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HEALTH PHYSICS DIVISION

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W. M. McMaster* and H. D. Waller**

Introduction

Since Oak Ridge National Laboratory began operation in 1943, radioactive wastes have been released on a continuous basis to the environment of Whiteoak Creek Basin. The natural factors affecting movement or retention of the radionuclides released are the water moving in and through the basin and the materials over and through which the water and its associated radionuclide load pass in transit.

Because the geology and soils of Whiteoak Creek Basin are the principal modifying agents in water movement and the soil selectively fixes radionuclides, a knowledge of their characteristics is necessary for an understanding of the manner in which radionuclides move through or are stored in the basin.

This report is a description of the geologic setting, the characteristic soils, and the general hydrologic characteristics of the geology and soils of the basin.

* On loan from Water Resources Division, U. S. Geological Survey.

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*** Abstracted in part from W. M. McMaster, Geology of the Oak Ridge Area, Tennessee(4).

Previous geologic and soils work

Parts of the geology and soils of Whiteoak Creek Basin have been mapped in some detail previously. In 1950 a geologic map of part of Bethel Valley was prepared by H. J. Klepser[1], Department of Geology and Geography, University of Tennessee, in which Klepser divides the Chickmauga Limestone into eight lithologic units. Klepser's subdivision is used in this report. In 1954 John Barnett, U. S. Corps of Engineers, mapped the southwestern part of Melton Valley and divided the Conasauga Group into four lithologic units[2]. A generalized soils map of the Oak Ridge area was compiled in 1961 by Dorothy Carrol, U. S. Geological Survey, giving a summary of mineralogical and chemical data for some soil and rock samples collected in the area[3]. A geologic map of the Oak Ridge area was prepared by W. M. McMaster, U. S. Geological Survey, and published in 1963[4].

The base map for the accompanying geologic and soil maps was prepared by the Graphic Arts Section at Oak Ridge National Laboratory and is a composite map made from the 1942 Stone and Webster map which has a scale of 1 in. to 400 ft. and a 10-ft. contour interval; the 1953 edition of the TVA-USGS Bethel Valley quandrangle which has a scale of 1 in. to 2,000 ft. and a contour interval of 20 ft.; and several recent planimetric maps prepared by the Plant and Equipment Division at ORNL.

Climate

According to the U. S. Weather Bureau (Local Climatological Data, 1963) the ORNL area has a record mean annual precipitation of 51.80 in. and a record mean temperature of 58.1° F. The average monthly rainfall varies considerably through the year, the maximum generally occurring in February, which has an average of 5.84 in.; and the minimum generally occurring in October, which has an average of 2.61 inches. The range of precipitation occurring in any one month, is however, widely variable; for example, recorded rainfall for October has ranged from none in 1963 to 6.43 in. in 1949. The period of greatest average rainfall closely corresponds to the period of lowest average temperatures.

Location and Description of Basin

Whiteoak Creek Basin is located in Roane Co., Tennessee, in the southern part of the Oak Ridge Reservation. It has an area of 6.01 sq. mi. The topography of the basin is similar to that elsewhere in the western part of the Tennessee section of the Valley and Ridge province, consisting of parallel ridges and valleys trending northeast. The range of altitude is from 735 ft. above mean sea level at the mouth of Whiteoak Creek during low pool stage of Watts Bar Lake to 1,356 ft. at the crest of Melton Hill. The valley floors are at an altitude of about 800 feet and the crests of Haw Ridge and Chestnut Ridge at about 1,100 ft.

Drainage is by Whiteoak Creek to the Clinch River at Clinch River Mile 20.8. Whiteoak Creek originates as a series of springs in the northern part of the basin, from where it flows southwest through Bethel Valley to a water gap in Haw Ridge to enter Melton Valley, then flows through a small impoundment known as Whiteoak Lake which is created by a highway fill dam 0.6 mile upstream from the stream's mouth. Most of Melton Valley is drained by Melton Branch which joins Whiteoak Creek at Whiteoak Creek Mile (WOCM) 1.55.

In the basin the ridges are predominantly wooded. Bethel Valley is mostly grassland and Melton Valley is partly wooded, partly open.

Use of Basin

Prior to 1942, the valleys and lower hillsides in Whiteoak Creek Basin were largely under cultivation. The ridges, then as now, were mostly wooded and unused. Since 1942, the basin has been the site of the Oak Ridge National Laboratory. The main laboratory area is in Bethel Valley, but some facilities are located in Melton Valley.

Since 1943, segments of the environment of Whiteoak Creek Basin have been used for the disposal of radioactive wastes, which are of four general types: liquid wastes discharge directly to streams; liquid waste discharged to pits and trenches; solid or packaged wastes disposed of by burial; and gaseous wastes released to the atmosphere through stacks. In all, there are more than 20 known sources of radioactive contamination in the basin[5].

General Geology

Four major rock units or formations occur in Whiteoak Creek Basin; from oldest to youngest, they are the Rome formation, which underlies Haw Ridge, made up of shale, siltstone, and sandstone; the Conasauga Group, which underlies Melton Valley, made up of shale, siltstone, and limestone; the Knox Dolomite, which underlies Chestnut Ridge and Melton Hill; and the Chickamauga Limestone, which underlies Bethel Valley.

These rocks originated early in the Paleozoic era as marine sediments. Towards the end of the Paleozoic, they were subjected to lateral compressive forces and uplifted. As a result of the deformational forces, the Rome was thrust-faulted over the Chickamauga. The strata dip to the southeast at angles ranging generally between 20° and 40°, and strike northeast at about 35°. Local departures from prevailing strike and dip are present, particularly in the Conasauga Group.

A mantle of residual material is nearly everywhere present, in places more than 100 ft. thick. Generally, the Chickamauga has the least thickness of residual material and the Knox has the greatest. Table 1 describes the geologic characteristics of the formations and the units mapped, and the residual materials developed from these rocks. The accompanying geologic map, figure 1, shows areas of outcrop of the formations and units mapped, and the attitude of the strata.

Hydrologic characteristics of the formations

Rome Formation

The Rome has a very limited capacity for receiving, storing, and transmitting water. In the unweathered bedrock, the occurence of water is largely limited to small openings that occur along joints and bedding planes. In addition, the steep terrain underlain by the Rome increases surface runoff and reduces recharge. The thin mantle of residual clay and the near-surface weathered bedrock zone having slightly enlarged openings probably account for the greater part of water movement in the Rome. Ground water discharge during the dry months is very low.

Conasauga Shale

Ground water in the Conasauga occurs principally in the weathered zone where openings along joints and bedding planes have been slightly enlarged by circulating water. Because these enlarged openings occur only to shallow depths the total capacity for water storage is small. During the winter months, springs are common in the small valleys along the northwestern side of Melton Valley, principally in unit Ꞓcb, but during April and May discharge is greatly decreased as recharge is reduced and the water-bearing material is drained. During the summer months very little water is discharged. Discharge of ground water from units Ꞓcd and Ꞓce is small even during the winter months; during the late summer months no discharge is known to occur from these units into Whiteoak Creek Basin.

Water levels range in depth below land surface from less than one foot in the lower elevations to a measured maximum of 47 ft in the higher elevations of the line of low hills on the northwestern side of the valley.

Knox Dolomite

The Knox of Chestnut Ridge is the principal aquifer in Whiteoak Creek Basin. The thick mantle of overburden appears to have a high infiltration capacity, minimizing overland runoff of rainfall, and also serving as a reservoir of ground water feeding underlying solution openings, many of which probably are of large size.

The springs occurring along the base of Chestnut Ridge and in its valleys are the chief source of the base flow discharge of Whiteoak Creek. The Knox of Copper Ridge, however, is not known to discharge ground water into Whiteoak Creek Basin. Discharge from this area probably takes place to the southeast along the Clinch River.

Depths to the water table in the Knox of Chestnut Ridge range up to a known maximum of 125 feet at the crest of the ridge. Water levels are progressively farther below land surface with increasing elevation. In Copper Ridge, the known maximum depth to the water table is 289 ft, near the crest of Melton Hill.

Chickamauga Limestone

Large cavities do not occur in the Chickamauga, most openings being only a few inches in width (diameter). In addition, the characteristics of the clay overburden are such that infiltration (by recharge) is restricted. Although a substantial quantity of water probably is stored in the many small openings present in bedrock within about 100 ft of land surface, rates and quantities of water movement are for the most part relatively small.

Storm runoff from much of Bethel Valley is high, due in part to the large areas of pavement and roof, but also due to the low infiltration capacity of much of the soil and residual cover.

Description of Soils occurring in Whiteoak Creek drainage basin

This section describes the soils that are associated with the different geologic units occurring in the Whiteoak Creek drainage basin. Included is a soil-association map (Fig. 2) listing the approximate location and soil series which commonly occur within each land form or geological unit[7]. Also, attached is a table giving a brief description of physical properties, identifying characteristics and genetic relationships of the soils found within this drainage basin (Table 2). The percent land area occupied by individual soil series within each geologic belt is listed in Table 3.

By comparing the soil map with the accompanying geologic and topographic map, soil series can be associated with land form and geology. In order to estimate and understand the hydrologic characteristics of a given area, the overlying soil mantle and the underlying geology are equally important. The effects of each should be considered simultaneously. Also, many soil characteristics, including both chemical and physical properties, may be directly related to the underlying geologic formation.

Soil classification of any soil study area or soil-geology study area gives a systematic means of cataloging and interpreting many soil properties. Many of the physical and chemical properties are common to one soil series, or in many instances a given set of physical or chemical properties may be common to a large group of soils. This permits variation of one set of characteristics while other properties, both chemical and physical, may be held within a similar range. Agencies such as Soil Conservation Service, Agriculture Research Service, State Universities, and experiment stations have already done much of the basic research on some of the more extensively occurring soils which are important to agricultural management. Therefore, the use of a classification system based upon soil genesis and morphology (such as used by the U. S. Department of Agriculture) permits extrapolation to other areas, since these soils occur regionally.

Soils occurring within the Whiteoak Creek drainage basin belong largely to the broad groups of red-yellow podsolic, reddish-brown lateritic and lithosols. These soils occur extensively in the southeastern United States over most of the coastal plain, much of the Piedmont and southern end of the Appalachian Plateau and the Valley and Ridge province. In general, soils in this area are strongly leached, acid in reaction, low in organic matter, and have exchange capacities less than 10 milliequivalents per 100 grams of soil.

The soils occurring within the drainage basin have a wide range of both physical and chemical properties. Depth of the soil profile varies from 6 inches in some of the shale and sandstone areas to depths of 15 feet or more in some of the dolomitic limestone areas and alluvial deposits along drainageways. The pH ranges from near neutrality in the Bland and young alluvial soils to strongly acid in some of the weathered upland shale and sandstone soils such as Litz and Lehew. Texture of the surface is dominately silt loam or cherty silt loam; but in eroded areas, such as commonly found in the Bland soils, the surface may be a silty clay. Texture of the subsoil ranges from cherty silt loam (Clarksville soils) to a firm, plastic clay (Talbott and Colbert soils). Entrance of surface water into the soil profile varies from rapid (up to 10 inches per hour) in Clarksville soils to slow (less than .2 inch per hour) in eroded Colbert and Bland soils. Internal soil drainage ranges from poorly drained in Melvin series to excessively drained in the Clarksville and Muskingum series. Other soils such as Pace and Leadvale have fragipan layers (occurring at 24 to 30 inches depths) which impede the downward percolation of soil water(7).

The soils derived from the Knox Dolomite contain kaolinite as their principal clay mineral, those from the Conasauga Shale contain illite and vermiculite as principal clay minerals and the soils derived from the Chickamauga Limestone contain a mixture of kaolinitic and illitic minerals with some units probably having a significant amount of montmorillonitic clay minerals. The clay minerals are under-saturated with bases, leaving H^+ in the exchange positions of the clay(3). Per cent base saturation varies from less than 10 to more than 60 percent.

Both illitic and vermiculitic clay minerals are more efficient in fixation of potassium and other comparable ions into less available positions than are the kaolinitic minerals. However, the initial rate and direction of movement of many ions (including radionuclides) are largely controlled by the physical properties of that soil system, especially if the contaminant is in the form of a surface application. The chemistry and mineralogy will serve as a modifier to the effect of the physical properties through their chemical capacity in selectively removing certain ions or radionuclides from the soil solution.

Since soil water (soil solution) is one of the primary instruments in the translocations of ions either in solution or by physical movement, factors affecting water movement and storage will also affect chemical movement. If rainfall and vegetation are held constant, the rates and direction of the initial movement of surface water are controlled by the physical properties of the soil system. The surface movement, both laterally across the surface and infiltration into the surface will be controlled by topographical features of the surface soil and permeability of the surface layers. Vertical movement within a profile of a soil system will be greatly controlled by the relative pore space and relative clay content of the particular soil horizon in question.

With the many different topographic features and contrasting soil characteristics (both chemical and physical) present within the drainage basin, one should be able to define the effect of the soil system upon ultimate movement and recycling of elements over a relatively wide range of conditions.

Summary

The manner in which radionuclides move through a natural environment is determined by the movement of water which bears the radionuclides, and the physical and chemical characteristics of the materials over and through which the water passes, as well as the chemical characteristics of the nuclide. Geology and soils are basic determinants of the hydrology of an environment and the soils are chemically active in selectively removing certain radionuclides from solution.

Whiteoak Creek Basin is underlain by four major geologic formations which dip southeast and strike northeast. The two oldest, the Rome Formation and Conasauga Group, are made up of shale, siltstone, sandstone and limestone and are poor water-bearing formations.

The two younger formations, the Knox Dolomite and the Chickamauga Limestone, are the principal water-bearing formations of the basin and discharge from the Knox is the main source of base flow in Whiteoak Creek.

The residuum in the basin is thinnest in the Chickamauga outcrop area, where it commonly is between 1 and 10 ft thick, and thickest in the Knox outcrop area where it is commonly between 30 and 125 ft thick. The residuum of the Knox is a major ground water reservoir, feeding underlying solution cavities in the bedrock. The residuum of the Conasauga bears practically all the ground water in Melton Valley.

The soils of the basin belong to the red-yellow podsolic, the reddish-brown laterite and lithosol groups. They are strongly leached,

low in organic matter, acidic, and generally have exchange capacities of less than 10 milliequivalents per 100 gm of soil. Soil profiles range in depth from 6 inches in some shale areas to about 15 ft in the dolomite and alluvial areas. Textures are from silty loam to plastic clay and infiltration capacities range from 10 in/hr to less than 0.2 in/hr. Clay minerals present include illite, kaolinite, and montmorillonite; base saturation ranges from 10 percent to more than 60 percent.

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Table 1. Geologic Characteristics and nature of Residual Materials of Units Mapped, Whiteoak Creek Basin.

AGE	FORMATION NAME AND THICKNESS	UNIT	GEOLOGIC CHARACTERISTICS	RESIDUAL MATERIAL
Early Cambrian	Rome Formation (Ꞓr) ~800 ft		Siltstone, shale, and sandstone. Variegated color, including brown, tan, red-brown, maroon, and green. Mica common, mostly on bedding surfaces. Thinly bedded; sandstone beds generally less than one ft thick. Siltstone and shale dominant in lower half. Upper half contains interbedded sandstone. Small faults and folds common. Lower beds generally dip very steeply; dip decreases towards upper beds. Rome is thrust-faulted over Chickamauga. Underlies Haw Ridge.	Silty, sandy, coarse-textured material containing small amounts of light-colored primarily micaceous clay; contains fragments of siltstone and sandstone remnants up to boulder size. Probably everywhere less than 20 ft to unweathered bedrock.
Middle Cambrian	Conasauga Group (Ꞓc) 1,500-2,000 ft (?)	Ꞓca	Shale and siltstone, mostly brown, red-brown, maroon, and green-brown. Fine mica abundant on bedding surfaces. Deformation by folding and faulting appears to be much less than that of overlying unit. Contains little limestone or calcareous shale. Underlies narrow valley at southeastern base of Haw Ridge.	Silty brown, tan, greenish and maroon primarily micaceous clay retaining bedding of parent rock in most places; elsewhere, contains many thin flakes of shale. Depth to bedrock less than 20 ft.

AGE	FORMATION NAME AND THICKNESS	UNIT	GEOLOGIC CHARACTERISTICS	RESIDUAL MATERIAL
Middle Cambrian	Conasauga Group (continued)	€cb	Variable lithology, ranging from shale and siltstone to limestone. Limestone is characteristically pebble conglomerate or edgewise conglomerate having irregular bedding surfaces coated with thin film of dark gray clay and marked by abundant ropy "worm trails". Limestone occurs in zones of shale and siltstone. Siltstone in this unit is commonly calcareous and white or light gray when fresh. Shale is thinly bedded, colored brown, olive, and tan, and locally, maroon. In many places unit is deformed by very small, sharp folds and faults of small displacement. Underlies line of low knobs on northwestern side of Melton Valley.	Unit weathers to bedded shale appearance, leaving little or no indication of original calcareous nature. Limestone weathers to porous brown siltstone or to light orange-yellow illitic clay. Residuum is generally light tan to yellow-brown but local variations include maroon and green bands. Black manganese oxide stains common on joint surfaces. Residuum is locally more than 20 feet thick on crests of knobs, but is less than 20 ft thick on flanks of knobs.

AGE	FORMATION NAME AND THICKNESS	UNIT	GEOLOGIC CHARACTERISTICS	RESIDUAL MATERIAL
Middle Cambrian	Conasauga Group (continued)	Ꞓcc	Exposures of this unit are very limited; appears to be similar to unit Ꞓcb but contains less limestone. Minor folding common. Underlies central, lowest part of Melton Valley.	Appears to be more thoroughly weathered than unit Ꞓcb. Residuum consists of yellow-tan clay containing abundant flakes and chips of shale. Thickness not known.
Late Cambrian		Ꞓcd	Alternating zones of limestone and shale, limestone increasing in proportion towards upper part of unit. Limestone is very similar to that of unit Ꞓcb but is commonly siliceous, more thickly bedded, and more resistant to weathering; also, pebble conglomerates are less common than edgewise conglomerates. Oolitic limestone present in upper part of unit. Shale is very thinly bedded, brown, tan, and gray. Underlies belt along base of Copper Ridge, where basal layers form low, rounded knobs.	Yellow-tan to brown clay containing abundant shale chips and locally containing dense caramel-brown to jasper chert up to boulder size. Ground surface commonly strewn with boulders and blocks of limestone. Residuum is very thin and projecting ledges of limestone are very common.

AGE	FORMATION NAME AND THICKNESS	UNIT	GEOLOGIC CHARACTERISTICS	RESIDUAL MATERIAL
Late Cambrian	Conasauga Group (Ꞓc) (continued)	Ꞓce	Fairly pure limestone and dolomitic limestone, light to medium gray, finely to coarsely crystalline, in beds from less than 1 ft to 5 ft thick. Thin beds of interbedded shale in lower part. Contains very little chert. Crops out along northwestern face of Copper Ridge.	In most places overburden is very thin, but where present is a light orange-red granular clay containing little or no chert.
Late Cambrian-Early Ordovician	Knox Dolomite (OꞒk) 2,600 ft		Mostly siliceous dolomite, medium to light gray, dense to coarsely crystalline, in beds up to four ft thick. Upper 400 ft is largely light-gray to medium-gray dense to finely crystalline dolomite and dolomitic limestone containing jasper chert. Underlies Chestnut Ridge and the upper part of Copper Ridge.	Generally light yellow-tan to red to red-brown largely kaolinitic clay containing abundant chert fragments and blocks ranging up to boulder size. Thickness of overburden is in most places greater than 30 ft; known maximum thickness on Chestnut Ridge is 125 ft and on Copper Ridge, 65 ft.

AGE	FORMATION NAME AND THICKNESS	UNIT	GEOLOGIC CHARACTERISTICS	RESIDUAL MATERIALS
Middle Ordovician	Chickamauga Limestone (Och) 1,800 ft	Ocha	Mixture of calcareous siltstone, limestone, and bedded chert; siltstone is olive, gray, and maroon; limestone is dark to light-gray; chert is dark gray. About 250 ft thick.	Residuum on Chickamauga typically heavy yellow or yellow-brown montmorillonite-like clay generally containing small chips of white or yellow chert, fragments of porous brown siltstone, and small blocks of limestone. Unit Ocha, however, has thick overburden of extremely cherty red clay, the chert occurring as loose rectangular blocks or in beds inter-layered with residual clay. Also, unit Ochb has only a very thin veneer of overburden in most places and in relatively large areas none is present. A series of 50 core holes drilled into units Oche, Ochf, Ochg, and Ochh by Stockdale showed depths to bedrock ranging from 1 ft to 25 ft. This range of thickness
		Ochb	Laminated calcareous shaly siltstone, mostly maroon but locally contains blotches of green and yellow. About 200 ft thick.	
		Ochc	Limestone, light to medium gray, finely to coarsely crystalline, partly shaly. Contains some thin beds of light maroon calcareous siltstone. Nodular gray chert present in more pure limestone. About 120 ft thick.	
		Ochd	Shaly, cherty limestone, gray to olive, thinly bedded. Contains abundant chert in lower beds, resulting in resistance to erosion. Underlies chain of low hills on northwestern side of Bethel Valley. About 220 ft thick.	

AGE	FORMATION NAME AND THICKNESS	UNIT	GEOLOGIC CHARACTERISTICS	RESIDUAL MATERIAL
Middle Ordovician	Chickamauga Limestone (Och) (continued)	Oche	Shaly limestone and calcareous shale, gray to gray tan, containing some maroon-gray limestone in lower part of unit. Shale partings along bedding planes common. Upper part of unit weathers to produce small rounded masses of yellow, silt-encrusted limestone mixed with clay residuum. About 380 ft thick.	is probably typical of all units except units Ocha and Ochb.
		Ochf	Calcareous shaly siltstone, mostly maroon. Very similar to unit Ochb. 25-30 ft thick.	
		Ochg	Mixture of various types of limestone, mostly medium to light gray and brown gray; generally shaly and thin bedded. About 300 ft thick.	
		Ochh	Maroon calcareous siltstone at base, overlain by gray or maroon-gray shaly limestone, about 300 ft thick.	

Table 2

CHARACTERISTICS AND GENETIC RELATIONSHIPS OF SOILS FOUND IN WHITE OAK CREEK DRAINAGE BASIN

Great Soil Group and Soil Series and Map Symbol		Brief Profile Description	Physiographic Position	Soil Drainage Classes (1)	Slope Range (per cent)	Parent Material and Geologic Formation
ZONAL						
Red-Yellow Podzolic soils						
Colbert	Cbl	Dark yellowish-brown silt loam surface over a very firm yellowish-brown clay. Weathered argillaceous limestone bedrock is at 18 to 30 inches. Rock outcrops are common. Top soil usually removed from nonforested areas by sheet erosion.	Upland	Moderately well drained	2 to 7	Argillaceous limestone Chickamauga Limestone
Fullerton	Ful	Grayish-brown cherty silt loam over yellowish-red cherty silty clay or cherty clay underlain at 36 inches by red cherty silty clay variegated with yellowish-brown and strong brown. Depth to bedrock usually ranges from 8 to 25 feet.	Upland	Well drained to excessively drained	4 to 50	Cherty dolomite or limestone Knox Dolomite, Chickamauga Unit Ocha and Ochc
Hartsells	Har	Yellowish-brown loam surface over yellowish-brown loam subsoil. Depth to weathered bedrock is generally 24 to 30 inches. Occurs intermittently on the broader ridge crests on Haw Ridge.	Upland	Well drained	5 to 12	sandstone Rome Formation

Great Soil Group and Soil Series and Map Symbol		Brief Profile Description	Physiographic Position	Soil Drainage Classes (1)	Slope Range (per cent)	Parent Material and Geologic Formation
Jefferson	Jef	Yellowish-brown loam surface over yellowish-brown or brownish-yellow moderately friable clay loam subsoil which becomes slightly mottled with yellow and gray at 36 inches. Depth of the colluvial deposit ranges from 2 1/2 to 8 feet and is underlain by shale or sandstone residuum.	Foot slopes and colluvial benches	Well drained	4 to 30	Colluvium from sandstone Rome Formation
Minvale	Min	Brown to dark yellowish-brown silt loam surface over yellowish-red silty clay subsoil. Depth of colluvial deposit varies from 3 to 8 feet, generally underlain by dolomitic limestone residuum. Developes in colluvial material generally transported from Fullerton Upland soils.	Foot slopes and colluvial benches	Well drained	4 to 20	Colluvium from cherty dolomite and limestone Chickamauga Unit Ocha
Muse	Mus	Yellowish-brown silt loam surface over strong brown silty clay loam or silty clay subsoil. Depth to colluvial deposit varies from 2 1/2 to 6 feet and is underlain by acid shale residuum.	Foot slopes	Well drained	3 to 20	Colluvium from acid shale
Sequoia	Seq	Brown silt loam or silty clay loam surface over yellowish-red silty clay subsoil which grades into yellowish-red shaly silty clay at 20 to 22 inches. Weathered shale bedrock generally occurs at 28 to 30 inches. Usually occurs on the broader, smoother hill tops.	Upland	Well drained	3 to 12	Yellowish-red acid calcareous shale Conasauga Unit (-Ccb, Chickamauga Unit Ochh)

Great Soil Group and Soil Series and Map Symbol		Brief Profile Description	Physiographic Position	Soil Drainage Classes (1)	Slope Range (per cent)	Parent Material and Geologic Formation
Talbott	Tal	Brown silty clay loam over yellowish-red very firm clay subsoil which grades into a yellowish-red clay, mottled with yellow and brown at 25 inches. Depth to weathered bedrock ranges from 3 to 5 feet. Occurs on relatively chert-free units in areas where rock outcrops are less common.	Upland	Well drained	3 to 20	Argillaceous limestone Chickamauga Limestone
Grading toward Planosols						
Leadvale	Lea	Grayish-brown silt loam surface over yellowish-brown silty clay loam subsoil. Fragipan at 24 inches. Colluvial deposit is generally 1 1/2 to 5 feet thick and is underlain by shale residuum. Developed in soil deposits transported from Litz and Sequoia soils.	Foot slopes and colluvial benches	Moderately well drained	3 to 12	Colluvium and local alluvium from acid calcareous shale Conasauga, Chickamauga Unit Ochh
Pace	Pac	Light yellowish-brown silt loam over yellowish-brown silty clay loam subsoil. Fragipan layer at 28 inches. Depth of the colluvial deposit varies from 3 to 10 feet and is underlain by cherty dolomitic limestone residuum. Developed in soil deposits transported from cherty Fullerton and Clarksville soils.	Foot slopes and colluvial benches	Moderately well drained	2 to 12	Colluvium from cherty dolomite, and limestone

Great Soil Group and Soil Series and Map Symbol		Brief Profile Description	Physiographic Position	Soil Drainage Classes (1)	Slope Range (per cent)	Parent Material and Geologic Formation
Grading toward Regasols						
Clarksville	Cla	Pale-brown very cherty silt loam surface underlain at 12 inches by strong-brown very cherty silty clay loam. Variegated yellow, brown, red, and gray very cherty silt loam substratum occurs at 30 inches. Depth to weathered cherty dolomitic limestone bedrock ranges from 5 to 20 feet, but chert beds are common below a depth of 26 inches. Occurs on the more cherty hill crests along Copper Ridge and Chestnut Ridge.	Upland	Excessively drained	5 to 50	Cherty dolomite or limestone Knox Dolomite, Chickamauga Unit Ocha and Ochc
Grading toward Reddish-Brown Lateritic Soils						
Dewey	Dew	Brown silt loam surface over red silty clay or clay subsoil. Profile is relatively chert free. Weathered bedrock is at 15 to 40 feet. Occurs intermittently along the broader, smoother, more chert-free ridge crests.	Upland	Well drained	3 to 30	Dolomite Knox Dolomite
Hermitage	Her	Dark-brown silt loam surface over yellowish-red friable silty clay loam subsoil. Depth to colluvial deposit is generally from 2 1/2 to 4 feet. It is usually underlain by dolomitic limestone residuum. Developed in soil deposits that have been transported primarily from Dewey and Bolton soils.	Foot slopes and colluvial benches	Well drained	3 to 12	Colluvium and local alluvium from limestone

Great Soil Group and Soil Series and Map Symbol		Brief Profile Description	Physiographic Position	Soil Drainage Classes (1)	Slope Range (per cent)	Parent Material and Geologic Formation
Reddish-Brown Lateritic Soils						
Bolton	Bol	Dark-brown silt loam over a red or dark red friable silty clay loam. Profile is generally chert free. Depth to bedrock is 30 to 50 feet or more. Soil is on east or northeast facing slopes. Occurs on long, smooth, chert-free slopes throughout Copper Ridge.	Upland	Well drained	7 to 30	Sandy dolomite
Humic Gley Soils						
Burgin (Ortho)	Bur	Dark grayish-brown silty clay loam surface which grades to a silty clay at 6 inches. A very dark grayish-brown firm clay subsoil is at 12 inches, which becomes mottled with depth. Extensive surface cracking occurs during dry summer months. Thickness of alluvium over limestone rock ranges from 2 to 5 feet. Most extensive area is located along the northern base of Copper Ridge.	Depressions and narrow bottoms	Poorly drained	3	Local alluvium, argillaceous limestone

Great Soil Group and Soil Series and Map Symbol		Brief Profile Description	Physiographic Position	Soil Drainage Classes (1)	Slope Range (per cent)	Parent Material and Geologic Formation
Low-Humic Gley						
Melvin	Mel	Dark grayish-brown silt loam surface over gleyed subsurface layers that become finer textured with depth. The grayish-brown subsurface layers are mottled with yellow and brown. Water table generally is within 2 feet of the surface. Depth to bedrock is generally greater than 5 feet. Occurs primarily in White Oak Creek flood plain. Sometimes called Prader in areas where alluvium originates primarily from sandstone and shale soils.	Bottom	Poorly drained	0 to 2	General alluvium from mixture of sandstone, shale and limestone
AZONAL						
Lithosols						
Armuchee	Arm	Dark grayish-brown silty clay loam surface, underlain at 10 inches by grayish-brown shaly silty clay. Interbedded weathered shale and limestone rock are at 16 inches. Limestone outcrops are common to most areas. Occurs along the northern foot hills of Copper Ridge.	Upland	Well drained	5 to 30	Shale with interbedded limestone lenses Conasauga shale unit-Ccd

Great Soil Group and Soil Series and Map Symbol		Brief Profile Description	Physiographic Position	Soil Drainage Classes (1)	Slope Range (per cent)	Parent Material and Geologic Formation
Bland (Ortho)	Bla	Reddish-brown silt loam surface, underlain by weak-red silty clay at 8 inches. Weathered bedrock is at 14 to 16 inches. Class 1 rockiness is common over most areas. Very erodable; surface soil has been removed over much of the area by sheet erosion.	Upland	Well drained	5 to 60	Calcareous siltstone (muddy limestone) Chickamauga Unit Ochb
Lehew	Leh	Weak-red loam surface underlain at 8 inches by weak-red shaly loam substratum. Weathered bedrock is at 16 inches. The weak-red color is not uniform, there are many brownish-yellow bands interwoven.	Upland	Excessively drained	5 to 60	Interbedded sandy shale, and siltstone
Litz	Lit	Yellowish-brown silt loam surface over yellowish-red shaly silt loam or shaly silt clay loam subsoil. Weathered bedrock is at depths of 16 to 18 inches. Gully-erosion common in areas that had been cultivated prior to AEC purchase.	Upland	Well drained to excessively drained	5 to 30	Acid shale Conasauga Shale Units Ꞓcb, Ꞓce Chickamauga unit Ochh
Montevallo	Mon	Dark grayish-brown silt loam surface underlain at 6 inches by brown silt loam soil material mixed with grayish colored shale fragments. Soil depth is 10 to 12 inches.	Upland	Well drained	5 to 30	Fissle shale Conasauga Unit Ꞓca
Muskingum	Mus	Yellowish-brown or brown fine sandy loam surface underlain at 9 inches by brownish-yellow stony fine sandy loam subsoil. Depth to weathered sandstone bedrock is generally less than 18 inches. Class 2 and Class 3 rockiness are common.	Upland	Excessively drained	8 to 75	Sandstone Rome Formation

Great Soil Group and Soil Series	Map Symbol	Brief Profile Description	Physiographic Position	Soil Drainage Classes (1)	Slope Range (per cent)	Parent Material and Geologic Formation
Grading toward Red-Yellow Podzolic Soils						
Colbert and Talbott very rocky soils	Tc-Rk	These soils are rocky and fine textured. The soil material between rock exposures generally has a brown or dark-brown silty clay loam surface underlain by yellowish-red very firm clay[1]. Class 2 and Class 3 rockiness.	Upland	Well drained	5 to 30	Argillaceous limestone Chickamauga limestone
Alluvial Soils						
Emory	Emo	Dark reddish-brown loam surface underlain at 14 inches by a weakly developed reddish-brown silty clay loam subsoil. Alluvial deposit is 3 to 10 ft thick.	Narrow bottom toe slopes and depressions	Well drained	2 to 5	Local alluvium chiefly from limestone Knox Dolomite, Chickamauga Limestone
Greendale	Gre	Brown silt loam surface over yellowish-brown silt loam subsoil that becomes somewhat finer textured with depth, grading to a silty clay loam. Free of mottling to a depth of 30 inches or more.	Toe slopes alluvial fans and narrow drainageways	Well drained	2 to 5	Local alluvium from cherty dolomitic limestone Knox Dolomite
Lindside	Lin	Brown silt loam that becomes slightly mottled at 15 inches and becoming progressively more mottled with depth. A mottled dark grayish-brown layer occurs at 24 inches. Depth to bedrock varies from 3 to 20 feet. Sometimes called Hamblen in areas where the alluvium originates primarily from sandstone and shale areas.	Bottoms and local alluvial areas	Imperfectly to moderately well drained	0 to 3	General alluvium and local alluvium from mixture of sandstone, shale, and limestone

[1]As defined in "Soil Survey Manual" (8).

Table 3

ESTIMATES, PERCENT DISTRIBUTION OF SOILS OCCURRING WITHIN EACH GEOLOGIC BELT

Geologic Belt and unit	Soil Series	Percent of Geologic Belt or Unit Occupied	
		Physiographic Position	Soil Series
Knox Dolomite	Upland Soils[1]	82	
	Fullerton		70
	Clarksville		5
	Bolton		5
	Dewey		2
	Colluvial Soils[2]	10	
	Minvale		-
	Hermitage		-
	Pace		-
	Local Alluvial[3]	8	
	Emory		-
	Greendale		-

[1] Upland soils are those weathered in place from underlying geology.

[2] Colluvial soils are those soils developed along foot slopes in material transported from adjacent uplands primarily by gravitational forces.

[3] Local alluvial soils are found along narrow drainageways and depressions; they have formed in soil material transported primarily by water and are subject to flooding during rainy seasons.

Geologic Belt and Unit	Soil Series	Per Cent of Geologic Belt or Unit Occupied: Physiographic Position	Per Cent of Geologic Belt or Unit Occupied: Soil Series
Chickamauga Limestone			
Unit Ocha	Upland Soils	100	
	Fullerton		80
	Clarksville		20
Unit Ochb	Upland Soils	80	
	Bland (includes rockland)[4]		60
	Colbert		20
	Colluvial Soils (From adjacent slopes)	20	
Unit Ochh	Upland Soils	80	
	Sequoia		15
	Litz		25
	Armuchee (includes rockland)		40
	Colluvial Soils from Rome	20	
	Muse		-
	Jefferson		-
Units Ochd, Oche, Ochf, Ochg	Upland Soils	80	
	Talbot		35
	Colbert		35
	Rockland		15
	Alluvial-Colluvial Deposits	20	
	Leadvale		-
	Lindside		-

[4] Rockland is used for soil areas having more than 25% of their surface areas covered with rock outcrops.

Geologic Belt and Unit	Soil Series	Per Cent of Geologic Belt or Unit Occupied	
		Physiographic Position	Soil Series
Rome Formation	Upland Soils	90	
	Muskingum		60
	Lehew		25
	Hartsells		5
	Colluvial Soils	10	
	Jefferson		-
	Muse		-
Conasauga Shale Unit €ca	Upland Soils	85	
	Montevallo		60
	Litz		25
	Colluvial Soils	15	
	Muse		-
	Jefferson		-
	Barbourville		-
Unit €cb	Upland Soils	85	
	Litz		50
	Sequoia		35
	Colluvial and Local-Alluvial	15	
	Leadvale		-
	Muse		-
	Lindside (Hamblen)		-

Geologic Belt and Unit	Soil Series	Per Cent of Geologic Belt or Unit Occupied: Physiographic Position	Per Cent of Geologic Belt or Unit Occupied: Soil Series
Unit Ꞓcc	Upland Soils	85	
	Litz		70
	Sequoia		15
	Colluvial and Local-Alluvial	15	
	Leadvale		-
	Lindside (Hamblen)		-
Unit Ꞓcd	Upland Soils	90	
	Armuchee		55
	Rockland		20
	Litz		15
	Colluvial Soils	10	
White Oak Creek Alluvium			
	Lindside[5]	-	-
	Melvin[5]	-	-
	Burgin	-	-
Clinch River Terraces[6]			
	Nolichucky	-	-
	Waynesboro	-	-

[5] These soils, if developed on materials transported primarily from sandstone and shale areas, are sometimes called Hamblen and Prader respectively.

[6] Clinch River Terrace deposits are found near the junction of White Oak Creek and White Wing Road; the area occupied by these terrace deposits contributes little to the White Oak Creek drainage basin.

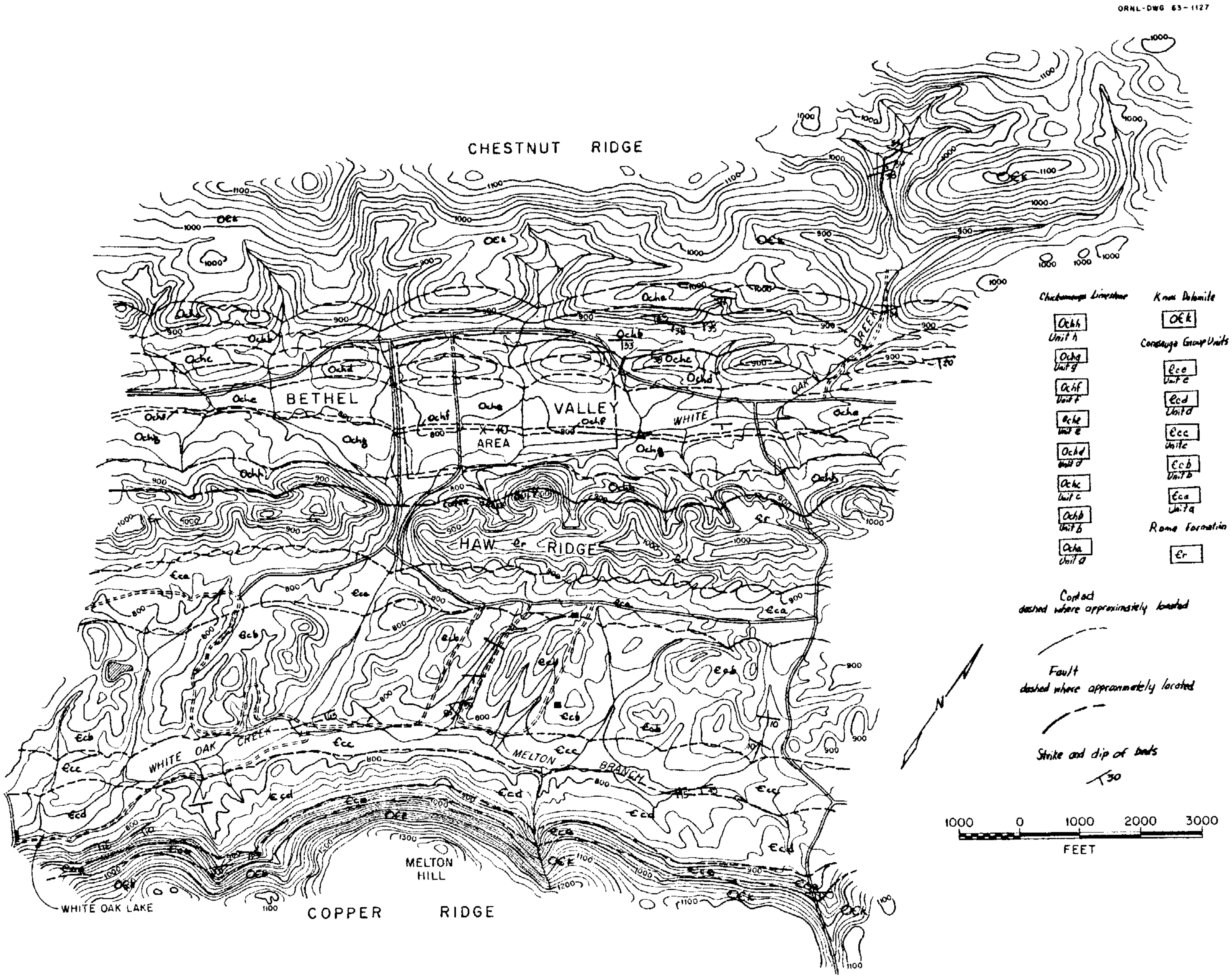

Figure 1. Geologic Map of Whiteoak Creek Basin.

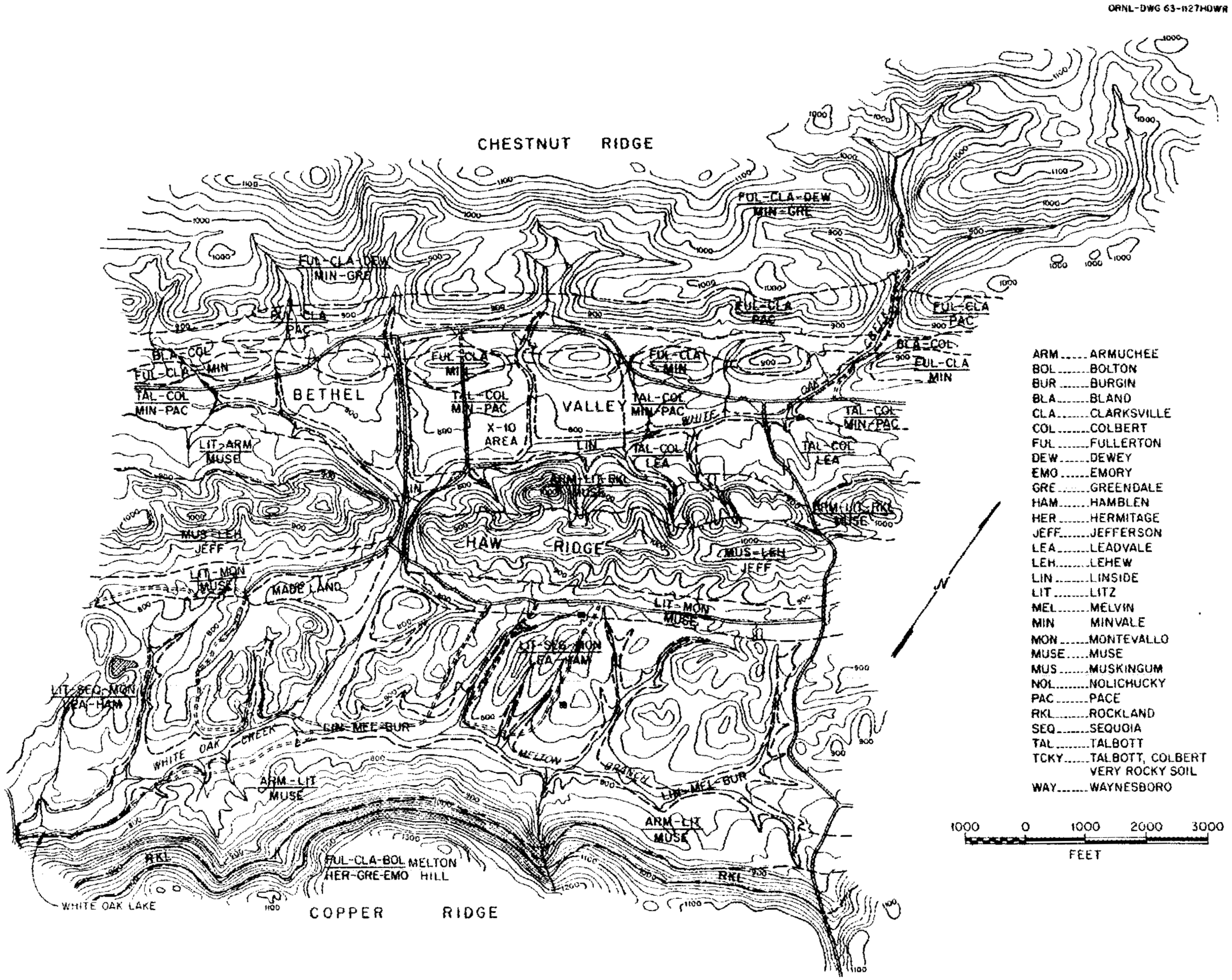

Figure 2. Soil Association Map of Whiteoak Creek Drainage Basin. Common occurring soils within each geologic belt, geologic unit, or topographic unit are listed according to relative abundance (most abundant appear to the left) and toposequence (upland soils in the numerator and colluvial-bench soils or bottom land soils in denominator).

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