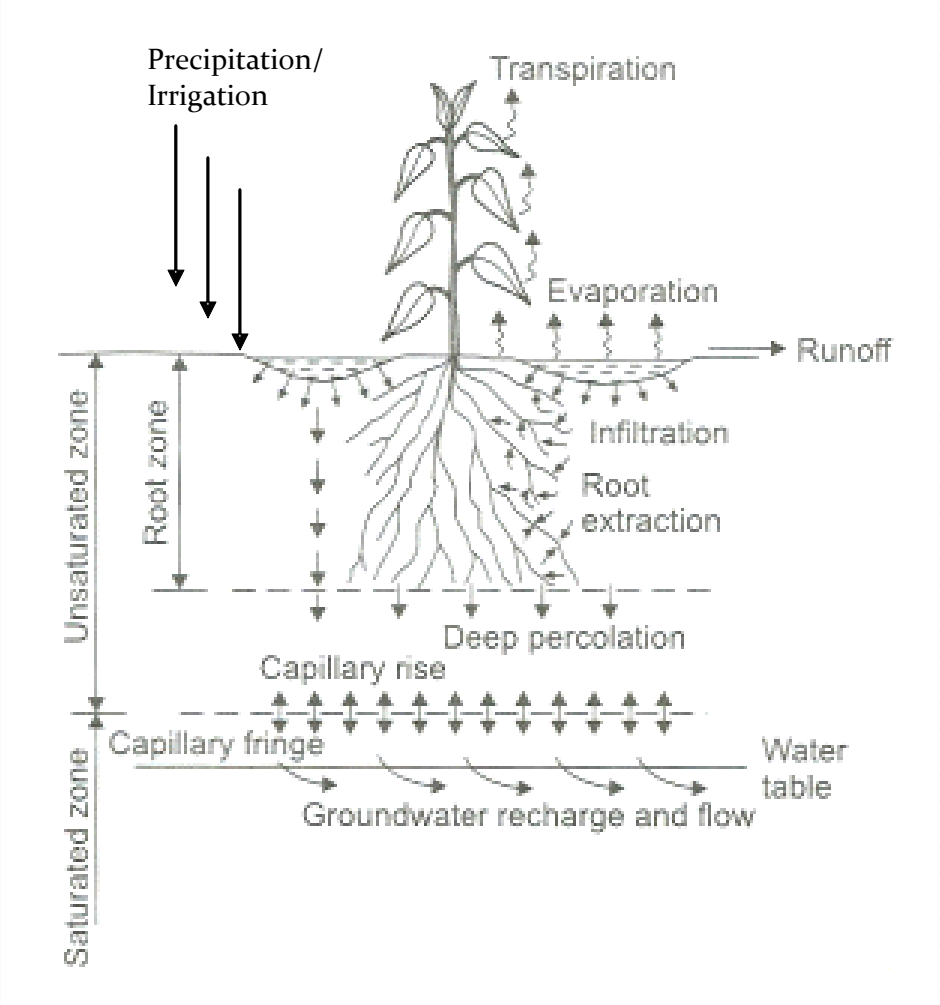

D. Merkler

# Water balance - Win - Wout = $\underline{\Delta W}$

$\underline{W_{in}}$ - Water gains:
P - Precipitation
I - Irrigation
U - Upward capillary flow
$R_{on}$ - Runon

$\underline{W_{out}}$ - Water losses:
E - Evaporation from soil
$T_r$ - Transpiration from plants
$R_{off}$ - Runoff
D - Downward drainage

$\underline{\Delta W}$ - Change in storage:
$\Delta S$ - Change in water storage
$\Delta V$ - Change in vegetative mass




After Michael H. Young, 2008

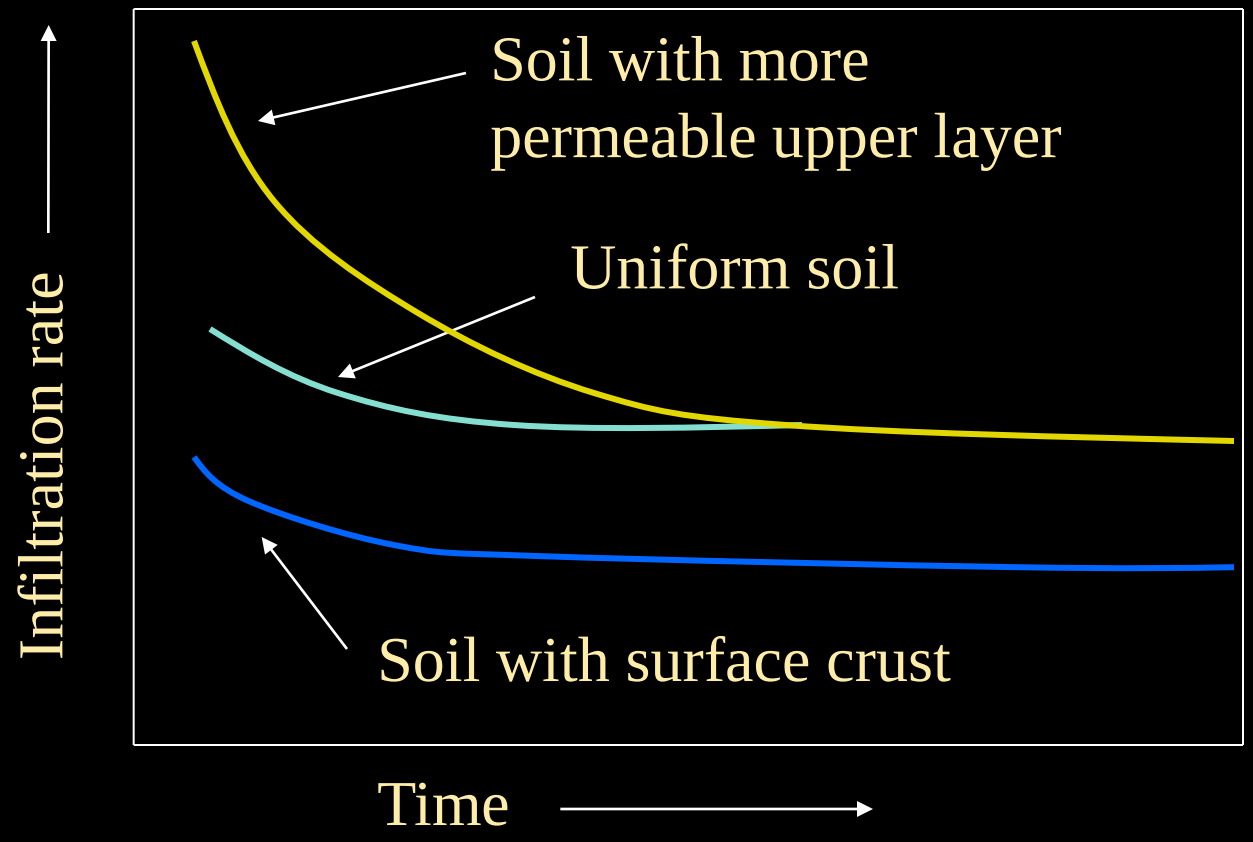
Vesicular crusts

Infiltration related to soil structure

Dr. Brenda Buck, UNLV

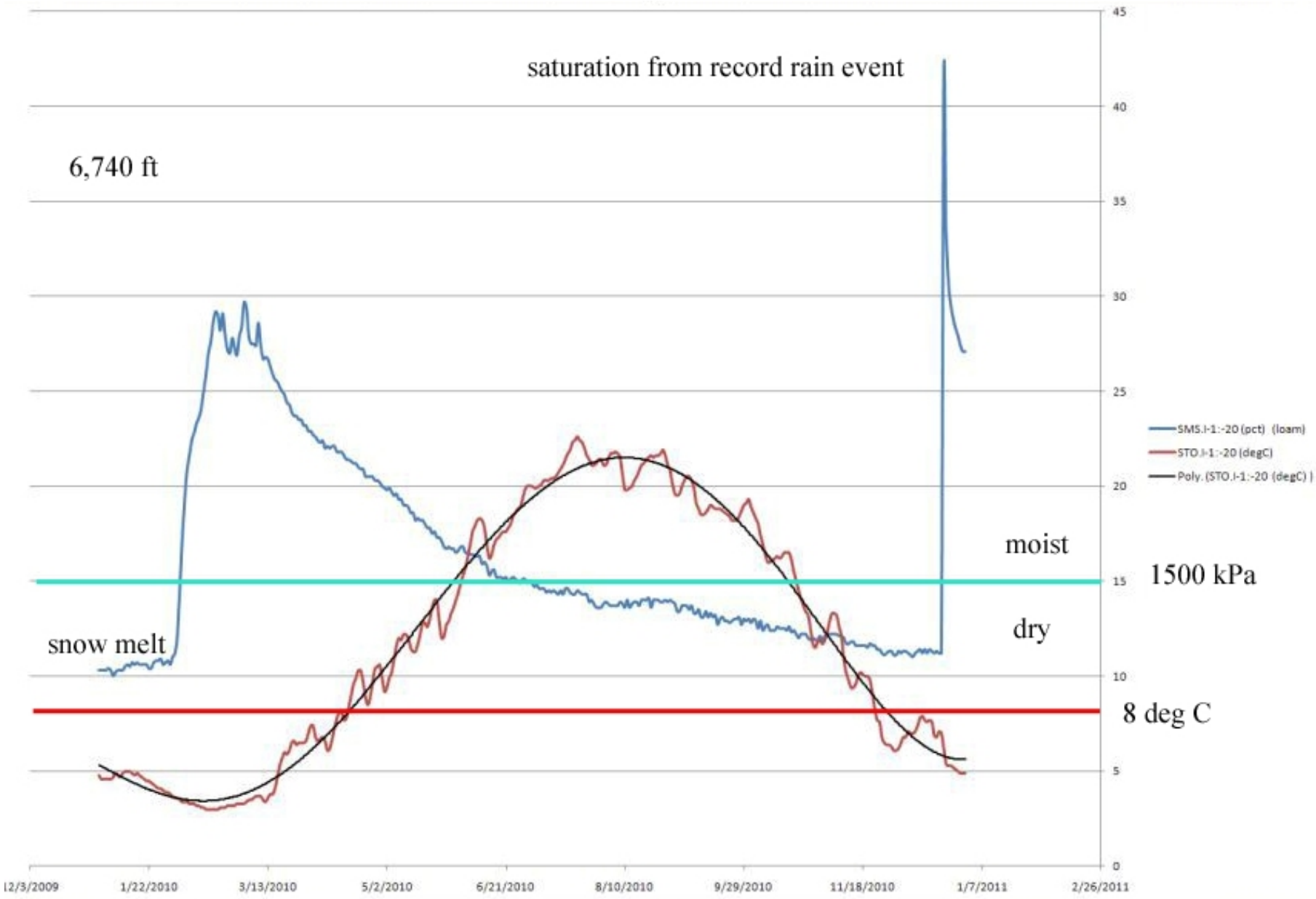
GSA
PHOTO SCALE/FOCUS GUIDE
CM
IN
Grain Size Scale
1 2 3 4 5
mm

# Surface vs Profile controlled Infiltration




(Hillel, 1982)

# Pine Nut - 2010



Brooks, R.H., and Corey, A.T., 1964, Hydraulic properties of porous media: Fort Collins, Colorado State University Hydrology Paper no. 3, 27 p.

Haverkamp, R., Vauclin, M., Tovina, J., Wierenga, P.J., and Vachud, G., 1977, A comparison of numerical simulation models for one-dimensional infiltration: Soil Science Society of America Proceedings, v. 41, p. 285-294.

Healy, R.W., 1990, Simulation of solute transport in variably saturated porous media with supplemental information on modifications to the U.S. Geological Survey's computer program VS2D: U.S. Geological Survey Water-Resources Investigations Report 90-4025, 125 p.

Painter, T. H., A. P. Barrett, C. C. Landry, J. C. Neff, M. P. Cassidy, C. R. Lawrence, K. E. McBride, and G. L. Farmer (2007), Impact of disturbed desert soils on duration of mountain snow cover, *Geophys. Res. Lett.*, 34, L12502, doi:10.1029/2007GL030284.

Saito, L.S., Biondi, F., Fenstermaker, L., Arnone, J., Devitt, D., Riddle, B., and Young, M.. 2011. The Nevada NSF EPSCoR infrastructure for climate change science, education, and outreach project: investigations of ecological change and water resources along elevational gradients in arid environments. Abstracts of the World Environmental and Water Resources Congress, Palm Springs CA, May 22-26.

Zobeck, T. M., and L. A. Daugherty. 1982. Calculating the depths of soil moisture control sections from laboratory data. Soil Sci. Soc. Am. J. 46:792-795.