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OFFICE OF POLLUTION CONTROL
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WATER-RESOURCES INVESTIGATIONS REPORT 94-4088
Soil permeability map and report text—SHEET 1 OF 1
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PERMEABILITY OF SOILS IN MISSISSIPPI

INTRODUCTION

Ground water is one of Mississippi's most important natural resources. The Mississippi Department of Environmental Quality, Office of Pollution Control, and the Mississippi Department of Agriculture and Commerce are developing a program to protect the aquifers in Mississippi from contamination from surface sources. The U.S. Geological Survey, in cooperation with these two agencies, is conducting a series of studies to delineate the outcrop areas of the major aquifers in Mississippi and those parts of the outcrop areas that are susceptible to contamination from surface sources. The susceptibility of Mississippi's major aquifers to contamination is determined through the analysis of data from a statewide data base which describes geologic, hydrologic, physiographic, and cultural factors using a vector-based geographic information system (GIS).

This map shows the areal distribution of the permeability of soils in Mississippi. The permeability of soils is an important factor in determining the susceptibility of major aquifers to contamination. The mapped permeability ranges for soils are the area-weighted harmonic mean of the permeabilities of a vertical succession of horizontally oriented soil layers in a given area. The resultant permeability map provides a representative vertical soil permeability for a given area sufficient for county, multi-county, and area planning, and can be used as the soil permeability data component in the evaluation of the susceptibility of major aquifers to contamination.

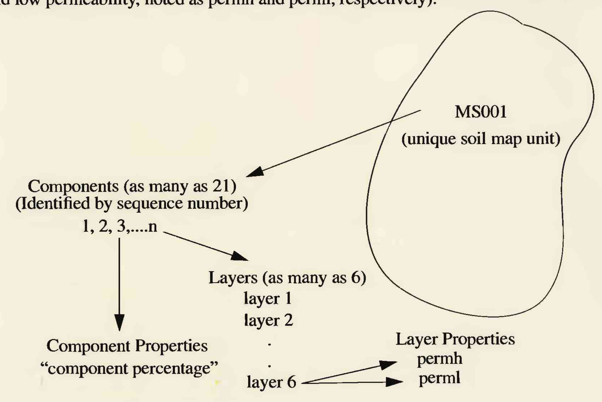
SOURCE OF DATA

The U.S. Soil Conservation Service's State Soil Geographic Data Base (STATSGO) was the primary source of data for the determination of area-weighted soil permeability. STATSGO provides soil layer properties that are spatially referenced to mapped areas. These mapped areas are referred to as polygons in the GIS. The polygons represent the boundaries of soils mapped as a group and are given unique Map Unit Identifiers (MUIDs). The data describing the physical characteristics of the soils within each polygon are stored in a tabular data-base format and are referred to as attributes. The U.S. Soil Conservation Service developed STATSGO to be primarily used as a guide for regional resource planning, management, and monitoring. STATSGO was designed so that soil information could be extracted from the properties tables at the layer level, combined by component, and statistically expanded to cover the entire map unit. STATSGO soil map units are not homogeneous and continuous; each soil map unit is normally composed of soils of highly different permeabilities, and the area-weighted harmonic mean permeabilities generated by this study for each soil map unit will not reflect local permeability conditions related to a specific soil. Furthermore, the total depth of soil layers represented by STATSGO is variable; most of the soil samples that were used to develop STATSGO were collected from approximately the uppermost 64 inches of the soil profile. Because most water-table aquifers in Mississippi are at a depth greater than 64 inches, STATSGO provides an indication only of the permeability of the upper part of the unsaturated zone. The results should not be interpreted either as representing the hydrogeologic characteristics of the underlying lithologic units or as indicating that aquifer recharge within the outcrop is fully defined by these results. The results of this report are not intended to substitute for field level surveys or site specific investigations.

COMPILATION OF THE MAP

Each soil map unit has its own unique identifier (MUID), areal extent, and bounding polygon. The soil map unit polygons have sub-classes of soils called "components" which may number as many as 21 per MUID. The components are not individually mapped in STATSGO and do not have individual bounding polygons; however, they are listed in tabular data-base format and are attributed with an item which details the percentage of the MUID that component covers. The component percentage is defined as being the "percentage of the component of the map unit." Components may have as many as six layers, each of which contains property values including a range for permeability values.

The following diagram, modified from the STATSGO Data Users Guide (U.S. Department of Agriculture, 1991) illustrates the relation between a soil map unit, its constituent components, layers within each component, and the layer items of interest in the determination of permeability (values for high and low permeability, noted as permh and perml, respectively).



The analytical technique used to extract permeability values for soils from the STATSGO data set is provided in the following equations that determine a value for an area-weighted harmonic mean permeability:

Equation 1 uses the layer properties permh and perml to determine the logarithmic mean of the reported permeability range for each layer in a component. A log transformation is used in the determination of mean permeability because permeabilities generally are log-normally distributed (Freeze and Cherry, 1979).

$$\overline{Pln} = 10^{\frac{(\log(perml) + \log(permh))}{2}} \qquad (1)$$

$\overline{Pln}$ - the log mean permeability of soil layer n

Equation 2 determines the harmonic mean permeability (*HMP*) for a specific component within a given soil map unit by combining the log mean permeabilities of all layers in the component. The *HMP* of the soil component is determined by the same method as used in aquifer modeling to determine the vertical series conductance of horizontally layered hydrologic units (McDonald and Harbaugh, 1984). This method uses the values for layer thickness (b) and log of the mean permeability of the layer ($\overline{Pl}$) to determine the harmonic mean of the permeability of the entire thickness of the vertical succession of layers in the component. Here, permeability is assumed to be the saturated permeability of the soil sequence. However, it is unlikely that soil layer conditions will always be saturated, in which case effective permeability values will be slightly affected by such factors as porosity, water content, and other textural aspects of the soil materials.

$$\frac{\sum_{i=1}^{n} bi}{HMP} = \sum_{i=1}^{n} \frac{bi}{\overline{Pli}} \qquad (2)$$

Equation 3 determines an area-weighted harmonic mean permeability *(AWHMP)* for a soil map unit by summing the product of the *HMP* of each component *(i)* and its component percentage *[comppct (i)]* for all components in the map unit (which may number as many as 21 per soil map unit).

$$AWHMP = \sum_{i=1}^{n} (comppct(i) \times HMP_{component}) \qquad (3)$$

A final step determines the adjusted area-weighted harmonic mean permeability to account for the component percentage of surface-water bodies within a soil map unit. For each map unit, surface-water bodies are included in the total area covered and each surface-water body has its own component percentage *(comppct)*. Therefore, each map unit is composed of soil components and surface-water components which together total 100 percent of the map unit. Because surface-water bodies cannot be assigned layers and soil properties, the sum of soil component percentages do not necessarily total to 100 percent. Thus, the AWHMP must be adjusted to 100 percent by dividing the total AWHMP by the sum of the soils component percentages totaled for the map unit.

The analytical technique detailed above was performed using an Arc Macro Language (AML) program run in an ArcInfo[1] GIS environment for each map unit in the STATSGO data set for the State of Mississippi. The permeability values generated were subdivided into permeability ranges to generate the color-shaded permeability range map. The resultant mapped permeability ranges provide a representative average permeability for the entire vertical succession of soil layers for a given area.

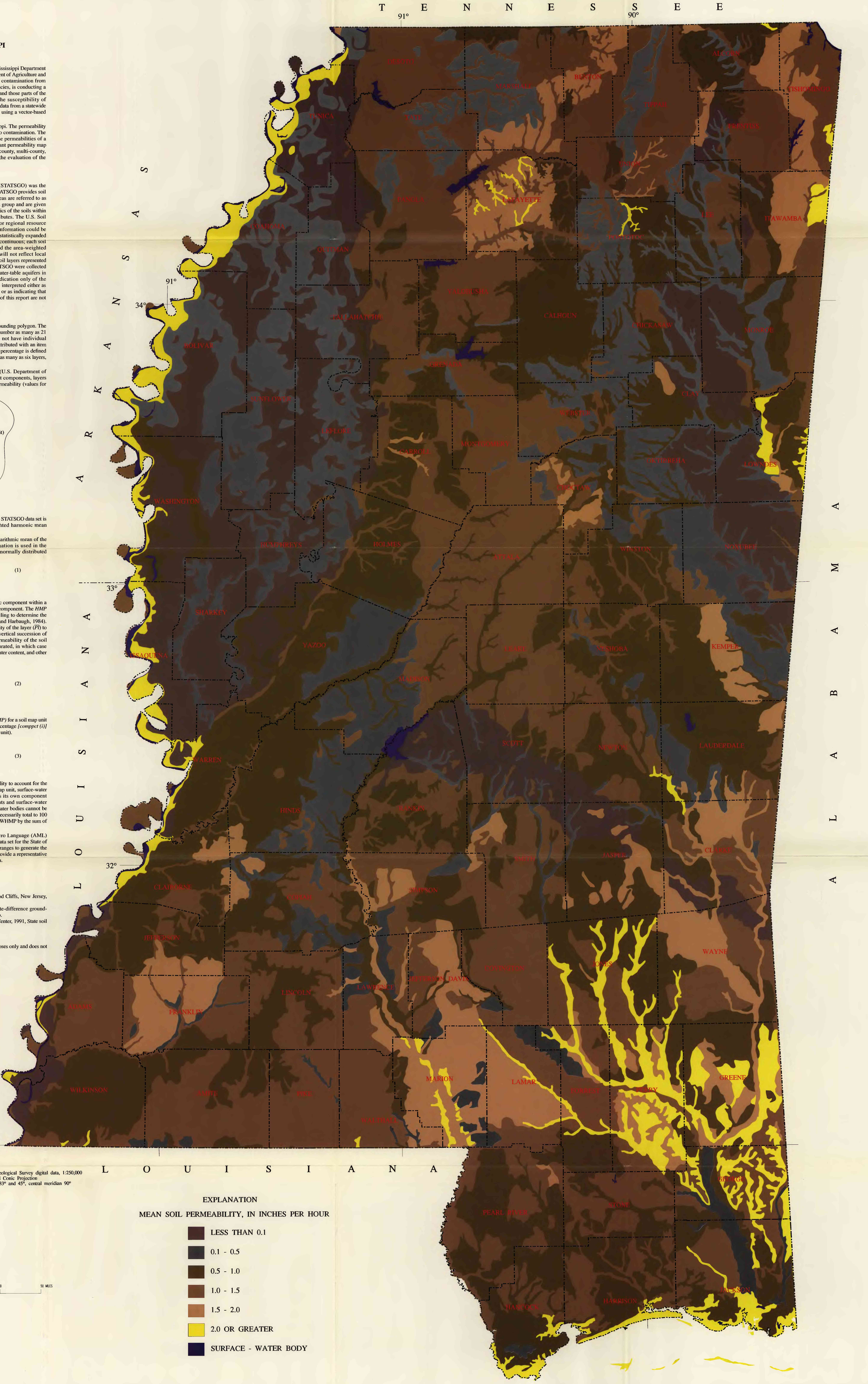
REFERENCES CITED

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Prentice Hall, Inc., Englewood Cliffs, New Jersey, 604 p.

McDonald, M.G., and Harbaugh, A.W., 1984, A modular three-dimensional finite-difference ground-water flow model: U. S. Geological Survey Open-File Report 83-875, 528 p.

U.S. Department of Agriculture, Soil Conservation Service, National Soil Survey Center, 1991, State soil geographic data base, data users guide: Lincoln, Nebraska, 86 p.

[1]The use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.



Base from U.S. Geological Survey digital data, 1:250,000
Lambert Conformal Conic Projection
Standard parallels 33° and 45°, central meridian 90°

SCALE 1:500,000

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

EXPLANATION

MEAN SOIL PERMEABILITY, IN INCHES PER HOUR

- LESS THAN 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 OR GREATER
- SURFACE - WATER BODY

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Permeability of Soils in Mississippi

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